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Technology Consortia:

A Prisoner's Dilemma?

by

Rhoda Caldwell
Analyst
Economic and Trade Policy Group
Policy Staff

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Comments or enquiries on this paper should be addressed to the Policy Staff (CPD), External Affairs and International Trade Canada, 125 Sussex Drive, Ottawa, Ontario, K1A OG2 (Tel.: 944-0388 or 944-0367; Fax: 944-0687). ISSN 1188-5041. Copies may also be obtained by faxing the Department's InfoExport Centre (BPTE) at 996-9709, quoting code SP28A.

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Canada

Table of Contents

EXECUTIVE SUMMARY

In a comparatively short period of time, "strategic" trade theory has become to economic theory what the "cold fusion" controversy is to science. Whether or not it represents a paradigm shift is debatable from a theoretical perspective but, from a practical perspective, free trade remains the optimal choice. What is perhaps more obvious is the increasing international network of corporate alliances, particularly those which involve some exchange of technical information, within the OECD and among the U.S., EC and Japan in particular.

It is difficult to draw conclusions from the vast array of complex and often contradictory information available on the subject of technology consortia. As noted in the conclusions, precise definitions are not available, the term 'precompetitive' frequently applied to such endeavours may be a misnomer for 'precommercial' and it is not clear that there exists a significant demand for access to foreign consortia on the part of Canadian stakeholders. Furthermore, at a more fundamental level, we still do not know what role technology consortia play in national innovation systems.

It has become evident, over the course of researching this paper, that Canada may have much to gain from seeking improved access to publicly supported technology consortia in other countries. As a relatively small, advanced economy which contributes modestly to the industrial world's technology, we can ill afford to pursue an isolated approach to technology acquisition. Increasingly, we are seeing the "visible" hand of government in technology creation activities, not just during the early stages of basic scientific research but also at the prototype and field testing stages of development. If our major trading partners continue to restrict access to their public R&D programs, Canadian firms will be disadvantaged.

In the United States, Canadian-based firms, even those bringing their own funding and expertise, are prevented from joining many publicly supported consortia by patent, national competitiveness and national defence legislation, and may face an even greater variety of implicit barriers through government procurement regulations. It also remains to be tested whether recent amendments to the National Cooperative Research Act, which protects firms from punitive damages in an anti-trust suit, discriminate against Canadian members of U.S.-based consortia.

In Europe, Canadian-based firms have, for some time, faced barriers to joining Community supported R&D projects. Even those firms which have affiliates in Europe have encountered resistance to their membership in publicly supported consortia from competitors in other member states. The Fourth Framework Program for Research

and Technological Cooperation (1994-98) will require that non-EC membership in Community R&D projects be permitted only on the basis of a bilateral cooperation agreement. Without such an agreement, Canadian-based firms will not be able to participate in Community-funded projects on a full partnership basis, with full rights to intellectual property, either at the program or the project level of research.

In Japan, Canada has lobbied successfully to be included in international research programs sponsored by the Japanese government. With respect to government funded domestic R&D consortia, the picture is less clear. Canadian organisations face numerous challenges in gaining access to these programs designed to enhance the competitiveness of the national industry. The success rate is abysmal, notwithstanding the existence of a bilateral science and technology cooperation agreement since 1986 and the availability of financial assistance from the Japan Science and Technology Fund.

Canadian firms contacted for comments during the course of this study were unanimous in their support of Canadian government efforts to secure improved access to technology consortia in these countries. All of them reported benefits from their R&D cooperation activities such as product enhancement, increased network of contacts, stronger ties with existing partners and potential for increased sales to the region. However, it is recommended that EAITC, in partnership with ISC and other interested departments, undertake further study to determine the capacity of Canadian high-technology firms to participate in and benefit from membership in foreign-based technology consortia.

Finally, it will be necessary to consult with a number of federal departments and agencies in order to achieve a consensus on this issue since a necessary corollary of improved access may be the requirement to adapt similar Canadian programs to provide reciprocal access to foreign-based firms. It is recommended that the consultation process be initiated, given indications that policy trends in our major trading partners may be moving in a protectionist direction with respect to technology creation activities, a move which might be detrimental to the interests of Canadian firms and to full Canadian participation in the development of new technologies.

RÉSUMÉ

Sur une courte période en comparaison, la théorie du commerce «stratégique» est devenue à la théorie économique ce que la controverse sur la «fusion à froid» est à la science. Qu'il s'agisse ou non d'un changement de paradigme, cela est discutable d'un point de vue théorique, mais d'un point de vue pratique, le libre-échange demeure le meilleur choix. Il existe un phénomène peut-être plus évident encore : c'est la croissance du réseau international d'alliances entre sociétés, particulièrement celles où il y a échange de connaissances techniques, au sein de l'OCDE et surtout entre les États-Unis, la CE et le Japon.

Il est difficile de tirer des conclusions de l'abondance de données complexes et souvent contradictoires sur les consortiums technologiques. Tel que souligné dans la conclusion, les définitions précises ne sont pas disponibles, l'expression 'précompétitive' souvent utilisée pour de telles entreprises signifie fréquemment 'précommerciale', et il n'est pas toujours évident qu'il existe un grand intérêt de la part des firmes canadiennes pour y accéder. Plus fondamentalement, nous ne connaissons guère le rôle que jouent les consortiums technologiques dans les processus d'innovation nationaux.

Il est apparu évident, lors des recherches qui ont mené au présent document, que le Canada aurait avantage à accroître sa participation, dans d'autres pays, à des consortiums technologiques bénéficiant d'un soutien de l'État. Notre économie étant relativement petite et avancée et contribuant modestement à la technologie industrielle mondiale, nous ne pouvons guère nous permettre de chercher en solitaire à acquérir de nouvelles technologies. La participation des gouvernements aux activités d'innovation technologique est de plus en plus évidente et ce, non seulement à l'étape initiale de la recherche scientifique fondamentale, mais aussi à l'étape du développement, au moment de la réalisation de prototypes et de la mise à l'essai. Si nos principaux partenaires commerciaux continuent de restreindre l'accès à leurs programmes publics de R. et D., les entreprises canadiennes se trouveront désavantagées.

Aux États-Unis, les lois relatives aux brevets, à la concurrence nationale et à la défense nationale empêchent les sociétés canadiennes de se joindre à plusieurs consortiums bénéficiant d'un soutien public, même si elles apportent leurs propres capitaux et leurs propres compétences, et la réglementation sur les marchés publics contient un nombre encore plus grand d'obstacles implicites. Il reste encore à voir si les amendements apportés récemment au National Cooperative Research Act, qui met les entreprises à l'abri des poursuites pour violation de la législation antitrust, ne sont pas discriminatoires pour les membres canadiens de consortiums basés aux États-Unis.

En Europe, les entreprises canadiennes désireuses de participer à des projets de R. et D. appuyés par la Communauté se heurtent depuis un certain temps à des obstacles. Même celles qui sont affiliées à des sociétés européennes voient leur participation à des consortiums bénéficiant d'un soutien public contestée par des concurrents d'autres États membres. Le Quatrième programme cadre de recherche et de développement technologiques (1994-1998), ne permettra la participation d'entreprises étrangères aux projets de R. et D. de la Communauté que dans le cadre d'accords de coopération bilatérale. Sans de tels accords, les sociétés canadiennes ne pourront pas participer à des projets financés par la Communauté à titre de partenaires à part entière bénéficiant de tous les droits relatifs à la propriété intellectuelle, que ce soit au niveau des programmes ou des projets.

Au Japon, le Canada a réussi à faire accepter sa participation aux programmes de recherche parrainés par le gouvernement nippon à l'échelle mondiale. La situation n'est cependant pas aussi claire pour ce qui est des associations de R. et D. et des autres consortiums nationaux bénéficiant de fonds publics. En vertu de l'accord de coopération bilatérale de 1986, une entreprise canadienne peut négocier une alliance avec un partenaire japonais, et certains des frais d'établissement et de maintien de l'alliance peuvent provenir du Fonds de coopération scientifique et technologique avec le Japon. Toutefois, on a signalé récemment que les sociétés canadiennes ne seront pas autorisées à participer à des programmes nationaux visant à accroître la compétitivité de l'industrie nippone.

Les entreprises canadiennes contactées dans le cadre de la présente étude appuient de façon unanime les efforts déployés par le gouvernement de Canada en vue de faciliter l'accès aux consortiums technologiques dans ces pays. Elles ont toutes mentionné avoir tiré des bénéfices de leurs activités de coopération en R. et D. : produit amélioré, réseau de relations élargi, liens resserrés avec les partenaires et possibilités accrues de ventes dans ces régions. Il est toutefois recommandé qu'AECEC, en coopération avec ISC et les autres ministères intéressés, entreprenne d'autres études pour déterminer dans quelle mesure les sociétés canadiennes de technologie de pointe peuvent se joindre à des consortiums basés à l'extérieur du pays et en bénéficier.

Il sera enfin nécessaire de consulter un certain nombre de ministères et d'organismes fédéraux (à vocation scientifique) afin d'en arriver à un consensus dans ce dossier, car un meilleur accès pourrait se traduire par la nécessité d'adapter les programmes canadiens semblables de façon à assurer un accès réciproque aux sociétés étrangères. Il est donc recommandé d'amorcer le processus de consultation, vu l'émergence éventuelle de tendances protectionnistes chez nos principaux partenaires commerciaux pour ce qui est de l'innovation technologique, tendances

pouvant nuire aux intérêts des entreprises canadiennes et empêcher leur pleine participation au développement de nouvelles technologies.

The ideas of economists and political philosophers, both when they are right and when they are wrong, are more powerful than is commonly understood.... I am sure that the power of vested interests is vastly exaggerated compared with the gradual encroachment of ideas." J.M. Keynes

I. INTRODUCTION[1]

The 1980s witnessed a dramatic increase in the number of international technical alliances formed within the Triad (U.S., EC and Japan). This has been documented by numerous authors and is depicted numerically in Table 1.[2] Simultaneously, over the last decade a consensus has been developing on the inadequacy of traditional (Ricardian) models of trade in light of recent trends in the postwar trading environment[3] and the development, in the 1970s, of a new set of analytic tools.[4]

TABLE 1

INTER-FIRM TECHNOLOGY AGREEMENTS BY MODES OF CO-OPERATION
Number of New Agreements

	1973-76	1977-80	1981-84	1985-88
Joint ventures	64	112	252	345
Joint R&D	22	66	25	653
Technology exchange	4	33	152	165
Direct investment	29	168	170	237
Customer-supplier relations	19	47	133	266
One-directional technology flow	15	71	269	271
Total	153	496	1 223	1 936

Note: Data are for OECD countries only. Some 350 additional agreements involved firms of OECD countries with firms of other countries, mainly in East Asia.

Source: Hagedoorn, J., "Organizational Modes of Inter-firm Co-operation and Technology Transfer", *Technovation*, Vol. 10, No. 1, 1990, pp. 17-30.

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1 The author wishes to thank the following individuals for their valuable insights and contributions: Terry Ford, Paul Dufour, William Ehrlich, Gregory Kostyrsky, Deanna Horton, Chris Gosnall and all those who provided their comments and observations on the paper.

2 A number of scholars have established databases on international cooperative agreements as noted in the OECD paper by Chenais. However, the paper cautions us about the limitations of the data contained therein because they are frequently built on the basis of information published in the economic and professional press. It is therefore highly dependent on the degree of disclosure of such agreements within the industry which can vary considerably from industry to industry and from country to country.

3 For an extensive treatment of the key elements of "globalisation" and the broad implications for public policy in Canada, see Keith Christie, "Globalisation and Public Policy in Canada: In Search of a Paradigm", Policy Staff Paper No. 93/01 (January 1993).

4 It was in the latter part of the 1970s that a number of economists first began to apply concepts drawn from industrial organisation theory to the analysis of international trade. This body of theory challenges the fundamental tenets of the Ricardian model, that trade is based on the principle of comparative advantage in perfectly competitive markets.

By focusing on the notion of "imperfect" competition in strategic environments in the analysis of international markets, a heated debate was set in motion such that some economists were accused of providing theoretical justification for protectionist industrial policies.[5] However, other economists have interpreted the evidence differently. As one author comments: "An early flirtation with quasi-mercantilist perspectives has been followed by growing analytic consensus, supported by recent empirical research, that trade liberalization in strategic environments is generally (admittedly not always) a more powerful generator of economic benefits than ever."[6]

Nevertheless, it is now apparent that emerging policy trends in the U.S. and Europe reflect, in some measure, an acceptance of the interventionism advocated by strategic trade theory, with its emphasis on stimulating innovation and, in particular, public support for high-technology consortia. This may imply increased restrictions on foreign participation in these consortia and, therefore, may represent a barrier to Canadian access to technology.

The purpose of this paper is to examine the issue of Canadian firms' access to membership in foreign-based technology consortia. The scope of research has been limited to technology consortia engaged in precompetitive research which receive government support. There is also a bias towards the commercial aspect of these alliances, since this bias appears to be prevalent in much of the management literature on innovation and public policy.

More specifically, the task was to compile an inventory of major consortia[7], together with details of membership requirements, funding levels and any relevant government regulations that might apply to foreign members. We can then determine whether Canadian firms seeking to participate, on a full partnership basis, but without access to foreign government subsidies, are being treated in a non-discriminatory manner. By "full partnership basis", we mean those firms which are capable of dedicating the appropriate resources in terms of expertise and financial commitment, and should, therefore, be entitled to participate and to enjoy the benefits of intellectual property rights arising from the consortium, commensurate with their contribution.

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5 For a non-technical critique of strategic trade policy models, see Klaus Stegemann, "Policy Rivalry Industrial States: What Can We Learn From Models of Strategic Trade Policy?", International Organization, 43:1 (Winter 1989).

6 J. David Richardson, "The Political Economy of Strategic Trade Policy", International Organization, 44:1 (Winter 1990), pp. 108-109.

7 This will include major funding programs which are initiated by government to improve the competitive position of national industries in global markets.

The first section of the paper is descriptive, providing a glossary of terms, some reference to types and a brief summary of the relative merits of technology consortia. With regard to typologies, it is important to note that selecting an appropriate typology, which in the author's opinion is more art than science, does not assist us in answering the fundamental questions of this paper.[8]

The second section provides a brief overview of policy trends in the Triad which underlie the phenomenon of international technology consortia. The objective of this section is to highlight some of the positions taken by various stakeholders in Canada and the Triad with a view to understanding how the rules of participation may be affected by competing interests.

The next section is a compilation of documentary and anecdotal evidence gathered from various sources, together with some case histories and commentary received from Canadian companies and industry associations. Finally, the paper concludes with some general comments and a number of recommendations for future study.

[8] Selecting a typology would only improve the analysis if it were to illuminate some distinguishing characteristics of how certain "types" of technology consortia are treated under various trade policy regimes. However, research has indicated that distinguishing characteristics are more likely to be found along industry sectoral lines and in the degree of government involvement. Furthermore, it has been observed by some authors that the formal structure of collaborative ventures often has little to do with either their management or their success and there are indications that the difference between a contractual and an equity relationship is highly exaggerated. "Sophisticated 'cooperators' seem to downplay the importance of ownership control as compared to management control or control through other means.": Gullander (1976), p. 86, cited in David C. Mowery and Nathan Rosenburg, Technology and the Pursuit of Economic Growth, (Cambridge University Press: 1989), p.242.

II. MAJOR CONCEPTS AND DETERMINANTS

2.1 Terminology

A consortium is a group or association of organisations (i.e., separate legal entities such as firms, non-profit organisations, government research institutions, universities, etc.) which reach an agreement to accomplish a set of common objectives for a given period of time. Such a consortium may be government initiated or industry initiated. Under this definition, a consortium is synonymous with an alliance which is also an association of organisations with common interests.

Technology is the knowledge about products, processes and plant organisation that is used in the production of goods and services. **Technology consortia** are, therefore, associations of organisations which come together for the purpose of creating or acquiring new, state-of-the-art knowledge. This knowledge may be embodied in machinery, equipment, handbooks, blueprints, designs or human skills (expertise).[9]

Conceptually, **high-technology** industries are those industries in which "knowledge is a prime source of competitive advantage for firms, and in which firms invest large resources in knowledge creation." These industries are generally characterized by above average spending on R&D and above average employment of scientists and engineers.[10]

Another concept that requires some explanation is **innovation**. A number of models have been used to characterize the innovation process from basic scientific research to applied R&D and commercialisation of the new product or process.[11] In

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9 J. Niosi, "Technical Alliances in the Canadian Electronics Industry: An Empirical Analysis", Technovation, 12:5, (1992), p. 309. According to Dr. Niosi, this definition of technology is generally agreed upon in the literature on economics and management of technology.

10 Paul R. Krugman, "Technology and International Competition: A Historical Perspective", in Martha Caldwell Harris and Gordon E. Moore, eds., Linking Trade and Technology Policies, (National Academy Press: Washington D.C. 1992), p. 13.

11 One such characterization is the "innovation network model" described in a recent paper by Sylvia Ostry and Michael Gestrin of the University of Toronto, entitled "Foreign Direct Investment, Technology Transfer and The Innovation Network Model", (March 1993), pp. 10-11:

"Early models of technology transfer were based upon a linear conceptualization of the process of technology development and innovation. At the heart of this conceptualization was a linear flow of information 'downstream', beginning with basic research in laboratories and ending in the manufacture of a more technology intensive product.... The innovation network model is similar to its linear predecessor in so far as it identifies several of the same important nodes of activity in the innovation process. Basic research continues to be concentrated in universities, and in private

my research, I have attempted to focus on what has been termed "precompetitive" R&D. This would include research from basic to applied and the early stages of product/process development.

2.2 Typology

There are a number of ways in which consortia can be divided into types or categories, such as number of partners, degree of cooperation, stage of cooperation, degree of organisational interdependence and degree of ownership and control.[12] The OECD has done some work on classifying inter-firm cooperation for the purposes of establishing various databases on inter-firm agreements. An article by François Chenais, which appeared in STI Review, comments on the high degree of variability of terms used to categorize inter-firm agreements in the literature, perhaps reflecting the variety of responses that firms can give to the need to access technology and markets.[13]

Joint ventures are described in industrial economics as "operations whereby a legally independent and autonomously managed business enterprise is set up by two or more parent companies to run a clearly defined set of activities in the common interest of the founding firms."[14] Research joint ventures are, therefore, "arrangements in which some firms agree to share the expenditures and the benefits associated with a given research project."[15]

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and government research facilities. The application of basic research in the production of new technologies and innovations remains predominantly in the hands of firms. The innovation network model, however, identifies numerous feedback loops within this system, as opposed to a linear transmission of information from 'producers' of basic science to 'black box' research and development facilities of firms."

12 John Hagedoorn is in charge of the research program Technology, Diffusion and International Competitiveness at the Maastricht Economic Research Institute on Innovation and Technology (MERIT). In "Organizational Modes of Inter-firm Co-operation and Technology Transfer", Technovation, 10:1 (1990), he classifies modes of co-operation by degree of organizational interdependence. Under my broad definition of consortia, the first three types of Hagedoorn's typology would constitute technology consortia where the objective of the co-operation is the creation of new knowledge, i.e., on the frontier. This includes joint ventures, research corporations, joint R&D and technology exchange agreements.

13 François Chenais, "Technical Co-operation Agreements Between Firms", STI Review, OECD, (October 1988), p.55.

14 Ibid, p. 55.

15 Jean Tirole, The Theory of Industrial Organization, (The MIT Press: Cambridge, Ma. 1992), p.413.

In the business literature, research joint ventures are generally distinguished from R&D consortia by the degree of ownership and control. For example, William Evan and Paul Olk of the Wharton School write:

> "The R&D Consortia that are the focus of this article have emerged since the early 1980s as an inter-organizational alternative to licensing arrangements, acquisitions, and joint ventures, especially when a consortium involves only two member companies.... So, in what respects do consortia differ from joint ventures? R&D consortia include direct competitors, while most joint ventures do not. An R&D consortium tends to have a less focused goal because its potential output is uncertain and it is difficult to get members to agree on specific goals. Also, the equity and other inputs from members of a consortium tend to be appreciably less than those invested by each member of a joint venture.... An R&D consortium tends to be a more loosely coupled organization than a two-sponsor joint venture."[16]

For the purpose of this paper, I will use the broad definition of a research joint venture employed in Canada's Competition Act.[17] Research joint ventures are, therefore, a type of technology consortium. Since a merger involves the creation of a single legal entity, it does not constitute a consortium as defined in this paper.

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[16] William M. Evan and Paul Olk, "R&D Consortia: A New U.S. Organizational Form", Sloan Management Review, (Spring 1990), p.38.

[17] Chapter C-34 (Part VIII), Section 95 (1) of the Competition Act states:

The Tribunal shall not make an order under section 92 (referring to Mergers) in respect of e combination formed or proposed to be formed, otherwise than through a corporation, to undertake a specific project or a program of research and development if

(a) a project or program of that nature
  (i) would not have taken place or be likely to take place in the absance of the combination, or
  (ii) would not reasonably have taken place or reasonably be likely to take place in the absence of the combination because of the risks involved in relation to the project or program and the business to which it relates;
(b) no change in control over any party to the combination resulted or would result from the combination;
(c) all persons who formed the combination are parties to an agreement in writing that imposes on one or more of them an obligation to contribute assets and governs a continuing relationship between those parties;
(d) the agreement in paragraph (c) restricts the range of activities that may be carried on pursuant to the combination, and provides that the agreement terminates on the completion of the project or program; and
(e) the combination does not prevent or lessen or is not likely to prevent or lessen competition except to the extent reasonably required to undertake and complete the project or program.

Mergers are defined in section 91 as follows:

In sections 92 to 100, "merger" means the acquisition or establishment, direct or indirect, by one or more persons, whether by purchase or lease of shares or assets, by amalgamation or by combination or otherwise, of control over or significant interest in the whole or a part of a business of a competitor, supplier, customer or other person.

Furthermore, we would not count licensing agreements as technology consortia since their primary purpose is the transfer/sale of existing technology rather than the creation/acquisition of new technology.

2.3 The Pros and Cons of Consortia

It has been noted by a number of authors that, quite contrary to what one might expect, R&D consortia often comprise firms which operate in direct competition in product markets. What incentives lead competitors to cooperate in their R&D?

One the reasons postulated to explain this phenomenon is that in high-technology industries, characterized by high fixed costs in research and development and a tendency to high market concentration, a company is likely to find partners with comparable research capabilities and complementary technology among its competitors.

The Pros

Among the benefits of cooperation are [18]:

a) **Risk Management:** collaboration permits the sharing of R&D costs of high risk technologies, the so-called "high impact" technologies such as superconductivity, and femtosecond technology.[19] Thus it spreads the risk over a larger number of investors.

b) **Project Management:** collaboration reduces some of the duplication of effort that would occur if competitors were to pursue their own lines of enquiry. It therefore promotes the development of synergies among participants, thereby reducing costs. By pooling their resources, the cost of doing R&D is reduced for each participant. In other words, collaboration can facilitate the

[18] These benefits are derived from a report on a seminar on Consortia in Canadian Business held in Banff in April 1992.

[19] Femtosecond technology is research concerning ultra-fast phenomena around 100 femtoseconds or shorter. It includes but is not limited to electro-optic sampling, soliton transmission, and several other femtosecond regime electronics and optics. It is expected that the femtosecond technology will contribute to the future information society as one of the infrastructures.

achievement of higher profits by the members of the consortium.[20] Collaboration also speeds up the cycle time of the innovation process.[21]

c) **Technology Transfer/Diffusion:** collaboration improves the participant's ability to cope with both the pace and magnitude of technological change by giving participants access to a network, whereby they can more effectively monitor the environment and recruit skilled personnel.[22] The consortium provides a mechanism for effective technology transfer by integrating the efforts of university and government labs with those of the private sector. Researchers from member companies working alongside consortium researchers can more readily adapt technologies to customer requirements.

d) **Competitive Dynamics:** collaboration forces members to clarify longer term objectives and establish targets (i.e., to formulate a strategy) and may provide intelligence on competitor strengths and weaknesses. It can even provide an opportunity to influence the rules of the game. For example, participation provides members with an opportunity to influence regulatory or performance standards which may emerge as a result of consortium-based new technology development, such as in the case of high definition television.

e) **Innovation Dynamics:** collaboration creates innovative or "technology smart" organizations which can create more products to maintain a competitive edge. Since "use of technology" is a less knowledge intensive task than "creation of technology", the mere users will remain less competitive.[23]

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20 An example of this is the U.S. HDTV consortium which was formed to "avoid wasting future profits". See I. Prakash Sharma, "Optimal Patent Term and Trade: Some Considerations for the Road Ahead", Policy Staff Paper No. 93/11 (forthcoming), p. 43.

21 Numerous authors and business "gurus" such as Tom Peter (e.g., Thriving on Chaos) have commented on the trend to shorter product life cycles, particularly in the knowledge-based or R&D-intensive industries. This puts considerable pressure on firms to commercialize new products which, in turn, is a function of the firm's R&D costs.

22 Sylvia Ostry and others have remarked on the significance of "networks" in the innovation process (see footnote 11 on the "innovation network model"). One seminar participant observed: "The value of the network within the consortium may exceed the value of the technology created."

23 This view is controversial. Ostry notes that under the traditional view of technology diffusion, innovative economies are assumed to be able to diffuse technology more quickly because a degree of innovative capacity is required to absorb new technology. However, Soete has observed that some less innovative economies have been able to leapfrog ahead in certain industries, for example Japanese and Italian steel, automotive and electronics industries, by adopting new technologies at lower costs than in the innovating countries themselves, where expensive existing capital stocks impede the adoption of innovations. This can be seen in Canada's forest products industry where existing plants and equipment long impeded the adoption of waste water treatment processes and other new process technology which could have made them more competitive internationally. Fortunately, the industry has taken steps to rectify this situation over the last few years.

f) **Economies:** the economics and business literature refer to economies of scale, scope and learning.[24] Research on Canadian technical alliances in the electronics industry has revealed that, in fact, economies of scope may be more important than economies of scale, although the latter are important for smaller firms.[25]

g) **Reduced Market Failure:** collaboration encourages members to undertake a level of research that they would not otherwise consider economical due to the limited appropriability of research results.[26]

h) **Signalling Effect:** Finally, government support for R&D consortia can signal support for the development of particular technologies of "strategic" importance to the economy, and can act as a source of "patient" capital for important technologies which take a long time to commercialize, as in the case of certain biotechnologies.

The Cons

The negative aspects of R&D cooperation include[27];

a) **Anticompetitive Dynamics:** collaboration in research can undoubtedly provide an impetus to collusive behaviour in product markets, particularly if the adoption of new technologies is staggered among firms to promote rapid diffusion. However, the potential also exists for such collusion to restrict the diffusion of a technology in the early stages of its development or to prevent the adoption of a variety of approaches to application within a technology.

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[24] Economies of scale are cost savings associated with large scale production; per unit costs are reduced by spreading fixed costs such as buildings, equipment, etc. over a larger number of units produced. Economies of scope are defined as those resulting from the use of processes within a single operating unit to produce and distribute more than one product. Economies of learning, also termed "first mover advantages", are the benefits (cost savings) derived from being the first to achieve efficiencies in production from a new manufacturing process.

[25] J. Niosi and M. Bergeron, "Technical Alliances in the Canadian Electronics Industry: An Empirical Analysis", Technovation, 12:5 (1992), p.316.

[26] This point is more technical and is a benefit to both society and individual firms. It has long been recognized that innovation is a public good. In fact, empirical studies have confirmed that the social benefit from R&D may be greater than the benefit derived by the innovator. In some cases, social rates of return exceeded private rates of return by an amount ranging from two to ten times, depending on the industry. *Bernstein and Nadiri, cited in M.L. Katz and Janusz A. Ordover, "R&D Cooperation and Competition", Brookings Papers: Microeconomics, (1990), p.137.* The point is that co-operation can serve to internalize the external benefits created by technological spillovers, thus increasing the incentive to invest in R&D.

[27] All of the following disadvantages are derived from Mowery and Rosenberg, pp. 239-241.

b) **Narrowed Focus:** the elimination of duplication may increase the efficiency of group research efforts. But narrowing the focus of research for the industry as a whole may reduce the number of independent lines of inquiry, thus reducing the overall productivity of research in that industry.

c) **Dearth of Empirical Evidence:** there is not a lot of empirical evidence to support the claims that cooperation in R&D contributes to economies of scale. Research into Canadian technical alliances has revealed some industry specific differences with regard to economies achieved by R&D cooperation. For example, Niosi of UQAM has concluded that, for technical alliances in the electronics industry, economies of scope may be a more important benefit than economies of scale. However, his research in the advanced materials industry confirmed that economies of scale were a major determinant.

III. THE POLICY FRAMEWORK

2.1 Technoglobalism vs Technonationalism

Technoglobalisation is the trend toward internationalization of industrial activities due to technological needs.[28] This trend is being driven largely by corporations pursuing global market strategies who have a critical need for "best practice"[29] technology. Technonationalism, on the other hand, is a force emanating from government policies which act to restrain technoglobalism. Technonationalism is a policy, falling under the aegis of strategic trade policy, which aims to restrict access to technology developed domestically to those firms which meet a definition of national firms. According to Candice Stevens of the OECD, it is "a territorial view, usually national but also regional, which treats technology as a commercial and strategic asset to be nurtured and kept at home."[30]

Ms. Stevens points out that although markets and competition in a number of industries are increasingly global, most multinational firms retain their roots in the nation-state, subordinating their subsidiary operations to the discipline of corporate headquarters and conducting the bulk of their R&D in their country of origin. She writes: "Technology is a driving force behind both the globalization of industry and growing trade protectionism. **Today's multinational corporations are pursuing technoglobalist corporate strategies while supporting technonationalist government policies.** Various theories have been advanced to explain this seeming dualism in corporate behaviour. Corporate managers may be practising "short-termism" with regard to government trade policies in ignoring the longer-term consequences for their global activities."[31]

Another view put forward by Lestor Thurow of MIT[32] is that the end of the "cold war" marks the beginning of a new confrontation among the economic

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28 Candice Stevens, "Technoglobalism vs. Technonationalism: The Corporate Dilemma", Columbia Journal of World Business, VolXXV, No. 3, (Fall 1990), p. 42.

29 "Best practice" technology is not necessarily the "best available" or even "state-of-the-art" technology, but is that which is the most commercially viable given the underlying costs and benefits of the technology.

30 Ibid, p. 44.

31 Ibid, p.42.

32 Author of Head to Head: The Coming Economic Battles Among Japan, Europe and America. These remarks are extracted from an overview of his book which appeared in the Sloan Management Review, Spring 1992, entitled "Who Owns the Twenty-First Century?", and from related conversations with Canadian officials.

superpowers known as the Triad (the U.S., EC and Japan). He views the conflict of the post war period as having shifted from a military to an economic basis. Technology features very prominently in this "head-to-head" competition. He advocates a general strategic growth policy for the U.S. that would retain public investment in skills and infrastructure domestically and would use public funds to lever R&D that is privately instigated and privately managed. With regard to trade policy, he predicts freer trade within regions and managed trade between regions.

David Mowery believes that, paradoxically, technonationalist policies, which he terms "technological mercantilism", actually foster technoglobalism in the private sector. He observes that the results of research are often hoarded by nations as a source of power or competitive advantage. In this context, the transfer of technology across borders is viewed by some governments as a zero-sum game. He writes: "National (and, in the EC, regional) R&D projects that exclude foreign firms coexist with, and provide additional incentives for, transnational collaborations that in turn further 'technoglobalism'."[33]

2.2 Technoglobalism: Who Benefits?

In the past, the Japanese have been criticised for benefitting from the open system of scientific research in other nations, specifically the United States and in Europe, and for not contributing sufficient resources to international scientific research. Some observers say that their industrial policy of importing technology for rapid commercialisation has left them without the basic science capability necessary to generate their own technology.[34] Therefore, they conclude that it is imperative that the Japanese maintain access to scientific discoveries in other nations as well as building their own science base in order to fulfil the technological needs of Japan Inc..[35]

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[33] D.C. Mowery, "Techno-Globalism and US Technology and Trade Policies: Declining Hegemon, Wounded Giant, or Ambivalent Gulliver?" University of California, Berkeley, Working Paper prepared for the OECD Symposium "Toward Techno-Globalism", (March 5-9, 1990), p.3.

[34] OECD statistics show Japanese Gross Expenditures on R&D (GERD on a Purchasing Power Parity basis for the period 1984-88) to be second only to the United States. In terms of GERD as a percentage of GDP, their expenditures on R&D are comparable to those of the U.S., ranging from 2.6-2.9% of GDP for the period 1984-88. The data for Japan may be somewhat overestimated.

[35] This sentiment, whether justified or not, is apparently shared by a number of people in both the U.S. and Europe. In Europe, ICL, a computer company located in the UK which is 80% owned by Fujitsu, was ejected from European computer research and technological development programs, whereas IBM was accepted into JESSI, a Eureka sub-program. Legislation in the U.S. which restricts the participation of foreigners in domestic R&D programs is allegedly targeted primarily at the Japanese. A recent call for participation in the Japanese instigated Real World Computing program resulted in an enquiry from Digital Equipment Corporation (DEC) Canada. DEC USA would not sanction the involvement of its subsidiary in this program.

In a pamphlet published by the Japanese Ministry of International Trade and Industry (MITI) entitled "Issues and Trends in Industrial/Scientific Technology - Towards TechnoGlobalism", this criticism of Japanese industrial policy is addressed as follows: "Industrial/scientific technology activities cannot be completed wholly within the border of a country. Policies related to these activities are increasingly taking on international significance and must always be considered from a global perspective. In other words, there is a growing recognition of the concept of technoglobalism where related policies should be developed with the purpose of maximizing the benefit of science and technology to people all over the world. This is a concept that should be promoted with international cooperation and coordination. There is a need to clarify the foundation and the contents of this concept."

It can be argued the technoglobalism favours Canada, even if some of our programs have de facto restrictions on eligibility similar to those applied in the U.S. and Europe, because, as a relatively small, export-oriented economy, we cannot source all our technological needs domestically. Canada's historical dependency on foreign sources of technology is attested to by the Technology Balance of Payments Coverage Ratio[36] which measures the extent to which a country covers its own technological requirements. Canada's ratio is less than one for every year except 1988 when it rose to 1.05, in comparison to the United States, which ranges from a low of 5.26 (1989) to a high of 7.30 (1983), and Japan, which ranges from a low of .76 (1987) to a high of .99 (1984).[37]

However, patent statistics, on which the coverage ratio is partially based, provide only a limited overview of the national technological capacity. Leclerc and Dufour have calculated a ratio of Business Enterprise R&D(BERD)/technologies payment to define the relative portion of national and foreign sources of technological progress. Canada's ratio (1:5) is among the worst, indicating that "the import of technology is relatively large in relation to the national R&D [effort]."[38] Furthermore, for the years 1984 to 1987, Canada had the highest proportion of business enterprise R&D financed from abroad of all OECD countries.[39]

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[36] This ratio is calculated by taking the receipts from patents, licenses, trademarks, designs, technology and closely related technical services (including technical assistance) and industrial R&D carried out abroad, and dividing this amount by the payments to off-shore sources.

[37] OECD, Main Science and Technology Indicators, (1990:2), Table 82, p. 49.

[38] Michel Leclerc and Paul Dufour, "International S&T Collaboration", in John de la Mothe and Paul Dufour, eds., Science and Technology in Canada, (Longman Group: UK Ltd., 1993), p.127.

[39] OECD, Main Science and Technology Indicators (1990:2), p. 29.

In some sense, Canada shares many of the characteristics of small economies with regard to R&D expenditures.[40] A paper discussing the relevant contributions of science and technology to economic growth in small advanced economies argues that the nature of the science and technology developed by a small country may be determined by the existence of a technological paradigm outside of the country. This can be seen in Canada's commitment of resources to space science and technology through its involvement in the U.S. Space Station program.[41]

Lacking a large domestic market, firms are obliged to export to recoup the money spent on R&D. However, the risks and uncertainties involved in marketing the innovation on an international scale are magnified. Together with the non-appropriability problem, this adds to disincentives to expend scarce resources on R&D. One author writes: "All other things being equal (such as the probability of success), there is a stronger incentive to commit resources to an innovation where the market is large than where it is small."[42]

It has also been noted by the OECD that there is a tendency for researchers from small countries to emigrate to larger ones where more resources are allocated to their discipline.[43] Furthermore, the paper concludes that "while small countries contribute to the international pool of knowledge (in fields chiefly determined by the larger countries) thus providing research results accessible to the larger countries, the larger countries contribute more heavily to innovation-oriented R&D which is more likely to be subject to commercial or national secrecy and therefore not freely available to the smaller countries. The implication of this is that indirectly, the larger countries are exploiting the small ones, as a result of small countries' lack of resources."[44]

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[40] According to some authors, it is debatable whether Canada can legitimately be included in the group of "small" economies. A discussion of the size debate is found in Vivian Walsh, "Technology, Competitiveness and the Special Problems of Small Countries", **STI REVIEW**, (September 1987). She writes: "Dividing these countries into two groups, large and small, is fairly arbitrary. By any standards the U.S. is a large country and Luxembourg and Iceland are small ones. For the purposes of this discussion, the line has been drawn after the largest seven countries. Australia, the largest of the "small" countries thus defined has a GDP about half that of Canada, the smallest of the "large" countries, although other studies, (e.g., Tisdell, 1982; Arnold, 1986) have included Canada as a small country." (p. 87).

[41] The Canadian Space Agency's (CSA) contribution to the space laboratory is budgeted at $1.3 billion to the year 2000. During fiscal year 1990/91, the CSA contributed $207 million to 45 alliances, while non-federal partners contributed $2 million. Source: ISTC, Federal Science and Technology Alliances Report (1992), p. 11.

[42] Op. cit., Walsh, p.101.

[43] OECD 1984 document cited in Walsh, p. 106.

[44] Ibid, p.108.

2.3 Technonationalism: Protectionism in Disguise?

There is little doubt that the mood has become more protectionist in the United States and perhaps nowhere more so than in technology creation activities. The question, however, remains as to whether this growing sentiment has actually translated itself into technonationalist policies. One of the chief proponents of the view that trade in technology should be "managed" is Laura Tyson, the new Chair of the Council of Economic Advisors. In her book Who's Bashing Whom: Trade Conflict in High-Technology Industries, she argues that, although free trade is the preferred objective, the reality is that trade in these industries has little to do with pure market forces.

Tyson, who has recently come under criticism from Paul Krugman[45], argues that the U.S. must pursue a more active trade policy in high-technology industries which focuses on "opening foreign markets rather than closing the domestic market".[46] In a recent paper, Tyson acknowledges the potential link between "strategic" technology policies and protectionism when she notes that such measures as preferential procurement, aggressive R&D subsidies targeted at commercial technologies but limited to domestic producers, and local content restrictions can be "beggar-thy-neighbour" and constitute a form of "technological mercantilism".[47]

Europe has had a dirigiste policy of subsidizing R&D for a number of years which has similarly restricted access to the research activities or results of nationally sponsored R&D programs. According to a recent article in Business Europe: "In determining EC priorities, Mr. Ruberti [the EC's new R&D commissioner] will pay attention to technologies identified in the U.S.A and Japan for funding.".[48] This would seem to suggest that the Community is willing to use its R&D subsidies to counteract the impact of technology policies being pursued elsewhere.

Analysts in Europe have commented that international cooperation in R&D was strong in the late 1980s, but has since diminished due to the recession. There is now

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[45] Krugman, an economist with the Massachusetts Institute of Technology (MIT) and one of the chief proponents of the 'new' strategic trade theory, recently published an article in which he makes a practical case for a trade policy based on the concept of free trade. See Paul Krugman, "The Narrow and Broad Arguments of Free Trade", American Economic Review, Vol 83:2 (March 1993), pp. 362-366.

[46] Tyson cited in Inside U.S. Trade, March 26, 1993, p. 8.

[47] Laura D'Andrea Tyson, "Managing Trade Conflict in High Technology Industries", M.C. Harris & G.E. Moore (eds.), Linking Trade and Technology Policies (Wash. D.C.: National Academy Press, 1992), p.74.

[48] The Economist Intelligence Unit, Business Europe, March 29-April 4, 1993, p.3.

more concern over industrial adjustment, as Europe adapts itself to a pan-European business environment. An OECD document comments:"The design and implementation of industry-related policies at the European Community level is a relatively recent phenomenon. It has been prompted by concern about the performance of EC-based industries in comparison to that in other OECD countries, especially in high-technology areas like segments of the electronics and information technology industry."[49]

The question still remains as to whether Japan is pursuing a truly technoglobal agenda. Despite recently publicized, high profile initiatives in the international arena, it is not clear that all programs are as accessible to foreign participation. The Very Large Scale Integration (VLSI) program from 1976-79 strictly excluded foreign participation from all activities.[50] Section 4.1 of this paper details those ventures of which we are aware, but our knowledge of R&D programs in Japan is far more limited due to language barriers and the fact that a larger proportion of R&D is conducted in the private sector.

[49] OECD, Industrial Policy in OECD Countries, (Annual Review 1992), p.19.

[50] Yoshio Nishi, R&D Centre, Integrated Circuits Business Division, Hewlett-Packard, "Semiconductor R&D Consortia in Japan", presented to the U.S. House of Representatives, House Science, Space and Technology Committee, Subcommittee on Technology and Competitiveness, July 23, 1991.

IV. MEMBERSHIP

4.1 Major Consortia

A. United States

U.S.-based consortia are reasonably easy to identify because they may register with the Department of Justice to receive protection from punitive damages in an antitrust suit if they are engaged in the conduct of "precompetitive research".[51] This protection from antitrust action has been afforded them by the **National Cooperative Research Act of 1984.** The act, which has recently been the subject of extensive debate in the United States, establishes the following:

- that precompetitive cooperative R&D is not illegal "per se", but rather the possible antitrust implications should be dealt with on a case-by-case basis,

- that if the case is analyzed and found to contravene antitrust laws, the consortium must pay actual damages, but is relieved from the prospect of paying treble damages (provided that the consortia has notified the government of its activities), and

- in order to deter "nuisance" suits, the court is empowered to penalize the plaintiff and require them to pay the legal expenses of the defendant.[52]

To date over 300 consortia have filed with the Department of Justice, over half of these within the last three years.[53] The major "players" in the U.S. are members of the Council of Consortia CEOs which was formed in April 1990 by the late Dr. Robert Noyce (formerly CEO of SEMATECH, founder of Fairchild Semiconductor 1957 and Intel Corporation 1968), Mr. Grant Dove (former President and CEO of Microelectronics and Computer Technology Corporation (MCC)) and Mr. Larry Sumney (President and CEO of Semiconductor Research Corporation (SRC)).

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[51] Pre-competitive research "encompasses experimentation and study of phenomena and observable facts, development or testing of engineering techniques, development of prototypes and models, and collection and exchange of research information." (Olk, 1990)

[52] Ibid.

[53] The opening statement of Congressman Jack Brooks (D-Tex), Subcommittee on Economic and Commercial Law hearing on H.R. 1313, the "National Cooperative Production Amendments of 1993", Thursday, March 18, 1993, stated that over 300 joint ventures have been reported to anti-trust agencies under that law. Olk states that as of August 1989, 137 consortia had registered and that new consortia were filing at the rate of about one or two per month.

The Council membership includes two Canada-based consortia: Strategic Microelectronics Consortium (SMC) of Kanata and Telecommunications Consortium of Canada (TCC) also of Kanata (based at Newbridge Networks). The Council was formed to lobby the U.S. government to give more prominence to science and technology issues on the national economic agenda. Its stated objective is to "sustain the vitality of technology development, transfer and application". It was formally decided at the last meeting, held in Kanata recently, that the Council would extend membership to Canadian consortia due to Canada's special status under the Free Trade Agreement (FTA).

Consortia are being formed in a variety of industries, for example, the motion picture industry, television, chemicals and forest products, with concentrations in the automobile, telecommunications, and electronics industries.

One of the better known consortia in the U.S., of those receiving government funding, is the Semiconductor Research Corporation (SRC). Created in 1982 by the Semiconductor Industry Association (SIA), its mission is "to encourage increased efforts by manufacturers and universities in long term semiconductor research, and to add to the supply and quality of degreed professional people."[54] SRC research goals are focused on generic chip technology that meets customer-defined requirements. At one time, SRC did not accept foreign members. However, this has changed due to the efforts of Techware, a Canadian supplier of semiconductor manufacturing equipment, who lobbied the corporation and the U.S. government for access with the assistance of Industry and Science Canada (ISC) and External Affairs and International Trade Canada (EAITC).

In contrast to SRC, the Semiconductor Manufacturing Technology Consortium (SEMATECH) was established in 1987 with the goal of developing manufacturing process (as opposed to product) technology for member companies. Research objectives include: a) a reduction in the time required to produce new semiconductors (the inter-generation time) by 25%, b) the development of modelling and simulation tools to permit the introduction of new products with less demand for successive phototyping, and c) the development of more systems capability. Half the budget, approximately US $100 million, comes from the Advanced Research Programs Agency (ARPA), a division of the U.S. Department of Defense. Small suppliers affiliated with SEMATECH have formed an umbrella organization called Semi-SEMATECH which has a single seat on SEMATECH's Board of Directors.

[54] The late Dr. Robert N. Noyce, SIA Chairman, from the press release, December 16, 1981.

Another well established research consortium in the United States is the National Centre for Manufacturing Sciences (NCMS) with headquarters in Ann Arbour, Michigan. Membership consists largely of machine tool companies in the U.S., many of which are small in size. The consortium receives government funding, including approximately $5 million per year from the U.S. Airforce. The consortium operates by participating in research projects led by member companies, supporting research that is of interest to the consortium.

In recent years, ARPA has increased funding for other precompetitive technology consortia. In fiscal year 1991, at a cost of US $50 million, these included The Ceramic Fiber Consortium, officially called IHPTET, the Advanced Composites Technology Consortium, the Optical Network Technology Consortium, the Optoelectronics Technology Consortium, the Advanced Static Random Access Memory, the Linguistic Data Consortium, the Scalable Computing Systems Consortium and the Superconducting Electronics Consortium. In fiscal year 1992, at a cost of US $60 million, they included DRAM Capacitor Materials Consortium, the Data Storage Consortium, the Electro-Magnetic Code Consortium, the Micromagnetic Components Consortium, the Precision Investment Casting Consortium and the Ultra-Fast All-Optical Communication Systems Consortium. Additionally, 1993 Title IV Defense Conversion appropriations will fund initiatives in Advanced Materials Synthesis and Processing, and Agile Manufacturing and Enterprise Integration.

B. Europe

According to one European research director: "In America, science is business. In Europe it is still seen as culture."[55] Europe's multi-year funding of research and technological development (RTD) under the EC Framework Programs (FPs)[56] has been criticised for being inadequate to the task of improving the international competitiveness of European industry. It has even been suggested that international

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[55] Carlo Rubbia, head of CERN, a multinational particle-physics laboratory near Geneva. Cited in "Europe's Technology Policy: How Not to Catch Up", The Economist, January 9th, 1993, p. 19.

[56] The Framework Programs support "precompetitive stages of research involving at least two mutually independent companies from different member states". There have been three FPs to date as follows:

Framework Programs	Interval	Budget*
First	1984-87	3.8
Second	1987-91	5.4
Third	1990-94	5.7
Fourth (proposed)	1994-98	14.7

* In Billions of ECUs where 1 ECU = $1.60 Cdn. It is estimated that almost US$2 billion was spent in 1991 (although this represents only 4% of total civilian R&D expenditures in Europe).

programs have done little more than contribute to improving the bottom lines of the recipients.[57]

Sub-programs of the FPs include ESPRIT (European Strategic Program for Research and Development in Information Technologies) with a budget of 1.4 billion ECUs for the period 1990-94, BRITE/EURAM (Basic Research in Industrial Technology for Europe/Europe Research in Advanced Material), RACE (Research and Development in Advanced Telecommunications Technologies for Europe, BRIDGE (Biotechnology Research for Innovation, Development and Growth in Europe, SCIENCE (Stimulation des coopèrations internationales et des échanges nécessaires aux chercheurs en Europe), the Controlled Thermo-nuclear Fusion program and the Environment program.

The Community has also supported some projects (HDTV and JESSI) under EUREKA, which is an independent research program involving some 20 countries, including the EC 12[58]. EUREKA was created in 1985 as the result of a Franco-German initiative in response to former U.S. President Reagan's Strategic Defense Initiative. Funding of EUREKA projects comes predominantly from national governments. EUREKA sub-programs include JESSI (Joint European Submicron Silicon Initiative), EUREKA Audiovisual or HDTV (High Definition Television Project) and PROMETHEUS (Program for European Traffic with Highest Efficiency and Unprecedented Safety).

JESSI, which is the "flagship" of the EUREKA program, has been plagued by a number of difficulties. This program "launched in 1989, ...at a cost of 3.8 billion ECUs, was seen as a response to SEMATECH", with the focus of its research on developing new chip technology. Since its inception, the consortium has experienced funding problems (in 1991 the EC cut its contribution and participant companies, which are only required to match public funds, also cut theirs) and some changes in membership (Philips dropped out in 1990 due to a shortage of cash and IBM joined through its partnership with JESSI participant Siemens).

During the French presidency of EUREKA, the number of new EUREKA projects has grown to 200 from 100 in 1992. Priority is now being focused on smaller projects among small and medium sized enterprises. Also, there has been an attempt

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57 See recent article in The Economist entitled "Europe's Technology Policy: How Not to Catch Up", January 9th, 1993. A UK Treasury survey concluded: "The best evidence available suggests that special fiscal incentives increase R&D by an amount that is roughly one-half of the revenue foregone by the government: the remainder goes to swell companies' cash flow and post-tax profits." From Paul Stoneman, "The Use of a Levy/Grant System as an Alternative to Tax Based Incentives to R&D", Research Policy, 20 (1991), pp. 195-201, cited in OECD, DSTI/STP (93) 3, The Impacts of National Technology Programs.

58 EC Research Funding, 3rd Fully Revised Edition, A Guide to Applicants(January 1992), p. 33.

to enhance cooperation between EUREKA and the Community's Framework Programs through invitations to EUREKA members, including Canadian partners, to attend seminars on corresponding projects.

The FPs and EUREKA represent only a fraction of what Europe spends on RTD. Member states have created their own funds and initiated their own programs to target the development of particular technologies. What follows is a non-exhaustive compilation of information provided by several Canadian embassies in Europe on publicly supported RTD consortia in Europe.

France

The idea of targeting support for various critical technologies has preoccupied French economic planners since the early 1980s and has been the subject of a number of studies and, occasionally, government initiatives. A decade ago, the French government created the GIPs (Groupement d'Interet Public) which operate as fora for inter-firm cooperation centred on public laboratories. Public support is kept to a minimum of 51% of GIP capital and, although support is provided for a given period of time for specifically defined projects, the time period can last 5, 10 or even 15 years. Some examples of industries in which GIP have been formed are information technologies and biotechnologies, for example, Mutations Industrielles and Agence Nationale de Recherche sur le SIDA.

Another program used to support industrial cooperation and technology transfer in an international context is FACET, the French-American Cooperative for Entrepreneurship and Technology, which is managed by the Agence nationale de valorisation de la recherche (ANVAR). The latter is the French agency responsible for the development of industrial innovation.

It bears mentioning that a number of Canadian firms have gained access to Community RTD programs through strategic alliances with French companies. A list of Canadian companies who have formed partnerships with French companies under EUREKA is attached in Appendix A.

Britain

The UK now provides little support for near market R&D following the disappointing results of early programs such as the Alvey program for information technologies. However, there are indications that this view may be changing as a result of a recent policy review conducted under the auspices of a new independent

office of science and technology. Reportedly William Waldegrave, the official in charge of this review, sees a case for "direct support for 'strategic' research in key areas, that is, work somewhere between completely unfocused 'blue sky' investigation and product development."[59] Those consortia that are formed in the UK up until now are predominantly private sector initiatives. There is one program called "LINK" which defrays up to 50% of the costs associated with joint industry-academic projects.

Germany

Among the better known institutions which engage in R&D for transfer to industry and which receive public support are:

A) AIF - Arbeitsgemeinshaft Industrieller Forschung: a private sector organisation which promotes industrial R&D on behalf of small and medium-sized enterprises (SMEs).

B) RKW - Rationalisierungs Kuratorium Der Deutschen Wirtschaft: a large organisation offering a broad range of services to industry, including the facilitation of company management of technology and manufacturing problems among others.

C) FHG - Fraunhofer Gesellschaft for Applied Research: a series of institutes established to bridge the gap between industry and universities. Founded in Bavaria in 1949, the FHG's mission is market oriented, the main focus of which is the translation of research results into innovation.

Italy

Funds to support the formation of consortia in order to lower R&D costs are available to Italian companies through the Fund for Applied Research (FRA) which was instituted in 1968. The fund was created to "promote R&D integration of SMEs in order to obtain necessary critical mass", but it has also benefited larger industrial groups conducting R&D in pursuit of specific technologies.

Several consortia formed under the FRA have achieved commercial success, including Technomare, a group of large engineering firms which exploits opportunities in the off-shore marine market. Together, they employ some 220 persons and

59 Tim Beardsley, "Keeping the Sun Shining on British Technology", Scientific American (July 1993), p. 107.

perform all of their R&D in-house. Other successful consortia include SAGO and Technobiomedica, both active in the health care market, and Technotessile, in textiles.

Others

Outside of its contribution to European Community R&D programs and EUREKA, we are not aware of any Dutch government support to other international R&D consortia. The Dutch Government does have a number of programs which support domestic consortia between industry and R&D centres in the following sectors; biotechnology, advanced materials, environmental technologies, information technology and telematics. These programs are managed by SENTER, an independent organisation at arm's length from the Ministry of Economic Affairs. We are not aware of any major R&D consortia programs in the Scandinavian countries. Danish R&D support programs are administered by the National Agency of Trade and Industry. There are a large number of small enterprise consortia and industrial research is carried out at Danish technological institutes. These institutes are actively seeking foreign participation in their R&D consortia.

C. Japan

The Japanese have launched a number of major international research programs aimed at addressing the negative perception of Japanese companies as "free riders" on the investments of other nations. Among these have been the Human Frontier Science Program, the Intelligent Manufacturing Systems (IMS) program and the Real World Computing (RWC) Program. Although Canada was not initially invited to participate in the IMS program, it was felt that Canada could derive net benefits from participating in the program and should have been included anyway because the program was open to other G7 members. Canadian firms may now participate.

During the 1991-1992 period, Japan launched a number of domestic research programs through the New Energy and Industrial Technology Development Organisation (an operational research arm of MITI), which are open to international participation. These programs are in the following fields; Silicon Based Polymers; Micromachine Technology; Complex Carbohydrates; Quantum Functional Devices; Environmentally Friendly Technology for the Utilization of Reusable Materials; Environmentally Friendly Technology for the Production of Hydrogen. Information on these programs has been disseminated through public advertising (i.e., Nature Magazine) and by briefings to foreign embassies in Tokyo.

Apparently there exist other programs which do not invite participation from foreign researchers and which are particularly directed at the private sector in Japan, but we have very little information on them. The 1991 White Paper on Science and Technology lists the following as examples of Government sponsored/supported programs relating to private corporations. The Cooperative Development of Industrial Technology (JRDC), the Large-Scale Project Program, the Next-Generation Fundamental Industrial Technology Research and Development Program, Japan Key Technology Centres Program, the Bio-Oriented Technology Research Advancement Institution and the Adverse Drug Suffering Relief and Research Promotion Fund.

All of these appear to be large scale, granting programs, and not private sector initiated consortia per se. A list of sixteen R&D associations supported by the Ministry of Agriculture, Forestry and Fisheries in the food industry with private sector participants was published in a recent issue of **Science and Technology in Japan.** However, none of these compare with the renowned Very Large Scale Integration (VLSI) Consortium which is credited with improving the international competitive position of Japanese industry.[60] The VLSI Cooperative Research Laboratory was established in 1976 as a central research organization with five member companies: Hitachi, Fujitsu, Mitsubishi, NEC and Toshiba. MITI provided approximately 40% of an estimated total cost of US $280 million with the rest coming from member companies.[61]

D. Canada

Technology consortia have been a part of the landscape in Canada since 1925 when Paprican, a consortium of Canadian pulp and paper companies, began conducting joint R&D. Atomic Energy of Canada, Ontario Hydro and Canatom formed a large consortium to design and build the Candu reactor in the late 1940s. However, these joint R&D initiatives were formed only within a small number of Canadian industries. In the 1980s, stimulating cooperative R&D became the target of federal and provincial spending.

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[60] Niosi states that both the VLSI and the Fifth Generation Computer Project were crucial to the Japanese being able to catch up in computer and communications technology so rapidly. On the other hand, economists have concluded that an analysis of the semiconductor market "suggests" that the Japanese success was actually a net loss to the Japanese economy: Richard E. Baldwin and Paul R. Krugman, "Market Access and International Competition: A Simulation Study of 16K Random Access Memories", reprinted in Paul Krugman, Rethinking International Trade (Cambridge: MIT 1990), p. 200.

[61] Op. cit., testimony of Dr. Nishi.

Consortia have been forming in Canada at a rapid pace in recent years and they are numerous. Some examples include:

CANARIE Inc. (Canadian Network for the Advancement of Research, Industry and Education): This federal government project will build a national electronic highway that will link Canadian educational and research organizations coast-to-coast by a high speed, broadband electronic information highway funded jointly by the private and public sectors.

PRECARN Associates Ltd.: a large group of consortia with approximately thirty-four member companies altogether whose mission is to carry out advanced research and development in robotics and artificial intelligence (AI), among others.

OP-COM soon to be Opto-Electronics Inc.: a consortium of Canadian opto-electronics companies which has evolved out of initiatives taken by the Ottawa-Carleton Research Institute. This consortium is engaged in the development of communications technology within an opto-electronic computing environment.

SMC - Strategic Micro-electronics Corporation: a research corporation formed by Canadian micro-electronics and telecommunication companies.

TCC - Telecommunication Consortium of Canada: a telecommunication industry R&D consortium.

A more complete and detailed list of Canadian R&D consortia is available through the industry sector branches of Industry and Science Canada (ISC).

4.2 Rules of Participation

A. United States

i) Explicit Rules on Access (Participation)

At first glance, the rules of participation in federally supported R&D consortia appear to be fairly clear, open and above board. However, a more extensive review of regulations concerning technology support and R&D procurement reveals that restrictions do exist, although their application is fairly arbitrary.

Most U.S. technology initiatives do not seem to have discriminatory provisions. As technology assistance shifts towards support of commercial and non-defence R&D,

however, we are seeing nationality restrictions being applied to "dual-use"[62] technology consortia, while the concept of "national security" is being extended to include that of economic security.[63] Although such provisions are primarily targeted at Japan and, to a lesser extent, at Europe, Canada has no explicit access to publicly supported R&D programs under either the North American Free Trade Agreement (NAFTA) or the FTA.

A recent article in Science magazine reports that the new Clinton administration is re-orienting the focus of U.S. technology policy away from support for basic research to stimulate the development of commercially viable technologies. They will no longer rely on commercial spinoffs from defence research, but will attempt to "lure industry into high risk experiments" with large potential economic returns in areas of strategic importance to the economy as a whole.[64]

An example of this may be The Technology Reinvestment Project which has been established to "stimulate the transition to a growing, integrated, national industrial capability which provides the most advanced, affordable military systems and the most competitive commercial products."[65] Under this project, the Advanced Research Projects Agency (ARPA) of the Department of Defense, the Department of Energy/Defense Programs (DOE/DP), the Department of Commerce's National Institute of Standards and Technology, the National Science Foundation and the National Aeronautics and Space Administration (NASA) are collaborating to "expand high quality employment opportunities in commercial and dual-use United States industries and demonstrably enhance U.S. competitiveness."

Section 2.2.2. of the Guidelines for Assembling a Team of Eligible Participants refers to the definition of "eligible firm" that appears in 10 USC Section 2491(9). It states that: "Determinations of eligibility of firms in this last category will be made by the Secretary of Commerce as mandated by 10 U.S.C. Section 2491(9). No prior certification of eligibility will be issued or accepted, and the burden of establishing eligibility will ultimately rest on the proposer." Contract management officials at ARPA have emphasized that foreign participation in U.S. -based technology consortia

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62 Dual-use technologies are those which have both commercial and defence applications and spin-offs.

63 See 10 USC Section 2501 relating to Congressional Defense Policy Concerning National Technology and Industrial Base, Reinvestment and Conversion.

64 Jerome Cramer, "R&D Policy That Emphasizes the 'D'", Science, Vol. 259 (March 26, 1993), p. 1816.

65 From the Program Information Package for Defense Technology Conversion, Reinvestment, and Transition Assistance (March 10, 1993), p. 1-1.

will be permitted. However, the consortium's eligibility will be evaluated by the Secretary of Commerce on the basis of the project's impact on the U.S. economy. This process lacks transparency and is open to abuse by special interest groups.

On the question of improved access to participation, the record is mixed. There have been cases where Canadian firms have gained access to consortia where they were able to mount attractive proposals. There have been some difficulties with such high profile programs as SEMATECH, which have been moderated, on the weapons technology side, by diplomatic representations to have Canadian firms recognized as part of the U.S. industrial base. In fact, 10 USC Section 2491(1) defines the term "national technology and industrial base" to mean persons and organisations that are engaged in research, development, reduction, or maintenance activities conducted within the United States and Canada.

Proposed legislation would further restrict access to U.S. technology support initiatives if passed with recent amendments that narrow the eligibility criteria for federally supported programs under the Stevenson-Wydler Act and the National Competitiveness Act.[66] In particular, the Manton (Collins) amendment imposes rigid, new domestic manufacturing and sourcing commitments on funding recipients such that they would agree to "promote the manufacture within the United States" of products resulting from the technologies developed with government assistance. Furthermore, the Secretary of Commerce would be directed to consider a company's agreement "to procure parts and materials ... from competitive United States suppliers". Appendix B contains the full wording of the proposed amendment.

In 1991, ISC commissioned a study of U.S. federal programs that promote applied research, technology development and technology transfer.[67] The programs selected were chosen for their focus on developing and transferring technology to promote industrial competitiveness. Some conclusions arising from that study indicated:

- the U.S. government has placed an increasing emphasis on transferring federally-developed technology to the private sector;

- aid to small and medium-sized U.S. businesses has become a high priority in federal technology support, with many programs giving preferential treatment

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[66] These amendments do not appear in the Senate version of the act.

[67] The following information is derived from background material from the former Bilateral Trade Policy Division of the Trade Policy and International Affairs Branch, of ISC.

to small, minority and native American U.S. firms as well as firms owned by women, as prime or sub-contractors under the Small Business Administration Act[68];

- federal dollars are flowing in larger amounts to the development of technologies at stages closer to commercialization; and

- a demonstrated shift is taking place from funding for weapons technology to funding for commercially applicable research.

A listing of those programs which subsidize the operations of technology consortia with references to the relevant statutes that impose eligibility criteria is attached as Appendix B. Membership in SEMATECH, which is funded out of the Pentagon's Advanced Research Projects Agency (ARPA),[69] is only available to U.S. owned or controlled semiconductor or materials and equipment manufacturers or participating U.S. universities and federal agencies. Northern Telecom is a member through its U.S. subsidiary, which employs more than 20,000 Americans, in effect making it a bigger employer of American citizens than some of the "U.S. companies" that are also members of SEMATECH.[70] However, Northern Telecom is not listed as a member company in the Fact Sheets published by SEMATECH dated March 1993.

The aforementioned 1991 study by ISC concluded: "Of the twenty-three [U.S.] federal government programs reviewed: four are limited to U.S. nationals; three require security clearances; and two are limited to U.S. businesses (a term which is not clearly defined but may be a reference to ownership). The remainder appear to be open to Canadian-owned firms, though several require a U.S. plant location. It is

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68 Contracting dollars disbursed in support of small business have been estimated at US $42 billion for FY 1992 out of a total of US $200 billion for federal contracting only, both civilian and defence, and representing prime contracts only.

69 Previously known as DARPA and recently renamed ARPA to reflect its new mandate to target civilian commercial technology, it is being considered by some to be the U.S. answer to MITI.

70 It is not clear whether membership for Northern has translated into research jobs in Canada. Northern Telecom advises that the bulk of their R&D is conducted in Canada and that their involvement with foreign technology consortia is not a large proportion of their R&D expenditures. Dr. Niosi of UQAM advises that there is no manufacturing of semiconductors in Canada, even though 8 - 10% of the world's chip designs originate here. This is due to a lack of the appropriate manufacturing expertise in Canada, the prohibitively high level of fixed costs associated with establishing a facility combined with a small domestic market and a critical shortage of venture capital. Dr. Niosi states thet large Canadian firms tend to locate their R&D operetions close to their customers which explains why a number of Canadian enterprises conduct as much as one-third of their R&D off-shore. He is conducting more research on this to be published in a forthcoming paper.

worth noting that at least one, a NASA program, may have become open to Canadian firms as a result of the FTA."[71]

ii) Implicit Rules Affecting Procurement Practices

In terms of federal procurement, U.S. government R&D contracting is subject to the Federal Acquisition Regulations (FARs) of the Code of Federal Regulations, with most of the major departments having their own set of supplementary regulations. Proposed federal expenditures on R&D, including both procurement and investment in facilities (civilian and defence), is US $75.6 billion for FY 1994. The FARs distinguish between:

a) government contracts for R&D which are used to support the acquisition of goods or services for the direct benefit or use of the Federal Government, and

b) grants and cooperative agreements, when the principle purpose of the transaction is to stimulate or support research and development for another public purpose.

Contract-type restrictions related to government procurement exist in the form of small business set-asides and, in some cases, federal funding comes with "Buy America" restrictions which arise out of federally sponsored research projects. A recent case involved a Canadian participant in a consortium who complained that a "competitiveness clause" in the procurement contract precluded any manufacture in Canada.[72]

An investigation of this case was pursued with the legal counsel of the consortium. The most relevant legislation cited appears to be the "National

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71 The NASA Industrial Applications Centre is available to Canadian companies irrespective of location as a result of the Canada-U.S. Free Trade Agreement.

72 The legislative authority for this restriction is contained in Title 18 of the U.S. Code, Chapter 18, Part 204 "Preference for United States Industry". Chapter 18 deals with patent rights in inventions made with federal assistance. Part 204 states: "Notwithstanding any other provision of this chapter, no small business firm or nonprofit organization which receives title to any subject invention and no assignee of any such small business firm or nonprofit organization shall grant to any person the exclusive right to use or sell any subject invention in the United States unless such person agrees that any products embodying the subject invention or produced through the use of the subject invention will be manufactured substantially in the United States. However, in individual cases, the requirement for such an agreement may be waived by the Federal agency under whose funding agreement the invention was made upon a showing by the small business firm, nonprofit organization, or assignee that reasonable but unsuccessful efforts have been made to grant licenses on similar terms to potential licensees that would be likely to manufacture substantially in the United States or that under the circumstances domestic manufacture is not commercially feasible."

Competitiveness Technology Transfer Act of 1989" which amended the "Stevenson-Wydler Technology Innovation Act of 1980". This legislation focuses on technology transfer from U.S. government labs to the private sector and on patent rights for technologies. However, it was observed that limitations on manufacturing arising from this legislation may restrict the participation of Canadian companies in government-funded R&D contracts.

Another "competitiveness clause" recently appeared in a case involving a U.S. air force contract. The contract contained the following evaluation factor: "the extent to which the proposal meets the congressional intent to maintain U.S. worldwide leadership in civil satellite land remote sensing." Additionally, contracting of one agency may refer to regulations of another agency for R&D contracting. For example, certain R&D contracting under the Clean Air Act, administered by the Environmental Protection Agency, refers to provisions for acquisition, construction or furnishing of test facilities and equipment in R&D military contracting, which contain limitations on the location of facilities outside of the United States(10 U.S.C 2353).

Since almost 90% of U.S. government procurement is not covered by any trade disciplines under the GATT, FTA or NAFTA, it can be used effectively as a means to restrict participation in R&D consortia where the products or services arising from the technology developed are to be sold to a federal department or agency. For example, suppose a federal department or agency seeks to procure a piece of equipment to fulfil a particular operational requirement. The procurement officer may contract the work in stages requesting a proposal on the design of a prototype which, following approval, will be tested in government laboratories and so on. If the consortium submitting a bid has a foreign member by virtue of their technological expertise in some related area, the consortium could become ineligible because the procurement regulations governing that procurement may not be subject to international trade disciplines. This could effectively bar the Canadian firm not only from participating in a potentially lucrative contract, but also from the opportunity to derive benefits from participating in the joint research project. Preliminary estimates of U.S. federal R&D procurement dollars going to Canadian-based companies derived from General Accounting Office figures indicate that the Canadian share is approximately 0.1%.

B. Europe

i) EC-wide

The Framework Programs (FPs) for RTD were initiated in 1984 when the EC felt that it had been falling behind in high technology and the national R&D efforts of

member states would not be sufficient to reverse this trend.[73] In 1987, the Single Europe Act brought research and technological development activities within the purview of the Community, giving it far-reaching authority over EC project identification and funding.

Europe is currently on the Third Framework Program. Under the current access agreement, Canadian-based firms may participate in European consortia as sub-contractors but have no specific rights to the intellectual property developed by consortia. Furthermore, the Canadian government would be obliged to contribute enormous sums of money to have access to Framework Programs research at the Program level. European-based affiliates of Canadian firms are not prevented from participating in projects since they are considered European firms, but there has been some resistance from competitors at the EC member state level to allowing foreign-owned subsidiaries to join European consortia. One of the cases, discussed below in section 4.3, provides a good illustration of some of the real frustrations facing Canadian companies.

The Maastricht Treaty (on European Union) will introduce substantial amendments concerning the breadth of scope of the FPs. In particular, the 4th FP (1994-1998) will include "all the RTD activities covered by the Treaty. Thus all Community research and technological development activities, whatever their form and under whichever common policy they fall, are included within the framework programme."[74] This would include EUREKA. Another amendment concerns the participation of a non-EC country under joint RTD projects, which will only be allowed under a bilateral S&T agreement.

Article 130g of the Maastricht Treaty specifies that the FP will comprise the following four activities:

a) implementation of research, technological development and demonstration programmes, by promoting cooperation with and between undertakings, research centres and universities;

b) promotion of cooperation in the field of Community research, technological development and demonstration with third countries and international organisations;

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[73] Ibid.

[74] Commission of the European Communities, Working Document of the Commission Concerning the Fourth Framework Programme of Community Activities in the Field of Research and Technological Development (1994-1998), p.4.

c) dissemination and optimization of the results of activities in Community research, technological development and demonstration; and

d) stimulation of the training and mobility of researchers in the Community.

Under activity b), the basis of cooperation with non-European industrialised third countries is as follows:

> "The objective is to strengthen the Community's scientific and technological capacity through promoting the access, **on a reciprocal basis,** to current knowledge and RTD activities as well as through the development of a favourable environment for synergies in the field of advanced science and technologies. **Cooperation operates in the context of ad hoc agreements or arrangements linked to priority themes, notably in the form of information exchange, promotion of mobility and of scientific and technical networks, and of joint research activities of mutual interest.... . Similarly, participation in prenormative research, the development of international standards, their diffusion and their application are included in this context."**

Canada will soon begin negotiations with the EC to establish a bilateral agreement for scientific and technological cooperation with the EC. A key benefit of this agreement will be the right of Canadian-based firms to participate in RTD projects on a full partnership basis with full rights to the intellectual property of the consortium.

ii) Member States

To our knowledge, there is no specific member state legislation restricting the participation of Canadian companies in domestic R&D consortia, nor any regulations harsher than those of the Community.

France

There were no obstacles identified to Canadian participation in publicly supported French consortia other than the Community's competition laws. In fact, there are a number of examples of Canadian partnerships with French firms for the purpose of participating in the EUREKA program (see Appendix A).

Britain

Not only does the U.K. government not restrict access to its RTD consortia, but it actively supports the participation of foreign firms in European projects. For example, the U.K. has strongly supported the right of ICL (owned 80% by Fujitsu and 20% by Northern) to participate in European computer R&D projects; particularly the European Computer Research Centre (other members are Bull and Siemens). Canadian firms are not restricted from joining LINK projects. For example, Northern Telecom has participated in some LINK projects.

Germany

Germany does not, to our knowledge, have any legislation restricting Canadian companies from participating in RTD consortia. It is not considered likely that Germany will move to impose restrictions on Canada in this context.

Italy

According to AIRI, the Italian National Association for Industrial Research, while there is no restriction on foreign participation in programs established which support the formation of RTD consortia, there exists a strong de facto bias in favour of companies with a local identity. Competition for funds is fierce and projects involving foreign companies with no sizeable presence in the country or commitment to the market are the first to be rejected.

Others

Generally, it appears that constraints to Canadian participation lie in the realm of inadequate contacts, planning and commitment of resources on the part of Canadians, and not in any specific barriers to access erected by host governments.

C. Japan

Japan's early attempts to extend participation in their scientific research programs were hampered by bureaucracy. Cooperation was being extended on a government-to-government basis which proved to be a complex management challenge. The Intelligent Manufacturing Systems (IMS) program was designed to be private sector driven, but Canada was not initially invited to participate. Last year, the Japanese government began announcing their domestic R&D programs by publishing a notice or Request for Proposal in widely disseminated scientific journals such as Nature magazine. This approach has generated some frustration within Canadian industry because of short deadlines, given that proposals must be submitted in Japanese and as it is difficult to get additional information on the projects before a bid must be submitted.

More recently, the Japanese have taken a new approach. Their programs now incorporate a one to three year initial study phase, which is more consultative in nature. Companies may submit proposals. However, it is not yet clear what the roles and responsibilities will be in such projects, in which case access by foreign participants to intellectual property rights is not yet well defined.

Generally speaking, there are no official restrictions on the participation of Canadian firms in Japanese-sponsored consortia. Canadian firms are free to bid on projects, although none have been successful. The limited resources of Canadian firms in the fields of research chosen for support (predominantly small and medium

sized enterprises (SMEs)) and the considerable language and distance barriers are contributing factors.

D. Canada

In Canada, there is no shortage of programs to support the formation of technology consortia, both domestically and with foreign partners. One commentator writes: "In the 1980s, provincial and federal governments became rivals in creating new links between corporations, both private and public, and universities."[75]

The following federal programs support cooperative networks in research and development. Generally speaking, Canadian programs appear to be more open to foreign access through consortia in their application than in the United States and Europe. Officials report that Canadian consortia with foreign based members will be considered for support if the consortium can demonstrate that it will generate net benefits for the Canadian economy.

The Technology Outreach Program, established in 1986, funds cooperative networking to promote technology acquisition and diffusion. Technology Centres supported by this program do not appear to limit access to their services and are considered open to foreign participation. Officials report that the program encourages international linkages.

The Strategic Technologies Program, also managed by ISTC, is designed to enhance Canadian industrial innovation capabilities by promoting the development and diffusion of strategic technologies and encouraging the formation of strategic alliances, which may include foreign partners, although the alliance must be led by a Canadian firm. This $30 million program was approved in 1988 for a five-year period. It has three components, targeting Biotechnology, Advanced Industrial Materials and Information Technologies. Assistance will not be provided directly to foreign companies or institutions but such organisations may be sub-contractors to, or participants in alliances to which assistance is provided.

The Industrial Research Assistance Program (IRAP) is managed by the National Research Council. Cost shared funding is available to aid firms in conducting collaborative R&D involving other industry and federal research organisations.

[75] Op cit. Niosi, p. 311.

This program has also been used to fund collaboration with foreign partners even when their base of operations is outside of Canada if the collaboration will generate net benefits for Canada.[76]

The Japan Science and Technology Fund, which is managed by EAITC, was established in 1989 to promote bilateral "mutually beneficial collaboration with Japan" in science and technology. One of the program goals is to promote collaboration in research, standards setting and similar initiatives to facilitate exports to Japan. Therefore, the program is only open to Canadian firms. Estimated funding for this program was set at $25.1 million for the first five years.

Provincial programs to support cooperative links also exist. Quebec's **Programme d'Actions structurantes** was created in 1984 to forge links between universities and industries, and the **Fonds de Développement technologique**, established at $300 million for the 1989-94 period, supports the formation of large consortia. Ontario's **Centres of Excellence** program was established in 1986. In the same year, Ontario created the **Ontario Technology Fund**, which committed $1 billion to the formation of consortia between 1986 and 1996. In July 1992, the fund was renamed **Technology Ontario** with a new commitment of $81 million per year.

The Defence Industries Productivity Program assists aerospace and defence industries through R&D funding, capital assistance, the establishment of operations and feasibility studies. Assistance is limited to firms with Canadian manufacturing operations, but the program does not discriminate on the basis of ownership. More than 50% of funding goes to Canadian subsidiaries of foreign firms. In addition, foreign firms are not excluded from sub-contracting. This program has rarely been used to fund consortia or alliances of firms, but in such cases eligibility for funding is determined on a case by case basis depending on various criteria such as the strength of the proposal itself, the sector strategy and whether or not the foreign partner is contributing its own funding and expertise.

As a concluding remark to this section, it is important to note that there appears to be a general lack of demand by Canadian firms for changing the rules of the game for access to publicly sponsored consortia in other countries at this particular point in time. Dr. Niosi's research has led him to conclude that Canadian companies are a lot more connected with international technology networks than we might at first have surmised. Many of these alliances, formed on a private basis, have not required the active assistance of the federal government's S&T counsellors or

[76] Discussion with NRC officials.

technology development officers in our embassies and are not accompanied by a public announcement.

Also, the international scientific community is similarly well connected through their publications in scientific journals and their attendance at international conferences. There are also indications that those Canadian firms which can and do participate in a number of R&D consortia are becoming "consortia-fatigued". With a number of technology development initiatives to choose from, these few firms must allocate their resources carefully in order to maximize the net benefit to the firm of its membership in these networks.

4.3 The Canadian Participants: Some Case Histories

A Story of Perseverance in Penetrating U.S. Technology Consortia

A small Canadian equipment manufacturer supplies an equipment control instrument to the semiconductor manufacturing industry. It has been affiliated with SRC for three years now. More than eight years ago (1986), it established a relationship with the University of Michigan which has since become one of the U.S. Centres of Excellence. Through contacts with its customers and the University of Michigan, the manufacturer became aware of the activities of SRC and determined that it would be in the firm's interest to become a member. However, the membership regulations at that time specified no foreign members.

With the assistance of ISC and EAITC, the manufacturer launched a campaign in 1987 to lobby the Semiconductor Research Corporation (SRC) and the U.S. government for membership access. It took two and a half years of lobbying to secure access to SRC. It became an affiliate member in March 1990. The firm is very happy with the relationship it has established with SRC and consider that this relationship has contributed to an expansion of their customer network in the U.S.. In particular, membership has helped to establish the firm's credibility in the industry. It now supplies equipment to some of the largest U.S. manufacturers of semiconductors, such as Motorola and Intel.

Unfortunately, the firm has not been so successful in its efforts to gain access to SEMATECH. It has approached the Board of Directors of SEMATECH twice, with requests to become a member. Even though the consortium has purchased equipment from this Canadian manufacturer, SEMATECH has reportedly maintained a stance of restricting participation to U.S. firms only. This, in fact, conflicts with Northern Telecom's apparent success with respect to the involvement of their subsidiary in the United States. This company has been advised by the head of Semi-SEMATECH that no Canadian companies are permitted membership in SEMATECH. Furthermore, the firm may now be facing some competition in the U.S. from Honeywell, a member of SEMATECH, which is being encouraged to form a partnership with Lam Research to develop a competitive product.

Struggling with Bureaucracy in Europe

An Ontario-based company makes lasers for application in defence electronic systems, but which also could have numerous commercial applications. Wholly owned by Japanese investors, the firm is headquartered in Canada. It conducts 20% of its

R&D in Canada and has facilities in Europe and the United States. Through its subsidiary in the UK, it has participated in two EUREKA projects, including one in which it was the lead company, and three BRITE/EURAM projects[77]. Although it has three plants in the U.S., it has not had much success in gaining access to government-sponsored technology development programs in that country.

This firm has experienced some frustration with the bureaucracy involved in the European-based projects in terms of the approval process and with the lack of a market orientation. The UK office commented that targeted funding of R&D in laser technology had not led to market opportunities so much as it had increased the number of competitors in a market that is still largely undeveloped. However, the firm did say that participation had helped to strengthen relationships with partners, led to a broadened product development perspective and increased the firm's network of contacts.

With regard to the funding, it found that the EUREKA program created some delays in project implementation because of the requirement to seek funding from each company's national government. Some governments were more timely in the disbursement of research funds than others. For example, one company was still left waiting for funds three years after the project was scheduled to commence! In the case of Framework Programs, on the other hand, the funding comes from one source (the EC Commission), so that every eligible partner starts off on relatively the same footing.

Product Development & Technology Transfer in Europe

Another company participated in one aspect of a EUREKA project called Mermaid. The firm has a unique product which is a type of water quality monitoring instrumentation. Due to the fact that this product is unique in the world, it was able to gain access to this project with the assistance of some Canadian government funding which covered communications and some marketing costs. All of the R&D was conducted in Canada, except for the field testing.

As a result of their participation in this $10 million project, the company has developed a more sophisticated version of its own product. A prototype was recently sent to Germany. The firm reports that the Germans are satisfied with the product.

[77] EUREKA programs cover near market research in semiconductors, high-definition television and new road and traffic systems. BRITE/EURAM is a sub-program of the FPs which funds research in advanced materials and manufacturing technology.

The firm is very positive about its future prospects in the European market and believes that there is great potential for sales based on the relationships that have been developed through this project.

The firm has had less success gaining access to the Community-funded research programs, due to its lack of a presence (i.e., affiliate) in Europe. They applied to join the Marine Science and Technology Program (MAST) three years ago, but were turned down in Brussels. The firm is now engaged in establishing a presence in Europe and is setting up a joint venture in Prague with the assistance of EAITC's Renaissance Eastern Europe program.

V. CONCLUSIONS

5.1 Free Trade or Managed Trade?

Drawing conclusions from the relatively limited information as that obtained during the course of this short study is admittedly problematic. There exist several obstacles to meaningful analysis. It is difficult to achieve a consensus on terminology. Different authors employ different definitions, many of which are grossly imprecise and elude comprehension. Commentators with different professional backgrounds frequently have different concepts of technology consortia.

Secondly, the whole innovation process is not well understood, so that it is fairly arbitrary to carve out a 'precompetitive'[78] phase for public support.[79] Perhaps this explains the observed difficulties that governments have faced in giving their programs a commercial orientation. Both Europe and the U.S. have struggled with this question recently. Not to mention recent changes in Canadian programs that deliver assistance to the private sector.

Thirdly, a clearer understanding of the interests of stakeholders would require more than mere anecdotal information, accompanied by a few case histories of Canadian companies that have participated in international alliances. It is possible that a good proportion of Canadian high-technology firms may not be able or willing to avail themselves of the opportunities afforded by greater access. However, this information is not readily available.[80] Some suggestions are given at the end of this section. In the absence of a more systematic survey of opinion, we must formulate our conclusions on the basis of some expert opinion and theoretical models.

In response to the first question as to whether Canadian firms are being discriminated against (on either a most-favoured-nation or national treatment basis), the answer is both yes and no. In some cases, where Canadian firms have unique

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78 The term 'precompetitive', although widely used, is now largely considered to be a misnomer for 'precommercial' because it is not possible to define a stage of R&D that is not competitive, but it is possible to speak of a given research project being precommercial.

79 Laura Tyson notes that it is difficult to get precise distinctions between basic, pre-competitive and applied research, and that according to most scientists and technologists these distinctions do not exist, so that R&D subsidy disciplines will require agreement on some tough definitional issues.

80 The preliminary results of a survey, contracted by EAITC to determine whether Canadian firms might wish to participate in the Real World Computing program, reveal that, of twenty-two organisations contacted, none was particularly interested in joining the research program. Respondents reported a preference for relying on their own established networks of contacts and a reluctance to be tied into such a long-term program. Their timeframes for research are much shorter than that of the RWC program.

proprietary technology, foreign governments can and have waived regulations. In other cases, small Canadian firms lacking market power are unable to exploit their comparative advantage in proprietary technology to gain access to consortia. Certainly the rules of participation are skewed to favour domestic industry but, in general, Canadian firms can circumvent them by establishing a domestic presence in the host country.

Does this domestic location requirement, which appears to be almost universally applied, distort investment patterns? The answer is surely affirmative, although precise measurement is impossible as a practical matter. It may be possible to analyze this quantitatively by correlating foreign direct investment (FDI) with government expenditures on industrial R&D for various industries. Intuitively, we can see that this bias in favour of a domestic location may be one aspect of the global competition for FDI dollars. New technology stimulates investment with its implied economic benefits. By encouraging firms to locate R&D within national borders, governments hope to secure the lion's share of the economic benefits arising from new technology in terms of increased market share in global markets, and from new investment in terms of job creation. There is a need for further study of the linkage between innovation and investment.

What is equally important is the question of access to product markets. If a key benefit of participation in technology consortia is access to a network of contacts and market information, then lack of access to this mechanism could imply operating at a competitive disadvantage.[81] This argument may be overstated if one considers that many publicly funded consortia are politically motivated and do not always attract the key players in an industry. However, there is little doubt that technology consortia, even politically motivated ones, have been responsible for promoting stronger networks within domestic (and, in the case of the EC, regional) industry. Can access to these networks afford small and medium sized enterprises with a cost effective means of entering new markets? There is a need for further analytical work on the role of consortia, and in particular their function in penetrating new markets.

Should the profile of this issue be raised in Canadian trade policy? Yes, because the literature strongly suggests that technology may be a key source of shifting comparative advantage and that Canada has much to lose by allowing others to develop and determine how intellectual property rights should be assigned in

[81] A Canadian company with foreign subsidiaries wrote in the following observation: "It occurred to me after your call that I probably had not stressed adequately the value that this type of programme can have in fostering supplier, customer, sub-contractor and Institute/University type collaborative links. [Our company] is continually trying to develop closer network type relationships that help our understanding of customer needs and aspirations, and the technologies that might be used to address these needs."

international technology consortia. There are also indications that our major trading partners are giving more attention to stimulating industrial innovation driven by concerns over trade imbalances, particularly with Japan.

We know that Canadian firms need a certain degree of innovative capacity in order to absorb new technology. Ensuring greater access to sources of leading edge technology would be self-defeating if firms lack the ability or interest to absorb and commercialize such information, as suggested by the results of a survey of clients of science-based departments and agencies (SBDAs).[82] Although an essential first step, ensuring access does not automatically ensure benefits. In order to gain a better understanding of the concerns of industry and the S&T community in general on this issue, EAITC, in partnership with ISC, would need to conduct, or contract out, a professional survey of the research community's opinion, with emphasis on those who commercialize technology.[83]

From the perspective of Science Based Departments and Agencies (SBDAs), the issue of participation in international R&D networks is extremely important and should receive far more prominence on the trade policy agenda.[84] With respect to Canada's S&T strategy, the Council of Science and Technology Ministers released a National Science and Technology Framework for Action in May 1991 which called for the "promotion of strategic partnering and cooperation in R&D, both domestically and internationally, between private companies, universities and federal and provincial government institutes...".[85] Similarly, Inventing our Future, Canada's action plan for prosperity, calls for a "coordinated global trade, investment and technology strategy led by the private sector to increase exports, double the number of firms exporting and promote strategic alliances."

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82 The results suggested that for SMEs, the lack of technologically trained individuals, capable of absorbing and applying S&T knowledge from government and other sources to stimulate the product development necessary for their companies' continuing viability, is particularly crucial: ISTC, Federal S&T Alliances Report (1992), p. 22.

83 Some work of this nature has already been done. For example, the aforementioned report on federal S&T alliances collected data from twenty-nine science departments and agencies on more than eight thousand alliances to establish a data base. Unfortunately, only the clients of these SBDAs were surveyed for their opinions and the questionnaire was designed to survey their opinions about domestic consortia only. To get a fuller picture, the sample should be extended to a more representative sample of Canadian high-technology firms, perhaps selected randomly, although this would depend on the appropriate sampling methodology as approved by Statistics Canada. See the relevant Treasury Board Directive on public opinion surveys.

84 From conversations with ISC officers and NRC officials.

85 Canadian Science and Technology: Moving Forward to Cooperate with the R&TD Programs of the European Community, Government of Canada (June 30, 1992), p. 16.

A recent working paper by the Business Council on National Issues advocates that Canadian firms build strategic alliances and participate in collaborative ventures focused on precompetitive technology research. The paper notes that R&D expenditures are on the rise in Canada and are predicted to grow at an average annual rate of 6% between 1994 and 1997.[86] However, their prescription for government is to restrict its role to that of establishing framework policies. They argue that government should avoid any attempt to pick winners or target "strategic" industries. In their words: "Governments' greatest contribution to building a more competitive economy is not through industrial policy. Far more important are sound macroeconomic and framework policies."[87]

While it is true that many of Canada's small and medium sized companies are not necessarily represented by the views of the BCNI, the council does represent a number of Canada's major exporters. Comments received by those companies consulted for case histories supported the view that Canadian business wants less investment in large funding programs and cooperative infrastructures and more short term funds to reduce the risk factor in pursuing international collaboration which they themselves initiate. One firm, an environmental service firm, commented that the real value of government assistance for them was in sharing the risks in a market which is largely driven by government regulations, such that a change in regulations could wipe out their market and prevent them from recouping the costs of their R&D.

In terms of options, we can accept the de facto situation which limits participation in publicly funded consortia to domestically incorporated firms, or we can pursue improved access by negotiating rules for participation of Canadian-based firms in international consortia.[88] If we select the latter, it may be possible to contemplate establishing base criteria for participation in public consortia. For example, Canadian firms bringing their own expertise and funding would be able to participate in foreign technology consortia funded, at least in part, by other governments. This would require adapting similar Canadian programs to permit non-discriminatory participation by foreign-based companies bringing their own expertise and funding.

The first option (limiting participation to domestically incorporated firms) is widely advocated because it is supported by the view that public funds should enhance the competitive position of domestic industry and, therefore, should not,

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[86] The Conference Board of Canada, R&D Outlook for 1993, cited in BCNI, "Building a New Century Economy", a working paper of the BCNI (March 1993), p. 32.

[87] Ibid, p. 43.

[88] Various options have already been considered in relation to the multilateral services negotiation.

under any circumstances, contribute to the development of technological expertise in other countries even if domestic industry benefits at the same time. It is also, in some sense, driven by social Darwinist fears that larger commercial groups in foreign countries may overpower domestic firms, taking the lion's share of the economic benefits of cooperative research. Thus, it is necessary for the government to protect domestic technology from predation. If restrictions are reciprocated in the major industrialized countries, then we can probably expect to see increased conflict over government subsidies in the not too distant future, particularly if the latest round of multilateral trade negotiations remains unresolved.

Nonetheless, there is also a strong argument that Canada should seek improved access to foreign technology consortia because incentives to conduct R&D will be enhanced by improved access to foreign networks of market information and the stimulus of new approaches to R&D in other countries. This will entail ensuring that Canadian firms bringing their own expertise and funding can participate in foreign technology consortia from their base in Canada. It will also mean that they can do so without facing limitations on their ability to exploit the technology arising from these joint initiatives. It makes very little economic sense for governments to be setting the terms on which companies conduct their business operations.

Naturally, there will be some challenges in terms of assigning intellectual property rights. EAITC has already undertaken extensive interdepartmental consultations in this area to develop a Canadian negotiating position in preparation for its negotiations with the EC on a bilateral S&T cooperation agreement. Chapter 17 of the NAFTA will govern Canada/U.S./Mexican rights and responsibilities with respect to these matters.

It will also be necessary to ensure that access to markets for exports of advanced technology products is not impeded, since this would similarly reduce incentives to invest in R&D. Improved access to consortia located in one of the largest, most technologically advanced economies in the world (i.e., the U.S.) can only serve to increase the potential for Canadian firms to be more innovative. Without access to end product markets, however, they will be limited in their ability to obtain a sufficient return on their investment in R&D. This will require further multilateral trade liberalization overall. In many ways the access to end product markets is absolutely critical to creating the right incentives for R&D in Canada.

Furthermore, it will be necessary to seek greater disciplines on government procurement practices (even within North America) which inhibit the participation of Canadian firms in foreign consortia by favouring consortia that are exclusively comprised of domestic firms. For example, legislation aimed at enhancing national

competitiveness may require that government procurement place a premium on proposals received from exclusively domestic consortia. We should continue to work against such provisions, as well as seeking to liberalize government procurement practices more generally on a mutually beneficial basis.

The risk of pursuing this is option is that Canadian firms will not take full advantage of the opportunities afforded by improved access and may find their own research programs being dominated by foreign corporate interests, even if they bring their own expertise and funding. The other disadvantage of this approach is that it could stimulate increased demand for public support of R&D in Canada at a time when fiscal resources are at an all time low. What we now require is a comprehensive assessment of the risks involved if we do obtain improved access on these terms versus the risks (opportunity costs) if we don't.

5.2 Recommendations for Future Areas of Study

There are noticeable gaps in our knowledge which could be pursued at greater length. Our knowledge of provincial programs designed to promote international cooperation in science and technology is limited. How do provincial programs affect the participation of Canadian firms in foreign-based technology consortia? Do inter-provincial trade barriers impede the formation of pan-Canadian alliances to participate in large international research programs?

There may be some merit to investigating the comparative access of our trading partners to publicly supported technology consortia. How does Canada's record of access to these consortia compare with U.S. and Japanese firms with respect to the Framework Programs? Do Japanese firms have better access to U.S. R&D networks than Canadian firms by virtue of the many informal agreements between U.S. and Japanese firms, or through the presence of Japanese researchers at U.S. research institutes? A recent article in the **California Management Review** by David Mowery and David Teece discusses Japan' s growing capabilities in industrial technology and its implication for U.S. public policy. In particular, they explore the links between the U.S. and Japanese systems of R&D. In a table showing the number of international research joint ventures by nation for the period 1982-87, over all technology fields Canada had a total of 4 out of 135 for all nations, compared with 93 for the U.S., 13 for the U.K., 9 for Germany, 7 for France, 5 for Italy, and 4 for other nations.[89]

[89] Table 6 (Source MITI, 1987), in David C. Mowery and David Teece, "Japan's Growing Capabilities in Industrial Technology: Implications for U.s. Managers and Policymakers", California Management Review (Winter 1993), p. 23.

Our understanding of the impact of various government procurement regimes in our trading partners warrants more than a cursory examination. Government procurement has been, and will continue to be, used as a vehicle to promote technology creation and diffusion. With almost 90% of government procurement remaining outside trade disciplines, we will need to assess what types of subsidies to R&D are legitimate mechanisms for reducing market failure.

The current Multilateral Trade Negotiations (MTN) subsidies/countervail negotiating text defines a non-actionable category, to generally available subsidies, where assistance for research activities and regional development assistance would be non-countervailable if the provision for research assistance would not exceed 50% of basic research costs or 25% of the costs of applied research (with certain limitations as to eligible costs).[90] Signatories can also avail themselves of a regional development carve out provided "a general framework of regional development program" exists. Within the framework of a national regional development program, a subsidy deemed specific could be granted non-actionability status provided income or GDP per capita is not 85% of the average for the territory concerned, or the unemployment rate is 110% of the average for the territory concerned.

Since the formation of international technology alliances has become a part of the trade policy landscape, it is worth investigating the impact of these consortia on the domestic competitive environment. Do international technology consortia lead to increased competition or reduced competition domestically? How do they affect product markets? How do they affect factor markets such as the supply of skilled labour within Canada? Some studies suggest that they increase the supply of scientists and engineers to industry. However, as was previously noted, cooperation in international alliances may have the opposite affect, if skilled labour is lured away by large funding programs in other countries. Is the "brain-drain" effect greater than the domestic stimulus to skilled labour?

As has been already suggested, a professionally designed survey of the Canadian high-technology industry and various scientific research institutes and non-profit organizations could provide some valuable information for decision making. The research community would undoubtedly welcome the opportunity to contribute their insights.

[90] More generous subsidies would remain countervailable.

5.3 Some Concluding Remarks

This paper's final observation relates more to process than to policy matters. Before we can determine our priorities with regard to technology consortia, we need to know where the prerogative resides to formulate a coherent technology strategy, if such is needed, and who is going to implement it.[91] It has become apparent, over the course of researching this paper, that a number of federal departments and agencies are interested in taking the initiative in this area and this has created some confusion. Both ISC and EAITC have a substantial interest in various aspects of Canada's trade policy related to international technology alliances. There are numerous other federal departments and agencies that have some interest in contributing to the debate. Furthermore, it is apparent from the Prosperity Initiative's Action Plan that the private sector also wishes to be an active participant in the process.

The recent Policy Staff Paper on globalisation[92] has already identified areas where trade policy increasingly intrudes upon the domestic policy domain. If we are to handle these issues effectively, jurisdictional conflicts will have to be resolved. At a time when resources are scarce, this will require some tough decisions and the political will to see it through. There is scope for clearer rules, not only for international cooperation in technology development, but also for managing change within and between governments, so that we can deal with complex issues more effectively.

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[91] A recent ISC report analyzing federal science and technology alliances states: "There appears to be a consensus among the authors that rapid global growth of knowledge-based industries has resulted in an internationalization of technology research, development and application. Some authors conclude that this internationalization trend calls for strategic decision-making on S&T issues by governments."

[92] See footnote 3.

APPENDIX A

SOME CANADIAN PARTNERS IN EUREKA PROJECTS: THE FRENCH CONNECTION

LUMONICS LTD:
(through its U.K.-based affliliate
J-K Laser of Warwickshire)

GENETEC of
Ste-Foy (Quebec)

INO L'Institut Nationale d'Optique of
Ste Foy (Quebec)

DMR Groupe of
Montreal (Quebec)

Zenon Environmental Inc. of
Burlington (Ontario)

Seastar Optic Inc. of
Sidney (BC)
now called Axys Environmental Inc.

Cogni-Case of
Montreal (Quebec)

APPENDIX B

OVERVIEW OF U.S. FEDERAL PROGRAMS SUPPORTING THE OPERATIONS OF TECHNOLOGY CONSORTIA

DEPARTMENT OF COMMERCE:

National Institute of Standards and Technology (NIST)

Advanced Technology Program:

The program is limited to U.S. businesses, joint research and development ventures, and independent research organizations, and this only to the extent that they contribute to the competitiveness of U.S. industry. Administered by the National Institute of Standards and Technology (NIST), consortia are supported on the basis of a variety of funding instruments such as procurement contracts, grants and cooperative agreements. Officials report that proposals are evaluated on the basis of the following five criteria: 1) Scientific and Technical Merit, 2) Potential for Broad Based Market Application, 3) Technology Transfer, 4) Experience and Qualifications of the Proposers, and 5) The Level of Commitment of the Firm. Even if it brought its own funding and expertise, a Canadian firm participating in a U.S.-based consortium (whether incorporated in the U.S. or not) could make the consortium ineligible if a) either the research was conducted outside of the United States, or b) the manufacturing of products resulting from the technology developed with ATP funding were to be conducted outside of the United States. Final determinations of eligibility are made by the Secretary of Commerce, if the consortium with a foreign member has a competitive bid and it is determined that the consortium would not be viable without the foreign member. Not only is this process not transparent, but the high costs of submitting a bid under such uncertainty acts as a strong disincentive to U.S.-based consortia that might otherwise seek Canadian partners.

New legislation that is awaiting action by the U.S. Senate amends the definition of the term "United States company" in existing statutes (the Stevenson-Whydler Technology Innovation Act of 1980). According to HR 820 Section 206a(20) of the National Competitiveness Act of 1993, a "United States company" means an entity which:

a) maintains substantial employment in the United States;
b) agrees, with respect to a technology arising from assistance provided under this Act or the National Competitiveness Act of 1993, to promote the

manufacture within the United States of products resulting from that technology;
c) agrees to procure parts and materials for such products from competitive United States suppliers; and
d) either --
i) is a United States-owned company; or
ii) is a company incorporated in the United States with a parent company incorporated in a country which the Secretary finds--
(I) affords to United States-owned companies opportunities comparable to those afforded to any other company to participate in programs and to have access to resources and information equivalent to the opportunities authorized under this Act or the National Competitiveness Act of 1993 to foreign-owned entities engaged in commerce in the United States;
(II) has a standards development and conformity assessment process that is open and transparent, and that results in standards that are fair and reasonable and do not discriminate against United States products and production processes;
(III) affords to United States-owned companies local investment opportunities comparable to those afforded any other company; and
(IV) affords adequate and effective protection for the intellectual property rights of United States-owned companies.

According to U.S. legal advice, this wording is more restrictive in its impact on a firm's participation in technology initiatives than previous legislation and may even make some U.S.-owned and incorporated firms ineligible for assistance from federal technology support programs.

DEPARTMENT OF DEFENSE:

Advanced Research Projects Agency (ARPA)

The Advanced Research Projects Agency (ARPA) is a separately organized agency within the Department of Defense under a Director appointed by the Secretary of Defense. As the central research and development organization of the Department

of Defense[93] with a primary responsibility to maintain U.S. technological superiority over potential adversaries, ARPA is mandated to:

- pursue imaginative and innovative research and development projects offering significant defence utility;
- manage and direct the conduct of basic and applied research and development projects that exploit scientific breakthroughs and demonstrate the feasibility of revolutionary approaches for improved cost and performance of advanced technology for future applications; and
- stimulate a greater emphasis on prototyping in defense systems by conducting prototype projects that embody technology that might be incorporated in joint programs, programs in support of deployed U.S. Forces (including the Unified and Specified Commands), or selected Military Department programs, and on request, assist the Military Department in their own prototyping programs.

Some Prominent Consortia Funded by ARPA

Semiconductor Manufacturing Technology (SEMATECH):

Membership into Semiconductor Manufacturing Technology consortium is available only to U.S.-owned or controlled semiconductor or materials and equipment manufacturers or participant U.S. universities and federal agencies. With regard to ARPA funding, the relevant statute would be the definition of eligible firm found in 10 USC Section 2491(9). The SEMATECH legislation 15 USC Section 4601e(2) states: "The term "Sematech" means a consortium of firms in the United States semiconductor industry ...".

[93] ARPA actually receives only a relatively small proportion of the Department of Defense's funding for R&D. ARPA has been allocated approximately US$2.2 billion out total U.S. defence R&D spending of US$41.9 billion. These figures are from the Presidential budget proposal for FY 1994.

Microelectronics and Computer Technology Corporation*:

Participation in Microelectronics and Computer Technology Corporation as either a shareholder or an associate is available to any information technology company that has majority ownership and control by U.S. or Canadian citizens.

Semiconductor Research Corporation*:

Participation in Semiconductor Research Corporation either at full, associate, or affiliate member level is available only to U.S. or Canadian semiconductor and high technology manufacturers, or to faculty and students of U.S. universities on a competitive basis.

* These consortia may receive federal funding from a variety of sources (i.e., not just the Department of Defense).

NATIONAL SCIENCE FOUNDATION:

Industry-University Cooperative Research Centers:

The program is informally restricted to one or more industries through use of the National Science Foundation's determination of eligibility for assistance. Determination of eligibility depends on:

- industry need,
- capability of a centre to meet industry needs,
- potential for a centre to achieve self-sufficiency, and
- presence of industry support.

In accordance with National Science Foundation policies, no person may be excluded from participation in, denied any benefits, or be subject to discrimination on grounds of nationality under any program or activity receiving funding from the National Science Foundation. However, the aforementioned National Competitiveness Act of 1993, in reference to the role of the National Science Foundation (NSF), states (June 18th edition): "The Director of the NSF, after appropriate consultation with the Secretary, the Under Secretary, and the Director shall-- (1) work with United States companies to identify areas of research in advanced manufacturing technologies and practises that offer potential to improved United States productivity, competitiveness, employment, and sustainable economic growth; (2) support research at United States

universities to improve advanced manufacturing technologies and practices; and (3) work with the Technology Administration and the Institute and, as appropriate, other Federal agencies to accelerate the transfer to United States companies of manufacturing research and innovations developed at universities." The definition of United States company for the purposes of this act is provided in the section covering eligibility for the ATP above.

Although not specifically intended to support the operations of consortia, a number of other federal programs which are designed to support industrial innovation may contribute funds to consortia activities. These might include; the Manufacturing Extension Partnership (Manufacturing Technology Centres), Engineering Research Centres (18), Energy Related Inventions, Fossil Energy Research Development Program, Renewable Energy Research Development Program, Superfund Innovative Technology Evaluation Program, NASA Industrial Applications Centre, Forest Products Laboratory and the Small Business Innovation Research (SBIR) Program. As an example of such programs, eligibility for the SBIR program is described below:

The Small Business Innovation Research Program is informally restrictive through the use of discretion in deciding eligibility for assistance grants. Only small businesses, as defined by law, may apply. In addition, small businesses are subject to specific eligibility requirements established by the Small Business Administration such as the requirement that they be more than 51% owned by U.S. citizens. With certain projects, small businesses may be ineligible for grants due to requirements for maintaining national security classifications.

Regulations that Apply to All Departments and Agencies

CRADAs, Cooperative Research and Development Agreements are legally distinct funding instruments that may be used to support a whole variety of research and development activities. For example, in 1994 it is projected that the U.S. federal government will spend approximately US $3 billion on some 1700 CRADAs. These agreements, which may be used by any federal department or agency, have restrictions placed on them in the statutes as follows. Title 15 USC 3710a (c) 4B, dealing with CRADAs, refers to a special consideration for small business firms and consortia involving small business firms. It also gives preference to firms with a U.S. location for research and to companies agreeing that products embodying inventions made under the CRADA will be manufactured substantially in the U.S.. This means that even if the eligibility criteria of a given funding program permit the participation of foreign owned subsidiaries in a research project, the use of a CRADA as a funding instrument could add further limitations on the activities of the consortium so as to discourage the participation of foreign members.

DOCUMENTS DU GROUPE DE LA PLANIFICATION DES POLITIQUES/ POLICY STAFF PAPERS

Récents documents sur des questions économiques et de politique commerciale:
Recent Papers on Economic and Trade Policy Issues:

1 From a Trading Nation to a Nation of Traders: Towards a Second Century of Trade Development, by Andrew Griffith. 92/5 (March 1992)

2. World Population Growth and Population Movements: Policy Implications for Canada, by Michael Shenstone. 92/7 (April 1992)

3. Trade and the Environment: Dialogue of the Deaf or Scope for Cooperation?, by Michael Hart and Sushma Gera. 92/11 (June 1992)

4. Globalization and Public Policy in Canada: In Search of a Paradigm, by Keith H. Christie. 93/1 (January 1993) (aussi disponible en français)

5. Pour des sanctions efficaces et appropriées, par Jean Prévost. 93/4 (mars 1993) (also available in English)

6. Black Gold: Developments in the World Oil Market and the Implications for Canada, by Sushma Gera. 93/5 (February 1993) (aussi disponible en français)

7. Exports and Job Creation, by Morley Martin. 93/6 (June 1993) (aussi disponible en français)

8. Globalization: The Impact on the Trade and Investment Dynamic, by Dennis Seebach. 93/7 (June 1993) (aussi disponible en français)

9. Different Strokes: Regionalism and Canada's Economic Diplomacy, by Keith H. Christie. 93/8 (May 1993) (aussi disponible en français)

10. Merger Control under Trade Liberalization: Convergence or Cooperation?, by Nicolas Dimic. 93/09 (August 1993) (aussi disponible en français)

11. Technology Consortia: A Prisoner's Dilemma?, by Rhoda Caldwell. 93/10 (August 1993) (aussi disponible en français)

12. Optimal Patent Term and Trade: Some Considerations on the Road Ahead, by I. Prakash Sharma. 93/11 (forthcoming)

13. Canadian Commercial and Economic Interests in Central/Eastern Europe and Former Soviet Union (CEE/FSU) by Jean Prévost. 93/12 (forthcoming)