High-Technology Trade Pattern Analysis: Its Use and Application for Industry Competitiveness Response and Government Policy Development

Report of the Rapporteur
CATA / Industry Canada Workshop on High-Technology Trade Statistics
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Introduction

The Canadian Advanced Technology Association (CATA) in collaboration with Industry Canada, sponsored a workshop on high-technology trade statistics in Ottawa, 19 October 1995. A copy of the program is attached. The purpose of the workshop was to review various approaches to high-technology trade pattern analysis, its use, and application for industrial competitiveness responses and government policy development.

There has been concern for many years over Canada's competitiveness, relative to its trading partners, in the area of technology-intensive products and the associated exchanges of intellectual property. The Canadian economy runs a substantial merchandise trade surplus, mainly with the U.S., but there is a deficit in high technology products. Part of this deficit is attributed to the fact that while we run a trade surplus in resource-based products, we appear to do poorly in areas that involve new technologies. There are exceptions in parts of the aerospace and telecommunications industries, but as a whole, Canada is a net importer of technology. This situation is not unusual; most nations are net importers of technology and technology-intensive products.

The CATA Workshop on High-Technology Trade Statistics

The CATA Workshop on High-Technology Trade Statistics was convened to bring together experts in the field to exchange information and views on the measurement of trade in high technology products and indicators of the competitiveness of high technology industrial sectors. The conference was chaired by Mr. John Reid, President of CATA. The workshop started with four presentations which are summarized below:

Background to the High-Technology Trade Issue: Denzil Doyle, Doyletech Corp.

Mr. Denzil Doyle presented the results of a report prepared by Doyletech Corp. for Industry Canada on trade in Canadian trade in advanced technology products (ATP). ATP are covered by approximately 500 of a total of 22,000 commodity classification codes used by the U.S. Bureau of the Census in reporting U.S. merchandise trade. These codes meet the following criteria:

- the code contains products whose technology is from a recognized high-technology field;
- these products represents leading edge technology in that field, and
- the products constitute a significant part of all items covered in the selected classification code

These classification codes are usually aggregated into ten high-technology fields:

- Biotechnology
- Life Science
- Opto-electronics
- Information and Communications
- Electronics
- Flexible Manufacturing
- Advanced Materials
- Aerospace
- Weapons
- Nuclear Technology

The aggregate of U.S. ATP imports, exports and trade balance are reported in the monthly trade bulletin published by the U.S. Bureau of the Census. Doyletech acquired the list of U.S. ATP and, with the assistance of Statistics Canada, convened the U.S. product codes into Canadian product codes to derive a list of Canadian ATP.

The Doyletech data updated earlier estimates of Canadian high-tech imports, exports and trade balances by technology, which had been based upon approximations. Thus while earlier figures had indicated a high-tech trade deficit of over $11 billion in 1993, the Doyletech data show a trade deficit of less than $4 billion in that year and $5.8 billion in 1994 (see attached table). Based on these figures the report suggests that if the ATP trade deficit were to be reduced to zero, 40,000 direct jobs, 120,000 indirect jobs, $600 million R&D expenditures, and $1.2 billion in new taxes would be generated.

Table 1

Canadian Balance of Trade	1990	1991	1992	1993	1994
Biotechnology	-$92,897,730	-$107,095,261	-$138,061,242	-$175,673,290	-$213,037,111
Life Sciences	-$388,312,694	-$503,617,643	-$471,960,900	-$514,597,092	-$700,738,133
Opto-Electronics	$4,248,093	-$2,502,923	-$60,998,870	-$61,196,364	-$81,033,327
Information & Communication	-$2,118,294,099	-$1,634,015,345	-$2,334,095,528	-$2,726,430,955	-$2,556,272,351
Electronics	$1,218,438,606	-$206,710,222	-$1,636,902,817	-$2,128,274,453	-$3,853,846,747
Flexible Manufacturing	-$563,061,629	-$462,075,529	-$407,738,782	-$414,358,038	-$680,259,342
Advanced Materials	$82,992,577	-$822,893,845	$3,283,593	$27,173,408	$41,959,768
Aerospace	$2,638,501,879	$2,058,718,972	$490,963,674	$2,292,945,187	$2,554,386,788
Weapons	-$72,625,824	-$67,661,573	-$43,571,865	-$114,058,049	-$195,827,451
Nuclear	-$100,008,745	-$47,035,238	-$107,654,205	-$31,542,362	-$163,277,950
Total	$608,980,436	-$1,794,888,607	-$4,706,736,940	-$3,846,012,008	-$5,847,945,855

Mr. Doyle noted that it is mainly suppliers of equipment that do R&D, not users, and that while product R&D creates jobs, process R&D tends to eliminate them. Canada is a major importer of technology, both as intellectual property and in its tangible form as ATP. Canada should therefore have some way of measuring its annual trade in ATP. In this connection, Mr. Doyle presented the format for a proposed bulletin on high-tech, to be published by industry and/or government.

Statistics Canada's View: *Dr. Fred Gault, Statistics Canada*

Dr. Gault reviewed the various efforts that had been undertaken by Statistics Canada to measure high-tech trade and the reasons why each had been eventually abandoned. He noted that measurement of high-tech trade was difficult because of the temporal changes in technology; what is high-tech today may be low-tech ten years later. He also noted that it is important to have a variety of indicators available, and that a single number for high-tech trade, and hence high-tech competitiveness could be misleading.

OECD Work on SAT Performance Indicators, with a Special Focus on High-tech Trade: *Andrew Wyckoff, OECD*

The OECD has for some years been carrying out analyses of sectoral trade performance. Until recently it focused on data sorted by industrial sector, on the grounds that most other performance data, such as employment, are available on an industry sector basis, not on product classifications.

The OECD has used different schemes to categorize industrial sectors:

Technology Intensity:

- high technology
- medium technology
- low technology

Wage Levels:

- high wage
- medium wage
- low wage

Specialization:

- resource intensive
- labour intensive
- scale intensive
- specialized suppliers
- science based

Table 2

U.S. Department of Commerce High Technology Indicators

High-tech Indicator	Advantages	Disadvantages
Technology-based: "Critical technologies"	• Specific to particular policy issues	• Do not link directly to performance measures by industry sector • rely on opinions of experts • invention and production locations frequently delinked
Industry-based: "DOC-3" list of high-tech industry sectors – selected on the bases of R&D/sales ratios	• Easily reproducible • Can be linked to industrial performance indicators • List of sectors is stable (at least for U.S.)	• R&D expenditures not always a good proxy for embodied technology • Levels of disaggregated R&D data severely limited • Substantial time lags between R&D expenditure and industrial output • R&D Intensities can vary between imports and exports • Substantial differences between technology intensity at industry, firm and product levels • Limited data in service industry sectors
Product-based: Advanced Technology Products (ATP); U.S. Census Bureau list based on ten technologies	• Specific to traded products , thus picking up products not on the DOC-3 list and excluding low-tech products included on the DOC-3 list • ATP data can be aggregated by technology	• ATPs are independent on selection by experts • Cost of making periodic reviews and non-comparability over time • Leading edge process technologies are not captured
Firm-level: Use of advanced manufacturing technologies	• Provides insight into firm-level performance • Can be aggregated up to industry sector, based on firm classification	• No direct link between use of technologies and national economic indicators (e.g. trade)

Table 2: Intensity of R&D Expenditure in the OECD area
R&D Expenditure/Production (%)

Rank	1972-1974	
High		
1	Aerospace	19.85
2	Computers	10.57
3	Electronics	7.16
4	Pharmaceuticals	6.14
5	Instruments	3.99
6	Electrical machinery	3.39
Medium		
7	Motor vehicles	2.44
8	Chemicals	2.18
9	Rubber & plastics	1.16
10	Machinery nec	1.14
11	Other manufa. Ind.	0.97
12	Pertolium refining	0.83
Low		
13	Ship building	0.62
14	Stone, clay & glass	0.57
15	Non-ferrous metals	0.54
16	Other transport	0.47
17	Ferrous metals	0.36
18	Fabricated metals	0.35
19	Paper & printing	0.24
20	Food, drink & tobacco	0.18
21	Textiles and clothing	0.16
22	Wood & furniture	0.1

Rank	1979-1981	
High		
1	Aerospace	14.32
2	Computers	9.12
3	Pharmaceuticals	7.6
4	Electronics	7.54
5	Instruments	5
6	Electrical machinery	3.33
Medium		
7	Motor vehicles	2.74
8	Chemicals	2.12
9	Machinery nec	1.4
10	Other manufa. Ind.	1.1
11	Rubber & plastics	1.09
Low		
12	Stone, clay & glass	0.68
13	Ship building	0.64
14	Pertolium refining	0.59
15	Non-ferrous metals	0.58
16	Other transport	0.53
17	Ferrous metals	0.48
18	Fabricated metals	0.47
19	Paper & printing	0.25
20	Food, drink & tobacco	0.22
21	Textiles and clothing	0.16
22	Wood & furniture	0.16

Rank	1987-1989	
High		
1	Aerospace	20.28
2	Computers	12.52
3	Electronics	10.94
4	Pharmaceuticals	10.39
Med-High		
5	Instruments	4.86
6	Motor vehicles	3.53
7	Chemicals	3.39
8	Electrical machinery	3.34
Med-Low		
9	Machinery nec	2.09
10	Other transport	1.59
11	Ship building	1.46
12	Stone, clay & glass	1.15
13	Other manufa. Ind.	1.1
14	Pertolium refining	1.06
15	Rubber & plastics	1.01
16	Non-ferrous metals	0.92
Low		
17	Ferrous metals	0.68
18	Fabricated metals	0.61
19	Food, drink & tobacco	0.33
20	Paper & printing	0.24
21	Textiles and clothing	0.22
22	Wood & furniture	0.16

Source: OECD, DSTI (STAN/ANBERD) database, 1992

High, medium and low technology industries have been selected on the basis of research intensity, that is, on the basis of having high R&D expenditure to total sales ratios. The OECD list of research-intensive industries is attached. Their research shows that high-tech industrial sectors are research intensive even when indirect inputs are included. Wyckoff displayed a graph (attached) from the OECD STAN database which shows a correlation between annual growth rates in R&D expenditures and employment in high-tech industries.

Recent OECD results also show a link between total factor productivity and levels of R&D embodied in products The OECD is now reviewing a high-tech product list, but has not yet submitted it to national experts for acceptance as an OECD (and hence, international) standard.

The U.S. Experience: *Lester Davis, U.S. Department of Commerce*

Mr. Davis pointed out that the U.S. government has used high-tech trade indicators to examine:

- technology leadership
- competitiveness of U.S. industries
- U.S. trade performance, and,
- impact of high-tech trade on employment and wages

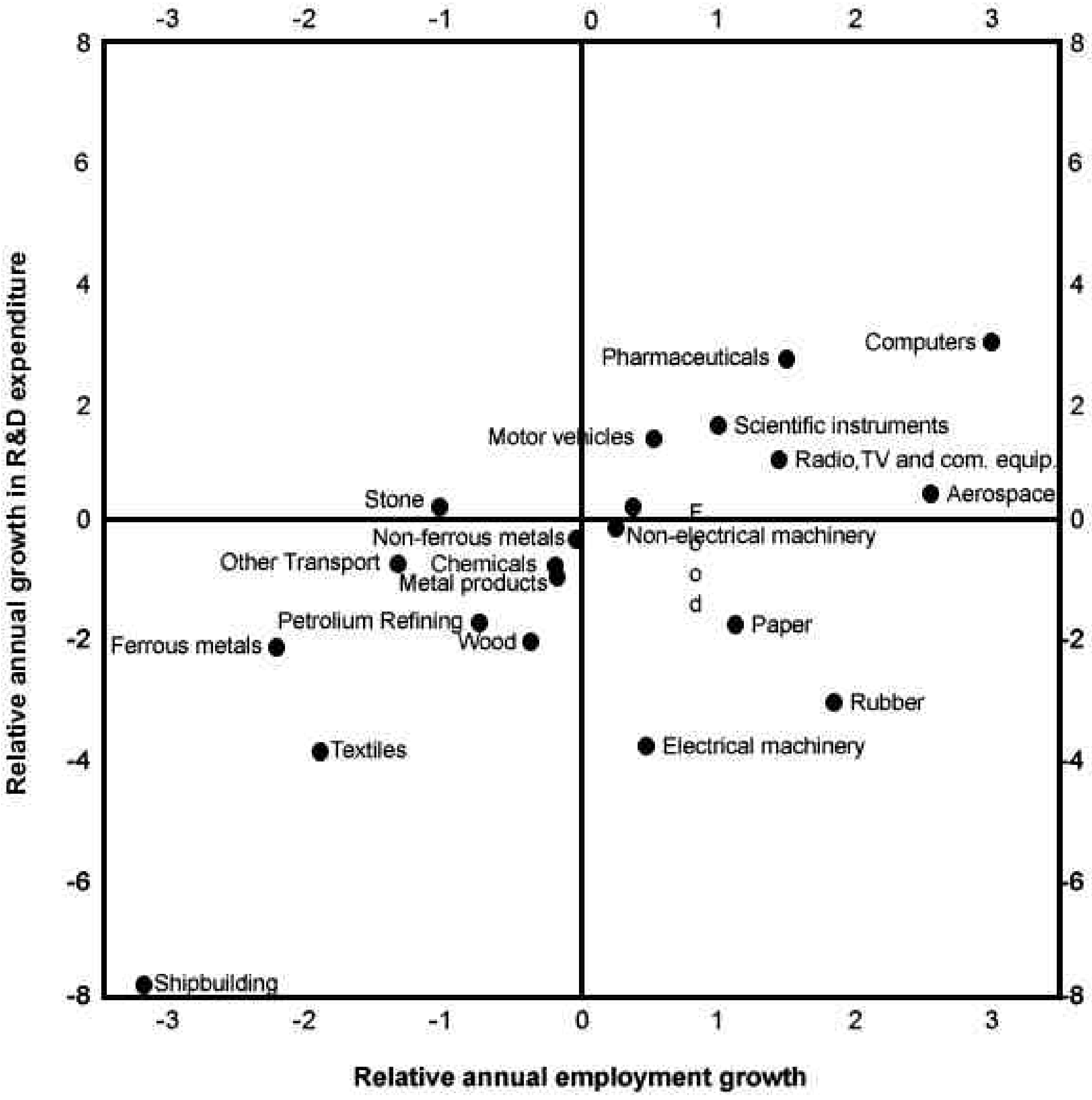
To do this they have used different types of indicators:

- technology-based indicators; identification and competitive analysis of "critical technologies",
- industry (sector) based indicators; the "DOC-3" industrial sector list based, like that of the OECD, on research intensities,
- product-based indicators; the U.S. Census ATP list referred to above, and,
- firm-based indicators; surveys of the use of advanced manufacturing technologies

Each indicator has its advantages and disadvantages. The attached table summarizes Mr. Davis' notes. Data based on the DOC-3 methodology show that high-tech industries' output and employment have risen sharply relative to all other manufacturing industries over the past four decades. Despite this shift, their share of total output of goods and services has edged up only slightly, and their share of manufacturing employment and total employment actually dropped, due to the more rapid growth of productivity in high-tech industries and the rapid growth of the services sector. However, due to their spillover effects, exports of high-tech industries have been found to make a much higher indirect contribution to employment in other industries than the direct effect on their own industries.

Table 4: R&D Expenditures and Employment Growth, 1973-90

Average percentage growth rates by industry relative to total manufacturing groth for 13 OECD countries[1]



[1] Australia, Canada, Denmark, Finland, France, Germany, Italy, Japan, The Netherlands, Norway, Sweden, The United Kingdom and The United States

Group Discussions: Are High- Technology Trade Statistics Appropriate for Industry Performance Indicators?

After the presentations the workshop was split into discussion groups which were asked by the chairman to consider three questions:

- should one high-tech indicator or several be used?
- if so which one or ones?
- what use should be made of the information?

Each of the three discussion groups found common ground in the following areas:

- more than one high-tech indictor is required. The ATP list provides precise data on trade balances, but industry-based data show linkages to other economic performance indicators

- the underlying force driving the interest in high-tech indicators is the question of jobs. The effect of investment in technology must be linked to employment, including both the number and quality of jobs

- high-tech indicators must be dynamic and reflect changing technologies and economic structures

The group presentations and consequent discussion suggested several observations:

- who are the users and what are the end-uses of high-tech indicators?

- multiple indicators are absolutely necessary; trends derived from one indicator alone do not have any possibility of verification

- it appears that regardless of how high-tech trade balances are calculated for Canada there is always a deficit. This is probably a structural feature of the Canadian economy; a feature that mayor may not be "bad". Attempts to erase the deficit, while providing direct employment to workers in high-tech industries, may constrain growth in other sectors that are consumers of high-tech capital goods, particularly service industries

- high-tech indicators must conform to international standards and be capable of international comparison. Information on high-tech trade balances is only meaningful when published in the context of the trade figures of our competitors

Summary and Closing: *Ozzie Silverman, Industry Canada*

Mr. Silverman reviewed the findings of the workshop by posing and answering a series of question. They were:

Q: What is Canada's "high-technology" trade deficit?

A: According to the Doyletech findings, the deficit using the U.S. Dept. of Commerce ATP methodology was $3.85 billion in 1993, compared with $10.57 billion produced by an earlier study. There is no time series that would allow accurate measurement of the growth of the trade deficit.

Q: Is the A TP approach an acceptable methodology?

A: Although it has drawbacks, they are fewer than with other methodologies. Nevertheless, one such indicator should not be used alone for either private or public policy.

Q: What has been the U.S. experience?

A: The ATP figures (overall) published by the U.S. contribute to the public debate on technology policy; however their relevance to private sector corporate planners is unclear

Q: What value could be derived from tracking and reporting ATP figures for Canada?

A: In addition to potential public policy applications (e.g. trade strategy), the utility for industry will probably only be determined when various industry associations and firms have had an opportunity to work with the data and determine implications for corporate strategy.

Q: What are viable strategies to reduce the ATP trade deficit?

A: Controlling imports may hamper the development of those manufacturing sectors that use high-tech components as they add value to their final product or both manufacturing and or service sectors that increase productivity through technology use. While increased exports are desirable, those sectors which have increased exports significantly in the past may be unable to expand faster through further private sector investment. An all-out drive to eliminate the ATP trade deficit would likely result in a misallocation of resources and damage industries which enjoy a comparative advantage.

Mr. Silverman proposed a three-point set of complementary actions, as the possible base for future directions:

- Consider whether to continue the collection of ATP data, perhaps on a pilot basis for the next two years, to determine its strategic value to business and government.
- Any strategies to increase exports would have to start at the firm level and build to the sector level. Canada's competitors are adopting new tools (e.g. "technology road maps") to anticipate technology investment needs and where they will intersect with the market. We need a new private and public sector partnership to anticipate the future. ATP-based numbers would be an input to such deliberations.

- Statistics Canada, in collaboration with Industry Canada, will be developing a new generation of output indicators to track the performance of the economy. These would complement ATP data.

Finally, Mr. Silverman invited CATA to participate with the Canadian delegation, in a conference on new S&T statistics and indicators for a knowledge-based economy, which the OECD will convene in 1996.

Acknowledgments

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The opinions expressed in this report are those of the author and do not necessarily reflect those of the participants, the Canadian Advanced Technology Association or the Government of Canada.

High-Technology Trade Pattern Analysis: Its Use and Application for Industry Competitiveness Response and Government Policy Development

Workshop on High-Technology Trade Statistics
October 19, 1995, the Citadel Inn, Ottawa

AGENDA

8:30	Coffee and Croissants
9:00	Opening of Workshop: Mr. John Reid, President, Canadian Advanced Technology Association (CATA)
9:10	Background to the High- Technology Trade Issue: Mr. Denzil Doyle, President, Doyletech Corporation
9:30	Statistics Canada's View: Dr. Fred Gault, Director, Services, Science and Technology Division, Statistics Canada
10:15	Coffee Break
10:30	The U.S. Experience: Mr. Lester Davis, Office of the Chief Economist, U.S. Department of Commerce
11:15	The OECD Work on S&T Performance Indicators, with a Special Focus on High-Technology Trade: Mr. Andrew Wyckoff, Program Director, Industry, Telecommunications and Commerce Program, Office of Technology Assessment, U.S. Congress
12:00	Lunch
13:15	Group Discussions: *Are High-Technology Trade Statistics Appropriate for Industry Performance Indicators?*
14:30	Coffee Break
14:45	Plenary Session

Chairperson: Mr. John Reid, President, CATA

Facilitator: Dr. Roger Voyer, Senior Partner, Nordicity Group

		Ltd.
	Resource Person:	Dr. Robert McGuckin, Chief, Center for Economic Studies, U.S. Bureau of the Census
	Rapporteur:	Mr. Adam Holbrook, Senior Research Associate, Centre for Policy Research on Science and Technology (CPROST), Simon Fraser University
15:45	Closing Remarks:	Mr. Ozzie Silverman, Director General, Science Strategy, Industry Canada
16:00	Adjournment	

Selected *Bibliography*

Publications using Canadian data

Bloskie, C., "Output and Employment in High-tech Industries", *Canadian Economic . Observer,* September 1992, pp 4.1 - 4.11

Squires, Robert, "Trade in Advanced Technology Products", *Resource Book for S&T Consultations,* Vol II, Industry Canada, 1994, pp 57- 60

Wong, Fred, "High Technology at Work", *Perspectives,* Statistics Canada, Spring 1990, pp17-28

OECD Papers

"The Measurement of high technology, existing methods and possible improvements", OECD Secretariat, DSTI/IP/88.43

Papers presented at the seminar on high technology industry and products indicators, 25-26 November, 1993, including:

- Tracing the flows of embodied R&D in eight OECD countries (DSTI/EAS (93)5/REV I)
- Technology intensity of U.S., Canadian and Japanese manufactures, outputs and exports (DSTI/EAS/IND/STP(93)7)
- List of high tech products in EEC countries (DSTI/EAS/IND/STP/(93)8)
- EC trade in high tech products 1989-92 (DSTI/EAS/IND/STP(93)9)
- Structure and intensity of industrial R&D efforts (DSTI/EAS/IND/STP(93)11)

Papers by United States authors

Abbott, T.A., "Measuring High Technology Trade: Contrasting International Trade Administration and Bureau of Census Methodologies and Results", *Journal of Economic and Social Measurement,* No.17, 1991, pp. 17- 44

Davis, Lester, "An Assessment of U.S. Competitiveness in High Technology Industries", U. S. Department of Commerce, International Trade Administration, 1983

Doms, Mark, & Herrick, Paul, "Trade in Advanced Technology Products", *Bureau of the Census Statistical Brief* SB-2-89, US Department of Commerce, 1989

McGuckin, R.H., Abbott, T.A., Herrick, Paul, & Norfolk, Leroy, "Measuring Advanced Technology Products Trade: A New Approach", *Journal of Official Statistics,* Statistics Sweden, Vol. 8. No.2, 1992, pp.223 - 233