2010: Canadian Defence Industry at a Crossroads?

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The Claxton Papers

The Queen's University Defence Management Studies Program, established with the support of the Canadian Department of National Defence (DND), is intended to engage the interest and support of scholars, members of the Canadian Forces, public servants, and participants in the defence industry in the examination and teaching of the management of national defence policy and the Canadian Forces. The program has been carefully designed to focus on the development of theories, concepts, and skills required to manage and make decisions within the Canadian defence establishment.

The Chair of the Defence Management Studies Program is located within the School of Policy Studies and is built on Queen's University's strengths in the fields of public policy and administration, strategic studies, management, and law. Among other aspects, the program offers an integrated package of teaching, research, and conferences, all of which are designed to build expertise in the field and to contribute to wider debates within the defence community. An important part of this initiative is to build strong links to DND, the Canadian Forces, industry, other universities, and non-governmental organizations, in Canada and in other countries.

This series of studies, reports, and opinions on defence management in Canada is named for Brooke Claxton, Minister of National Defence from 1946 to 1954. Brooke Claxton was the first post–Second World War defence minister and was largely responsible for founding the structure, procedures, and strategies that built Canada's modern armed forces. As defence minister, Claxton unified the separate service ministries into the Department of National Defence; revamped the *National Defence Act*; established the office of Chairman, Chiefs of Staff Committee—the first step toward a single Chief of Defence Staff; established also the Defence Research Board; and led defence policy through the great defence rebuilding program of the 1950s, the Korean War, the formation of NATO, and

the deployment of forces overseas in peacetime. Claxton was unique in Canadian defence politics: he was active, inventive, competent, and wise.

The editor and the authors wish to thank Ellen Barton for her thorough and professional job as copyeditor, as well as Mark Howes and Valerie Jarus for their continued, accomplished efforts to change the work of "mere scholars" into an attractive, readable publication. We all thank Heather Salsbury for her unflagging good spirits and willing support to the Chair of Defence Management Studies.

The Chair in Defence Management Studies at the School of Policy Studies is supported in part by a grant to Queen's University from the Department of National Defence within the Security and Defence Forum (SDF) program. The Chair acknowledges support of the SDF for this workshop and the continuing collegial partnership of The Royal Military College in this and other research endeavours.

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Introduction

Over the last five years there have been a number of occasions where the government has announced its intention to purchase new equipment for Canada's military. Many of these purchases generated significant debate and discussion by mainstream media, industry lobby groups, and the opposition parties in Parliament. Much of the discussion was and continues to be focused on cost, affordability, actual need for the equipment in question, and the need for competition. Underpinning all these topic areas has been a broader discussion about the state of Canada's defence industry and whether or not there is a need for a defence industrial policy. This edited collection of essays addresses these significant national issues.

On 19 March 2010, Defence Management Studies at the School of Policy Studies at Queen's University and the Institute for Defence Resources Management at The Royal Military College of Canada held the workshop "Canadian Defence Industrial Base." The workshop focused on the state of Canada's defence industry, the economic impact of defence industry activity, and the relationship between industry and military procurement. This Claxton Paper records the highlights of that workshop with papers selected to provide representation from each area of the discussion.

The first chapter by Steven Tzeferakos discusses the general state of the Canadian defence industry with specific emphasis on the Canadian commercial aerospace, defence, industrial marine, and industrial security sectors. Tzeferakos provides a summary of a larger survey conducted by Statistics Canada and identifies some of the key challenges associated with trying to survey these important sectors of the economy. Tzeferakos concludes that the 2007 survey provides useful and more recent defence sector estimates but ultimately represents insights into activities only at one particular point in time. In essence the data can best be seen as a complement to other sources of related information, and an appropriate degree of caution is required in the use of data. Nevertheless, the data when combined with other sources

provide a fairly useful profile of the Canadian defence sector over time, as well as potential policy-related insights.

In the next chapter, Binyam Solomon reviews from an economics perspective the Canadian Association of Defence and Security Industries' (CADSI) recent report *Canada's Defence Industry: A Vital Partner Supporting Canada's Economic and National Interests*. CADSI, a defence industry advocacy group, completed the report in response to a Government of Canada request for industry input on how to maximize the economic returns from the planned re-equipment of the Canadian Forces (CF) over the next 20 years at an estimated cost of $240 billion. Solomon notes that the biggest potential for Canadian industry and future innovation rests in the government's Canada First Defence Strategy (CFDS) and the planned acquisition identified in the document.

Solomon argues that there is a need to align various government and department-specific policies on innovation and acquisitions (for example, defence S&T strategy and Materiel's acquisition strategy) and make explicit reference to how these are going to be aligned. To the extent that there is a policy vacuum and uncertainty regarding the acquisition and sustenance of the capital portion of the CFDS, some clear communication from the government is indeed desirable. In this context, CADSI's call for a government policy is justified. If the dual requirements of economic development and efficient/cost-effective delivery of defence resources are not deemed mutually exclusive, then the defence policy or plan better articulate how this will be achieved.

In his conclusion Solomon indicates that a defence industrial policy may be useful if it provides

- comprehensive data on the industrial sector under consideration and particularly the challenges and opportunities facing the sector,
- an outline of the Canadian government strategy toward the sector (CADSI's implicit requirement),
- the key industrial capabilities that Canada wishes to retain and, most importantly,
- the socioeconomic rationale for the policies and the premium or explicit cost we are prepared to pay for the policy and sustainment of the sector.

In the third chapter, Craig Stone uses the history of past defence expenditures to examine the impact of defence expenditures on the Canadian economy, in the context of an increasing Canadian defence budget from

$11.5 billion in 2000–01 to an expected expenditure level of $20.6 billion in 2010–11. Stone notes that this is a significant increase in expenditure level and that it is therefore prudent to examine whether or not this has an impact on the economy at both the macro and regional levels and what, if any, impact it has on the defence industrial base. The chapter begins with a general analysis in order to develop a beginning framework for further study and to provide an assessment of what, if anything, has happened in the intervening years since March 1996 when the last annual assessment was completed. Stone notes that the intention of the chapter is to provide a brief review of the past methodology in order to set the stage for a discussion of the results of additional simulations using the Statistics Canada Input-Output Model. The chapter presents some early results of the recent simulations and discusses a way forward for future research.

Chapter 4 looks at whether or not there is an optimal mix between the two procurement aims of direct or indirect benefits. Greg van Bavel notes that this issue may initially appear to be a classical optimization problem, but this is not the case in the Canadian context. Since the Canadian Forces (CF) engage in combat, attaining military advantage is strategically attractive. One might imagine that an adversary of Canada would rather that procurements for the CF aim exclusively at indirect benefits and just forget about military advantage altogether. Therefore, the question of an optimal mix of procurement strategies must await the answer to the higher-level question: How is adversarial activity affected by the defence procurement aims of the Government of Canada? In his chapter, van Bavel models the strategic interactions between the Government of Canada (GoC) and an Adversary of Canada (AoC) using Game Theory. Game Theory provides the analytical methods and means, is well known, and is a great exploration tool because one can vary some aspects, but not others (*ceteris paribus*), then calculate the impact on the results.

In his conclusion, van Bavel finds that in the strategic interaction between the Government of Canada and the Adversary of Canada, the strategic problem for the AoC was whether to expand, maintain, or reduce its operations against Canada. In the model, the Canadian Defence Industrial Base (CDIB) was a passive agent whose welfare depended upon the GoC procurement strategy, and a utility indicator helped assess the effect on the CDIB. The model also included the risk tolerance of the two players: the GoC was relatively risk averse and the AoC was relatively risk tolerant. The analysis found several equilibria. The most stable outcome had GoC aiming at balanced procurement and AoC maintaining the status quo. In that case, the CDIB fared moderately well.

The second most stable outcome had GoC and AoC probabilistically mixing two strategies: GoC aimed at military advantage with 89 percent probability and indirect benefits with 11 percent probability; AoC expanded operations with 60 percent probability and reduced operations with 40 percent probability. If a mixture differed from the equilibrium point, it periodically fluctuated about the equilibrium point. Thus, the CDIB achieved its best outcome, but only sporadically. The least stable outcome had both players mixing all of their actions, but any state that differed from the equilibrium point would evolve to one of the more stable equilibria.

The final chapter by Kamal Jayarathna examines the relationship between the Canadian and American defence industry from an inflation perspective in order to enhance the understanding of the causes of inflationary pressures on defence goods produced in Canada and also to examine the extent of price integration between the two countries. Using Low in One Price and Cointegration tools, Jayarathna specifically looks at the aircraft and shipbuilding sectors. He concludes that since Canadian and US companies are integrated through the supply chain and export/import of inputs in various stages of the production process, this may explain the high degree of foreign exchange rate pass-through to the domestic prices. Moreover, since the size of the Canadian market is relatively small, US suppliers are not likely to adjust US$ base prices to maintain the same price in CDN$ (Canadian buyers are "price takers"), which would imply that changes in the foreign exchange rate are likely to influence domestic prices. Specifically, Jayarathna notes that the foreign exchange rate appears to be a significant source of inflation, at the producer level, for the aircraft and shipbuilding sectors. This finding suggests that the industry would have to realize productivity improvements and gain competitive advantage through new product innovation in order to be competitive and maintain profitability, thus emphasizing the importance of investments in research and development. Consequently, despite the implementation of various free trade policies and military trade agreements between the two countries over the last several decades, empirical analysis fails to demonstrate any long-term price integration.

Finally, in addition to the papers presented in this edition of the *Claxton Papers*, an Executive Summary and two PowerPoint presentations from the workshop are included in the appendices. First, the presentation by Tim Page, President of the Canadian Association of Defence and Security Industries, provides the results of the Association's engagement of industry conducted on behalf of the Ministers of Defence, Public Works, and Industry. Included with this presentation is the Executive Summary from the

military procurement report *Canada's Defence Industry: A Vital Partner Supporting Canada's Economic and National Interests*. In the report CADSI calls on the government to urgently adopt a series of recommendations to enable effective spending on defence at a time when every dollar counts. In the second presentation, Norm Weir, Canadian Commercial Corporation, provides information on how and why Canadian industry is an essential element of the larger North American Technology and Industrial Base (NATIB). Both these presentations supplement significantly the material presented in the chapters.

The five chapters presented in this issue of the *Claxton Papers* represent a cross-section of research being conducted by both academics and practitioners interested in the future of Canada's defence industrial base. These papers reflect both the state of the defence industrial base and the need for government to articulate some clear policy choices. While the state of the defence industry can be assessed based on empirical evidence and survey data, the requirement for the government to articulate a policy is much more problematic. The present Conservative government would consider its 2006 Advantage Canada to be a clear articulation of its industrial policy, and defence industries fall within that framework. As well, more recent speeches and statements by the Minister of National Defence about the shipbuilding industry reflect policy choices by the government of the day.

Anyone expecting the government to follow the trend of some of the more traditional allies and release a specific defence industrial policy will be disappointed. Such a policy document would require the government to make choices, some very politically difficult, and that would reduce future flexibility. Even discounting the difficulties associated with the existing minority government, no Canadian government is going to introduce a policy that appears to give one region of the country priority over another. Yet choices will be necessary in any defence industrial policy intended to allow industry to plan for future investments and future research and development activities. In the absence of such a policy, documents like CFDS and Advantage Canada and speeches by key ministers will have to suffice as the only guide to industry leaders as they struggle to plan future activities.

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CHAPTER 1

The Canadian Defence Sector: Highlights from the Canadian Commercial Aerospace, Defence, Industrial Marine and Industrial Security Sector Survey, 2007

Steven Tzeferakos

Introduction

While Canada's defence industrial capabilities are broadly understood, basic economic estimates profiling the defence sector have been partial and were becoming increasingly dated. Due to perceived data deficiencies for sectors important to Industry Canada's (IC) Aerospace, Defence and Marine Branch (ADMB), it was decided in 2007 to pursue a survey as one means of addressing such deficiencies.

ADMB therefore approached Statistics Canada to conduct a survey of four sectors: commercial aerospace, industrial marine, industrial security, and defence. In order for Statistics Canada to be able to proceed, ADMB first worked with stakeholders to establish a list of businesses from which to collect information. Based on multiple sources, an initial list of businesses known as active or *possibly* active in the targeted sectors was established.

Work then began to try to narrow down this list to only relevant businesses with actual sales of sectors' products and services produced in Canada (for example, sales of defence products and services, rather than sales of non-defence items to defence clients). For the commercial aerospace,

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industrial marine, and defence sectors, this task was facilitated by significant pre-existing information and experience in dealing with these sectors and their main stakeholders. In the case of industrial security, definitional issues and ADMB's more limited information and experience with this sector made it more challenging to identify the relevant businesses. In the end, the group of businesses to be surveyed for fiscal year (FY) 2007 was narrowed down to a list of just over 1,500 businesses.

These businesses were believed to account for the majority of key sector attributes like sales and employment, and to be generally representative of the sectors' overall composition. Businesses were excluded if their relevance was uncertain and it was believed that the economic impact of excluding them would likely be quite small. There was a fairly high level of certainty that the relevant businesses were included for the commercial aerospace, industrial marine, and defence sectors. In the case of industrial security, there was a lesser degree of certainty that all relevant businesses were identified in time for the survey.

Furthermore, among the list of businesses to be surveyed, a priority subgroup was developed that focused on major businesses. About 10 percent of the businesses were identified as priority target businesses due to their importance in areas such as sales and employment, and their strategic position in one or more of the sectors. During the course of the survey, businesses in this priority subgroup received special attention from Statistics Canada to maximize the probability of receiving completed survey forms and a strong response rate from these leading businesses.

The survey was distributed to over 1,500 businesses in October 2008 with the intention of obtaining data for the most recent fiscal year, from 1 April 2007 to 31 March 2008. An overall response rate of 58.5 percent was achieved, and the response rate was even higher for the subgroup of priority businesses.[1] This response rate was considered very good in relation to other surveys, and served as the basis for Statistics Canada's survey estimation of sectors' characteristics.

It should be stressed that, given the possibility that some relevant firms may have been missed, results are not strictly industry-level *census* estimates, but should rather be understood as survey-based estimates. Despite its limitations, a significant amount of useful information resulted from this exercise. This information is in the form of the continuously evolving list

[1] Response rates are based on business counts, adjusted for the fact that certain businesses proved to be out of business, out of scope, or duplicates, etc.

of business operations identified as possibly active in the four sectors, and the aggregate sector-level survey estimates.[2] The remainder of this chapter will address these results.

Defence Sector Findings

For the purposes of the survey, ten main defence product and service groups were specified, as well as an 11th "other defence" category. Together, these spanned the AIR—LAND—SEA domains:

- Aircraft fabrication, structures and components;
- Missiles, rockets and drones;
- Troop support;
- Combat vehicles and components;
- Ammunition and other munitions;
- Firearms and other weapons;
- Information technology (including software) products and systems;
- Simulation systems and components;
- Shipbuilding, repair and maintenance;
- Electronics and communications; and
- Other defence.

Among the surveyed firms, 471 reported FY 2007 sales of defence products and services produced in Canada. Most of the businesses were incorporated and privately owned, with about 18 percent having a parent company in another country. Based on the survey results, total FY 2007 defence sales were estimated at almost $7.6 billion, with exports accounting for 54 percent of sales as shown in Figure 1.1.[3] Related data suggest that

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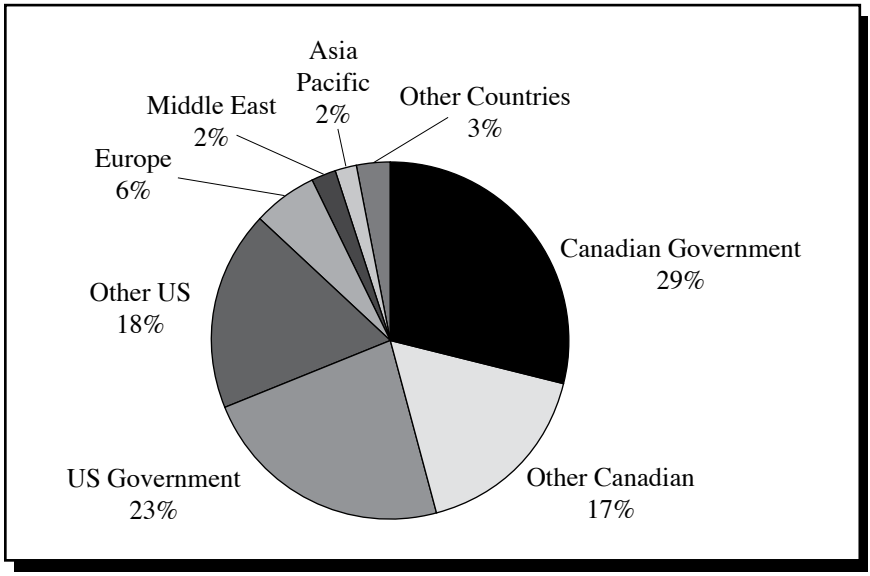
[2] Given the ongoing gradual entry and exit of businesses into the market space over time and the challenges of identifying all relevant businesses in any given year, ADMB continues its internal efforts to refine and update lists of businesses.

[3] Unfortunately, the survey did not break down exports by specific product or service groups. Non-survey data from other sources based on Harmonized System (HS) trade codes for US *goods* imports suggest that items related to aerospace and armoured vehicles account for a significant share of Canadian exports to the US of defence *goods* as identified under HS codes. It should stressed that these codes offer partial coverage as some defence goods could not be identified by HS codes, and services are not covered.

many businesses active in the defence sector also had non-defence products and services sales, but that for many businesses sales were concentrated in one or a few defence product-and-service lines.

FIGURE 1.1
Global Distribution of Defence Product or Service Sales: $7.6B (54% Export Intensity*)

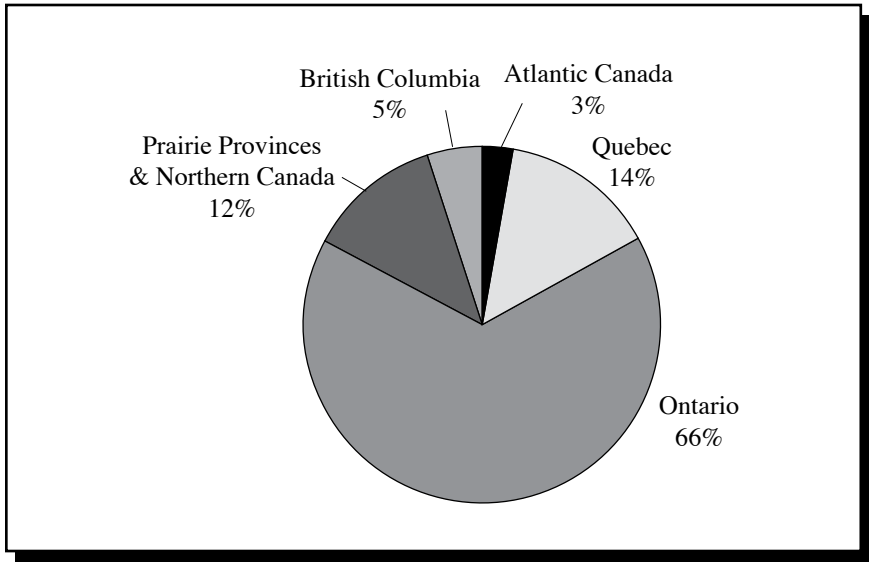


Note: *Export intensity as a ratio of exports to total sales.
Source: Statistics Canada, Canadian Commercial Aerospace, Defence, Industrial Marine and Industrial Security Sector Survey, 2007.

A subquestion on the share of the four surveyed sectors' sales of (defence and non-defence) products and services to the "defence market" was also asked, but results were not deemed reliable. In terms of lead export destinations, exports to the United States accounted for about 76 percent of Canadian defence sector exports (41 percent of total Canadian defence sector sales), followed by exports to Europe. The share of defence sector exports destined for the US is similar to the share of total Canadian goods exports that go to the US.

While activities spanned all regions of Canada, FY 2007 defence-related sales and employment were largely concentrated among businesses in central Canada, particularly the province of Ontario. As shown in Figure 1.2,

FIGURE 1.2
Defence Products or Services Sales Distribution by Region



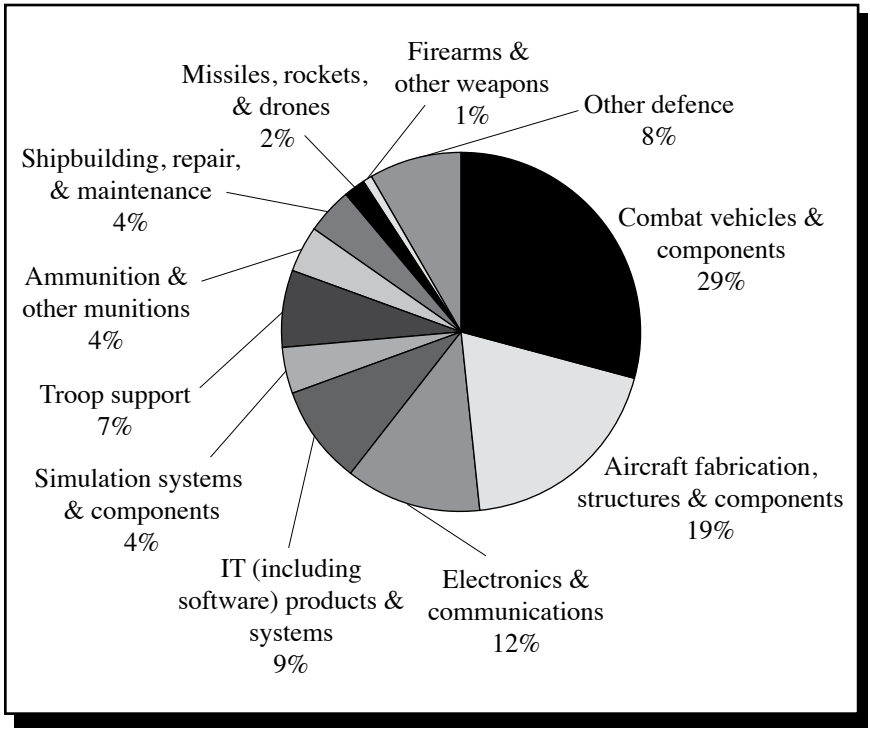
Source: Statistics Canada, Canadian Commercial Aerospace, Defence, Industrial Marine and Industrial Security Sector Survey, 2007.

the combined Ontario and Quebec sales accounted for about 80 percent of the sector's 2007 fiscal year sales.

When examining the composition of these product and service sales, Figure 1.3 shows that aircraft and combat vehicles and components accounted for almost half of FY 2007 sales. The relative importance of these groups as suggested by the survey seems consistent with trade data from other sources, which also suggested related products account for significant shares of Canadian defence *goods* exports to key markets like the United States. Collectively, electronics and communications, simulation systems and components, and IT products and systems (including software) accounted for about a quarter of sales—reflecting the importance of electronics and information-based systems in modern warfare.

Based on survey responses, defence sector employment was estimated at almost 32,000 persons in FY 2007. As with sales, this was concentrated in Ontario and Quebec, with production workers being the largest employee group as defined by the survey. Figure 1.4 shows the percentages and types of employee groups in defence products and services.

FIGURE 1.3
Defence Product or Services Group Sales

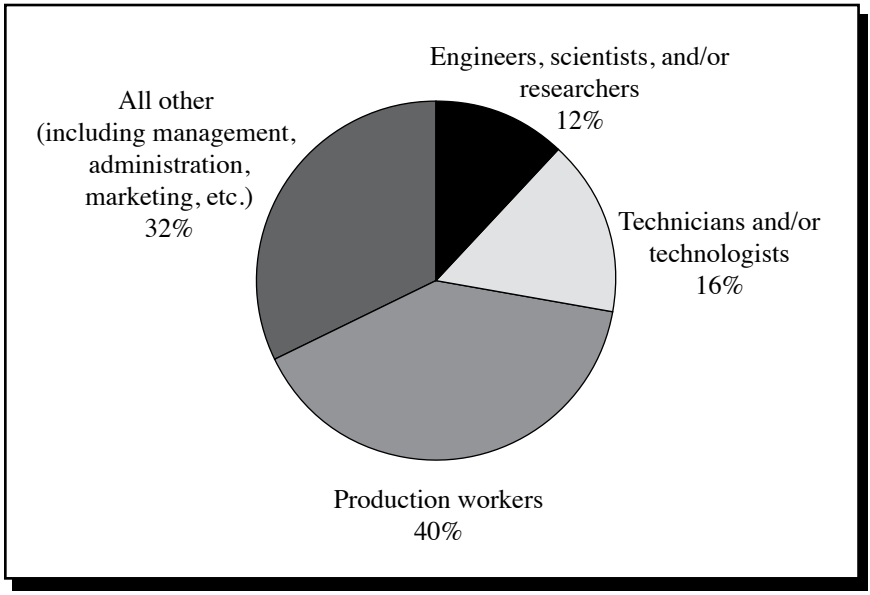


Note: The percentages total 99 percent due to rounding.
Source: Statistics Canada, Canadian Commercial Aerospace, Defence, Industrial Marine and Industrial Security Sector Survey, 2007.

In terms of expenses and investment activity, the ratio of firms' defence-associated operating expenses relative to defence sales stood at about 90 percent (dominated by employee compensation, and materials and supplies spending). In terms of investment, the overall investment-to-sales ratio was estimated at about 9 percent in FY 2007, with research and development (R&D) investment estimated at $152.6 million—suggesting a 2 percent R&D intensity (relative sales). However, this figure is not fully reflective of total defence-related R&D investment in Canada, which involves both the private and public sectors, with important linkages between the two. Furthermore, R&D intensities are likely to vary across different submarket segments, and over time with shifts in the relative emphasis on new product/services or process innovation.

In addition to export estimates and the high export intensity they imply, the survey provided other insights into the relative importance of

FIGURE 1.4
Defence Product or Services Employee Groups



Source: Statistics Canada, Canadian Commercial Aerospace, Defence, Industrial Marine and Industrial Security Sector Survey, 2007.

international linkages to the Canadian defence sector. Survey data indicated that businesses with parent companies outside Canada play a major role in the Canadian defence sector. These businesses accounted for a disproportionately large share of sales, exports, investment, and related employment; had higher average defence sales; were more export oriented; and had higher sales per employee in FY 2007.

In addition to Canadian exports and military purchases of US and other foreign defence products and services, global value chains play an important role in the supply chains of domestic defence production. US companies and distributors appear to be second only to Canadian ones for purchases of materials and supplies (M&S) from defence sector firms in Canada. Purchases of materials and supplies from external companies and distributors accounted for about 49 percent of the defence sector's purchases of M&S in FY 2007. Given that M&S purchased from domestic companies or distributors might also have external origins or contain external intermediate inputs, survey estimates likely do not fully represent the actual importance of M&S inputs from external sources.

Concluding Thoughts

While providing useful and more recent defence sector estimates, the Statistics Canada survey ultimately represents insights into activities only at one particular point in time, FY 2007, and does not address all variables of potential interest to researchers and policy-makers. As such, these data can best be seen as a complement to other sources of related information.

While an appropriate degree of caution is required in the use of data from different sources, used properly, data from the 2007 survey together with other sources provide a fairly useful profile of the Canadian defence sector over time, as well as potential policy-related insights. Although it is beyond the scope of this chapter to fully discuss all available sources and their collective insights into Canada's defence sector, a few types of information and sources are listed below for interested readers.

Harmonized system (HS) codes. HS codes classify internationally traded commodities (goods, excludes services trade) to a rather precise level of disaggregation and provide insights into Canadian trade with key markets like the United States, for example. US import data based on HS codes are fairly detailed, identifying exports to the US of many military goods, and goods like parts for military equipment, over a period of several years. However, it should be noted that beyond excluding services trade, there are some military goods, or items for use by/with military goods, that are not easily tracked through HS codes and are likely lumped in with other non-defence-related product HS code groups.

Organisation for Economic Co-operation and Development (OECD). Regarding defence-related research and development, the OECD provides time series data on defence-related Government Budget Appropriations and Outlays for R&D (GBAORD) for a range of countries. This information, together with data on nations' GDP and overall defence spending, provides some internationally comparable insights into levels of defence GBAORD spending and relative intensities that can be used for analysis.

Stockholm International Peace Research Institute (SIPRI). SIPRI also provides useful international data on such things as national expenditures on defence, international arms transfers, and major defence firms.

North Atlantic Treaty Organisation (NATO). NATO publishes data regarding the military expenditures of member states over time, including information related to their military equipment spending.

Official publications. Various official publications exist in Canada and in key markets like the United States that provide valuable data on past, current, and planned activities; for instance, US Department of Defense (DoD)

budgetary documents, reports on foreign sources of supply and contracting activity, and US Administration budget documents.

Domestically, the Department of Foreign Affairs and International Trade (DFAIT) periodically publishes reports on exports of military goods from Canada (exports beyond the US). In addition, various documents of the Department of National Defence (DND) such as the annual Report on Plans and Priorities, and documents like the Federal Budget, the Government Expense Plan, the Main Estimates, and the Canada First Defence Strategy also provide details on past and planned defence-related spending.

In addition to the aforementioned sources, a variety of other sources such as think tanks, academic researchers, and private sector organizations offer defence-related expertise and insights.[4]

[4] For further information regarding the Statistics Canada survey and access results, interested parties should visit Statistics Canada's official release on the survey at http://www.statcan.gc.ca/daily-quotidien/091109/dq091109b-eng.htm.

CHAPTER 2

An Economics Perspective on a Defence Industrial Policy

Binyam Solomon

Introduction

This chapter reviews the report *Canada's Defence Industry: A Vital Partner Supporting Canada's Economic and National Interests* largely from an economics perspective. The report was prepared by the Canadian Association of Defence and Security Industries (CADSI 2009), a defence industry advocacy group, in response to the Government of Canada's request for industry input on how to maximize the economic returns from the planned re-equipment of the Canadian Forces over the next 20 years at an estimated cost of about $240 billion.

The CADSI report puts forward three interrelated recommendations focused on the development of a defence industrial policy and the streamlining of the procurement process, practices, and governance. Other scholars have also indicated the need for an industrial strategy that sets forth a coherent message and plan from the government (Stone 2008). The review contained in this chapter compares and contrasts an economics approach to the problem posed by the Canadian government of maximizing both military capability and economic return to the industry solution outlined in the CADSI report.

The Stylized Facts about Defence Spending in Canada

The Government of Canada, like any household or business, faces resource allocation challenges. Specifically, it is faced with the challenge of funding its policies and programs within available fiscal room. These federal government policies are often communicated, in broad terms, through the Speech from the Throne and operationalized via the federal budget. In addition, policy statements and White Papers provide more precise expectations

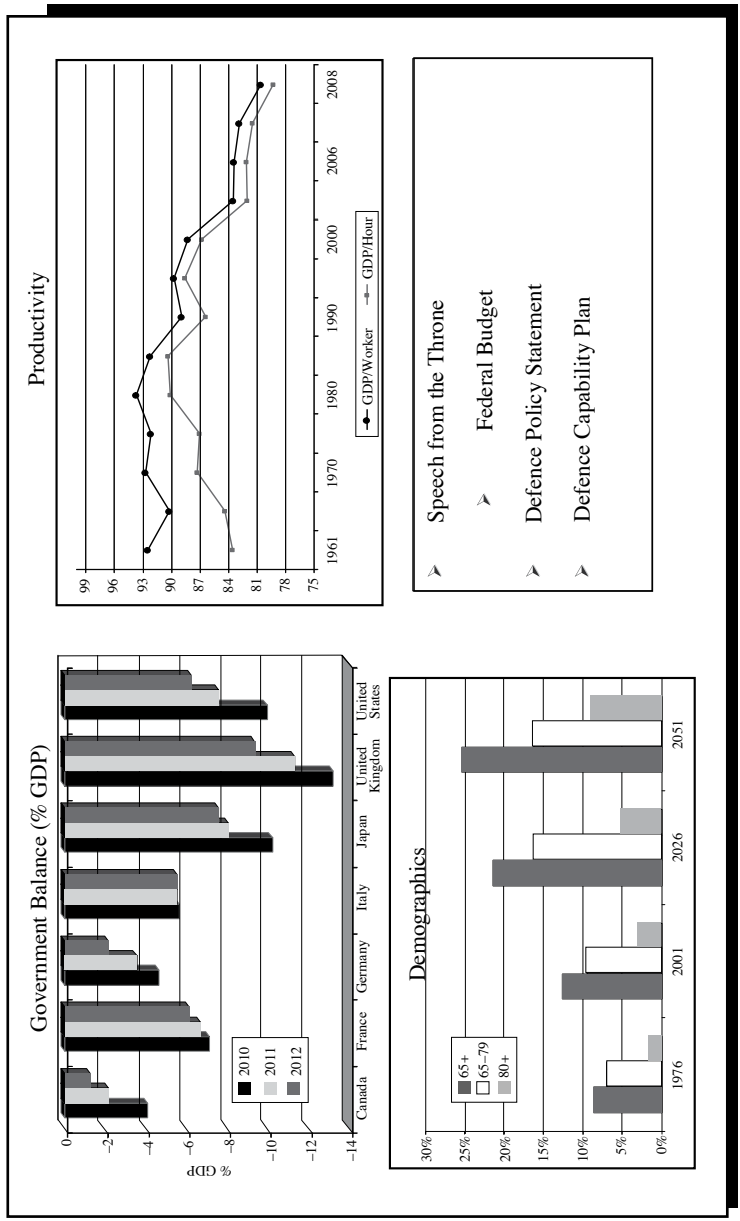
and directions of the central government to specific departments or policy areas. The Canada First Defence Strategy (CFDS) is one such direction that specifically pertains to defence.

The most recent federal budget stressed the global financial crisis, its impact on Canada's fiscal health, and the consequential impact on government programs. While defence is expected to receive cuts of about $1 billion in the next year or so, the long-term funding articulated in the CFDS remains largely in place. As shown in Figure 2.1, Canada' fiscal health is in better shape than that of its counterparts in the Group of Seven highly industrialized nations. This favourable picture is partly due to prudent financial management and positive economic conditions fostered by its open economy and strong global demand for Canadian natural resources. Despite these positive aspects of the Canadian economy, two important factors cloud the long-term prospects of the nation.

The first is demographic, as the aging population will account for about 50 percent of the population by 2050 and the traditional working-age population (18–64) will peak that year. This will put upward pressure on spending and downward pressure on revenues (see demographic chart in Figure 2.1). Second, Canadian productivity continues to decline. This in turn reduces the standard of living and tax revenue. For example, gross domestic product (GDP) per worker and GDP per hour worked have declined against the United States since the mid-1970s. In 1980, GDP per worker peaked at about 94 percent of the US rate and since then declined until it reached its lowest level in 2008 at 81 percent. Similarly GDP per hours worked peaked at 90 percent of the US rate in 1985 before declining to its 2008 level of 79 percent (Figure 2.1).

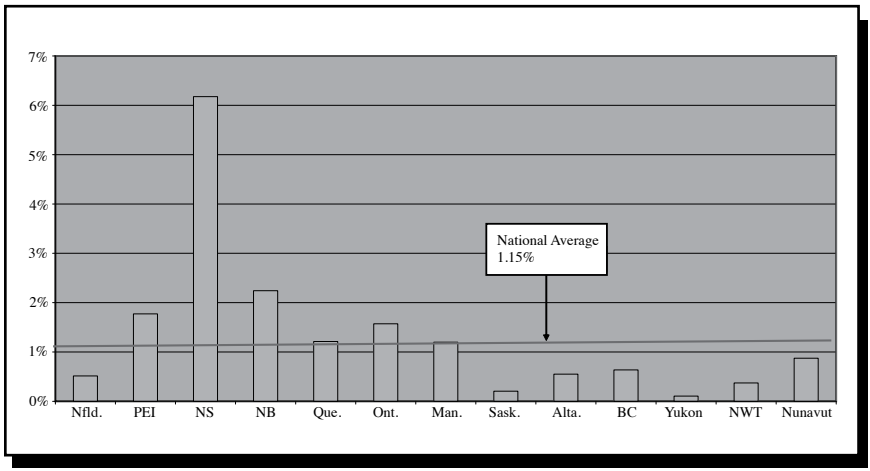
With these long-term challenges and the current federal government deficit forecasted to reach roughly $50 billion by the end of fiscal year 2009–10, the commitment to broadly maintain the CFDS long-term funding is good news for the Canadian Forces (CF) and the Department of National Defence (DND). The roughly $20 billion spent on military expenditures in Canada represents about 1.3 percent of GDP. In some regions and provinces of Canada, however, defence is a major player (see Figure 2.2). Particularly, in the provinces of Nova Scotia and New Brunswick defence spending accounts for more than 6 percent and 2 percent of their respective GDP. The East Coast navy and army presence in Nova Scotia and large army bases in New Brunswick have a relatively significant economic presence in these Atlantic provinces that still rely heavily on primary industries (fishing, mining, etc.). Not surprisingly, in the highly diversified and populous provinces of Ontario and Quebec, DND's presence is relatively insignificant. This pattern also holds for defence industrial production and exports.

FIGURE 2.1: Federal Government Challenges



Sources: Statistics Canada (various years), *Canadian Economic Observer: Historical Statistical Supplement*, Cat. No. 11-210-XPB, 15; International Monetary Fund (various years), World Economic Outlook Database, http://www.imf.org/external/pubs/ft/weo/2010/02/weodata/index.aspx; Centre for the Study of Living Standards (various years), Income and Productivity Data, http://www.csls.ca/data/ptabln.asp.

FIGURE 2.2
Total National Defence Impact as a Percentage of GDP, 2009



Source: Department of National Defence (various years), *DND Estimated Expenditures by Electoral District and Province,* http://admfincs.mil.ca/Publications_e.asp.

For the Canadian defence industrial sector as discussed in studies by Rosenbluth (1967), Treddenick (1987), Poole and Wall (1992), Caron (1994), and Solomon (1999), the significance of domestic defence spending is also waning. With the exception of the shipbuilding industry and to some extent the aerospace sector, the industrial impact was not as significant either. Similarly, the roughly 100,000 defence employees across Canada do not represent a solid majority in the relevant provinces and constitute about 0.5 percent of total employment in Canada (Solomon 1999). The relative insignificance of the economic impacts of defence and the lack of visibility of the military in major urban centres may be factors that explain the perceived lack of interest by both politicians and the public.

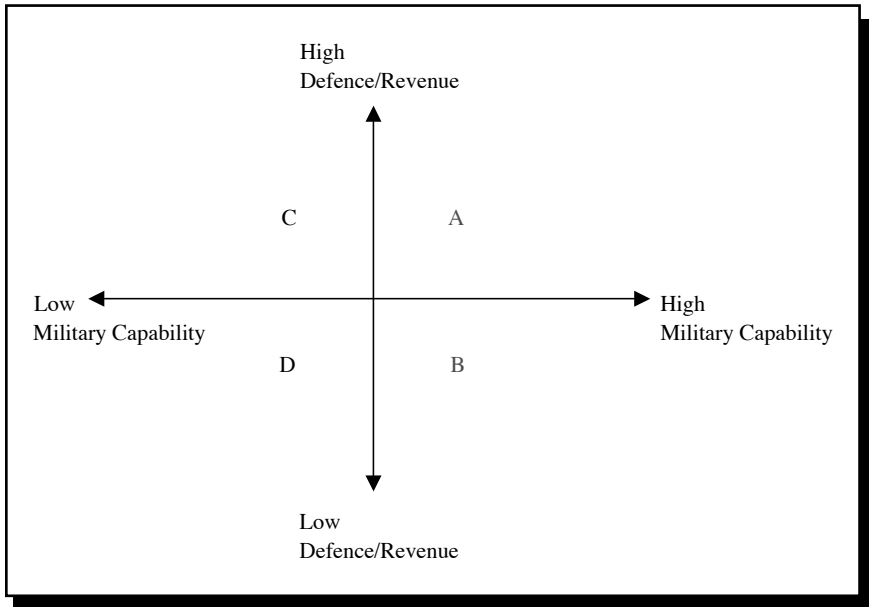
Recommendations and Economics

The Defence Industrial Base

Implicit in the CADSI report and the associated recommendations is the existence of a Canadian Defence Industrial Base (CDIB) that is dependent on defence sales, and that the government is equally reliant on it for the provision of national defence goods and services. The need for a defence industrial policy also implies that the industrial base operates

in a relatively non-competitive market as a result of government policies, technology, or economies of scale. Figure 2.3 posits a distribution of the Canadian industrial sector in four quadrants. Quadrant A includes firms that are highly dependent on defence sales and also produce goods and services that have very few buyers, most likely defence departments. In addition, the government is likely to be reliant on these groups of firms. Firms in this group, for example, would include shipyards with submarine specialty. If it is nuclear submarines, then the firm has additional constraints in the form of national security.

FIGURE 2.3
Defence Industrial Base Map



Firms in quadrant B are also of interest to national governments since they produce military capabilities with sufficient specialization and asset specificity. However, these firms do not rely on defence sales and have a larger and viable civilian market. Examples of firms in this category include firms producing dual-use technologies such as Bombardier, and Pratt & Whitney Canada. These are successful aerospace firms that have both defence and civilian clientele.

Firms in quadrants C and D produce generic goods and services of relatively low importance to the military. A quadrant C firm, for example, that is the exclusive supplier of paper towels to the military base in Moose Jaw might consider defence an important customer, but the firm is not dependent on sales to the military. Nor is defence reliant on that company. Since the CADSI report is based on the motivation of the Government of Canada to extract as much domestic economic activity as possible from the planned purchases of major military equipment articulated in the Canada First Defence Strategy, the relevant portion of the CADSI membership for further scrutiny are those firms that populate quadrants A and B. While this schematic more narrowly defines the Canadian Defence Industrial Base from an industrial mobilization perspective, the firms in quadrants A and B are a reasonable proxy of the CDIB for purposes of defence industrial policy design.

Note that the $240 billion commitment for equipment discussed in the CADSI report comprises about $60 billion in previously announced equipment such as the C-17 and C-130J Hercules, new major fleet replacements such as destroyers and frigates, and weapons and communications equipment; $40 billion in infrastructure; and about $140 billion in spares, maintenance, and training. Since the CADSI membership includes all types of firms that have business with CADSI, the $240 billion needs to be seen from this wider perspective. However, an industrial strategy, assuming one is needed, should focus on specific sectors.

Fundamentally, the dual characteristics of dependence on and importance to the military are not the sole justification for a defence industrial policy or government intervention. Ironically, the need for government intervention is mainly due to the fact that the defence industrial sector is characterized by government-induced market failure (Solomon 2009). Specifically, governments tend to influence the size and structure of the firms by manipulating defence budgets or by controlling mergers, competition, and subsidies.

Published studies on the size and composition of the CDIB (Caron 1994; Solomon 1999; Treddenick 1987) show that most of the firms, fortunately, belong in the B quadrant, indicating less revenue dependence on DND. The defence revenue for most of these firms comes in the form of exports to the United States. This export orientation of the CDIB conveys important facts about the sector's capital intensity, productivity, and overall competitiveness.

In addition, the Canadian government has not actively re-engineered the sector given the modest defence spending and security posture. Exceptions exist: the high industrial mobilizations during the Second World War

and, to a lesser extent, the Korean War. Government-owned defence firms, in particular for the provision of munitions, have been successfully privatized, and the current Munitions Supply Program (MSP) has unfortunately morphed into a one buyer–one seller (monopsony-monopoly) relationship.

Given a single buyer (the government), firms react to this government-induced market failure by transferring risks associated with production to the government and by innovating on red-tape and extraction of rent from the bureaucracy rather than on market efficiencies. In addition, the complex nature of military technology leads to intricate contractual engagement with the government that increases transaction costs. Finally, the uncertainties surrounding government contracts (potential for cancellation) leads to risk-averse and less efficient production by the firm—utilizing less capital, more labour, and higher contingencies.

Policy Implications

Business and economic transactions are about incentives. Given the uncertainties and complexities associated with defence acquisition, firms are unwilling to incur sunk costs without some assurance that research and development (R&D) and capital investments will generate profits. It is possible to design some workable arrangements that respect the lessons learned from transaction cost economics (TCE). First, one can reduce uncertainties related to demand through multiyear contracts. These multiyear relationships will also help in building trust and in collecting data about the firms and sectors of interest. Second, incentives to firms may be coupled with credible penalties, which may include a credible threat of entry by foreign firms. Third, incentives can be more strategic by sharing investments in infrastructure and capital equipment or by partitioning tasks. The recent Defence Science and Technology Strategy calls for a number of public-private partnerships that foster mutual trust and benefits to reduce a number of the costs identified by the TCE literature (Solomon 2008).

There is also a significant urgency in aligning broader federal policies on innovation (read productivity), science and technology (S&T), and industrial benefit programs. The declining productivity mentioned earlier and the relatively poor performance in business R&D have led the federal government to articulate an S&T strategy that reduces the government's footprint in the economy. Specifically, the government intends to reduce personal and corporate taxes, review and update competition policies, and redesign Intellectual Property Rights. Focusing on the latter, the implication is that more can be gained by identifying and developing the Intellectual

Property policy "sweet spot" that provides the legal protection necessary to give copyright-based industries the confidence to invest and make full use of leading-edge technologies, while promoting and facilitating access to the knowledge and information needed for innovation and competitiveness.

Recent studies have shown that the S&T or R&D gap between Canada and most advanced economies is due mainly to lack of business R&D. For example, for every dollar in R&D spent in the United States, Canada spends 65 cents (Baldwin and Gu 2007). Research by Baldwin, Maynard, and Wells (2000) identified three reasons for the lack of Canadian business R&D investment. The first factor is the low educational attainment of Canadian managers. Only 33 percent of Canadian managers have a university degree while about 50 percent of their US counterparts hold a university degree, many of them advanced degrees. Surveys of managers on both sides of the border revealed that not only are Canadian managers less educated but they do not seem to appreciate the value of an education.

The second factor relates to the lack of industrial clusters and the pressure and support they provide. Industrial clusters provide a breeding ground for innovation by allowing high-level local competition and by fostering sophisticated consumers who are constantly placing new demands on local firms for innovative designs and processes. The third factor is market size, which is an important factor for facilitating innovation. In addition, Canada's bizarre interprovincial barriers and multiple regulatory environments send the wrong signal to firms to undervalue innovation.

The policy prescription that results from these studies points to a more hands-off government approach and a major redesign of the federal fiscal and regulatory environment. The CFDS planned acquisitions may provide opportunities for Canadian industry; however, without the fundamental structural changes prescribed above, the defence industrial strategy and CADSI recommendations may not have the desired long-term benefit to Canada.

Summary and Conclusions

The biggest potential for Canadian industry and future innovation rests in the CFDS planned acquisition. As such, there is a need to align various government and department-specific policies (for example, defence S&T strategy and Materiel's acquisition strategy) on innovation and acquisitions and make explicit reference to how these are going to be aligned.

To the extent that there is a policy vacuum and uncertainty regarding the acquisition and sustenance of the capital portion of the CFDS, some clear communication from the government is indeed desirable. CADSI's

call for the policy from this perspective is justified. If the dual requirements of economic development and efficient/cost-effective delivery of defence resources are not deemed mutually exclusive, then the defence policy or plan better articulate how this will be achieved.

Specifically, a defence industrial policy may be useful if it provides

- comprehensive data on the industrial sector under consideration and particularly the challenges and opportunities facing the sector,
- an outline of the Canadian government strategy toward the sector (CADSI's implicit requirement),
- the key industrial capabilities that Canada wishes to retain and, most importantly,
- the socioeconomic rationale for the policies and the *premium* or explicit cost we are prepared to pay for the policy and sustainment of the sector.

REFERENCES

Baldwin, J.R., J.P. Maynard, and S. Wells. 2000. "Productivity Growth in Canada and the United States." *Isuma* 1:119-24.

Baldwin, J.R. and W. Gu. 2007. "Long-Term Productivity Growth in Manufacturing in Canada and the United States, 1961 to 2003." *Canadian Productivity Review,* No. 15: 1-29. Cat. No. 15-206-X, Statistics Canada.

Canadian Association of Defence and Security Industries (CADSI). 2009. *Canada's Defence Industry: A Vital Partner Supporting Canada's Economic and National Interests*. Available at https://www.defenceandsecurity.ca/UserFiles/File/IE/Military_Procurement_Main_Report_March_09_2010.pdf.

Caron, S. 1994. "The Economic Impact of Canadian Defence Expenditures." Centre for Studies in Defence Resources Management (CSDRM) Report 23. Department of National Defence, Kingston, Ontario.

Centre for the Study of Living Standards (CSLS). Various years. Income and Productivity Data. Accessed March 2010 from http://www.csls.ca/data/ptabln.asp.

Department of National Defence (DND). Various years. *DND Estimated Expenditures by Electoral District and Province*. Ottawa: Public Works and Government Services. Accessed April 2010 from http://admfincs.mil.ca/Publications_e.asp.

International Monetary Fund (IMF). Various years. World Economic Outlook Database. Accessed October 2010 from http://www.imf.org/external/pubs/ft/weo/2010/02/weodata/index.aspx.

Poole, E. and P. Wall. 1992. *The Economic Impact of Canadian Defence Expenditures FY 1990-91*. Centre for Studies in Defence Resources Management (CSDRM) Report 22. Kingston, ON: CSDRM, Royal Military College of Canada.

Rosenbluth, G. 1967. *The Canadian Economy and Disarmament*. Toronto: Macmillan.

Solomon, B. 1999. "The Canadian Defence Industrial Base." ECAAR, Strategic Finance and Economics, Department of National Defence. Available at www.ecaar.org/Articles/solomon.pdf.

— 2008. "Defence Science and Technology Strategy: An Economics Perspective." Defence Research and Development (DRDC), Centre for Operational Research, TM 2008-50.

Statistics Canada. Various years. *Canadian Economic Observer: Historical Statistical Supplement*. Cat. No. 11-210-XPB. Ottawa: Statistics Canada.

Stone, C. 2008. "Canada Needs a Defence Industrial Policy." *International Journal* 63(2):339-55.

Treddenick, J. 1987. *The Economic Significance of the Canadian Defence Industrial Base*. Centre for Studies in Defence Resources Management (CSDRM) Report No. 5. Kingston, ON: CSDRM, Royal Military College of Canada.

CHAPTER 3

The Economic Impact of Defence Expenditures in Canada: Early Results of Increased Defence Budgets

Craig Stone

Introduction

In 1980 the Centre for Studies in Defence Resources Management (CSDRM) was assigned the task of providing "a comprehensive view of the impact on the Canadian economy of current levels and patterns of defence expenditures and to develop a capability to provide such assessments on a continuing basis" (Treddenick, 1983, xiii). The Centre was successful in meeting this task, and provided the first baseline report in 1983 and annual updates until 1996. The Centre was closed in 1997 as part of the budget and force reduction activities associated with the *1994 White Paper on Defence* and the 1995 federal budget. Since that time, the impact of defence expenditures on the Canadian economy has not been assessed in any systematic way except for a journal article in 1999 (Solomon), and a master's thesis in 2001 (Lemon) that examined the impact of defence spending on the Canadian industrial base.

Based on recent budget announcements, there is a renewed interest in determining whether or not the increases in defence spending will have any impact on the Canadian economy and the defence industrial base. Therefore, the purpose of this chapter is begin the process of once again examining the impact of defence expenditures on the Canadian economy, particularly since the defence budget in Canada has increased from $11.5 billion in 2000–01 to an expected expenditure level of $20.6 billion in 2010–11. For Canada, this is a significant increase in expenditure level, and it would seem prudent to examine whether or not this has an impact on the economy at

both the macro and regional levels and what, if any, impact it has on the defence industrial base.

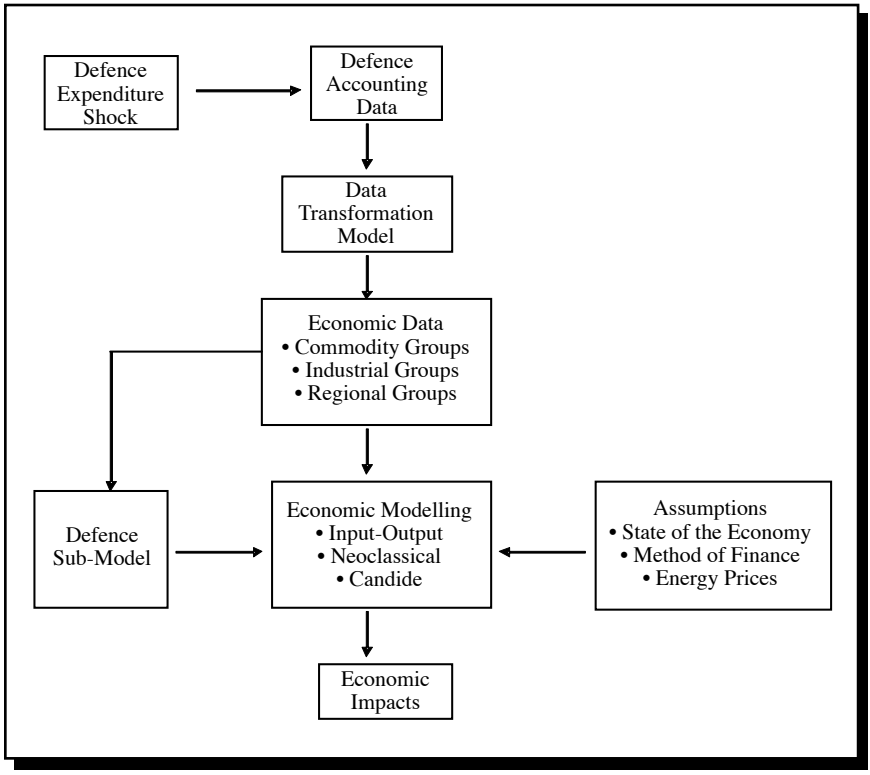
Examining the results at the macro and regional levels is important because past studies by the CSDRM determined that the impact of defence expenditures was quite small at the macro level but could be significant at the regional level. This chapter is the first step in a broader intention to begin looking at the impact of defence expenditures in a more detailed manner and on a more regular basis. It will begin with a very general analysis in order to develop a beginning framework for further study and to provide an assessment of what, if anything, has happened in the intervening years since March 1996 when the last annual assessment was completed (Deschenes 1996). The chapter briefly reviews past methodology in order to set the stage for a discussion of the results of additional simulations using the Statistics Canada Input-Output Model. It will then present the results of the recent simulations and discuss a way forward for future research.

Past Methodology

One of the main intentions in the original study (Treddenick 1983) and subsequent reports was to estimate the overall effect of defence expenditures on production and the industrial makeup of that production. More importantly, the original report established the conceptual framework for examining economic impact. It discussed some of the difficulties associated with estimating impact and the reasons for using what are commonly referred to as macroeconomic interindustry models. These models allow the "examination of detailed industrial impacts of defence expenditures and at the same time indicate the overall effect of defence spending on the economy" (Treddenick 1983, 35).

Three models were examined in the original study: the Statistics Canada Input-Output Models, a so-called neoclassical model, and the CANDIDE 2.0 econometric model maintained by the Economic Council of Canada. Each of these models was modified by adding defence submodels because none of the models were designed with the application of defence expenditures in mind. The procedure adapted in the original study is shown in Figure 3.1. This figure shows that the defence expenditure shock of interest—which may be a change in the level of defence expenditure, a change in the composition of defence expenditures, or both—was initially identified in terms of defence accounting data. These accounting data were based, for the most part, on the form of expenditures classified by resource codes because that is how the Department of National Defence (DND) captured the data for purposes

FIGURE 3.1
Modelling Defence Expenditure Impacts



Source: Treddenick (1983), p. 36.

of budgetary control and management. These data were not suitable for the application of economic models, and therefore an economic model was developed to transform the accounting data to economic data.

The results of the transformation model and the detailed technical aspects and their theoretical underpinnings were discussed in the original study and will not be repeated here. However, since the Statistics Canada National Input-Output Models were used to obtain the first estimates of industrial impact and were subsequently used for each of the annual updates throughout the 1980s and 1990s, there are some important background points that will be useful to the reader prior to discussing the current data.

The Statistics Canada Input-Output Models are an excellent source of data because the models provide the greatest level of detail compared to

any other Canadian models available in a coherent time-series construct. Nevertheless, economic impact is a somewhat ambiguous term and can be defined in many ways. For example, some of the earlier annual updates by the CSDRM traced the path of a dollar spent throughout the local and national economy broken into direct and indirect generated income (Herring 1988; Poole and Wall 1992). In contrast, Deschenes (1996) focused on measuring the importance of defence spending to the national and provincial economy as well as industrial sectors. The method chosen has generally been left to the author based on the availability of data at the time of writing.

Importantly, the input-output tables generated by Statistics Canada are part of the Canadian System of National Accounts (CSNA), a system of integrated statistical accounts consisting of four main components: input-output accounts (national and provincial), income and expenditure accounts (national and provincial), balance of payments, and the financial and wealth accounts. This system is "integrated" in the sense that all of the data belonging to this system are consistent with one another. These tables are compiled every year by Statistics Canada using newly instituted surveys and other improved sources that are designed to collect reliable statistics from each jurisdiction.

Statistics Canada describes the model in detail and indicates that the tables are set up on a year-by-year basis, rather than in time series. National-level tables date back to 1961, while regular subnational tables began with the 1996 reference year. The tables identify transactions in three ways. First, they show data by commodity, a neutral term for a group of goods or services or type of transaction (e.g., "wages" or "indirect taxes"). The most detailed tables, the Worksheet tables, group all transactions into 727 commodities. Second, the tables show data by industry defined as a group of producing units, such as establishments or enterprises that are engaged in market transactions in goods or services. The term *industry* does not imply that they are industrial businesses. Third, they show data by categories of final demand, which is a convenient breakdown that identifies transactions that constitute final sales of goods and services.

Expenditure data obtained from National Defence costing services staff are provided by resource code and geographical code. Data can then be adjusted to remove grants and contributions, and expenditures in foreign currencies, or to account for specific circumstances such as the provincial adjustments to the Canadian Patrol Frigate program. Data are then sent to Statistics Canada and inserted into the national model, which includes 719 input-output commodity codes.

Although Statistics Canada devotes a great deal of time and effort in updating and adjusting the complex matrices that form the model, there is a multi-annual delay in updating the models. This has the potential to create some consistency issues between the interprovincial and national models if both the interprovincial model and the national open model, the two models used most often for the DND expenditure impact studies, have not been updated to the same base year at the time of running the simulations. For example, the data used in the early work associated with this study are based on the 2005 version of the model while the more recent provincial data are based on the 2006 version of the model.

As well, like all models, there are limits imposed by the set of assumptions used in developing the model. For example, in the case of the input-output models used in this study, it was assumed that civilian and military technologies are the same, that there are no economic prices in the model, and that there are no input supply constraints. Consequently, despite the care taken in choosing and manipulating the data, the reader needs to interpret the data as rough orders of magnitude. What is important in the longer term are trends over time rather than the short-term impact.

Defence Expenditures

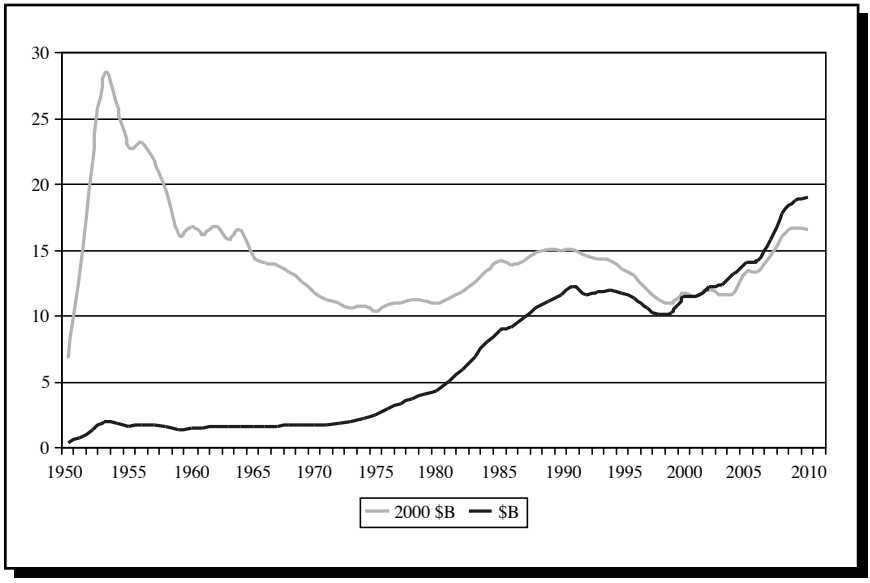
Table 3.1 provides the defence expenditures from 1995 to 2010 while Figure 3.2 shows defence expenditures over a longer period of time, in actual expenditures and constant year 2000 expenditures, in order to provide a broader perspective for some of the analysis later in the chapter.

TABLE 3.1
Defence Expenditures 1994–95 to 2009–10

Fiscal Year	*Total ($B)*	*Fiscal Year*	*Total ($B)*	*Fiscal Year*	*Total ($B)*
1994–95	10.6	2000–01	9.7	2006–07	15.7
1995–96	9.8	2001–02	10.4	2007–08	17.3
1996–97	8.8	2002–03	11.8	2008–09	18.7
1997–98	9.1	2003–04	12.9	2009–10e	20.9
1998–99	9.3	2004–05	14.3	2010–11e	20.6
1999–00	10.1	2005–06	15.0	2011–12e	19.7

Source: Department of Finance (2009), Table 7, p. 15, and Department of National Defence (2009), p. 8.

FIGURE 3.2
Canadian Defence Expenditures 1950–2010



The decline in 2011–12 from $20.6 billion to $19.7 billion reflects the planned withdrawal of Canadian Forces from Afghanistan and therefore a reduced requirement for supplemental funding for the war effort. More important is whether or not the planned increase of 2 percent per year beyond 2011 will come to fruition. There is every indication at the time of writing that this will not be the case. The fiscal realities of the Canadian government (and many others) as a result of the economic crisis resulted in reductions to the defence budget being announced in the 2010 federal budget speech. Specifically, the government's budget plan indicated that

> The Government remains committed to continuing to build the Canadian Forces into a first-class, modern military. However, as part of measures to restrain the growth in overall government spending and return to budget balance in the medium term, the Government will slow the rate of previously planned growth in the National Defence budget. Budget 2010 reduces growth in National Defence's budget by $525 million in 2012–13 and $1 billion annually beginning in 2013–14. (Department of Finance 2010, 158)

As well, operating budgets for all departments of government are frozen at the 2009–10 level until 2012–13. DND will still receive its defence escalator

but will not receive additional funding for already established wage increases over the same period.

While Figure 3.2 does show the longer term story of defence spending, it is difficult at this point in time to know what will occur. Will the budget continue to increase as planned in the Canada First Defence Strategy or will it stagnate as it so often has in the past when governments are under fiscal pressure?

Impact

The results of the simulation runs for this study are presented in the tables and figures that follow. The simulations were conducted for defence expenditure data from 2001–02 to 2006–07, and again for 2008–09. The first two periods were chosen because the year 2001 is at an early point in time for defence budget increases after the reduction in the 1990s and is just before the 11 September 2001 terrorists attacks on the World Trade Center and the Pentagon, while 2006–07 reflects substantial growth in the budget but only half of the planned increases. Fiscal year 2006–07 provides a mid-point to a planned 2010–11 repeat of the simulations in order to track longer term impacts. The 2008–09 simulation was conducted within the context of a Strategic Review that provided some empirical data for the review team.

As indicated at the outset of this chapter, the intention is to examine only a limited selection of results as part of a larger plan. More specifically, the results that follow are focused on the actual dollars that could have been spent on the defence industrial base and address the direct GDP impact in terms of dollars and employment for the major defence industry sectors. The most significant issue for this limitation is that wages, which are a significant portion of the defence budget, are not part of the expenditures being examined. In other words, the data is limited to just those defence dollars that can reasonably be spent directly on goods and services within the defence industry. Table 3.2 shows the direct impact of defence expenditures on GDP before the expenditures go through the economic system while Table 3.3 shows the impact after the defence expenditures have gone through the system, both based on the results using the 2004 version of the Input-Output Model.

The results show that there has been some growth over the period, but that should be expected based on the increases to the defence budget and the increased expenditures on capital investment. However, the impact has been more significant in some areas than others. For example, within the aircraft equipment manufacturer sector, there was a 48 percent increase

TABLE 3.2
Direct Supply and Demand by Industry ($thousands), 2004 Model

CDIB Impact	*Direct GDP*		*Diff*	*% Change*
	2001–02	*2006–07*		
Firearms and explosives	62,859	75,159	12,299	19.6
Army equipment manufacturers	41,232	49,930	8,697	21.1
Air equipment manufacturers	126,921	188,905	61,983	48.8
Naval equipment manufacturers	11,912	21,285	9,372	78.7
Professional services	195,316	346,378	151,062	77.3
Scientific services (incl R&D)	46,775	65,047	18,272	39.1
Other equipment	28,610	41,906	13,295	46.5
Other service (security service-commission)	110,052	175,181	65,128	59.2
Total all industries	1,736,665	2,312,314	575,649	33.1

Note: The table reflects data for defence-specific sectors and a total for all sectors (defence and non-defence). Numbers will not add up to the total. CDIB = Canadian Defence Industrial Base.

TABLE 3.3
Total Supply and Demand by Industry ($thousands), 2004 Model

CDIB Impact	*Direct GDP*		*Diff*	*% Change*
	2001–02	*2006–07*		
Firearms and explosives	64,187	76,958	12,771	19.9
Army equipment manufacturers	45,020	54,621	9,601	21.3
Air equipment manufacturers	147,976	220,774	72,797	49.2
Naval equipment manufacturers	12,078	21,519	9,441	78.2
Professional services	220,298	386,241	165,943	75.3
Scientific services (incl R&D)	76,140	106,342	30,201	39.7
Other equipment	31,638	46,318	14,680	46.4
Other service (security service-commission)	114,794	181,514	66,720	58.1
Total all industries	2,580,770	3,435,022	854,251	33.1

Note: The table reflects data for defence-specific sectors and a total for all sectors (defence and non-defence). Numbers will not add up to the total. CDIB = Canadian Defence Industrial Base.

from 2001 to 2006. As well, this sector was 7.3 percent of the total impact in 2001–02 and 8.2 percent in 2006–07. This compares to the army equipment manufacturers sector, which was 2.4 percent of the total in 2001–02 and only 2.2 percent in 2006–07. This percentage is both lower than the air equipment sector and a reduction rather than an increase.

The results displayed graphically show the significance of these differences in a much clearer way than the data in the tables. Figure 3.3 reflects Table 3.2 data while Figure 3.4 reflects Table 3.3 data.

Table 3.4 and Figure 3.5 show direct and indirect results for 2008 in relation to the previous data. Of note is that the 2008 data use the 2006 version of the Statistics Canada Input-Output Model, and direct impacts are not provided. What is clear from the data is that there have been increases in some sectors and decreases in other sectors despite the confirmed increase in defence expenditures. The largest increase has been in professional services and air equipment manufacturers. This is most likely due to the increased number of contractors that are being utilized by the department. The largest decrease has been in army equipment manufacturers. Here the most likely reason is the reduction in spending in Canada, which has been offset by spending outside the country to support operations in Afghanistan.

FIGURE 3.3
Direct Supply and Demand by Industry – GDP

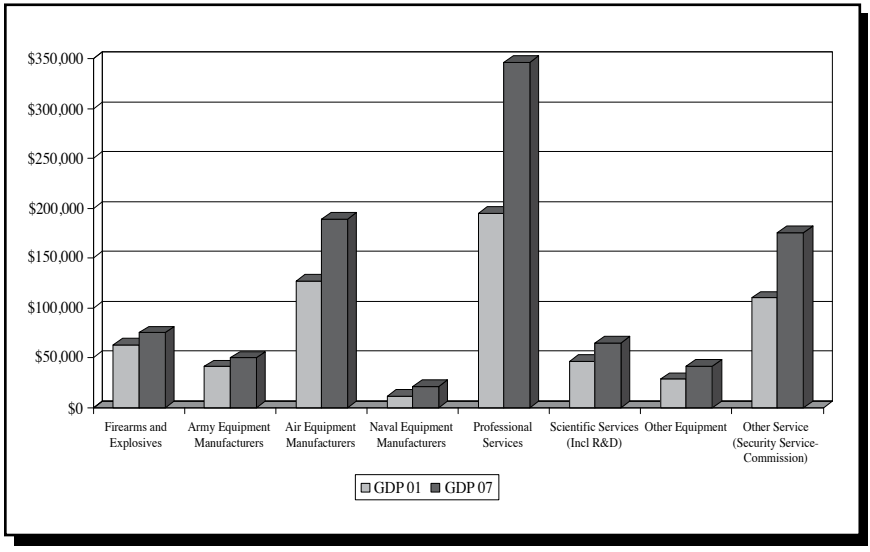


FIGURE 3.4
Total Supply and Demand by Industry – GDP

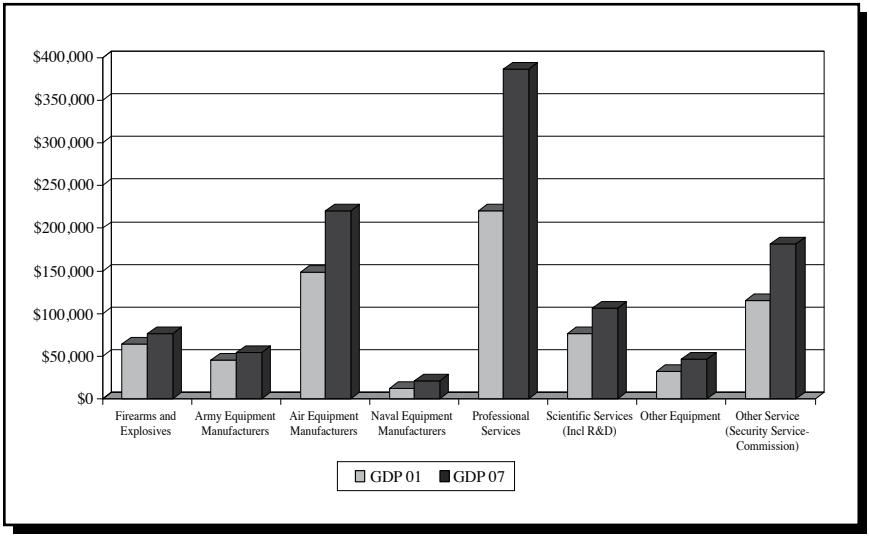
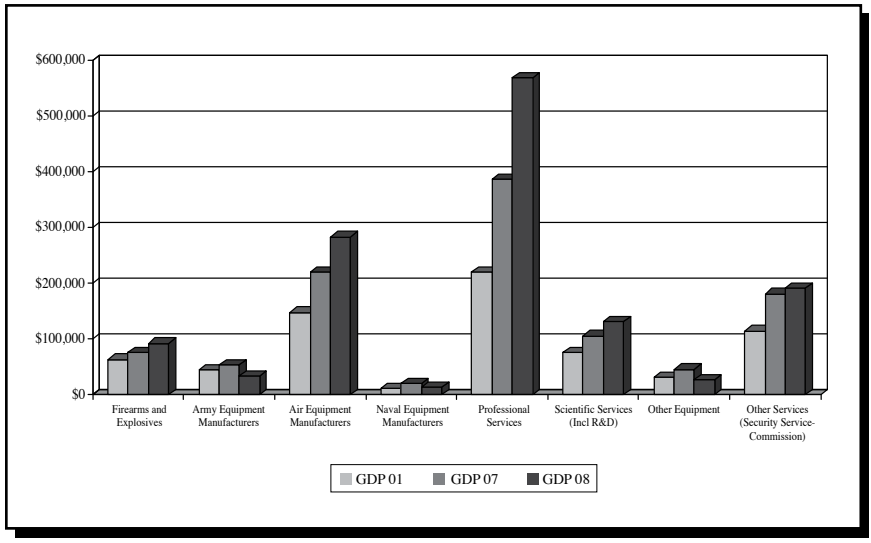


TABLE 3.4
Total Supply and Demand by Industry ($thousands), 2006 Model

CDIB Impact	*Direct GDP*			*Difference % Change 01–02 to 07–08*
	2001–02	*2006–07*	*2007–08*	
Firearms and explosives	64,187	76,958	92,980	45
Army equipment manufacturers	45,020	54,621	33,329	–26
Air equipment manufacturers	147,976	220,774	283,523	92
Naval equipment manufacturers	12,078	21,519	13,974	16
Professional services	220,298	386,241	567,678	158
Scientific services (incl R&D)	76,140	106,342	130,864	72
Other equipment	31,638	46,318	28,208	–11
Other service (security service-commission)	114,794	181,514	190,696	66
Total all industries	2,580,770	3,435,022	4,167,526	61

Note: The table reflects data for defence-specific sectors and a total for all sectors (defence and non-defence). Numbers will not add up to the total. CDIB = Canadian Defence Industrial Base.

FIGURE 3.5
Total Supply and Demand by Industry, All Years



Tables 3.5 and 3.6 show the direct and indirect effects of defence spending with respect to employment. The results from Table 3.5 show that employment reflects similar results when compared to the dollar impact on supply and demand. Those industries with reduction in GDP also show reductions in employment. However, the results are not identical to the GDP impact. The largest increase remains the same with professional services but the next largest increase in jobs is in scientific services rather than air equipment manufacturers. The largest decrease is in other equipment rather than army equipment manufacturers.

At the same time, Table 3.7 clearly shows where reductions have occurred. Although more work needs to be done to determine why the reductions have occurred, an initial hypothesis would be that the losses in army and air equipment manufacturing are related to sole source purchases of equipment from foreign supplies without Canadian offsets. Clearly the impact between sectors is different, and the most significant difference is the larger employment impact within the service sectors rather than the manufacturing sectors. More importantly, when examining the issue of effective or efficient spending of taxpayer dollars, there appears to be mixed

TABLE 3.5
Direct and Indirect Effects of Defence Spending on Employment

Direct CDIB Impact	*Direct*			*Total*		
	01–02	*06–07*	*07–08*	*01–02*	*06–07*	*07–08*
Firearms and explosives	710	848	995	725	869	1,028
Army equipment manufacturers	281	341	260	307	373	267
Air equipment manufacturers	1,446	1,994	1,731	1,684	2,338	2,226
Naval equipment manufacturers	167	298	191	169	302	192
Professional services	2,875	5,098	6,842	3,242	5,685	7,770
Scientific services (incl R&D)	993	1,381	1,515	1,616	2,257	2,547
Other equipment	347	493	259	393	557	290
Other service (security service-commission)	3,874	6,167	5,583	4,041	6,390	5,801
Total defence industry jobs	10,693	16,620	17,376	12,177	18,771	20,121

Note: CDIB = Canadian Defence Industrial Base.

TABLE 3.6
Employment as a Percentage of the Total Impact of Defence Spending

CDIB Impact	*Direct (%)*			*Direct and Indirect (%)*		
	01–02	*06–07*	*07–08*	*01–02*	*06–07*	*07–08*
Firearms and explosives	1.9	1.7	2.4	1.7	1.6	1.7
Army equipment manufacturers	0.7	0.7	0.6	0.7	0.7	0.4
Air equipment manufacturers	3.8	4.0	4.2	3.9	4.2	3.7
Naval equipment manufacturers	0.4	0.6	0.5	0.4	0.5	0.3
Professional services	7.6	10.3	16.5	7.5	10.2	13.0
Scientific services (incl R&D)	2.6	2.8	3.7	3.7	4.1	4.3
Other equipment	0.9	1.0	0.6	0.9	1.0	0.5
Other service (security service-commission)	10.3	12.5	13.5	9.4	11.5	9.7

Note: CDIB = Canadian Defence Industrial Base.

TABLE 3.7
Employment Comparison Differences

CDIB	*Diff 02 to 07*		*Diff 02 to 08*		*Diff 07 to 08*	
	Direct	*Total*	*Direct*	*Total*	*Direct*	*Total*
Firearms and explosives	138	144	285	303	147	159
Army equipment manufacturers	60	66	–21	–40	–81	–106
Air equipment manufacturers	548	654	285	542	–263	–112
Naval equipment manufacturers	131	133	24	23	–107	–110
Professional services	2,223	2,443	3,967	4,528	1,744	2,085
Scientific services (incl R&D)	388	641	522	931	134	290
Other equipment	146	164	–88	–103	–234	–267
Other service (security service-commission)	2,293	2,349	1,709	1,760	–584	–589
Total defence industry jobs	5,927	6,594	6,683	7,944	756	1,350

Note: CDIB = Canadian Defence Industrial Base.

results in terms of overall job increases when compared to defence spending increases. For example, is the $6.9 billion increase in defence expenditures from 2002 to 2008 good value for 6,683 direct defence industry jobs and 7,944 total jobs? (Note these figures are different when comparing 02 to 07 and 07 to 08.)

Figures 3.6 and 3.7 depict graphically the data from Table 3.5. It is visibly clear that it is services that are getting the most significant benefit from defence expenditure increases and not new equipment.

FIGURE 3.6
Direct Employment

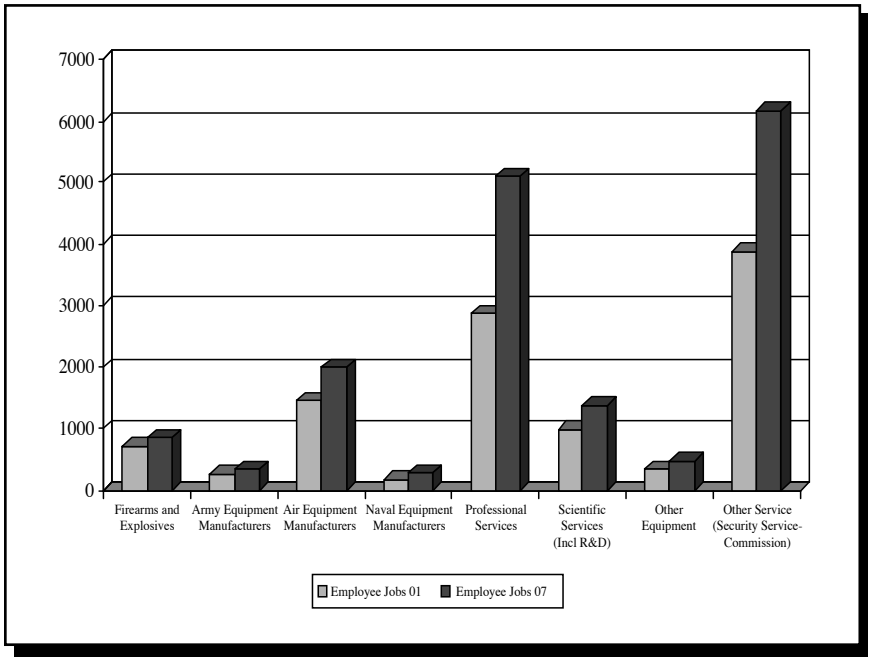
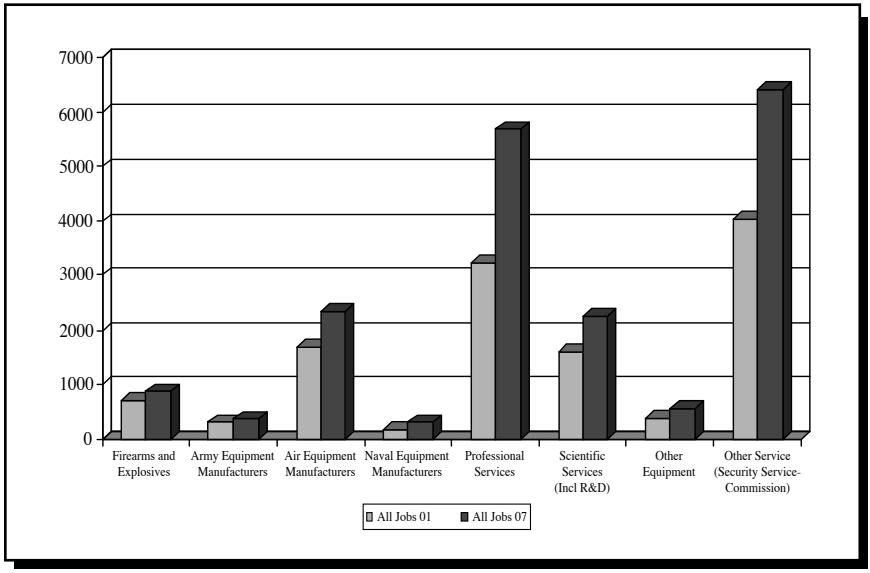


FIGURE 3.7
Total Employment



Provincial Results

In the very first instance of running the Statistics Canada model at the beginning of this project, only the national-level model was utilized. More recently, when the 2008 simulation was conducted, the expenditure data were also run through the interprovincial model. In the same way that defence expenditures were inserted into the national model, the same expenditure data were inserted into the interprovincial model to determine results.

Tables 3.8 through 3.11 below provide provincial data on GDP impact and on employment numbers. As might be expected, the largest amount of spending occurs in the most populated provinces in the country, Ontario and Quebec. But it is also clear that certain sectors of the defence industry are concentrated in particular areas. This is in line with the notion of centres of excellence for particular sectors, although it may work at cross-purposes to a government's desire to promote regional development and technology investment through defence expenditures.

Further Research

This has been a very brief examination of a small part of the larger economic impact problem that needs to be addressed as the Canadian government continues down a path of significant increases to defence expenditures. While this chapter examined only the impact of defence spending that could have been spent on defence industries, there is a requirement to expand this research to include the impact of wages and other spending that goes into the economy. This needs to include the impact of that defence spending on both the defence industrial base and the broader Canadian economy. More importantly, in order to make a more thorough comparison to the results of earlier studies, the interprovincial models will need to be examined to compare the regional impacts.

TABLE 3.8
Direct GDP Impact of Defence Spending

Direct CDIB Impact	*Firearms and Explosives*	*Army Equipment Manufacturers*	*Air Equipment Manufacturers*	*Naval Equipment Manufacturers*	*Professional Services*	*Scientific Services (Incl R&D)*	*Other Equipment*	*Other Service (Security Service-Commission)*
Nfld. & Labrador	886	0	377,177	102	13,744	10,340	45,045	205
PEI	1	0	8,641,879	10,452	780	325,381	0	41
Nova Scotia	1,233	164	68,272,064	253,998	79,928	426,490	3,153,564	14,311
New Brunswick	6,286	–6	89,163	5,134	28,183	112,768	76,117	3,396
Quebec	85,522,544	212,558	89,745,731	1,887,332	816,080	3,089,974	3,266,580	68,775
Ontario	2,114,512	37,066,546	42,922,087	542,836	26,639,164	35,457,100	45,397,783	55,435
Man.	2,907	316,584	4,398,590	24	105,542	267,104	93,818	2,306
Sask.	37	0	44,800	0	13,048	19,762	299,718	77
Alberta	56,855	3,157	12,797,792	6,002	1,384,589	778,392	473,287	184,590
BC	478,120	–3,713	12,128,003	10,386,643	623,130	5,167,830	1,250,131	25,008
Yukon	0	0	23,902	0	5,605	9,770	63	2
NWT	0	0	18,537	0	7,076	4,550	0	1
Nunavut	0	0	33	0	3	2	0	0
Abroad	0	0	0	0	0	0	0	0
Total	88,183,381	37,595,291	239,459,756	13,092,523	29,716,873	45,669,461	54,056,106	354,148

Note: CDIB = Canadian Defence Industrial Base.

TABLE 3.9
Direct and Indirect GDP Impact of Defence Spending

Direct CDIB Impact	*Firearms and Explosives*	*Army Equipment Manufacturers*	*Air Equipment Manufacturers*	*Naval Equipment Manufacturers*	*Professional Services*	*Scientific Services (incl R&D)*	*Other Equipment*	*Other Service (Security Service-Commission)*
Nfld. & Labrador	3,073	0	1,297,542	1,433	142,905	219,010	54,517	133,695
PEI	17	0	8,801,246	11,696	70,753	476,141	0	13,272
Nova Scotia	5,870	328	75,395,295	489,497	894,320	1,807,981	3,350,123	465,768
New Brunswick	36,315	–9	718,766	5,966	1,028,060	501,823	92,674	157,251
Quebec	87,258,599	541,111	113,938,107	1,961,192	7,595,466	12,540,153	3,974,863	2,875,786
Ontario	4,052,352	38,103,007	65,797,377	616,640	39,848,826	67,424,675	47,218,076	7,242,214
Man.	36,149	321,386	7,738,817	27	639,537	869,174	115,487	199,158
Sask.	15,228	0	236,944	0	117,733	204,492	312,095	37,614
Alberta	272,334	3,511	15,729,871	6,628	4,711,543	4,176,660	555,688	1,116,590
BC	680,328	–4,596	17,408,395	10,534,363	2,305,404	9,200,986	1,401,583	1,156,240
Yukon	0	0	34,617	0	12,282	21,589	155	1,418
NWT	0	0	44,922	0	15,224	14,857	0	2,933
Nunavut	0	0	33,709	0	173	5,121	0	2,476
Abroad	0	0	0	0	0	0	0	0
Total	92,360,265	38,964,739	307,175,606	13,627,441	57,382,227	97,462,665	57,075,262	13,404,415

Note: CDIB = Canadian Defence Industrial Base.

TABLE 3.10
Jobs Directly Affected by Defence Spending

Direct CDIB Impact	*Firearms and Explosives*	*Army Equipment Manufacturers*	*Air Equipment Manufacturers*	*Naval Equipment Manufacturers*	*Professional Services*	*Scientific Services (Incl R&D)*	*Other Equipment*	*Other Service (Security Service-Commission)*
Nfld. & Labrador	7	0	7,601	2	194	250	947	7
PEI	0	0	171,813	67	18	8,489	0	2
Nova Scotia	9	0	570,705	4,097	1,464	13,007	40,078	580
New Brunswick	70	0	1,353	84	530	3,656	1,179	129
Quebec	966,746	1,603	575,207	15,537	14,325	64,380	38,152	2,435
Ontario	21,216	297,630	420,061	6,649	338,186	673,497	426,545	1,783
Man.	98	5,120	42,484	1	1,944	8,044	2,119	126
Sask.	1	0	505	0	253	446	7,352	3
Alberta	444	31	138,959	6	15,932	13,454	3,200	5,038
BC	7,927	–113	166,462	137,459	10,195	117,167	14,403	880
Yukon	0	0	470	0	71	229	0	0
NWT	0	0	288	0	97	83	0	0
Nunavut	0	0	0	0	0	0	0	0
Abroad	0	0	0	0	0	0	0	0
Total	996,517	304,271	2,095,907	163,903	383,209	902,703	533,974	10,984

Note: CDIB = Canadian Defence Industrial Base.

TABLE 3.11
Direct and Indirect Jobs

Direct CDIB Impact	*Firearms and Explosives*	*Army Equipment Manufacturers*	*Air Equipment Manufacturers*	*Naval Equipment Manufacturers*	*Professional Services*	*Scientific Services (Incl R&D)*	*Other Equipment*	*Other Service (Security Service-Commission)*
Nfld. & Labrador	24	0	26,126	33	2,020	5,288	1,152	4,854
PEI	1	0	174,815	75	1,618	12,423	0	502
Nova Scotia	43	0	642,495	7,896	16,384	55,139	42,230	18,865
New Brunswick	405	0	14,084	97	19,318	16,271	1,586	5,995
Quebec	986,371	4,080	773,432	16,145	133,325	261,275	48,372	101,823
Ontario	40,659	305,952	678,232	7,553	505,884	1,280,712	446,242	232,981
Man.	1,214	5,197	80,297	1	11,779	26,175	2,638	10,878
Sask.	234	0	2,960	0	2,286	4,615	7,559	1,664
Alberta	2,126	35	172,715	7	54,215	72,189	3,913	30,472
BC	11,279	–139	239,282	139,414	37,718	208,608	16,678	40,694
Yukon	0	0	680	0	155	506	0	24
NWT	0	0	697	0	210	273	0	71
Nunavut	0	0	350	0	2	56	0	88
Abroad	0	0	0	0	0	0	0	0
Total	1,042,355	315,125	2,806,164	171,222	784,912	1,943,530	570,370	448,911

Note: CDIB = Canadian Defence Industrial Base.

REFERENCES

Canada. Department of Finance. 2009. *Fiscal Reference Tables 2009*. Ottawa: Department of Finance.

— 2010. *Budget 2010 Leading the Way on Jobs and Growth: Canada's Economic Action Plan*. Tabled in the House of Commons by the Honourable James M. Flaherty. Ottawa: Department of Finance.

Canada. Department of National Defence. 2009. *Report on Plans and Priorities 2009–10*. Ottawa: Department of National Defence.

Deschenes, A. 1996. "The Economic Impact of Defence Expenditures." Occasional paper 1-96. Centre for National Security Studies Report No. 25, Kingston.

Lemon, B.K. 2001. "The Economic Impact of Defence Spending on the Canadian Industrial Base." Master's thesis, Royal Military College of Canada, Kingston.

Herring, P. 1988. *The Economic Impact of Defence Expenditures FY 1986/87 Update*. Centre for Studies in Defence Resources Management (CSDRM) Report No. 17. Kingston, ON: CSDRM, Royal Military College of Canada.

Poole, E. and P. Wall. 1992. *The Economic Impact of Defence Expenditures FY 1990/91*. Centre for Studies in Defence Resources Management (CSDRM) Report No. 22. Kingston, ON: CSDRM, Royal Military College of Canada.

Solomon, B. 1999. "The Canadian Defence Industrial Base." ECAAR, Strategic Finance and Economics, Department of National Defence. Available at www.ecaar.org/Articles/solomon.pdf.

Treddenick, J.M. 1983. *The Economic Impact of Defence Expenditures*. Centre for Studies in Defence Resources Management (CSDRM) Report No. 2. Kingston, ON: CSDRM, Royal Military College of Canada.

CHAPTER 4

Balanced Procurement, Military Advantage, and the Canadian Defence Industrial Base

Gregory H. van Bavel

Introduction

The Deputy Chief of Staff (Materiel) tasked the Directorate Materiel Group Operational Research team to study the mix of two procurement aims: direct versus indirect benefits. Direct benefits go to the Canadian Forces and the Department of National Defence in the form of military advantage, which allows them to accomplish their mission(s). Indirect benefits go to the Canadian people in the form of regional development, offsets (e.g., industrial and regional benefits), and related employment opportunities.

The research question addressed in this chapter is: What is the optimal mix of the two procurement aims? It may appear that this is a classical optimization problem, but this is not the case in the Canadian context. Since the Canadian Forces (CF) engage in combat, attaining military advantage is strategically attractive. One might imagine that an adversary of Canada would rather that procurements for the CF aim exclusively at indirect benefits and just forget about military advantage altogether. Therefore, the question of an optimal mix of procurement strategies must await the answer to the higher-level question: How is adversarial activity affected by the defence procurement aims of the Government of Canada?

The approach used in this chapter is to model the strategic interactions between the Government of Canada (GoC) and an Adversary of Canada

(AoC). Game Theory provided the analytical methods and means, because it is "the study of mathematical models of conflict and cooperation between intelligent rational decision-makers" (Myerson 1991, 1).[1] Other advantages of Game Theory are (1) it is well known, and (2) it is a great exploration tool because one can vary some aspects but not others (*ceteris paribus*), then calculate the impact on the results.

The results of this analysis are relevant to the Canadian Defence Industrial Base (CDIB) and the findings of the Canadian Association of Defence and Security Industries (CADSI) regarding procurement strategies, policies, processes, and governance (CADSI 2009). The model includes the CDIB as a passive agent, which roughly approximates the limited influence the CDIB has over the strategic interaction between GoC and AoC. The results showed that the CDIB fared better in times of turmoil than it did in times of moderate stability. Therefore, if the CDIB is to make the most of good times, it must operate well under uncertainty. Furthermore, the analysis identified a combined GoC/AoC course of action as the harbinger of the "peace dividend" and its paradox: GoC procurement strategy aims at indirect benefits, which favours the CDIB, yet GoC procures less, which disfavours the CDIB.

Game Theory Analysis of Procurement Strategies

> The Government of Canada remains committed to capitalize on its major purchases to generate the greatest amount of economic benefit to Canadian industry and the economy at large. Canada's Industrial and Regional Benefits Policy is in place to ensure that prime contractors generate long-term and significant economic activity in Canada.
>
> —Tony Clement, Industry Canada Minister
> (quoted in Arcand and Grigoroff 2009)

The scenario has two players, whose interdependent decision making is the prime topic of the analysis that follows:

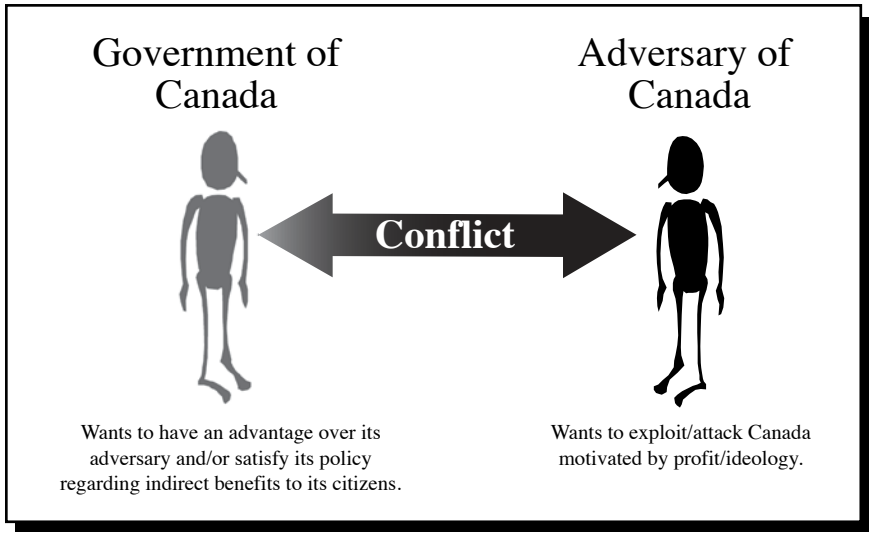
1. Government of Canada (GoC)—wants to procure military materiel and provide indirect benefits to its people

[1] The assumption for "intelligent" is that the players know the game at least as well as the modeller, while the assumption for "rational" is that the players adhere to their preferences—*not* equivalent to the concept of sanity.

2. Adversary of Canada (AoC)—wants to exploit/attack Canada for profit/ideology

A schematic depiction of the decision makers is shown in Figure 4.1. By concentrating on the two principals, other organizations who may play a major role in the real world are set aside. Although this is the cost of modelling the essential elements of a problem, the second and third sections below will discuss how the players' actions affect the Canadian Defence Industrial Base. That discussion will make use of a utility indicator that depends directly on the GoC procurement strategy.

FIGURE 4.1
Motivational and Relational Aspects of the Two Decision Makers



Actions

The possible actions of the players are shown in Table 4.1. There are three courses of action available to both the Government of Canada (GoC) and the Adversary of Canada (AoC). Therefore, there are nine possible outcomes of the interaction between GoC and AoC. Note that the outcomes can be recognized in terms of what the players actually *do*, and that what they do is *observable*. The players' *perceptions* or *feelings* are not observable and therefore the outcomes are not defined in terms of perceptual or emotional states. Therefore, the model is falsifiable (Popper 1994). Some of

the important terms in Table 4.1 receive further elucidation in the subsections that follow.

Definition of Military Advantage

The definition of military advantage can be viewed as a decisive state-of-affairs that adversaries cannot counter or they are penalized when they try. Another way to think about is it that if one has military advantage in a conflict, then one can accomplish one's mission. This is distinct from technological advantage, which is not a sufficient condition to prevail.

Knowing how to do something better is not the same as actually doing something better. Technological advantage entails that one has superior abstract knowledge; military advantage entails that one has superior physical capability. This distinction is vital in the analysis below.

TABLE 4.1
Players' Options for Action

Player	*Description*
Government of Canada	• Aim for *balanced procurement*, such that each procurement yields some military advantage and some indirect benefits • Make *military advantage* the exclusive aim of procurement • Make *indirect benefits* (e.g., regional development, offsets) the exclusive aim of procurement
Adversary of Canada	• Expand operations against Canada • Maintain status quo • Reduce operations against Canada

Mixed Versus Balanced Procurement

The concepts of mixed procurement and balanced procurement deserve some attention. On the surface these terms appear synonymous, but for the purposes of this analysis they are not. In the discussion that follows, *mixed* is meant to convey the idea that components are taken separately in certain proportions, whereas *balanced* is meant to convey the notion of components combined simultaneously to make something different than either ingredient. For example, in mixed procurement, each procurement is aimed at either

indirect benefits or military advantage, but not both. Consider the analogy of having toast or eggs. In contrast, in balanced procurement, each procurement is aimed at a certain proportion of both indirect benefits and military advantage. Consider the analogy of French toast.

An example of mixed procurement is if GoC made 75 percent of its procurements purely for the purpose of regional development: eliciting ship-repair bids from Maritime firms, procuring ammunition from Quebec manufacturers, and asking for proposals for aircraft maintenance from companies located in the western provinces. The other 25 percent of its procurements would focus on the military requirements and bidding would be open to foreign corporations, who would be attracted by the large value of the contract.

In contrast, balanced procurement blends elements of military advantage and indirect benefits in every procurement; the proportions of the two would depend entirely on the materiel or service under consideration. Currently, there is a monetary-value threshold above which GoC must insist upon indirect benefits (i.e., offsets) from foreign prime contractors (Defence Industries Directorate 2005). Balanced procurement would use the military value of the procurement to focus its strategy: the greater the military value, the more the procurement aims at military advantage and the less it aims at indirect benefits. The opposite would also hold. However, note that it is easier to use monetary value to determine procurement balance, because military advantage is a difficult, tenuous accomplishment that requires a deep familiarity with one's adversary.

Preferences

The preferences of each player determine their willingness to take a course of action open to them. The analysis of the strategic interaction depends entirely on the preferences (Osborne 2004), because the preferences allow the construction of a mathematical representation of the players' will to act. Table 4.2 shows the hypothetical preferences for GoC, and Table 4.3 shows the same for AoC. In both tables, the left column contains a hypothesis, and its associated generic principle is in the right column.

These hypotheses are the author's assumptions; they are not results, but rather premises from which the results follow. This is how the algorithm proceeds: having translated the hypotheses into precise mathematical relations involving each player's utility function, check the completeness and consistency of the system of hypotheses (van Bavel 2009). If both properties hold, then the ordering of preferences is unique, which is the case for both players in this model.

TABLE 4.2
Preferences of the Government of Canada

Preference	*Generic Principle*
GoC prefers military advantage whenever AoC expands its operations against Canada.	The cost of military advantage is justified whenever the adversarial threat grows.
GoC prefers to make indirect benefits the sole aim of its procurement activity whenever AoC does not expand, but especially whenever AoC reduces operations.	Indirect commercial benefits can be the ultimate goal whenever the adversarial threat does not expand.
GoC prefers balanced procurement to military advantage whenever AoC does not expand its operations.	Military advantage is less necessary when the adversarial threat does not grow.
GoC prefers balanced procurement to indirect-benefits procurement whenever AoC does not retreat.	Balanced procurement is required if indirect benefits are not accompanied by a reduction in the adversarial threat.
Whenever GoC aims at balanced procurement, GoC most prefers that AoC maintain the status quo and least prefers that AoC expand its operations.	Balanced procurement is most worthwhile when the adversary dwells, and is least worthwhile when the adversary advances.

The critical preferences in Tables 4.2 and 4.3 are those related to a player's own actions, and these critical preferences are listed first. The order in which the hypotheses are stated affects neither their completeness nor their consistency. In particular, one hypothesis explicitly states the circumstances under which a player would prefer one of the actions over the other two. The goal is that no single action dominates any other, otherwise the dominated action would be superfluous (i.e., a player would never choose it) and therefore subject to elimination (Fundenberg and Tirole 1991).

The Game and Its Results

This section presents the results of the model constructed in the previous section. The complete and consistent ordering of the players' preferences, as represented by ordinal utility scores, provide the foundation for a Game Theory analysis. The results include static and dynamic representations

TABLE 4.3
Preferences of the Adversary of Canada

Preference	*Generic Principle*
AoC most prefers to expand its operations whenever GoC procurement does not aim exclusively at military advantage.	Expansion of operations is better if the mark (i.e., prospective victim) is more vulnerable.
AoC prefers to retreat if GoC procures exclusively for military advantage, and AoC would rather retreat than expand if GoC balances procurement.	Retreat is preferable to expansion—and possibly the status quo—when the mark has some advantage.
AoC prefers the outcome in which GoC balances procurement and AoC maintains the status quo over other outcomes in which the following hold: • GoC exclusively procures military advantage, • GoC balances procurement, and • GoC exclusively procures for indirect commercial benefits while AoC retreats.	Maintaining the status quo is preferred with a balanced mark, and is better than having the mark gain the advantage or retreating when the mark is vulnerable.
AoC prefers maintaining the status quo to expanding its operations whenever GoC exclusively procures military advantage.	If the mark has an advantage, maintaining the status quo is less difficult than expansion.
Whenever AoC retreats, AoC most prefers that GoC exclusively procures for military advantage, and least prefers that GoC exclusively procures for indirect benefits.	Retreat makes most sense when the mark has an advantage, but makes least sense when the mark has a vulnerability.

of the scenario, as well as a comparison of simultaneous and sequential strategic interactions.

Table 4.4 shows the ordinal-score matrix (also known as a payoff matrix) for the interdependent-decision analysis cast as a strategic game, wherein the players move simultaneously. The Government of Canada (GoC) has its three actions (aim at balanced procurement, military advantage, or indirect benefits) listed at the left side of the rows, and the

Adversary of Canada (AoC) has its actions (expand, status quo, reduce its operations) listed at the top of the columns. The intersection of each row and column is a possible outcome. Each outcome has a pair of ordinal scores that represent the preferences of GoC and AoC for that outcome. The first number in each pair is GoC's ordinal score and the second number is AoC's ordinal score. Asterisks indicate a player's best response given the other player's actions; the best response for GoC is the highest ordinal score in each column, and the best response for AoC is the highest ordinal score in each row.

TABLE 4.4
Ordinal-Score Matrix for the Strategic Game

		Adversary of Canada		
		Expand	**Status Quo**	**Reduce**
Government of Canada	**Balanced Procurement**	2, 4	8*, 7*	7, 5
	Military Advantage	5*, 1	4, 2	3, 6*
	Indirect Benefits	1, 9*	6, 8	9*, 3

Note: * A player's best response given the action of the other player.

The stable outcome is indicated by the boxed pair of ordinal scores 8*, 7* and is called a *Nash equilibrium*. Any Nash equilibrium is stable because if one player deviates and the other player does not, then the deviating player strategically fares worse (i.e., obtains a lower ordinal score) or gains nothing (i.e., obtains the same ordinal score). The stable outcome of the strategic game corresponds to the following combination of actions:

1. The Government of Canada aims for *balanced procurement*, which yields military advantage and indirect benefits for each procurement; and
2. The Adversary of Canada maintains the *status quo.*

The GoC attains its second-best outcome (ordinal score of 8), whereas AoC attains its third-best outcome (ordinal score of 7). In a strategic sense,

both players fare well. However, considering the relationship between the two players (i.e., large government vs. small adversary), the equilibrium outcome is analogous to a opportunistic parasite (AoC) that does little harm to its healthy host (GoC). Note that ordinal scores in Table 4.4 indicate relative preference, but not magnitude. For example, GoC's ordinal score for stable outcome (in the box) is 8, but it is not four times better than its ordinal score of 2 for the outcome in which it aims at balanced procurement and the AoC expands operations. In the next section, the ordinal scores are converted to cardinal utility.

Mixed Strategies – Static Picture

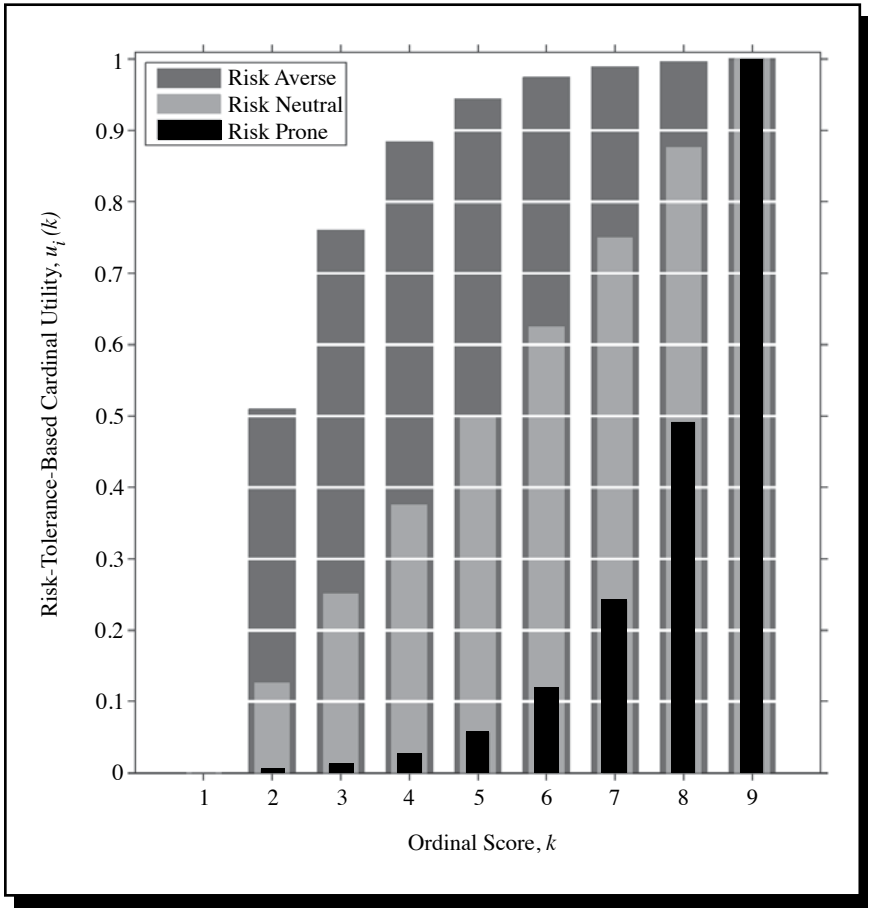
In a mixed strategy, a player selects its course of action in a probabilistic manner. This introduces an element of uncertainty. How players respond to uncertainty depends upon their risk tolerance. Therefore, the analysis of mixed strategies begins with the assessment of the players' risk tolerance (Keeney and Raiffa 1993). The quantitative evaluation of risk tolerance converts ordinal utility scores to risk-based cardinal values.

The method considers how a player chooses between a certain outcome and an uncertain lottery. A player prefers a certain outcome to an uncertain lottery unless the lottery offers a probability of a better outcome that is great enough. The analysis uses the following factors-of-two definitions for three kinds of risk tolerance:

1. *Risk aversion*. A risk-averse player accepts the lottery only if gain is at least twice as likely as loss.
2. *Risk neutrality*. A risk-neutral player accepts the lottery only if gain is at least as likely as loss.
3. *Risk prone*. A risk-prone player accepts the lottery only if gain is at least half as likely as loss.

Figure 4.2 graphically shows the results of applying the above risk-tolerance definitions. It illustrates how risk affects utility. The risk-tolerance-based cardinal utility of the risk-neutral player has a steady increase from the lowest ordinal score of 1 to the highest ordinal score of 9. The risk-prone player has a basin of failure at lower ordinal scores and a pinnacle of success at the highest ordinal score of 9. The risk-averse player has a chasm of failure at the lowest ordinal score and a plateau of success at the higher ordinal scores.

FIGURE 4.2
Risk-Tolerance-Based Cardinal Utility



Tables 4.5 and 4.6 show the two Mixed-Strategy Nash Equilibria (MSNE) that ordinary, textbook methods found (Osborne 2004). As shown in Table 4.5, each player mixes two actions probabilistically in MSNE-1: GoC mixes the aim of military advantage (89 percent probability) with the aim of indirect benefits (11 percent), and AoC mixes the expansion of operations (60 percent) with reduction (40 percent). In MSNE-2, shown in Table 4.6, both players mix all three of their actions: GoC mixes balanced procurement (20 percent), the aim of military advantage (71 percent), and the aim of indirect benefits (9 percent); AoC mixes expansion (57 percent), status quo (7 percent), and reduction (36 percent). Note that these mixtures cannot happen simultaneously. The probabilities reflect the likelihood that one would observe the action if one player observed the other player at random.

TABLE 4.5
Mixed-Strategy Nash Equilibrium One (MSNE-1) Probabilities When Risk-Neutral GoC and Risk-Prone AoC Both Play Two Actions

			Adversary of Canada		
			Expand	**Status Quo**	**Reduce**
			60*	0*	40*
Government of Canada	**Balanced Procurement**	0*	Ø	Ø	Ø
	Military Advantage	89*	[53]	Ø	[36]
	Indirect Benefits	11*	[7]	Ø	[4]

Note: * The percentage probability of the action in the MSNE.
[00] contains the percentage probability of the outcome in the MSNE.
Ø outcome does not occur in the MSNE.

TABLE 4.6
Mixed-Strategy Nash Equilibrium Two (MSNE-2) Probabilities When Risk-Neutral GoC and Risk-Prone AoC Both Play Three Actions

			Adversary of Canada		
			Expand	**Status Quo**	**Reduce**
			57*	7*	36*
Government of Canada	**Balanced Procurement**	20*	[11]	[1]	[7]
	Military Advantage	71*	[41]	[5]	[26]
	Indirect Benefits	9*	[5]	[1]	[3]

Note: * The percentage probability of the action in the MSNE.
[00] contains the percentage probability of the outcome in the MSNE.

Mixed Strategies – Dynamic Picture

In contrast to the static picture, the fundamental properties of Mixed-Strategy Nash Equilibria (MSNE) for the dynamic picture imply that the rate of change of the probability with which a player selects an action is proportional to the probability of selecting the action of interest and the difference between the expected utility of the action of interest and the expected utility of the entire mixed strategy (Gintis 2009).

If we sprinkle initial conditions over all mixed-strategy profiles, then

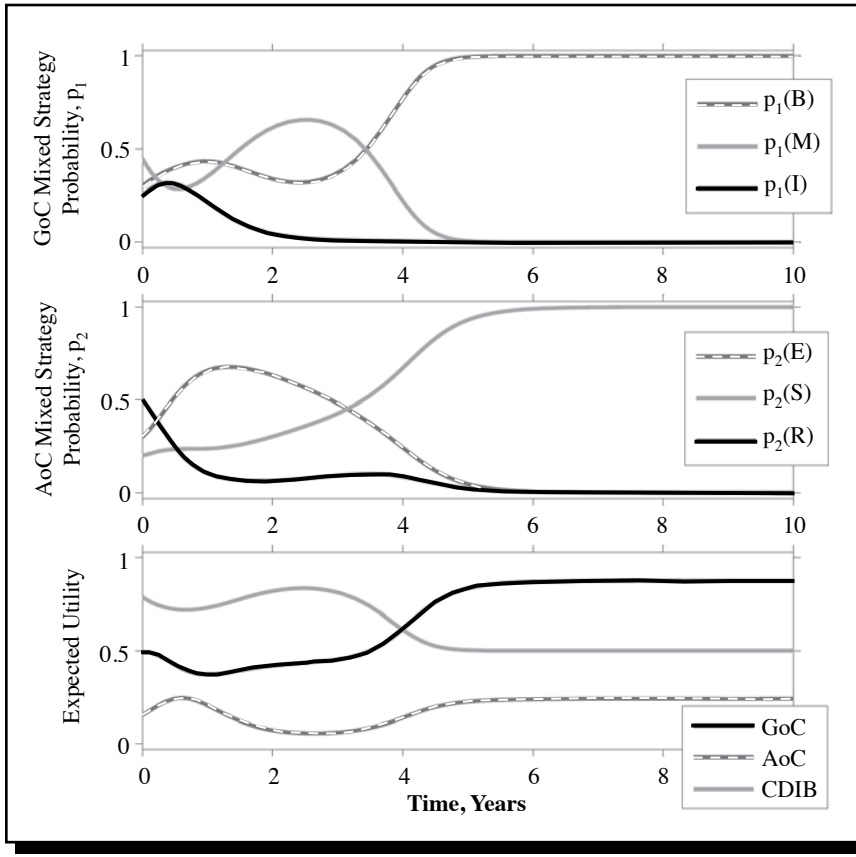
- Pure-Strategy Nash Equilibrium attracts about 65 percent of initial conditions (see Table 4.4);
- Mixed-Strategy Nash Equilibrium One (MSNE-1), in which both players mix two actions, attracts about 35 percent of initial conditions (see Table 4.5); and
- Mixed-Strategy Nash Equilibrium Two (MSNE-2), in which both players mix three actions, attracts no initial conditions (see Table 4.6).

Figure 4.3 shows how the strategic game evolves from a mixed strategy toward the pure-strategy Nash equilibrium in which the Government of Canada (GoC) aims at balanced procurement (*B*) and the Adversary of Canada (AoC) maintains the status quo (*S*). The AoC responds to the initial mixed strategy by expanding operations: the dashed line $p2(E)$ in the middle panel increases for about a year. GoC responds by aiming at military advantage: the grey line $p1(M)$ in the top panel increases from year one to three. After that time, AoC favours the status quo more and more: the grey line $p2(S)$ in the middle panel increases from year one onward, and reaches its maximum value of 1 by year six. Similarly, GoC favours balanced procurement more and more: the dashed line in the top panel $p1(B)$ increases from year two onward, and reaches its maximum value of 1 by year five.

Consider an indicator of the utility to the Canadian Defence Industrial Base of any mixed strategy. Since it is meant as an indicator only, factors of two are sufficient to lend it the required sensitivity to variations in the GoC's mixed strategy. The CDIB utility indicator

- depends on the GoC's mixed strategy only,
- varies with the probability that GoC aims at balanced procurement,
- varies with twice the probability that GoC aims at military advantage, and
- varies with half the probability that GoC aims at indirect benefits.

FIGURE 4.3
Mixed Strategy to Pure Strategy



Note: B = balanced procurement. M = military advantage. I = indirect benefits. E = expand. S = status quo. R = reduce. GoC = Government of Canada. AoC = Adversary of Canada. CDIB = Canadian Defence Industrial Base.

The last point is the "peace dividend," which has a paradoxical meaning for CDIB. As a first example, consider the bottom panel of Figure 4.3. During the evolution toward a steady state, the overall effect on GoC or AoC expected utility is the opposite of the effect on CDIB utility. In other words, the time-evolution increases the expected utility GoC and AoC above their initial values, whereas CDIB's utility ends up lower than it began. That is, while GoC aims at military advantage, related procurement spending is higher. However, once GoC favours balanced procurement, then procurement

spending falls. The important point is that the high spending levels (year zero to three) are unstable, whereas the moderate spending levels are stable (year five onward).

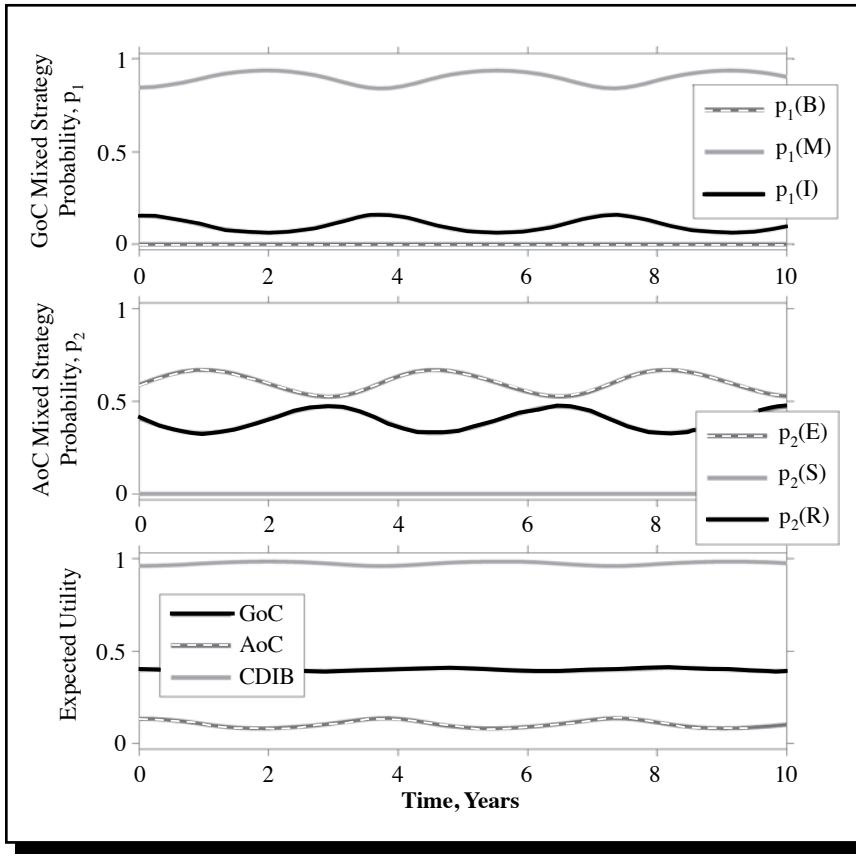
Consider the time-evolution of the mixed strategy shown in Figure 4.4. Here is a case in which the system fluctuates about the Mixed-Strategy Nash Equilibrium One (MSNE-1), but never settles upon it like the case shown in Figure 4.3. The strategic game cycles moderately about MSNE-1, detailed in Table 4.5. The amplitude of the oscillations is 5 percent or less, because the mixed strategy is initially near MSNE-1; the oscillation period is almost four years. The Government of Canada aims at military advantage with about 90 percent ± 5 percent probability: grey line $p1(M)$, top panel. GoC aims at indirect benefits with about 10 percent ± 5 percent probability: black line $p1(I)$, top panel. The Adversary of Canada expands operations with about 60 percent ± 7 percent probability: dashed line $p2(E)$, middle panel. AoC reduces operations with about 40 percent ± 7 percent probability: black line $p2(R)$, middle panel.

In the bottom panel of Figure 4.4, the black line represents GoC's expected utility and the dashed line represents AoC's expected utility. Note that GoC's expected utility is always greater than AoC's expected utility, but the amplitude of the oscillations in GoC's expected utility is noticeably smaller than the oscillations in AoC's expected utility. The grey line represents the Canadian Defence Industrial Base utility value, which oscillates near its maximum relative value of 1. Thus, GoC fares better than AoC, GoC's utility is less variable, and CDIB fares about as good as it gets, but with some variability.

The cyclic behaviour of the mixed strategy exhibits oscillations of greater amplitude in Figure 4.5 than in Figure 4.4 about MSNE-1, which is in Table 4.5. The amplitude of the oscillations is larger (30 percent or more) because the game was initially further from MSNE-1. The period of oscillation is about six years, which is longer than the case shown in Figure 4.4. GoC aims at military advantage for about three years of the six-year cycle: grey line $p1(M)$, top panel. GoC aims at indirect benefits with more than 50 percent probability for about half a year: black line $p1(I)$, top panel. The probability that the Adversary of Canada expands operations falls from 90 percent to 20 percent over an interval of about five years: dashed line $p2(E)$, middle panel. At the same time, the probability that AoC reduces operations rises from 10 percent to 80 percent: black line $p2(R)$, middle panel. Finally, there is a one-year reversal before the cycle repeats.

The player's expected utility curves, which appear in the bottom panel of Figure 4.5, all exhibit variations of about 0.1 to 0.2 in relative utility. The

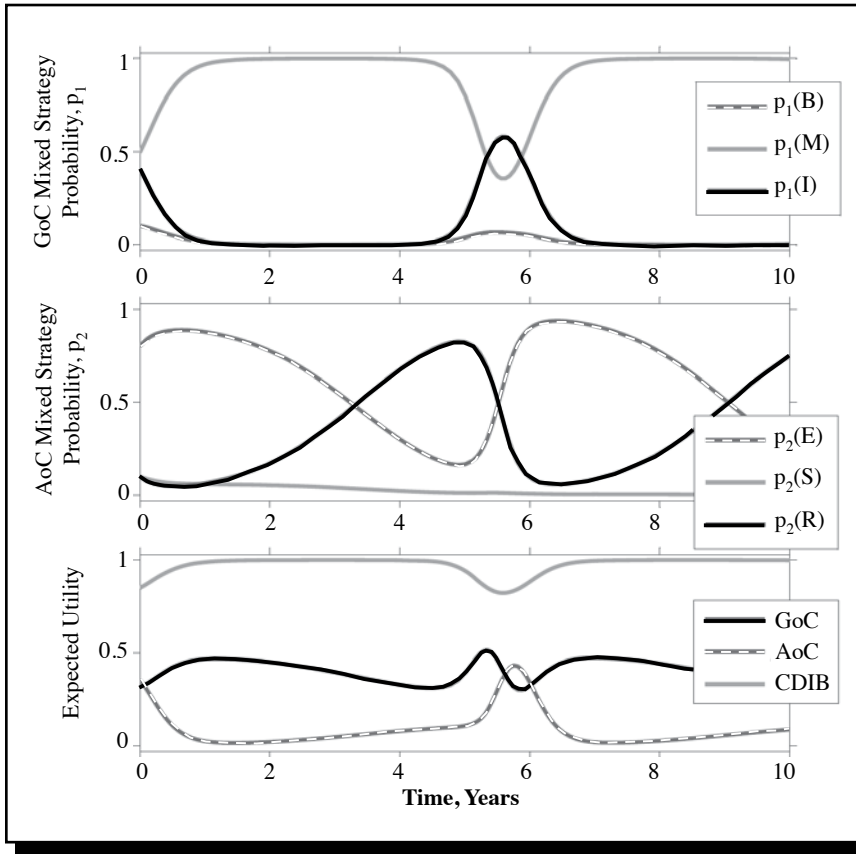
FIGURE 4.4
Mixed-Strategy Fluctuation around MSNE-1



Note: B = balanced procurement. M = military advantage. I = indirect benefits. E = expand. S = status quo. R = reduce. GoC = Government of Canada. AoC = Adversary of Canada. CDIB = Canadian Defence Industrial Base.

black line representing the GoC's expected utility is nearly always above the dashed line representing the AoC's expected utility, except for the short period of time (less than half a year) when the probability that AoC expands operations rises rapidly: dashed line *p*2(*E*), near year six, middle panel. The grey line representing the CDIB utility value stays near 1, except when the probability that GoC aims at indirect benefits peaks: black line *p*1(*I*), top panel. Thus, even in this scenario in which the GoC and AoC undergo large changes in mixed strategies, the CDIB fares well.

FIGURE 4.5
Oscillations around MSNE-1

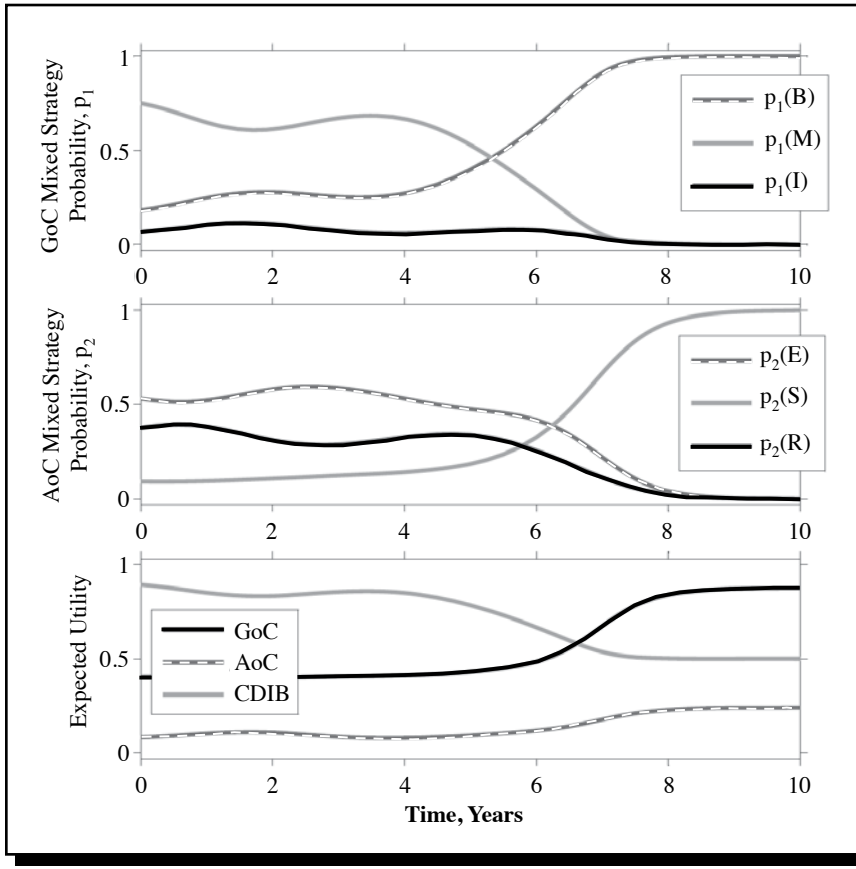


Note: B = balanced procurement. M = military advantage. I = indirect benefits. E = expand. S = status quo. R = reduce. GoC = Government of Canada. AoC = Adversary of Canada. CDIB = Canadian Defence Industrial Base.

Figure 4.6 shows a case in which the mixed-strategy probabilities evolve away from MSNE-2, for which Table 4.6 specifies the precise values of the steady-state probabilities. The mixed strategy evolves toward the pure strategy Nash equilibrium, in which the GoC aims at balanced procurement (*B*) and the AoC maintains the status quo (*S*). Table 4.4 has further details. Even though the initial mixed strategy was within ± 4 percent of the MSNE-2, this equilibrium point does not attract the mixed strategy.

The black line in the bottom panel of Figure 4.6 represents the GoC expected utility, which increases for the entire time interval, but increases

FIGURE 4.6
Mixed Strategy to MSNE-2



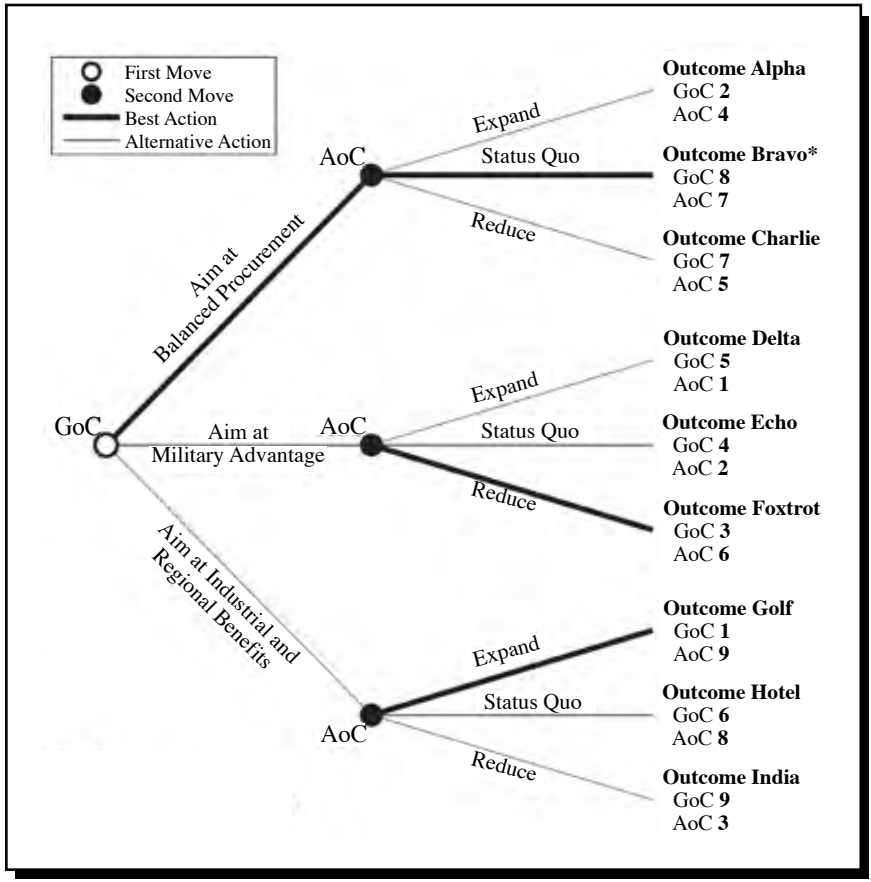
Note: B = balanced procurement. M = military advantage. I = indirect benefits. E = expand. S = status quo. R = reduce. GoC = Government of Canada. AoC = Adversary of Canada. CDIB = Canadian Defence Industrial Base.

quickest between year six and eight. The GoC expected utility reaches a greater value at year ten than its initial value. The dashed line shows that the AoC expected utility behaves in a manner similar to the GoC expected utility, except that it remains at a lower value and increases less. The CDIB utility value, which is represented by the grey line in the bottom panel, falls from its initial peak value of about 0.9 to settle on a lower value of 0.5. Although CDIB does better when the GoC and AoC mixed strategies are near the non-attracting MSNE-2, CDIB fares worse when the GoC and AoC are in the pure-strategy Nash equilibrium.

Extensive Game 1

Let the decision tree in Figure 4.7 represent Extensive Game 1 (EG1). That is, let Figure 4.7 define the move order (aka., player function) and the terminal histories for EG1. Let the terminal histories of EG1 correspond to the action profiles discussed at the beginning of this section for the strategic game (SG). Holding players and preferences constant, Figure 4.7 shows EG1 results: EG1 is a sequential-move analogue of the simultaneous-move model in Table 4.4.

FIGURE 4.7
Results of Extensive Game 1



Note: * Nash equilibrium. GoC = Government of Canada. AoC = Adversary of Canada.

Outcome Bravo, which has an asterisk in the game tree shown in Figure 4.7, is the stable outcome (technically, it is a subgame perfect equilibrium) that corresponds to a Nash equilibrium strategy profile, which combines the plan of action of both players. The stability of Outcome Bravo follows from the fact that if any decision maker changes his or her action, then the deviating decision maker suffers an outcome of lesser strategic value. Note that the sequential Outcome Bravo corresponds to the Nash equilibrium obtained simultaneously in the strategic game in Table 4.4. In other words, the same state resulted from both models.

Figure 4.7 shows that the extensive game without the threat of military advantage yields a Nash equilibrium at Outcome B (noted with an asterisk). The scores show that the government of Canada fares better (score of 8) than its adversary (score of 7), but they both fare well, which is typical of parasitic relationships in which the parasite has a relatively small (~1 percent) effect upon the host.

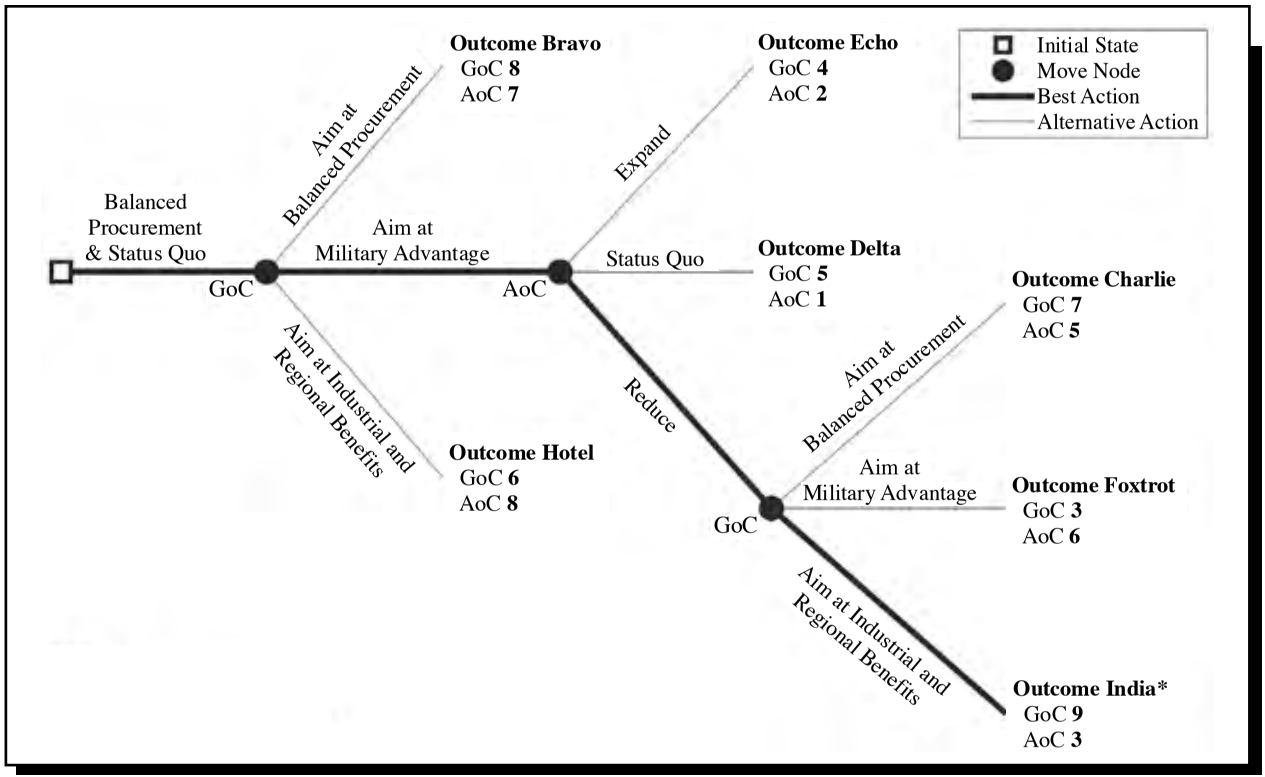
Extensive Game 2

Let the decision tree in Figure 4.8 represent Extensive Game 2 (EG2). Let Figure 4.8 define the move order and the terminal histories, and let the action profiles discussed at the beginning of this section correspond to terminal histories composed of the same latest actions, then *ceteris paribus* (players and preferences held constant) EG2 follows. Note that *Nature* moves to provide an initial state that corresponds to the Nash equilibria discussed earlier in this section and that is a terminal history in EG2 only if GoC aims at balanced procurement in its first move.

Outcome India is the outcome of the Nash equilibrium strategy profile, which combines the plan of action of all players:

- Nature's Nash equilibrium strategy profile is to simultaneously yield GoC aiming at balanced procurement and AoC maintaining the status quo;
- GoC's Nash equilibrium strategy profile is to aim at military advantage on its first move, and then aim at indirect benefits on its second move; and
- AoC's Nash equilibrium strategy profile is to reduce operations against Canada on its only move.

FIGURE 4.8
Results of Extensive Game 2



Note: The extensive game in which the threat of military advantage yields a Nash equilibrium at Outcome India (noted with a "*"). The Government of Canada (GoC) attains its best outcome (score of 9), whereas its adversary (AoC) fares much worse (score of 3).

Discussion

> The Federal Government is at the front end of a 20-year, $240B investment in rebuilding Canada's military across land systems, aerospace and maritime requirements. This is the most significant investment in a generation and will define not only the capability of the Canadian Forces, but also the shape and viability of Canada's defence industrial base for the next 20 years.
>
> —CADSI's Military Procurement Report (2009)

This discussion focuses on the implications of this study's results for the Canadian Defence Industrial Base, which was not an active player in the model but a passive agent (i.e., an "innocent bystander") in the conflict between the Government of Canada and the Adversary of Canada. The previous section introduced the CDIB utility indicator, which was simply a quantitative indicator of how much procurement spending could be expected given the procurement strategy of the GoC. The assumptions were as follows:

1. The CDIB utility indicator is high whenever GoC aims at military advantage, because procurement spending is highest;
2. The CDIB utility indicator is moderate whenever GoC aims at balanced procurement, because procurement spending is moderate; and
3. The CDIB utility indicator is low whenever GoC aims at indirect benefits, because procurement spending is lowest.

In the discussion to follow, the CDIB utility indicator serves as a convenient means to elucidate how well the CDIB fares under various scenarios involving the GoC and its enemy, AoC.

The Strategic Game

The model developed in the second section yielded the strategic game shown in Table 4.4. In a strategic game, the players select their actions simultaneously. The stable outcome corresponded to GoC aiming at balanced procurement and AoC maintaining the status quo. For this outcome, both GoC and AoC fared well: GoC attained its second-best outcome and AoC attained its third-best outcome. However, this stable state corresponds to a moderate value for the CDIB indicator.

Risk Tolerance and Mixed Strategies

The stable state discussed above was a pure-strategy Nash equilibrium, which means that GoC and AoC each selected a single action with complete certainty. In order to model uncertainty regarding the selection of actions, it was necessary to assess the risk tolerance of the two players. Having done that, the assumptions were that GoC was relatively risk averse and AoC was relatively risk tolerant. Quantitative risk-tolerance specifications allowed for the determination of Mixed-Strategy Nash Equilibria (MSNE). The stability of the MSNE follows from the fact that if a player deviates from a mixed strategy while the other does not, then the deviating player cannot fare better. The analysis found two MSNE.

The first equilibrium, MSNE-1, had both players mixing two actions:

- GoC aimed at military advantage with a probability of 89 percent and at indirect benefits with a probability of 11 percent; and
- AoC expanded its operations against GoC with a probability of 60 percent and reduced its operations with a probability of 40 percent.

The CDIB utility indicator is high for 89 percent of GoC procurements; therefore, CDIB fared well in MSNE-1.

The second equilibrium, MSNE-2, had both players mixing three actions:

- GoC aimed at balanced procurement with 20 percent probability, military advantage with 71 percent probability, and indirect benefits with 9 percent probability; and
- AoC expanded its operations against GoC with 57 percent probability, maintained the status quo with 7 percent probability, and reduced its operations with 36 percent probability.

The CDIB utility indicator is high for 71 percent of GoC procurements and moderate for 20 percent. Therefore CDIB still fared well in MSNE-2 but not as well as it did in MSNE-1.

Stability of Mixed Strategies

Modelling the strategic game as a dynamical system enabled further exploration of the stability of the pure and mixed strategies. The pure-strategy Nash equilibrium attracted about two-thirds of all possible mixed strategies, whereas MSNE-1 (two vs. two actions) attracted about one-third,

and MSNE-2 (three vs. three actions) attracted none. However, any mixed strategy attracted to the pure-strategy Nash equilibrium converged to that equilibrium; hence it was asymptotically stable. Mixed strategies attracted to MSNE-1 oscillated without attenuation about that equilibrium; thus, MSNE-1 was less stable, but the least stable of the equilibria was MSNE-2, from which mixed strategies diverged if they were offset.

The CDIB utility indicator is moderate for the dynamically stable pure-strategy Nash equilibrium, but it is high for the oscillatory MSNE-1 and moderate to high for the non-attracting MSNE-2. However, both MSNE-1 and MSNE-2 entail much more change over time than the highly stable pure-strategy equilibrium; the more changeable the situation, the higher the CDIB utility indicator. Therefore, the more suited the CDIB is for weathering variable procurement practices, the better it can take advantage of the good times.

Extensive Games

In the strategic game, including the time-dependent model, the GoC and AoC selected or updated their strategies simultaneously. Modelling sequential moves required the construction of extensive games. In Extensive Game 1, both players moved once, with the GoC moving first. The equilibrium yielded the same outcome as the strategic game. Thus, the same stable state manifested whether GoC and AoC moved simultaneously or sequentially.

Extensive Game 2 answered the question of whether GoC could improve its outcome. The answer was yes. GoC could force AoC to choose the best of a set of bad choices, such that GoC attains its best outcome and AoC falls to its third-worst outcome. In practice, this strategic activity would depend on GoC's willingness to initially aim at military advantage and then not aim at indirect benefits until AoC reduced its operations.

The CDIB utility indicator would be high after GoC's initial move in Extensive Game 2, but would fall to low after GoC's second move. The real-world example of this boom-and-bust scenario for the CDIB is the "peace dividend" that followed the end of the Cold War. Even though indirect benefits became the aim of procurement, the result was a reduction in GoC procurements. This model indicated that CDIB would face the same outcome for a generic conflict. Although the boom-and-bust cycle seems inevitable—even for a generic conflict—CDIB could anticipate such an outcome by recognizing when GoC and AoC act in accord with Extensive Game 2.

Impact on the Real CDIB

The results of the model agree with some findings of a recent Canadian Association of Defence and Security Industries report (CADSI 2009), but disagree with others. The first recommendation of the CADSI report is that GoC establish a Defence Industry Policy, which should align with the Canada First Defence Strategy (CFDS) and economic priorities. However, the model presented in this chapter suggests that the better CDIB can operate under uncertainty, the better it can take advantage of favourable conditions. The CFDS is not a permanent characteristic of the Canadian Forces, nor are current economic priorities.

It would be better for CDIB if the Defence Industry Policy was aligned with a more enduring characteristic of the Canadian Forces. This report made much of the notion of military advantage. The Canadian Forces are not a regional development agency; they are an armed force. The fundamental mission of the Canadian Forces is to prevail in armed conflict: that is the enduring characteristic with which the Defence Industrial Policy ought to align. In fact, the CADSI report agreed with this notion:

> They [CDIB representatives] acknowledged the policy should be a living document that is reviewed and updated regularly to ensure that it remains relevant to changing technology and to Canada's needs. The recently released update to the Australian Defence Industrial Policy was identified as a good template for Canada to consider. (CADSI 2009, 10)

The above quote is in complete accord with the principal results of this paper. Thus, CADSI's recommendation of alignment with the CFDS should be amended to recommend that a Canadian Defence Industrial Policy should align with the fundamental mission of the Canadian Forces and should change with the evolving strategic posture of the GoC. Explicit recognition of the variability of their relationship with GoC will help CDIB become adept at making the most of favourable conditions. Moreover, the CDIB must also acknowledge the impact of Canada's adversaries on their business, because knowledge of the enemy would do much to ensure that CDIB can profitably deliver the military advantage that the Canadian Forces will always require.

Concluding Remarks

The model of the strategic interaction between the Government of Canada (GoC) and the Adversary of Canada (AoC) focused on how GoC

procurement activity would influence AoC operations against Canada. The particular question of interest to the model GoC was: Should procurement aim at military advantage, aim at indirect benefits, or balance the two? For AoC, the strategic problem was whether to expand, maintain, or reduce its operations against Canada. The model Canadian Defence Industrial Base was a passive agent whose welfare depended upon the GoC procurement strategy. A utility indicator helped assess the effect on CDIB.

The model also included the risk tolerance of the two players: the GoC was relatively risk averse and the AoC was relatively risk tolerant. Those considerations allowed for the modelling of the time-evolution of the strategic interaction between GoC and AoC. The analysis found several equilibria. The most stable outcome had GoC aiming at balanced procurement and AoC maintaining the status quo. In that case, the CDIB fared moderately well.

The second-most stable outcome had GoC and AoC probabilistically mixing two strategies: GoC aimed at military advantage with 89 percent probability and indirect benefits with 11 percent probability; AoC expanded operations with 60 percent probability and reduced operations with 40 percent probability. If a mixture differed from the equilibrium point, it periodically fluctuated about the equilibrium point. Thus CDIB achieved its best outcome, but only sporadically.

The least stable outcome had both players mixing all of their actions, but any state that differed from the equilibrium point would evolve to one of the more stable equilibria. Again, CDIB fared well when the mixture was near the least stable equilibrium point, but was subject to less favourable variations when the two players moved away.

When the situation was stable, the CDIB fared moderately; when the situation was variable, the CDIB fared better. Therefore, if the CDIB is to make the most of good times, it must operate well under uncertainty. Furthermore, it must beware of a willingness on the part of GoC to aim exclusively at military advantage and a subsequent move by AoC to reduce operations. That pattern of activity is the harbinger of the "peace dividend": GoC procurement strategy aims at indirect benefits, which favours the CDIB, yet GoC procures less, which disfavours the CDIB. Therefore, a Canadian defence industrial policy must evolve with military-strategic and economic conditions, yet recognize the enduring goal of military advantage.

Future work on this model would split the GoC into three players: Department of National Defence, Public Works and Government Services Canada, and Industry Canada. Such a partitioning of GoC would enable an analysis of the internal strategic interactions that were absent from the

model presented in this chapter. Other players to add would be foreign prime contractors and, of course, the CDIB.

REFERENCES

Arcand, A. and I. Grigoroff. 2009. "Contract for Chinooks Strengthens CF Abilities at Home and Abroad." *Materiel Matters* (Fall). Accessed at http://www.forces.gc.ca/aete/newsmat-actualitesmat-eng.asp.

Canadian Association of Defence and Security Industries (CADSI). 2009. *Canada's Defence Industry: A Vital Partner Supporting Canada's Economic and National Interests*. Ottawa: CADSI. Accessed at http://www.defenceandsecurity.ca/UserFiles/File/IE/Military_Procurement_Main_Report_March_09_2010.pdf.

Defence Industries Directorate. 2005. *Canada's Industrial and Regional Benefits (IRB) Policy: An Info Kit for Small- and Medium-Sized Enterprises*. Ottawa: Industry Canada.

Fundenberg, D. and J. Tirole. 1991. *Game Theory*. Cambridge, MA: MIT Press.

Gintis, H. 2009. *Game Theory Evolving: A Problem-Centered Introduction to Modeling Strategic Interactions*. Princeton, NJ: Princeton University Press.

Keeney, R.L. and H. Raiffa. 1993. *Decisions with Multiple Objectives: Preferences and Tradeoffs*. Cambridge: Cambridge University Press.

Myerson, R.B. 1991. *Game Theory: Analysis of Conflict*. Cambridge, MA: Harvard University Press.

Osborne, M.J. 2004. *An Introduction to Game Theory*. New York: Oxford University Press.

Popper, K.R. 1994. *Objective Knowledge: An Evolutionary Approach*. Rev. Ed. Oxford: Oxford University Press.

van Bavel, G.H. 2009. *Completeness and Consistency by Relational Analysis of a System of Hypotheses*. DRDC CORA Technical Note TN 2009-035, distribution limited. Defence R&D Canada – CORA, August.

CHAPTER 5

Examining Canada and US Defence Industry Price Integration

Kamal Jayarathna

Introduction

Since the end of the Cold War, the global defence industry has experienced major changes in terms of the nature of potential threats, the capabilities required to address such threats, and the level of funding allocated to defence by governments. The global defence industry, including the Canadian defence industry, has responded to the changing landscape by transforming the industry through mergers and acquisitions, outsourcing, and becoming efficiency focused and specialized. Furthermore, a number of trade policies and agreements have been introduced by both Canada and the United States to facilitate the trade of defence industrial goods and services. The Canadian Defence Industrial Base (CDIB) is largely foreign-owned or subsidiaries of the large European and US aerospace and defence corporations. The CDIB is a small niche player and export dependent. The export orientation and reduced dependence on domestic defence procurement signals that Canadian plants operate efficiently enough to thrive in international markets (Solomon 2009). The Canadian defence industry is often referred to as an integrated part of the North American market.

The objective of this chapter is to examine the relationship between the Canadian and US defence industry from an inflation perspective to enhance the understanding of the causes of inflationary pressures on defence goods produced in Canada and also to examine the extent of price integration between the two countries.

The author wishes to thank Binyam Solomon and Chen Hu for many helpful comments and assistance in implementing a quantitative model.

Literature Review

A literature review was completed in the context of this study on the topics of Low of One Price, and Cointegration.

Low of One Price

A number of analytical tools are being employed to examine the integration of global industries: (1) analysis of trade and investment flows for a given industry between two countries, (2) examination of trade policies and reforms, and (3) analysis of inflation integration/convergence.

The market for a specific good is considered integrated if prices for the good in different localities move in tandem with each other over time. The notion of a spatially integrated market is consistent with Low of One Price (LOP) when abstracting from transportation and real-world frictions inhibiting trade. According to LOP the prices will either equalize (Absolute LOP) or move in tandem across freely trading areas (Relative LOP; Dornbusch 1987). The integration of spatial market is typically viewed as a measure of degree of integration rather than a specific relationship as is the case with strict adherence to the LOP (Fackler and Goodwin 2000). It is also seen as a long-run phenomenon.

In a competitive and efficient market, the prices would equilibrate or move in tandem due to the spatial arbitration. Where there is price disparity between two markets for similar products, the traders would seek profits by buying the commodity from one market and selling it in the other market, resulting in a disappearance of any significant price differentials. However, the presence of such factors as lack of price transparency, trade barriers, and monopoly power/lack of competition would restrict the degree of integration.

The LOP framework has been widely employed by applied economists to examine the integration of regional economies, product markets, and financial markets. Moodley, Kerr, and Gordon (2000) estimated an econometric purchasing power parity (PPP) model to examine the relationship between producer prices in Canada and the United States. Taking together the cointegration and Kalman-filter, the empirical results showed a convergence in the producer price indices and evidence of a long-run PPP relationship for the two countries. Vollrath and Hallahan (2006) adopted a detailed LOP framework to isolate the impact of foreign prices and foreign exchange rate on domestic prices of selected livestock and meat products between Canada and the United States. The empirical results demonstrated that Canadian–US hog- and pork-product markets were more integrated than

the Canadian–US steer- and beef-product markets. Evidence also showed that the Canadian–US exchange rate inhibits cross-border integration in these commodity markets.

Cheung and Lai (1993) accounted for measurement error in prices (e.g., the type of error that might arise when including non-traded goods in price indices used to test for international commodity arbitrage) in an econometric model of long-run purchasing power parity. The data used comprise monthly consumer price indices and monthly wholesale price indices.

Cointegration

Based on the appropriate unit-root test, if the data series are deemed to be non-stationary, as it is the case with many price indices, required level of differencing, integrated of order *d*, could be used (Box and Jenkins method) to transform them into stationary. The differenced data series are used for the analysis. In using this method, it is recognized that some important information, such as long-term equilibrium prices, could be lost due to the differencing.

In the empirical analysis, the cointegration techniques are commonly used to address this problem in testing market integration. The two most common approaches in testing cointegration are (1) the autoregressive distributed lag (ARDL) modelling approach, which can be applied regardless of the stationary properties of the variables (Pesaran and Pesaran 1997); and (2) the maximum likelihood approach, which implicitly requires or presumes that the variables under consideration are first-difference stationary (integrated of order 1; Johansen 1991). If such information is not readily discerned through unit-root tests, one cannot assess the existence of long-run relations. Solomon (2005) examined the determinants of the demand for Canadian military expenditures through the estimation of a demand for defence expenditures model for the time period 1952–2001 using, among others, the autoregressive distributed lag approach to cointegration to estimate and test cointegration and long-run relationships.

Methodology

The relative version of LOP (weak form) framework has been adopted for this chapter and is expressed as follows:

$$P^{D}{}_{t} = \beta_0 + \beta_1 P^{F}{}_{t} + \varepsilon_t, \tag{1}$$

where P^D and P^F refer to domestic prices and foreign prices denominated in a common currency while ε refers to the error term.

It should be noted that the relative LOP (weak form) framework accommodates for short-term price deviations but requires prices to move in tandem, on a one-to-one basis, in the long run. In the international context, it is often desirable to isolate the effect of exchange rates and to use own-currency prices (Goldberg and Knetter 1997). One can isolate the impact of foreign prices and foreign exchange rates in order to ascertain the extent to which domestic prices in local currency respond to these variables by decomposing equation (1) (Vollrath and Hallahan 2006). An econometric representation of the relative LOP model derived from equation (1) can be expressed as follows:

$$P_t = \beta_0 + \beta_a P^*_t + \beta_b FX_t + \varepsilon_t, \tag{2}$$

where P_t refers to domestic prices and P^* refers to foreign prices denominated in their respective national currency. FX refers to the spot exchange rates, defined as price of a unit of foreign currency in domestic currency terms, while ε refers to the error term. Transportation and other transaction costs are assumed to vary proportionally between the two regions and are assumed to be captured by β_0, the intercept.

β_a is defined as the price transmission elasticity, which is the responsiveness of the home-country price to a change in the partner-country price, while β_b is defined as the exchange rate pass through (ERPT) elasticity, which is the responsiveness of the home-country price to a change in the relative value of the US dollar to the Canadian dollar.

Given that this analysis emphasizes overall price levels (price indices) instead of the actual price of certain commodity products, the measurement error approach of Cheung and Lai (1993) is employed. True price indices are observed only with error. As such, a measurement error is introduced to the observed price indices. The econometric representation for observed price indices is expressed as follows:

$$p_t = A + \beta_1 p^*_t + \beta_2 FX_t + \mu_t, \tag{3}$$

where p and p^* refer to the observed domestic and foreign price indices, respectively, denominated in home currency; FX refers to the spot exchange rate, which is defined as the price of a unit of foreign currency in domestic-currency terms; and μ_t is a stationary error process term.

A positive β_1 implies that an increase in foreign prices would result in an increase in domestic prices. A positive β_2 implies that a depreciating domestic

currency (increasing ***FX***) would translate into higher domestic prices, while appreciating (decreasing ***FX)*** would lead to lower domestic prices.

The autoregressive distributed lag (ARDL) approach was adopted in testing for cointegration. Estimating a model using the ARDL approach to cointegration means estimating a model of the form

$$\theta(L,p)y_t = \alpha_1 + \alpha_2 T_t + \sum_{i=1}^{k} \beta_i(L,q_i)x_{\mathbf{i}} + \varepsilon_t \ , \qquad (4)$$

where x_{it} are exogenous variables, T_t is a deterministic time trend, and θ (L,p) and $\beta_i(L,q_i)$ are polynomial lag operators with maximum lags of p and q_i respectively (Pesaran and Pesaran 1997). The order of the distributed lag function on y_t and the forcing variable x_t are selected using the Schwartz Bayesian Criterion (SC).

The Pesaran and Shin (1999) test consists of adding, in the first differenced version of equation (4), lags of first differences of the variables so as to orthogonalize the relationship between the explanatory variables and the residual term *g*. Testing for cointegration then amounts to an F-test on the joint statistical significance of adding level regressors of the variables suspected to be cointegrated. Under the null hypothesis of no cointegration, the distribution of such an F-statistic is non-standard so the usual critical values do not apply. Pesaran, Shin, and Smith (2001) tabulated the relevant critical bounds for I(0) and I(1). Instead of the conventional critical values, this test involves two asymptotic critical value bounds, depending on whether the variables are I(0) or I(1), or a mixture of both. If the test statistic exceeds the respective upper critical values, then we can reject the null hypothesis of no cointegration regardless of the order of integration of the variables, thus providing evidence of a long-run relationship. If the test statistic is below the critical value, then we cannot reject the null hypothesis of no cointegration. If it lies between the bounds, inference is inconclusive.

The error-correction form of (4) can be represented as

$$dP_t = \beta_{0+} \sum_{i=1}^{N} \beta_1 \, dP^*_{t-1} + \sum_{i=1}^{N} \beta_1 \, FX_{t-1} + \varepsilon_t \, . \qquad (5)$$

A variable addition test where the lagged values of the level variables represented as

$$\phi_1 p_{t-1} + \phi_2 p_{t-1} + \phi_3 FX_{t-1} \, . \qquad (6)$$

One can use the variable addition test to fit a more parsimonious model of domestic prices of defence goods. For example, if by dropping a variable *x* from the model it ceases to be cointegrated, then we can infer that *x* has

a significant effect on the price levels of the domestic defence goods in the long run. However, if the reverse holds, then one can remove the variable. The use of the F-test to eliminate variables is similar to one employed by Beenstock (1998) to test significance of variables for cointegration in Israel's demand model. Specifically, if the null hypothesis in the test for long-run relations is sensitive to the removal of the variable in question, then one can safely assume that the variable in question is likely a long-run forcing variable explaining domestic defence inflation.

Data

The quarterly average industrial price indices for the aircraft sector[1] and shipbuilding sector[2] and nominal spot foreign exchange rates were used to conduct the empirical testing. In the absence of defence-specific price indices from Canada and the United States for these sectors, the broader price indices were selected for aircraft and shipbuilding sectors, which include both military and non-military goods. However, it should be noted that the industrial price index selected for the shipbuilding sector appears to have a much broader scope. The historical movement of selected price indices are shown in Figures 5.1 and 5.2. For illustration purposes, the indices are converted into a common base year of 1985Q1 = 1.

In this chapter the variables are summarized as follows: PDA = domestic (Canadian) aircraft and related equipment level; PFA = US aircraft price level; FX = nominal spot foreign exchange rate (CDN$/US$); PDS = domestic (Canadian) ships and boat building; and PFS = US shipbuilding and repair.

Empirical Results

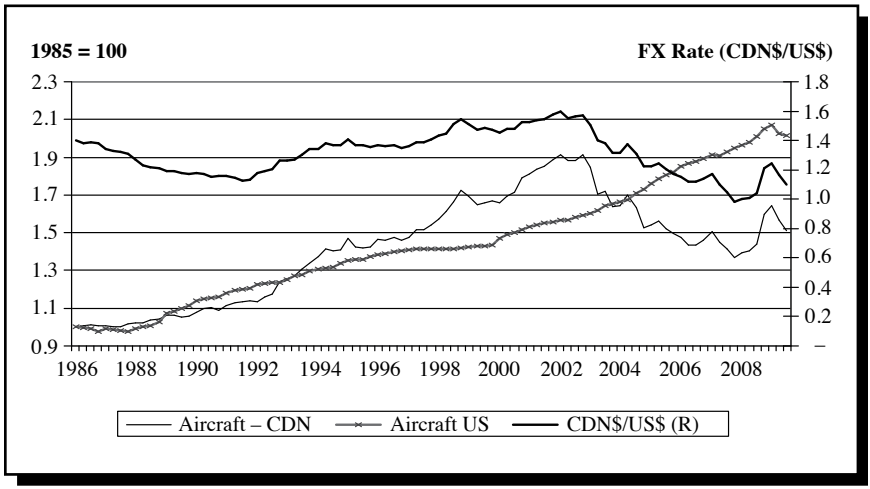
Variable Addition Test

The variable addition test (OLS case) was conducted using all three variables and using various lags. If the computed F-statistic falls outside the critical value band, a conclusive decision can be made without knowing

[1] CDN aircraft and related equipment (V1575661) versus US aircraft (PPI336411).

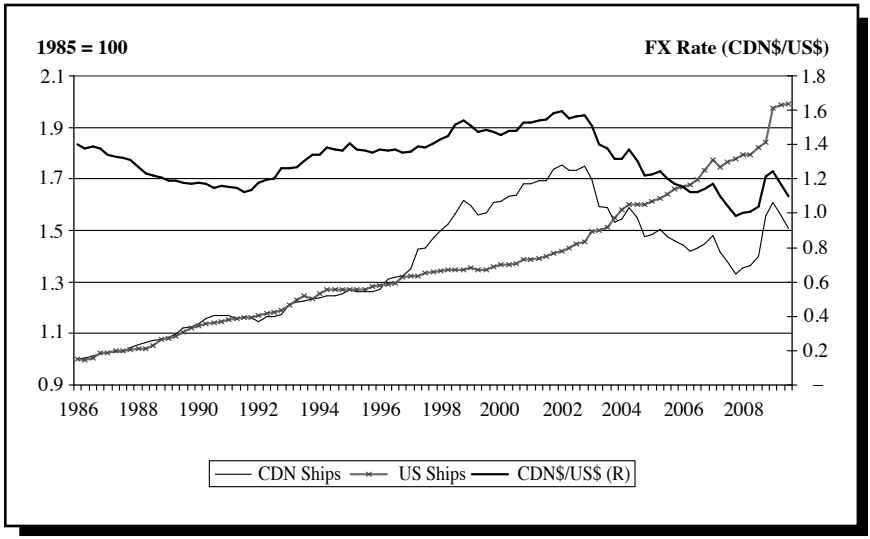
[2] CDN ships and boats (V1575673) versus US shipbuilding and repair (PPI336611).

FIGURE 5.1
Historical Price Indices – FX vs. Aircraft



Note: FX = nominal spot foreign exchange rate (CDN$/US$).

FIGURE 5.2
Historical Price Indices – FX vs. Ships



Note: FX = Nominal spot foreign exchange rate (CDN$/US$).

the order of integration of the variables. If the computed statistic falls within the critical value band, however, extensive unit-root tests have to be conducted on all variables. As shown in Table 5.1, the joint-F statistics (joint test of zero restrictions on the coefficients of additional variables) for aircraft sector variables do not fall outside of the critical values. As such, the tests of the null hypothesis of non-existence of the long-run relationship (no conintegration) between the dependent variable of domestic (Canadian) aircraft price level and the independent variables of US aircraft price level and nominal foreign exchange rate (CDN$/US$) through a joint testing of the level variables cannot be rejected.

TABLE 5.1
Variable Addition Test (OLS case)

Aircraft Sector		*Shipbuilding Sector*	
Dependent Variable	*F Statistic*	*Dependent Variable*	*F Statistic*
DPDA	2.369	DPDS	1.0281
DPFA	1.2534	DPFA	1.2534
DFX	2.7097	DFX	2.7097

Note: Ninety observations were used for estimation from 1987Q2 to 2009Q3. D denotes the first difference of the variables. PDA = domestic (Canadian) aircraft and related-equipment level. PFA = US aircraft price level. FX = nominal spot foreign exchange rate (CDN$/US$). PDS = domestic (Canadian) ships and shipbuilding. The critical values for F-statistics at 5 percent (Pesaran et al. 2001) I(1) with no restrictions on the intercept, and the trend is 5.85.

The joint F-statistics for the shipbuilding sector are also not significant. As such, the null hypothesis of non-existence of the long-run relationship between the dependent variable of domestic (Canadian) shipbuilding price level and the independent variables of US shipbuilding price level, and nominal foreign exchange rate (CDN$/US$) through a joint testing of the level variables cannot be rejected.

Unit Root Test

Unit root tests for all the time series were conducted using the Dickey-Fuller (ADF) regressions. The test indicates that all the time series DPA, FPA, FX, DPS, and FPS are of integrated order 1.

Error Correction Representation for the ARDL Model

In the absence of a long-term relationship between domestic prices, foreign prices, and exchange rates in both the aircraft and shipbuilding sectors, an error correction model was developed to identify any potential short-term relationships. The results are shown in Table 5.2 and 5.3 for the aircraft and shipbuilding sectors, respectively.

Aircraft Sector

The model points to a weak foreign price transmission into the domestic price levels (DPFA coefficient of 0.05), and a very strong foreign exchange rate pass through transmission into the domestic aircraft price level (DFX coefficient of 0.76). The error correction coefficient (ecm(-1)) is also very low, which implies slow responsiveness of domestic price adjustments due to a shock.

TABLE 5.2
Error Correction Representation for the Selected ARDL Model – Aircraft Sector

Regressor	*Coefficient*	*Standard Error*	*T-Ratio[Prob]*
DPFA	0.050893	0.028121	1.8098[.074]
DFX	0.76731	0.03591	21.3678[.000]
$D\beta_0$	0.1442	0.031658	4.5549[.000]
ecm(–1)	–0.091655	0.036291	–2.5256[.013]
R-squared	0.84992	R-bar-squared	0.84294
SE of regression	0.010231	F-stat. F(3, 87)	162.3464[.000]
Mean of dependent variable	0.0044465	SD of dependent variable	0.025816
Residual sum of squares	0.0090018	Equation log-likelihood	290.4406
Akaike info. criterion	285.4406	Schwarz Bayesian Criterion	279.1634
Durbin-Watson statistic	1.8963		

Note: ARDL(1,0,1) selected based on Schwarz Bayesian Criterion. D denotes the first difference of the variables. PDA = domestic (Canadian) aircraft and related-equipment level. PFA = US aircraft price level. FX = nominal spot foreign exchange rate (CDN$/US$). ecm = error correction term. β_0 = intercept.

Shipbuilding Sector

The short-term error correction model also reveals similar results for the shipbuilding sector, implying a weak foreign price transmission and a strong foreign exchange rate pass through transmission to domestic shipbuilding price level. The error correction coefficient is also low, indicating a longer price adjustment period due a shock.

TABLE 5.3
Error Correction Representation for the Selected ARDL Model – Shipbuilding Sector

Regressor	*Coefficient*	*Standard Error*	*T-Ratio[Prob]*
DPFS	0.035283	0.02109	1.6730[.098]
DFX	0.60764	0.041502	14.6413[.000]
$D\beta_0$	0.11002	0.040445	2.7203[.008]
ecm(–1)	–0.063962	0.02592	–2.4676[.016]
R-squared	0.72399	R-bar-squared	0.71115
SE of regression	0.011994	F-stat. F(3, 87)	75.1930[.000]
Mean of dependent variable	0.0043032	SD of dependent variable	0.022317
Residual sum of squares	0.012373	Equation log-likelihood	275.9693
Akaike info. criterion	270.9693	Schwarz Bayesian Criterion	264.6921
Durbin-Watson statistic	1.7849		

Note: ARDL (1,0,1) selected based on Schwarz Bayesian Criterion. D denotes the first difference of the variables. PDS = domestic (Canadian) ships and shipbuilding. PFS = US shipbuilding and repair. FX = nominal spot foreign exchange rate (CDN$/US$). ecm = error correction term. β_0 = intercept.

Summary and Conclusions

The LOP-based framework used in this chapter isolates the impact of foreign price levels and the foreign exchange on the domestic price levels while cointegration analysis using ARDL examines the potential long-term relationships among selected variables.

In light of the fact that we cannot reject the null hypothesis that none of the variables enter significantly in the equations for foreign price, and domestic and foreign exchange, there is no long-run relationships between domestic and foreign price as well as foreign exchange. Another factor is the error correction model of the equation, which shows that the error

correction coefficient is significant but closer to zero, further stressing the lack of long-term relationships.

Given the presence of the number of factors limiting full spatial arbitration opportunities in aircraft and shipbuilding industrial sectors, a sign of perfect market integration is not expected. As such, the results generated by the model are in-line with the expectation of non-perfect integration. The partial market integration would affect the magnitude of foreign price transmission. Given the limitations to spatial arbitrage, a low or modest level of foreign price transmission is expected. Canadian and US companies are integrated through the supply chain and export/import of inputs in various stages of the production process. This may explain the high degree of foreign exchange rate pass through to the domestic prices. Moreover, the size of the Canadian markets is a relatively small. As a result, US suppliers are not likely to adjust US$ base prices to maintain the same price in CDN$ (Canadian buyers are "price takers"), which would imply that the changes in the foreign exchange rate are likely to influence domestic prices. The foreign exchange rate appears to be a significant source of inflation, at the producer level, for the aircraft and shipbuilding sectors, which means the industry would have to realize productivity improvements and gain competitive advantage through new product innovation in order to be competitive and maintain the profitability. This would re-emphasize the importance of investing in research and development.

Despite the implementation of various free trade policies and military trade agreements between the two countries over the last several decades, empirical analysis fails to demonstrate any long-term price integration.

Limitations

Typical problems associated with the use of aggregate price indices relating to the comparability of the products, industrial structure, and tax regimes could influence the results of the analysis. A lack of comparable defence industry price data makes it difficult to draw specific conclusions with regard to defence-specific products.

REFERENCES

Beenstock, M. 1998. "Country Survey XI: Defence and the Economy in Israel." *Defence and Peace Economics* 9(3):171-222.

Cheung, Y. and K.S. Lai. 1993. "Long-Run Purchasing Power Parity during the Recent Float." *Journal of lnternational Economics* 34:181-92.

Dornbusch, R. 1987. "Purchasing Power Parity." In *The New Palgrave: A Dictionary of Economics*, edited by J. Eatwell, M. Milgate, and P. Newman, 1075-85. New York: Stockton Press.

Fackler, P. and B.K. Goodwin. 2000. "Spatial Price Analysis." In *Handbook of Agricultural Economics*, edited by G. Rausser and B. Gardner. North-Holland Press.

Goldberg, P.K. and M.M. Knetter. 1997. "Goods Prices and Exchange Rates: What Have We Learned?" *Journal of Economic Literature* 35(Sept):1243-72.

Johansen, S. 1991. "Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models." *Econometrica* 59:1551-80.

Moodley, R.D, W.A. Kerr, and D.V. Gordon. 2000. "Has the Canada-US Trade Agreement Fostered Price Integration?" *Review of World Economics* 136(2):334-54.

Pesaran, M.H. and B. Pesaran. 1997. *Working with Microfit 4.0: Interactive Econometric Analysis*. Oxford: Oxford University Press.

Pesaran, M.H. and Y. Shin. 1999. "An Autoregressive Distributed Lag Modelling Approach to Cointegration Analysis." In *Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium*, edited by S. Strom. Cambridge: Cambridge University Press.

Pesaran, H., Y. Shin, and R. Smith. 2001. "Bounds Testing Approaches to the Analysis of Level Relationships." *Journal of Applied Econometrics* 16:289-326.

Solomon, B. 2005. "The Demand for Canadian Defence Expenditures." *Defence and Peace Economics* 16(3):171-89.

— 2009. "The Defence Industrial Base in Canada." In *The Public Management of Defence in Canada*, edited by C. Stone. Toronto: Breakout Educational Network.

Vollrath, T. and C. Hallahan. 2006. "Testing the Integration of U.S.–Canadian Meat and Livestock Markets." *Canadian Journal of Agricultural Economics* 54(1):55-79.