

Estimating the Demand for
Defence Expenditures:
A Ratio Approach for Assessing
the Defence Burden and the
Determinants of Canadian
Defence Expenditures

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Introduction

Since the end of World War II and the onset of the Cold War era, economists have made significant contributions to the broad study of defence and strategic thought. A central area of focus for economists has been the study of collective-action within alliances and the mechanisms by which burdens are shared among members of a collective security regime. This field of investigation has considerable relevance for the Canadian security experience, as it is conventionally accepted that Canada's underinvestment in its military and defence institutions has been subsidized by the spill-in benefits derived from US defence expenditures and, to a lesser extent, from NATO defence expenditures.

However, with the exception of a few studies notably, Murdoch and Sandler (1982, 1991) and Murdoch, Sandler and Hansen (1991), econometric estimation of the demand for Canadian defence expenditures has been largely absent from the literature. The above studies treated Canada as a member of the NATO alliance, where theories of collective goods and alliance burden-sharing were the objective hypotheses tested, rather than being a country-specific analysis of national defence expenditures.

Typical country-specific analyses of defence expenditures attempt to develop models that estimate the real defence spending of a country over time. This was the case with a study performed by Solomon (2005) where Canada's real defence expenditures were estimated based on a single dynamic equation model with joint product specification. While an informative and useful approach to analysing defence spending, the study performed by Solomon (2005) fails to demonstrate the burden defence spending

places on the Canadian economy, which can only be demonstrated by expressing defence expenditures as a share of national income or GDP.

Therefore, the purpose of the following study is to develop a defence demand model for Canada using a single dynamic equation approach with joint product specification to estimate the defence burden on the Canadian economy and analyze critically the free-rider status of Canada in NATO and North American defence. As well, this paper will assess the impact, if any, of a military prices index on defence demand (an explanatory variable often dropped from estimation models) and assess the accuracy and capabilities of defence demand models that range in specificity from the neo-classical, tightly specified theoretical base, to a more loosely defined, atheoretical model.

The structure of this study will be as follows. Firstly, an elucidation of the theory of military alliances will be conducted and an associated literature review of pertinent studies undertaken. This section will provide theoretical insight as to the nature of defence outputs, that is, if defence outputs are a purely public good or possess some joint product characteristics. In either case, the analyst will be provided with several testable hypotheses that have significant implications for understanding the nature and dynamics of defence activities. The second section will discuss the neo-classical demand for defence model refined by Hartley and Sandler (1995) and review a selection of pertinent studies that employ this neo-classical model but which have been adapted for country-specific estimation purposes. The following section will provide a basic time-trend analysis of the determinants of Canadian defence expenditures since the end of World War II. Subsequently, a discussion of data-related issues including data sources and reliability, challenges of data compilation, and some econometric issues relating to

defence estimation will be presented. The next section will present the data, empirical model and method of estimation. The following section will discuss the empirical findings and the final section will conclude the analysis and suggest future directions of research.

Models of Military Alliances

As explained by Warr (1983) there is a close relationship between the theoretical literature addressing military alliances and the private provision of public goods literature.¹ Because the origins of some models remain unclear (for example, the joint product model appears to have its roots in military alliances), certain theoretical arguments can be linked primarily to military alliance literature.² Why this close relationship exists will become clear once defence, as an output of a single actor or an alliance of nations, is defined.

As defined by Olson and Zeckhauser (1966), and subsequently adopted as the standard definition, an alliance is a group of nations that are bound to provide protection to all members from aggression by common enemies.³ The alliance as a whole seeks security, or deterrence, which, from the perspective of the individual ally, is a public good. When individual allies aggregate their respective security or deterrence capabilities an alliance-wide public good is produced. This public good, regardless of whether or not it is purely or impurely public, provides an analyst with testable hypotheses about the behaviour of individual allies within a broader alliance such as NATO. Therefore, many public goods issues arise where economic analysis may be employed to examine, for example, methods of provision, resource distribution, allocative efficiency and burden sharing.

While there is a vast array of literature on the subject of demand for defence expenditures, one may differentiate studies by examining the theoretical specification from which the authors premise their analyses. Most studies will take a theoretical specification of either the Pure Public Goods Model or the Joint Product Model. The

choice of theoretical specification is significant because it informs us as to the nature and characteristics of the good being studied and determines which theoretical hypotheses deserve empirical attention.

The following two sections will discuss the theoretical framework of the Pure Public Goods Model and the Joint Product Model. Following this treatment some empirical contributions will be reviewed according to the theoretical specification employed; as well, other studies that do not fit neatly in either category but are nonetheless significant for their novel approach or hypotheses will be reviewed. The following mathematical sections have been taken from Smith (1995), which source was selected for its thoroughness and wide-ranging acceptance by the defence economics community.

The Pure Public Goods Model

The Pure Public Good Model characterizes the behaviour of an ally who belongs to an n -country alliance. The i th ally is assumed to allocate its national income, I^i , between military activity, q^i , and a private non-defence numeraire good, y^i . The military activity produces a pure public good for all allies, called deterrence, z^i . The production relationship is governed by

$$z^i = f(q^i) \quad (1)$$

where $df/dq^i = f' > 0$ and $d^2f/dq^{i2} = f'' \leq 0$. Alternative specifications of equation (1) are employed in the literature. The most common specification is to simply set $z^i = q^i$ (Sandler, 1993). The qualitative conclusions of the model are basically unaffected by these restrictions and we maintain Equation (1) for more generality and to set up the joint product model.

Total deterrence, Z , is non-rival and non-excludable; thus, all allies receive Z regardless of how much they contribute. The *technology of public supply* in the basic, pure public good model is additive with unit weights on contributions:

$$Z = \sum_{i=1}^n z^i \quad (2)$$

This simple aggregation implies perfect substitutability of z^i among allies. As discussed below, this technology may not be appropriate for some alliances.

From the i th country's perspective, total deterrence is

$$Z = z^i + \tilde{Z}^i, \quad (3)$$

where \tilde{Z}^i is the level of deterrence that “spills-in” to a country i . Using equations (1)-(3)

we can express Z as a function of the q^i ’s:

$$Z = f(q^i) + \sum_{j \neq i} f(q^j) = f(q^i) + h(\tilde{Q}^i), \quad (4)$$

with $h' > 0$ and $h'' \leq 0$. Here we are implicitly assuming a functional form for the $f(\cdot)$

function such that $h(\tilde{Q}^i) = \sum_{j \neq i} f(q^j)$.

The budget constraint for ally i is

$$I^i = y^i + pq^i, \quad (5)$$

where p is the price per unit of the military activity and the price of the numeraire has been normalized to one. The preferences of the i th ally are assumed to be represented by an unspecified agent with a utility function,

$$U^i = U^i(y^i, Z, E^i), \quad (6)$$

where E^i represents (possibly) a vector of exogenous environmental influences that shift the utility function. In many treatments, E^i represents, in part, the military strength of the allies common enemies, referred to as threat. Other influences included in E^i may be the price of oil or periods of time. Rather than denoting the preferences of an agent for the entire nation, the utility function may represent other decision makers. For example, Dudley and Montmarquette (1981) and Murdoch, Sandler and Hansen (1991) test the median voter hypothesis by redefining Equation (5) to reflect the budget of the median voter. In this case, the optimal choice of the median voter is assumed to be translated into national action.

Substituting Equation (4) into (6), we specify the Nash problem for ally I as

$$\max_{y^i, q^i} \{U^i(y^i, f(q^i) + h(\tilde{Q}^i), E^i) \mid I^i = y^i p q^i\}. \quad (7)$$

A Nash equilibrium requires a vector $q^* = (q^{1*}, \dots, q^{n*})$ and $y^* = (y^{1*}, \dots, y^{n*})$ such that Equation (7) is simultaneously satisfied for every ally. The first-order conditions require satisfaction of the budget constraint and

$$f MRS_{Zy}^i = p, \quad (8)$$

where MRS_{Zy} denotes the marginal rate of substitution of deterrence for the private good.

Equation (8) illustrates that each ally will provide q^i until their marginal valuation of deterrence, weighted by the productivity of q^i in producing deterrence, is equal to the marginal cost of q^i . The allocative inefficiency of the Nash equilibrium is evident in

Equation (8), since a Pareto optimal level of Z would require that $f' \sum_i MRS_{Zy}^i = p$. The

Nash solution generates a provision level that is less than the Pareto level, because each ally does not consider the marginal valuation of the other allies that its defence provision conveys.

At a Nash equilibrium, the first order conditions of Equation (7) imply a set of “demand” equations for the military activity:

$$q^i = q^i(I^i, p, \tilde{Q}^i, E^i), \quad (9)$$

illustrating that the demand for military activity depends on the national income, price per unit of activity, the total military activity of a nation’s allies, and various shift measures.

The demand equations facilitate hypotheses about the relationships between q^i and the exogenous variables. For example, comparative static results suggest a direct relationship between q^i and I^i and an inverse relationship between q^i and p , assuming that the

military activity is a normal good Murdoch and Sandler (1984). Moreover, the comparative static relationship between q^i and \tilde{Q}^i , $(\partial q^i / \partial \tilde{Q}^i)$, is expected to be negative and is called the slope of the “reaction path”. Much of what distinguishes the alliance literature concerns this reaction path; i.e., how one ally responds to the actions of the other allies. In contrast, arms-race models concern how an ally responds to the actions of an enemy over time; hence, the analysis focuses on $(\partial q^i / \partial \tilde{Q}^i)$ in a dynamic model.

The Joint Product Model

Olson and Zeckhauser (1966) produced the seminal economic model for understanding military alliances; however, by the late 1960s there emerged certain observable facts that were not explained by their model. A central conclusion of Olson and Zeckhauser's Pure Public Good Model was that there existed a strong correlation between economic size and defence burden size but as observed by Russett (1970), this correlation was now insignificant for a sample of NATO countries.⁴

One possible solution for this discrepancy was forwarded by van Ypersele de Strihou (1967), who argued that defence burden sharing must be influenced by the "private benefits" of defence which might include such activities as: the protection of colonial interests; drug traffic interdiction; search and rescue; and, aid to the civil power. These activities are described as private benefits because they are only available to the nation undertaking such activities but not to the other members of the alliance. Therefore, given these assumptions, the benefits may be considered purely public to the citizens of the providing nation, but are private to the citizens of the other nations in the alliance as they could be withheld for purely domestic purposes. As van Ypersele de Strihou (1967) concludes, if private benefits are a significant proportion of the defence benefits received, burden sharing is more likely to reflect the benefits-received principle.⁵

Sandler (1977) extended the analysis by proposing a joint product model, for which the defence activity of an ally produces a vector of outputs that may be purely public (e.g., deterrence), impurely public (e.g., damage limitation), and private (e.g., policing terrorist activities at home).⁶ This work by Sandler (1977) was a significant contribution to the alliance theory literature because, as an extension of the pure public

good model, it facilitated a more accurate modeling of complex contemporary military arsenals. For example, for nations that possess both a conventional and a nuclear weapons arsenal, where both pure and impure defence goods are produced, the joint product model can be used to assess the particulars and proportion of the benefits derived from each good. For these reasons the joint product model has numerous applications to public economics, providing analysts with a variety of testable hypotheses.

In the basic joint product model, the military activity, q^i , produces the pure public good, z^i , as described above, and a private good, x^i , which enters the ally's utility function. The joint product relationships are

$$x^i = g(q^i), \quad z^i = f(q^i), \quad (12), (13)$$

while the utility function is

$$U^i = U^i(y^i, x^i, Z, E^i), \quad (14)$$

where $g' > 0$, and $g'' \leq 0$, and f is as described above. Substituting Equation (12) and (4) into (14), the Nash problem for the i th ally is derived

$$\max_{y^i, q^i} \{U^i(y^i, g(q^i), f(q^i) + h(\tilde{Q}^i), E^i) \mid q^i = y^i + pq^i\}, \quad (15)$$

which is the same as Equation (7) except for the addition of the private defence output, x^i . Once again, the Nash equilibrium requires vectors q^* and y^* such that Equation (15) is simultaneously satisfied for all allies.

The first-order conditions imply that

$$g'MRS_{xy}^i + f'MRS_{zy}^i = p. \quad (16)$$

Hence, each ally equates the weighted sum of its MRS for the private defence good and the MRS for the public defence good to the price, where the weights are the marginal

products of the defence activity in producing the defence outputs. As in the pure public good model, the equilibrium is still suboptimal in the Pareto sense, because each ally only considers its MRS_{Zy}^i in the provision decision; Pareto optimality would require a summing over all MRS_{Zy}^i 's. The joint product model provides a plausible explanation to the phenomenon noted by Russett (1970); if the military activities of individual nations generate more private benefits, then the level of q^i must increase to satisfy Equation (16), making the burdens more equitably shared. However, the largest alliance contributor may value private benefits even more which could therefore work against this equality of defence burdens.

The joint product model implies a demand equation that appears the same as that implied by the pure public good model. Thus, the first-order conditions of Equation (15) (by the implicit function theorem) imply

$$q^i = q^i(I^i, p, \tilde{Q}^i, E^i) \quad (17)$$

However, the relationship between q^i and \tilde{Q}^i in Equation (17) is potentially quite different when compared to the same relationship in Equation (9). Murdoch and Sandler (1984) noted $(\partial q^i / \partial \tilde{Q}^i)$ may be positive or negative in the joint product model; a key determinant in signing this derivative is the complementarity of the joint products. When the joint products are Hicksian complements (two goods are Hicksian complements if the Hicksian compensated demand for one good falls when the price of the other good rises) the derivative may be positive – the opposite of the predicted sign in the pure public good model.

Murdoch and Sandler (1991) argued that the different theoretical results observed from the derivation of the joint product model have important implications for understanding NATO because the alliance switched from providing protection via a nuclear deterrent (the doctrine of massive retaliation colloquially known as MAD or mutually assured destruction) to protection via a mix of conventional and nuclear forces (the doctrine of flexible response). According to the flexible response doctrine, NATO should respond to external threats in a variety of ways; e.g. conventional ground forces, air power, or limited nuclear strikes. Hence, as would be predicted by the joint product model, the latter doctrine enhanced the complementarity of the private and public defence goods. The result of this effect, over time, is to generate more equalized burdens in NATO.

Empirical Studies of the Pure Public Goods Model and Joint Product Models

Early empirical studies employed cross-sectional data from select NATO members to investigate the relationship between the economic size and the defence expenditure burden of an alliance country. Of particular interest at the time was to understand why there existed such a disparity of defence burdens among NATO members. A lack of available time-series data prevented Olson and Zeckhauser (1966) from using such statistical methods when they first proposed their economic theory of alliances; however, by the second half of the 1970s enough variation in time-series data for each NATO ally was available and a switch to time-series analysis occurred. Not only did methodology change but the objective of such analyses shifted from burden sharing to estimating national demand equations for defence expenditures (see equations (9), (17), and (22), for examples). Several direct tests of the public goods model as well as investigating how and why defence burdens may fluctuate among allies became central research questions in this time-series era.

Since Olson and Zeckhauser (1966), there have been many empirical studies which have sought to analyze the economic dynamics of military alliances. Similarly, one can classify such studies in many different ways; therefore, this analyst will provide a brief review of the empirical works that demonstrate the range and breadth of the issues and methodologies within the economics of alliance literature. The studies have been organized according to their theoretical specification, that is, by pure public goods model or joint product model. As well, studies that have taken a novel methodological or issue-based approach have been included to show the burgeoning use of the atheoretical

method of estimation where a strict theoretical specification is replaced by a choice of descriptive variables.

Pure Public Goods Tests

Olson and Zeckhauser (1966) hypothesized that within an alliance, and all else being equal, larger nations, in terms of economic size, should “devote larger percentages of their national incomes to defence than do the smaller nations”. They sought to test this hypothesis by examining the Spearman rank correlation coefficient between GDP and the defence budget as a percentage of GDP in 1964 for fourteen NATO nations. The alternative hypothesis of positive association between variables was accepted and the null hypothesis of no association was not accepted. Therefore, free-riding, as predicted by the pure public goods model, and which subsequently gained support from this simple analysis, demonstrated the ability of smaller NATO allies to exploit the larger allies. One point of interest that emerged from their study was the definition of defence burden (i.e. the percentage of national income devoted to defence) became the *de facto* definition and not until the 1980s did alternative measures and definitions for defence burden emerge.⁷

Although data permitted a parametric analysis of NATO allies, by, for example, regressing national income on defence burden, Olson and Zeckhauser were reluctant to take such an approach. Rather they cited a central deficiency of the ordinary least squares estimation (OLS) procedure. This deficiency lies in the fitting technique of OLS whereby observations are weighted by their squared deviations from the mean. Therefore, when examining an alliance system like NATO, where, like other alliances, there are members who are relatively large (the USA) and relatively small (Luxembourg), OLS estimation

gives too much weight to the very large nation such that the fitted line is forced through that point regardless of the general pattern of the other data points. Such a procedure results in misleading parameter estimates that are of little statistical value. To overcome this deficiency, Dudley and Montmarquette (1981) formulated the median-voter model whereby data was pooled from NATO countries (and other alliances) into one cross-sectional sample.⁸

Smith (1995) summarizes the medium-voter model estimated by Dudley and Montmarquette where all expenditures are in real terms:

ME_i = military expenditures in nation i ,

N_i = population in nation i ,

GNP_i = gross national product in nation i ,

$SPILL_i$ = sum of the ME_i nation i 's allies that are in the sample,

$OSPILL_i$ = sum of the ME_i of nation i 's allies that are not in the sample,

E_i = auxiliary variables that may shift the relationship

Then using a Stone-Geary utility function, they derive an empirical approximation to the demand for defence as:

$$\frac{ME_i}{N_i} = \beta_0 + \beta_1 \left(\frac{GNP_i}{N_i} \right) + \beta_2 + \left(\frac{1}{N_i^{1-\alpha}} \right) + \beta_3 \left(\frac{SPILL_i + OSPILL_i}{N_i} \right) + \beta_4 E_i + \varepsilon_i \quad (18)$$

where the β 's are unknown parameters and ε_i is a random disturbance term. The inverse

population measure $\left(\frac{1}{N_i^{1-\alpha}} \right)$ facilitates a test of the publicness of defence in consumption

since, as α approaches zero, defence approaches a pure public good in the model. The linearity of the form and the test for publicness are artefacts of the Stone-Geary utility function.

Dudley and Montmarquette (1981) used data from 38 countries and several alliances in their analysis. The parameters were estimated with data from 1960, 1970, and 1975, using a full-information maximum likelihood (FIML) routine. The FIML estimator was necessary because of the simultaneity between ME_i and $SPILL_i$. The results generally supported the pure public model with the median-voter as the decision maker; i.e., β_1 was positive and significant, β_3 was negative and significant, and α was not significantly different from zero. To solve for the underlying parameters of the model Dudley and Montmarquette employed a Stone-Geary utility function which allowed them to determine that defence was a superior good, where income elasticity is greater than one, and that the elasticity with respect to the tax price of defence was somewhat elastic.

As described above the equalization of defence burdens within NATO resulted in the formulation of the joint product model, an extension of the pre-existing pure public goods model. Oneal (1990a, 1990b) and Oneal and Elrod (1989) argued that, with respect to NATO, the basic predictions of the pure public good model held true well into the 1980s. Additionally, they argued that the potential for complementarity between the joint products, owing to the doctrine of flexible response, was actually quite limited.⁹ Murdoch and Sandler (1991) provide a critique on this point. The authors noted that even into the 1980s, NATO resembled a “uniquely privileged group” with the USA shouldering the bulk of the defence for the alliance. Although this argument is much more complex than this simple observation would suggest, empirical testing provided evidence (given

appropriate controls and assumptions) that the estimated relationship between measures of defence burden and measures of economic size is positive and significant. The problem with the simple rank correlations which, as indicated above, showed the relationship was not significant after the mid-1960s, is that they do not hold the other influences constant (Smith 1995).

Oneal (1990a) used data from 15 NATO countries for the years 1950-1984 to estimate the following relationship:

$$\frac{ME_i}{GDP_{it}} = \beta_0 + \beta_1 \left(\frac{GDP_i}{\sum_i GDP_{it}} \right)^2 + \beta_2 E_{it} \quad (19)$$

Thus, the economic size variable is stated relative to the total economic size of NATO, where size is gross domestic product (GDP). Other variables included by Oneal (1990a) are: a measure of Soviet defence burden; European interdependence; and, two dummy variables, one indicating Greece, Turkey and Portugal and one indicating the other European nations. The parameters are estimated using a pooled, time-series, cross-sectional estimator and it was determined that the estimate on β_1 was positive and significant and robust to alternative samples and transformations of the size measure.

Another interesting application of the pure public goods model was provided by Okamura (1991) wherein the author sought to test the USA-Japan alliance under the aforementioned theoretical specification. Okamura employed a Linear Logarithmic Expenditure System (LLES) to derive the Nash reaction function for the USA and Japan. The real defence expenditures of the Soviet Union (*THREAT*) entered both reaction

functions, while the defence expenditure of the NATO allies, excluding the USA (ME_N) entered the US equation. Price deflators for military expenditure and consumption, P_M and P_C , were also employed and the parameters of the two equation system (γ 's, α 's, β 's) were estimated using the expenditure share equations.¹⁰

Consistent with pure public model, the LLES estimates performed as expected. The USA and Japan both responded positively to GDP and Soviet defence expenditures. The USA responded negatively to Japan's defence expenditures and a similar effect was observed for Japan, which responded negatively to the defence spending of the USA. Okamura reported a stable Nash equilibrium, with the USA spending \$150.79 billion and Japan spending \$51.64 billion in 1982 dollars. This study deserves special attention for its inclusion of a measure of military prices despite the failed expectation of significance of that price term in the demand equation for Japan (Smith, 1995).

Joint Product Model Tests

Sandler and Forbes (1980) sought to test the pure public goods model and predictions from the joint product model using data from NATO allies by extending the empirical methodology of Olson and Zeckhauser (1966). In their first test, they computed a year-by-year Kendall rank correlation statistics (τ) between GDP and ME_i / GDP_i . Sandler and Forbes found generally significant correlations before 1967 but insignificant correlations afterwards and this fell in line with their expectations. Furthermore, they extended their analysis by computing the first and second order partial τ 's in an attempt to hold constant the private benefits of defence that were specified by the joint product model. In the first order τ , the GDP per capita was held constant, while the second τ ,

both GDP per capita and the exposed border variable were held constant. Sandler and Forbes concluded that they must reject the pure public goods model because even at higher-order statistics, their observations were generally insignificant after the year 1967 (Smith, 1995).

Following the rejection of the pure public goods model, Sandler and Forbes looked for evidence in favour of the joint product model, arguing that under the joint product model, the private benefits of defence rather than the relative economic size of an ally, should predict the level of defence burden sharing. By comparing the relative defence burdens ($ME_i / \sum_i ME_i$) to a private benefit measure, Sandler and Forbes found that by 1975 the private benefits did in fact predict the defence burdens better, when compared to 1960. The private benefit variable was compiled by taking the average share of GDP, exposed border and population of NATO members to the entire alliance. While the questions and hypotheses posed by Oneal (1990a) and by Sandler and Forbes (1980) are similar, the two studies used different statistical methods and arrived at what are basically opposite conclusions. Further studies on the subject have revealed that the conclusions reached by Sandler and Forbes should be more highly favoured owing to the amount of supporting evidence that has subsequently emerged (Smith, 1995).

The emergence of the comparative method of analysis of the demand for military expenditures was precipitated by two papers written by Murdoch and Sandler (1982, 1984). Just as the theoretical basis for understanding burden sharing within a military alliance underwent a paradigmatic shift from the pure public to the joint product, so too had the empirical methods of studying alliances changed from the cross-sectional approach to the time-series approach. This change in methodology emphasized the

significance and utility of conducting country-by-country comparisons of the demand for military expenditures. Murdoch and Sandler's demand interpretation was derived from the reduced-form demand equation [see Equation (17)]. By setting the price of military activity to one, the authors expected that military expenditures would best measure military activity, q^i . The following equation is the classical estimation function for military expenditure that is so widely accepted today, where:

$$ME_{it} = \beta_{i0} + \beta_{i1}GDP_{it} + \beta_{i2}SPILL_{t-1} + \beta_{i3}E_{it} + \varepsilon_{it} \quad (20)$$

for each ally i in an alliance. Thus, they generally presented an estimated equation for *each ally* that was based on the time-series variation in the data. Various measures have been considered for E_{it} , including the ratio of the USA's strategic defence force to that of the Soviet Union's, force thinning, the price of oil, a dummy variable for the Vietnam War, and Soviet defence expenditures. The simultaneity between ME_{it} and $SPILL_{it}$ was addressed by lagging the spill-in measure (Smith, 1995).

The findings of the Murdoch and Sandler (1984) study were mixed. For some of the NATO allies, the response to spill-ins (β_{i2}) was positive (5 out of 10), while for others it was negative. Although a negative response to spill-ins was reported for some of the NATO members, such an occurrence is not necessarily inconsistent with the pure public good or joint product model; contrarily, for those members who reacted positively to spill-ins, this means necessarily that the pure public model must be rejected. The doctrinal shift to flexible response adopted by NATO provided the real-world justification to develop a more specific test of the joint product model. Such a policy

shift, it was reasoned, would result in increased complementarity between the joint products of defence, and, therefore, a shift in the β_{i2} coefficient toward the positive direction could be expected. In line with expectation, their estimates [see Equation (20)] with a slope shifter on $SPILL_{it}$ after 1974 indicated that β_{i2} was more positive after the doctrine of flexible response in 7 out of 10 allies in their sample. Therefore, Murdoch and Sandler concluded that, based on the evidence of a positive β_{i2} coefficient for a majority of the NATO allies, the joint product model should be accepted.¹¹

Hansen, Murdoch and Sandler (1990) provided another study of the utility of the joint product model for predicting the free-riding behaviour of NATO members. Their approach involved the separation of military expenditures in NATO into expenditures on conventional forces and strategic forces. Such an approach facilitated the identification of complementarity between conventional forces and substitutability between conventional forces and strategic forces.¹² As dictated by the theoretical specification, free-riding in NATO was possible only on the public good strategic nuclear forces provided by the nuclear allies and not on the impurely public or potentially private conventional forces of the allies (Smith, 1995).

Sandler and Murdoch (1991) employed Equation (22) to again test the joint product model for the NATO alliance by using time-series data for the period 1956-1987 to estimate via a two-stage least squares estimator:

$$\sum_i ME_{it} = \beta_{i0} + \beta_{i1}(GDP_{it} + SPILL_{it}) + \beta_{i2}SPILL_{it} + \beta_{i3}E_{it} + \varepsilon_{it} \quad (21)$$

While the above independent variable is the same for each NATO ally, the specification of the pure public good model sets a restriction such that $\beta_{i2} = 0$.¹³ Sandler

and Murdoch found that the pure public good restriction must be rejected for all ten of the allies. Given the results of this parametric study, and the non-parametric findings by Sandler and Forbes (1980), sufficiently convincing evidence favours the superiority of the joint product model (Smith, 1995).

Other Empirical Contributions

There are several other studies that employ unique empirical techniques that deserve mentioning. These studies are useful because they provide a framework for investigating other public economic issues and they show how the study of military alliances can be adapted for other useful purposes. In this section, three studies that offer unusually interesting contributions are reviewed.

Murdoch, Sandler and Hansen (1991) sought to test the competing models of oligarchy-choice and median-voter to examine collective action decision-making in NATO. With the exception of Dudley and Montmarquette (1981), most military alliance studies have implicitly or explicitly assumed an oligarchy choice perspective (Smith, 1995). The oligarchy model assumes the budget set constrains the choices of a decision-making body (or person) that acts on behalf of the entire nation or constituency. The median-voter model assumes that a national referendum decides the level of defence expenditure for the nation and that this level is determined by the consumption decisions of the voter with the median income. Under a joint product scenario, where the median voter must allocate resources between civilian and military consumption, the defence activity will produce both a pure public good and an impure nation-specific good. The demand function for the median voter is represented as:

$$q = f(I, \alpha p, Q) \quad (22)$$

where αp is the cost to the median voter of a unit of defence (the tax rate can be used as a proxy), I is the income of the median voter and Q represents defence spill-ins. As a substitute to national defence output, the spill-in coefficient would be negative. For the median voter under joint product specification, the demand equation is the same as Equation (22) except α would be set to one. An estimation model was generated by Murdoch, Sandler and Hansen:

$$ME_{it} = \beta_{i0} + \beta_{i1} + \left(\frac{1}{N_{it}} \right) + \beta_{i2} \left(\frac{GDP_{it}}{L_{it}^{\lambda_i}} \right) + \beta_{i3} SPILL_{it} + \varepsilon_{it} \quad (23)$$

which showed that restrictions on ME_{it} are consistent with the oligarchy or median-voter model. Data for ten NATO countries for the period 1965-1988 was used as the sample for the estimation model.

The results of Murdoch, Sandler and Hansen (1991) were again mixed for the NATO allies; while some exhibited median-voter-like behaviour, others followed the oligarchy choice model. Still others exhibited behaviour that was not consistent with either model. In particular, the median-voter model could not be rejected for Belgium, the Netherlands and the United Kingdom, while the oligarchy model was accepted for West Germany, France, Italy and the USA. Neither model was supported for Canada, Denmark and Norway.¹⁴

As in earlier studies, the authors dropped the price variable from their estimation model citing the argument that military and civilian prices tend to move together. As well, as a proxy for median voter income, GDP per employee was used where the average tax burden for defence was assumed to be shared equally by the population. The

case of Canada was of particular interest to the authors as an initial acceptance of the median-voter model was later rejected citing a positive response to price increases (tax increases) which clearly violates classical economic interpretation (Murdoch *et al.*, 1991). In terms of NATO-wide free-riding, the authors noted “there is little evidence to suggest a tendency for gross free-riding behaviour by members of the NATO alliance”. Data for Canada indicated a positive and significant coefficient for spill-ins indicating Canada is not a free-rider in NATO.

Seeking further insight into the collective action behaviour of NATO allies, Murdoch and Sandler (1991) took a game-theoretic approach to test whether NATO member behaviour follows either the Nash-Cournot allocation mechanism or the Lindahl process. Taking a joint product specification, where both a private and public good are produced from defence activity, the Nash-Cournot process states that each agent chooses both to optimize its utility subject to a constraint *and* the prevailing public good contribution of the rest of the community. Again, under joint product specification, the Lindahl process states that an agent agrees to pay its share of the cost of the public good, assuming that share is equal to one, therefore resulting in a more optimal allocation of resources within the alliance. This was a novel study for it sought to address the allocative efficiency question that is of great importance to collective action regimes; if the NATO states follow Lindahl behaviour, this would imply Pareto-efficiency within the alliance; if not, then a sub-optimal allocation equilibrium would persist.

The joint product augmented Nash-Cournot and Lindahl models were estimated for 10 NATO members for the period 1955-1987. While a price variable appeared in the theoretical model it was subsequently dropped from the estimation model citing

previously stated assumptions about the co-movement of civilian and military prices (Murdoch and Sandler, 1991). The test requires estimates from four equations for each nation. The first is derived from the Nash joint product model:

$$\sum_i ME_{it} = \beta_{i0} + \beta_{i1}(GDP_{it} + SPILL_{it}) + \beta_{i2}SPILL_{it} + \beta_{i3}E_{it} + \varepsilon_{it}, \quad (24)$$

while the second represents the Lindahl

$$\sum_i ME_{it} = \beta_{it} + \beta_{i1}(GDP_{it}) + \beta_{i2} \left(\frac{ME_{it}}{\sum_i ME_{it}} \right) + \beta_{i3}E_{it} + \varepsilon_{it}. \quad (25)$$

The third and fourth equations are “joint” or combinations of Equations (24) and (25) that serve as auxiliary equations in order to implement the *J* test developed by MacKinnon, White and Davidson (1983). For Equations (24) and (25), *GDP* represents income, *SPILL* represents the spill-in variable and *E* represents the threat variable proxied by Soviet defence spending. For Equation (25) though *SPILL* is dropped and, instead, a relative burden measure is employed to define an ally’s defence expenditures as a proportion of total NATO defence expenditures. Given the joint product specification, it was predicted that a Lindahl process would best describe NATO behaviour as opposed to the sub-optimal process of the Nash-Cournot (Murdoch and Sandler, 1991).

Murdoch and Sandler found that the US, UK, France, West Germany and Canada rejected both models and that the other five states rejected the Lindahl process. Their conclusion, that a sub-optimal Nash-Cournot process characterized NATO behaviour, suggested a sub-optimal defence allocation equilibrium. With respect to Canada, the spill-in coefficient was positive and significant, meaning Canada was no longer a free-rider as previous studies (except Murdoch *et al*, 1982) had determined.

Alliance Theory Conclusion

The close parallel between the study of military alliances and the theory of public goods has provided economists with numerous opportunities to contribute to the understanding of individual actor behaviour within a wider collective-action regime. The ability to predict the dynamics of burden sharing and allocative efficiency within, for example, the NATO alliance, has been greatly enhanced by rational actor theory and the competing, yet complimentary theories of the pure public goods and joint product models. Just as the development of the joint product model resulted in more accurate behavioural modelling so too has the development of time-series analysis improved our ability to test the implications of theoretical specification. Moreover the employment of time series analysis enables researchers to perform cross-country comparisons which give further insight into burden sharing and allocative efficiency, to say nothing of its wider applicability to other public goods problems.

The Demand for Defence Model

The following section surveys the extensive literature of theoretical models and optimization-based econometric studies which endeavour to explain the level of military expenditure of a country. This section begins with a brief review of the standard neo-classical model in which nation states are represented as rational agents who maximize a utility function depending on security and economic variables and subject to a budget constraint which includes military spending, and a function which determines its security in terms of its own and other countries military forces. A single equation that will permit a partial equilibrium estimation analysis of Canadian defence expenditures will be derived.

Theoretical Framework

The joint product model of alliance behaviour derived above contains within it a determinant variable for the individual country's demand for military expenditures. Therefore, the focus of this section will be to derive an optimization equation where the demand for military expenditures is determined by the relative prices of military and civilian goods, national income, a variable representing the spill-in benefits received from the military expenditures of allies, a threat variable which can be proxied by the defence spending of a military rival, and some other variable that accounts for strategic considerations, political demeanour of a country or periodic defence or fiscal budget reviews.

The standard microeconomic formulation of welfare or utility maximization subject to a budget constraint can be adapted to the neo-classical model of the demand for military expenditures.

Assume a country must maximize welfare or utility, W , where the economy produces only two goods, civilian goods, C and military goods, M . The state, forced to choose appropriate levels of each good, faces the following utility function:

$$W = W(C, M) \quad (26)$$

This optimization problem is subject to a budget constraint and a security function:

$$Y = p_c C + p_m M, \quad (27)$$

where Y is national income or GDP, p_m and p_c are the prices of real military spending, M and consumption, C .

Security, S , which can be understood as perceived freedom from threat of attack, is an unobservable and so must be replaced by a set of quantifiable variables. Therefore, we can represent S as the sum of the spill-in benefits received from the military spending of allied countries (M_1, \dots, M_n), and the benefit derived from the home country's military spending (M_A), plus some other strategic or political variable, X , which parameterize shifts in the security function:

$$S = S(M_A, M_1, \dots, M_n, X) \quad \text{such that} \quad S = M_A + \sum_{i=1}^n M_i + X. \quad (28)$$

Spill-ins are akin to positive externalities whereby the actions of a third party induce positive benefits or increase the utility of an agent. In the case of military alliances the military expenditures of an ally increases the security of one's country. Conversely, a country may have rivals or enemies and so an increase in their military spending

increases the ‘threat’ faced by one’s country (Smith, 1995). Threat will be denoted by TH and if more than one rival exists, simply summing their expenditures (as was done with allied spending) would serve as a satisfactory proxy.

Aggregating the sum of allied forces can be done in two ways: total alliance military effectiveness may be simply determined based on the sum of forces (as articulated above) or the weakest link versus best shot concept, whereby the ‘weakest link in the chain’ determines military effectiveness or the maximum force of the strongest ally is the determining factor. The forces of individual country are similarly determined and Conybeare, Murdoch, Sandler (1994) test between these alternative aggregation technologies (Smith, 1995).

Focusing on the partial equilibrium determination of one country’s forces given those of the others, we may solve the optimization problem to derive a demand function for the level of military spending:

$$M = M(p_m / p_c, Y, S, TH, X). \quad (29)$$

Finally, a functional form must be chosen for purposes of estimation and this analysis will employ a linear functional form which represents the demand for military expenditures function as:

$$M_t = \alpha + \beta_1 \left(\frac{p_m}{p_c} \right)_t + \beta_2 Y_t + \beta_3 S_{t-1} + \beta_4 TH_{t-1} + \beta_5 X_t + \varepsilon_t, \quad (30)$$

where subscripts on the variables indicate the time period, α denotes a constant, β_i ’s are coefficients to be estimated and ε is an error term.

Interpretation of the Demand for Defence Model

As stated previously a single equation approach to estimating a country's demand for military expenditures is acceptable if the objective is a partial equilibrium analysis. The utility of using the single equation approach becomes obvious when one seeks to investigate the behaviour a small sized participant in an alliance. In such a case, the dominant allies in an alliance are unlikely to respond significantly to a smaller ally's military expenditures. Moreover, the level of both spill-ins from other allies and the military expenditures of a rival may be treated as exogenous. If spill-ins and threat were to be considered endogenous variables then a multi-equation demand system would need to be estimated.

Recall Equation (29) where it was demonstrated that military expenditures are a function of relative military to civilian prices, national income or GDP, spill-ins from allies, threat from rivals, and a strategic/political shift variable. Let us now investigate how each of these determinant or explanatory variables affects the demand military expenditures.

Income or GDP is a crucial explanatory variable. As GDP rises, a nation will have more resources to dedicate towards national defence. Therefore, GDP and military expenditures are hypothesized to be positively related, meaning defence is a normal good whose demand increases with income.

Spill (or spill-ins) is another important variable. As a member of an alliance, a country depends on its allies to help support the public good of deterrence, which serves to protect and provide security to the entire alliance. When using time series data, spill is often lagged a period as changes in other allies' spending is assumed take one period for

it to have an impact and for other allies to react to it (Murdoch and Sandler, 1994). Spill can be calculated and expressed in two ways: firstly, by denoting the sum of military expenditures for the rest of the alliance, or as a vector of military expenditures for the other allies. If one wishes to use the latter expression, then perfect substitutability among spill-in sources may no longer apply because the estimated coefficients associated with this vector are no longer equal across all components (Smith, 1995). As well, spill-ins can express the technology of good publicness, that is, it can represent alliance strength by either the weakest link or best shot approach discussed earlier.

The threat variable can be understood in similar ways to spill-ins. Typically, threat is represented by the real defence spending of an enemy nation. If multiple enemies or rivals exist, their defence spending must be aggregated to get one overall threat measure. As with spill-ins, lags of one period or more are often employed in estimation models because, conceivably, a nation must experience the threat before it may react to it.

An analyst may also wish to investigate whether a structural change in the sample data has occurred over the time period under review. Here, the strategic/political shift variable X can represent a dummy variable, for example, the Cold War, Vietnam War, or NATO policy change. The hypothesis for including such structural variables is that its existence or potential interaction with other explanatory variables may have a significant impact on a country's military expenditures (whether or not that impact is positively or negatively related to military expenditures depends on the choice of the dummy variable).

Government and Military Expenditures

The above framework for estimating demand for military expenditures has been widely used by analysts but at the same time it raises some fundamental questions about the specific circumstances and influences that governments must acknowledge and accommodate when choosing appropriate levels of military expenditure. However, to satisfy any simple structural relation requires putting forward an argument that says governmental choices are constrained in particular ways that limit the potential freedom of a government, and in turn, make it behave in predictable ways. Such constraints must be plausible, empirically and theoretically identifiable and testable; if these preconditions are met, an analyst may make conditional predictions about governmental expenditure activity (Smith, 1995).

For democratic governments the electorate, and its desires, represents one binding constraint on government activity. Dudley and Montmarquette (1981) took a median voter approach to determining the demand for military expenditures. The median voter approach states that by using a referendum to determine an appropriate military expenditure level (the only referendum issue), the median voter's preference would be the amount of per capita defence spending the government would expend. In a two-party system, electoral competition would force both parties to converge to the median voter's preference, assuming preferences are both unimodal and symmetric. Moreover, because military spending is determined by income, then the person with the median income would determine the level of military spending. However, owing to the multi-issue nature of elections and the absence of a non-uniform distribution of preferences among the electorate (much more likely is a bimodal preference towards defence spending, that is,

hawks and doves) the model loses some of its explanatory power (Dudley and Montmarquette, 1981). A study performed by Murdoch, Sandler and Hansen (1991) employed military expenditures by NATO allies to test between median voter and oligarchy models.

Other studies have noted the restrictions imposed by rationality on the demand for military expenditures. Where the aim of resource allocation is to maximize utility (the welfare function) subject to some budgetary constraint, rational actor theory suggests that choices must be made in predictable ways. However, criticisms abound when rational actor theory is applied to models of military expenditure. Firstly, governments are not unitary rational actors because they are made up of complex political coalitions operating in a political and bureaucratic environment. Other entities and influences like the effects of inter-service rivalry, private lobby groups, and class-struggles have been cited as further evidence for government non-unitarity (Smith, 1995). Smith (1977, 1978), Griffen, Wallace and Devine (1982) and Sandler and Hartley (1995) reviewed this wide range of influences on government decision-making. The bargaining and log-rolling that characterize governmental activity would almost assuredly fail to meet rationality requirements. As well, owing to the complexity of governmental problems and constraints imposed by sub-optimal information processing capabilities, even if the government were to be considered unitary and rational, its decisions might not be. Given these problems, an analyst attempting to predict government activity would be even less informed than the government he is investigating. For example, consider Cypher (1987) and Privetti (1992) who argued that the main factor influencing US military expenditures was the need to offset the tendency toward economic stagnation. This argument is

basically a rational model of military Keynesianism but, because it employs a different objective function (differing from the aforementioned neo-classical one), it has a much different prediction of the determinants of military expenditures.

Still other studies [for example, Ostrom (1978), Cusack and Ward (1981) and Kamlet and Mowery (1987)] examined structural rather than optimizing models based on bureaucratic, interest-group or satisfying behaviour, whereby the government is constrained to follow certain rules of thumb or standard operating procedures that implant a certain degree of predictability into government activity. However, as argued by Stoll (1992), such constraints may not directly apply to military spending as simple rules of thumb and 'weapons-counting' can account for much of the governmental spending behaviour that is not captured by optimization models. In fact, Rattinger (1975) insisted upon the concept of *incrementalism* to explain military spending; whereby this year's military budget is best determined by the previous year's budget. This conclusion is, however, one that has been suggested by other organizational models as well as optimization models (Smith, 1995).

While the aforementioned constraints (rationality, bureaucracy and political pressure) may in fact be plausible in their existence and influence, it is much less certain, and indeed, it is much less plausible that these constraints are constant over time. The ensuing effects of such structural instability (owing to sufficient variance of the constraints) would have a debilitating effect on the model's predictive capability.

Empirical Studies of the Demand for Defence Model

There is a great variety of studies estimating the demand for military expenditures. It will be useful to summarize a number of these case studies where a standard model for estimating military expenditures as a function of GDP, threat, spill-ins and other variables such as governing party or strategic posture are employed. However, final estimation models differed slightly depending on the objective country. Some creativity was evident in the authors' choice of other non-traditional and dummy variables, but because this was in the hope of developing a more accurate and predictable model, model specification produces a great variety of useful insights. Reviewing a selection of these studies will give some perspective and comparability with this paper's specific model for Canada.

Looney and Mehay (1990) offered a generalized least squares (GLS) estimate, corrected for autocorrelation (AR1) by a Cochrane-Orcutt transformation, where US real defence spending (1965-1985) was regressed on its lagged value, anticipated and unanticipated Soviet defence spending, inflation, deviation from the trend in federal revenues, lagged federal deficit, a Vietnam dummy, deviations from the trend in other NATO spending and a détente dummy. Searching for a statistical fit to the data, the authors did not relate their final estimates back to a theoretical model. They found that real military expenditures were positively related to these expenditures in the previous period suggesting some kind of bureaucratic influence was at work. As well, their NATO trend, Soviet Union expenditure, Vietnam War and federal revenue variables all had a positive influence while inflation and budget deficits had a negative influence on defence expenditures.¹⁵ The absence of any price or income variable in their estimation model

means that it cannot be tied back to a theoretical foundation; therefore, its use as a “demand equation” is limited.

Smith (1990b) used a single-equation estimate for British and French demand for defence expenditures from a loosely based oligarchy-choice theoretical perspective. Unlike numerous other studies, Smith included price indices for civilian and military goods and therefore used the share of military expenditures to GDP as the dependent variable. Therein, he regressed the change in UK share of military spending (1951-1987) on the change in the US share, the difference between UK share and the Soviet share in the previous period and dummies for the Korean War, defence reviews, and the NATO 3% commitment. The dependent variable responded positively to changes in US burdens and to the Korean War dummy. Threat was proxied by the lagged Soviet defence burden and was reported as having a negative and significant influence on the dependent variable. Defence reviews also had a negative impact. As was hypothesized, when applied to the French data set the estimation model provided the same parametric results.¹⁶

Fritz-Asmus and Zimmerman (1990) estimated a single-equation demand for defence expenditures for West Germany for the period 1961-1987 by regressing German defence spending in constant dollars on GDP, the lagged level in French spending, the lagged level of defence spending of the other NATO countries, lagged Soviet defence spending, and a dummy for government composition, where the coefficients of the spill-in terms were allowed to shift with the change in NATO strategy in 1974. Unexpectedly, the coefficient for GDP was negative but insignificant. The NATO coefficient was also negative indicating free-riding but after the change of NATO to flexible response this

free-riding disappeared. The coefficients for French defence spending and Soviet spending were both positive and significant and the political dummy variable had no effect.¹⁷

Murdoch and Sandler (1990) developed a single-equation estimation model for Sweden for the period 1958-1985 using a log-log equation to explain real Swedish military expenditure in US dollars. They regressed their dependent variable on GDP, population, the lagged real military expenditure of Norway, lagged Soviet spending and a fiscal dummy. Similar to Fritz-Asmus and Zimmerman (1990) the coefficients of the Norwegian spill-in terms were allowed to shift with the change in NATO doctrine. Sweden's unique position as an armed neutral nation means that it aims to be self-reliant in defence spending. Many different combinations of nations were used for the spill-in variable including NATO and Sweden's neighbours, Denmark and Norway. A negative and significant coefficient on spill-in would indicate a degree of free-riding. The best estimates of this model indicated that Swedish defence spending responded positively and significantly to GDP, indicating for Sweden that defence is a normal good. Norway represented the only significant source of spill-in and this was attributed to fears that any Soviet attack would come down through Norway. The fortification of Norway's northern flank in 1974 therefore provided Sweden with some measure of protection from the Soviets and this was indicated by a significant and negative sign on spill-in after 1974. Surprisingly, Sweden did not respond significantly to Soviet defence spending, while the population and fiscal response variables reacted negatively indicating the greater social burden associated with greater populations.¹⁸

Hilton and Vu (1991) developed a simultaneous equation Stone-Geary type expenditures system based on a pure public good model specification to assess the economics of 14 NATO members for the period 1958-1985. The study estimated an expenditures equation for aggregates such as defence, non-defence public expenditures and private expenditures. The authors included the following variables in their estimation equation: Warsaw Pact GNP and population, per capita GNP and population of allies and dummy variables for the oil shock and the Vietnam War. The study sought to classify free-riding in NATO into four separate groups which included: competitive free-riders, those countries that increase their own expenditures in response to others but do not react positively to threat, selfless free-riders, those that react negatively to spill-in for other allies but react positively to threat, free-riders that react negatively to both threats and spill-ins, and competitive nationalists, who react positively to both threats and spill-ins.¹⁹

Hilton and Vu (1991) found the following results. No country was characterized as a free-rider (react negatively to threat and spill-in); eight countries including Canada were characterized as competitive free-riders (react negatively to threat but positively to spill-in); the USA, Italy, Greece, Norway and Denmark were characterized as self-less free-riders (react positively to threat and negative to spill-in); and, the UK was characterized as a competitive nationalist (react positively to both spill-in and threat).

A study by Conybeare, Murdoch and Sandler (1994) employed a game-theoretic specification to test the “best shot” vs. “weakest link” specification. The “best shot” specification refers to an alliance system where allies rely on the dominant ally to provide security and the “weakest link” specification refers to a situation where allies match as closely as possible their respective defence provisions. For sample data, the study

examined numerous alliances including: NATO, the Warsaw Pact, Triple Alliance and the Triple Entente.

Regarding their findings for the NATO alliance, the authors found that neither specification was strongly supported for the NATO countries. In particular for Canada both specifications were significant at the 10% level but, owing to the closeness of the probability values at the 10% level, it makes it difficult to draw any specific conclusions.²⁰

The most recent and closely related study of estimating the demand for defence expenditures comes from Solomon (2005) who developed a single dynamic equation for real Canadian defence expenditures for the period 1952-2001. Here, the dependent variable was regressed on its lagged defence expenditure value from the previous year, the relative prices of military to civilian goods, GDP, a spill-in variable for NATO and the USA and a catch-all variable that includes a range of factors such as defence White Papers, geopolitical shocks and non-defence expenditures. The autoregressive distributed lag approach to cointegration (ARDL) was used to estimate and test cointegration and long-run relationships.

The estimation model suggested several interesting relationships. Firstly, the notion of Canada as a free-rider in NATO was not proven in the data and a positive and significant response to NATO spill-ins and to a lesser extent US spill-ins was observed. Solomon noted Canada's significant and numerous international obligations as proof of these foreign-borne influences. Secondly, for most models tested the relative price variable was negative and significant indicating that defence was normal good whose demand falls when prices increase. However, the GDP variable was insignificant in the

estimation model suggesting that defence is neither a normal nor an inferior good. Depending on the time period examined the model appeared to give mixed results as to the nature of defence output in Canada. Finally, a significant structural break in the sample data occurred after 1970 where the author speculates that the change in NATO doctrine from massive retaliation to flexible response instigated a positive and significant impact on both spill-in variables (Solomon, 2005).

Each of these studies reflects a priori that the structures generating military expenditures do not differ greatly from country to country. The differences observed can be attributed to the particular beliefs of the authors as they pertain to their objective country and the particular statistical techniques they employed when developing an estimation model. Therefore, the classical debate as to which type of model to adopt, theoretically based or data based, continues. What is unquestionably demonstrated by this range of studies is the ability to construct estimation models that explain military expenditures well in terms of R^2 and significant t statistics. However, since the advent of time-series methodology, analysts must be ever-vigilant for detecting and testing errors associated with spurious correlations. More meticulous demands on the statistical methodology and interpretation of the estimates must be pursued in future research where any number of sophisticated tests might be employed including: tests for cointegration, lack of serial correlation, functional form, normality and heteroskedasticity. Moreover, owing to the dynamic and unpredictable nature of domestic and international political systems, more emphasis on tests for structural stability and whether regression parameters remain constant over time are useful avenues for investigating model accuracy and robustness (Smith, 1995).

Canada-Specific Determinants and the International Security Environment

The following section traces the history of Canadian defence policy and our involvement in multilateral security initiatives. Therefore, we can link the international and domestic security exigencies of Canada with their temporal expenditure counterparts to decipher and more fully understand the defence spending habits of successive federal governments from the post-World War II era to the present post-Cold War era. Appendix 1 presents graphs of both the real and share measures of defence expenditures for Canada, United States and NATO. The reader is advised to refer to these graphs periodically to match strategic and political developments to changes in spending patterns.

Since the end of WWII, Canada's military function has had practically nothing to do with our national security, and practically everything to do with supporting and sustaining our national diplomacy.²¹ The conduct of foreign policy in such a manner can be attributed to the close relationship between Canada and the US (PJBD, Hyde Park Agreement) during WWII, which 'pitch forked' Canada out of the British alliance and squarely into the American one.²²

Canada's participation in North American defence is conditioned by the nature of the threat to the continent. Since the primary threat to Canadian security in the post-WWII era came from ICBMs (Inter-continental ballistic missile) and SLBMs (Sea-launched ballistic missile), with lesser threats posed by manned bombers and SSNs (nuclear submarine), carrying ALCMs (Air-launched cruise missile) and SLCMs (Sea-launched cruise missile), Canadian defence policy was designed to secure the country from attack by contributing to the collective nuclear and conventional deterrent posture of

the West. In so doing, Canada hoped not only that aggression would be deterred and war prevented, but also that the international stability achieved would allow it to pursue its economic and political interests at home and abroad.²³ While Canada's participation is relatively insignificant to the overall calculation of the international balance of power, its security is dependent on it, and its defence policy is oriented towards helping to maintain this balance of power.

Collective security rather than issues of preserving civil power focuses the majority of Canadian defence policy spending. However, this does not correlate into any lack of resources to satisfy the demands of sovereignty protection. Rather it has been theorized that collective-defence forces mutually assist in protecting Canadian sovereignty. This is labelled the "defence against help" role of the armed forces, and is applicable especially in the North American model of defence. In this capacity, the forces respond to domestic sovereignty concerns by fulfilling collective-defence tasks.

This model operates on a basic principle that, without a Canadian military contribution to the defence of North America at sea and particularly in the air, the entire burden of protecting the continent's frontier would be assumed solely by the United States. As a result, Canada would not be informed of US measures, implemented to defend the continent.

Canada's commitment to collective defence was manifested in its joining the North Atlantic Treaty Organization (NATO) alliance in 1949, and also its involvement in NORAD (North American Aerospace Defence Command) beginning in 1959. Canada's main motive in the proposed Atlantic Alliance was political rather than strategic. Its great appeal lay in the opportunity to multilateralize Canadian-US defence relationships,

already becoming too intimate and too lopsided for comfort, by involving Western Europeans (Gordon, 1966).

During the 1950s and the first half of the 1960s, NATO relied on US strategic force superiority to dissuade Soviet use of its conventional force advantage in Western Europe. NATO conventional forces were outmatched by Soviet conventional forces since the Soviets had been operating its defence industry at wartime levels, while NATO allies had largely converted their defence industries to peacetime levels.²⁴

Thus, Soviet territorial expansion was held in check by NATO's adherence to a deterrence strategy of Mutually Assured Destruction (MAD), in which any Soviet advancement involving NATO allies would result in a massive nuclear attack. This strategic method was upheld in MC48, a document approved by the NATO council in 1954. This method was favoured because, up until the mid 1960s, the Soviet nuclear forces were at risk of pre-emptive strike, which would allow US strategic nuclear forces to attack with impunity (Hartley and Sandler, 1999).

Since the US had little to deter it from unleashing a pre-emptive nuclear strike, the US threat to retaliate on behalf of its European NATO allies was credible and fairly automatic. As a corollary, a large proportion of the defence output derived from the allies' defence efforts was deterrence, which was a fundamentally non-rival and non-excludable good (Hartley and Sandler, 1999).

This alliance structure implied the likelihood of the exploitation of the large by the small, suboptimal resource allocation, and free-riding. The adoption of MAD occurred at a time when Canadian defence expenditures, both real and relative, began to drop. However, Canada contributed to the maintenance of the nuclear deterrent in two

ways: by cooperating with the United States in the air defence of North America and by providing airfields for U.S. strategic bombers (Hartley and Sandler, 1999).

In order to further advance the interests of nuclear deterrence, Canada and the US established NORAD in 1959. Canada agreed to join NORAD because of the realization that through such defence cooperation, Canada would provide warning and surveillance for the US strategic forces, satisfy its own defence interests, and fulfill its commitments to NATO.²⁵

The normalization of NORAD-based cooperation posed many challenges to Canadian defence policy-makers. Firstly, so as to not be excessively influenced by a bilateral defence agreement with the US, Canada moved to link North American air defence initiatives institutionally to NATO. Second, having Canadian forces under the command of US commanders during wartime and peacetime posed a threat to Canadian sovereignty. A single command structure would require Canada to become involved in all US fighting. Finally, the prospect of having to base US nuclear weapons on Canadian soil was an entymeme to Canada's stated declaration of being a non-nuclear state.

Canada's decision to accept nuclear warheads from the US in February 1959 has been noted by observers to have compromised Canada's position with respect to US space-based defence programs. This interpretation has been argued by Canadian defence policy observers to have been a consequence of Canada playing its necessary role during the Cold War; that is, their decisions were forgone conclusions because of its middle-power status in the international system of states. This argument rests on the premise that Canadian defence policy is determined by the historical, geo-strategic, economic, and political factors that predicted its alliance arrangements. These determinants of Canadian

defence policy decisions exist due to certain conditions in Canada which include: the nature of the political/military relationship within Canada, the phenomenon of Canadian military professionalism, and the transitional-transgovernmental nature of the Canada-US cooperative military relationship. These factors contribute to what Morris Janowitz refers to as 'unanticipated militarism' in Canadian security decision making, which is a gradual acceptance of policies that do not always correspond with the government's own assessments of the exigencies of the strategic international environment (Crosby, 1997).

This arises because within the context of air/aerospace defence of the continent during the Cold War, a Soviet attack on the US would have had to pass through Canadian airspace. In such a situation the Canadian government would be unable to adopt defence postures that ran contrary to the interests of the US.

While it is necessary for Canada to protect its citizenry, the general public has demonstrated a lack of interest in defence matters, which is usually reflected in the political system. Such apathy is manifested in governmental-political control which is exercised through budget demands, bureaucratic procedures and the politics surrounding procurement.²⁶ From an academic perspective, most defence economics-related studies in Canada tend to focus quite narrowly on industrial policies and base closures.²⁷

The apparent public and government apathy towards defence and security indicates that the response of defence expenditures in Canada to income or GDP may be at best insignificant or at worst negative. The inadvertent union of apathy in the political system and military professionalism may also result in bureaucratic infighting. The battleground would of course be the federal defence budget.

Owing to its circumstance as a transnational actor involved in transgovernmental relations with the US military, the Canadian military has both the means and the reasons to significantly influence Canadian defence policy decision-making. Its ability to presume the strategic framework of the US military and in having a professional interest in maintaining the cooperative relationship, the Canadian military assumes a vested interest in having Canadian defence policy mirror the interests of its alliance partner.

In terms of exercising influence through participation in defence program planning for the continent through forums that for the most part are inaccessible and 'unmonitorable' by Canadian political decision-makers, the military sets the agenda by which politicians debate by way of its privileged access to the US defence community. This enables the military to control the information by which politicians base their decisions. This is especially true during the period of 1945-64, which is labelled by Douglas Bland, Professor and Chair of the Defence Management Studies Program in the School of Policy Studies at Queen's University, as being the "Command Era". He characterizes this period as being one in which the Canadian Forces (CF) were "militarily efficient" with decisions made "based on military concepts...and... subjectivity based on experience." (Sokolsky and Middlemiss, 1989) Such decisions were further enhanced by the Diefenbaker government preferring to make defence policy decisions on an ad hoc and individual basis, which resulted in approving the NORAD agreement without referring to any cabinet defence committee debate or decision.

According to Bland, a fundamental change in the command and control of the CF began in 1964 with the government decision to integrate and unify the CF and the Department of National Defence (DND). In comparison to the "Command Era," Bland

calls the period after 1964 the “Management Era” during which business management practices replaced a military ethos and the chain of command was replaced by functional organizations that “operate in long parallel lines from National Defence Headquarters (NDHQ) to practically the lowest levels of the Department of National Defence and the Canadian Forces.” (Sokolsky and Middlemiss, 1989)

According to Bland, the overall impact of the transition from the Command Era to the Management Era on defence policy was first, to weaken the military’s role in policy making, and second, to turn the application of civilian control of the military over to public servants rather than to Parliament. In sum, the Minister of National Defence’s senior military advisors had a marginal impact on major policy decisions, and parliamentary control over the military establishment has been seriously eroded. In reality the consequence of this weak conceptual framework and poor policy guidance has been that “defence decision making has tended to respond to political demands and to narrow service or task-oriented pressures without reference to more comprehensive military assessments and needs.”²⁸

By the early 1960s, the high cost of weapons, combined with the new demands on the federal government to allocate more to social programs, necessitated a re-evaluation of the conduct and character of Canada’s national defence policy. The White Paper of March 1964 was “not so much interested in international aspects of Canadian defence policies,” as it was in “reorganizing the Canadian Forces” (Sokolsky, 1995). In the next few years, the headquarters of the separate services were integrated under a single Chief of the Defence Staff (CDS), and eventually a National Defence Headquarters emerged, combining the civilian and military leadership of the CF and DND. In 1968 the three

services were ultimately unified into a single entity. The government argued that the savings derived from this reorganization could be channelled into purchasing new equipment.

Another fundamental change in defence policy was NATO's adoption of the flexible response strategy. Starting in the early 1960s, the US began pressing for a doctrine of flexible response that required strategic nuclear forces, tactical nuclear forces, and conventional forces to cooperate. NATO's heavy reliance on US forces and nuclear deterrence gave it little choice but to go along with the new doctrine, which strove to limit escalation toward a nuclear exchange.

In 1967, NATO adopted directive MC14/3, which outlined the principles of flexible response. This doctrine enabled NATO to respond in alternative methods to a Warsaw Pact challenge; conventional forces or strategic forces could be used, and in the latter case, a missile exchange could be restricted or escalated depending on the nature of the threat. According to the flexible response doctrine, belligerence would be countered with a measured response based on the nature of the aggravation. In pursuit of this goal, NATO needed to strengthen both its conventional and tactical forces. The European allies could no longer rely on the nuclear deterrent umbrella for their collective security (Hartley and Sandler, 1999). While fiscal concerns were a significant concern, the "flexible response" ideas then being put forth by U.S. Defence Secretary Robert S. McNamara were used to justify unification. DND contended this new organization would make the CF highly mobile and flexible, able to combine air, sea, and ground units. Such forces, the Minister argued, would be available to meet the needs of peacekeeping and "brush-fire" wars and related missions (Sokolsky and Middlemiss, 1989).

The problem was that, since the Korean War, Canada had deliberately avoided participating in limited or "brush-fire wars". Peacekeeping did not necessitate the deployment of Canadian troops in the face of hostile attack. As David Burke observed, "Canada's world-wide intervention force . . . was literally all dressed up with nowhere to go . . . Canada had a structurally unified defence force without a mission to match. Moreover, since no allied commitment has been dropped, Canada continued to supply discrete air, sea and land units to NATO and NORAD" (Sokolsky and Middlemiss, 1989). In addition, any possible savings from unification, which were supposed to go into capital procurement, were squandered both by reduced defence budgets and inflation.

In contrast to the endeavours of the "flexible response" strategy, the Trudeau government introduced a measure with which it intended to repatriate Canadian defence policy. The details of this measure were published in the 1970 White Paper entitled "Defence in the 70s." Internationally, approximately 50% of the Canadian forces stationed in Europe were returned to Canada. Trudeau also revamped the committee system established by the Pearson government, so that the Committee on Priorities and Planning was given the pre-eminent role in developing and coordinating the broad policy objectives of government (Sokolsky, 1995). This decision was made based on the assumption that East-West tensions would continue to ease and that mutual nuclear deterrence reduced the risk of war, and the European allies could assume more of the burden for conventional defence (Sokolsky, 1995).

According to Bland:

Until 1972 the administration of defence policy in Canada was considered to have two aspects; that is, it was viewed as a command problem to be addressed by military concepts, and as a public administration problem amenable to theories of public management. Two distinct power centers, the Chief of Defence Staff and the Deputy Minister, approached these problems with organizations and processes particular to their aspect of the problem. In this context it was a political

responsibility to reconcile differences and risks. After 1972, the administration of defence policy became defined as a managerial problem alone, with the expectation that better management practices could make the “sharp end sharper”. (Sokolsky, 1995)

Thus, although Canada’s alliances set the context for which defence-posture decisions are made, resulting in an armed force geared almost exclusively to NATO and NORAD roles, the Canadian government has had considerable flexibility in selecting the kinds and levels of weapons it purchases and where it deploys them. While external forces exert influence on Canadian defence policy, it does not automatically determine the substantive details of the policy itself.

An example of Canada’s sovereign decision making is its routine participation in United Nations (UN) peacekeeping missions. The reason that Canada continues to send forces to fulfill peacekeeping initiatives are numerous. Firstly, it has been consistent with the rudimentary internationalist approach that has been the foundation of Canadian foreign policy since 1945. In this approach, Canada has aligned its interests with the broader goal of global stability. Therefore contributing to the peaceful resolution of disputes can be assumed to be a part of Canada’s national interest. Second, peacekeeping has afforded Canada the prospect of playing a role in world affairs somewhat beyond the framework of its military alliances and collective-defence demands. Thirdly, peacekeeping has been attractive to defence policy makers because it does not contradict collective-defence obligations. Fourthly, peacekeeping does not constitute a major drain on defence resources.

While reflecting on the period of détente in international relations, the 1971 White Paper was inconsistent with NATO’s new strategy of flexible response and its emphasis upon conventional forces. Yet, as with the previous White Paper, the 1971 statement did not withdraw Canada from any allied commitments. The Trudeau government had

actually added a pledge to reinforce northern Norway. Thus, detente began to diminish as reduced defence budgets quickly took their toll, and the 1971 policy was already being reversed by 1974. As a result of the Defence Structure Review (DSR), allied commitments, especially those to NATO as opposed to sovereignty protection, re-emerged as the key determinant of force posture decisions (Sokolsky, 1995). Defence budgets were also increased. Over the next 10 years, Canada re-equipped its land forces in Germany with new tanks, acquired a new interceptor for NATO and NORAD operations and acquired new ASW long-range patrol aircraft (LRPA). Construction of a fleet of new ASW frigates also commenced.

Canada attempted to carve out some measure of independence for itself in the realm of defence policy. However, overall, Canada decided to align itself with the US believing it would have less of an effect on US policy and arms control if it adopted a neutral posture. This translated into the concentration of defence policy-making on issues such as posture and procurement, which peace and disarmament lobbyists rejected (Sokolsky, 1995).

In the post-1964 atmosphere of ongoing defence-expenditure constraint, the recurrent affordability-needs conflict has been resolved according to Bland by the politicians in favour of the civilians and against the professional advice of the military. This has been achieved by 1) restructuring the bureaucracy in a way that places the real decision-making power in the hands of the civilians and 2) redefining Canada's defence problem in terms of managerial rather than military effectiveness. As a result politicians have been able to avoid making expensive choices on the basis of undesirable and unpleasant military advice. This process may explain the present commitment-

capabilities gap. Thus, instead of following the highly structured, chronological steps of the formal model, the process during the Management Era was subject to arbitrary political intervention from the top (Sokolsky, 1995). This process was highlighted in the 1983-84 *Report of the Auditor General of Canada*, which stated that there was neither a formally approved amendment nor any formal defence posture assessment of the strategic assessment undertaken during the 1974-75 Defence Structure Review (DSR).

In the 1980s important events influenced NATO burden sharing even though the doctrine of flexible response still ruled. These included Reagan's build-up of US forces, with its emphasis on weapon procurement and strategic nuclear forces. A second principal event was the US support of the Strategic Defence Initiative (a.k.a. Star Wars or SDI). A complete SDI umbrella would bestow purely public benefits to US allies. However, SDI would have deterred NATO allies from contributing to NATO's defence.

Coinciding with the Reagan build-up was the Trudeau government's decision in 1981 to delete a clause from the NORAD Agreement which stated that the agreement did not obligate Canada to commit to any ballistic missile defence program. Subsequently, Canada agreed to allow the testing of US air launched cruise missiles over Canadian territory. As well, non-involvement in US space-based programs was further compromised when Canadian industry was encouraged to compete for SDI contracts despite the federal government's refusal to participate on a government-to-government basis.

Thus, building on the doctrine of flexible response, NATO adopted the forward-defence strategy in 1984. This strategy shifted the fighting focus away from NATO's eastern front by relying on precision-guided munitions to target and destroy the Warsaw

Pact's rear-level forces before they could be brought to reinforce the front (Sandler and Hartley, 1999).

In 1987 the government produced a White Paper which was an extension of the 1985 DND Defence Policy Implementation Process. The object of the DND report was to produce alternative expenditure force-structure options that would ultimately lead to a force-structure model adequate to the level of military capability needed for existing defence commitments (Sokolsky, 1995). Since the last White Paper, new factors had emerged, especially the advent of the cruise missiles and the growing importance of the Arctic, which directly threatened North American and Canadian security. Entitled *Challenge and Commitment*, The White Paper of 1987 also reinforced Canada's commitments to NATO and the defence of North America and proposed various equipment purchases to close what was perceived to be a commitment-capability gap in Canada's military establishment. To meet these challenges, the Mulroney government pledged to dramatically increase defence spending. It would acquire new and more advanced tanks for the ground forces in Germany, additional surface ships and LRPAs, and, most ambitiously, a fleet of 10-12 nuclear-powered attack submarines (SSNs) capable of under-ice operations. The SSNs were also justified on the grounds of the need to assert Canadian sovereignty in waters American SSNs were known to transit.

While public opinion polls had shown some concern about poor Arctic sovereignty and the state of the CF equipment, there turned out to be very little support for SSNs or for major defence expenditures given the improved international security environment. In addition, it turned out that the Minister of Defence had secured only tepid and conditional support from his cabinet colleagues, especially the Minister of

Finance, on the funding formula necessary to implement Challenge and Commitment.²⁹ The Mulroney government began to hedge on its defence pledges and deliberately avoided discussing the White Paper during the 1988 federal election campaign. Once returned to office, its 1989 budget essentially gutted the 1987 White Paper, cancelling the SSN program and postponing the tank purchase.

Subsequent budgets further reduced defence expenditures, eventually abandoning new tanks and other equipment, although continuing with the building of 12 new frigates and plans to replace land and seaborne helicopters with the EH 101. Between 1989 and 1992 planned DND expenditures were reduced by \$5.6 billion. A statement on defence policy released in April 1992 announced that the CF would be reduced from 81,000 to 75,000 regular forces, but the reserves increased from 29,000 to 40,000 (Bland, 1989). Most significantly, while the document reaffirmed Canada's commitment to NORAD and NATO, it also announced that Canada was withdrawing all of its air and ground forces from Germany. Up until this point, a physical presence in Europe, no matter how small, was entrenched in Canadian defence policy, considered the necessary price for a seat at the table.

The end of the Cold War saw a gradual decline in Canadian defence spending. This was a result of the modernization of French and British strategic forces in the 1980s. As these strategic modernizations were achieved, NATO burden sharing was drastically affected among the European members. Both France and Britain would be issuing near purely public benefits, as it relates to strategic forces, to their European allies (Hartley and Sandler, 1999).

In Britain, this modernization was anticipated to cost about 5% of the defence budget and 10% of the procurement budget. In France, modernization increased the nuclear force share of the military budget from 13.42% in 1976 to 17.52% in 1988. By 1988, French strategic nuclear force expenditures accounted for 0.65% of GDP, up from 0.48% in 1980. The build-up afforded the smaller European allies with some free-riding incentives that had been lost during the first decade and a half of flexible response. A nuclear attack on almost any European ally could not be ignored by these smaller nuclear powers owing to France's and Britain's proximity to the attack and the resulting collateral damage. As a result, the non-nuclear allies were predicted to free-ride somewhat and rely more heavily on Britain and France for their security (Hartley and Sandler, 1999).

Another important cause of the decrease in Canadian defence expenditures following the end of the Cold War was a change in NATO strategy. At a Rome Summit in November 1991, a new defence doctrine began to take shape as NATO took on responsibility for ensuring Europe's safety from threats both within and beyond NATO boundaries (Hartley and Sandler, 1999).

The 1994 White Paper reflects the more secure, yet uncertain international strategic environment that Canada now faces. It begins by declaring that "the primary obligation" of the DND and the CF "is to protect the country and its citizens from challenges to their security . . . In the final analysis, a nation not worth defending is a nation not worth preserving" (Sokolsky, 1995). The document stresses that the basic nature of the threats to Canadian security has changed. Regional and ethnic conflict, weapons proliferation, global overpopulation and environmental degradation all compete

for attention on the global security stage. But, as the February 1995 government statement on foreign policy, *Canada in the World*, emphasized, "Direct threats to Canada's territory are diminished" (Sokolsky, 1995). Future challenges to Canadian security are likely to be of a non-military nature but rather would constitute threats of an economic, environmental or demographic nature. Thus, while the "Government considers it necessary to maintain a military capability appropriate to this still uncertain and evolving international environment, including continued membership in the North Atlantic Treaty Organization and the North American Aerospace Defence Command, "we are making adjustments within that capability to enhance our ability to contain conflict." (Sokolsky, 1995)

Overall, the current defence policy is based more upon domestic determinants rather than trying to style the CF to keep pace with allied demands and strategies. Most notable is the diminished role given NATO, heretofore, the central pillar of Canadian defence policy and force structure (Sokolsky, 1995). At the same time, multiple roles and, indeed, multilateralism, are very much a part of the new defence policy and, certainly, the White Paper calls for the establishment of new military ties with countries of Latin America and the Pacific. While the White Paper promises a global presence for Canada, it, along with the budget, does imply global commitments. As in previous White Papers, the current policy largely retains the four traditional roles for the Canadian Forces; sovereignty protection, NATO, bilateral military cooperation with the United States (especially NORAD), and peacekeeping.

Previous White Papers have rhetorically restructured priorities, but reality and force building have tended to reinforce the centrality of NATO and, to a lesser extent,

bilateral cooperation as key determinants in defence policy. The 1994 Defence White Paper and the 1995 budget mark a significant change in this approach. Canada had already withdrawn its air and ground forces from Germany. The government would continue to supply maritime forces to the Standing Naval Force Atlantic and to provide crews to the NATO Airborne Warning and Control aircraft and individual personnel to various NATO staff positions. Forces withdrawn and retained in Canada would be available to the Alliance consistent with allied strategy, which foresaw no major challenge to Western European security and would rely upon mobilized forces in the event one were to emerge. However, within the White Paper, commitments and contributions to NATO were included under general support for international security and multilateral operations such as the United Nations and ad hoc coalitions. Canada would also seek to reduce its financial contributions to the allied infrastructure program. In contrast, the 1994 White Paper devotes considerable attention to the roles and missions of the CF in North America. It devotes one whole chapter to the protection of Canada and another to Canada-United States defence cooperation.

In the future, NATO would be less concerned with guarding its perimeter than with addressing demands that unfavourably affect European economic and military security. This strategy necessitated the development of more mobile forces that could be projected where needed. This new strategy has alliance burden-sharing implications. One of the greatest expenditures for the Combined Joint Task Forces, a multilateral force created in 1993 that included air, land, and maritime capabilities, is the investment in air and sea transports to project forces to any trouble spot.

According to this strategy, NATO allies will rely on the US for power projection, unless the other allies enhance their transport capabilities. This dependence will place significant burdens on the US to guarantee and support the new doctrine. Additional burdens will be born by France, Germany, and Britain. As a result, the new Crisis Management doctrine may revive exploitation and free-riding concerns.

Data: Sources, Challenges and Econometric Issues

The Price of Military Expenditures

A central challenge in estimating the demand for military expenditures involves the use of prices as an explanatory variable. As stated above, defence is considered a normal good whose demand increases with national income. In response to a price increase and holding the assumption of defence as a normal good, an increase in the price of military activities (deployments, capital acquisitions, recruitment and training) will cause demand for those activities to fall. Therefore, the inclusion of a price variable is necessary for determining optimal public provision level. However, a lack of good information on military prices makes its use questionable but, given the importance of the price variable as an explanatory variable in an estimation equation, this deficit of information makes estimation potentially unreliable. Moreover, the practical and conceptual difficulties of building a military price index suggest their potential unreliability (Smith, 1995). While indices have been published for the USA, UK and, as we will see, Canada, the inclusion of a price variable in demand estimation is not widely discussed in the literature.

If the price variable is dropped from the theoretical demand model [see Equation (29)], the analyst risks serious specification errors which in turn bias the estimated coefficients of the included variables. Many studies do however drop the price variable from their estimation models and, in their defence, researchers commonly point to two factors that they believe nullify the impact of dropping price from an estimation model. Firstly, a study by the Stockholm International Peace Research Institute (SIPRI) indicated that the price of civilian and military goods moves or changes in the same proportion

(SIPRI, 1983: 195-211).³⁰ If this assumption holds then the price effect is captured by the intercept term in a linear equation. Second, if a GDP deflator is substituted for a price index, it is assumed to include the price variation of the military sector. That is, if the price and income elasticities of demand are unity, then military expenditures as a share of GDP should be used as the dependent variable (Smith, 1995). An interesting example of this potentiality comes from Smith, Humm and Fontanel (1987) who sought to determine the capital intensity of military postures across developed and developing countries. They found that the mix between personnel and equipment differs systemically across countries; high-wage countries choose more capital intensive postures than low-wage countries.³¹ If prices are assumed constant, the example just described demonstrates how distorted an estimation model might be if a price index is not used.

Solomon (2003, 2005) provides extensive analysis on the necessity of employing a relative price measure for Canada and because this study will employ the same price index as that used by Solomon (2005), a brief summary of the arguments for its inclusion must be presented. Although a relative price variable has been used for demand estimation for Israel [see Beenstock (1998)], never has this variable been used for a NATO member. It is anticipated that in this study the relative price of military to civilian goods variable will be negative and significant.

Solomon (2005) states that substituting the GDP deflator as a proxy for defence inflation does not hold for Canada for a number of reasons. Firstly, (and according to previous demand modelling studies) owing to lack of measurement ability regarding the productivity enhancements of military goods, quality changes that would otherwise reduce price differentials between military and civilian goods do not cause these prices to

coincide or overlap. Attempts by Bureau of Economics Analysis (Canada) to account for and adjust military prices for quality adjustment in military goods resulted in persistent differences between military and civilian prices. Secondly, the composition of a civilian and a military basket of goods differs significantly; therefore, civilian deflators are not suitable substitutes for the military. Thirdly, operational imperatives limit the military's ability to gain from substitution when prices increase. This means that price shocks to input prices are both immediate and persistent for defence goods.³²

Data Sources

There are many challenges faced by defence expenditure analysts. For example, military and non-military spending data can often be considered suspect. National governments may try to distort these figures for political purposes, usually to underestimate the total, but even honest reporting can contain major ambiguities. While the definition of military expenditures is widely used, there still exists disagreement as to how to account for: conscripts, paramilitary forces, pensions, and dual-use nuclear and space programs. The principal sources of data on military expenditures employing the standard NATO definition come from the Stockholm International Peace Research Institute, SIPRI, and the US Arms Control and Disarmament Agency, ACDA, and these were the sources employed in this study.

An example of the dubious nature of defence spending reporting can be seen in the repeated efforts of analysts to determine Soviet defence spending levels during the Cold War. This was a particularly difficult and imprecise task. Any official data put forth by the Soviet government was almost certainly too low; moreover, it is unclear whether

anyone in the Soviet Union actually knew the true cost of the program. The CIA, tasked with estimating Soviet military strength, employed a “building block figure”, whereby aggregating Soviet forces using US prices to obtain a dollar figure (a measure of the physical amount of forces available to the Soviets) was converted into roubles using an exchange rate. CIA could then estimate the defence burden on the overall economy and determine rough opportunity costs (economic costs) for maintaining Soviet military forces. Although intuitively attractive, this method was subject to large uncertainties. For example, CIA reports during the mid 1970s showed sharp increases in Soviet defence spending as a share of GDP; however, this spike was not due to any real increases in defence spending but, rather, the CIA revised its estimates of Soviet industrial efficiency and so necessitated a change in the exchange rate (US dollars to roubles) employed in previous analyses (Smith, 1995). Therefore, when we employ a ‘threat’ variable in explaining NATO military spending, it does not matter what the Soviets actually spent but what NATO countries *thought* the Soviets spent and this is a much easier figure to calculate.

Comparing military expenditures across countries can be very useful; however, to do this effectively one must convert spending figures into a common currency. Employing market exchange rates can result in large fluctuations and significant volatility that might be unrelated to actual military realities; therefore, expressing these figures in terms prices and exchange rates of a base year is an often used practice. But again, this method could be error prone as the results may be sensitive to the base year chosen. Employing purchasing power parity (PPP) exchange rates could be used, but a deficit of military price indices makes this approach less attractive. Therefore, a principal

advantage of using shares of military expenditure to national output is that they can be compared internationally without having to rely on exchange rates. This proposal however relies heavily on the theoretical assumptions of a model and the questions being investigated. Nevertheless, the share approach is the one most favoured for the purposes of this study.

Econometric Issues

The quantitative regression approach, like the optimizing approach, is controversial. This approach has been described as excessively tailoring an estimation model without regard to the plausibility of the statistical assumptions, whereby analysts are preoccupied with technique rather than plausibility (Smith, 1995). The motivations for using such an atheoretical technique are twofold; firstly, to give a model descriptive status (for forecasting purposes or summarizing certain characteristics about the data) and secondly, to give the model structural or causal status. Vector Autoregression (VAR) and Granger causality are the principal tests employed for this approach and studies by Chowdhury (1991) and Payne and Ross (1992) respectively employed these techniques.

Countering this argument for the atheoretical approach is the fact that the strict theoretical approach (provided it maintains valid restrictions) increases the efficiency of estimation, allows the coefficients to be interpreted within a wider intellectual and institutional framework, and enables theoretical propositions to be tested. The debate between those who believe that the estimating equation should be determined by a tightly specified theoretical model and those who think it should be determined by the best fit to the data continues. In this context, fit means more than R^2 ; all the statistical assumptions

of the model need to be tested. A compromise position is to start from a loose general theoretical specification and allow the data to decide the exact form (Smith, 1995). The prevailing problem with the atheoretical approach is that if a model is designed to fit the data, then that same cannot be used to test the model's capabilities and robustness. Smith (1989) discusses these issues further and tests a general to specific model (designed for the UK and tested on France) that passed all the diagnostic tests.

Several statistical assumptions of the Classical Linear Regression Model must be met for the reliability of econometric estimates and inferences to be considered valid. Such assumptions include: a correctly specified linear relationship with constant parameters, exogenous regressors and normally distributed, serially independent, homoskedastic disturbances. Failure of normality, serial independence and homoskedasticity leave OLS estimators unbiased, though not fully efficient, while the reported standard errors and test statistics are wrong, making inference invalid. Cochrane-Orcutt type transformations can be employed when serial correlation is observed, but the danger in this procedure is that the existence of serial correlation may be an indication of more fundamental dynamic misspecifications of the model (Smith, 1995).

For example, Murdoch and Sandler (1990) estimated the demand for real military expenditure for the four largest members of NATO (US, France, Germany, and the UK), for the period 1960-1985, using the following atheoretical, univariate dynamic model:

$$\ln(M_t) = \rho_0 + \rho_1 \ln(M_{t-1}) + \rho_2 \ln(M_{t-2}) + \eta t + \varepsilon_t \quad (31)$$

For the case of a random walk, $\rho_1 = 1$ and $\rho_2 = 0$; for the special case of first order autoregression in the growth rates, $\rho_1 + \rho_2 = 0$. For either case, there is a unit root

in the process. For the four observed countries, the first order Dickey-Fuller statistic, ADF(1), does not reject the unit root hypothesis that the series is I(1) (variables are integrated of order one, i.e., stationary after being differenced once) and cointegrated. None of the equations indicated significant serial correlation and they indicated that at least 89% of the variation in real military expenditure can be explained ‘atheoretically’, purely from univariate dynamics. However, the high R^2 could have misled the researchers as its value drops steadily when the objective was changed to describe the year-to-year proportionate changes in military expenditures. The authors in fact found that they could not reject the hypothesis that real military expenditure is just a random walk with drift (Smith, 1995).

Smith (1994) examines further some of the econometric challenges of estimating military expenditures. Smith begins his discussion by citing several advantages of the cross-sectional approach to estimating military expenditures. As we have said, this method seems to have been surpassed by the time-series approach. While this study does employ a time-series technique, it would be beneficial to the researcher to know why cross-sectional data techniques have been used in the past and how useful they can be for this particular field of study.

When employing cross-sectional data for estimating the demand for military expenditures, several advantages become apparent: large variations in the independent variable can be observed; average long-run effects can be observed; and, the impact of regime type and non-linearities in the response can be also be observed. These advantages are however offset by several significant deficiencies. Cross-sectional models will not pick up the effects that are common to countries (but which vary over time) and

they will not give good estimates for country-specific effects which may be quite different from the average. As well, the more coefficients differ between countries, the larger the standard error of the cross section will be. Furthermore, if misspecification induces systemic patterns between estimated time-series coefficients and the exogenous variables, then the average time-series estimate will differ from the cross sectional estimate.³³

Methodology

Based on the discussion of the previous sections, the level of military expenditures is determined by several factors, as depicted in Equations (29) and (30). Such factors include the influence of external conflicts captured by the threat variable, the demands of international collective security regimes captured by spill-ins, economic factors captured by GDP, and other strategic/political influences captured by X. While there is some debate as to the practical implementation of a price of military goods, the variable p_m/p_c captures these price effects. The following estimation model to be employed for this analysis should be considered to be from the atheoretical side of the specification spectrum as it contains several variables that have been picked to best estimate Canada's demand for military expenditures. Equation (32) is formulated as follows and the description of the variables is below that:

$$ME/GDP_t = \alpha + \beta_1 ME_{t-1}/GDP_{t-1} + \beta_2 DEF_{t-1}/GDP_{t-1} + \beta_3 (P_m/P_c) + \beta_4 \varphi + \beta_5 \delta + \beta_6 UN + \beta_7 D + \beta_8 Z + \varepsilon_t$$

(32)

where:

ME_{t-1}/GDP_{t-1} = military expenditure as a percentage of GDP, lagged one period

DEF_{t-1}/GDP_{t-1} = fiscal deficit as a percentage of GDP, lagged one period

(P_m/P_c) = defence inflation index, relative price of military to civilian goods

$\varphi = Q_{(NATO)t-1}/GDP_{(NATO)t-1}$, the ratio of NATO military expenditure to GDP

$\delta = Q_{(US)t-1}/GDP_{(US)t-1}$, the ratio of US military expenditure to GDP

UN = number of UN peacekeeping deployments with Canadian participation during one period, lagged one period

D = number of battle deaths internationally for one period, lagged one period

Z = a dummy variable representing the Cold War

ε_t = error term, which follows all the underlying assumptions of the OLS estimation model

The above variables were chosen for several reasons beyond those of the purely theoretical argument. Firstly, the lagged spending variable ME_{t-1}/GDP_{t-1} was selected because previous studies have shown that defence budgets appear to exhibit a certain degree of momentum and, as the findings of Rattinger (1975) suggested, incrementalism may be the single best determinant of periodic defence spending.

The variable DEF_{t-1}/GDP_{t-1} was selected because it describes the fiscal position of the government for a given year. For instance, during years of high and persistent deficits we would expect defence spending to increase, owing to the ‘easy money’ or deficit financing that the government appears to be spending. However, the expected coefficient for this variable will be negative, because a deficit in a given year would mean that the DEF_{t-1}/GDP_{t-1} value would be negative for that year. Thus, multiplying two negatives will give a positive number, which will demonstrate the correct relationship between deficits and military expenditures; they are positively related because deficit financing is one method a government may use to reinvest in its military or increase capital procurement.

The variable (P_m / P_c) was chosen for many reasons that have been previously mentioned. That this price index was even available for this study necessitated its use as an explanatory variable.

Disaggregating NATO and US defence expenditures as a share of GDP was the obvious choice when one considers how integrated Canadian defence policy and industry are tied to the US. As well, throughout the years 1953-2001, Canada often sought a “third way” for its defence policy and Canada often looked to NATO Europe for guidance on

defence policy and spending. Hence the division of variables $\varphi = Q_{(NATO)t-1} / GDP_{(NATO)t-1}$ and $\delta = Q_{(US)t-1} / GDP_{(US)t-1}$. The quantity φ was calculated simply by taking the defence spending as a share of GDP for the UK, France, Germany, Denmark, Norway, Italy, Portugal, the Netherlands and Belgium, summing across the given year and then taking the average by dividing by the number of allies. Spain's late arrival to the NATO alliance, the Greco-Turkish conflict, and the marginal contributions of Luxembourg and Iceland necessitated their absence from the aggregated figure.

The variable *UN* was employed because a significant portion of Canadian defence and foreign policy is directed towards Canada's overseas peacekeeping operations. Canada has sent troops overseas for various purposes over the years; the Korean War (1950-1953) could be considered to be the first of such overseas deployments of interest.

A dummy variable *D* is used to represent whether the existence of international conflicts has any influence on Canadian defence spending. A 0 indicates no major combat and a 1 indicates major combat (as described by the Correlates of War Project where conflicts with over 1000 casualties are counted). Finally, another dummy variable for the Cold War (1945-1990) was employed.

One year lags were employed for all variables except relative prices and Cold War for the reason that a change in fiscal position, a spill-in, a war, or an overseas deployment must occur first before the demand for military expenditures can react to it.

While there is no standard methodology or empirical approach for estimating the demand for military expenditures (Solomon, 2005) this study employs a single dynamic equation and will estimate military expenditures via an Ordinary Least Squares (OLS) estimation method. All standard diagnostic tests will be performed and the parametric

results interpreted. Moreover, this study will run several other tests that are of interest including: the Chow-test for structural stability, multicollinearity among regressors and a test for autocorrelation of the unexpected random errors ε_t and the dependent variable. Following this initial analysis, three other models will be developed and tested. The first of these will drop the lagged dependent variable from the right side of the estimation equation to determine how much, if any, variation in the dependent is being absorbed by its highly correlated lagged value. A third model will drop the lagged dependent variable and the relative prices variable to determine what effects are observed when prices and the lagged dependent variables influences are removed. The fourth model will be a tightly specified adaptation of the neo-classical defence demand model (Equation 29) where only the variables for deficit, prices, spill-ins and the Cold War will be included. By moving from a multi-disciplinary atheoretical model to a tightly specified theoretical model, this study hopes to gain insights into the accuracy and robustness of empirically-based estimation models. As well, the initial hypotheses of Canada's free-rider status in NATO, the role and impact, if any, of a price index of Canadian defence expenditures and the overall accuracy and significance of competing models will be thoroughly investigated.

Empirical Results

The following section presents the findings and analyses of models which attempt to estimate the demand for defence expenditures in Canada. They are divided by type, variable choice and sample period and proceed from the loosely defined, atheoretical type to the strictly defined, theoretical type.

Model A1 – Full Estimation Equation, Sample Period 1952-2001

Variable	Coefficients (t-value)
CONSTANT	-0.90292 (-0.9669)
MEGDP (lagged)	0.91197 (23.87)***
DEFGDP	-3.1173 (-2.203)**
PMPC	0.41422 (0.7927)
USMEGDP	-0.0032054 (-0.114)
WAR	0.045684 (0.9069)
NATOAVG	0.13777 (1.094)
UNDEP	0.019582 (1.083)
COLDWAR	0.001994 (0.6044)
R^2	0.9933

Key: *10% significance, **5% significance, ***1% significance

Model A1 included all variables of the estimation model and should be considered an atheoretical model with a loose theoretical specification. To was developed with the Canadian experience in mind and its choice of variables reflect those determinants that best explain Canadian defence demand.

This test showed that the lagged independent variable MEGDP had the strongest impact on Canadian military expenditures. This result was not unexpected and demonstrates the validity of the arguments for budgetary inertia and incrementalism. The coefficient for MEGDP was positive and significant at the 1% level over the time period.

The only other variable to be found to be significant was the deficit variable DEFGDP which had a negative coefficient and was significant at the 5% level. However, recall that we are multiplying two negatives here so it becomes a positive, indicating a

positive and significant relationship between deficits and military expenditures. This is not unexpected because deficit financing is an often used practice of governments wishing to rapidly reinvest in an area of interest or concern.

The spill-in variables, NATOAVG and USMEGDP, provided mixed results. The coefficient for NATOAVG was positive but insignificant, meaning that Canada is not a free-rider in NATO. That said, our response to NATO Europe spill-ins is marginal. The coefficient for USMEGDP was negative and insignificant. This result would indicate that Canada is a minimal free-rider in the defence of North America.

The coefficient for the dummy variables WAR and COLDWAR were positive but insignificant, meaning that neither the Cold War backdrop of the period nor the persistence of overseas conflicts significantly impacted Canadian defence spending. As well, the coefficient for the UN deployments variable, UNDEP, was positive but insignificant meaning that overseas peacekeeping operations tended not to affect defence provision in Canada.

Finally, the relative price variable PMPC was positive but insignificant. This finding was somewhat surprising given the aforementioned assumptions of defence as a normal good that reacts negatively to price increases. Furthermore, this finding suggests defence provision is unrelated to costs and in fact (counter to classical economic interpretation) may be a superior good, where price increases also increase the demand for the good. Clearly, for this model, the price variable did not perform as expected.

Regardless of its final classification as an economic good, defence expenditures appear to be more significantly affected by the fiscal position of the government and the ingrained inertia and momentum of the previous defence budgets. The above model had a

R^2 value of 0.9933 meaning that nearly all of the variance of the dependent variables is explained by the aforementioned independent variables.

Model A2 and A3

In one of the previous sections where Canada's role in the International security environment was discussed, a watershed moment in NATO strategic policy occurred in 1970 with the adoption of the doctrine of flexible response. This new doctrine meant a renewed emphasis on more expensive conventional forces rather than relying solely on the strategic nuclear deterrent. Owing to this change in NATO doctrine, the author suspects a structural break in the sample data and so divided the entire sample period into two groups, 1952-1969 and 1970-2001, in hopes of discovering what impact if any this doctrine change might have had. It is hypothesized that a greater reliance on conventional forces would result in an upward shift in the observed defence expenditures of Canada.

Model A2 - Sample Period 1952-1969

Variable	Coefficients (t-value)
CONSTANT	-0.16711 (-0.0457)
MEGDP (lagged)	0.86188 (3.945)***
DEFGDP	-7.1640 (-0.9662)
PMPC	-0.79223 (-0.2290)
USMEGDP	-0.021503 (-0.3234)
WAR	0.10605 (0.6923)
NATOAVG	0.24848 (0.5079)
UNDEP	-0.0060083 (-0.07384)
COLDWAR	0.010727 (0.5034)
R^2	0.9890

Key: *10% significance, **5% significance, ***1% significance

For the initial sample period, 1952-1969, the model produces very similar results to that of A1. Again the lagged MEGDP variable was positive and significant suggesting that budget inertia was the most influential factor on Canadian defence provision during

the years of NATO's policy of Massive Retaliation. Again a high R^2 of 0.989 indicates that almost 99% of the variance in the dependent variable is explained.

This period was so strongly overshadowed by the nuclear threat and the nuclear powers that non-nuclear NATO allies like Canada had a strong incentive to free-ride owing to the high degree of "publicness" of the nuclear deterrent. This proposition is borne out in the data where the coefficient for the spill-in variable, USMEGDP, is negative though insignificant, meaning that Canada responded with a small degree of free-riding when faced with an increase in US military spending. Not surprisingly, the coefficient for NATO spill-in is positive, yet insignificant, meaning that Canada was not a free-rider in NATO; but, for the period under consideration, this positive coefficient may be a result of Europe's deficient nuclear deterrent relative to the US. Therefore, there was less of a public good incentive for Canada to free-ride. The variables for prices, deficits, overseas deployments and the two dummy variables provided mixed yet statistically insignificant results.

Model A3 - Sample Period 1970-2001

Variables	Coefficients (t-value)
CONSTANT	0.040227 (0.06099)
MEGDP (lagged)	0.06791 (0.6075)
DEFGDP	-4.1725 (-4.967)***
PMPC	0.36393 (0.6963)
USMEGDP	0.23971 (6.918)***
WAR	0.010076 (0.4003)
NATOAVG	-0.012177 (-0.1297)
UNDEP	0.011318 (1.073)
COLDWAR	-0.0073692 (-0.1137)
R^2	0.9793

Key: *10% significance, **5% significance, ***1% significance

During the era of flexible response, NATO members were forced to increase the size and readiness of their conventional forces. However, as noted earlier, conventional

forces are viewed as impure public goods and this forced NATO members to reveal their preferences. In fact, the ability and incentive to free-ride in the flexible response era was severely diminished by virtue of the impurity of conventional forces. Recall as well that the joint product model of alliances also developed during this period as it sought to explain some of the private benefits that NATO members might be enjoying from their defence expenditures.

The results from model A3 provide some useful insights. Firstly, the variable for fiscal deficit, DEF/GDP, was negative and strongly significant; but, recall that we are multiplying a negative coefficient by a negative variable resulting in a strongly significant, positive relationship. The Canadian economy underwent massive fiscal changes throughout this period. Canada had built up large debts and yearly deficits during the 1970s and early 1980s, but this changed for the period of about 1984-2000 when the government embarked on a strategy of debt repayment and budgetary balancing. The deficit financing practice resulted in a large real increase in defence spending (see Appendix), reflected in terms of share of GDP. Strong growth rates during this period obscure this real growth in defence expenditures.

The spill-in variable for the United States, USMEGDP, was positive and strongly significant indicating that increases in US defence expenditures elicited a positive response in Canada and shows that Canada is not a free-rider in North American defence. This is not an unexpected result and becomes much more of a factor of Canadian defence policy, which was oriented toward continental and homeland defence during the 1970s and 1980s; less emphasis was placed on reinforcing NATO-Europe security, which

therefore increased the likelihood of NATO free-riding during this period; hence we find the negative yet insignificant coefficient for NATOAVG.

The lagged MEGDP variable in this period was positive but insignificant, indicating that less bureaucratic control and budgetary inertia was influencing Canadian defence expenditures. As well, the relative price variable PMPC was positive and insignificant, indicating a near indifference towards the steadily increasing costs of more advanced military technology and equipment. The dummy variable for the COLDFWAR was negative and insignificant and the dummy variable for international conflict, WAR, was positive but insignificant and the same results were found for overseas deployments, UNDEP.

We can therefore conclude that both the Canadian fiscal situation and trends in US military spending exerted the strongest influence on Canadian defence expenditures. With an R^2 of 0.9793, almost 98% of the variance of the dependent variable can be explained by the above model.

Some Further Econometric Tests

As was described earlier, a principal motivation for splitting the sample data into two discrete time periods was to investigate whether NATO's strategic doctrine shift to flexible response (1969) represented a structural change in the sample data and hence a structural change in defence spending in Canada. A Chow Test was employed to test this proposition where the following hypothesis was tested:

Ho: No structural change, $\alpha_i = \alpha_j, \beta_i = \beta_j$

Ha: Structural change, $\alpha_i \neq \alpha_j, \beta_i \neq \beta_j$

After running the Chow test for structural stability, the p-value was found to be 0.081868 which means that at the 10% significance level we must reject the null hypothesis that there was no structural change and conclude that NATO's change in strategic doctrine did in fact shift Canada's military spending behaviour.

Next the author wished to determine in which direction this structural change did cause a shift in the data. By finding the sum of the residuals we can determine the direction of the shift. The sum of residuals was found to be -0.00000000827, which statistically is indifferent from zero. This finding indicates that any change that might have occurred from this policy shift was not highly significant for Canada and its provision of defence.

Another diagnostic test that should be performed is to ensure that there is no autocorrelation among the residuals. Dropping the lagged variable MEGDP from the model, and finding the residuals of estimation Model A1, we can now use the Breusch-Godfrey Test to determine if there is any serial autocorrelation among the residuals. Therefore, we can formulate the hypothesis as follows:

Ho: $p_1 = 0$;

Ha: $p_1 \neq 0$.

The p-value for the regressed residuals was found to be 0.234 which means that it is not significant even at the 10% level. Therefore, we may conclude that there is no serial autocorrelation using an AR(1) approach.

Finally, the author sought to examine the degree of multicollinearity between certain independent variables of the model. A correlation matrix was therefore constructed that included variables which previous studies indicated to be correlated. As

a general rule, a critical value of 0.8 is used where a value greater than 0.8 indicates a high degree of multicollinearity and a value lower than 0.8 indicates little or statistically insignificant multicollinearity. The following matrix was found:

MEGDP	1.0000					
DEFGDP	0.51569	1.0000				
PMPC	0.36243	0.93298	1.0000			
USMEGDP	0.58273	-0.26715	-0.43860	1.0000		
NATOAVG	0.61320	-0.15640	-0.31983	0.92372	1.0000	
	MEGDP	DEFGDP	PMPC	USMEGDP	NATOAVG	

Not surprisingly, the variables PMPC and DEFGDP exhibit a high degree of multicollinearity. This co-movement can be understood because, during periods of high deficits, where as we have seen defence spending tends to increase, the input prices for these defence goods are likely to rise with demand.

The only other two variables that exhibit strong multicollinearity are those of USMEGDP and NATOAVG. While this study did disaggregate US spending from the NATO average, the same NATO policies and demands are experienced by both these agents. As well, the real defence spending patterns of these two agents are very similar (see Appendix 1).

For these reasons, the author may conclude that while there is some evidence for the existence of multicollinearity in the model, this occurrence is not unexpected. Furthermore, the author does not believe the existence of multicollinearity among these variables will have deleterious effects on the predictive capabilities of the model.

Model A4 – First Difference Approach for MEGDP (no lagged dependent)

As mentioned earlier, there are several data-related issues involved in assessing the demand for military expenditures of a country. One recurring problem is that the data

compiled may not be stationary and in fact may possess a unit root. A preliminary look at Canada's military expenditures as a percentage of GDP (see Appendix 1) reveals a trend that is known as a random walk with drift. This suggests a unit root problem, a situation known as non-stationarity.³⁴ Therefore, the author sought to investigate whether the dependent variable, MEGDP had a unit root and was therefore non-stationary. A Dickey-Fuller test was used to test for stationarity. Therefore the hypothesis can be formulated as follows:

Ho: no unit root, MEGDP is stationary

Ha: unit root exists, MEGDP is non-stationary

By cointegrating the dependent variable, MEGDP, and examining the output of the $A(1)=0$ T-test (with trend), one finds a value of -2.9823. This value is greater than the critical value of -3.13, meaning that we reject the null hypothesis and conclude that MEGDP is non-stationary and has a unit root.

A second level cointegration test was performed on MEGDP to determine how many differences to take in order to avoid the unit root non-stationarity problem. The hypothesis was formulated as follows:

Ho: no unit root, MEGDP is stationary

Ha: unit root exists, MEGDP is non-stationary

Taking the first difference of the dependent variable and comparing the $A(1)=0$ T-test (without trend) to the critical t-value (found to be -2.625, which is less than the critical value of -2.57), we must therefore conclude that we do not reject the null hypothesis that there is a unit root after differencing the dependent variable once.

It is important to note that it is not only the dependent variable that may have a unit root. Any one of the explanatory variables may also possess a unit root and, owing to the similarity among variables, i.e. between MEGDP, USMEGDP and NATOAVG, the existence of still other unit roots is a significant possibility. A further refinement of this model would investigate this possibility and correct for such non-stationarity problems; however, such remedial action is beyond the scope of this study.

After satisfying the stationarity concerns for MEGDP, the author generated a new regression model using this first difference approach where the dependent variable now measures the proportionate changes in MEGDP from year to year. This proportionate change approach (as opposed to the levels approach used earlier and subsequently) is expected to generate different results from Model A1. The model estimates the change in MEGDP for the entire sample period (less one year after differencing of order 1) 1953-2001.

Variables	Coefficients (t-value)
CONSTANT	-1.69 (-1.904)*
DEFGDP	-4.2066 (-2.610)**
PMPC	0.88912 (1.799)*
USMEGDP	-0.01294 (-0.4942)
WAR	0.067051 (0.207)
NATOAVG	0.11186 (0.727)
UNDEP	0.042623 (2.243)**
COLDWAR	0.17151 (1.27)
R^2	0.6103

Key: *10% significance, **5% significance, ***1% significance

Model A4 provides some interesting results. Firstly, the R^2 for model A4 has fallen off significantly to 0.6103 where only about 61% of the variance in the dependent variable can be explained by the above variables. This finding however is not too surprising, because the first difference approach requires the researcher to drop the

lagged dependent variable from the entire explanatory variable set (a similar method is taken in Model B1 where the lagged dependent is dropped from estimation model).

This model found that the coefficient for the variable DEFGDP was negative (but becomes positive when multiplied by the DEFGDP data set) and significant at the 5% level. Because we are measuring the year to year changes in MEGDP, DEFGDP shows that deficit-based financing by the federal government had a significant and long-run impact on the year to year provision of defence in Canada. In fact, one could speculate that over short- and long-run periods, the deficit financing method is often employed for making unforeseen or urgent defence acquisitions (i.e. those that acquisitions that are not a part of long-term trend). Moreover, these kinds of dynamics are more acutely observed in this type of proportionate changes model.

Another type of defence expenditure that could be categorized as an unforeseen or urgent defence acquisition is that of the UN deployments variable, UNDEP. This variable was found to be positive and significant at the 5% level indicating that Canadian overseas commitments do in fact contribute significantly to the provision of defence in Canada. Unlike some of the findings of other models where the specific level of MEGDP was estimated, Model A4 found UNDEP to be significant when measured on a year to year basis. This is not unexpected because as a percentage of total defence spending, UN deployment costs are marginal; however, when examining the year to year fluctuations of the defence budget, UN deployment costs (which are likely to be urgent, unforeseen costs) become observable and are not overshadowed by long term influences like US or NATO defence spending.

A similar line of reasoning could be used to explain the observed significance of the PMPC variable. However, in this case, PMPC has a positive coefficient meaning that increases in the price of military goods actually increases their demand, this of course goes against classical economic interpretation. This result is difficult to interpret and one could draw two conclusion: this result could lend credence to the argument of defence-specific inflation as described by Solomon (2003); or, one could conclude that the acquisition of defence goods in Canada is unaffected by price changes. A more in depth investigation of price influences was conducted by Solomon (2003) wherein these hypotheses were investigated.

Finally, no other variable was found to be significant in Model A4. Owing to the nature of measurement, that is, the proportionate changes of MEGDP from year to year, shorter-term influences like deficit financing and UN deployments exercise a more significant influence on yearly defence provision in Canada than do the longer-term influences like US and NATO spending. Such longer-term influences are best captured by the level approach to estimation and that is the method of analysis employed for subsequent estimation models.

Model B1 – No lagged MEGDP, Sample Period 1952-2001

Model B1 returns us to the levels approach of estimating MEGDP. As was suggested earlier the inclusion of the lagged value of MEGDP on the right side of the estimation equation may be causing some bias or skewness in the dependent estimates. As suggested by Solomon (2005) “while it is tempting to speculate that bureaucratic inertia drives Canadian defence spending, it is more likely that the lagged endogenous variable (MEGDP lagged) is ‘soaking up’ all the unobserved effects that were not

captured by the traditional variables of threat, spill-in income and prices”. Therefore, the following model drops MEGDP lagged from the right hand side of the estimation equation.

Variables	Coefficients (t-value)
CONSTANT	10.504 (3.394)***
DEFGDP	-0.75830 (-0.1393)
PMPC	-6.8487 (-4.179)***
USMEGDP	0.32380 (3.418)***
WAR	-0.041921 (-0.2163)
NATOAVG	-1.0005 (-2.226)*
UNDEP	-0.10843 (-1.628)
COLDWAR	0.047639 (4.594)***
R^2	0.8975

Key: *10% significance, **5% significance, ***1% significance

Model B1 provides some very interesting results. The most obvious of these results is the apparent drop of R^2 to 0.8975, where only about 90% of the variance in the dependent variable can be explained by the above variables. Immediately this tells us that bureaucratic inertia in whatever form it take is exerting a significant degree of influence on the dependent variable; by consequence, the predictive power of the model has fallen. However, several new and statistically significant observations have been made apparent with this new, truncated model.

This model reveals that the constant in the model is positive and statistically significant and implies that, by holding all other variables at zero, Canada would devote approximately 10% of its GDP to defence. Such levels however have not been observed since the early 1950s and even then such a burdensome trend did not persist.

In this model, the variable for relative prices is negative and significant at the 1% level. According to this model, defence is unequivocally a normal good, where, according

to classical economic interpretation, demand for defence activities falls when its price rises. Solomon (2005) reinforces this finding by stating that “this may be explained by the fact that technological sophistication and capital intensity of defence resource allocation may have forced the department to optimize”. That is, given the rising costs of competing military technologies, the Department of National Defence may have been forced to base its decisions more on concerns of cost and depreciation than on a particular technology’s capabilities, thus explaining the strong influence of prices observed.

This model also reinforces the findings of model A3, where USMEGDP was found to be positive and significant at the 1% level. Removing the lagged variable shows us that much of Canadian defence activities are intended for continental and bilateral defence activities in conjunction with the United States. With a positive coefficient, this model shows Canada is not a free-rider in North American defence activities and that a positive response is elicited in Canada when US spending increases. As well, it reflects how Canada looks to the US to determine the threat level faced by North America or NATO. Here, US spending is an appropriate proxy for determining the threat faced by Canada, although there could be an argument raised that, owing to the US’s vast network of global alliances, a threat faced by the US may not necessarily be shared by Canada.

The coefficient for NATOAVG was found to be negative and significant at the 10% level, suggesting Canada is a free-rider within NATO. This finding may be due to Canada’s principal interest of protecting the continent and the country first, which has steadily evolved from the post-WWII era to the present. This suggestion is confirmed when we re-examine the coefficient for USMEGDP that was positive and significant.

The COLDWAR dummy variable was found to be positive and strongly significant at the 1% level. The removal of the lagged dependent variable reveals the disproportionate influence Cold War demands placed on Canada's national security planners. Moreover, this finding indicates that not only did Canada respond quite strongly to the Cold War strategic environment but its spending patterns did in fact change once the Cold war ended.

Again, the WAR dummy variable and the UNDEP variable did not perform as expected. Both were found to be negative and insignificant and this is somewhat surprising given Canada's record of contributing the Canadian Forces for overseas deployments.

Finally, the absence of the lagged dependent variable removed the influence that deficit-based financing of the Canadian Forces had on Canadian military expenditures. Without a variable to account for the bureaucratic inertia and budgetary momentum discussed earlier, the DEFGDP variable becomes statistically insignificant.

Model C1 – No Relative Prices, No lagged MEGDP, Sample Period 1952-2001

Variables	Coefficients (t-value)
CONSTANT	-0.85324 (-0.7954)
DEFGDP	9.5913 (1.523)
USMEGDP	0.31765 (2.882)***
WAR	-0.31085 (-1.498)
NATOAVG	0.93199 (2.502)**
UNDEP	-0.076423 (-1.064)
COLDWAR	-1.4458 (-3.081)***
R^2	0.8693

Key: *10% significance, **5% significance, ***1% significance

One principal focus of this study was to investigate the impact and utility of including a relative measure of military and civilians prices on the demand for Canadian defence expenditures. A tightly specified theoretical approach would suggest that prices

would play a pivotal role in the allocation decision of planners; however, when employed in a more loosely specified atheoretical model, its influence is mixed. As well, recall that with each new model presented, we are moving away from the atheoretical approach and closer to a more tightly specified theoretical model. Moreover, in the hopes of gaining insights into the other influences of the demand for Canadian defence expenditures, the lagged dependent variable will be dropped (as it is for Model C1). We have already attributed a high degree of influence to this variable (by virtue of bureaucratic inertia and budgetary inertia); therefore, to investigate more accurately the influences of the other variables, the lagged dependent variable will be dropped from the estimation equation.

Model C1 produced the lowest R^2 of any other competing model. With a value of 0.8693, only 87% of the variance of the dependent variable can be explained by the independent variables. This would suggest that the removal of both the relative prices and the lagged dependent variables has significantly weakened the predictive capabilities of the model. However, if one re-examines model B1, then we can attribute most of this loss of capability to the absence of the lagged dependent variable.

Model C1 provides what many Canadian defence observers might consider expected results. Both coefficients for NATOAVG and USMEGDP are revealed to be positive and significant at the 5% and 1% level, respectively. The implication of these findings has already been discussed and this model simply reinforces earlier findings that Canada is not a free-rider in North American and NATO-Europe defence (with the exception of model B1 for NATOAVG). By dropping the prices and lagged dependent variable, we can see that defence planners considered the demands of continental defence

and then European security to be of primary and secondary importance respectively; they thus directed resources accordingly.

The coefficient for COLDWAR was negative but highly significant at the 1% level and this finding runs counter to that found in Model B1. This result would suggest that the Cold War environment elicited a negative response in Canada's demand for military expenditures. A possible explanation for this finding might be that a security-apathy may have set in, in Canada, resulting in government action that directed more resources towards social programs than to maintaining the Cold War security apparatus.

As was observed in the previous model the variables for international conflict, WAR and overseas peacekeeping deployments, UNDEP, did not perform as expected and were both found to be statistically insignificant.

Model D1 – The Classical Theoretical Model, Sample Period 1952-2001

Variable	Coefficients (t-value)
CONSTANT	6.504 (3.958)***
PMPC	-5.2106 (-4.453)***
DEFGDP	-5.3241 (-1.148)
USMEGDP	0.35060 (3.833)***
NATOAVG	-0.51046 (-1.843)*
COLDWAR	0.03871 (4.722)***
R^2	0.8908

Key: *10% significance, **5% significance, ***1% significance

Thus far, we have examined more descriptive models, jointly classified as the atheoretical side of the spectrum. While certain variables have proven to be strongly influential in predicting Canadian defence provision, others like UNDEP and WAR have failed to provide the expected descriptive results. Therefore, the final model to be considered is the neo-classical demand for defence model developed and espoused by Hartley and Sandler (1995), where only variables for price, income, spill-ins, threat and a

political/strategic shift variable are included. The aim of using this model is to determine if this classical approach can be used to describe the Canadian experience.

In keeping with this classical approach, this model includes the relative prices variable, the disaggregated spill-in variables of USMEGDP and NATOAVG, a Cold War dummy variable and the deficit as a share of GDP variable DEFGDP which will proxy income (for it describes the “ability to pay” of the government).

Model D1 produces a high R^2 value of 0.8908 where 89% of the variance of the dependent variable can be explained by the included independent variables. As well, a constant of 6.504 (at a significance level of 1%) is reported which suggests that if all other variables are held constant, Canada would devote 6.5% of its GDP to defence provision. This level, though high in present terms, is much more realistic than that found in model B1. Surprisingly, the income proxy of DEFGDP, though negative (but when calculated becomes a positive) was statistically insignificant, meaning that there is no relation between prevailing fiscal deficits and the level of defence provision. Contrarily, the relative prices variable PMPC is negative and significant at the 1% level. This observation falls in line with expectations and classical economic interpretation. Therefore, in the context of the classical model the use of a relative prices variable does have merit for Canada.

Also, in line with expectations is the performance of the dummy variable COLDWAR, which is positive and significant at the 1% level. In contrast to the findings of model C1, the positive coefficient of COLDWAR suggests the maintenance of the Cold War collective security apparatus had a positive influence on Canadian defence provision. This is supported by the findings for the US spill-in variable, USMEGDP,

whose coefficient is positive and significant at the 1% level. This suggests Canadian participation in continental defence and international security regimes was mostly strongly influenced by trends in US spending. Finally, the coefficient for NATOAVG was negative and significant at the 10% level suggesting some free-riding on the part of Canada in NATO burden sharing. Unlike the findings of Model C1, where the coefficient for NATOAVG was found to be positive and significant, Model D1 provides a result that is hard to explain. Canada's status as a free-rider in NATO has been a hotly debated issue since the organizations founding, and while several parametric studies have found Canada not to be a free-rider the results of D1 are an indication to the contrary.

Conclusion

This paper presented an analysis of the determinants of Canadian defence expenditure as a share of GDP through the estimation of a demand for defence expenditure model for the time period 1952-2001. Various models were presented that span the theoretical specification spectrum including a purely descriptive Canada-specific model to the neo-classical model presented by Sandler and Hartley (1995). The objective partial equilibrium analysis sought to assess the defence burden on the Canadian economy and assess the free-rider status of Canada in continental defence and the NATO alliance. As well, a relative price variable that was often dropped in previous studies was included in the estimation equation to reflect the reality of defence-specific inflation in Canada.

The results of the estimation analysis uncovered several factors which affect the provision of defence in Canada. First, a basic trend analysis demonstrated that the defence burden on the Canadian economy was highest following the Korean War (7-8% range) and has since fallen off to NATO average levels (1-2% range). While real defence spending has increased over this period, strong economic growth coupled with larger shares of government fiscal spending being devoted to the social infrastructure of Canada, account for these observed trends.

Second, the status of Canadian free-riding in response to the strategic spill-in variables for the US and NATO were determined to be mixed. In response to US spill-ins, Canada had a positive and significant reaction (Models A3, B1, C1, D1) meaning Canada is not a free-rider in North American defence and generally reacts favourably to increases in US spending regardless of whether they are directed towards continental or

NATO defence. In response to NATO spill-in, some models predicted Canada would respond positively to NATO spill-ins (Model C1); in others, it was predicted to react negatively (Model B1 and D1). Therefore, owing to the degree of interaction and integration of Canadian and US defence institutions and industry, this finding is not surprising; however, it was expected that NATO spill-in would have a more influential impact on Canadian defence provision than what was observed.

Third, the discovery of a unit-root and non-stationarity for the dependent variable MEGDP necessitated the construction of an alternative estimation model that relied on taking the first difference approach to estimating Canada's yearly fluctuations of defence provision. This model revealed that deficit financing and UN overseas deployments had a strong influence on the short-term, year to year fluctuations in Canada's defence provision. These findings were not surprising as this model (A4) more acutely captures yearly deviations in spending that are likely caused by urgent, unforeseen costs which are otherwise overshadowed by long-term influences like US and NATO defence spending.

Fourth, there is strong evidence that a structural break in the Canadian defence data roughly coincided with NATO's policy change from MAD to flexible response. This suggests some sensitivity of the estimation model to the sample period chosen. For instance, during the first sample period (Model A2) the demand for defence expenditures was primarily motivated by the previous years' spending demonstrating the influence of budgetary inertia and bureaucratic momentum. In the second sample (Model A3), income effects (proxied by the deficit variable) and spill-in effects (disaggregated into US and NATO) were shown to be more influential.

Fifth, the relative price variable performed well for most of the models. In particular and when significant, it demonstrated that defence provision in Canada is a normal good that responds negatively to price increases. Theoretically, this observation is not unexpected and demonstrates the utility of including a relative prices measure for those countries that may suffer from defence specific inflation.

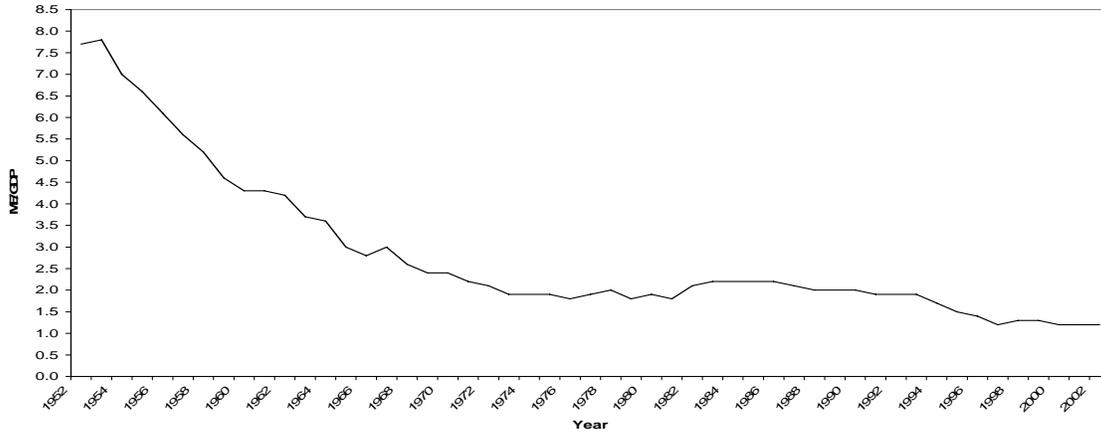
Finally, the other descriptive variables employed in the estimation model did not perform as expected. The inclusion of variables accounting for: the incidence major interstate conflict, overseas peacekeeping deployments and the Cold War, did not appear to contribute significantly to the estimation of Canadian defence demand and this may be explained for several reasons. First, owing to the geographic proximity of Canada to 20th century inter-state conflict, some events may simply have been too far away and Canada's interests so marginal that such events did not significantly affect defence planners. Second, international peacekeeping, as described above, does not represent a significant drain of defence resources. Third, strategic Cold War considerations were most likely manifested in the military's requests for funds and so is likely captured in the prevailing budgetary inertia and bureaucratic momentum of the Department of National Defence, hence the repeated significance of the lagged dependent variable.

This paper employed a standard OLS regression method whose estimates may be affected by data reliability issues. Although the researcher adjusted for the existence of a unit root in the dependent variable, future studies should investigate the existence of unit roots for all the explanatory variables. This would significantly increase the confidence and reliability of the data set and estimated coefficients. Another interesting path of investigation would be to apply the empirical model developed in this study to a variety

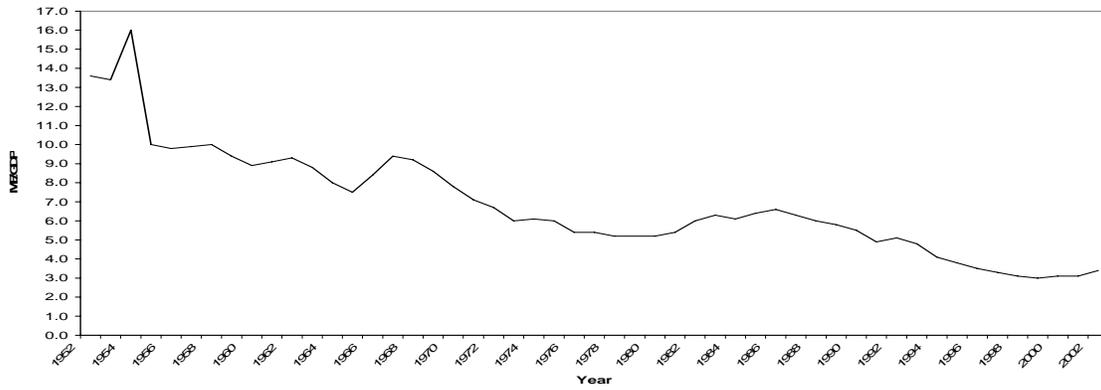
of similarly capable and strategically significant countries as Canada. This application would serve to investigate the robustness and accuracy of the estimation model. Possible contenders could include other small NATO members, as well as Australia and Israel.

Appendix 1

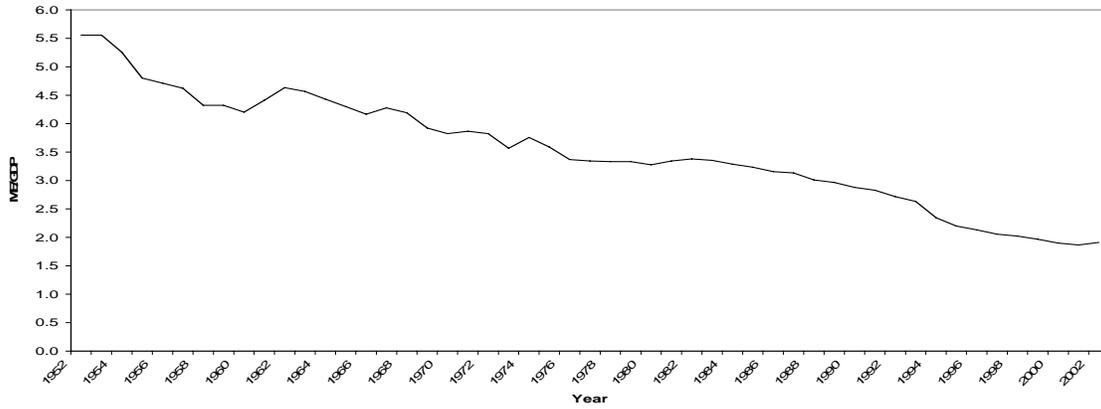
Military Expenditures as a share of GDP: Canada (1952-2002)



Military Expenditure as a Share of GDP: US (1952-2002)

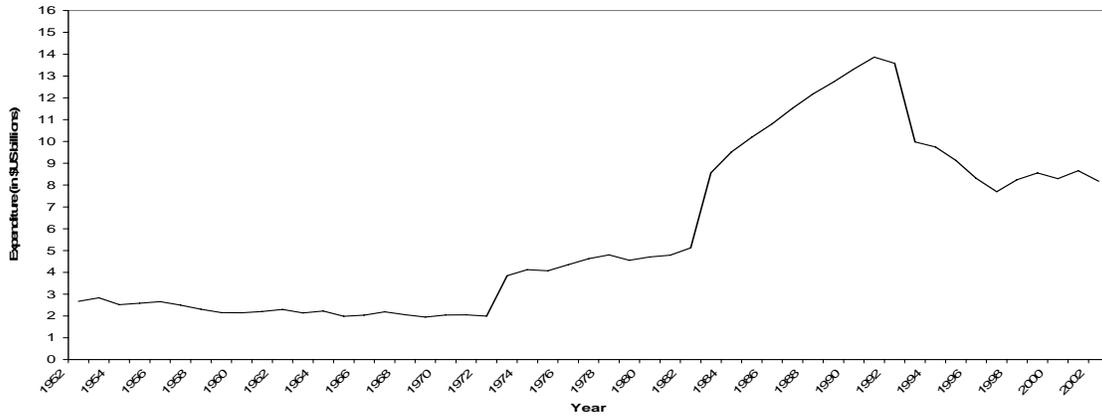


Military Expenditure as a Share of GDP: NATO (1952-2002)

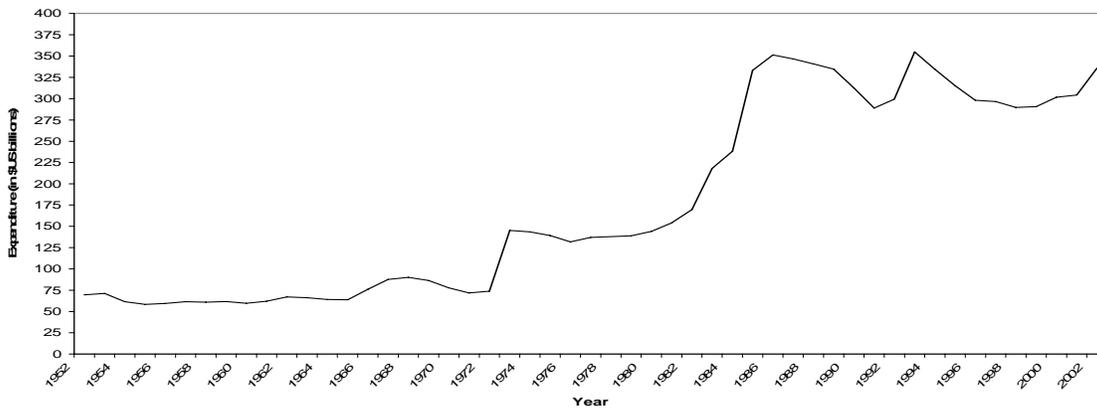


Appendix 1 - Continued

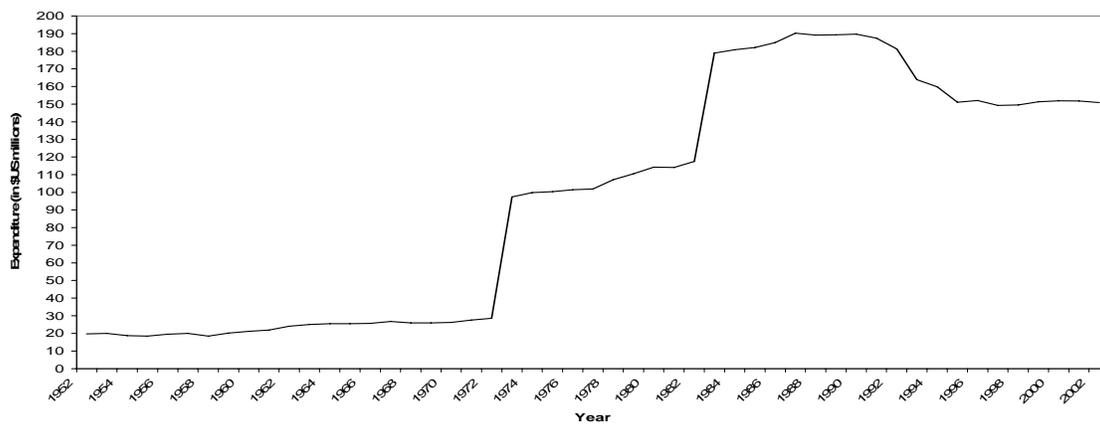
Real Canadian Military Expenditure (1952-2002)



Real US Military Expenditure (1952-2002)



Real NATO Military Expenditure (1952-2002)



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