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The Strategic Personnel Generation Model (SPGM) Version 1.0

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The Parliamentary Budget Officer (PBO) supports Parliament by providing economic and financial analysis for the purposes of raising the quality of parliamentary debate and promoting greater budget transparency and accountability.

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Executive Summary

As of September 21, 2017, the mandate of the Parliamentary Budget Officer includes estimating the cost of any election campaign financial proposal on request. Consequently, PBO is enhancing its capacities, including the development of models specific to key sectors of the economy or federal programs. One of these key sectors is national defence, which represents about 20 per cent of federal discretionary spending.

This note provides a technical description of a "personnel generation" model that estimates, and forecasts costs associated with, increases in military personnel. Personnel generation is central to military organizations; it is the first modelled within PBO's family of tools designed to assess the overall defence portfolio.

The model estimates the costs associated with both regular force members and primary reserves (part-time) and focuses on new recruits from external sources. However, any movement of personnel within military occupational classifications (infantry to logistics, and so on) is not modelled. Such internal movements are normally expensed from existing departmental budgets.

The key variable for the model is the recruit's time in training. Specifically, the model tracks the recruit's mode of entry (that is, through officer training, post-graduate officer and direct entry), as well as the associated duration in training before achieving operational functionality. During this training period, the model sums up costs associated with pay, operations and maintenance, base support and augmentation to training systems.

Depending on the election platform specifics, the model activates additional routines. The current version of the model accommodates special routines for skilled recruits, such as medical or legal, and surges (if the platform requires large intake of recruits beyond existing capacities in the Canadian Armed Forces).

To facilitate replication and transparency, the model uses publicly available data when available. However, such data tend to be highly aggregated to protect privacy or national security. The model includes several sensitivity and robustness checks to validate the results and to bound (provide upper and lower limits) estimated costs.

The following summary table provides a typical output from the model. Specifically, it details the costs associated with a hypothetical election platform promise to increase regular force members by 1,000.

Summary Table 1 Estimated Costs of Increasing Regular Force Members by 1,000

	FY 2018 Dollars	Then Year-BY Dollars
	$M	*$M*
Start Up -Recruitment and Training Costs		
Recruits Pay (in Training)	$161	$186
Pay after Graduation	$1,024	$1,294
Capital (Training)	$469	$528
Operations and Maintenance (Training)	$108	$125
Operations and Maintenance (Cost Move, Base, etc.)	$338	$509
Total Start Up Costs	**$2,100**	**$2,624**
Steady State Recurring Pay, Operations and Maintenance costs (1000 new personnel)		
Pay	$112	$159
O&M - in support of training only	$58	$67
Total - Recurring	**$170**	**$226**

As the table shows, the model separates the costs into start-up and recurring costs to distinguish between the key stages of the personnel generation cycle. The model also provides both FY 2018- and budget or then-year (including projected inflation) dollars estimates.

The model shows that recruiting and training 1,000 regular force members would cost just over $2 billion (FY 2018 dollars). About 60 per cent of the total start-up costs or in-training costs would be due to pay and allowances. Once training is completed and the new members achieve operational functionality, the steady state costs would be roughly $170 million, FY 2018 dollars.

Several enhancements are expected between now and early 2019 to accommodate any new data sources from the Department of National Defence and elsewhere. One important enhancement is the estimation of a military person-year that includes future benefit payments such as pensions and disability benefits.

In addition to reflecting the full fiscal cost of military personnel, a military full-up cost is an important variable to consider when comparing various options for improving the military-civilian ratio or the ratio of fighting troops (tooth) to support personnel (tail).

1. Introduction

As of September 21, 2017, the mandate of the Parliamentary Budget Officer (PBO) includes estimating the cost of election campaign financial proposals if requested. In preparation for this expanded mandate, PBO is enhancing its capacities, including tools and models.

This note provides a technical discussion and description of one of the models designed to estimate and forecast costs associated with increases in military personnel. The target audience for this technical note includes PBO analysts and other researchers interested in the technical aspects of the "personnel generation" model.

The Government of Canada recently released a defence policy (DND, 2017) containing a long-term commitment to fund the Canadian Armed Forces (CAF) and the Department of National Defence (DND). However, it is possible that political parties may still want to add to, subtract from or defer projects or commitments made in the policy.

For example, the Conservative Party platform of 2006 promised to "...recruit 13,000 additional regular forces and 10,000 additional reserve forces personnel." Note that this increase is above the 2005 policy statement of the Liberal Government that proposed an increase of 5,000 regular and 3,000 reserve personnel.[1]

Some political party platforms may include a combination of increases in capital and personnel. For example, a political party may adopt some or all the recommendations from the 2017 report by the Senate's Standing Committee on National Security and Defence (Senate of Canada, 2017). The Senate report included recommendations such as:

a. Recommendation (5): 55 Griffons replaced with medium-heavy lift helicopters
    i. Add 24 attack helicopters (could result in new capability)
    ii. Use VH-71 beyond cannibalizing parts
b. Recommendation (13): 12 new submarines
c. Recommendation (10, 11, 27): new pay model to attract and retain skilled labour, strategic plan to increase RCAF female participation and increase Rangers by 2,000 to 7,000.

Costing party platforms implies assessing the impact of the party platform on the country's fiscal conditions. There is no explicit requirement to assess the policy's relevancy. For example, we may cost the additional premium paid to build military equipment in Canada, but we may not assess the economic implications of a "buy Canadian" policy.

The model resides in a **Microsoft Excel ® Spreadsheet**. All sensitivity analyses and statistical models are conducted externally using **R**. R is a free (public) software environment for statistical computing and graphics.[2]

After briefly describing the scope of the model, the note is structured as follows: Section 3 outlines the mechanics of the personnel generation model. The next section discusses data sources and related advantages and limitations. In Section 5, we present model validation and sensitivity analyses. The last section points to possible future enhancements.

2. Scope

The strategic personnel generation model (SPGM) is designed to assess the impact at a strategic level. Specifically, it estimates the incremental funding required or the fiscal impact to accommodate a proposed increase in personnel.

This report focuses on new recruits from external sources as opposed to the movement of personnel within military occupational classifications or from non-commissioned members to officers. Costs associated with training to a specific military occupation are base-lined once the recruit reaches the operationally functional point (OFP).[3]

The external sources include the Direct Entry Officer (DEO)[4] and the Regular Officer Training Plan (ROTP). These sources are for officers. For the NCMs, direct recruiting (*ab initio*) is the main source.

Recruits admitted through the ROTP are often accepted at the Royal Military College of Canada (RMCC) or another Canadian university, and are designated as officer cadets (DND, 2018)[5]. They have an opportunity to earn a bachelor's degree and an officer's commission in the Canadian Armed Forces (CAF).

As a DEO, recruits can apply to join the CAF after obtaining a degree in a "suitable" discipline from a Canadian or recognized foreign university or institution (DND, 2018). Both entry types require basic officer training, instruction in a second language and military occupational training.

We expect the next iteration of the model to include the full cost of a military person-year. Specifically, the next version of the model updates costs associated with pay to include pensions, disability payments and other future benefits.

While this provides a more complete picture of the fiscal costs, the full cost of a military person-year also facilitates comparisons with other labour costs, such as primary reserves, civilians and contractors.

2.1. Skilled Entry

According to Straver and Christopher (2015), another external source is the skilled entry for both officers and NCMs, but this entry accounts for 5 per cent of the total intake. For NCMs, the CAF has a program called the NCM Subsidized Training and Education Plan, or NCMSTEP, which allows NCMs to acquire specialized skills in trades.[6]

Again, this is not one of the primary means of recruitment. Although we have a separate tab (or routine) for skills-based entry, we do not explicitly model it. If there is a specific requirement, the reserve or regular force models can be modified by increasing the time-steps to graduation (see next section for details).

The SPGM model also accommodates costing of reserve recruitment. There are no CAF-wide studies on reserve recruitment and retention. Doran (2016) cites statistics from a major Army reserve unit (34 Combat Engineering Regiment) and places the attrition rate at around 10 per cent. About 80 per cent of the reserve population consist of students who use the reserve to supplement incomes and leave the reserve within four to five years (Doran, 2016).

Since there is a lack of detailed data on reservists, we employ the training time step of NCMs as a proxy. Subsequent iterations of the model will include subroutines based on reserve force specific attrition and OFP patterns.

The various services or environments (Navy, Army, Air Force) have their own reserve components. These reservists have distinct employment patterns. Air Force reservists tend to be retired regular force members with specialized skills in aircraft repair or similar trade.

The Army, being labour intensive, tends to use reservists as extra labour and hires relatively unskilled recruits and students. It has a relatively easier time recruiting as the type of job, for example, infantry, is attractive to young students. The Army reserve units also account for 70 per cent of the total reserve population.

The Navy is platform-specific. Because of the decreased availability of platforms, the reserve activities are increasingly shifting to regular force. Some basic data on the primary reserve force are shown in the appendix.[7]

For purposes of personnel generation modeling, we use the Army reserve model as a proxy, given its relative size and nationwide presence. Note that civilian recruitment is not modelled, as the required education and training are acquired by the employee *before* hiring.

In addition, costs associated with professional development for civilian employees are often absorbed within existing budget envelopes.

3. Model

3.1. Assumptions

We use the following assumptions to construct the model.

1. The party platforms will be available at least two years after the introduction of the defence policy. We assume that some additional costs associated with force growth (71,500 regular force and 1,500 primary reservists) are already incorporated.
   a. Any additional increase proposed by party platforms will lead to surge[8] if it exceeds 2,000 additional recruits. (The policy's 3,500 plus 2,000 will exceed the availability capacity of 5,000 recruits).
2. There are costs associated with surge, especially if a party platform requires growth in the armed forces of more than 5,000 members and compresses the time to graduation to less than five years.
3. Time to graduation and OFP vary by type of external recruitment. The model accommodates most of these external recruitment strategies.
   a. If a recruit uses the ROTP strategy, the maximum time in training is about six to seven years.
   b. If the recruit is a DEO, then the maximum is about two years. If a party platform explicitly requires the recruitment of specialists, such as medical doctors, the model calculates these separately using a different training profile.
   c. The model accommodates a maximum of a 10-year recruitment period. This implies that the last recruit will graduate in 17 years, given the six to seven years of training expected for officers.
4. For capital cost augmentation, the primary items for consideration are costs for maintenance for trucks, small arms and training systems.
   a. If surge is assumed, then the model includes short (lease) and long-term infrastructure costs.

General statements on increasing military personnel by some amount usually entail an increase in operations and maintenance costs and a baseline increase in wages and salaries once a steady state is achieved. Before the steady state is achieved, however, the attrition rates during initial training and post full-time employment need to be incorporated to estimate the duration from recruitment to full-employment, or the operationally functional point.

3.2. Personnel Generation: Training

The request for general force expansion may be phrased as an increment from the CAF's existing total population. For example, the 2017 defence policy, *Strong, Secure and Engaged* states that: [9]

"In order to meet the high ambition, set out in this policy, the Canadian Armed Forces will increase its ranks by 3,500 Regular Force (to 71,500 total) and 1,500 Reserve Force members (to 30,000 total) …"

This stated incremental amount is one of the key variables in the personnel generation process. In addition, if the policy or party platform explicitly states the pace of recruitment (for example, 500 regular force members within three years), then this will constrain the number of recruits taken in future years.

Thus, given the CAF's current population at time t, and its desired force level at some future time t+n, the difference between the two represents the policy objective. The annual intake of recruits (AI) at some future time t+n is obtained by dividing the additional recruitment by the duration or pace implied by the policy pronouncement. The annual intake is scaled-up by a "retention factor" to account for attrition (failure rate).[10]

Symbolically:

$$AI_{t+i} = \frac{CAF_{t+n} - CAF_t}{n} \quad (1)$$

Once the annual intake of recruits (AI) is calculated, the model then allocates recruits to either the officer or NCM categories based on historical proportions. Historically, the NCM-to-officer ratio is about one officer for every five NCMs. Thus, in each recruitment/training year, the annual NCM intake is:

$$AI\_n = AI * NCM$$

And for officers,

$$AI\_o = AI * Offr$$

where *Offr* and *NCM* represent the proportion of new intakes that are officers and NCMs.

As noted earlier, the phasing of the recruits through the personnel generation system implies knowledge of typical attrition rates during training (Years of Service-YOS=0) and overall attrition rate for the CAF (YOS>1). We calculate the proportion that reaches OFP annually, given the pace specified by a political platform, by utilizing information on proportion by type of entry (ROTP, DEO, etc.).

According to historical data and Straver and Christopher (2015), DEO accounts for roughly 49 per cent of the officer recruit population, while ROTP accounts for 51 per cent.[11]

The time to OFP is similarly derived from historical data. The time to OFP for those officers recruited using the DEO stream is about three years and about 6.5 years for ROTP. Specifically, about 39 per cent of recruits will reach OFP by year two through the DEO stream and 50 per cent by year five for the ROTP stream.

Note that we are modeling the number of recruits in training during the in-take period outlined in a policy platform. As such, we are interested in the number of recruits in training in a given year and the total at the end of the recruitment cycle. (Equations 2 and 3 describe the totals in a compact form). Similarly, we calculate the number of (and total) graduates in a given year and at the end of the recruitment cycle (equations 4 and 5 represent the totals).

$$NCM_g = \propto \left[\sum_{k=0}^{m} b_k \left(\sum_{t=k+1}^{n} AI\_n_t \right) \right] \quad (2)$$

where α is the proportion of recruits who successfully complete basic training (one minus the training attrition rate YOS=0), b is training duration and AI represents annual intake.

For example, the number of NCMs graduating in the first year (t=1) consists of those expected to complete basic training in less than a year (k=0) minus the attrition rate.

For NCMs, the maximum number of years of service required to achieve OFP is four. The training period b is based on the OFP graduation rate (Straver and Christopher, 2015). The number of training periods (the k, in equation 2) starts from zero to four and corresponds to percentages of recruits who graduate between zero and four years and achieve OFP.[12]

As pointed out earlier, officers are recruited externally, either through the DEO or ROTP streams. Based on the last decade of data, about 49 per cent are recruited using the DEO stream.

$$Ofr_g = \propto_o \left[\sum_{k=1}^{m} bc_k \left(\sum_{t=k+1}^{n} AI\_O_t \right) \right] \quad (3)$$

The training period for officers is denoted by *bc* and includes the proportion who use either streams (DEO or ROTP), plus the duration in each before graduation or OFP. α_o denotes the proportion that succeeds in the training program.

Note that for graduating officers (Ofr_g), the minimum time to OFP is two years (hence, the time step *k* starts at 1 which leads to time *t*+*k*=2). The rest of the equation is identical to the NCMs.

In both equations (2) and (3), the maximum time (n) is based on the duration determined by a given policy platform, while the maximum duration in training (m) is determined by the historical trends of CAF training systems.

The number of trainees in the system is the other important cost driver related to personnel generation. These trainees are paid wages and salaries and other indirect costs, such as a clothing allowance. Again, we calculate the number of trainees in the system using the attrition and duration to OFP rates.

Given the annual intake, attrition rate and training cycle, the number of trainees in the system becomes constant once we reach the first graduates at some time *t*. Note that there will be trainees in the system two years beyond the duration specified by a policy platform to account for the lag due to the time required to achieve OFP.

the total number of recruits (NCM_r) in the system is shown as:

$$\alpha \left[\sum_{j}^{m} b_j \sum_{t}^{n+1} AI_t \quad + \bar{b} AI_{n+2} \right] (4)$$

Similarly, the number of officers in the training system (Ofr_r) at a given time *t* is shown as

$$Ofr\_r = \left[\sum_{t=1}^{n} (\alpha * AI_o) \sum_{k=1}^{m} bc_k \right] (5)$$

Since there are two external sources for officers and the time to graduation varies from two to six years, the officer cadre stays in the system longer (*n+6*).

3.3. Personnel Generation: Wages and Benefits

We calculate the wages and benefits for the officer cadets and trainees as they go through their respective training systems. The cost for the remuneration varies depending on the trainee or cadet's stage of training. We use the cadet or trainee's pay rate while in training and the average CAF pay rate once OFP is achieved.

3.4. Operations and Maintenance

During the training period, the CAF expends resources per recruit in terms of operations and maintenance (O&M). These costs include base operations and maintenance, medical screening costs and other indirect personnel costs. The key cost driver for military training is the duration in training and the intake rate. The latter can be changed by government directive or in response to urgent requirements.

For example, the government can direct the CAF to increase personnel strength by 5,000 in three years. Such a concentrated intake will increase the indirect costs associated with recruiters, support staff and accelerated facilities and equipment usage (depreciation).

There are two types of O&M costs. The first is the cost of training and the second is related to base or military infrastructure operating costs. Training related O&M is calculated in the same manner as in any educational institution. We identify the main training bases and calculate the total costs of these installations to derive the cost per student.

This cost can be considered as the average amount spent annually to provide education and related services to a recruit or trainee. However, training bases may have additional responsibilities and purposes even if their primary activity is training. For validation purposes, we include the cost of education from Ontario universities of similar size to compare the cost per student.

Base or military installation costs capture all the direct and indirect costs related to administrative support within a geographical region of a given installation. This cost is then attributed per capita.

Key cost types include facilities and information technology support, supply, construction engineering (CE) and communication. These cost types are normally aggregated as base O&M costs. There are also costs that are people-intensive, such as administration, pay, medical services, etc.

3.5. Other Incremental Costs

All recruits identified as Basic Training List (BTL) are entitled to a paid (cost move in CAF terminology) move as per the relocation directive (DND, 2018). After OFP, the cost move cycle will require about 300 cost moves annually to sustain personnel support and program mandate[13]. We apply an additional cost at the end of the recruitment cycle to account for these expected moves.

DND provides health services to regular and reserve forces. The cost attributed to health and dental units across the organization is apportioned to the expected increase in force level. Additional medical and dental costs associated with screening new recruits are included if there is a surge beyond the capacities in place at the training bases (Borden and St. Jean).

Note that the model is designed to cost increases in force in a generic fashion. It is possible that the existing facilities and training systems may not be able to handle a force increase beyond a given threshold.

DND is currently implementing the defence policy of 2017 (*Strong Secure Engaged*-SSE). When modeling requests for a force increase from a given political party platform, we must ascertain whether the proposed increase is above and beyond the 2017 policy.

SSE is expecting an increase of 3,500 regular force members, 1,500 primary reservists and 1,150 civilians (DND, 2017). If the requirement is more than 5,000 inclusive of the SSE, then there may be additional costs related to recruitment personnel and support, and capital costs related to facilities, training systems and equipment, such as weapons and trucks. The model uses a special routine for calculating these incremental costs once the threshold is exceeded.

The surge routine itself is incremental, based on CAF/DND decisions on how to deal with the increased demand on their personnel generation capacities. At the low end of the surge routine, the model estimates the costs associated with increased requirements for clerical support and operations and maintenance costs due to increased usage, as well as some additional specialized services for medical screening.

The second stage of the surge uses contractor support, increased capital spending for training systems, equipment, and so on. The last stage includes such items as infrastructure costs associated with new training facilities, students' accommodation and recruitment centres in key urban areas.

The choice of the surge routine depends on the timing and number of recruits articulated in an election platform and the most recent data on DND's capacities.

3.6. Model Outputs

The model produces the total cost of the personnel generation process by budget components of military pay, and expenditures on capital, operations and maintenance. The estimated cost covers the period from recruitment to steady state employment.

To illustrate, we model the cost of generating 1,000 regular force members within a 10-year period. The current version of the model accommodates a maximum 10-year recruitment to OFP phase. Table 1 presents the standard output of the model for the 1,000-member increase.

Pay, capital and operating and maintenance costs for training hires are depicted as item (A). These costs include salaries during training, any training system augmentations (capital) and costs associated with training, and relocations ("moves"). These costs amount to $738 million in 2018 dollars.

As recruits graduate out of the training system and before they relocate to their first assignment, salaries and benefits are summed up over the training phase (Item B). This pay amount is about $1.0 billion in 2018 dollars. Note that the training duration or phase is about 17 years in this exercise (to account for a 10-year recruitment and six to seven-year ROTP training).[14]

The model then sums up items A and B to provide the total cost from start-up to the last year of graduation (17 years in this exercise). This amount is estimated at $2.1 billion (2018 dollars). The estimated steady state costs are $170 million (2018) to account for ongoing full costs of the new members.

While costs are in 2018 dollars, the model also provides budget year dollars by inflating the costs by projected inflation rates from the PBO's fiscal and economic model.

Table 3-1 Model Output for Generating 1,000 Members

Start Up - 17 Year Recruitment and Training Costs (A)	*FY 2018 $M Dollars*
Military Pay	$161
Capital	$469
O&M	$108
Total (10+ year cumulative) Recruitment and Training Cost	**$738**
Start Up - 17 Year accumulated Mil Pay cost of employed pers (e.g. after completion of training)	
Military Pay (B)	$1,024
Total Start Up Costs (A+B)	
Military Pay	$1,185
Capital	$469
O&M	$446
Total Start Up Costs	**$2,100**
Steady State FY 34/35- Recurring P,O&M costs	*(1000 new personnel)*
Military Pay	$112
O&M - in support of training only	$58
Total - Recurring	**$170**

4. Data and sources

Ideally, publicly available data sources are the most expedient for facilitating research; they are the key conduit for replication and validity of model results. Unfortunately, disaggregated military data are not readily available. Some of the restrictions include privacy rules, while others are related to national security. For the personnel generation model, we use a combination of published research, public data and data provided by DND.

Specifically, we use a recent DND Cost Factors Manual (2017-18) for data on wages and benefits by rank. This information is unclassified, but not publicly available. For purposes of replication, we also consult a public version from the DND website on pay rates (http://www.forces.gc.ca/en/caf-community-pay/pay-rates.page)

The data generated from this public version are very similar to the manual and can be used for future iterations. Detailed comparisons of the data are shown in the next section.

For the cost of training or recruitment, we use the DND publication Expenditures by Electoral Districts and Provinces (EDIS) as well as data from the Common University Data Ontario (CUDO)[15]. The latter is used as a validation of the estimate derived from EDIS.

The Ontario universities used for cost validation include Laurentian, Nipissing and University of Ontario Institute of Technology. These institutions are similar in size and often considered as primarily undergraduate institutions much like the Royal Military College of Canada.

We also use data in DND's EDIS publications to estimate the operating cost per capita of the training base, as well as simple regression methods. In addition, we use other published work such as Kerzner (2011) to generate cost estimates for operating training bases and cross validate the results.

While the Cost Factors Manual (a DND product) can be used to generate training base operating costs, the last published work is at least five years old. Currently, the publication is undergoing a major overhaul to account for new establishments, capabilities and cost estimation techniques.

It should be noted that the manual is primarily used as a cost recovery tool. While cost recovery tools are relatively useful for personnel-related costs, they are ill defined for estimating equipment or activity costs.

To provide a standard cost for cost recovery, the data tend to be smoothed to dampen spikes in activity rates whenever the CAF is engaged in domestic or international operations. The moving average technique (for smoothing data) may sometimes remove key factors that explain significant shifts in structures and activity costs.

Interpretation of base support costs requires caution. A great deal of the variation in cost is the direct result of scale. Large bases that support a large population enjoy significant economies of scale. The opposite would be true for smaller bases.

Other factors that play an important role are the geographical size of the base property, the number of off-base responsibilities, the types of units supported by the base, and the historical development of the base.

4.1. DND Estimated Expenditures by Electoral District and Province (EDIS)

The purpose of this DND publication (EDIS) is to provide information on direct financial activity by provinces and electoral districts. While the publication has obvious public relations benefits for communicating the local and national presence of DND, it is rather limited for in-depth economic assessment (DND, 2016).

For example, capital and operating and maintenance costs attributed to ridings are based on the postal code or address of the vendor. If the vendor provided a head office address as opposed to the location where the activity occurred, we may overestimate the economic activity in that riding.

Similarly, individuals may spend their disposable income in a location different from where their pay cheques are delivered. For the purposes of the personnel generation model, we use this data source for the following two key reasons.

First, the main training bases, Borden and St. Jean, are in relatively remote locations. Thus, O&M and capital spending attributed to their respective ridings are likely related to the bases' spending. Note that this is potentially underestimating the true O&M and capital spending in these bases, as some capital spending related to the bases may have been paid out to firms that are headquartered outside the ridings. For this reason, we also use alternate public data on military installations costs.

As pointed out in the model description section, we consult Straver and Christopher (2015) for key variables such as the attrition rate during recruitment and post OFP. Because of the importance of these attrition variables, we also conduct sensitivity analyses on attrition rates using univariate time series models.

Forecasts from the time series models are used to establish the bounds for the sensitivity analysis and to assess cost implications of changes to the attrition rates. We present more discussions on the univariate models in the model validation section.

4.2. Strategic Cost Model (SCM)

The Strategic Cost Model-SCM (Kerzner, 2011) is an additional resource for data, particularly for the attribution of common and environment (Air, Land and Sea) specific training, base support and capital costs. The SCM provides some interesting insights on DND's force elements.

The 2008 version of the model, for example, indicated that military training accounted for $1.7 billion (2005 Dollars)[16] or 14 per cent of DND's budget. The most recent data are for 2012; CAF-wide training accounts for 16 per cent of DND funding ($3.4 billion in 2011-12 dollars).

The rationale for using an older vintage of SCM stems from the key assumption that the cost attribution and interrelationships between force elements and military capabilities resemble the industrial relationships depicted in input-output models. The key assumptions of input-output models include: fixed inputs to outputs proportions, unconstrained resources and fixed market shares[17].

If Defence, like private business, continuously adjusts its input requirements and sourcing, then the first assumption is inappropriate. However, note that recruitment and procurement take time in military organizations. Military organizations can mix labour inputs between a regular force and reserve, but the out sourcing of some military activities remains a challenge due to legal and regulatory constraints (Hartley, 2003).

Similarly, the third assumption of fixed market share can be questioned if Defence allows new entrants into national defence or mergers among the armed services. But the various branches of the armed forces are "franchise monopolies".

For example, all space and air activities are the exclusive domain of the Royal Canadian Air Force (RCAF). Even maritime patrol and the associated air assets belong to the RCAF. One cannot exploit the benefits of competition by having each armed services organization produce air-to-air combat. Like an input-output model, the SCM assumes that the market share for air assets remains constant for at least the medium term.

The older version of the SCM (2011-12) is still valid for other reasons as well. First, DND underwent budget reductions during fiscal 2011-12, limiting the introduction of new military capabilities and technologies. In addition, the most capital-intensive services, the air force and navy, have yet to introduce major platforms; this limits the ability to exploit new processes and means to generate military capabilities.

Second, the cost attributions used for the personnel generation model rely on overhead costs that tend to remain relatively static until a major shift in budgets or policy. However, we expect technologies to change with the successful implementation of the new defence policy (given the major capital projects and new capabilities in cyber, space and unmanned surveillance and defence).

5. Model validation

5.1. Wages and Benefits

Personnel and operations and maintenance are the main cost elements during the recruitment-full employment phase. These costs can be calculated on a per capita basis using the Cost Factors Manual or similar data or analyses.

From the DND official websites one can extract monthly wage data by rank. While the “true” weighted average of a typical CAF member may not be assessed from the data, simple averages can be derived from the available data[18].

Tables 5-1 and 5-2 show the data and the associated averages from the public data set. Table 5-1 highlights officers’ monthly pay scale, while Table 5-2 shows monthly pay for non-commissioned members (NCMs). The most recent Cost Factors Manual estimates the typical compensation cost of a CAF member (pay, allowances and benefits) at about $107,000.

Table 5-1 Pay Information from DND website for Officers

Rank	Pay Increment Basic	Pay Incr 1	Pay Incr 2	Pay Incr 3	Pay Incr 10	Average	annualized	EBP	Aggregate_ Simple	Aggregate based on 87/13 split
Officer Cadet	1,667	1,700	1,739	1,772		**1,720**	20,634	24,761		
Officer Cadet	3,011	3,135	3,626	3,767		**3,385**	40,617	48,740		
Second Lieutenant A	4,774	4,843				**4,809**	57,702	69,242		
Second Lieutenant E	5,274	5,431	5,594	5,761	7,082	**6,139**	73,669	88,403		
Lieutenant	5,202	5,555	5,909	6,260		**5,732**	68,778	82,534		
Lieutenant E	5,558	5,780	6,013	6,251	8,232	**6,817**	81,799	98,158		
Captain	6,596	6,846	7,097	7,347	8,718	**7,763**	93,152	111,782		
Major	8,919	9,077	9,231	9,385		**9,462**	113,541	136,249		
Lieutenant-Colonel	10,337	10,505	10,666	10,835		**10,669**	128,026	153,631		
Colonel	11,289	11,734	12,178	12,625		**11,957**	143,478	172,174		
Brigadier-General	13,340	13,697	14,074	14,442		**13,888**	166,659	199,991		
Major-General	15,310	16,188	17,099	17,983		**16,645**	199,740	239,688		
Lieutenant-General	19,674	20,208	20,768	21,300		**20,488**	245,850	295,020		
CAF Average									105,488	103,068

Note: * 87% of CAF are NCM, while 17% are officers. Employee Benefits Plan (EBP) Monthly data

Table 5-2 Pay Information from DND website for NCMs (Monthly data)

Rank	Pay Increment	Trade Group Standard	Trade Group Specialist 1	Trade Group Specialist 2	Average	annualized	EBP
Private 1	1	2,985			2,985	35,820	42,984
Private	2	3,647			3,647	43,764	52,517
Private 3	3	4,382			4,382	52,584	63,101
Corporal	1	5,088	5,714	6,065	5,622	67,468	80,962
Corporal	4	5,302	6,009	6,419	5,910	70,920	85,104
Sergeant	1	5,817	6,517	6,904	6,413	76,952	92,342
Sergeant	4	5,995	6,705	7,091	6,597	79,164	94,997
Warrant Officer	1	6,476	7,052	7,319	6,949	83,388	100,066
Warrant Officer	4	6,660	7,233	7,503	7,132	85,584	102,701
Master Warrant Officer	1	7,153	7,633	7,790	7,525	90,304	108,365
Master Warrant Officer	4	7,370	7,860	8,009	7,746	92,956	111,547
Chief Warrant Officer	1	7,945	7,945	7,945	7,945	95,340	114,408
Chief Warrant Officer	4	8,190	8,190	8,190	8,190	98,280	117,936
Chief Warrant Officer	1	8,502	8,502	8,502	8,502	102,024	122,429
Chief Warrant Officer	4	8,765	8,765	8,765	8,765	105,180	126,216
Chief Warrant Officer	1	8,841	8,841	8,841	8,841	106,092	127,310
Chief Warrant Officer	4	9,113	9,113	9,113	9,113	109,356	131,227

The average calculated from the monthly data is between $103,000 and $105,000, depending on the calculation. The $103,000 figure is derived by weighting the NCM compensation by 87 per cent and the officers' pay by 17 per cent to reflect the makeup of the current CAF. The $105,000 figure, on the other hand, is a simple average of all data combined for officers and NCMs.

During the recruitment stage, we use the average salary of a second lieutenant, which is about $87,400, according to the Cost Factors Manual, or $88,400, according to public data. The differential is significant for NCMs or privates.

The public data place the compensation rate for privates at $63,100, which is about $6,000 less than the Cost Factors Manual. These differences are incorporated into the sensitivity analysis to illustrate potential cost paths.

5.2. Attrition

The personnel generation model starts at the point where successful applicants begin their basic training. As such, the key variables of interest are the attrition rates during training and after OFP.

There are, of course, costs incurred during the initial screening process and the personnel time associated with recruiters. Since these organizations are already set up, we consider it a sunk cost (unless there is demand for more recruits beyond current capacities).

Maximizing the supply of recruits is of crucial importance to DND, given the SSE requirement to increase the regular force to over 70,000 and the primary reserves to 30,000. When costing a party platform, it should be noted that DND may not be able to fulfil the requirement if the supply of recruits fails to match the increases in required force.

As noted by Fetterly (2018a), one of the key factors that may limit intake of new recruits is the recent reduction in recruiting footprint. In addition, DND also reduced training funds in response to the 2011 federal deficit reduction action plan (DRAP).

The attrition rate is set to increase in the coming years in response to the bulk of the baby boomers retiring. CAF's current strength is below the authorized level of 68,000 (Fetterly, 2018b).

Since the model uses the Straver and Christopher (2015) attrition rates to generate the O&M and associated costs, we employ our own simplified attrition forecast as a model validation exercise and sensitivity analysis. Specifically, we employ a single variable time series model (Univariate ARIMA) to forecast attrition rates.

ARIMA Forecasts

We use the publicly available statistical software R to build the univariate Autoregressive Integrated Moving Average (ARIMA) model. Box and Jenkins (1970) is the authoritative text; one can also consult Kennedy (2008) for a more practical discussion on application and limitations.

ARIMA models are theory free and use the data generating process to forecast the future values. The variable of interest is modeled by regressing it on its own past values. The regression error is modelled as a linear combination of current and past realizations.

Most socio-economic data sets tend to exhibit non-stationarity. This means that the mean and variance of the variables change over time. The I in ARIMA thus stands for "integrated", which indicates a process to make the variable of interest stationary. This is achieved by subtracting the variable by its lagged version. Symbolically (Kennedy, 2008),

$$Y_t' = \alpha_1 Y_t' + \alpha_2 Y_{t-1}' + \cdots + \alpha_p Y_{t-p}' + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \cdots + \theta_q \varepsilon_{t-q}$$

where α and θ are unknown parameters and the error term is denoted by ε. The time series of interest Y is expressed in terms of its lagged (past) values and the regression error term is expressed in terms of current and past values.

The modelling process according to Box and Jenkins (1976) includes a three-stage iterative process starting with identification of the number of lagged values for the autoregressive (p) and the moving average (q) processes. The model is estimated in the second stage using the maximum likelihood estimator. The last stage is designed for conducting diagnostics and model adequacy in terms of parsimony, white noise errors, etc.

For the attrition rate modeling we use data from the annual report of the Director General Military Personnel Research and Analysis (DGMPRA) on regular force attrition. The dataset includes attrition rates for YOS=0 (basic training attrition) from 1996-2017 and YOS>0 for the years 1985 to 2017.

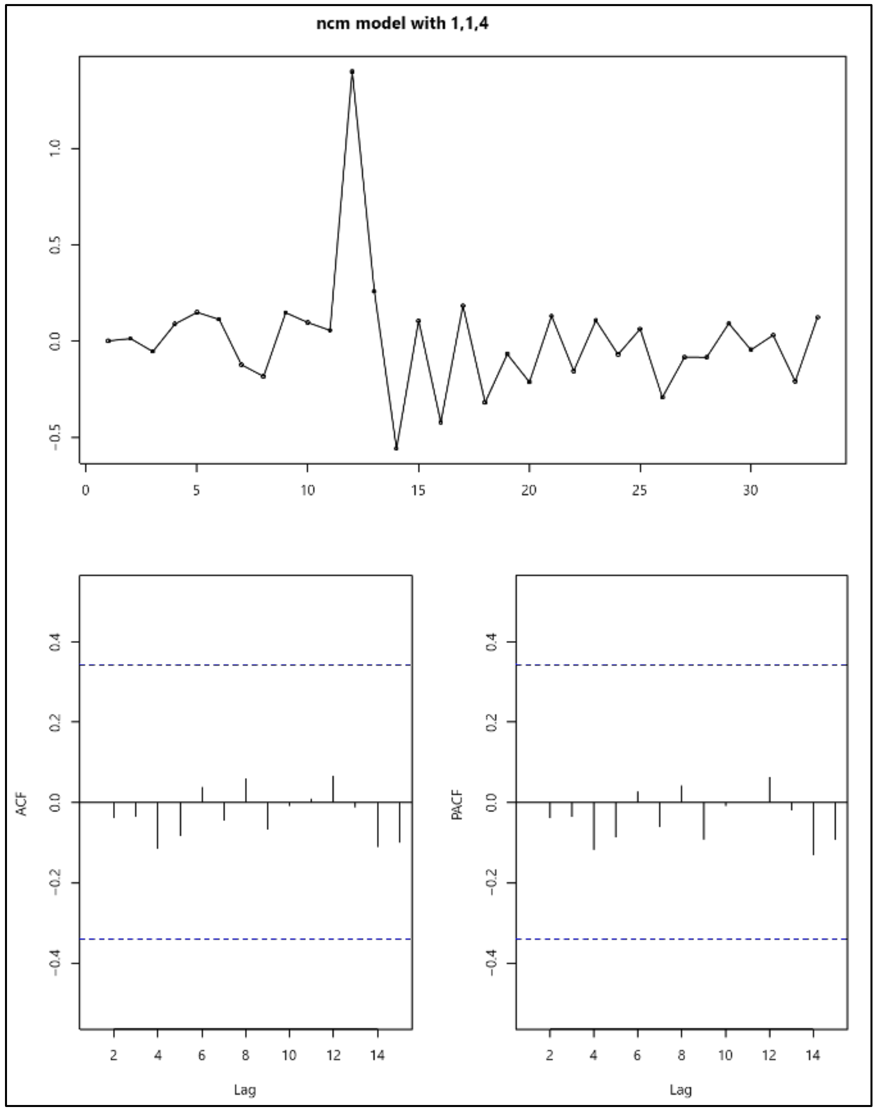
Given the fact that we are working with annual data, a longer time series would have been desirable. We hope to collect more historical attrition rates in subsequent iterations of the model.

We begin the modeling process by examining the stationarity properties of the attrition rates for the officer and NCM variables. Once the appropriate level of differencing is determined, we move to the estimation stage. It should be noted that most socio-economic time series require no more than first level differencing (or in time series parlance integrated of order 1).

Figure 5-1 below shows the attrition rates and model residuals for the NCM series. Note that the series is labelled (1, 1, 4) indicating that it required first order differencing and contains an autoregressive term and a moving average process up to lag 4. We conduct similar identification for the officer and total (officer and NCM) attrition data.

Note also in the second panel of Figure 5-1 that the autocorrelation and partial autocorrelation functions show no significant autocorrelation. This confirms that the model is adequate for forecasting purposes. The original NCM data are log transformed to render the time series variance stationary.

Figure 5-1 NCM Attrition Rate Model and Diagnostics



The Office of the Parliamentary Budget Officer web site contains the R Codes for generating the ARIMA models. We use a forecast accuracy test as discussed in Hyndman and Koehler (2006). These authors propose scaling the forecast error by using the in-sample mean absolute error. The naïve forecasting method is the comparator (the last period's actuals are used as this period's forecast, without adjustments).

This scaled measure is known as the mean absolute scaled error (MASE). A measure greater than 1 implies forecasts are worse than in-sample one-step forecasts from the naïve model (Hyndman and Koehler, 2006).

Table 5-3 presents the results from the accuracy check of the attrition data. Note that the attrition rate is for the steady state (or after successful completion of training). The general CAF and NCM attrition rates have a MASE of less than one when we account for the outliers.

The forecast for officers, however, performs poorly. The MASE for this series is greater than one (worse than the naïve model).

Table 5-3

Forecasting Attrition Error Comparisons

YOS>1	ME	RMSE	MAE	MPE	MAPE	MASE	ACF1
Officer	0.00	0.27	0.16	-1.68	7.88	1.02	0.03
NCM	0.01	0.30	0.18	-0.73	7.96	0.95	0.00
CAF	0.00	0.27	0.16	-1.12	7.27	0.92	0.04

Note: ME: Mean Error, RMSE: Root Mean Squared Error, MAE: Mean Absolute Error, MPE: Mean Percentage Error, MAPE: Mean Absolute Percentage Error, MASE: Mean Absolute Scaled Error, ACF1: Autocorrelation of errors at lag 1

Table 5-4 presents forecast errors for the year zero attrition or attrition during training. For all the relevant time series the MASE is less than one, indicating the forecasts are at least superior to the naïve model.

Once we are comfortable with the forecasting model adequacy and performance, we generate an out-of-sample forecast for the attrition rates of various components of the CAF. Figure 5-2 shows forecasts and the 80-90 per cent forecast intervals for the NCM series that are adjusted for outliers.

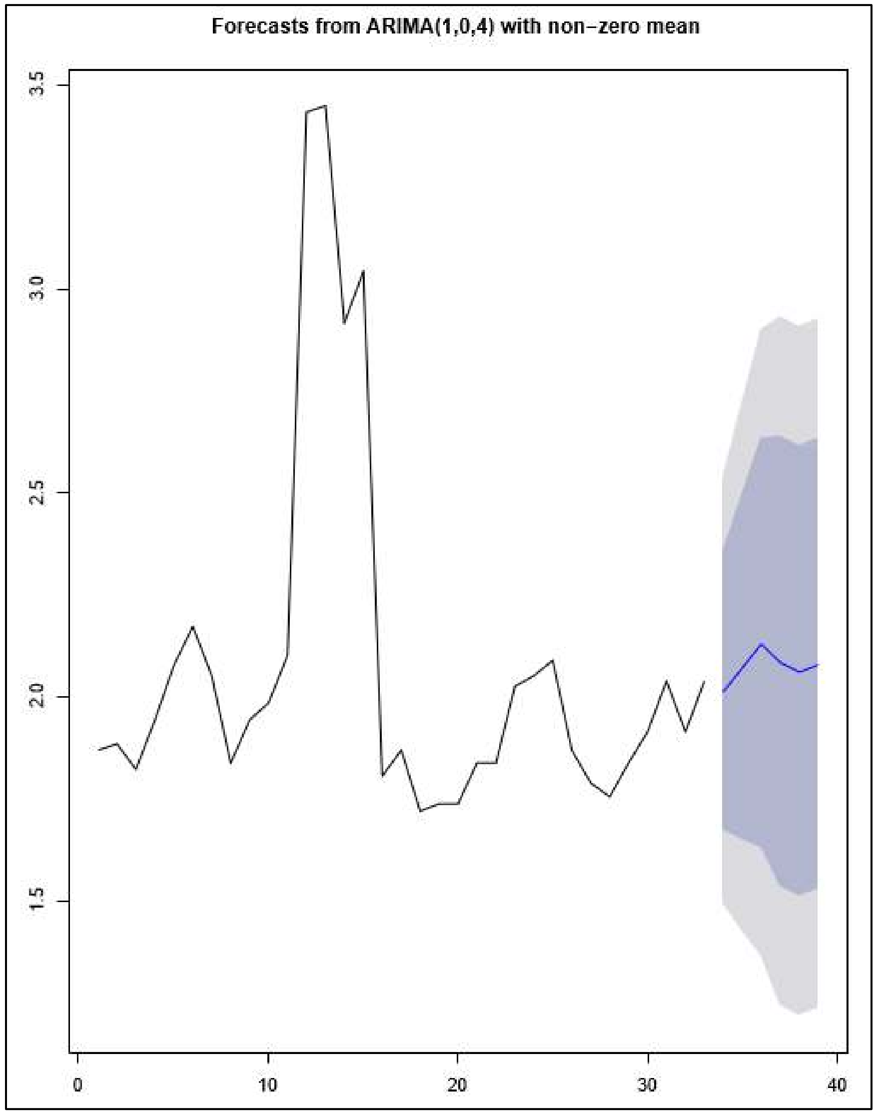
Table 5-4

Training Attrition Rate Forecasting Error Comparisons*

YOS=0	ME	RMSE	MAE	MPE	MAPE	MASE	ACF1
CAF	0.00	0.23	0.17	-0.77	5.90	0.75	0.02
NCM	0.01	0.25	0.18	-0.40	6.18	0.71	-0.07
Officer	0.00	0.40	0.32	-2.51	12.74	0.87	-0.01

Note: See Table 5-3 for explanation of column acronyms

Figure 5-2 NCM Attrition Forecast (Outlier Compensated)



The point forecast for the NCM series starts out at about 2.05 (log form) or 7.8 per cent attrition. It rises to about 2.15 or 8.6 per cent before settling at about 8.2 per cent. This is a percentage higher than the DGMPRA forecast, but in line with the expected attrition rate resulting from the retirement of the baby boom cohort.

While forecasting attrition is not the primary role of the personnel generation model, it is an important component for conducting sensitivity analysis. As an alternative validation check, one can use triangular distribution around expected, high and low attrition values for the historical data. The choice of model validation is only constrained by data availability.

5.3. Training, Base Elements and Capital Costs

As pointed out in the data section, costs associated with supporting military training bases are derived primarily from EDIS and older versions of the Cost Factors Manual. These data sources have some serious limitations and an alternate source is required to validate the costs generated. We use the SCM as one potential candidate since it attributes departmental expenditures to various military capabilities and force elements.[19]

An updated version of the SCM is also a potential candidate for PBO to do force structure costing. For purposes of the personnel generation model, the older vintage (2011-12) can be used to ascertain the attributable portions of costs for training base support and capital costs[20].

The standard method to assess costs of training is to calculate total institutional expenditures and divide by the total full-time equivalent student body. For national comparisons, we use Statistics Canada (2017) and as noted earlier, the Common University Data Ontario.

Table 5-5 Cost of Training per Student per Year

Institution/Region	**Source**	**Cost Per Student $000**
Canada	Statistics Canada (2017:54)	31.65
Ontario	Statistics Canada (2017:54)	29.36
Quebec	Statistics Canada (2017:54)	28.17
Laurentian University	CUDO*	21.73
Nipissing University	CUDO*	15.48
University of Ontario Institute of Technology	CUDO*	18.13
DND/CAF Average	EDIS	26.91
DND/CAF All Training +	SCM	62.74

Note: *Common University Data Ontario + per CAF population

Table 5-5 presents training costs per student calculated from the data sources noted above and the SCM. Note that the EDIS estimate for DND at $27,000 compares favourably with the data from the Ontario and Statistics Canada databases. The training costs attributable to the SCM are for all CAF members, as each member undergoes training at some rank interval throughout their careers.

While considerably higher than the other averages reported in Table 5-5, we believe that the SCM-based estimate is a reasonable upper limit for sensitivity analysis, as training in DND includes specialized equipment, environmental controls and professional development programs.

The SCM is also a potential source for attributing base or military installation costs per recruit or regular force member. The Cost Factors Manual attributes about $30,000 per person for installations associated with basic and common training.

A typical military installation will include the following four elements: Housing units for single and married military personnel; personnel support (human resources, pay, etc.); communications (information technology and management); and health services.

The aggregate Canada-wide cost for these elements is estimated at about $970 million (2011 dollars). On a per capita basis, this works out to about $17,000 (if the entire CAF is included), or $46,000 per recruit and trainee.

Capital costs for personnel generation involve training systems, trucks and small weapons. If a recruitment surge is anticipated, then the model will account for augmentation costs for infrastructure. The baseline scenario uses the attributed capital and sustainment costs of military trucks. Training systems, ammunition and small weapons are assumed to be available in inventory.[21]

Using the 1,000-member increase as an illustration, selected results from the sensitivity analyses are shown in Table 5-6.

Table 5-6 Selected Results from Sensitivity Analyses ($Millions)

Start Up - 17 Year Recruitment and Training Costs (A) (2018 Dollars)	Total (10+ year cumulative) Recruitment and Training Cost	Total Start Up Costs	Total - Recurring
Pay High	$11.9	$139.5	$13.7
Pay Low		-$14.6	-$117.2
O&M Base Low		-$71.1	-$7.4
O&M Base High		$526.9	$54.9
Attrition High	$11.8	$11.8	
Attrition Low	-$13.3	-$13.3	
Reduction in Annual Intake*	-$194.8	-$380.8	

Note: * excludes costs associated with increased depreciation of equipment and related O&M.

Note that the base operating costs from sources such as the Cost Factor Manual tend to be on the low side. For example, using the SCM as the source for data on training base spending increases O&M costs by about $500 million. Variations in the attrition rate have modest effects (about $11-13 million).

Significantly, compressing the recruiting period by five years reduces costs by as much as $380 million. However, past experiences show that the CAF is unable to recruit at such a pace given the competition for recruits from other sectors of the economy.

6. Future modifications

There are two key avenues for future research. The first deals with areas of improvement to make the model more robust. The second deals with potential expansion of mandates beyond costing to the realms of policy implications and feasibility of legislative changes on national security and defence.

Within the first avenue, the following two topics are discussed below: Forecasting models for attrition beyond univariate time series, and principal component or related models for forecasting operations and maintenance costs.

To the extent that we can gain access to longitudinal data on the progression of CAF members throughout their military career, we can replicate or modify the time to OFP and attrition rates developed by Straver and Christopher (2015). We can continue to use the univariate time series model for sensitivity analysis.

As mentioned earlier, EDIS is a poor substitute for detailed historical data on military installations expenditures and personnel size. The type of installation (army, air force, etc.), as well as size, also affects the trend in expenditure. Such information is not available in EDIS.

The information management system at DND can generate historical data to at least the late 1990s. If we gain access to this dataset, we can use panel data regressions or orthogonal linear projections (factor analysis) methods to identify factors that predict military base spending.

6.1. Policy Evaluation

In a 2016 report, the Auditor General of Canada (OAG, 2016) noted CAF's inability to achieve the required number of trained personnel. The report said the goal of achieving the desired number of members by 2018-19 will not be reached.

In addition, there are certain demographic realities that may complicate the supply of labour. For example, competition for young recruits will be intensified, given the aging Canadian work force.

It is conceivable that parliamentarians may begin to ask questions beyond the cost of proposals. In response to evaluations such as the OAG's, parliamentarians may ask for studies on the recruitment process and potential improvements. Similarly, they may ask about enhanced compensation strategies to maximize recruitment and retentions. These types of questions will require a new set of tools and models.

Assuming an individual is rational and forward looking, each member's decision to stay or leave differs in his or her preference for the military versus the civilian sector (Asch et.al, 2007). Symbolically,

$$U_M = W_M + \tau_M \ > U_C = W_C + \tau_C$$

In the above case, a preference of military life (depicted with subscript M) implies that wages and the non-pecuniary aspect of military life must outweigh the civilian equivalent. Therefore, an individual decides to join the military if

$$WM \ - WC > \tau C - \tau M$$

Or, the individual may decide to join if the pay differential exceeds the net preference for civilian life. The distribution of τ over the relevant population determines the supply curve and elasticity with respect to pay. A very useful way to model this behavioral relationship is a dynamic programming model and detailed longitudinal military database.

One could also model the recruitment process to identify potential areas for improvement by using either a discrete or continuous time Markov process. The benefits of Markov models are the translation of processes such as recruitment through the identification of absorbing and transition states, association of probabilities to events and evaluation of the optimal time to final employment.[22]

Conclusions

The "personnel generation" model provides a reasonable representation of a typical recruit's time in the training system once admitted to basic training. The operations and maintenance, base support and pay related costs are then tracked throughout the recruit's time in training.

There are additional routines in the model that are activated if there is an explicit requirement in a party's platform. These additional routines are for skilled recruits and surge costs if capacity is exceeded.

While the model primarily resides in an Excel spreadsheet, most of the statistical analyses and model validation are conducted using R. R is publicly available with an open architecture so new statistical methods and algorithms are continuously added. The statistical methods and tests used in R are also available in E-Views ® or STATA ®.

Appendix A: Acronyms

ATL	Advanced Training List
BTL	Basic Training List
CAF	Canadian Armed Forces
CBP	Capability-Based Planning
CFR	Commissioned from the Ranks
DEO	Direct Entry Officer
GSO	General Service Officer
DGMPRA	Director General Military Personnel Research and Analysis
FP&R	Force Posture and Readiness
FS	Facility Support
HRMS	Human Resources Management System
HS	Health Services
MARS	Maritime Surface and Sub-Surface Officer
MOSID	Military Occupational Structure Identification
NCM	Non-commissioned member
NES	Non-Effective Strength
OFP	Operationally Functional Point
O&M	Operations and Maintenance
ROTP	Regular Officer Training Plan
RS	Retirement Strength
SCM	Strategic Cost Model
SIP	Strategic Intake Plan
SUTL	Subsidized University Training List
SPHL	Service Personnel Holding List
TEE	Trained Effective Establishment

TES	Trained Effective Strength
UTPNCM	University Training Plan-NCM
YOS	Year(s) of Service

Appendix B: Regression Results

We run a simple regression model using the EDIS data. Specifically, we use the O&M expenditures in St. Jean and/or Borden (the main training bases) as the dependent variable. The independent variables are regular force personnel count, lagged dependent variable and time trend.

Figure B-1 shows the regression results, while Figure B-2 presents the diagnostic test results. We can explain roughly 76 per cent of the variation in St. Jean base spending using the above mentioned three variables.

The model does pass all the relevant diagnostic tests. Interestingly, the lagged dependent variable explains about 13 per cent of the variation, while the time trend and personnel count each account for roughly 30 per cent of the variation.

While the estimated model indicates that one additional personnel on base results in an increase of $46,400 (2007 dollars) in base spending, we do not use this information to calculate training costs per recruit.

However, it does provide some preliminary indication that we can develop a forecasting model (as opposed to a predictive-explanatory) by using data on base spending, personnel count and related data.

Figure B-1 Regression Results for CMR (St. Jean)

OLS Estimation CMR (St. Jean)

Dependent variable is NXCMR (CMR Base Expenditures)

21 observations used for estimation from 1997 to 2017

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
B0	-20657.2	20904.9	-.98816[.337]
TND	3915.1	1659.8	2.3588[.031]
RFCMR	46.4557	13.6816	3.3955[.003]
NXCMR(-1)	.45612	.15124	3.0159[.008]

R-Squared	.79830	R-Bar-Squared	.76271
S.E. of Regression	34572.5	F-Stat. F(3,17)	22.4280[.000]
Mean of Dependent Variable	134482.1	S.D. of Dependent Variable	70972.2
Residual Sum of Squares	2.02E+10	Equation Log-likelihood	-247.0461
Akaike Info. Criterion	-251.0461	Schwarz Bayesian Criterion	-253.1351
DW-statistic	2.3392	Durbin's h-statistic	-1.0782[.281]

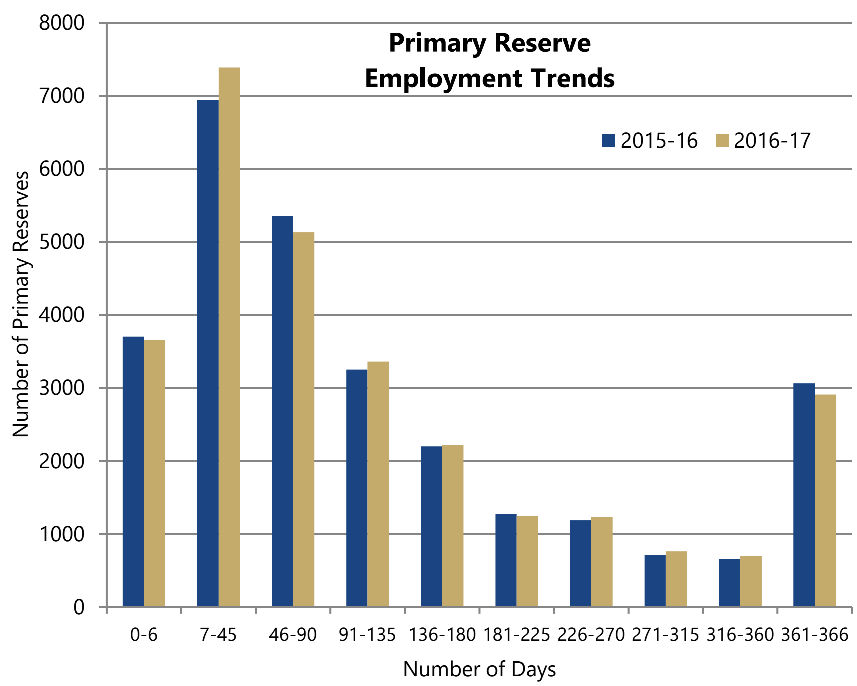
Figure B-2 Diagnostic Tests for the regression reported in Figure 3

```
                              Diagnostic Tests
_____________________________________________________________________________
*    Test Statistics  *        LM Version       *          F Version          *
_____________________________________________________________________________
* A:Serial Correlation*CHSQ(1)  =   1.0556[.304]*F(1,16)      =   .84680[.371]*
* B:Functional Form   *CHSQ(1)  =   1.1675[.280]*F(1,16)      =   .94189[.346]*
* C:Normality         *CHSQ(2)  =   .52843[.768]*       Not applicable        *
* D:Heteroscedasticity*CHSQ(1)  =   2.7398[.098]*F(1,19)      =   2.8508[.108]*
_____________________________________________________________________________
   A:Lagrange multiplier test of residual serial correlation
   B:Ramsey's RESET test using the square of the fitted values
   C:Based on a test of skewness and kurtosis of residuals
   D:Based on the regression of squared residuals on squared fitted values
```

Appendix C: Primary Reserve Data

Although we lack detailed data on the external recruitment pattern for the primary reserves, we do have some basic population data. The following charts and tables illustrate some relevant information about the Primary Reserve Force and Army reservists.

Figure C-1 Primary Reserve Employment Trends



Based on the last two fiscal years of data (Figure C-1), about 25 per cent of the Primary Reserve Force serves between seven and 45 days a year followed by 19 per cent serving between 46 and 90 days. In general, the typical reservist serves 117 days a year. This last figure is used to annualize and attribute wages, and operations and maintenance and related costs.

The Army reserve component represents 70 per cent of the Primary Reserve Force. Some demographic data on the Army reservists are shown below (Table C-1), using snapshot data from June 2018.

Table C-1 Army Reserve data 2018 June

Total Count	17,997	Proportion
Active	17,730	99%
NCMs	15,428	86%
Female	2,140	12%
Foreign Born	2,362	13%
Unattached	13,465	75%
Single	11,426	63%

The officer-to-NCM proportion is similar to the Regular Force, where the NCMs account for 86 per cent of the population. Women account for 12 per cent of the Army reserve population, while foreign-born reservists account for 13 per cent.

Most Army reservists are single (63 per cent) or unattached (75 per cent), such as divorced, separated, widowed and so on. These proportions are much larger than those in the Canadian population (39 per cent and 52 per cent, respectively). The Canadian data come from Statistics Canada's population profile 2017 (https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1710006001).

Table C-2 Age Distribution of Army Reservists

Age Group	Count	Army Reserve	Canada
16-20	2,905	16.1%	5.6%
21-30	8,005	44.5%	13.8%
31-40	3,675	20.4%	13.8%
41-50	2,111	11.7%	13.0%
51-69	1,301	7.2%	26.4%
Total	17,997		36,708,083

Note: Canadian data are from Statistics Canada (https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1710000501)

Army reservists tend to be younger than the overall Canadian population (Table C-2). Specifically, 45 per cent of Army reservists are aged between 21 and 30, while the same age group represents only 14 per cent of Canada's population. Similarly, Army reservists aged between 31 and 40 represent 20 per cent of reservists, compared with 14 per cent for the wider Canadian population.

Within the female population in the Army reserve, the ratio of officers to NCMs follows the overall pattern (87 per cent, Table C-3); however, the proportion who are single is lower for the female cohort. There are no discernible differences in select demographic characteristics in the foreign-born cohort compared with the overall Army reserve population (Table C-4).

Table C-3 Army Reserve Profile: Female

Female			Proportion
	NCM	1,866	87%
	Single	1,234	58%
	Unattached	1,539	72%
	Non-Active	56	3%
	Born Outside Canada	233	11%

Table C-4 Army Reserve Profile: Foreign Born

Foreign Born			Proportion
	NCM	2,068	88%
	Single	1,485	63%
	Unattached	1,836	78%
	Non-Active	32	1%

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Notes

1. Stand up for Canada Conservative Party of Canada Federal Election Platform 2006 Page 45 and A role of pride and influence in the world - defence: Canada's international policy statement 2005, Page 3

2. Microfit ® econometric software is also used to conduct some basic regressions. Note that the analyses can be ported to other software. Scripts are documented in the Appendix.

3. Movement from NCM to officer population will not require incremental funding as these individuals have already completed the required basic training and their total compensation is within the military wage salary envelope. We include re-enrollees, component transfers (CT), commissioning from the ranks (CFR) and University Training Plan for NCM (UTPNCM) in this group that are not costed.

4. See http://www.forces.gc.ca/en/about-policies-standards-defence-admin-orders-directives-5000/5002-2.page Accessed May 2nd, 2018

5. See https://www.rmc-cmr.ca/en/registrars-office/regular-officer-training-plan-rotp

   Accessed May 3rd, 2018

6. http://www.forces.gc.ca/en/about-policies-standards-defence-admin-orders-directives-5000/5002-7.page Accessed May 3rd, 2018

7. Data provided by Jim Hampson of Chief of Programme, DND.

8. The model activates the surge routine whenever a party platform exceeds recruitment capacities in the CAF.

9. DND (2017:19)

10. The retention factor is one over the retention rate or the proportion that completes basic training.

11. Excluding skilled and other internal entries. Note that Skilled entry is modelled separately using similar subroutines.

12. The attrition rate at Year of Service 0 corresponds to attrition during basic training. Regular attrition is defined as any attrition after one full year of service. Symbolically, the number of NCM recruits (NCMr) who are in the training system at a given time t is represented as

$$\alpha\left[\sum_{j}^{m} b_j \sum_{t}^{n+1} AI_t \quad + \bar{b}AI_{n+2}\right]$$

   For t>2 and $\bar{b}$= $(b_3 + b_4)$. Similarly, the number of officers in the training system at a given time t is shown as

$$\alpha\left[bc_1 \sum_{t-1}^{n+1} AI_t + bc_2 \sum_{t-2}^{n+2} AI_t \dots bc_6 \sum_{t-6}^{n+6} AI_t\right]$$

For t>2

13. Based on discussions with staff from the Comptroller's office of the Military Personnel Command.
14. This is the maximum the model allows in terms of phasing. Most party platform would like to see shorter recruitment period to coincide with their first mandate.
15. http://cou.on.ca/numbers/cudo/ accessed May 15th, 2018.
16. Unless specified as above, all dollar figures are in current or budget year dollars
17. For a more robust and technical discussion on input-output models from a Canadian National Accounts perspective see Ghanem (2010) or Poole (1995).
18. By true weighted average we mean wages calculated for each CAF member depending on rank and incentive level. For the purposes of the model the calculated averages are adequate.
19. Force elements are enablers for military capabilities. Military capabilities include a combination of people, systems, doctrine that can achieve a military effect. Strategic Lift is one obvious capability (The C17 aircraft along with the associated people and support are used to deliver aid to a region of interest).
20. We estimate a simple regression model using EDIS data to estimate base O&M costs as a function of personnel, past costs and time trend. The results are presented in the Appendix
21. Note that a recent news article pointed out that some of these equipment in inventory have been donated to Ukraine. http://ottawacitizen.com/news/national/defence-watch/where-are-those-missing-canadian-military-sleeping-bags-try-ukraine
22. See Ng et. al, 2014 for an application to intelligence processing http://www.ismor.com/31ismor_papers/31jul/31ismor_mitchell.pdf