



# Modelling Voluntary Attrition of Civilian Personnel in the Department of National Defence

Christopher Penney  
Research Associate, Royal Military College

Prepared by: Christopher Penney  
Project Manager: Robert M.H. Burton  
Contract Number: PA12018  
Contract Scientific Authority: Abderrahmane Sokri

The scientific or technical validity of this Contract Report is entirely the responsibility of the contractor and the contents do not necessarily have the approval or endorsement of Defence R&D Canada.

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April 2013

**Defence R&D Canada**  
**Centre for Operational Research and Analysis**

Defence Economics Team



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Principal Author

*Original signed by Christopher Penney*

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Christopher Penney

Research Associate, Royal Military College

Approved by

*Original signed by Binyam Solomon for*

---

R.M.H. Burton

Section Head, Joint Systems Analysis

Approved for release by

*Original signed by Paul Comeau*

---

Paul Comeau

Chief Scientist

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# Abstract

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Making use of a detailed panel dataset, this paper undertakes an econometric analysis of the factors affecting the attrition decision for members of the public service working with the Department of National Defence. Using Random Effects methods, several consistent factors were associated with an individual's likelihood of attrition. Factors that decreased this probability included the number of Pensionable Years of Service, a Change of Command, and residing in the provinces of Quebec, Newfoundland or Saskatchewan. Factors that were associated with an increase in the likelihood of attrition included speaking French as a first language, belonging to the Purchasing and Supply and Engineering Support groups, and residing in the province of Alberta; most interestingly, higher salaries were associated with greater likelihood of attrition, a finding that has not been consistently shown in prior research.

# Résumé

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À partir d'un ensemble détaillé de données longitudinales, nous avons procédé à une analyse économétrique des facteurs influençant le personnel civil du ministère de la Défense nationale dans leur décision de quitter leur emploi. Grâce à la méthode des effets aléatoires, nous avons été en mesure de cerner certaines constantes influant sur la probabilité de départ des employés. Parmi les facteurs diminuant cette probabilité, nous avons entre autres noté le nombre d'années de service ouvrant droit à pension, un changement à la direction, et

le fait de résider dans les provinces de Québec, de Terre-Neuve ou de la Saskatchewan. À l'inverse, les facteurs augmentant la probabilité de départ que nous avons relevés sont notamment : avoir le français comme langue maternelle, appartenir au groupe Achats et approvisionnement et au groupe Soutien du génie, et demeurer dans la province de l'Alberta. Fait intéressant : nous avons remarqué que les gens gagnant les salaires les plus élevés sont les plus susceptibles de partir. Aucune recherche n'était arrivée à une telle conclusion auparavant.

# Executive summary

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## **Modelling Voluntary Attrition of Civilian Personnel in the Department of National Defence**

Christopher Penney; DRDC CORA CR 2013 - 063; Defence R&D Canada – CORA; May 2013.

As the issue of attrition of skilled public servants can be especially costly in terms of replacement and search costs, an analysis into the factors associated with this behaviour can be carried out in order to point out problem areas and determine whether policy measures could be adopted in order to lower attrition rates and reduce overall costs.

To this end, this paper takes a detailed look at the factors surrounding the issue of attrition of civilian personnel working with the Department of National Defence. By making use of a detailed dataset, econometric methodology is employed in order to determine which factors are associated with attrition behaviour, and to determine the extent of these relationships.

Factors considered in this study include a variety of socio-demographic variables such as age, marital status, province of residence and first official language; information on area of expertise, cumulative years of service and pensionable years of service, pay scale, as well as unemployment rates in the service sector.

The population under study includes members of the Electronics (EL), Engineering (ENENG), Engineering Support (EG), and Purchasing and Supply (PG) groups. There are a total of

5,215 individuals included with observations over a period of 10 fiscal years, from 2002 to 2011.

As the dataset used in the analysis has both cross-sectional and time dimensions, modern panel data methodology is employed. In this vein, the main approach of the analysis involves the estimation of a *Random Effects Linear Probability Model*. This model allows the estimation of factors that vary over time, such as unemployment rates, as well as those factors that are stationary across time periods, such as gender and first official language. A Fixed Effects specification is also employed in order to verify the results of the primary model, and no substantial differences are found.

The results of the analysis showed a number of consistent influences on attrition rates. Factors associated with a decrease in the probability of attrition included the number of pensionable years of service a given individual had accumulated and whether an individual resides in certain provinces such as Quebec, Newfoundland and Saskatchewan. Factors shown to have positive effects on the likelihood of attrition included speaking French as a first language, being a member of the Purchasing and Supply group and, to a lesser extent, the Engineering Support group, and residing in the province of Alberta.

Perhaps the most interesting result obtained within this research, however, is the increased tendency for higher-salaried workers to leave the service as compared to lower earners. This result, while unexpected, can be explained by the hypothesis that salary is correlated with ability, and higher ability renders individuals either more attractive to, or more likely to accept, outside employment opportunities. As striking as this result is, both models adopted in this study demonstrated this effect.



The analysis is limited somewhat by the lack of availability of certain, potentially useful, factors; these include the number of dependents each individual has to care for, measures of health for these dependents, and self-reported individual health measures. On the whole, however, the analysis provides a good deal of insight into the factors affecting attrition rates, and its findings point at possible avenues to explore in order to reduce them, such as the implementation of financial incentives aimed at retaining skilled employees.

# Sommaire

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## **Modelling Voluntary Attrition of Civilian Personnel in the Department of National Defence**

Christopher Penney ; DRDC CORA CR 2013 - 063 ; R & D pour la défense

Canada – CARO ; mai 2013.

Les départs de fonctionnaires compétents peuvent entraîner des coûts importants, en particulier en matière de recherche et de remplacement d'employés. Ainsi, nous avons conduit une analyse des facteurs associés aux tendances relatives aux départs afin d'être en mesure de dégager les points posant problème et de déterminer si l'on pourrait adopter des mesures stratégiques afin de diminuer le taux d'attrition et les coûts globaux.

À cette fin, dans le présent document, nous nous penchons sur les facteurs d'attrition du personnel civil au sein du ministère de la Défense nationale. À partir d'un ensemble détaillé de données, nous avons utilisé la méthode d'analyse économétrique dans le but de cerner les facteurs relatifs aux tendances de départ et de déterminer l'importance de ceux-ci.

Dans le cadre de cette étude, nous avons tenu compte de facteurs sociodémographiques tels que l'âge, la situation familiale, la province de résidence et la langue maternelle. Nous avons également retenu des données concernant les domaines d'expertise, le nombre d'années de service ouvrant droit à pension, l'échelle salariale ainsi que le taux de chômage dans le secteur tertiaire.

L'échantillon à l'étude était composé de membres des groupes Électronique (EL), du Génie (EN-ENG), Soutien du génie (EG) et Achats et approvisionnement (PG). En tout, nos observations reposent sur des données concernant 5 215 personnes sur une période de dix années financières, soit de 2002 à 2011.

Comme les données recueillies sont de nature transversale et temporelle, nous avons eu recours à la méthode moderne de l'analyse longitudinale. Par conséquent, notre approche consistait principalement à dresser un modèle de probabilité linéaire à effets aléatoires approximatif. À partir de ce modèle, nous avons fait une estimation des facteurs variables au fil du temps (p. ex., le taux de chômage) ainsi que des facteurs fixes comme le sexe et la langue maternelle. Nous avons également utilisé un modèle à effets fixes afin de vérifier les résultats du premier modèle, sans toutefois remarquer de différences notables.

Les résultats de l'analyse révèlent quelques constantes influençant le taux d'attrition. Parmi les facteurs associés à un décroissement de la probabilité de départ, nous avons relevé le nombre d'années de service ouvrant droit à pension qu'une personne a accumulées et le fait de demeurer dans certaines provinces, notamment le Québec, Terre Neuve et la Saskatchewan. À l'inverse, les facteurs contribuant à l'augmentation de la probabilité de départ sont, entre autres : avoir le français comme langue maternelle, être membre du groupe Achats et approvisionnements et, dans une moindre mesure, du groupe Soutien du génie, et le fait de résider en Alberta.

Toutefois, le résultat le plus intéressant de cette recherche est certainement le fait que les employés aux salaires les plus élevés soient plus susceptibles de quitter leur emploi que ceux gagnant des salaires moins élevés. Bien qu'inattendu, on peut tenter d'expliquer

ce résultat en émettant l'hypothèse que si le salaire est lié à la compétence, il serait alors logique de supposer que les personnes gagnant un salaire élevé, donc les plus compétentes, sont celles qui sont les plus attrayantes aux yeux des employeurs externes ou qui sont les plus susceptibles d'accepter une offre. Aussi étonnant que cela puisse sembler, les deux modèles utilisés indiquent le même résultat.

La validité de cette analyse est toutefois limitée par l'indisponibilité de certains facteurs potentiellement utiles tels que : le nombre de personnes à charge de chacun, l'état de santé de celles-ci et l'état de santé autodéclaré des participants. Cependant, de façon générale, l'analyse donne un excellent aperçu des facteurs influençant le taux d'attrition et, grâce aux résultats obtenus, nous serons en mesure d'envisager diverses solutions possibles en vue de le réduire telles que la mise en place d'incitatifs financiers visant à retenir les employés compétents.

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# 1 Introduction

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Previous research on military attrition rates has primarily focused on regular and auxiliary service members of the various military branches. Of particular concern in these analyses are those members who decide to attrite prior to the end of their first-term obligation, as the costs associated with these attritions are especially high and may create issues in terms of manpower management and overall readiness.

The issue of attrition of skilled public servants in the Department of National Defence has, conversely, not been studied in great detail as of this writing. Given the differing nature and circumstances surrounding these types of positions as compared to those directly involved in military service, an alternate focus is required in analyzing the attrition decision. For instance, early attrition is a less prominent concern, as costs associated with training for civilian personnel are generally lower due to the fact that public servants generally find employment after already having completed their education. Another key difference regards the applicability of the skill sets of educated public servants in more conventional employment areas. Since military professionals generally do not have skills that are as easily transferable to non-military applications, they are not as likely to have to choose between competing offers from the private sector.

Thus, due to relatively high search costs, stiff competition with the private sector and the potential difficulty in retaining skilled professionals in the long term, it appears important to carry out analyses that may identify the various factors that can have an impact on the likelihood of attrition from the public service. Such findings may, from a policy perspec-

tive, allow for more efficient hiring initiatives and incentive structures aimed at increasing retention rates.

It should be noted here that, in comparing the prevalence of attrition between military groups and the public service, rates in the public service are markedly lower. For instance, Sokri (2013) analyzed the socioeconomic factors in voluntary military attrition, finding that over a 16-year period, 37.2% of the respondents left the service; meanwhile, the sample used in the current research finds an attrition rate of 7.5% over 10 years. It would appear, then, that the rigors of military service may serve as a greater impediment to continuation than the factors public servants are subjected to. This evidence further suggests that a differing approach should be taken in the present analysis, though reviewing past studies on military attrition may still be a worthwhile endeavor.

## **1.1 Aim**

Pursuant to the statement of work prepared by DRDC CORA, this research intends to shed light on the factors surrounding the issue of attrition of civilian personnel in the Department of National Defence, in particular those belonging to the Engineering (ENENG), Engineering Support (EG), Electronics (EL) and Purchasing and Supply (PG) groups. Factors involved in this analysis are to include socio-demographic variables such as *age*, *marital status*, *province of residence*, information on *area of expertise*, *cumulative years of service*, *pay scale*, and some controls for economic factors including *service sector unemployment rates*. Other variables of interest that will be tested in the analysis include *first official language*, the effect of *changing command* as a lateral movement within the service, and



total *pensionable years of service*.

## 1.2 Scope

Employing a large dataset graciously provided by Department of National Defence,<sup>1</sup> this study intends to employ econometric methodology as a means to develop a “*stay / leave*” decision model using the aforementioned factors and characteristics. This dataset has information on 5,215 individuals observed during 10 time periods, covering FY 2002 through FY 2011. After removing redundancies and cleaning the data, there are a total of 28,913 person-wave observations in the dataset.

## 1.3 Methodological Approach

The present research will involve an econometric analysis of the likelihood of attrition. As the data involves a large number of individuals observed over multiple time periods, panel data methods may be used. In this vein, the following approach is adopted:

The panel nature of the data will be exploited to produce a *Random Effects Linear Probability Model*.<sup>2</sup> This model will allow the estimation of both time-varying and time-invariant factors, while simultaneously taking into account the potential bias caused by unobserved heterogeneity. A *Fixed Effects Linear Probability Model* will be used to serve as a robustness check to confirm the primary model’s results.

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<sup>1</sup>The dataset includes subsets of the Financial Management Accounting System (FMAS) and the Human Resources Management System (HRMS) databases.

<sup>2</sup>Estimated by Generalized Least Squares.

## 1.4 Document Structure

This paper will begin with an overview of pertinent research, with careful attention paid to methods employed and potential issues in the analysis as a means to properly motivate and justify choices in methodology for the present study. Rather than being an exhaustive review of related literature, this overview will instead examine an assortment of studies that represent or otherwise provide insight on certain key aspects of this research, namely methodology (cross section and duration models), the effects of bonus structures and socio-demographic factors, and the impact of economic factors on the decision to attrite.

Following this review, a synopsis of the econometric methodology will be presented, followed by a description of the Data and variables of interest, with a separate section discussing the estimation procedures and results. A discussion of the overall findings and limitations of the study will then be offered, along with some closing remarks.

## 2 Literature Review

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Two main methodological approaches are prominent in the literature: one involving cross-sectional data, where information is collected at a given point in time, with the realized 'attrition' indicator for each individual described by a vector of explanatory variables, and another involving survival analysis, where the effect of explanatory variables on the hazard rate (i.e., the chance of attrition during a small interval) is quantified.

As the present research is aimed to develop a “stay/leave” decision model<sup>3</sup> that examines the factors that have an effect on the attrition decision, careful attention will be paid to areas of research dealing with cross-sectional analysis.

## 2.1 Cross-Sectional Models

Cross-sectional models are a rather popular approach to modelling voluntary military attrition behaviour, as evidenced by a large body of research.<sup>4</sup> These analyses typically make use of maximum likelihood estimation procedures, especially logit, to predict the likelihood of attrition. Models of this type can be expressed as:

$$Y_i = f(B_i, SD_i, E_i, X_i) \quad (1)$$

where  $Y_i$  indicates a given individual’s likelihood to attrite,  $B_i$  represents any monetary incentives for retention accruing to the individual,  $SD_i$  represents a vector of socio-demographic controls,  $E_i$  represents a vector of economic factors, and  $X_i$  represents a set of other informative variables, often including information on type of position, deployment, and so on. The purpose of such analyses is to determine the impact of the right-hand-side variables on the likelihood of attrition. Such inference, however, may be complicated in this context by certain issues. Primarily, this type of analysis neglects the effects of factors that vary over time. For instance, if a given individual experiences a change in marital status or in number of dependents over the course of his/her term of service, the effect on the like-

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<sup>3</sup>Though this research adopts a panel data perspective, rather than cross-sectional, as is prominent in the current literature.

<sup>4</sup>Fullerton (2003), Kearn and Nelson (1992), Cox et al. (2003), and Stone et al. (1998) to name but a few.

likelihood of attrition might be more pronounced than if these factors had been stable since the time of initial enlistment. Studies by Fullerton (2003) and Kearn and Nelson (1992), among others, have shown that number of dependents has a significant effect on reducing the likelihood of attrition; then, it seems plausible that an increase in dependents might have an even greater impact due to the sudden increase in lifetime costs for the affected individual(s).

Under a certain set of assumptions, obtaining a stay/leave decision model from cross-sectional analysis appears to be a reasonable methodological approach. However, if time-varying factors are especially important in determining attrition behaviour, this model type will not do as well as its alternatives, such as panel data methods.

## **2.2 Duration Models**

Duration models entail a somewhat different approach as compared to cross-section analysis. Instead of, in the present context, directly estimating the effects of a set of observables on the likelihood of attrition, duration models can explain how much time is served before a given individual attrites. Parametric analysis is of particular interest, as these methods allow researchers to observe the effects of explanatory variables on the time to attrition. A popular method used in the present context is the Cox proportional hazards model,<sup>5</sup> which allows the estimation of the net effect of a given characteristic while controlling for other characteristics, not unlike the “partialling out” interpretation of coefficient effects in cross-sectional analysis.

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<sup>5</sup>This model type has been used to describe attrition behaviour by authors Marquis and Kirby (1989), among others.

The Cox proportional hazard model assumes a hazard function (i.e., the function explaining the instantaneous chance of attrition for members of the sample who have not yet left the service) for a given individual with characteristics given by a vector of observables ‘ $x$ ’ given by:

$$h(t,x) = g(x) \cdot h_0(t) \quad (2)$$

where  $t$  represents the amount of time that has passed since an individual has entered the service;  $h_0(t)$  represents an underlying attrition rate function, and  $g(x)$  is a function of the observable characteristics included in the model.

The Cox model has relatively relaxed assumptions when compared to alternative models, making it an attractive candidate for this type of analysis. For example, no strict assumptions are made regarding the underlying hazard function mentioned in the equation above,  $h_0(t)$ ; it is completely arbitrary. Moreover, in terms of obtaining a policy analysis perspective on the issue of attrition, of primary interest are the factors  $x$  affecting the attrition decision; the underlying path towards time of attrition is of less interest in this regard.

Given that the present research is primarily concerned with determining the factors that have an effect on the “stay / leave” decision, a duration model approach will not be adopted in the current analysis.

## **2.3 Explanatory Variables**

This subsection describes the effects of important explanatory variables in previous studies. Socio-demographic controls, economic controls, financial retention incentives, and finally other miscellaneous controls will be discussed in turn.

### **2.3.1 Socio-Demographic Controls**

Socio-Demographic factors, such as Age, Marital Status, Province of Residence and Gender have been widely employed as controls in studies on attrition.

The *a priori* effect of Age on the likelihood of attrition is not immediately obvious. From one perspective, older individuals have a greater knowledge of the job market and outside opportunities available to them; further, older individuals may have an extra incentive to leave the service in search of private sector opportunities with the reasoning that increased time spent in military service may be viewed as less desirable to potential employers. Indeed, the effect of age has been shown to have a positive relationship with the likelihood of attrition in certain studies, such as that of Fullerton (2003), which examines specifically the attrition behaviour of US Air Force pilots. It appears likely that the effect of age on the likelihood of attrition is dependent upon the group under study.

The effects of other socio-demographic controls such as Marital Status and Gender are more straightforward. Marital Status is believed to have either a negligible or negative effect on attrition; this is due to the potential effect of having to care for a family and the associated need for income security. These effects are shown in studies by Fullerton (2003), Kearl and Nelson (1992), Marquis and Kirby (1989), Stone et al. (1998) and Cox et al.

(2003).<sup>6</sup> As for Gender, it can be expected that females have a slightly higher likelihood of attrition due to the possibility of bearing children and assuming family responsibilities.<sup>7</sup>

### **2.3.2 Economic Controls**

Of particular interest in retention analysis are the economic factors influencing individuals in the service. A simple way to control for the quality of the external job market is to include a variable indicating the regional level of unemployment; this captures, albeit in a rather broad sense, the external economic conditions and perhaps even the quality of job offers available to individuals. Studies making use of this variable in explaining attrition include Fullerton (2003) and Kearn and Nelson (1992), while Thompson (2011) carries out an empirical analysis examining the explicit effect of unemployment rates on attrition. In all cases, unemployment is shown to have an inverse relationship with the likelihood of attrition, though the magnitudes of the impacts vary from study to study.

### **2.3.3 The Effects of Retention Incentives**

From a policy analysis perspective, evaluating the effects of retention incentives on attrition rates is especially important given the costs and readiness issues associated with such behaviour. In reviewing the literature, however, it is difficult to ascertain whether retention incentives are actually successful in decreasing attrition rates, for a number of reasons: first, the groups under study vary frequently from study to study; air force pilots, as in the

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<sup>6</sup>Note that in Kearn and Nelson (1992), the effect of Marital Status is not estimated, and in Stone et al. (1998) this effect is not statistically significant.

<sup>7</sup>This is shown in multiple studies, including Fullerton (2003), Kearn and Nelson (1992), and Stone et al. (1998).

case of Fullerton (2003), face differing conditions and incentive structures than those in the Armed Forces; second, the relative size of the financial incentives also vary greatly from group to group. On this last point, it is worthwhile to note that Air Force Pilots received retention bonuses up to \$25,000<sup>8</sup> in recent years, which represents a relatively large figure even when compared to the average salary of pilots; meanwhile, reenlistment bonuses offered to Army Reserve members is both quantifiably and relatively lower with respect to annual salaries.<sup>9</sup> These incentives undoubtedly reflect costs associated with training and recruitment, as it is likely far more expensive to train an Air Force pilot than it is to train an Army reservist.

On the whole, retention incentives have largely been shown to decrease attrition rates.<sup>10</sup> Whether these effects justify the expenditures from the administrative perspective, however, is left up for debate.

### **2.3.4 Other Controls**

Length of tenure is generally believed to decrease the likelihood of attrition, as it may act as a proxy that describes the level of commitment an individual has to his/her given profession. However, a review of the literature indicates some rather conflicting results; certain studies, such as that of Fullerton (2003), indicate that as the number of years of service increase beyond the end of the first service contract, the likelihood of an individual

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<sup>8</sup>Per Fullerton (2003).

<sup>9</sup>Based on extrapolation from figures offered by Marquis and Kirby (1989).

<sup>10</sup>This is demonstrated in the works of Fullerton (2003) and Marquis and Kirby (1989), while Stone et al. (1998) presents some confounding results.



attriting to the private sector increases.<sup>11</sup> In Marquis and Kirby (1989), on the other hand, the effect is shown to have a somewhat kinked relationship; while a greater tenure leans towards decreasing the length of time to attrition, the effect of tenure between 7 and 9 years is not statistically different from zero at any reasonable level of significance. This may be indicative of conflicting incentives around this time, such as bonuses and pay scale increases that accrue to reservists after a given number of years. Given these results, it appears necessary to devote further research in this area in order to determine what the prevailing effect may be from the perspective of skilled public servants in the Department of National Defence.

Alternatively, and perhaps more importantly for determining the likelihood of attrition, a variable indicating the *pensionable* years of service will be included in the present analysis. This should capture the increasing effect that a pensionable year should have on post-retirement benefits, and one can expect an unambiguously negative effect on attrition. The key difference between this variable and a simple 'years of service' variable is as follows: the 'years of service' variable keeps track of the number of years a given individual has spent in his or her position. The effect this has on the dependent variable, then, largely has to do with the level of familiarity, comfort, and level of 'fit' the individual has with his or her position. Meanwhile, the 'pensionable years of service' will, after having taken into account the effect of 'years of service', account for the financial impact caused by the abovementioned post-retirement income increases. It is important to note that the present analysis will include both variables, so that these separate impacts can be measured

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<sup>11</sup>This may be, of course, due to the population in this study consisting of U.S. Air Force pilots who are undoubtedly subject to unique labour market conditions

individually.

Other factors potentially affecting the attrition decision include health of the individual and his or her dependents,<sup>12</sup> and the type of position occupied in the service. Regarding this latter variable, it had been reported that positions within the military service that have less applicability outside of the military context are shown to decrease the likelihood of attrition, though this may be due to selection bias; i.e., an individual who has a greater “taste” for military service, and thus may be less likely to attrite to begin with, may select into these types of positions.<sup>13</sup> To determine whether such an effect exists in the present context, it appears reasonable to control for the group a given individual belongs to, such as “*engineer*” or “*purchasing and supply*”.

### 3 The Model

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Assuming that obtaining a model describing the stay/leave decision of civilians in the Electronics, Engineering, Engineering Support, and Purchasing and Supply groups in the public service is of primary interest, it seems reasonable to rule out duration analysis as the preferred means to study this behaviour. This section will therefore focus on proposing the *Random Effects* model as a primary means of analysis.

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<sup>12</sup>These have been shown to have a negative impact on the likelihood of attrition in Fullerton (2003); unfortunately, this type of data is not available for the present analysis.

<sup>13</sup>Consider that in Fullerton (2003), fighter pilots were shown to have a significantly decreased likelihood of attrition as compared to trainer pilots or strategic airlift pilots, two positions that are not combat-oriented.

### 3.1 The Random Effects Model

Cross sectional analysis, as discussed in section 2.1, does not exploit the panel nature of the available data, and may miss a few key aspects that may be especially important in describing the attrition decision. These aspects include changes in marital status, increases in salary, changes in years of service and so on. And, as discussed in the previous section, it is possible that cross-sectional analysis produces biased results due to a failure to control for time-invariant individual heterogeneity.

To properly take into account time-varying factors and deal with this issue of individual heterogeneity, the primary model employed within this research will be estimated via *Random Effects*.<sup>14</sup>

To properly motivate this specification, however, it is worthwhile to detail the manner by which it can produce consistent results, even in the presence of confounding statistical problems such as unobserved individual heterogeneity. To see this, a simple *Pooled Ordinary Least Squares* specification will first be presented here. This model type neither takes into account the panel structure of the data, instead treating each person-wave as a unique individual observed at a given point in time, nor deals with the bias caused by unobserved individual heterogeneity.

The *Pooled OLS* model, assuming the absence of individual heterogeneity, may be ex-

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<sup>14</sup>The dependent variable in this model is a binary variable equalling unity if the given individual attrites from service and 0 otherwise; the current specification is therefore that of a Linear Probability Model. An argument for the superiority of this specification over its obvious alternatives – Logit and Probit – will be presented at the end of this section.

pressed as:

$$Y_{it} = X_{it}\beta_{it} + u_{it} \quad (3)$$

where  $Y_{it}$  represents the binary attrition decision for individual  $i$  at time  $t$ ,  $X_{it}$  represents a vector of factors affecting the attrition decision,<sup>15</sup> and  $u_{it}$  represents a random error term.

Now factoring in the presence of unobserved individual heterogeneity, the error term  $u_{it}$  can be rewritten as:  $u_{it} = a_i + v_{it}$  where the unobserved heterogeneity is represented by term  $a_i$ .<sup>16</sup> The  $v_{it}$  term therefore represents purely the random error.

Rewriting Equation 3 yields:

$$Y_{it} = X_{it}\beta_{it} + a_i + v_{it} \quad (4)$$

Now, if it is reasonable to assume that the unobserved  $a_i$  term is uncorrelated with each of the explanatory variables in each time period, it is possible to employ *Random Effects* estimation without fear of obtaining inconsistent estimates. However, it must be noted that this assumption is rather strong and may not ultimately hold; for this reason, a *Fixed Effects* model – which does not require this assumption in order to produce valid and consistent estimates – will be employed as a robustness check.

On a technical note, the *Random Effects* model is to be estimated via *Generalized Least Squares*. This method allows for the controlling of autocorrelation of the error term  $u_{it}$

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<sup>15</sup>As discussed in section 2.3.

<sup>16</sup>Note that this term lacks a 't' subscript as it is assumed not to change over time.

across time periods, a necessary step due to the presence of individual heterogeneity.

The *Random Effects* model eliminates the unobserved heterogeneity term  $a_i$  through a process of *quasi time-demeaning*, and so the final specification can be written as follows:

$$\hat{Y}_{it} = \hat{X}_{it}\beta_{it} + \omega_{it} \quad (5)$$

where  $\hat{Y}$  now represents the quasi-demeaned binary attrition decision for individual  $i$  at time  $t$ ,  $\hat{X}$  represents the quasi-demeaned vector of explanatory variables, and  $\omega_{it}$  represents a random error term.

### 3.1.1 Linear Probability Model and its Alternatives

Due to the potential issue of the incidental parameters problem associated with nonlinear panel data models<sup>17</sup> such as probit and logit, it appears necessary to move forward with a Linear Probability Model specification. Despite having some undesirable properties, such as often failing to fit predicted likelihoods within the [0,1] bound, it is more robust to specification error, and does not suffer from the aforementioned incidental parameters issue. Also, according to Angrist (2006), when a model is composed entirely of binary explanatory variables, the linear probability model estimates the conditional mean *perfectly*, meaning it is superior to the alternatives. While the present research uses a few non-binary variables,<sup>18</sup> this point is worth bearing in mind. An additional benefit to this estimation method is the rather straightforward interpretation of the marginal effects of the

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<sup>17</sup>First noted by Neyman and Scott (1948) and further investigated in Fernandez-Val (2009).

<sup>18</sup>Age, Years of Service, Pensionable Years of Service and the Service Sector Regional Unemployment Rate are the only non-binary variables used in the current research.

coefficients; these are readily interpreted as the percentage point change in the likelihood of attrition caused by a unit increase in the relevant explanatory variable.

## 3.2 Data

The population of interest in this study are public servants belonging to the Electronics, Engineering, Engineering Support, and Purchasing and Supply groups that work with the Department of National Defence. As mentioned, a total of 5,215 individuals are observed during the 2002 - 2011 fiscal years, with a total of 12,423 person-wave observations.

Descriptive statistics for this dataset are presented in Table 1. It can be seen that those leaving the service tend to be younger, have fewer years of service (as well as fewer *pensionable* years of service), are less likely to be married, more likely to be female, and more likely to speak French as a first language. Of course, not much can be gleaned from these statistics alone, though they do provide a basis for expectations in regression analysis.

### 3.2.1 Imputations

As is often the case with panel datasets, there are often missing data entries or otherwise incomplete records. Given that the data provided in this research largely consists of the actual *population* meeting the criteria for the study, there were relatively few gaps that needed to be filled. The following rules were adopted in cleaning the data: first, time invariant variables, such as *first official language* or *gender*, were made to be the same across all periods. Second, variables that change infrequently, such as *province of residence* or *marital status*, were set to equal their *last reported value* in cases where any such values

were missing.

Some more complex imputations involved important explanatory variables, including *years of service* and *pensionable years of service*. In each case, the most recent value was adopted, with prior years assigned incrementally lower values to ensure agreement with the most recent value. For instance, if an individual had a reported 25 years of service in 2011, this number would be set to 24 for 2010, 23 for 2009 and so on, assuming these values were missing.

Finally, and most crucially, some imputations involving the dependent variable of interest – *attrition* – were necessary. First, if an individual was shown to leave the service, either by resigning or transferring out, and then returned less than two years later, they would be set as never having left the service in the first place. This is, to say, that *temporary* departures from the service were not counted as part of attrition. Second, if an individual were to leave the service for more than two years, but return at some later date, the initial attrition would be counted, and the individual's return would not remain in the sample. This is based on the assumption that long-term departures from the service fit the criterion for attrition, and is adopted within this study for simplicity. Finally, if an individual leaves the service more than once, only one of these departures will be counted according to the above criteria, i.e., if said individual returned after one year, then left subsequently, then only the second departure would count; if they returned after three years, the first departure would count. This is done to preserve the model's ability to determine the likelihood of attrition, particularly in the case of duration analysis, where only one "failure" can occur per individual.

### 3.2.2 Variables

The dependent variable in this analysis is ‘*Attrition*’; a binary variable equalling one if the individual either resigns or transfers out to another branch of the public service that is not covered in this study.

This analysis adopts an extensive set of variables that are potentially useful in describing the attrition decision: *Age*, *Years of Service*, *Pensionable Years of Service*,<sup>19</sup> *Marital Status*, *Gender*, *First Official Language*, a dummy variable indicating a *Change of Command*, *Province of Residence*, *Group* (i.e. Engineer, Electronics, etc.), *Salary Level* (in constant 2010 dollars), and *Regional Service-Sector Unemployment Rate*.

Regarding the salary variable, it is worthwhile to note that categorical values here are used rather than total dollar values. That is, salaries are recorded as ‘levels’ in intervals of 10,000. This is done in order to capture any nonlinearities that may exist in the effects of salary, which would not be accounted for otherwise. Further, the values used for the salaries are set at constant 2010 dollars, as this is the only year for which data was available for all groups.<sup>20</sup> A possible issue with the recording of salaries in this manner is that an individual earning close to, but just under, a given salary level, would be considered by the model to be earning roughly the same amount as another individual who barely meets the requirements for that level.<sup>21</sup> However as the sample size is rather large, this is not likely to be a major problem in the analysis.

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<sup>19</sup>This variable is referred to as “Pensionable YOS” in the regression results.

<sup>20</sup>Salary data was imputed based on Group and Level, using values obtained from the Treasury Board of Canada.

<sup>21</sup>For example, the model does not differentiate between an individual earning \$49,900 and another earning \$40,000 per year.



In this analysis, both *Years of Service* and *Pensionable Years of Service* are used as explanatory variables. While the theoretical justification for the inclusion of both of these variables is given in Section 2.3.4, it is important to ensure that these variables are not close to being perfectly collinear, as this would violate important assumptions used in regression analysis. In this dataset, the level of correlation between these two variables is 0.5443. Therefore, the issue of perfect collinearity is not a concern when including both these variables in a regression. It is also important to bear in mind that the *Years of Service* variable records strictly the number of years an individual has spent in their *current* command, and does not carry over after a transfer, while *Pensionable Years of Service* continues to rise so long as the individual remains within the public service.

The *Service Sector Unemployment Rate* for each observation have been obtained as follows: using the “*Province of Residence*” variable and the fiscal year in which the observation occurred, the *Service Sector Unemployment Rate* for that region was entered. For instance, all residents of Quebec during the 2005 fiscal year were assigned a *Service Sector Unemployment Rate* of 4.9, measured in percent. All data on unemployment rates was obtained from Statistics Canada.<sup>22</sup>

## 4 Results

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Following the outline described in Section 3, the main econometric specification of this study, the *Random Effects* model, is estimated. A subsection will relate the findings of

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<sup>22</sup>Specifically: Statistics Canada, Table 282-0085, Labour force survey estimates (LFS), supplementary unemployment rates by sex and age group, unemployment rates with fiscal year cut-offs.

an alternate *Fixed Effects* analysis as a means to provide evidence that the initial model is indeed sound. Following the discussion of these results, a separate subsection will explore the limitations of the analysis.

## 4.1 The Random Effects Linear Probability Model

The results of the *Random Effects* model are presented in Table 2. The coefficients presented in this table can be interpreted rather straightforwardly: a coefficient indicates a change in the absolute probability of attrition associated with a change in that variable.

Reviewing the results, it appears there are somewhat diverging effects between the *Years of Service* and *Pensionable Years of Service* variables; the former returns a slightly positive association with the likelihood of attrition, increasing by approximately 0.0265 percent per year, while the latter shows a negative association, reducing the absolute likelihood of attrition by 0.0824 percent per year. While seemingly contradictory, it is important to note that these variables do not always increase uniformly. Certainly, every further year in the service will increase *Years of Service*, but the same is not true for *Pensionable Years of Service*. Individuals do not always receive increases in pensionable years of service, particularly in cases where one begins their career as a part-time or contract worker. Thus, these differing effects stand to reason. The coefficient indicated by *Years of Service* can be linked to the increased incentive to leave the service when working one more year while *not* receiving a pensionable year of service. Meanwhile, since *Pensionable Years of Service* always increases with years of service, the sum of these two coefficients,  $-0.000559$ , indicates that every increased year of service for which a pensionable year is awarded is

associated with a decrease in the likelihood of attrition of roughly 0.056 percent. This association follows standard economic theory that explains increasing pensionable years should yield increasing disincentives to leave the service due to the potential increases in post-retirement income.

The effects of either being *married* or *female* are shown to not have a significant impact upon attrition. While previous studies have hinted that these variables would both have significant effects on the likelihood of leaving the service, there are two possible reasons these results have not been verified in this analysis. First, in the case of the '*Married*' variable, the effect of interest is not necessarily whether being married alone has an effect on the likelihood of attrition, but whether having *dependents* has such an effect. It is possible that this variable is not accurately representing, on aggregate, whether individuals have dependents or not. Further, actual data on 'dependents' would indicate the number of dependents for each individual, and one can expect that a greater number of dependents creates an even greater need for job security and income, such that the likelihood of attrition would decrease substantially. Unfortunately, no such data was available in this context. Secondly, previous analyses on attrition have largely centered upon military professions, and it is possible that both having dependents or wanting to start a family (perhaps importantly for female individuals) would have more important effects in the military context than in the current scenario. For instance, bearing children might be seen as less compatible with military service than working in the public sector.

Regarding the coefficients returned on the 'Province' variables, Alberta residents show a higher likelihood of attrition; this can be attributed to the strong economy and prevalence

of high-paying private sector jobs in that province. Newfoundland and Saskatchewan both show significant and negative coefficients, lowering the absolute likelihood of attrition by roughly 3 and 1.5 percentage points respectively.

Residents of Quebec are also more likely to remain in the service, though the association is not as quantifiably large as that which was returned in the case of Newfoundland and Saskatchewan: residing in Quebec is associated with a  $-0.5$  percent decrease in the absolute likelihood of attrition. Seemingly contradictory to this result, however, is the coefficient returned on the *French* variable; speaking French as a first language is associated with an increase of 1.32 percent in the attrition likelihood. Taken together, French-speaking Quebec residents would be 0.763 percent more likely to attrite than individuals who do not speak French as a first language and reside in Ontario.<sup>23</sup>

This finding merits further discussion. While this somewhat counterintuitive result may seem to have come about by chance, perhaps due to a small sample of English-speaking Quebec residents with lower rates of attrition, this is not the case. In fact, of the 1290 individuals in the sample who report speaking French as a first language, 749 reside in Quebec; meanwhile, a total of 906 individuals who live in Quebec report speaking English as a first language. Thus it is quite clear that the associations reported here have sufficient sample sizes, and the respective effects of *French-speaking individuals being more likely to attrite* and *Quebec residents being less likely to attrite* hold.

Of the ‘*Group*’ variables, individuals belonging to the Purchasing and Supply or the Engineering Support classifications have higher likelihoods of separation, as compared to their

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<sup>23</sup>Ontario is the comparison group of the provincial dummy variables.

Electronics group counterparts, at about 5 and 2.2 percentage points respectively

Perhaps most interesting for this analysis are the effects of *Salary* on attrition. According to the results in Table 2, Those in the lowest salary range – under \$40,000 per year – are about as likely to attrite as individuals making between \$40,000 and \$60,000 per year. Then, those in the upper salary range, specifically \$60,000 and above, show a positive likelihood of attrition that increases with each subsequent Salary bracket. While somewhat surprising, the intuition behind this relationship can possibly explained by economic theory.

For those individuals in the low-to-middle portion of the Salary distribution, the decreased likelihood of attrition is probably due to the fact that the public-sector pay scale is generally high when compared to alternatives; together with the job security and benefits that come with such employment, these aspects may create a disincentive for employees to leave the service.

Regarding the top earners, it is possible that the higher likelihood of attrition is related to higher ability. These individuals are perhaps subject to more attractive opportunities in the private sector due to their level of education,<sup>24</sup> expertise and experience in a high-responsibility government position. Further, it is likely that public sector salaries pale in comparison to their private sector comparables *at the upper end of the salary scale*. That is, individuals on the upper part of the salary scale in the public sector can possibly earn more in the private sector.

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<sup>24</sup>Which could not be controlled for in the current analysis

### **4.1.1 Verifying the Results of the Random Effects Model**

An alternate estimation method, *Fixed Effects*, is carried out in order to ensure that the results of the potentially vulnerable *Random Effects* specification are reliable. Specifically, concerns relating to the violation of the assumption that the *unobserved effects in the model are not correlated with error term* need to be addressed.

The results of the *Fixed Effects* estimation show, however, very few differences with those of the primary model. All of *Pensionable Years of Service*, the *Group* variables, and *Salary* show relatively similar effects. While there are a few relatively minor discrepancies, it is clear that the majority of the results serve to provide support for the primary model. It is therefore reasonable to assert that the estimates obtained in the *Random Effects* model are indeed reliable.

This study is, of course, not without its limitations. These are described in the following section.

## **4.2 Limitations to the Analysis**

First and foremost, the inability to provide a clear indication of *causality* is perhaps the main drawback of the work herein. Without a means to obtain exogenous variation in variables – that is, to say, that the issue of *selection* cannot be divorced from the data obtained – it is difficult to say with confidence that a given effect actually refers to a *ceteris paribus*, *causal* effect. The results, however, do indicate associations and relationships between variables and, wherever possible, these results are matched with theory to provide

maximum insight.

Another shortcoming that should be discussed is the inability to control for some variables of interest. Regretfully, data on potentially important explanatory variables such as *Number of Dependents*, *Self-Reported Health Status* and *Health of Dependents*, to name only a few, could not be included in the model due to lack of availability.

## 5 Conclusion

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Employing a large panel dataset generously provided by the Department of National Defence, this research made use of modern econometric regression methods in order to shed light on the issue of attrition among public servants. To the author's knowledge, this research represents the first attempt to tackle this issue in the context of panel data. As evidenced by the results of the primary model – the *Random Effects Linear Probability Model* – and further supported by an alternate *Fixed Effects* specification, this research has succeeded in shedding light on some of the crucial factors associated with the attrition behaviour.

A possible policy consideration that is worth exploring involves the use of retention bonuses, particularly those aimed at retaining high-end, skilled employees. While the attrition rates in the observed sample were not excessively high, a policy goal of lowering these rates would potentially bring about the use of such instruments. Given the results of Marquis and Kirby (1989) and Fullerton (2003), it would be interesting to see what effects these have in the present context.

Future research into this topic would do well to take into account gaps in the literature caused by data availability, as is the case with the current analysis, and explore possible methods that may mitigate the issue of a lack of causal inference.



## 6 Tables and Regression Output

**Table 1: Descriptive Statistics**

Variable	Mean	Std. Deviation	Mean, Attrite = 1 <sup>†</sup>
Age	46.6	9.65	41.1
Years of Service	11.2	10	5.7
Pensionable YOS	17.9	11.97	10.9
Married	.664	-	.563
Female	.219	-	.341
French as 1st Lang.	.231	-	.274

  

Province	Frequency	Percent
AB	2,221	7.62
BC	1,944	6.67
MB	552	1.89
NB	510	1.75
NL	84	0.29
NS	3,214	11.03
ON	11,542	39.62
QC	9,031	31
SK	37	0.13

  

Group	Frequency	Percent
EG	12,351	42.02
EL	3,930	13.37
ENENG	7,081	24.09
PG	6,030	20.52

  

Yearly Salary <sup>‡</sup>	Frequency	Percent
Under 40k	848	2.89
40 to 50k	7,704	26.21
50 to 60k	6,501	22.12
60 to 70k	2,135	7.26
70 to 80k	5,296	18.02
80 to 90k	4,269	14.52
over 90k	2,639	8.98

Notes: Data obtained from the Department of National Defence.

<sup>†</sup> This column indicates the means of the variables given that an individual has left the service.

<sup>‡</sup> Measured in constant 2010 dollars. Does not account for cross-year increases in salaries for given groups and levels; assumes salaries are stable, in real terms, across the 10-year sample.

**Table 2: Random Effects Model Estimates**

Variables	Effect on Likelihood of Attrition	Std Error
Age	0.000364	(0.000248)
Years of Service	0.000265*	(0.000158)
Pensionable YOS	-0.000824***	(0.000218)
Married	0.00298	(0.00300)
Female	0.00649	(0.00519)
First Lang. French	0.0132***	(0.00450)
Change Command	-0.00147	(0.00177)
Province of Residence <sup>a</sup>		
AB	0.0218**	(0.00851)
BC	-0.00000442	0.00541)
MB	-0.00486	(0.00887)
NB	-0.0053	(0.00733)
NL	-0.0312***	(0.00711)
NS	-0.00723	(0.00474)
QC	-0.00557*	(0.00339)
SK	-0.0148*	(0.00601)
Group <sup>b</sup>		
Engineer	-0.00596	(0.00442)
Pur. & Supply	0.0495***	(0.00648)
Eng. Support	0.0218***	(0.00568)
Salary Range <sup>c</sup>		
40 to 50k	0.00989	(0.00651)
50 to 60k	0.00815	(0.00648)
60 to 70k	0.0246***	(0.00845)
70 to 80k	0.0300***	(0.00842)
80 to 90k	0.0397***	(0.00925)
Over 90k	0.0437***	(0.0100)
Unemployment Rate <sup>d</sup>	0.000186	(0.00139)
Constant	-0.0229*	(0.0134)
Observations	28,913	
R <sup>2</sup>	0.0077	

\*\*\* p < 0.01, \*\* p < 0.05, \* p < 0.1

Note: Regression data obtained from the Department of National Defence.

Clustered Standard Errors shown in parenthesis.

a: Effects are relative to living in Ontario. Note that there are no PEI residents in the sample.

b: Effects are relative to the 'Electronics' group.

c: Compared to a salary of under 40k per year.

d: Regional Unemployment Rate in the Service Sector.

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Making use of a detailed panel dataset, this paper undertakes an econometric analysis of the factors affecting the attrition decision for members of the public service working with the Department of National Defence. Using Random Effects methods, several consistent factors were associated with an individual's likelihood of attrition. Factors that decreased this probability included the number of Pensionable Years of Service, a Change of Command, and residing in the provinces of Quebec, Newfoundland or Saskatchewan. Factors that were associated with an increase in the likelihood of attrition included speaking French as a first language, belonging to the Purchasing and Supply and Engineering Support groups, and residing in the province of Alberta; most interestingly, higher salaries were associated with greater likelihood of attrition, a finding that has not been consistently shown in prior research.

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