



A Socio-economic Analysis of Military Attrition: The Case of Non-Commissioned Members of the Canadian Armed Forces

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Abstract

Voluntary attrition has been a persistent concern for military organizations. It could hamper personnel management, diminish readiness, and generate substantial recruiting costs. Understanding and quantifying the effect of its key factors could ease these problems and mitigate these costs. A survival analysis approach was used in this study to examine the relationship between voluntary attrition and the socio-economic characteristics of Canadian Non-Commissioned Members. The baseline hazard of attrition was also estimated as a function of the civilian unemployment rate. To the best of our knowledge, this study is the first to link the economic state to voluntary attrition through the baseline hazard. This analysis indicates that higher education, being male, and being single are associated with higher risk of attrition, whereas higher rank and older age at hire have consistent negative effect (i.e., lower risk) on attrition. The study also states that the lower the civilian unemployment in the Canadian economy, the higher the hazard of attrition. The proposed model would enable decision-makers to better understand attrition and achieve more targeted retention policy objectives.

Résumé

L'attrition volontaire demeure une préoccupation continuelle pour les organisations militaires. Elle peut nuire à la gestion du personnel, affaiblir l'état de préparation et entraîner d'importants coûts de recrutement. Le fait de comprendre et de quantifier les effets de ses principaux facteurs peut aider à atténuer le problème et à réduire les coûts. Dans la présente étude, nous avons utilisé une analyse de survie pour examiner la relation entre l'attrition volontaire et les caractéristiques socioéconomiques des militaires du rang canadiens. Le risque d'attrition de référence a aussi été estimé en tant que fonction du taux de chômage civil. À notre connaissance, il s'agit de la première étude à établir un lien entre la situation économique et l'attrition volontaire par l'intermédiaire du risque de référence. L'analyse indique qu'avoir un degré de scolarité supérieur, être de sexe masculin et être célibataire sont des caractéristiques associées à un risque d'attrition plus élevé, tandis qu'occuper un grade supérieur et faire partie d'un groupe d'âge supérieur au moment de l'enrôlement sont des caractéristiques dont l'effet négatif sur l'attrition (risque d'attrition inférieur) est systématique. L'étude révèle également que plus le taux de chômage civil est bas dans l'économie canadienne, plus le risque d'attrition est élevé. Le modèle proposé pourrait aider les décideurs à mieux comprendre l'attrition et à établir des politiques de maintien en poste dont les objectifs sont mieux ciblés.

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Executive summary

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Abderrahmane Sokri; DRDC CORA TM: 2013-088; Defence R&D Canada – CORA, June 2013.

Background

Voluntary attrition is the most unexpected and volatile component of total attrition in the Canadian Regular Force [4]. First-term voluntary attrition occurs when a military member intentionally leaves military service before the end of his or her first-term enlistment contract. This kind of attrition is particularly crucial in military organizations due to its cost and impact on military manpower management. An inaccurate forecast of attrition may lead to very costly miscalculations by management [4].

From a management perspective, first-term enlisted voluntary attrition could hamper efficient personnel management [5]. Any higher than anticipated attrition could result in shortage of the active military manpower available for deployment [1], and reduces the pool of potential members for the future force. It would degrade unit performance and waste valuable training and recruiting resources [6].

From a financial standpoint, the cost of first-term enlisted voluntary attrition consists of pay and all provisions provided during training. It also includes all the costs associated with the recruiting process. In the absence of Canadian data, American statistics can help to give a rough idea about the overall order of magnitude of the voluntary attrition cost. Using fiscal year (FY) 1993 cost estimates, the U.S. Government Accountability Office (GAO) showed that \$1.3 billion (or \$17,889 per capita) was spent on the 72,670 enlistees who entered the services in 1993 and left early. Nearly 61.54% of this amount was spent on pay and allowances. The remaining 38.46% was spent on recruiting and training sites, instructors, and recruiters [7]. These costs can be reduced, if the underlying causes of attrition can be identified early at recruitment.

To inform decision-making, this study examines how the socio-economic factors can affect individual military personnel decisions to attrite. In accordance with the Canadian defence strategy, this study would enable decision-makers to better understand attrition and develop an integrated CAF retention strategy that accounts for emerging demographic challenges and workforce characteristics.

Aim

This study examines the voluntary attrition of the Canadian Non-Commissioned Members (NCM). It has three objectives:

- to capture the relationship between the risk of voluntary attrition of the Canadian NCM and their personal characteristics.
- to describe the relationship between the risk of voluntary attrition of the Canadian NCM and the whole economy.
- to develop a stay/leave decision model to predict attrition of the Canadian NCM.

Methodology

A survival analysis [9] is used to examine the factors that affect military NCM's voluntary attrition. The target population includes 23,377 NCM who enlisted between FY 1995/96 and 2005/06. A two-stage estimation procedure is used.

- **In the first step**, the risk of attrition and the time to attrite are related to a function of socio-economic characteristics of military personnel such as rank, age, marital status, and education. At this stage the effects of the main personal contributors to attrition are identified and quantified.
- **In the second stage**, the baseline risk of attrition is estimated as a function of a broad indicator of the economy, i.e., the annual variation in the civilian unemployment rate.

Common statistical tests were used to investigate the key assumptions of the model and its goodness-of-fit. The results showed that the assumptions were valid and that all the explanatory variables were statistically significant beyond the acceptable levels. To our knowledge, this study is the first to link the economic state to voluntary attrition through the baseline risk.

Conclusion

This analysis provided some insights regarding the main factors involved in attrition. It indicated that higher education, being male, and being single were associated with higher risk of attrition whereas older age at hire and higher rank reduce attrition. The study suggested that the state of the Canadian economy affects the military personnel attrition. There is evidence that the lower the unemployment in the Canadian economy, the higher the hazard of attrition.

This study provides an appropriate tool to identify and quantify the main factors of the Canadian NCM attrition. It would help in developing an integrated CAF retention strategy that accounts for emerging demographic challenges and workforce characteristics. Further efforts are ongoing to explore the impact of socio-economic characteristics on the voluntary attrition of specific military and civilian occupation groups. To optimise the mix of people and skills within the CAF, further analysis should be undertaken to address other aspects of attrition. Examples of such studies include (but are not limited to): What is the cost of early-career attrition and how to reduce it?

Sommaire

A Socio-economic Analysis of Military Attrition: The Case of Non-Commissioned Members of the Canadian Armed Forces

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Contexte

L'attrition volontaire est la composante la plus imprévue et la plus instable de l'attrition totale dans la Force régulière du Canada [4]. L'attrition volontaire à la première période de service se produit quand un militaire quitte délibérément le service militaire avant la fin de son premier contrat d'enrôlement. Ce type d'attrition a une importance particulière pour les organisations militaires en raison de ses coûts et de ses effets sur la gestion de la main-d'œuvre militaire. Une prévision imprécise de l'attrition peut amener la direction à faire de mauvais calculs coûteux [4].

Dans une optique de gestion, l'attrition volontaire des enrôlés au cours de la première période de service peut nuire à la gestion efficiente du personnel [5]. Une attrition plus importante que celle qui avait été prévue pourrait se solder par une pénurie de main-d'œuvre militaire active disponible pour les déploiements [1] et réduire le bassin de membres potentiels pour la future force. Elle pourrait affaiblir le rendement des unités et provoquer le gaspillage de précieuses ressources affectées à l'instruction et au recrutement [6].

Dans une perspective financière, le coût de l'attrition volontaire des enrôlés au cours de la première période de service comprend la solde et tout ce qui est fourni pendant l'instruction, ainsi que les coûts associés au processus de recrutement. En l'absence de données canadiennes, les statistiques américaines peuvent donner une idée approximative de l'ordre de grandeur du coût global de l'attrition volontaire. D'après les estimations de coût de l'exercice 1993, le Government Accountability Office (bureau de la responsabilité gouvernementale) des États-Unis a montré que les 72 670 recrues qui s'étaient enrôlées en 1993 et qui avaient quitté l'armée prématurément avaient coûté 1,3 milliard de dollars (ou 17 889 \$ par tête). Environ 61,54 % de cette somme a été versée au titre de la solde et des indemnités, et 38,46 % de la somme a été affectée aux sites de recrutement et d'instruction, aux instructeurs et aux recruteurs [7]. Ces coûts pourraient diminuer si les causes sous-jacentes de l'attrition étaient cernées tôt, à l'étape du recrutement.

En vue d'éclairer les décideurs, nous examinons dans la présente étude comment les facteurs socioéconomiques peuvent influencer sur la décision individuelle de quitter les Forces canadiennes. Conformément à la stratégie de défense du Canada, l'étude permettra aux décideurs de mieux comprendre l'attrition et d'élaborer une stratégie intégrée de maintien en poste des Forces canadiennes qui tiendra compte des nouvelles difficultés d'ordre démographique et des caractéristiques de la main-d'œuvre.

But

L'étude porte sur l'attrition volontaire des militaires du rang (MR) canadiens. Trois objectifs sont définis :

- cerner le lien entre le risque d'attrition volontaire des MR canadiens et leurs caractéristiques personnelles;
- décrire le lien entre le risque d'attrition volontaire des MR canadiens et l'économie dans son ensemble;
- élaborer un modèle de la décision de partir ou de rester en vue de prédire l'attrition des MR canadiens.

Méthodologie

Nous avons recours à l'analyse de survie [9] pour examiner les facteurs qui influent sur l'attrition volontaire des MR. La population cible comprend 23 377 MR qui se sont enrôlés entre 1995-1996 et 2005-2006. Une procédure d'estimation en deux temps est utilisée.

- **Dans un premier temps**, le risque d'attrition et le moment du départ sont liés à une fonction des caractéristiques sociodémographiques du personnel militaire comme le grade, l'âge, l'état matrimonial et le degré de scolarité. À cette étape, les effets des principaux facteurs personnels contribuant à l'attrition sont cernés et quantifiés.
- **Dans un deuxième temps**, le risque d'attrition de référence est estimé en tant que fonction d'un vaste indicateur de l'économie, à savoir la variation annuelle du taux de chômage civil.

Nous avons mené des tests statistiques courants pour vérifier les principales hypothèses du modèle et son ajustement. Les résultats montrent que les hypothèses étaient valides et que toutes les variables explicatives étaient statistiquement significatives au-delà des niveaux acceptables. À notre connaissance, il s'agit de la première étude à établir un lien entre la situation économique et l'attrition volontaire par l'intermédiaire du risque de référence.

Conclusion

La présente analyse jette un certain éclairage sur les principaux facteurs qui interviennent dans l'attrition. Elle révèle qu'avoir un degré de scolarité supérieur, être de sexe masculin et être célibataire sont des caractéristiques associées à un risque d'attrition plus élevé, tandis qu'occuper un grade supérieur et faire partie d'un groupe d'âge supérieur au moment de l'enrôlement sont des caractéristiques qui réduisent le risque d'attrition. L'étude donne à penser que la situation de l'économie canadienne influe sur l'attrition du personnel militaire. Les résultats semblent indiquer que plus le taux de chômage dans l'économie canadienne est faible, plus le risque d'attrition est élevé.

L'étude fournit un bon outil pour cerner et quantifier les principaux facteurs qui contribuent à l'attrition des MR canadiens. Elle pourra servir à l'élaboration d'une stratégie intégrée de maintien en poste des Forces canadiennes qui tiendra compte des nouvelles difficultés d'ordre démographique et des caractéristiques de la main-d'œuvre. D'autres travaux en cours portent sur la façon dont les caractéristiques socioéconomiques influent sur l'attrition volontaire de groupes professionnels militaires et civils particuliers. Pour doter les Forces canadiennes d'une combinaison optimale de personnes et de compétences, il faudrait approfondir les analyses en vue de comprendre d'autres aspects de l'attrition. Par exemple, il conviendrait d'étudier notamment le coût de l'attrition en début de carrière et la façon de la réduire.

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1. Introduction

“Military personnel management is not about process; it is about real people.”
MGen W. Semianiw, February 2008

1.1 Background

Military attrition rate is defined as the percentage of military personnel who voluntarily or involuntarily separate during a fiscal year before achieving retirement eligibility [1]. The Department of National Defence (DND) defines it as the rate of loss of personnel that occurs as a result of voluntary resignation, discharge, retirement or death¹. Voluntary attrition is defined as deliberately leaving military service before the end of a contracted term of service. This personal decision to leave generally takes the form of voluntary resignation. This definition excludes individuals who involuntarily separate for reasons such as death, retirement, or disability.

Identifying and understanding the factors influencing attrition is a key requirement for any effective military personnel management [2]. It is important for properly planning the recruitment and training of new members as well as for budget planning purposes [3]. As shown in Figure 2, recruitment and retention form the pillars of the Canadian Conceptual Model of the personnel generation system.

Voluntary attrition is actually the most unexpected and volatile component of total attrition in the Canadian Regular Force [4]. The Regular Force is formed by members who have a full-time career, and have usually signed long-term contracts². First-term voluntary attrition occurs when a military member intentionally leaves military service before the end of his or her first-term enlistment contract. This kind of attrition is particularly crucial in military organizations because of the cost and impact on military manpower management. An inaccurate forecast may lead to very costly miscalculations by management [4].

From a management perspective, first-term enlisted voluntary attrition could hamper efficient personnel management [5]. Any higher than anticipated attrition could result in shortage of the active military manpower available for deployment [1], and reduces the pool of potential members for the future force. It would degrade unit performance and waste valuable training and recruiting resources [6].

From a financial standpoint, the cost of first-term enlisted voluntary attrition consists of pay and all provisions provided during training. It also includes all the costs associated with the recruiting process. In the absence of Canadian data, American statistics can help to give a rough idea about the overall order of magnitude of the voluntary attrition cost. Using fiscal year (FY) 1993 cost estimates, the U.S. Government Accountability Office (GAO) showed that \$1.3 billion (or \$17,889 per capita) was spent on the 72,670 enlistees who entered the services in 1993 and left early. Nearly 61.54% of this amount was spent on pay and allowances. The remaining 38.46% was spent on recruiting and training sites, instructors, and recruiters [7]. These overall costs of attrition can be reduced, if its underlying causes can be identified early in the initial stages of enlistment.

¹ Defence Terminology Bank

² Forces.ca



Figure 1: Pillars of CAF military personnel management³

For the past several years, the Canadian Armed Forces (CAF) has faced many challenges in retaining military personnel. Annual attrition rate in the Canadian Regular Force showed a larger than expected increase between 2001 and 2008. This rate reached its maximum of 9.1% between 2007 and 2009 [5]. This rate was considered within the high-normal range by DND in its military personnel retention strategy. Most interestingly, two thirds of this attrition is voluntary. Voluntary attrition has particularly become an important issue at two career points. It is high during the first year of service and at, or shortly after, the 20 years-of-service point [8].

To inform decision-making, this study examines how the socio-economic factors can affect individual military personnel decisions to attrite. In accordance with the Canadian defence strategy, this study would enable decision-makers to better understand attrition and develop an integrated CAF retention strategy that accounts for emerging demographic challenges and workforce characteristics.

1.2 Aim

This paper examines voluntary attrition of the Canadian Non-Commissioned Members (NCM). It has three objectives:

- to capture the relationship between the risk of voluntary attrition of the Canadian NCM and their personal characteristics.
- to describe the relationship between the risk of voluntary attrition of the Canadian NCM and the whole economy.
- to develop a stay/leave decision model to predict attrition of the Canadian NCM.

1.3 Methodology

A semi-parametric survival analysis [9] is used to examine the factors that affect military NCM's voluntary attrition. A two-stage estimation procedure is used.

³ Source: Director General Military Personnel (2013).

- In the first step the hazard rate of attrition and the time to attrite are related to a function of socio-economic characteristics of military personnel such as rank, age, marital status, and education. At this stage the effects of the main personal contributors to attrition are identified and quantified.
- In the second stage, the baseline hazard is estimated as a function of a broad indicator of the economy, i.e., the annual variation in the civilian unemployment rate.

Common statistical tests were used to investigate the key assumptions of the model and its goodness-of-fit. The results showed that the assumptions were valid and that all the explanatory variables were statistically significant beyond the acceptable levels.

The target population includes 23,377 NCM who enlisted between FY 1995/96 and 2005/06. A NCM is any person, other than an officer, who is enrolled in the CAF⁴.

To our knowledge, this study is the first to link the economic state to voluntary attrition through the baseline hazard.

1.4 Document structure

This paper is organized into six sections. Following the introduction, Section 2 provides a comprehensive review of literature on military personnel's attrition. Section 3 sets up the employed model and presents its mathematical derivations. Section 4 contains a full estimation of the model. Section 5 provides a discussion of the results. Finally, in Section 6, some concluding remarks are made.

⁴ Defence Terminology Bank

2. Literature review

A growing body of literature recognizes attrition as a crucial factor to effective personnel management [2]. This literature has primarily attempted to identify the characteristics that distinguish individuals who are at high risk of attrition from those at low risk. This literature can be divided along methodological lines into two main approaches to analyzing attrition: Time series methods and binary response models.

The first category uses the Box-Jenkins [10] stochastic time-series method and other traditional econometric techniques, particularly when economic factors are considered. The dependent variable could be the attrition rate and the explanatory variables could include economic factors (e.g., unemployment rate). The unknown parameters are estimated to arrive at coefficients which best fit the selected model.

Dale and Gilroy [11], for example, examined the effects of the business cycle and other factors on enlistments of non-prior service high school graduates. The authors concluded that unemployment and educational benefits are significant determinant of Army enlistment rates. They also indicated that military pay must keep pace with civilian wages for military service to be an attractive alternative to employment in private industry. Solomon [12] proposed a transfer function framework to forecast voluntary attrition. The result indicated that transfer function models provide a better forecasting and explanatory capability than univariate time series models. Lebreton [4] examined alternative techniques used to forecast voluntary attrition. The author provided an automated package designed to identify turning points and generate forecasts. More recently, Asch et al. [13] applied statistical models to examine the enlistment, attrition, and reenlistment effects of bonuses. The estimated models are used to address questions about the cost-effectiveness of bonuses and their effects in offsetting other factors that might adversely affect recruiting and retention, such as changes in the civilian economy and frequent deployments.

The second category of attrition modeling methodologies uses binary response models and survival analysis to explain the relationship between a group of socio-economic variables (explanatory variables) and the probability of attrition (dependent variable). The simplicity of this functional approach added to its flexible nature makes it very attractive to analysts. Since the seminal paper by Cox [9] introducing semi-parametric proportional hazard models for survival data, this literature has grown considerably.

Marquis and Kirby [14], for example, used survival analysis techniques to study the timing of attrition. The authors found sizable differences in attrition for different demographic groups. Increasing years of military experience, age, and education are associated with decreasing rate of attrition. They also found that increases in military pay significantly reduce the rate of attrition at any point of time. Kearl and Nelson [15] used a binary-logistic model to estimate the effects of personal characteristics, economic conditions, and recruiting incentives on the Delayed Entry Program (DEP) loss. The results indicated that the largest determinants of DEP loss are related to personal characteristics. They also indicated that the improving economy and reduced recruiting incentives increased DEP loss. Stone et al. [16] developed a logit model to evaluate the effects of key individual and institutional factors on pilot retention. The authors showed that relative military to civilian compensation and relative airline hiring were statistically significant. Fullerton [17] examined the factors affecting the retention of pilots. The results of this study suggested that economic factors had the largest impact on retention. Elliott et al. [18] estimated a pilot attrition

model that examines the impact on attrition from factors such as compensation, deployment, voluntary separation programs, and civilian airline hiring. The authors found that increases in major airline hiring tend to increase military pilot attrition to a great degree in the Air Force and to a lesser extent in the Navy. More recently, Thompson [19] used probit models to analyze the effects of unemployment on first-term attrition for United States Navy enlisted personnel. The study indicated that consistent negative effects on attrition included unemployment rate, being black, more years of education and higher pay grade, and that positive influences included older age, having no dependents, and being females.

While many important findings have been reported, the existing models still suffer from a lack of integration and simplicity. They are not able to adequately relate attrition to economic conditions and workforce characteristics within the same framework. The few papers that tried to shed some light on this question used regional unemployment rates matched by year as local economic conditions. This variable is based on an individual's home state of residence at the time of enlistment [16, 19]. To limit the amount of bias, this literature introduces dummy variables for each fiscal year and each region. Thompson [19], for example, created eight dummy variables for the periods 1999-2007 and 50 dummy variables for states. Moreover, regional unemployment rates could not be applied easily to explain attrition in countries with labor mobility. Models from this literature could not be used in countries with the same level of economic development across regions. This study seeks to address this deficiency by combining in an easy way the workforce characteristics and economic conditions within the same survival analysis. The baseline hazard is used as a common ground of integration to bring together the national economic shape and personnel characteristics. Furthermore, the proposed model can also easily analyze the time it takes for attrition to occur.

3. The Model

This section sets up the employed binary model and presents its mathematical derivations.

Let T be a random variable representing survival time. The probability of a military personnel member staying longer than time t is given by the following survival function,

$$S(t) = \Pr(T \geq t). \quad (1)$$

$S(t)$ is a decreasing function with $S(0) = 1$. $S(t)$ could also be interpreted as the proportion of military personnel that are still on the job by time t .

The hazard function, which assesses the instantaneous risk of attrition at time t , conditional on survival to that time is given as follows,

$$h(t) = -\frac{d[\ln S(t)]}{dt} = -\frac{\dot{S}(t)}{S(t)}. \quad (2)$$

The hazard rate of attrition $h(t)$ could be interpreted as the proportion of individuals who attrite per time unit. If $h(t)$ is high, survival is low and vice versa.

To examine the influence of a set of k covariates (x_1, x_2, \dots, x_k) upon survival, the risk of attrition at time t may be written as:

$$h(t|x_1, x_2, \dots, x_k) = h_0(t)\exp(\beta_1 x_1 + \beta_2 x_2 + \dots + \beta_k x_k), \quad (3)$$

where

- $h(t)$ is the hazard rate of attrition;
- x_1, x_2, \dots, x_k are covariates (e.g., age, gender, and education observed at recruitment);
- $h_0(t)$ is the baseline hazard;
- t is time-to-event i.e. time to attrite;
- $\beta_1, \beta_2, \dots, \beta_k$ are the respective regression coefficients.

Equation (3) defines a well-recognized statistical technique for analyzing survival data known as the Cox model [9].

The hazard ratio of the covariate p , $1 \leq p \leq k$, read as follows,

$$\exp(\beta_p) = \frac{\exp(\beta_1 x_1 + \dots + \beta_p (x_p + 1) + \dots + \beta_k x_k)}{\exp(\beta_1 x_1 + \dots + \beta_p x_p + \dots + \beta_k x_k)}. \quad (4)$$

The hazard ratio expresses the relative risk when the covariate x_p is increased by 1, holding all other predictors constant.

The conventional Cox model [9] leaves the baseline hazard function $h_0(t)$ unspecified. To describe the relationship between the hazard rate of attrition and the whole economy, we will investigate the relationship between the baseline hazard and a broad indicator of the economy (e.g., the civilian unemployment rate).

Denoting by U the civilian unemployment rate, the parametric model in (3) could be rewritten as

$$h(t|x_1, x_2, \dots, x_k) = h_0(t, U) \exp(\beta_1 x_1 + \beta_2 x_2 + \dots + \beta_k x_k). \quad (5)$$

By (5) we have defined an augmented Cox model where the baseline hazard is linked to the economic situation. This model relates the hazard rate of attrition and time to attrite to a function of the economy and socio-economic variables (x_1, x_2, \dots, x_k) . It provides a way to identify the major contributors to voluntary attrition. It allows quantifying in the same framework the impact of economic and demographic changes on the NCM attrition. It can also help determine which policy changes may be suitable in the future.

4. Estimation

This Section is devoted to the estimation of the statistical model. It also discusses the sources of data and describes the dependent and independent variables used in the regression analyses.

4.1 Data sources

The dataset for this study was taken from two sources. The socio-economic variables were provided by DND. Given that their values were recorded at hire, all these variables are time-independent. The economic variables were drawn from Statistics Canada.

4.2 Target population

The data contain records on 23,377 active duty non-prior enlisted NCM who enlisted between FY 1995/96 and 2005/06. NCM were observed between 1995/96 and 2011/12, inclusively. The subjects are primarily male (86.6%), single (65.3%) and under the age of 25 (77.63%). Individuals who involuntarily separated for reasons, such as retirement, disability, or death were excluded. In this population, 60.8% of the subjects decided to continue and 39.2% decided to attrite.

4.3 Variables

To identify the factors and characteristics that influence the NCM voluntary attrition, seven socio-economic explanatory variables were deemed statistically significant. Survival analysis was concerned with studying the time between enlistment and attrition (Years of Service). Therefore, Years of Service is a central variable in this analysis. This variable represents time-to-event or time to attrite in the mathematical model. The dependent variable (Attrite) is an indicator function taking the value 1 if the individual did attrite and zero otherwise. The independent variables include age at hire, education, gender, marital status, rank, and the civilian unemployment rate.

4.4 Statistical model

The Cox regression analysis was carried out on the target population. This model included five explanatory variables (age, education, gender, marital status, and rank). The results are summarized in Table 1. In this table, the first column indicates the explanatory variables, while the following are the coefficients of regression, the significance of each variable, the hazard ratio, and the variation in the risk of attrition.

Table 1: Cox regression model

	Coef. β	Signif.	Exp(β)	Δ Risk of attrition
Rank	-.548	.000	.578	-42.20%
Single	.330	.000	1.391	+39.10%
Male	.186	.000	1.204	+20.40%
Age	-.040	.000	.961	-3.90%
Education	.007	.000	1.007	+0.70%
Unemployment rate	-.333	.011	0.72	-28.32%

The first feature to note in Table 1 is the significance of each variable. The third column refers to testing the hypothesis $H_0: \beta_p = 0$; i.e., the variable p has no marginal effect on attrition. A

covariate is generally considered statistically significant if its p-value, denoted as ‘Signif.’ in Table 1, is under 5%. As shown in this column, all the explanatory variables are statistically significant at the .011 level.

The second thing to note is the sign of the regression coefficients. These coefficients represent the effects of the covariates. A positive sign means that the hazard (risk of attrition) is higher for subjects with higher values of that variable. Thus, being single, male, and highly educated are associated with higher risk of attrition, whereas older age and higher rank are associated with lower risk of attrition. The impact of the unemployment rate will be analyzed in detail in the next subsection.

The regression coefficient may be interpreted in terms of the relative risk when the covariate is increased by 1. More specifically, it is the increase in the natural logarithm of the hazard for an increase of 1 in the value of the covariate.

For a continuous variable, the exponentiated coefficient known as the hazard ratio may be interpreted as the predicted multiplicative change in the hazard for a unit increase in the predictor. Holding the other covariates constant, the risk of attrition decreases, for example, by $\text{Exp}(-0.040) = 0.961$ times if an individual is a year older; that is, a $100\% - (100\% \times 0.961) = 3.9\%$ decrease in the risk of attrition. Similarly, an additional year of education increases the hazard by a factor of 1.007 (or 0.7%) and each supplementary rank reduces the hazard by a factor of 0.578 (or -42.2%).

For a binary covariate, the hazard ratio is the estimate of the ratio of the hazard rate in one group to the hazard rate in another group. The value of the hazard ratio for gender means that the attrition hazard for a male is $\text{Exp}(0.186) = 1.204$ times that of a female. In the same way, the value of the hazard ratio for marital status means that the attrition hazard for a single person is 1.391 times that of the other marital statuses.

4.5 Economic factor in NCM attrition

The baseline hazard function does not have to be specified in the Cox regression model. To describe the relationship between the hazard rate of attrition and the whole economy, the baseline hazard is statistically estimated as a function of the civilian unemployment rate. Equation 6 below was built by applying an Ordinary Least Squares (OLS) regression. It gives the natural logarithm of the baseline hazard, $\ln(h_0(t))$, as a function of the variation in the unemployment rate, $(U_t - U_{t-1})$.

$$\ln(h_0(t)) = 4.674 - 0.333(U_t - U_{t-1}). \quad (6)$$

The coefficients of regression in equation 6 are statistically significant at the .011 level. The Ljung-Box portmanteau test [20] was used to check the residuals. This test returned a p-value greater than 0.05 for all numbers of lags to be tested, providing insufficient evidence of any autocorrelation between errors. If both sides of this expression are exponentiated, the predicted baseline hazard will be:

$$h_0(t) = 107.156 \exp(-0.333(U_t - U_{t-1})). \quad (7)$$

Equation 7 shows that the baseline risk of attrition decreases by $\text{Exp}(-0.333) = 0.716$ times if the unemployment rate increases by one percentage point; that is, a 28.32% decrease in the risk of

attrition. Let $x_1, x_2,$ and x_3 be the covariates denoting respectively the rank, age, and years of education of a military personnel. Let x_4 and x_5 be the covariates denoting respectively being male and being single. Denote by x_6 the annual variation in the unemployment rate.

The final model yields an equation for the hazard as a function of the unemployment rate and the five precedent explanatory variables. The prediction equation is given by

$$h(t) = 107.156 \exp(-0.548x_1 - 0.04x_2 + 0.007x_3 + 0.186x_4 + 0.33x_5 - 0.333x_6). \quad (8)$$

Equation 8 provides the amount of increase (or decrease, if the sign of the coefficient is negative) in the natural logarithm of the hazard rate that would be predicted by a one unit increase (or decrease) in the predictor, holding all other predictors constant. It indicates that higher rank (x_1) and older age (x_2) are associated with better retention, whereas being highly educated (x_3), male (x_4), and single (x_5) are associated with more attrition. Last but not least, this equation also indicates that unemployment rate has a negative effect on attrition.

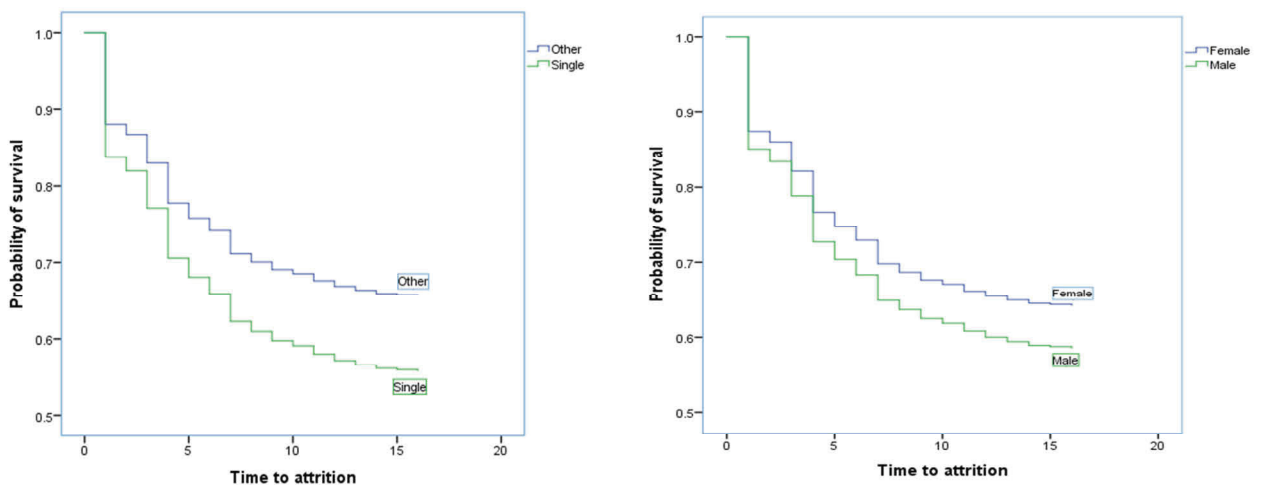
4.5 Survival curve

To examine the time it takes for attrition to occur, we can plot the survival curve associated to the fitted model. The survival curve displays the probability of survival as a function of the time to attrition during the period of observation. Denoting by $S(t)$ the probability that an individual survives more than time t , the survival curve has two main characteristics:

- first, as an individual is certain to survive more than zero time, $S(0) = 1$;
- second, as it is impossible for an individual to survive more than time t without surviving throughout the preceding time interval, $S(t)$ must get smaller as t gets bigger.

The probability of survival is measured from two variables: one numerical (time to attrition) and the other binary (presence or absence of attrition).

Figure 3 shows the survival curves $S(t)$ for the Cox regression model. The plots show the effect of the categorical covariates (gender and marital status) on time to attrite.



a. Survival function by marital status

b. Survival function by gender

Figure 2: Survival function at mean of covariates

The cumulative probability of surviving up to time t is the probability of surviving at time t , and surviving throughout the preceding time interval. The horizontal axis shows the time to attrition and the vertical axis shows the cumulative survival probability. Results indicate that the behaviour of attrition differs across categorical predictors. Males and singles have lower survival curves and then are more likely to have shorter times to attrite.

5. Discussion of results

Findings in Section 4 suggest that singles, males and highly educated enlisted individuals are more likely to attrite. It was also found that age, rank, and civilian unemployment rate had a negative effect on attrition. A further discussion of these results will be given in this section.

5.1 Statistical model

As shown in Table 1, it was found that each predictor significantly affected attrition. With a decreased risk of approximately 42%, rank particularly appears to be an important predictor of attrition. In general, women in the United States and Canada have consistently demonstrated higher attrition rates than their male counterparts [21]. This effect may be due to physiological characteristics, such as childbirth that may interrupt the career path of a female military. There is, however, an exception to this tendency for female NCM who demonstrate higher survival curve than their male counterparts. The risk that a NCM attrites increases by 20.40%, if he is male. Given that the most Canadian military personnel are NCM, this result marks a turning point for women in the CAF.

Analysis of the officer population, who enlisted between FY 1995/96 and 2005/06, shows that voluntary attrition levels and leaving patterns are dissimilar for the NCM and officer Corps. NCM with small age at hire are more likely to leave the military than young officers. At the age at hire of 20 years, for instance, the attrition rate is approximately 46% for NCM and about 33% for Officers. Figure 4 plots the attrition rate against the age at hire during the early career years of NCM and Officers, *ceteris paribus*. Initially strong, the attrition rate of NCM falls with age, continues a downward trend, and intersects the officer attrition rate between 27 and 28 year points. After the age of 28 years, the NCM rate becomes below that of Officers.

It is worthwhile to note that the attrition rate is defined in this analysis as the percentage of military personnel who enlisted between FY 1995/96 and 2005/06 and voluntarily separate, between FY 1995/96 and 2011/12, before the end of a contracted term of service.

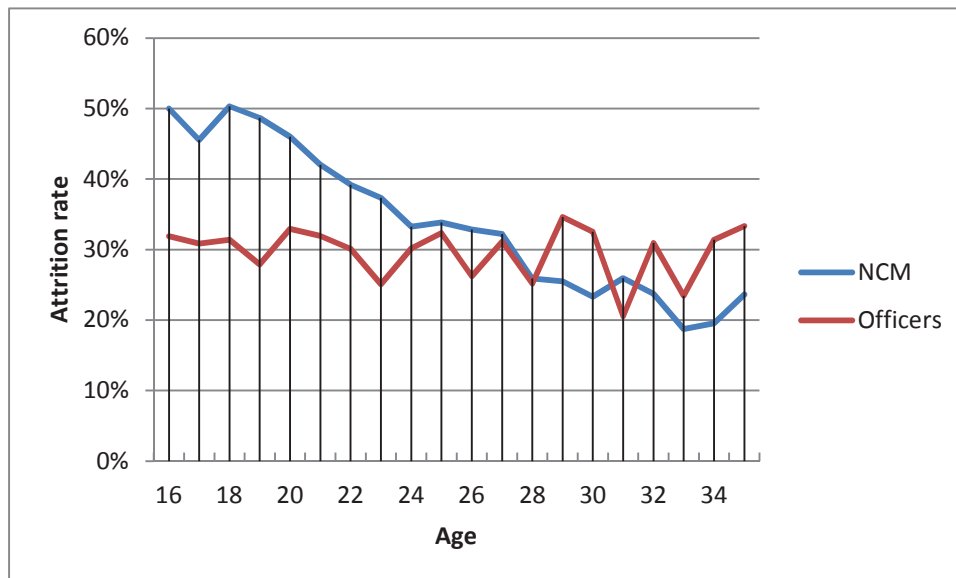


Figure 3: Attrition rate by age and rank

5.2 Economic factor

The findings in Section 4 indicate that civilian unemployment has a negative effect on attrition. The hazard to attrite decreases by 28.32% when the unemployment rate increases by one percentage point. In Equation 7, U_{t-1} looks like the natural rate of unemployment or the attrition-threshold unemployment rate. If $U_t < U_{t-1}$, attrition tends to accelerate. Similarly, if $U_t > U_{t-1}$, attrition tends to slow. When $U_t = U_{t-1}$, the exponential term drops out of the equation and the expected baseline risk of attrition is constant.

Plotting the baseline hazard rate (h_0) against the variation in the unemployment rate ($U_t - U_{t-1}$) gives the downward-sloping curve in Figure 5. This graph states that the lower the unemployment in the Canadian economy, the higher the hazard of attrition. Higher civilian unemployment reinforces retention because civilian jobs become relatively scarce. This result is on par with the existing American literature which suggests that as unemployment increases enlisted military personnel are less likely to leave. The findings are particularly consistent with the studies conducted by Thompson [19], Cox [22], and Ackerman et al. [23].

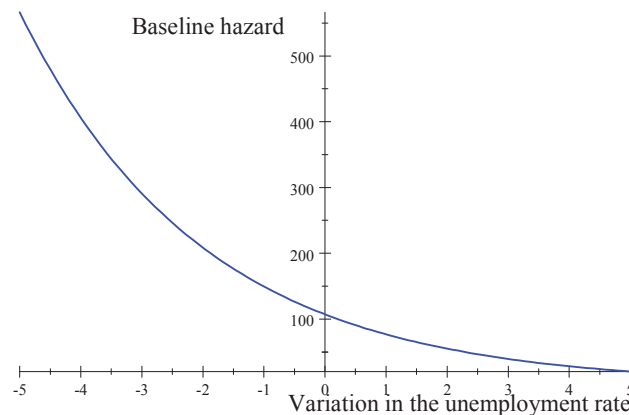


Figure 4: Baseline hazard rate of attrition against unemployment

5.3 Survival curve

The survival curves in Figure 3 give a visual display of the probability of survival against the time to attrition. In this Figure, the plot (a) shows the survival function for the NCM members by marital status. It indicates that single NCM are more likely to have shorter times to attrite. The plot (b) shows the survival function by gender. It indicates that female NCM have lower survival curve than their male counterparts. Therefore, the expected proportion of the male NCM who decide to stay falls more rapidly than the proportion of their female counterparts. This result does not agree with the general observation that military women have consistently demonstrated higher attrition rates than men [19].

To investigate the equality of survival curves across groups, three formal non-parametric statistical tests were used: Log rank (Mantel-Cox) test, the modified Wilcoxon test (Breslow), and Tarone-Ware test. These tests compare the overall survival rates between two groups, with the test statistic based on differences in group mean scores. Table 2 displays the test statistic and the level of significance for gender and marital status. The test statistic for the equality of the survival functions has an asymptotic chi-square distribution. Significance value is the probability of obtaining a test statistic at least as extreme as the one that was actually observed, assuming that

the null hypothesis is true. The lower the significance value, the less likely it is that the two survival functions are equal. In this case, the significance values are so low that they are displayed as .000. Since the significance values of the tests are all less than 0.01, one concludes that the survival curves are different across the groups. For each factor, the compared groups appear to have different survival functions and the three tests support the previous conclusions.

Table 2: Test of equality of survival distributions for gender and marital status

Test	Gender		Single	
	Chi-Square	Sig.	Chi-Square	Sig.
Log Rank (Mantel-Cox)	112.159	.000	470.338	.000
Breslow (Generalized Wilcoxon)	126.361	.000	528.681	.000
Tarone-Ware	121.077	.000	509.722	.000

A key assumption of Cox regression is proportional hazards. This means that the effect of a unit increase in a covariate is multiplicative with respect to the hazard rate. In other words, the hazard ratio is independent of time. The most straightforward check for testing proportionality is to plot the Kaplan–Meier survival curves together (e.g., Figure 3). In this study, the curves do not intersect and then the proportional hazards assumption is not violated. Another more sophisticated way for testing proportionality is based on the plot of the logarithm of the negative logarithm of the estimated survival function (log-log plot). As shown in Figure 6, the resulting lines are parallel meaning that the assumption is valid. If this was not, other techniques would have to be used.

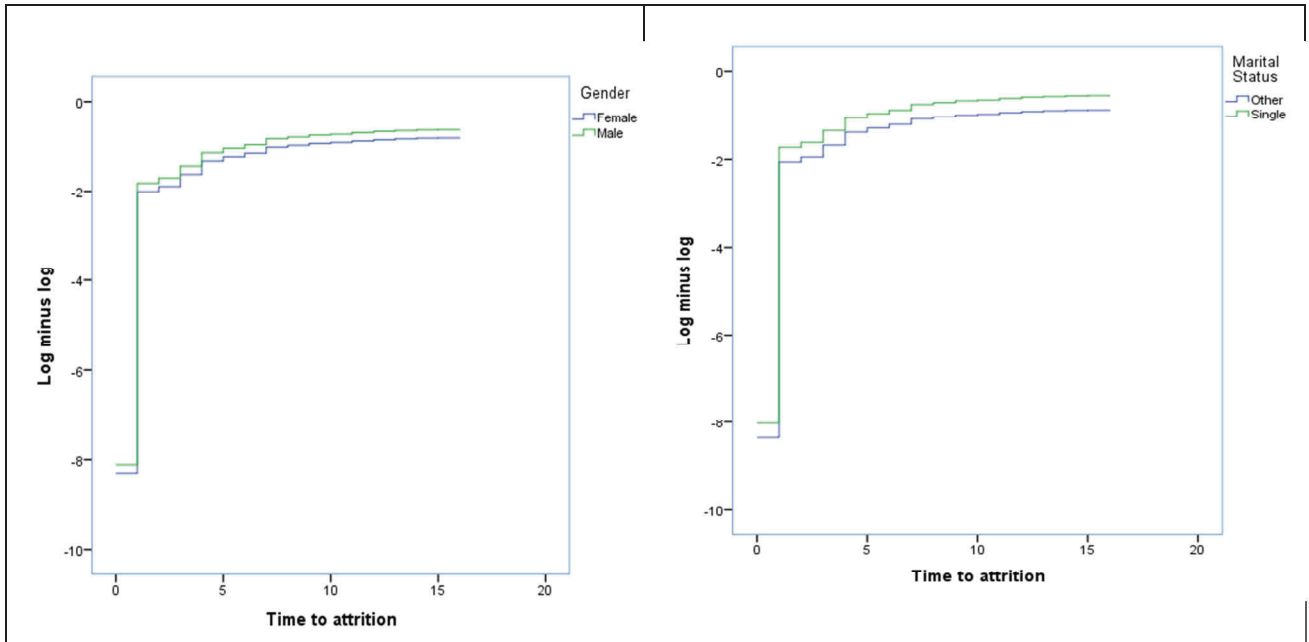


Figure 5: The log-log of the estimated survival function

6. Conclusion

Voluntary attrition is considered as a dysfunctional turnover by many scholars. This kind of attrition could hamper personnel management, diminish readiness, and generate substantial recruiting costs. Understanding and quantifying the effect of its potential determinant factors could ease these problems and mitigate these costs.

A survival analysis approach was used in this study to examine the relationship between voluntary attrition and socio-economic characteristics of military personnel such as rank, age, marital status, and education. The baseline hazard was also estimated as a function of the civilian unemployment rate as a broad indicator of the economy. To our knowledge, this study is the first to examine the economic factors on voluntary attrition by estimating the impact of the unemployment rate on the baseline hazard.

This analysis provided some insights regarding the main factors involved in attrition. It indicated that higher education, being male, and being single were associated with higher risk of attrition whereas older age at hire and higher rank had consistent negative effect on attrition. The study suggested that the state of the Canadian economy would affect the attrition of the military personnel. It states that the lower the unemployment rate, the higher the hazard of attrition.

This study provides an appropriate tool to identify and quantify the main determinant factors of the Canadian NCM attrition. It would also enable decision-makers to better understand attrition and achieve more targeted retention policy objectives. It could help in developing an integrated CAF retention strategy that account for emerging demographic challenges and workforce characteristics.

Further efforts are ongoing to explore the impact of socio-economic characteristics on voluntary attrition of specific military and civilian occupation groups. The military occupational classification of interest is Air Force Pilot. On the civilian side the population of interest is the skilled public servants such as Engineering and Electronics groups.

To optimise the mix of people and skills within the CAF, further analysis should be undertaken to address other aspects of attrition. Examples of such studies include (but are not limited to): What is the cost of early-career attrition and how to reduce it?

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List of abbreviations/acronyms

NCM	Non-Commissioned Members
FY	Fiscal Year
GAO	The U.S. Government Accountability Office
U.S.	United States
CAF	Canadian Armed Forces
DEP	The Delayed Entry Program
DND	The Department of National Defence
OLS	Ordinary Least Squares

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Voluntary attrition has been a persistent concern for military organizations. It could hamper personnel management, diminish readiness, and generate substantial recruiting costs. Understanding and quantifying the effect of its key factors could ease these problems and mitigate these costs. A survival analysis approach was used in this study to examine the relationship between voluntary attrition and the socio-economic characteristics of Canadian Non-Commissioned Members. The baseline hazard of attrition was also estimated as a function of the civilian unemployment rate. To the best of our knowledge, this study is the first to link the economic state to voluntary attrition through the baseline hazard. This analysis indicates that higher education, being male, and being single are associated with higher risk of attrition, whereas higher rank and older age at hire have consistent negative effect (i.e., lower risk) on attrition. The study also states that the lower the civilian unemployment in the Canadian economy, the higher the hazard of attrition. The proposed model would enable decision-makers to better understand attrition and achieve more targeted retention policy objectives.

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Attrition, Unemployment, Survival analysis, Cox model, Canadian Armed Forces

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