Office Decisions to Change Location: A Stress Triggered Approach

Ilan Elgar
University of California Transportation Center
University of California, Berkeley
2614 Dwight way, 2nd floor
Berkeley, California 94720-1782
Tel: 510 643 7378
Fax: 510 643 5456
ilan.elgar@gmail.com

Eric J. Miller
Department of Civil Engineering
University of Toronto
35 St George Street
Toronto, Ontario M4S 1A4, Canada
Tel: 416 978 4076
Fax: 416 978 5054
miller@ecf.utoronto.ca

Khandker M. Nurul Habib
Assistant Professor (Transportation Engineering and Planning)
Department of Civil & Environmental Engineering
School of Mining and Petroleum Engineering (SMPE)
3-004 Markin/CNRL Natural Resource Engineering Facility
University of Alberta
Edmonton, Alberta, Canada T6G 2W2
E-mail: khandker.nurulhabib@ualberta.ca
Phone: 1-780-492-9564
Fax: 1-780-492-0249

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Abstract

Firm mobility is one of the processes a firm can go through during its time of operation. When aggregated, the mobility decisions of numerous individual firms affect the spatial distribution of economic activity and employment as well as the outputs of the transportation system in urban areas. This paper presents a few models of mobility of office business establishments using hazard modelling and competing risk formulations. These formulations explicitly account for the effect of the duration of the firm in its current location as well as forecast what type of stress/push factor (for e.g. lack of space or excessive cost in its current location) will make the firm relocate. The results of the paper indicate that combining general hazard modelling with competing risk models could provide a foundation for modeling mobility decisions of firms as well as for estimating thresholds for the locations the firm may choose to move to.

Introduction

Firm mobility is one of the processes a firm can go through during its time of operation. When aggregated, the mobility decisions of numerous individual firms in an urban area affect the spatial distribution of economic activity and employment and through those the transportation system. In general, firm mobility is a decision by a firm to relocate from its current location to a different location.

Analysis of firm mobility aims at understanding the main factors that influence the decisions of firms to relocate. By modelling firm mobility researchers also try to develop credible tools that enable forecasting of these decisions.

A general premise in studying firm mobility is that firms try to avoid relocation as much as possible (1). In other words, there are inertial forces working together to ensure that the firm will try to alleviate the pressures in the current location as much as possible and will relocate only as a last resort (2).

Despite the preference for staying in the current location, there are other forces that work on the firm, making relocation a viable option. From the traditional economic perspective, the location of the firm is viewed as one of the factors that influence its profitability (3, 4). Once a firm faces losses or profits that are sub-optimal or low compared to other firms of the same industry, relocating is one of the strategies that it might consider (2, 5).

This paper focuses on studying the mobility decision of office firms based on information obtained through SOLD (Survey of Office Location Decisions). SOLD is an online
retrospective survey of office firms that was conducted in early 2006 in the Greater Toronto Area (GTA). The data accumulated through SOLD enables the researcher to measure the duration of firms in each location as well as track the reasons that led to relocation.

Based on the data acquired in SOLD the paper presents various hazard model formulations for firm mobility decisions, and highlights the strength and weaknesses of each method.

The paper begins with a short review of previous firm mobility modeling efforts. The second section of the paper describes variables that were found to be important to the mobility decision of firms. The third section describes the different hazard model formulations. The fourth section describes the data used for the modelling in the paper and its analysis. The fifth section presents the model results and their meaning. Finally the conclusion section of the paper highlights the main results and their implications.

**Modelling Business Establishment Mobility**

An overview of the firm mobility literature indicates that most mobility models are constructed using logit type models for the relocation decision. Kahn et al. (6) and Maoh and Kanaroglou (5) for example, studied mobility of firms using multinomial logit (MNL) formulations. In these models, the firm is faced with three options – to stay in its current location, to move within the modelled area or to move out of it. On the other hand, Van Wissen (7) and Bouwer et al. (8) used a binomial logit formulation to model mobility. In the binomial logit model the firm is faced with two options – to move or to stay; but other than the additional decision option (of moving out of the modelled area in the MNL models), the formulations of the four models are similar. A third modeling option in the literature was utilized by Van Dijk and Pellenbarg (2), who modeled firm mobility using an ordered logit specification, in which the dependent variable is the stated propensity to move in the next two years.

Regardless of the method used in each of the aforementioned studies, it seems as though all of them reached a similar conclusion, that the prevailing aspects that affect the mobility decision of firms are the firm specific factors, although the impact of some location aspects on the mobility decision was evident as well.
Contrary to most of the aforementioned firm mobility models (5, 6, 7, 8) which use a mostly cross-sectional approach to model firm mobility decisions in that they do not consider the effect the duration in the current location has on the decision to move; this study uses a longitudinal tool – hazard models, to the same end. Cross-sectional analysis does not allow exploring properly time dependent mobility decisions, which are long-term in nature (9, 10). Longitudinal models, on the other hand, refer to methods that track changes of the conditions leading to the particular decisions over time. Hazard modeling is an approach that can model inherent dynamic processes per se rather than modeling just the outcome, and is used in this study to track firm mobility decisions.

According to Bhat (11):

Hazard-based duration models represent a class of analytical methods which are appropriate for modeling data that have as their focus an end-of-duration occurrence [such as firm relocation], given that the duration has lasted to some specified time. This concept of conditional probability of termination of duration recognizes the dynamics of duration; i.e., it recognizes that the likelihood of ending the duration depends on the length of elapsed time since start of the duration.

Hazard models have been used for several decades in the medical sciences and industrial engineering to examine issues such as life-expectancy of patients with chronic diseases and the number of hours to failure of mechanical components, under various conditions.

The longitudinal approach, although not abundant in firm mobility modeling, is widely used for modelling residential mobility decisions (for example, 12, 13, 10, 14, 15, 16). The similarities between residential mobility and firm mobility decisions suggest that an attempt to model firm mobility using hazard models could be fruitful.

Utilizing a longitudinal model, such as hazard models, requires data that are collected in a supporting manner. SOLD is a retrospective survey that “follows” the firm over time, with respondents registering previous firm locations. Thereby, SOLD gathers longitudinal data from the participating firms, enabling longitudinal modeling.

**Variables Affecting Mobility**

Previous studies indicate that some firm-specific and location-specific aspects are likely to influence the decision of a firm to move from its current location. For instance, **firm age** is supposed to have impact on the willingness of a firm to move. The age of the firm might be more important to the propensity of young firms to relocate since the mortality
rates of young firms are especially high. According to Baldwin et al. (17) over half of the new Canadian firms that failed in their first decade of operation failed in the first two years. In other words, the first years of operation are the ones in which the firm is most vulnerable and therefore young firms will likely be more willing to move than others. Moreover, after the first few years firms accomplish some level of market penetration, in their current location, increasing relocation costs. Maoh and Kanaroglou (5), Van Wissen (7) and Bouwer et al. (8) all found that young firms are more willing to use the mobility strategy compared to older firms; therefore, it is anticipated that young firms would have a higher probability of relocating than older ones. In this study the variables operation and logoperation were used; operation indicates the age of the firm and logoperation is its natural log transformation.

**Firm size** is another variable with an important impact on the firm’s willingness to relocate, since small firms usually face lower relocation costs compared to larger firms. Van Dijk and Pellenbarg (2) also found small firms (of less than 10 employees) to be more likely to use the relocation strategy than larger firms. In this study, three different size related variables were tested; the first was size - indicating the actual size of the firm in terms of employees. The second size related variable was small - a dummy variable with value of 1 if the firm is smaller than 10 employees and 0 otherwise. The third size related variable was logsize – indicating a diminishing effect of firm size on the tendency to relocate.

**Location Ownership** – Van Dijk and Pellenbarg (2) mention that firms that own their location are less likely to move. In order to check the impact of owning the location on the decision of the firm to relocate a dummy variable of owning was tested (Own_dum).

**Firm Growth** – Van Dijk and Pellenbarg (2) theorize firm growth rates to be important to the firm willingness to move and Van Wissen (7) showed that growth increases the probability of a move. On the other hand, Maoh and Kanaroglou (5) found varying effects of growth among firms from different industries; but firm growth levels were insignificant for office firms in their study. Unfortunately, because of the method of collecting the data in SOLD, a growth variable could not be introduced to the model;
however, based on the findings cited this might not be a major limitation in a model focused on office firm relocations.

**Industry effects** – The industry the firm belongs to could be important to its inclination towards relocation. Creating prior expectations to which industry would view relocation as more beneficial is difficult; yet, Maoh and Kanaroglou (5) found that certain construction and retail industries are more likely to use this strategy than other firms. The firms participating in the study were divided into five “industry” categories introduced to the model as dummy variables. The five categories were Health, Business and Law, Engineering and Architecture, Communication and other firms.

**Area effects** – the inclination of firms to move could differ among firms that are located in different areas of the city. For instance, firms that are closer to the CBD could show higher or lower willingness to relocate. Maoh and Kanaroglou (5) found that firms that are located closer to the CBD are more likely to move than firms in the suburbs. Instead of using dummy variables for this effect, this study utilizes the distance between the centroid of the zone the firm is located in and chosen points in the urban space. The variables constructed are: distance to the Toronto CBD (*CBD_dist*), distance to the closest secondary employment centre in the GTA (*emp_dist*), distance to the closest highway ramp (*dist_HWY*) and distance to the closest transit station (*dist_trans*).

**Agglomeration and Competition effects** – agglomeration is supposed to be beneficial to firms, reducing the pressures that firms in high agglomeration areas are exposed to and decreasing their willingness to move. Competition, on the other hand, is regarded as having a negative effect on the firm by increasing the propensity of firms to move. Maoh and Kanaroglou (5) find that generally firms behave in the expected way with regard to agglomeration and competition. However, the difference between the two is often problematic and derived more from a subjective rather than an objective analysis, since locating in close proximity to similar firms could be viewed as either. In any event, previous stages of this research indicate that office firms do not view agglomeration as an important push factor (18). Nevertheless, two variables were constructed in order to check for possible agglomeration and competition effects – the number of jobs (in thousands) in the zone the firm is located in (*Jobs*) and the number of workers (in
thousands) that live in the zone the firm is located in (Workers). These variables are utilized as measures of accessibility to employees and firms.

Another firm-specific variable specified in this study is the number of previous relocations by the firm (no_prere). This variable would indicate whether some firms have a higher willingness to relocate than other firms, all other things equal. In other words, the number of previous relocations by a firm could indicate that some firms are intrinsically more prone to relocate than others.

One more type of variables that was not incorporated into the models in this paper despite its importance is price-related variables. Unfortunately, most of the firms in SOLD did not indicate lease costs in their previous location; therefore it was not possible to include this type of variables in the models.

A related issue is the treatment of time varying covariates in the models in this paper. Some variables (firm size for example) may fluctuate over time and thus could be estimated differently than variables that do not change or change along with the duration spell (such as firm age); this type of variables are termed time varying covariates (see 19 for in-depth explanation on the issue). Since the data used for estimating the models came from a retrospective survey, rather than a panel survey, it was not possible to incorporate time varying covariates as such in the models. Instead, the firm specific variables were modeled at their value at the time of relocation.

**Hazard Models for Firm Mobility**

**Hazard Models**

Hazard modelling has been applied to many fields, but it mostly draws upon statistical methods developed in industrial engineering and the medical sciences, where it is used to study the life span of machines and the effectiveness of different treatments (the basic theories of hazard models can be found at (19, 20, 21)).

The type of questions that hazard models are used to model are of the form - how long will it take (duration) until there will be a change of state (failure). Therefore, when specifying a hazard model for firm mobility the duration studied is the amount of time a firm will stay in its current location and the failure (termination) event is a move to a different location.
In hazard models, the duration of event $T$ is considered a positive, continuous and random variable. The probability distribution of duration can then be specified by the distribution function $F(t)$ with a corresponding density function $f(t)$:

\[
F(t) = \Pr(T < t) \quad (1)
\]
\[
f(t) = \frac{\partial F(t)}{\partial t} \quad (2)
\]

Another useful function is the survival function:

\[
S(t) = 1 - F(t) = \Pr(T \geq t) \quad (3)
\]

The probability that there is a failure within a time interval $dt$ conditional upon survival up to the time $t$ is $\Pr(t \leq T \leq t + dt \mid T \geq t)$. The average probability per unit of time for failure is then called the hazard rate. Considering the time interval $dt$ is very small, and $x$ is a vector of covariates, the hazard function of the duration, $\lambda(t)$ can be expressed as:

\[
\lambda(x,t) = \frac{f(t)}{S(t)} = \lim_{dt \to 0} \frac{\Pr(t \leq T \leq t + dt \mid T \geq t, X)}{dt} \quad (4)
\]

The application of hazard model function to firm mobility indicates a belief that, for instance, the hazard that a firm will decide to relocate from its current location at the eleventh year, conditional on it being located at that place at the tenth year is different from the hazard of moving in the third year.

Based on the functions above three general types of hazard models can be developed: Non-Parametric, Semi-Parametric and Parametric. In this study parametric models were used.

**Parametric Hazard Models**

Modelling termination events in a parametric hazard way involves two salient components; a vector of explanatory variables and their parameters and an assumed baseline distribution. The explanatory variables are estimated using the maximum likelihood function:
\[ L = \prod_{i=1}^{N} \lambda_i(t_i, X_i)^{\delta_i} S(t_i, X_i) \]  

(5)

Where \( N \) is the number of terminated observations, \( t_i \) is the observed failure time, \( X_i \) is a vector of parameters and \( \delta_i \) is a dummy variable taking the value 1 if the event \( i \) is uncensored (indicating that the firm actually moved) or 0 if the event is censored and a move was not observed for the firm.

Researchers usually utilize one of two widely used specifications for adjusting the survival functions for the effects of the covariates – the Proportional Hazard or the Accelerated Failure Time (19). The choice of which specification of hazard model to use, accelerated failure time or proportional hazard, does not affect the survival function and therefore is arbitrary. For this study the hazard models were estimated using the proportional hazard specification.

In the proportional hazard model the covariates have a multiplicative effect on the hazard function:

\[ \lambda(t_j) = \lambda_0(t) g(x_j) \]  

(6)

Usually \( g(x_j) = \exp(x_j \beta) \), while the function \( \lambda_0(t) \) could be an assumed distribution such as exponential or Weibull. Using the proportional hazard, the individual parameters could be interpreted as having an effect on the probability of termination (move). In other words, a parameter with a positive sign would have a positive impact on the probability of relocation.

The choice of the baseline distribution could sometimes be derived by theoretical considerations. However, in the case of the firm mobility study the Weibull distribution was found to be the most adequate distribution because it provided a better fit to the data. Other distributions that were examined (exponential, log-normal and log-logistic) provided lower log-likelihood values; however, the log-likelihood values of all the distributions were similar indicating that at the level of data SOLD provides, all the distributions give similar model fit. The stability across baseline distributions reduces the danger of misspecification of the distribution.
The estimated parameters are used to calculate the individual survival function for each firm. The equation for including parameters with Weibull baseline distribution into a proportional hazard survival function is:

\[ S_j = \exp(-\varphi_j t_i^p) \]  \hspace{1cm} (8)

where \( \varphi_j = \exp(x_j \beta) \), \( t_i \) is the duration in the current location and \( p \) is the ancillary parameter estimated in the estimation process.

The Concept of Stress and Competing Risk Hazard Model

The origin of the concept of stress is the seminal book of Rossi (22), where he argues that life cycle factors are a major trigger for household relocation decisions. Since then stress has been considered an influence on dwelling durations and residential mobility decisions (15). In general, stress is defined as the psychological pressure to adjust the current situation. Stress arises, therefore, when the current situation deviates from some alternative desired or optimal state (23, 24, 25). The psychological dimension of stress implies that stress is continuous in nature rather than discrete (26), despite the fact that some triggering factors like number of employees or owner relocation could occur at specific points of time, the stress corresponding to these factors is longitudinal (27). Overall, stress works as a continuous psychological factor that builds up gradually and leads to the termination of the present situation at some discrete point in time.

Based on the above definition of the concept of stress, it is quite obvious that the mobility decision of firms could be viewed as an outcome of stress; because of the importance of push factors in determining firm mobility. Moreover, Van Dijk and Pellenbarg (2) argue that the changing needs of a firm with regard to its location could be a result of its ‘life cycle’, which corresponds directly to Rossi’s work which originated the term stress. When considering stress, the previously discussed push factors are treated as continuous stressors - the specific causes of stress. The basic assumption is that mobility stressors affect the firm throughout its existence in a specific location; however, once a firm relocated, the different stressors start anew.
At any specific point in time the stressors could be looked upon as presenting a composite risk set with some probability of termination; i.e. some probability of a decision to move, which is a function of the cumulative impact of all stressors. On the other hand, the different stressors could be treated as having individual effect, in which case, they are competing with each other as to which stressor (risk) will be the dominant in bringing about the termination of the current state (make the firm relocate).

Each of the aforementioned treatments of stress implies a different specification to the firm mobility model as well as different strengths and weaknesses. Treating mobility stressors as a composite risk suggests modelling using a general parametric hazard model, the main strength of which is its ability to provide a time-dependent function for a decision to move. Conversely, looking at the specific risks individually requires a competing risk hazard model. Habib at el. (25) used competing risk hazard to model household mobility relocations, indicating that a competing risk approach is potentially helpful in providing information to the location decision models; for instance, if a firm decides to relocate based on lack of space, its current space could be treated as the minimal threshold for space in its location search. However, the competing risk hazard formulation (as depicted below) does not adequately address the possibility that a combination of stressors will bring upon the decision to move; in addition, the competing risk model, on its own, underestimates the probability that a firm will decide to relocate at any point in time.

According to the formulation of competing risk model, a termination of event (relocation) occurs due to only one cause, whichever cause happens first. Thus, if we consider \( r \) distinct types of stressors the likelihood function becomes:

\[
L = \prod_{i=1}^{N} \prod_{r=1}^{R} \lambda_{rr}(t_i, x_i) \delta_i S(t_i, x_i) \quad (9)
\]

The model implies that if an observation is terminated due to cause \( r \) it is right censored for all other \((R-r)\) causes. For any observation, the competing risk model defines a set of latent failure times \((T_1, T_2, T_3, \ldots, T_R)\). But what is observed is the realization of one \( T \) which is for the cause \( r \) for which \( T \) is minimum within the set. So, mathematically, we can define the hazard rate or survival rate of the risk which causes failure, but the rest are
not individually identifiable; hence, once a time for termination has been established for a firm in a location, the stressor that causes the termination is deterministic rather then stochastic.

**Mobility Data and Analysis**

The information about the relocation decisions of firms was gathered through SOLD (Survey of Office Location Decisions). SOLD is a retrospective web based survey designed at the University of Toronto in order to learn about location decisions of small and medium office firms (office firms of up to 100 employees). According to Canadian Business Patterns 2006, small to medium firms constitute about 96% of the firms in the relevant sectors in the Greater Toronto Area (GTA) (28).

Over two hundred firms participated in SOLD, out of a sample of 2300 firms that were randomly selected from the population of small to medium office firms in the GTA. In the process of completing the SOLD questionnaire managers and owners of office firms located in the GTA, were asked to provide information about their firm current as well as previous locations and its duration in each of them. Firms that relocated in the period of 1996-2006 were also asked to specify the reasons that led to their relocation decision. These firms were also asked to provide information about their general attributes (such as number of employees and the location tenure) both in their previous and current locations.

It was decided to model, in this study, only the last relocation of each firm, since SOLD provides size and *push factors* just for those relocations. Since the data gathered in SOLD provide duration in a location (in terms of months), as well as firm-specific information, it allows for a *general parametric* hazard model of duration; the availability of stated *push factors* provides the required information for estimating *competing risk* hazard models (for more information regarding SOLD see (18)).

This paper presents three alternative specifications for the mobility model. The first is a general hazard model, which determines the probability of moving without considering the reason for it. The second is a five stressor competing risk model and the third is a
three stressor competing risk model; the two competing risk models are specified in an attempt to determine what stressor representation is the most appropriate. Some aggregation of stressors was necessary because of the relatively small sample acquired through SOLD; a larger dataset would have enabled examining more push factors as independent stressors. The five specified stressors are:

1. **Space** considerations – this stressor entails moves aiming to increase space as well as to decrease it.
2. Desire to **own** the location – relocation in order to change tenure from lease to own.
3. **Owner move** – relocation of the firm as a result of relocation of the household of the owner
4. Costs and Termination (**C&T**) – relocation because of lease and tax costs as well as because of lease termination in the current location.
5. **Other** – all other reasons, including accessibility and agglomeration.

In the three stressor model, stressors 2 (desire to own) and 3 (owner move) were combined into stressor 5 (other).

After cleaning for missing and ambiguous information 151 relocations (out of the 222 firms participating in SOLD) where utilized for this paper; the minimum observed duration in a location of any of the firms is 1 month and the maximum is 599 months.

Prior to investigating the influence of different variables on the mobility decision, Figure 1 depicts the nonparametric estimation of the general hazard model - Censored (thick line) as well as the competing risk model for the 5 stressors considered. The nonparametric models enable the researcher to view the general relationships between the duration and probability of relocation for the general hazard model as well as the individual stressors. The nonparametric competing risk function is estimated using the modified Kaplan-Meier estimation method as specified in Gooley et al. (29). In that specification the observed cumulative probability function of mobility which estimates the probability of failure due to each stressor is plotted against the durations in specific locations.
The termination of the current duration may occur due to one of the 5 stressors or alternatively by the general hazard model. The figure reveals a number of interesting findings:

1. There is a considerable, almost linear, hazard of termination in the first 240-300 month (20-25 years) of locating in a site. However, firms that have not relocated in the first 25 years in a location will most probably stay in that location indefinitely (a similar finding is cited in 2). This is quite stable across stressors, except for the cost and termination of lease stressor (C&T) which becomes active again after about 36 years. This finding indicates that while the other stressors generally stop after 20-25 years, as firms become exceedingly stable, stresses that are generated from costs and lease termination keep having impact on firm mobility decisions.

2. The figure reveals that the cumulative termination function of the stressors Own and Owner move is significantly lower than those of the other stressors and peak at approximately 0.2, indicating that the probability that a firm will decide to relocate just because of them is relatively small. On the other hand the three remaining stressors are very close together indicating that they are indeed competing with each other.
Based on the finding above it was decided to add the stressors *Own* and *Owner move* into the stressor *other*. The three remaining stressors compete quite closely through the entire duration range, with costs and termination lease (*C&T*) playing a bit of a smaller part in relocation at first but a greater part, than the other stressors, after 30 years or more.

Another issue is that the general hazard model continuously predicts higher termination rates than the individual stressors. This is due to the fact that each individual stressor line includes only firms that relocated because of that specific stressor; while the general hazard model is influenced by terminations brought about by all the stressors. The reason that the individual stressor lines are quite close to the general hazard line, and the sum of their probabilities is well over 1 after some duration, is the large number of firms that indicated multiple stressors as important to their relocation decision.

The non-parametric models in Figure 1 provide information about the observed mobility behavior, but they do not provide the relationships between socio-economic and other policy variables and firm mobility decisions. The parametric models as described in the next section provide more insight into the firm mobility process as well as information needed to facilitate forecasting.

**Parametric Mobility Models**

The models described in this section were estimated using the cleaned sample of 151 office firms. The specific attributes and spatial variables of the location of the firm were considered in all modelling efforts; however, many variables (highway and transit accessibility, jobs in the zone, distance to the CBD and secondary employment centers etc.) were found to be statistically insignificant and therefore were omitted from the models. Some variables with lower *t-ratios* than the traditional 1.96 were retained in some cases because they were deemed to provide significant insight into the relocation process and because of the small sample size used in the estimation.

Table 1 presents the estimated mobility models. Some general notes regarding Table 1:
1. The ancillary parameters estimated in the table, are specific parameters of the distribution. In STATA the ancillary parameter for the Weibull distribution is defined as $\rho=1/\sigma$ so it is related to the dispersion parameter of the distribution.

2. The competing risk models contain arrays of stress-specific constants and ancillary parameters. The basic constant parameter (indicated as Constant in the upper part of Table 1) is the constant for the Space stressor. In order to calculate the constant for the other stressors, their constant values should be added to the general constant value. The same procedure should be applied for calculating the ancillary parameters, as well. For instance, in order to calculate the constant value for the other stress its stress specific constant (0.926 in the 3 stressor model) should be added to the basic constant (-7.459).

Comparing the three models, in Table 1, it seems as though there is relative stability in terms of coefficient magnitude and sign; yet, there are differences between the competing risk models in the value of the constant component of the other stressor and its t-stat. In the five stressor model the constant terms of the stressors own, owner move and other are extremely insignificant; once they are aggregated in the 3-stressor model the t-ratio of the constant of the other stressor increases to 1.16, indicating a better model structure. At the same time the t-stats of the ancillary parameters are more significant in the 3-stressor case than in that of the 5-stressor. Based on that analysis as well as the analysis of Figure 1, it was decided that the 3-stressor model provides a better structure than the 5-stressor model.

Choosing between the general hazard model and the competing risk model is less straightforward. The competing risk model provides insight into the reason of the move; that insight could be utilized, in other stages of the study, to provide thresholds for determining whether a specific location is adequate for the firm. For instance, if the terminating stressor is space related, it would make sense to assume that the space in the firm’s current location should be the minimum space requirement for an adequate future location. However, the general hazard model is free from difficulties of classifying stressor types and thus provides more stable parameter estimates, given the small sample
size we have. In addition as stated before, although the competing risk model accommodates competition among alternative risks, the formulation of the model does not allow the researcher to observe the probabilities corresponding to the set of risks that are competing at a given point in time. Rather we observe only the one stressor with the highest probability. Habib et al. (25) dealt with this shortcoming by using a hierarchical logit model to assign probabilities to the different stressors, but their method has its problems; such as non-standard estimation method and difficulty of determining model level of fit.

Table 1: Office Mobility Models

<table>
<thead>
<tr>
<th>Variables</th>
<th>General Hazard</th>
<th>3 Stressors</th>
<th>5 Stressors</th>
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<td>Coef. t-stat</td>
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<tr>
<td>Constant</td>
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<td>-9.47</td>
<td>0.00</td>
</tr>
</tbody>
</table>

| LN Ancillaire   |               |             |             |         |             |         |       |       |       |
| A_Own           | -0.02         | -0.16       | 0.87        |         |             |         |       |       |       |
| A_Owner Move    | -0.14         | -0.62       | 0.54        |         |             |         |       |       |       |
| A_C&T           | 0.11          | 0.86        | 0.39        | 0.11    | 0.86        | 0.39    |       |       |       |
| A_Other         | -0.08         | -0.94       | 0.35        | -0.06   | -0.61       | 0.54    |       |       |       |
| Constant        | 0.64          | 7.20        | 0.00        | 0.68    | 5.95        | 0.00    | 0.66  | 5.89  | 0.00 |

Because both the general hazard model and the competing risk hazard model have attractive attributes for the firm mobility decision it would be beneficial to use both of them when modelling this decision type. In order to do so, the models could be applied in sequence. In this framework the decision of whether the firm would relocate would be taken based on the survival function of the general hazard model; then, if the model indicates that the firm will relocate at that time, the attributes of the relocating firm will be used in the competing risk model to determine which stressor caused the move.
As aforementioned, the parameters affect the survival function in such a way that the sign and the magnitude of the coefficients affect the probability of moving. Therefore, a positive sign indicates an increased probability of mobility while a negative sign indicates the opposite impact.

The negative sign of the variable logsize indicates that smaller firms have a higher probability of relocation compared to larger firms. This effect of firm size is in keeping with the expectation that relocation is a strategy more frequently used by small firms, while larger firms turn to other strategies because of the higher relocation costs they face. The logarithmic form of logsize indicates a diminishing effect of firm size on the relocation probability.

The negative sign of the variable logoperation indicates that younger firms have a higher probability of relocation compared to older firms. The preference of older firms to choose strategies other than relocation was evident in previous studies; as mentioned Maoh and Kanaroglou (5) used a similar variable with similar results. The logarithm variable indicates that firm age has a diminishing effect on the probability of relocation.

The positive sign of the variable no_prere indicates that firms that underwent more relocations in the past are also more likely to choose relocation as a strategy again. This variable is particularly interesting because of the behavioral implications it suggests; different firms could have different attitudes toward using relocation as a strategy and those attitudes are not necessarily correlated with any measurable attribute of the firm.

The negative sign of the variable workers indicates that firms are less likely to relocate if they are already located in zones in which a lot of workers live. This variable could be regarded as an indicator of a desire of firms to be located close to employees. On the other hand, the variable jobs which indicates the number of jobs in the zone was not found to be significant.

The negative sign of the dummy variable health_dum indicates that health related firms are less likely to decide to relocate compared to other types of firms. One explanation of this finding could be the nature of relationships between this kind of firms and their clients. For instance, the clientele of a dentist office need face-to-face meeting with their service provider while the clientele of an insurance firm could probably do without any face-to-face meetings. This suggests that the dentist office will rely more
heavily on clientele in the vicinity of the firm; hence relocation would entail higher risk of loosing business for such a firm.

**Conclusions**

This paper explored office mobility and the factors and stressors that influence firm decisions to relocate. The paper presents both a general parametric hazard model and a competing risk hazard model as adequate formulations to model firm mobility decisions and highlights the pros and cons of using each method. The models in this paper are estimated based on SOLD data, utilizing the commercial software package STATA.

The analysis in the paper indicates that firm internal factors which relate to the firm life cycle are important to decisions of office firms to relocate. At the same time, the inclusion of the number of workers living around the firm location as a parameter in the mobility models could be regarded as an indication that external factors could also be important to this decision. Yet, other external factors that were examined, such as accessibility and agglomeration/competition related variables, were found to be insignificant and therefore were excluded from the model.

The firm internal factors that influence the decision to relocate are: the size and age of the firm, the type of firm and the number of previous relocations of the firm as well as the duration in the current location. The model indicates that larger and older firms tend to utilize relocation strategy less than other firms. Size and age of the firm have marginally decreasing effect over its decision to relocate. With regard to type of firms, firms that provide health related services tend to utilize relocation strategies less than other types of office firms. The model also indicates that all things equal, some firms inherently view relocation as a more acceptable strategy than others.

Choosing between general hazard and competing risk model is difficult and does not rely on statistical comparison. Rather, the choice of which model should be utilized depends of the application needs of the modeler. A need for a more accurate forecasting of the probability of termination would entail utilizing of general hazard models, while a desire to forecast the reason for relocation would involve utilizing competing risk models. One could also think about an option of combining those models for application needs, so that in the first stage the general hazard model would determine termination
timing; followed by the competing risk model which would determine the push factors leading to the relocation decision, based on the termination timing provided by the general model.

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References


(28) *Canadian Business Patterns* (2006), Statistics Canada