Modelling Start-up Size of Canadian Firms

Toka S. Mostafa, and Matthew J. Roorda
University of Toronto

Introduction

Researchers from regional and transportation planning have focused a large body of research towards Integrated Urban Models (IUMs) and agent-based microsimulation of urban systems (Miller et al., 2004; Waddell, 2002; Hunt et al., 2005; Wegener, 1995). IUMs provide a simulation environment that can be used to support strategic planning by forecasting the effects of policies on demographics, land use changes, and transportation patterns within regions. Within urban systems, firms are recognized as one of the interacting agents whose behaviour influence transportation systems. Firm events of entry, exit, and growth affect economic growth, labour dynamics, and transportation demands. New firms are sources of new jobs that induce urban changes by attracting skilled workers to the location of new jobs. This causes changes to transportation demand and ultimately affects commuter time.

Firm start-up size is an important determinant of new firms. Modelling firm start-up size at the micro level is essential to understand job creation dynamics and potentially measure the impact on transportation demand. Also, some studies suggest that firm start-up size influences the firm's subsequent performance and survival (Dunne et al., 1989; Audretsch and Mahmood, 1994; Mata and Portugal, 1994). Determinants of firm start-up size have been addressed largely for European countries (Arauzo-Carod and Segarra-Blasco, 2005; Audretsch et al., 1999; Barkham, 1994; Görg et al., 2000; Mata and Machado, 1996). To the best of the author's knowledge, research studies in a Canadian context that address determinants of firm start-up size are absent, both in terms of employment size or tangible assets. In this paper, ordered logit models of start-up size of Canadian firms are presented. Two aspects of size are considered: the number of employees and the firm's physical form represented as the tangible asset dollar values. The presented models are the components of a larger firm microsimulation platform introduced earlier by Mostafa and Roorda, (2015).

This paper starts by exploring determinants of firm start-up size surveyed from the literature. The data and modelling approach are then explained. Model results and interpretation followed by model goodness-of-fit and model validation are presented next. Concluding remarks and future directions are then discussed.

Determinants of Firm Start-up Size

The decision of firm start-up size is mainly governed by industry characteristics, firm characteristics, economic conditions, and founder characteristics (Barkham, 1994; Mata, 1996; Mata and Machado, 1996; Görg et al., 2000; Colombo et al., 2004; Colombo and Grilli, 2005). Industry characteristics include economies of scale, industry size and growth, and industry turbulence (e.g. entry and exit rates) (Mata, 1996; Görg at al., 2000; Arauzo-Carod and Segarra-Blasco, 2005). Economic conditions are reflected in GDP growth by (Reynolds and White, 1997). Finally, founder characteristics (age, gender, education, human capital, and work skills) are found in several studies to be the major driving factors to firm start-up size (Colombo et al., 2004; Mata, 1996; Barkham, 1994).

In this research, determinants of firm start-up size, including firm characteristics, economic conditions, competition, and industry characteristics, are investigated. Founder characteristics are not included in this research due to suitable data unavailability. The studied determinants are summarized in Table 1 along with their expected effect on firm start-up size.

Table 1. Investigated Determinants of Firm Start-up Size

Variable	Description	Expected effect
Industry class	A series of dummy variables to represent the 17 classes of the for-profit industries on the 2-digit NAICS code.	--
Province	A series of dummy variables representing the province where the firm is located. The investigated provinces are Ontario, Quebec, Alberta, British Columbia, Manitoba, Saskatchewan, Atlantic Canada (including Nova scotia, New Brunswick, Newfoundland and Labrador, and Prince Edward Island), and rest of Canadian provinces and territories (Nunavut, Yukon, and Northwest Territories)	--
Economic Indicators		
Yearly GDP growth rates (%)	The percent change in the GDP between year (t) and year (t-1).	Positive
(Log) GDP by industry (2-digit NAICS code)	The natural logarithmic value of the GDP classified by the industry for year (t)	Positive
Yearly provincial unemployment rate (%)	The unemployment rate of year (t) on the province level of where each firm is located	Negative
Industry characteristics and competition		
Entry rate by industry	Yearly firm entry rate on the 2-digit NAICS code	Negative
Exit rate by industry	Yearly firm exit rate on the 2-digit NAICS code	Negative
Average firm size (log)	The natural logarithmic value of the average firm size of each 2-digit NAICS code industry	Positive
Number of competitors in the same CMA/CA of the same NAICS-3 (log)	The natural logarithmic value of the number of competitors located in the same CMA/CA of where a firm is located, on the 3-digit NAICS code.	Negative

We expect that firm start-up size varies across industries in different provinces as highlighted in similar studies (e.g. Audretsch et al., 1999). Therefore, dummy variables of a firm's industry and province are considered. The literature indicates that economic growth has an impact on firm start-up size. A growing economy encourages firms to start large in size, while firms may choose to start small in size if the economy is declining. Three economic indicators are included in our models to reflect economic growth: 1) % growth in the GDP, 2) the dollar value of the GDP by industry (to represent the economic size of the industry), and 3) provincial unemployment rates.

Mata and Machado (1996) suggest that firm start-up size increases with economies of scale and the rate of firm entry and exit per industry. Also, the amount of capital required to operate a minimum efficiently scaled (MES) firm has a negative relationship with the new firm size, because of the higher start-up costs (Fonseca et al., 2001; Geroski, 1991; Mata et al., 1995). Entry and exit rates by industry, using the 2-digit NAICS code, are included in firm start-up size models. Firm start-up size and average firm size across industries vary according to the technology and innovation usage, and economies of scale in each industry (Mata and Machado, 1996). Since it is hard to quantify the MES by industry, average firm size of each industry is included as an indicator of the MES in the employment dimension. We hypothesize that the larger the average size of firm within industries, the larger the start-up size of new firms is.

Most of the studies in the literature used regression approaches to investigate determents of firm start-up size (Mata and Machado, 1996; Görg et al., 2000; Audretsch et al., 1999; Barkham, 1994). In our study, start-up size is considered to be a decision, and discrete choice model approaches are used to quantify the effect of each of the investigated determinants on the start-up size choice.

Data

The T2-Longitudinal Employment Analysis Program (T2-LEAP) database provided by Statistics Canada is used for model estimation (Statistics Canada, 2012). The data provide longitudinal information of Canadian firms between the years of 2001 and 2012. The study focuses on for-profit industries and excludes not-for-profit industries (i.e. Educational service, Health care and social assistance, and Public administration) because for-profit industries are mostly privately owned, and are more susceptible to economic growth. Not-for-profit entities mostly offer public services that are indispensable (e.g. education and health services) which are typically governmental, and their growth/shrinkage are affected mainly by public policies, and demand and supply. The T2-LEAP includes yearly information of firm employment size, province, industry class, sales value, and tangible assets. The data set is linked to CANSIM data to obtain the Canadian GDP (National GDP, GDP by industry, GDP by province, and GDP growth rates) (Statistics Canada, 2015a) and yearly unemployment rates (Statistics Canada, 2015b). Data are filtered to only include new firms that entered the market between 2001 and 2012. A new firm is marked when the first firm record is observed in year (*t*) and is not observed in previous years (t-*1*, t-*2*…etc.). The 2001 new firm population is excluded from the analysis as the data is left censored, and it is not evident whether firms that appear in the year 2001 have been present in previous years or not.

Method

Ordered logit model structure provides a better representation when the response variable (y) is ordinal (i.e. has more than two *ordered* responses). In ordered logit models, the response variable (y) takes values $i=1$ to N that are ordered, and the probability of $y_i = i$ is calculated as in Equation (1):

$$p_{ij} = \Pr(y_i = i) = \Pr\left(k_{i-1} < x_j\beta + u \le k_i\right) \quad (1)$$
$$= \frac{1}{1+\exp(x_j\beta - k_i)} - \frac{1}{1+\exp(x_j\beta - k_{i-1})}$$

where x_j is a vector of independent variables (covariates), and β is a vector of estimated coefficients of the covariates. The formula indicates that the probability that a specific outcome i is selected equals to the probability that the utility function ($x_j\beta + u$) is between two thresholds/cut-points k_i and k_{i-1}, given that k_{i-1} is always less than k_i. The vector β and the thresholds (k_i; i=1 to N-1) are estimated using maximum likelihood estimation. A positive sign of a coefficient indicates that an increase of one unit in the value of the associated covariate increases the ordered log-odds of being in the higher range for employment size by the coefficient value, while all other variables are held constant. A negative sign indicates the opposite.

The ordered logit model structure is selected for modelling the firm start-up employment size and tangible assets because they can be classified in ranges that are ordinal (as explained in Table 2).

Table 2. Firm start-up size ranges

Class	Number of Employees	Tangible Assets ($)
1	1 employee	0
2	2 employees	0.01 - 4,999.99
3	3-5 employees	5,000 - 19,999.99
4	Greater than 5 employees	20,000 - 49,999.99
5	---	50,000 - 99,999.99
6	---	> 99,999.99

Data show that 50% of the firms start with one employee, while 75% of the new firms have two employees or less. The average start-up size is 2.5 employees with a standard deviation of 4.3. The total number of firms under investigation is 275,517 for-profit industries. A hold-out sample of 20% of the records is kept for validation.

Results

Ordered logit models for firm start-up employment size and tangible assets are estimated using STATA statistical software package. Estimation results are summarized in Table 3 and Table 4. Only variables that are significant at a 95% level and higher are included. Estimation results include: estimated covariate coefficients, odds ratio, P-values, and the cut-points (thresholds) that are used to differentiate the adjacent levels of the response variables (k_i). Each cut-point separates response variable categories when all values of the covariates are evaluated at zero. For instance, k_1 value (1.164) in Table 3 is used to differentiate the response variable's first class from the rest of the classes. Firms that have a latent variable value less than 1.164 (when all model variables are evaluated at zero), are classified with a start-up employment size of one employee (the first class). Similarly, firms that have a value between k_1 and k_2 of the latent variable are classified in the second employment class (two employees), and so on. The model of firm start-up tangible assets uses the estimated number of start-up employees as one of the explanatory variables. In the tangible assets model, for confidentiality reasons, the estimation results for the 'Utilities' industry class are suppressed and only the sign of the coefficient can be included.

Table 3. Ordered logit model of firm start-up employment size

Covariates	Coef.	Odds Ratio	P>|z|
Province			
Ontario	-0.283	0.753	0.000
Quebec	-0.231	0.794	0.000
Alberta	-0.535	0.586	0.000
British Columbia	-0.264	0.768	0.000
Industry class			
Mining, Quarrying, and Oil and Gas Extraction	-1.279	0.278	0.000
Construction	-0.277	0.758	0.000
Manufacturing	-0.537	0.585	0.000
Wholesale trade	-0.524	0.592	0.000
Retail trade	-0.538	0.584	0.000
Transportation and warehousing	-1.171	0.310	0.000
Information and cultural industries	-0.792	0.453	0.000
Finance and insurance	-0.750	0.472	0.000
Real estate and rental and leasing	-0.509	0.601	0.000
Professional, scientific and technical services	-0.726	0.484	0.000
Accommodation and food services	0.807	2.241	0.000
Economic indicators of previous year's (*t-1*)			
(log) GDP by industry (dollars x 10^{-10})	0.097	1.102	0.001
Industry characteristics and competition of previous year's (*t*-1)			
Firm exit rate by industry (%)	-0.005	0.995	0.060
(log) No. of competitors (CMA/CA and NAICS 3-Digit code)	-0.056	0.946	0.000
(log) Average firm size by industry (2-digit NAICS)	0.254	1.289	0.000
$/k_1$	1.164		
$/k_2$	2.113		
$/k_3$	3.431		

Table 4. Ordered Logit Model of Firm Start-up Tangible Assets

Covariates	Coef.	Odds Ratio	P>|z|
Number of Employees (log)	0.601	1.825	0.000
Province			
Ontario	-0.022	0.979	0.038
Quebec	0.186	1.204	0.000
Alberta	0.067	1.070	0.000
Saskatchewan	0.279	1.322	0.000
Industry class			
Agriculture, Forestry, Fishing and Hunting	0.984	2.675	0.000
Mining, Quarrying, and Oil and Gas Extraction	0.117	1.124	0.003
Utilities	Negative		
Construction	-0.447	0.640	0.000
Wholesale trade	-0.761	0.467	0.000
Retail trade	-0.369	0.691	0.000
Transportation and warehousing	-0.173	0.841	0.000
Information and cultural industries	-1.427	0.240	0.000
Finance and insurance	-1.220	0.295	0.000
Real estate and rental and leasing	-0.077	0.926	0.023
Professional, scientific and technical services	-1.174	0.309	0.000
Management of companies and enterprises	-1.203	0.300	0.000
Administrative and support, waste management and remediation services	-0.772	0.462	0.000
Arts, entertainment and recreation	-0.196	0.822	0.000
Accommodation and food services	0.561	1.753	0.000
Other services (except public administration)	-0.179	0.836	0.000
Economic indicators of year (t)			
Yearly provincial unemployment rate (%)	-0.047	0.954	0.000
GDP growth (%)	0.007	1.007	0.007
Industry characteristics and competition of year (t)			
Yearly firm entry rate by industry class (NAICS2) (%)	-0.062	0.940	0.000
(log) No. of competitors in the same CMA/CA of the same NAICS-3	-0.056	0.946	0.000
$/k_1$	-2.704		
$/k_2$	-1.651		
$/k_3$	-0.735		
$/k_4$	0.087		
$/k_5$	0.800		

The results indicate that firm start-up size of employment and tangible assets vary across industries and provinces. For instance, the employment start-up size model (Table 3) indicates that firms located in Ontario, Quebec, Alberta, and British Columbia, when all other variables are held constant, are less likely to have their start-up employment size in higher classes compared to firms located in the rest of Canada. Ordered logit model probabilities are calculated using Equation (1) and it can be concluded that firms located in Alberta have the highest probability (85%) of starting with one employee, whereas firms in Quebec have a probability of 80% of starting with one employee. Furthermore, firms located in Quebec have a 2.5% chance of starting with five or more employees while firms located in Alberta have a probability of 1.8% of starting five or more employees (Figure 1). On the other hand, the tangible assets start-up size model (Table 4) indicates that firms located in Saskatchewan have higher odds of starting at higher ranges of tangible assets compared to rest of Canada, while firms in Ontario have the lowest odds of starting at higher tangible asset ranges as also explained by the calculated ordered logit probabilities in Figure 2.

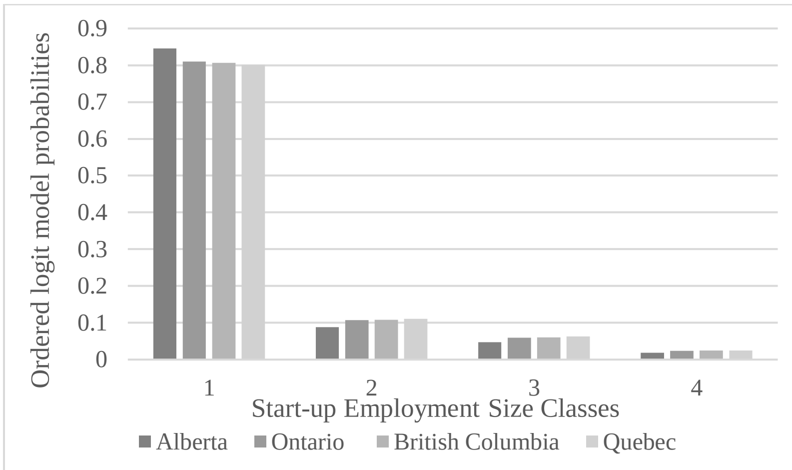

Figure 1. Probabilities of Firm Start-up Employment Size for Selected Provinces (when other variables are held constant)

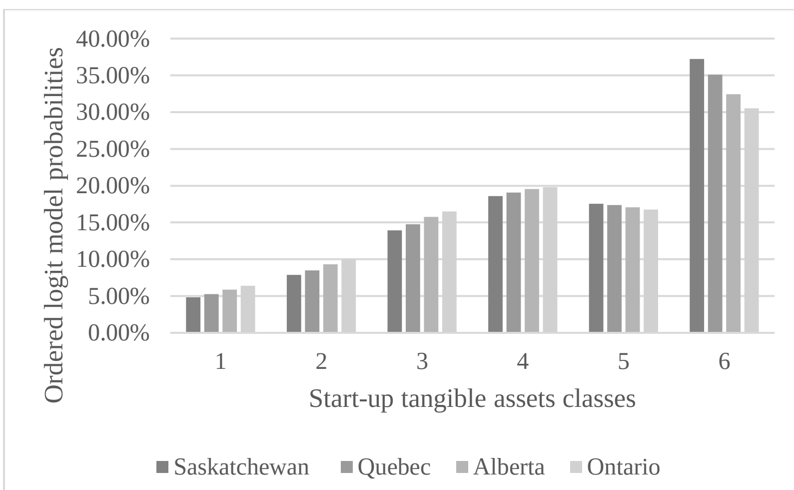

Figure 2. Probabilities of Firm Start-up Tangible Assets for Selected Provinces (when other variables are held constant)

Industry class influences the start-up size decisions. Some industries require larger start-up sizes compared to other industries. For example, the employment start-up size model (Table 3) indicates that firms belonging to 'Accommodation and food services' industry have higher odds of starting with more than five employees compared to other firms in other industries. The calculated ordered logit model probabilities (Figure 3) show that firms in this industry have a 6.8% chance of starting with more than five employees. On the other hand, Table 4 shows that firms that belong to ‘Agriculture, Forestry, Fishing and Hunting’ industry class have higher odds of higher start-up tangible asset values compared to other industries. This is due to the nature of this industry which requires land, machinery and equipment as fundamental assets. Other industries are less dependent on machinery and equipment as core assets (e.g. Information and cultural industries) and therefore have lower start-up asset values (Figure 4).

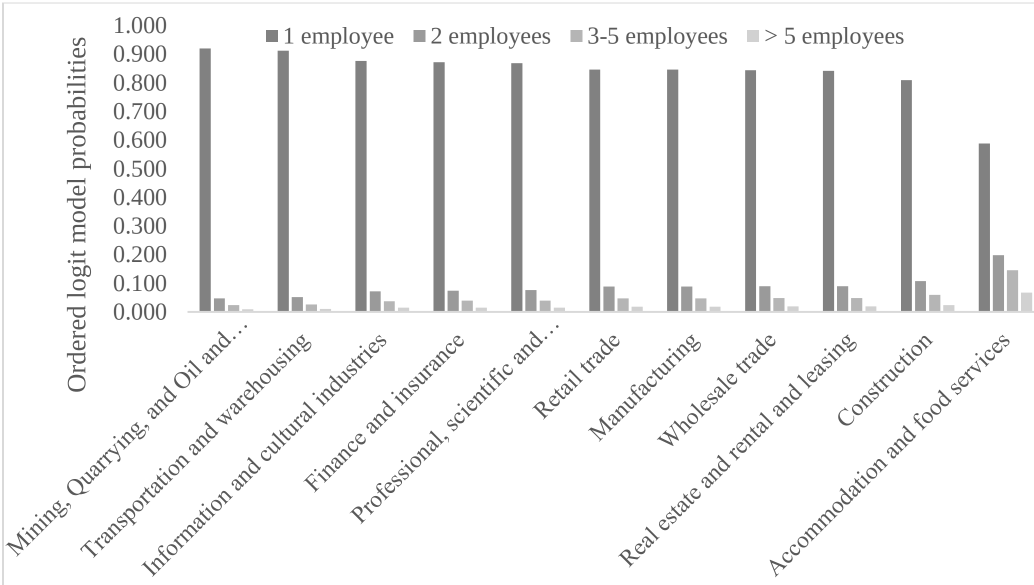

Figure 3. Probabilities of Firm Start-up Employment Size by Industry

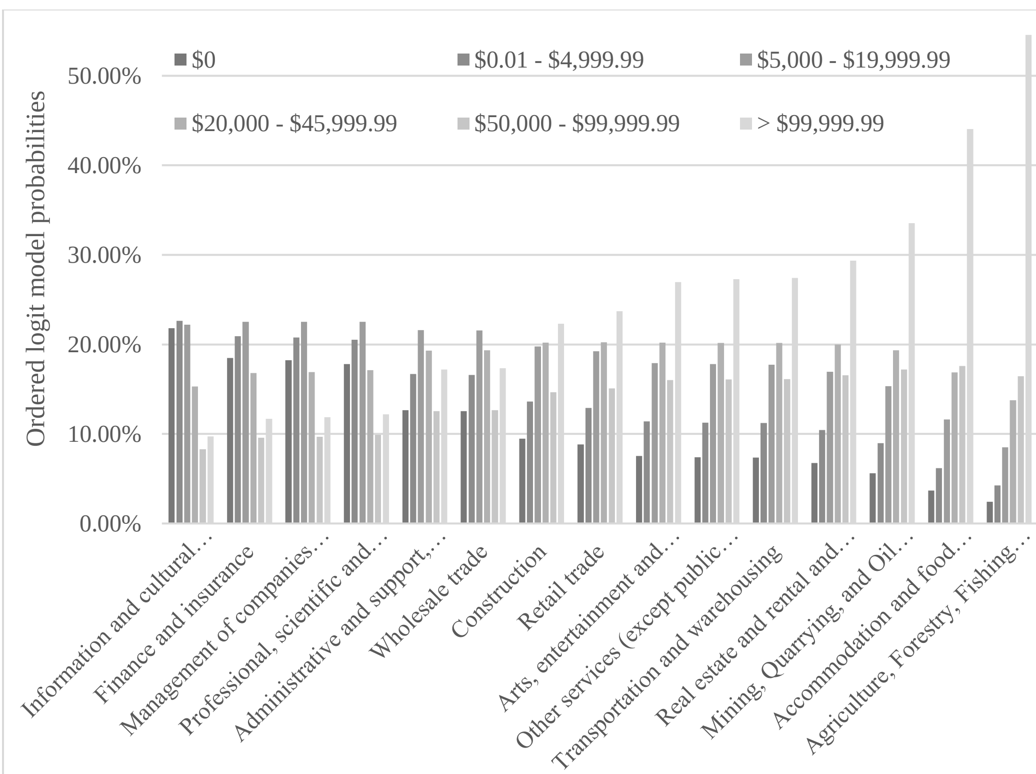

Figure 4. Probabilities of Firm Start-up Tangible Assets by Industry

The firm start-up employment size model (Table 3) also shows that GDP growth by industry increases the likelihoods of firms to start with larger employment size classes. Furthermore, higher firm exit rate reduces the likelihoods of firms to start large in size, which is intuitive as higher exit rates may indicate an economic decline in the industry growth. Also, competition is found to negatively influence the decision of firms to start with large number of employees. Average firm size is found to have a positive effect on firm employment start-up size. Firms that belong to industries with higher average firm size are more likely to start relatively lager in size to reach the average size quickly, as also explained in (Baldwin et al., 2000; Pagano and Schivardi, 2003).

The model estimation results in Table 4 indicate that employment size has a positive effect on the start-up tangible assets. An increase of one-unit in the log value in the number of employees increases the log of the odds for firms to start with larger tangible assets by 0.601. The calculated ordered logit probabilities using Equation (1), show that a unit increase in the log number of employees results in a 3.5% chance of starting the tangible assets in class #1, a 6% chance to be in the second class, a probability of 11.3% to start in the third class, and a 45% chance of starting at value greater than $99,999.99. Furthermore, Canadian GDP growth has a positive effect on firm start-up size. A growth of 1% in the GDP increases the log of the odds of firms to have higher values of start-up size with a magnitude of 0.007. Provincial unemployment rates have a negative impact on firm start-up tangible assets indicated by the negative sign of the coefficient. The calculated ordered logit probabilities indicate that an increase of 1% in the unemployment rate results in a 6.6% probability of firms to start with no tangible assets (range #1), and a 30% chance of starting with values greater than $99,999.99. The effect of Canadian GDP growth and provincial unemployment rates in the employment and tangible assets start-up size models confirm similar findings in other studies that a thriving economy encourages businesses to grow in size and decreases the likelihood of failure agreeing to van Wissen (2000). Firm entry rates by industry have a negative effect on start-up tangible asset values. Higher entry rates indicate higher competition of new firms in the market, which may increase the likelihood of failure. Moreover, the number of competitors aggregated to the CMA/CA and the sub-industry class (NAICS 3-digit code levels) has a negative similar effect on start-up tangible assets. Given these two findings, it can be concluded that firms are inclined to start smaller to minimize potential sunk costs as a result of higher competition of similar firms (Cabral, 1995).

Model goodness-of-fit and validation

The reported pseudo and adjusted R^2 statistics (Table 5) indicate a poor fit of the model (McFadden, 1978). However, pseudo and adjusted R^2 should not be the only measures to assess the model goodness-of-fit. Another measure of assessing the overall model significance is a chi-squared test for testing the null hypothesis that the model coefficients are not statistically different from zero. The chi-squared test performed for both model indicate that the null hypothesis cannot be true and the model coefficients are statically different from zero at a 99% and higher confidence (Greene, 2012).

Table 5. Model Estimation Summary and Model Goodness-of-fit

	Employment size model	**Tangible assets model**
Log likelihood (Null)	-191880	-400079.06
Log likelihood (Full)	-183794	-378437.96
Number of observations	167,972	226040
LR chi2(16)/(25)	16172.25	43282.21
Prob > chi2	0.000	0.000
Pseudo R^2	0.0421	0.0541
Adjusted- R^2	0.0420	0.0540

Although the pseudo R^2 and adjusted-R^2 statistics are considered measures of goodness-of-fit of model estimates, they are not enough to assess the predictive capabilities of the model. Cross-validation is a common technique that is widely used in discrete choice model validation (Roorda et al., 2008; Robin et al., 2009; Habib, 2013). The purpose of cross-validation is to compare the estimated model outcomes (the dependent variable) for a subset of the data set (a validation dataset; data that are not used in the model estimation), to the actual observed values of the outcomes in the data. Cross-validation is used to validate the predictive performance of firm start-up size models on the aggregate level. For this purpose, a hold-out sample (a validation set) of 20% of the firm population of investigation (43,281 records) is extracted, and not used in the estimation process. According to McFadden (1978), the predicted total probabilities (for each observation in the validation dataset) are calculated first and then divided by the validation sample size to calculate the predicted shares of the classes of the ordinal outcomes of the start-up employment and tangible asset sizes (Table 6). This number is compared to the observed shares of the start-up classes in the sample. Cross-validation results show that both models are with very good predictive performance on the aggregate level. The employment start-up size model is perfectly predicting the aggregate behaviour for the second and fourth employment class (zero difference in the observed and predicted total probabilities), while it under predicts the probabilities of the first class with 1.9%, and slightly under predicts with a 0.1% for the third class.

Table 6. Cross-Validation Results of Ordered Logit Models

	Employment size model			Tangible assets model		
Class	**Observed**	**Predicted**	**Difference (%)**	**Observed**	**Predicted**	**Difference (%)**
1	56.9%	55.0%	-1.9%	18.7%	17.5%	-1.2%
2	18.9%	18.9%	0.0%	19.0%	17.7%	-1.3%
3	15.8%	15.7%	-0.1%	18.7%	19.1%	0.4%
4	8.4%	8.4%	0.0%	16.2%	15.9%	-0.3%
5	---	---	---	10.4%	10.6%	0.2%
6	---	---	---	16.9%	16.9%	-0.1%

Conclusions

Firms are key agents in IUMs whose events of entry, growth, and exit influence land use, change urban forms, and affect transportation demand. In this paper, models of firm start-up size are explored. Start-up size is addressed in two dimensions: the number of employees and the dollar value of tangible assets. Models of firm start-up size are not found in the Canadian literature. The presented models fill this gap and enrich the literature. The models are the components of a larger firm microsimulation platform introduced by Mostafa and Roorda, (2015). Determinants of firm start-up size are explored and quantified. The models suggest that the decision of start-up size varies across industries and provinces. They also indicate that a growing economy encourages new firms to start large in size, increased competition has a negative effect on firm start-up size, and industry dynamics of entry and exit affect start-up size as it changes the demand within industries. Determinants related to firm characteristics, economic conditions, and industry characteristics are investigated in this research. However, determinants related to the founder characteristics are not covered. As a future research step, models that simulate the entrepreneurial decision of the firm start-up could be estimated using the publicly available data source of the Global Entrepreneurship Monitor database (Global Entrepreneurship Monitor, 2015). This database includes demographic information of firm founders such as age, education, gender, and work experience in different countries, including Canada.

The reported model goodness-of-fit of the presented models indicate a poor fit. Other model structures that consider firm start-up size in a continuous fashion is a potential future step. Examples of such models are Poisson regression that assume that all firms choose their start-up size independently (Kumar and Kockelman, 2008). Furthermore, endogeneity between employment and tangible assets is not considered in this research. Other model structures that consider the simultaneous decision of firm start-up size of employment and tangible assets, such as SURE and simultaneous equation models are potential future directions.

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