
Original Article

Using Cox regression to model customer time to churn in the wireless telecommunications industry

Received (in revised form): 8th February 2011

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ABSTRACT This article studies customer retention in the context of a Canadian wireless telecommunications company and explores the predictors of churn incidence as part of customer relationship management. This research contributes to the existing literature by building a comprehensive retention module that includes several kinds of time-varying covariates related to the customer behavioral and demographic characteristics of customers. Cox regression is used for longitudinal data analysis on 4896 customer records extracted from the wireless carrier's data warehouse. This article reveals that among all factors examined, rate plan suitability plays a key role in influencing customer churn in the wireless telecommunications industry.

Journal of Targeting, Measurement and Analysis for Marketing (2011) 19, 37–43. doi:10.1057/jt.2011.1;
published online 21 March 2011

Keywords: wireless; mobile; customer churn; Cox regression; marketing; Canada

INTRODUCTION

As markets mature and competitive pressure intensifies, companies can no longer ignore the importance of customer retention as their existing customer bases have become their precious assets.^{1–3} This is particularly true in the Canadian wireless telecommunications industry because the dominant barrier to switching, namely, the lack of wireless number portability,^{4,5} was eliminated in 2007 and the government has started to bring competition to the wireless sector by allowing new entrants to bid and operate on the Advanced Wireless Services spectrum.⁶ Furthermore,

consumers in most metropolitan areas can choose wireless services from over 10 different brands.⁷ With handset subsidy reaching over CDN\$350 on average, customer acquisition has become an expensive yet challenging task for marketers in the wireless telecommunications industry.⁸ This article aims to help wireless carriers address the churn issue by providing them with insights into the effects of customer demographic and behavior characteristics on churn rate through the use of a well-known statistical procedure called Cox regression.

LITERATURE REVIEW

Prior literature has shed some lights on the economic value of customer retention. Engel, Blackwell and Miniard⁹ argue that having a low

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churn rate allows organizations to focus on their customers' needs and hence reduces the need to approach new customers who may be risky from a financial perspective. Ganesh, Arnold and Reynolds¹⁰ point out that loyal customers buy more in the long run and further contribute to the organization's profitability. These long-term customers are expected to give positive word-of-mouth referrals if they are satisfied with the organization. It has also been suggested that organizations can serve existing customers in a less costly manner because of greater knowledge of their needs and consumption pattern. Athanassopoulos¹ suggests that organizations would incur opportunity costs when customers churn away due to loss of sales. In addition, it has been widely argued that acquiring a new customer is several times more expensive than retaining one.¹¹⁻¹³ Other benefits of having loyal customers include reduction of pricing and marketing sensitivity from competitive offerings.^{12,14}

Extensive studies have been undertaken on customer retention strategies in the wireless telecommunications industry since the late 1990s, underlining the relevance of this topic in the industry.¹⁵⁻²⁰ Many of them, however, focus on specific European and Asian markets in which market conditions are not the same as they are in Canada. Thus, this research aims to contribute to the existing body of knowledge by exploring the issue of wireless customer churn from a Canadian perspective. Furthermore, this research takes into consideration an emerging database marketing strategy known as rate plan optimization in the analysis.^{21,22}

RESEARCH METHODOLOGY AND DATA SELECTION

Unlike previous customer retention studies that used surveys as the data collection method, this study tries to avoid sample selection bias by utilizing customer records extracted directly from the data warehouse of a Canadian wireless carrier. A total population of 4896 postpaid residential customers from a particular rate plan segment were selected for observation over a study period of 44 months, starting from their

service activation month of May 2002 till the end of the observation period in December 2005.

Two major groups of independent variables were collected so that their impacts on the wireless churn rate could be analyzed. The first group considers demographic characteristics such as the customers' age, residing location and the primary language that they use for communication. This research did not include some commonly used demographic variables such as income, gender and education level because such information is not available from the wireless carrier. The second group of variables explores the customers' behavioral characteristics, including rate plan changing frequency, handset changing frequency, contract status and the suitability of wireless rate plan. Joo *et al*²¹ and Wong²² have argued that rate plan suitability can play an important role in influencing a customer's intention to stay with the wireless carrier, and hence the modeling analysis also includes this factor. Figure 1 presents the conceptual framework of this research study.

To gain a holistic view of the relationship between these independent variables and customer churn rate, the Cox regression model is adopted. Also known as proportional hazards regression analysis, it is a well-recognized statistical technique used to simultaneously investigate the effects of several explanatory variables on the survival of customers.^{23,24} Cox regression is based on a modeling approach to the analysis of survival data, making it suitable for use in this type of research, which considers right-censored observations and time-varying covariates.²¹

The hazard function measures the potential for the 'event' to happen at a particular time t , given that the event has not yet happened. A high hazard function value suggests that the event will likely happen. It is denoted by $h(t)$ which can be estimated using the following Equation (1):

$$h(t) = \frac{\text{Number of individuals experiencing an event in interval beginning at } t}{(\text{Number of individuals surviving at time } t) \times (\text{Interval width})} \quad (1)$$

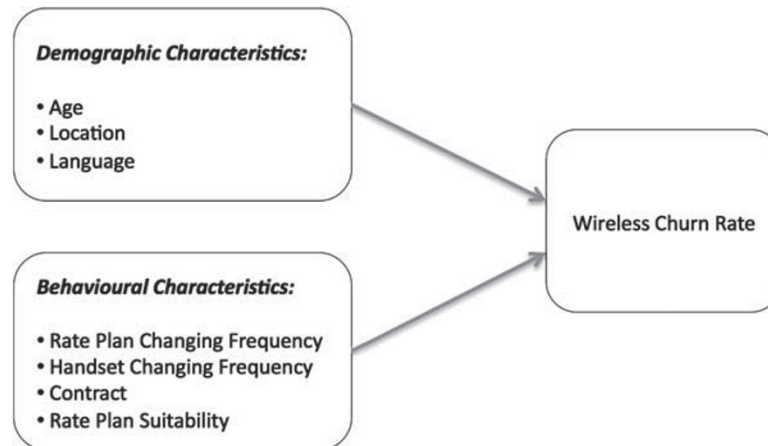


Figure 1: Conceptual framework.

In the context of data mining in the telecommunications industry, ‘survival’ refers to customer retention whereas the ‘hazard function’ can be viewed as the probability that a customer will churn away from the wireless carrier. Incorporating the various demographic and behavioral characteristics variables, we can express the risk of customer churn at time t as in Equation (2):

$$h(t) = h_0(t) \times \exp(b_{\text{age}} \cdot \text{age} + b_{\text{location}} \cdot \text{location} + \dots + b_{\text{suitability}} \cdot \text{suitability}). \quad (2)$$

where $h_0(t)$ is the baseline hazard at time t which corresponds to the probability of customer churn when all the explanatory variables are zero. The baseline hazard determines the shape of the hazard function over time. The regression coefficients, b_{age} to $b_{\text{suitability}}$, give the proportional adjustment that can be expected in the hazard, given the changes in the explanatory variables. In other words, the hazard function value is equal to the product of the baseline hazard and a covariate effect; the latter helps to determine the overall magnitude of the function. The use of Cox regression allows this research to precisely estimate the effects of customers’ demographic and behavioral characteristics on their churn intention. PAWS Statistics 17.0.2 software from SPSS Inc. is used to run Cox regression and other statistical procedures in this research study.

DATA ANALYSIS AND RESULTS

Customer profiles

The descriptive statistics (Table 1) shows customers to be 43 years of age on average. The majority of them reside in Western Canada and speak English primarily. Customers were found to change their rate plan 0.79 times and mobile handset 1.16 times on average during the study period. Only 38 per cent of the customers have active contracts and approximately half of all customers overpay for their wireless services due to inappropriate rate plan selection. This research also shows 34 months to be the mean customer tenure.

Demographic characteristics

The first part of this study investigated how some of the demographic characteristics such as age and location affect customer churn intention. Table 2 shows the Cox regression results. This research suggests that, with a hazard ratio of 0.979, the desire of wireless customers’ to churn from the wireless carrier decreases 2.1 per cent every year as the customers grow older. The other demographic variable, namely, the customer’s residing location, also seems to affect churn probability. It was found that customers who reside in Eastern Canada churn 1.304 times more than those residing in Western Canada. In this study, Eastern Canada is defined as the region of Canada east of Manitoba, including not only Ontario and Quebec but also the Atlantic

Table 1: Summary of demographic and behavioral characteristics

Variable	Descriptions	Customer count		Mean	SD
		Code=0	Code=1		
<i>Demographic characteristics (IV)</i>					
Age	Customer's age at the beginning of study period	NA	NA	43.399	14.704
Location	Customer's residing location: 0=Western Canada; 1=Eastern Canada	3162	1734	0.354	0.478
Language	Customer's primary language for communication: 0=English; 1=French	4485	411	0.084	0.277
<i>Behavioral characteristics (IV)</i>					
Rate plan changing frequency	Number of rate plan changes made with the carrier	NA	NA	0.788	0.926
Handset changing frequency	Number of handset changes made with the carrier	NA	NA	1.159	0.877
Contract	Customer's service contract status: 0=without contract; 1=with contract	3046	1850	0.378	0.485
Rate plan suitability	0=rate plan is financially optimized; 1=rate plan is not financially optimized	2224	2672	0.546	0.498
<i>Behavioral characteristics (DV)</i>					
Customer tenure	Number of months the customer stays with the wireless carrier since service activation	NA	NA	33.518	12.516
Customer account status	0=still active (censored); 1=already churned, at the end of the study period	2690	2206	0.451	0.498

NA=Not applicable.

Table 2: Estimates of variables in Cox regression

Variable	Regression coefficient (b)	SE (b)	Wald	Significance of variables	Exp (b)
<i>Demographic characteristics</i>					
Age (per year)	-0.021	0.002	160.137	0.000	0.979
Location (Western Canada vs Eastern Canada)	0.265	0.044	35.799	0.000	1.304
<i>Behavioral characteristics</i>					
Rate plan changing frequency (per change)	-0.252	0.027	86.895	0.000	0.777
Handset changing frequency (per change)	-0.255	0.029	76.765	0.000	0.775
Contract (without contract vs with contract)	-3.187	0.115	769.028	0.000	0.041
Rate plan suitability (optimized vs not optimized)	0.616	0.048	168.206	0.000	1.852

Note: Language is not included in equation (2) as its residual χ^2 is 0.076 with 1 DF significance of 0.783.

provinces such as Nova Scotia, New Brunswick and Prince Edward Island.

The third demographic variable, language, is not included in the final Cox regression model because its residual χ^2 is observed to be 0.076 with 1 degree of freedom and a significance level of 0.783 ($P > 0.05$), which means that any observed difference might be due to chance or error, and is not statistically significant. As a result, no comments can be drawn regarding the effect of language (that is, English versus French) on churn probability.

Behavioral characteristics

This research study also analyzed the effects of customer' behavioral characteristics on churn rate. In terms of rate plan changing frequency, it was found that customers are less likely to churn if they have made adjustments to their rate plans during the study period; as compared with customers who did not change their rate plans, those who changed theirs once during the 44-month study period have a 22.3 per cent lower chance of churning away from the wireless provider (that is, 1 - hazard ratio of 0.777;

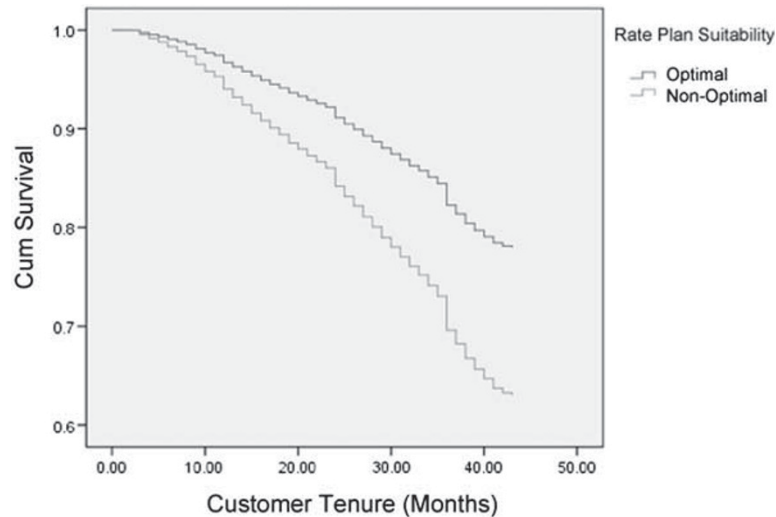


Figure 2: Survival plot.

$P < 0.001$). With this understanding, those who have adjusted their rate plans twice would have a 39.6 per cent lower probability of churning away from the wireless carrier (that is, $1 - \text{hazard ratio of } 0.604$; $P < 0.001$).

Similarly, customers are less likely to churn if they have upgraded their mobile handsets. As compared with customers who have not changed their handsets, those who have changed theirs once are 22.5 per cent less likely to churn (that is, $1 - \text{hazard ratio of } 0.775$; $P < 0.001$), whereas those who have changed handsets twice are argued to have a 39.9 per cent lower chance to churn. The churn rate further decreases as the frequency of changing rate plan increases.

The Cox regression analysis also gives insights into the importance of locking customers into service contracts. With a hazard ratio of 0.041, it was found that those with contracts are 95.9 per cent less likely to churn than are customers who do not have contracts. This result shows that the service contract can act effectively as a switching barrier for the wireless customers. This observation is not surprising considering the high early contract termination fees that customers need to pay if they want to churn before their contracts expire.

It may be observed from Table 2 that rate plan suitability is highly significant ($P < 0.001$) in influencing a customer's churn behavior. The

Table 3: Cross tabulation

		Rate plan suitability		Total
		Optimal	Non-optimal	
Customer churned?	Yes	864	1342	2206
	No	1360	1330	2690
	Total	2224	2672	4896

hazard ratio is 1.852, which is the highest among all independent variables considered in this research study. Customers with financially optimized rate plans are coded as '0' whereas those with non-optimal ones are coded with '1'. This means that after adjusting the effects of all other variables, customers with non-optimal rate plans are 1.852 times more likely to churn than are customers with optimal rate plans, the latter acting as a reference group in this analysis. The survival function plot in Figure 2 illustrates the importance of having customers on a suitable rate plan. The lower line (code = 1.00) refers to customers using wireless rate plans that are not financially optimized. It can be observed that these customers had a much lower survival rate during the study period as compared with optimal customers who are represented by the upper line (code = 0.00).

The cross-tabulation analysis as presented in Table 3 suggests that wireless customers who are using optimal rate plans have a lower churn rate

than those with non-optimal ones; the churn rates for these two groups are 38.8 per cent and 50.2 per cent, respectively. These results are in line with the findings from prior literature.^{21,22,25}

CONCLUSION

The Canadian wireless telecommunications industry is facing rapid changes as the government brings competition to the market by implementing wireless number portability and allowing new entrants to bid and operate on the Advanced Wireless Services spectrum. Faced with high customer acquisition costs and a fast maturing market, wireless carriers are urged to shift their marketing focus from customer acquisition to retention activities. Through the use of Cox regression, this article presents a model that marketers can use to identify customer segments that are sensitive to churning behavior. On the basis of the research results, extra retention efforts should be directed to younger customers and those who are residing in the Eastern Canada region. Moreover, wireless carriers should consider giving incentives to encourage existing customers to switch rate plans and upgrade their mobile handsets as these activities are shown to be effective in reducing churn.

This article also confirms prior research findings that about half of all customers are subscribing to rate plans that are not financially optimized, and that they are churning significantly faster than those with optimal ones. To better retain these customers, wireless carriers should proactively monitor their rate plan suitability and make necessary adjustments as part of their customer relationship management initiatives.

LIMITATIONS AND FUTURE RESEARCH

Although this study contributes to the knowledge on customer retention in the context of the wireless telecommunications industry, some limitations and opportunities for further research deserve to be mentioned. First of all, this research only analyses data provided by a Canadian

wireless carrier, so there is a geographical bias. This may be a first step towards assessing customer retention in the wireless telecommunications industry in North America or some other region. Second, this research focuses on the postpaid wireless service. Future studies can explore the prepaid market and develop explanatory variables that are applicable to such customer segment. Another limitation of this research is that only data from residential customers are used for analysis. Researchers can develop a more sophisticated model to cover the business customers as well.

In summary, the findings of this article may help researchers and practitioners in the wireless telecommunications industry adopt a holistic perspective and make informed decisions about the opportunities and challenges that churn management would present.

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