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A Competing Risks Analysis of the Determinants of Low Completion Rates in the Canadian Apprenticeship System

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A COMPETING RISKS ANALYSIS OF THE DETERMINANTS OF LOW COMPLETION RATES IN THE CANADIAN APPRENTICESHIP SYSTEM[1]

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ABSTRACT

In this paper, we estimate the determinants of low (and slow) completion rates with a competing risk duration model using data from the National Apprenticeship Survey (NAS) 2007. This allows us to distinguish the impact age and duration dependence on the probability of dropping out. We find older apprentices are less likely to transit toward completion after age 28. We also find duration dependence to be positive, meaning transition probabilities to completion increase with apprenticeship duration. However, the positive effect dies out quickly after 10 years of apprenticeship.

JEL Codes: *J24, I21*

Keywords: *Apprenticeship training, human capital, competing risks model*

EXECUTIVE SUMMARY

This report uses data from the National Apprenticeship Survey (NAS) 2007 to estimate the determinants of low (and slow) completion rates in the Canadian apprenticeship system. In the NAS, each apprentice is classified into one of three status: (1) Long-Term Continuers, (2) Completer and (3) Discontinuer. We use a competing risk duration model to estimate the impact of various demographic and apprenticeship characteristics on the probabilities of being classified into each one of the three status.

We find older apprentices are less likely to transit toward completion after age 28. We also find duration dependence to be positive, meaning transition probabilities to completion increase with apprenticeship duration. However, we also estimate large increases in the probability of discontinuation around 3-4 years and 6-7 years. It appears that policies to prevent dropping out must then act in these time windows to be most effective.

In terms of demographic characteristics, we find that apprentice with disability, immigrant, aboriginal, and apprentices with kids below 18 are all less likely to complete. Also, even controlling for all other factors, we find that apprenticeship in Building, Construction, and apprentices from the East are all less likely to complete. These groups could be targeted by policies to foster completion.
We also find that individuals who completed high school are more likely to complete. This could mean that restricting entry into apprenticeship to individual with a high school degree would increase the completion rates.

Finally, another interesting finding is the negative impact on the probability of completion if the technical training is taken through day-released or self-paced. This could indicate that learning by block (one week or more) could help increase completion rates.

INTRODUCTION

Many studies have found completion rates to be alarmingly low in the Canadian apprenticeship system. For example, Prasil (2005) finds that, over 11 years, from first registration in 1992, about half of apprentices completed the trade they had started and almost half dropped out. Similar numbers come from Morissette (2008) who examines the completion rates trends in apprenticeship programs for the 1993 cohort and finds completion rate over an 11 years varying from 50% in New Brunswick to 60% in Ontario. More recently, Desjardins and Paquin (2010) report similar completion rates for the 1994-95 cohort over 11 years. In addition, Sharpe and Gibson (2005) show that, in the Canadian apprenticeship system, completion rates do not seem to closely follow the level of registrations: total registrations nearly doubled between 1977 and 2002 while completion rates have remained relatively flat.

These low completion rates are cause for concern: some studies have found that high rates of apprentice desertion were the major reason for the decline of apprenticeship in the U.S. in the 19th century (Gospel (1994), Elbaum (1985), Farber (1967)). This is because, for an apprenticeship system to be workable, it is necessary for apprentices not to quit training before employers receive a positive return on their investment. Therefore, high rates of dropping out are a direct threat to the survival of an apprenticeship system.

According to Gunderson (2009): "*Understanding the causal determinants of the low completion rates in apprenticeships is important for developing policy initiatives that can reduce dropping out and foster completion*". Increasing completing levels could have positive effects on both firms and apprentices. However, while there is a large literature on dropping out behaviour for formal schooling (see for example the seminal contribution of Willis and Rosen (1979) or the influential article by Keane and Wolpin (1997)), there are still very few micro-level studies of the decision to drop out of apprenticeship. Because of the stark differences between the formal education and apprenticeship systems, it is possible that determinants of dropping out differ.

Two very detailed studies on the determinants of completion in apprenticeship systems are Bessey and Backes-Gellner (2008) and Bessey and Backes-Gellner (2007). In the context of the German apprenticeship system, they emphasize many characteristics associated with higher probability of completing the apprenticeship requirements, namely higher prior levels of schooling, more demanding training, good working atmosphere, lower outside employment opportunities, and being a native worker. On the other hand, Bilginsoy (2007) and Bilginsoy (2003) emphasize the role of union involvement in diminishing the probability of dropping out.

Our study adds to this limited evidence by using data from the National Survey of Apprentice (NAS) 2007 to estimate a competing risk model of the determinants of dropping out at the apprentice level. Since the dependent variable of interest is the length of time in an apprenticeship program, duration models must be used. The use of a duration model is also

important because it allows us to distinguish the impact age and duration dependence on the probability of dropping out. Duration dependence means that being an apprentice for a long time has an independent effect on not completing. However, because the NAS distinguishes between three different modes of exit for each apprentice (completion, dropping out, or long-term continuation), and since the determinants could vary depending on the exit, it is better not to use a simple duration model and we prefer estimating the determinants in a competing risk framework.

Within this framework, we find strong evidence of both state and age dependence. In particular, we find older apprentices are less likely to transit toward completion after age 28. We also find duration dependence to be positive, meaning transition probabilities increase with apprenticeship duration. However, the positive effect dies out quickly. For transitions from long-term continuation to completion, the estimated duration dependence is close to zero after 10 years.

DATA

We use the 2007 National Apprenticeship Survey (NAS) from Statistics Canada to undertake this research. Unfortunately, duration of apprenticeship information is not readily available from that survey and we must first spend some explaining how to build duration variables from the survey. We then describe explanatory variables that are going to be used in the analysis.

Survey respondents to the NAS were selected by Statistics Canada based on apprenticeship status in 2002, 2003, or 2004 (survey frame reference years) as reported by provincial or territorial jurisdictions.[3] The survey was conducted between January and May 2007. This yields a total sample of 30,572 apprentices.

However, we are not using this full sample in what follows. In particular, we drop apprentices from Québec because the sampling procedure was different. Lists of apprentices were provided by the *Commission de la construction du Québec* and cover only apprentices in the construction trade. Also, because there are so few female apprentices and because they tend to register in very different and specific trades (like hairdressing for example), we drop them from the sample as well. With these two restrictions, and with some minimal additional deletions because of missing information on some variables, we are left with a sub-sample of 19,976 apprentices.[4]

Table 1: Apprentice status in survey frame and 2007

	REF		2007	
Status	#	%	#	%
Long-Term Continuer	6,515	22.2	7,581	26.9
Completer	15,157	44.9	18,318	56.5
Discontinuer	8,900	33.0	4,673	16.7
Total	30,572	100%	30,572	100%

Reference years (REF): 2002, 2003, 2004

The three distinguished apprenticeship status in the NAS are (Statistics Canada (2007)):

[3] In the duration models literature, this is referred as stock sampling or length-biased sampling (Kiefer (1988)) and it is well known to cause problems akin to sample selection. This is because shorter apprenticeship spells (that finished before 2002) are outside the sampling frame. It should be expected that the NAS over-samples longer apprenticeship spells. Taking this into account is outside the scope of this paper. Let us note that the fact that reference years span three years mitigates the problem.

[4] Another concern with the NAS is the possibility of measurement errors due to imperfect recall by the respondent. We do not take that into account in our analysis.

1. Long-Term Continuers: people who still registered apprentices in 2004 and had registered as apprentices in 1999 or earlier (in the same trade as 2004) and who had not earned their certification by 2004.
2. Completers: people who had been registered apprentices and had completed their apprenticeship program (with or without certification) at some point during 2002 to 2004.
3. Discontinuers: people who had been registered apprentices at some point in the past and had discontinued their apprenticeship programs between 2002 and 2004.

All individuals were classified in on of these three categories both in the survey frame reference years (2002 to 2004) and again in 2007.

Table 2: Apprentice status in survey frame and 2007 (estimation sample)

	REF	2007
Status	%	%
Long-Term Continuer	18.5	24.7
Completer	50.1	60.3
Discontinuer	31.4	15.0
Total	100%	100%
Reference years (REF): 2002, 2003, 2004		
Number of observations: 19,976		

Table 1 shows status in the reference years and in 2007 for the complete sample.[5] Only 45% of apprentice had completed the requirement of their program in the survey reference years. This completion rate moves up to 56.5% in 2007. The rate of completion moves up in a similar way in Table 2 for our estimation sample, going from 50% to 60%. Overall, the breakdown of apprentices among the three statuses is pretty similar in both samples.

Table 3: Transition rates

	Status 2007		
Status (REF)	LTC	C	D
Long-Term Continuer (LTC)	56.0	36.5	7.5
Completer (C)	4.8	89.1	6.1
Discontinuer (D)	37.3	25.4	37.2
Number of observations: 30,572			
Reference years (REF): 2002, 2003, 2004			

Transitions rates, presented for the whole sample in Table 3 and for the estimation sample in Table 4 are again very similar. Quite interestingly, we see from Table 3 in which transition rates from each status are showed, that new Completers are almost as likely to come from Long-Term

[5] Note that all summary statistics and regression results presented below are computed using Statistics Canada sampling weights from the survey.

Continuer as Discontinuer. However, the majority of Discontinuers in the survey reference years are still Discontinuer in 2007.

Table 4: Transition rates (estimation sample)			
	Status 2007		
Status (REF)	LTC	C	D
Long-Term Continuer (LTC)	52.2	40.7	7.1
Completer (C)	5.1	88.9	6.0
Discontinuer (D)	40.0	26.1	33.9
Number of observations: 30,572			
Reference years (REF): 2002, 2003, 2004			

COMPETING RISKS AND DURATION OF APPRENTICESHIP

Since the duration of the apprenticeship is not directly available, we have to construct duration of apprenticeship dependent variables indirectly. For all apprentices, we have information, summarized in Table 5, on what year and age they began regular work or became registered as an apprentice for the first time. We see regular entry into apprenticeship programs until age 22. In fact, 50% of apprentices start their program before reaching 23. At the same time, many older individuals also start apprenticeship programs: 5.8% of entry occur between the age of 40 and 50.

Table 5: Age when first registered as an apprentice	
Age	%
Less than 18	8.3
18 years old	9.4
19 years old	9.6
20 years old	8.4
21 years old	7.1
22 years old	6.6
23 years old	5.5
24 years old	4.7
25-29 years old	17.2
30-34 years old	10.1
35-39 years old	7.2
40-49 years old	5.8
Total	99.9%

We also have detailed information on apprenticeship activities on a yearly basis from 2000 to 2007: for each apprentice, we know through nine separate questions whether they have done any work or technical training in each separate year from 2000 to 2007. Table 6 reports answers from the NAS. It shows the proportion of individuals undertaking apprenticeship activities slowly decline as years go by.

Table 6: Summary statistics for the question: Did you undertake any work or technical training as an apprentice in 2000-2007				
	YES		NO	
Year	#	%	#	%
2000	21,868	72	8,634	28
2001	24,258	80	6,244	20
2002	23,456	77	7,046	23
2003	19,536	64	10,966	36
2004	14,259	47	16,243	53
2005	9,269	30	21,233	70
2006	7,089	23	23,413	77
2007	5,464	18	25,039	82
Total: 30,502				

To build our duration variable we take the last year the respondent was observed undertaking work or technical training as an apprentice minus the year they began regular work or became registered as an apprentice. Table 7 provides an overview of the duration distribution. Most durations are between 3 to years but we observe some very long durations: 2.9% of spells last more than 20 years.

Table 7: Duration of apprenticeship variable	
Duration	%
Less than one year	6.2
1 to 2 years	8.0
2 to 3 years	9.5
3 to 4 years	14.1
4 to 5 years	16.2
5 to 6 years	11.7
6 to 7 years	7.6
7 to 8 years	6.3
8 to 9 years	4.6
9 to 10 years	3.4
10 to 15 years	8.2
15 to 20 years	5.3
More than 20 years	2.9
Total	100%

Table 8 shows average age and duration by 2007 status. While Completers seem slightly younger and Discontinuer slightly older, the average age difference between the two is only 1.4 years. However, differences are more striking looking at durations. Completers stay 5 years on average in their apprenticeship while Discontinuers spells last only 3.2 years. Not surprisingly, Long-Term Continuers have the longest duration (8.4 years).

In summary each apprentice's transition status is determined from his status in 2007 and each spell duration is taken to be the difference between the last year the individual is observed undertaking apprenticeship activities (inferred from Table 6) or 2007 and the year he or she started regular work or became registered as an apprentice. This measure of duration might look rather crude but is typical of what can be obtained using yearly panel data.

Table 8: Average age and duration by destination state

	Status 2007		
	LTC	C	D
Duration (years)	8.4	5.0	3.2
Age	25.5	24.7	26.1

LTC: Long-Term Continuer
C: Completer
D: Discontinuer

DETERMINANTS

Summary statistics on all explanatory variables for the whole estimation sample and broken down by apprenticeship status category are presented in Tables A1 and A2 in Appendix A. Determinants of apprenticeship duration and transitions fall mostly into five categories.

The first category refers to the apprentice and includes demographic characteristics: whether French if the preferred language, marital status, immigrant[6] and aboriginal status, whether an apprentice reported having a disability throughout his apprenticeship and number of kids under 18. Comparisons across columns can yield some preliminary insights on which factors are likely to have an impact of the probability of completing. For example, married apprentices are more likely to be classified as Completers whereas immigrants, aboriginal and individual with disability are under-represented as Completers. Having kids seems to be slowing down apprentices as parents are much more over-represented in the Long-Term Continuers category.

A second category includes variables describing the human capital and ability of the apprentice. Human capital is represented by the highest education level completed before undertaking the apprenticeship. The proxy we use for ability is the apprentice overall grade average in his last year of high school. There seems to be a pretty strong positive relationship between education and the probability of completion. Ability also seems linked to completion status but the impact is not as clear.

A third category of explanatory variables describes how much knowledge and support the individual has about apprenticeship. This is measured first by a dummy variable indicating whether the individual was involved in apprenticeship experience such as whether the individual was registered in a Youth Apprenticeship Program (YAP) before leaving high school and

[6] We define an individual as immigrant if his father or mother is not Canadian by birth.

whether the apprentice had parents, relatives, friends, or co-workers working in the same trade. We note, somewhat surprisingly, that taking part in a YAP does not seem to have a positive impact on being a Completer. Having parents or relatives in the same trade seem to increase the probability of being both a Completer or a Long-Term Continuer.

A fourth category included variables describing the apprenticeship experience. These includes whether the apprentice was a member of an union related to his trade, whether the apprenticeship involves technical training as well as the method of delivery (block- or day-release, self-paced),[7] whether at least one journeyperson was present at all times to supervise the apprenticeship, and whether the apprentice had more than one employer during the total length of the program. This category of explanatory variables is particularly interesting, as these are variables that could be particularly easy to influence through policy. The final category gives the number of employees at the last place the individual was employed

Table A2 shows the breakdown of the sample by province and trade. These province and trade indicator variables are used as controls in all regressions. Probabilities of completion seem higher in Ontario and in the Eastern provinces compared to the Central provinces and British Columbia and higher in most other trades compared to Construction.

[7] Block-release lasts one week of more.

METHODOLOGY

As discussed in the previous section, we are able to use information from the NAS to approximate the apprentice history from the first time in the apprenticeship system to one of three possible outcomes (Long-Term Continuer, Completer or Discontinuer). As a result, we are able to study the impact of different variables (for example demographic characteristics) on the time spent until a certain outcome is reached. This framework also allows us to take into account duration dependence (i.e., the possibility that the probability of reaching a certain outcome depends on the time spent in the apprenticeship). In particular, the framework we allow for two sources of duration dependence, age and time since the beginning of apprenticeship.[8]

However, a limitation of standard duration models is that they do not allow the impact of covariates to vary across potential exit states. This is likely to be very restrictive when examining the outcomes of apprenticeship programs using the NAS because, as explained previously, the survey design allows explicitly for three differentiated statuses. It seems therefore more appropriate to incorporate these three different statuses explicitly in the duration analysis. Consequently, we extend the basic duration model to a competing-risks framework.[9]

A competing risk model can be designed as a duration model in which the observed duration is the shortest of a number of latent durations.[10] A latent duration corresponds to a particular type of spell, where the observed spell and transition correspond to the shortest of the aforementioned latent durations. The competing-risks specification is required because the process underlying each type of completion status is likely to be different; implying different covariate effects and different duration dependence for each type of transition. These separate effects are confounded in single risk analysis of apprenticeship spells.

It is important to note that the probabilities of transiting into each of the three possible outcomes depend on two different types of duration dependence: age and state duration dependence. These two effects are separately identifiable because of variation in ages at the beginning of the apprenticeship and variation in duration for apprentices who started at the same age.

Although apprenticeship decisions may be affected by policies that are likely to change over time (i.e., are calendar time dependent) or the business cycle (Brunello (2009) and Muhlmann and al (2009)), we have not incorporated these effects in the analysis.[11] Identification of calendar effects is tricky as we observe only one apprenticeship spell per individual. In fact, calendar effects are in fact not distinguishable from age effects because of the survey design. If we had

[8] Allowing for duration dependence is not as straightforward in typical multinomial-logit models.

[9] See Crowder (2001) for a general treatment of competing-risks models or Dostie and Léger (2005), Dolton and van der Klaaw (1999), and Mealli and Pudney (1996) for detailed recent examples.

[10] A formal description is provided in Appendix B.

[11] For example, Bilginsoy (2003) finds that apprenticeship duration rises with unemployment.

detailed information on multiple apprenticeship spells for some individuals, we could use these multiples observations as an alternative source of variation to distinguish age and time dependence as the duration clock is reset to zero after a transition whereas the age clock is not.[12]

[12] Observing multiple spells per apprentice would also allow us to model unobserved individual heterogeneity. We do not incorporate unobserved heterogeneity in our model since unobserved heterogeneity in single-spell data is usually identified with non-testable parametric assumptions.

RESULTS

The main estimation results are presented in Tables A3 to A7 for all explanatory variables by category. While the results are separated in different tables, keep in mind that all coefficients are obtained from the estimation of the same model. As mentioned earlier, we show coefficients for two destination statuses: Completers and Discontinuers. Positive coefficients indicate higher probabilities of transiting while negative coefficients indicate the reverse. It would usually be expected that an explanatory variables would have different impacts on these two statuses, for example increase the probability of being a Continuer and decrease the probability of being a Discontinuer. However, it is also possible that both shown coefficients are of the same sign. For example, if they were positive, this would then imply a negative impact on the probability of being a Long-Term Continuer.[13]

DURATION DEPENDENCE

Our results in Figure 1 and 2 (from the estimated coefficients that can be found in Table A3) indicate interesting and complicated patterns of duration dependence that would have remained hidden using simpler models. Focusing first on transitions to Completion in Figure 1, we observe strong positive duration dependence after one year. However, duration dependence remains positive but declines rapidly afterwards. Positive duration dependence in the first few years is not surprising given the usual time requirement to complete training (Paquin (2009) and Desjardins and Paquin (2010)). It is however surprising to see it turns negative so rapidly after 4 years. Duration dependence appears to be somewhat negative after 5 years although our estimate becomes less precise (because we have less and less apprenticeship spells lasting longer durations). To summarize, in Figure 1, for transitions to Completers, we see strong positive duration dependence up to 4 years and approximately negative or zero duration dependence afterwards.

Turning to transitions to Discontinuers in Figure 2, we see duration dependence moving up in the first few years and first peaking between 3 and 4 years. However, we also see a second peak at 6-7 years. It seems natural to attribute the peak at 3-4 years to apprentices in 2-year or 3-year programs, who did not complete on time, and drop out after some additional efforts (and similarly for the (higher) peak at 6-7 years for those in 4-year programs). It appears that policies to prevent dropping out must then act in these time windows to be most effective. After that, we observe overall weak and negative duration dependence on the transition probability to Discontinuer.

[13] In discussing magnitudes, we usually compute the relative risk ratio that is obtained by exponentiating the relevant coefficients.

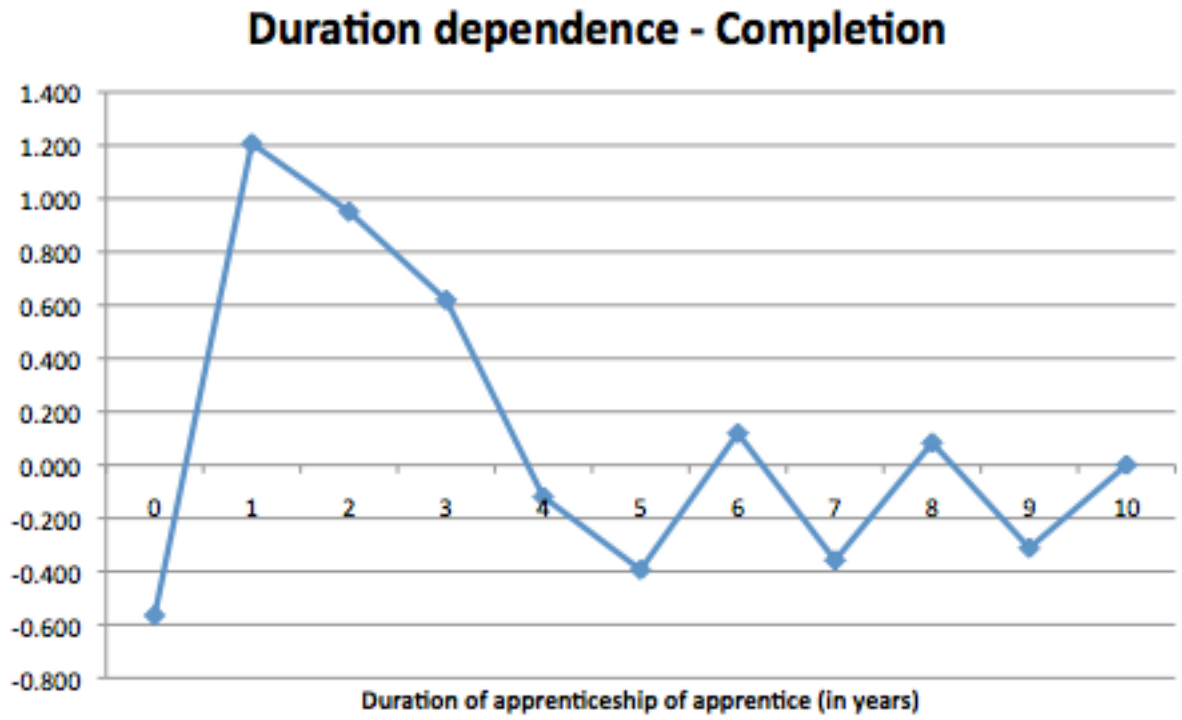

FIGURE 1

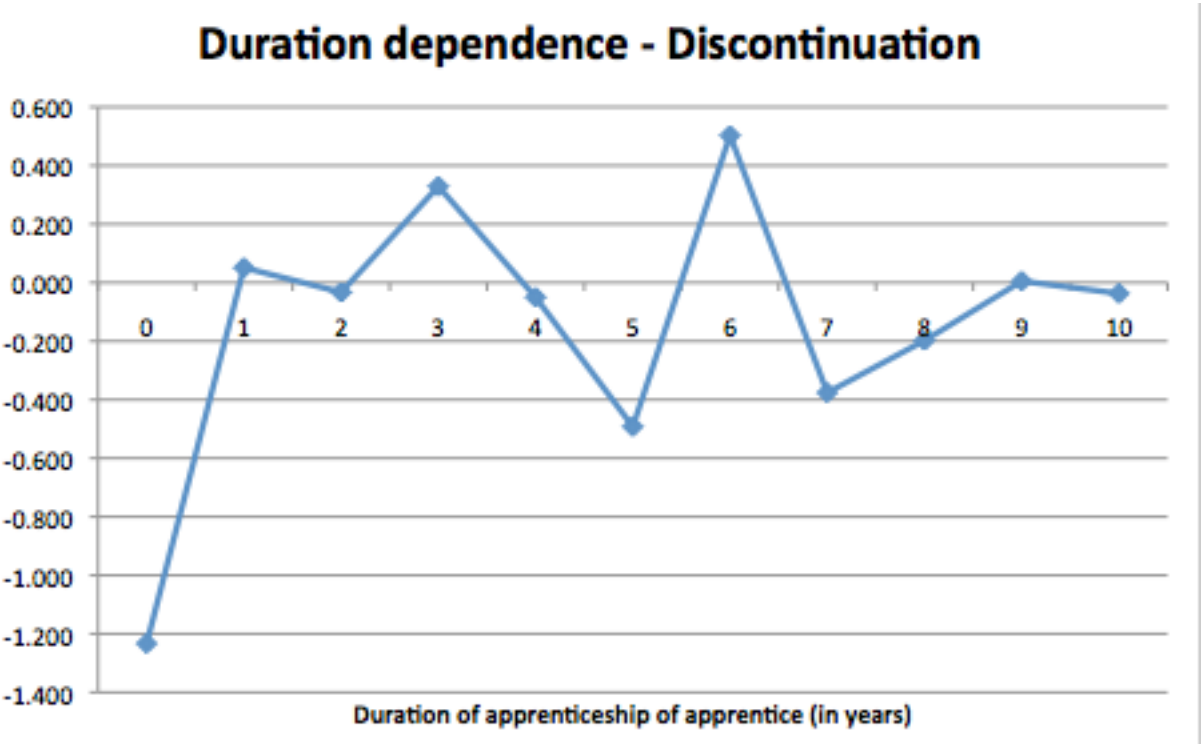

FIGURE 2

This is not surprising as these longer apprenticeship spells are classified as being Long-Term Continuers.[14]

AGE DEPENDENCE

Estimates of age dependence are presented in Figures 3 and 4 (with raw estimated coefficients available in Table A4). For transitions to Continuers, our results show positive duration dependence up to age 25 and mostly absent afterwards. In the case of the probability of transiting to being a Discontinuer, it is mostly the reverse pattern: age dependence moves around zero but then moves sharply into positive territory at age 28 and remains positive afterwards. This indicates that policies to foster completion might target older apprentices who are more likely to drop out after age 28.

DEMOGRAPHIC CHARACTERISTICS

In terms of demographic characteristics, our results are mostly consistent with those published in the literature (see in particular Laporte and Mueller (2010) who use the same data but a different methodological approach). For example, we find that having a disability is a statistically significant decreases the probability of being a Completer and increases the probability of being a Discontinuer. The magnitudes of the effects are quite large. Having a disability decreases the probability of completion by 25% and increases the probability of dropping out by 13%.

Immigrants and aboriginals are also less likely to complete their apprenticeship but in the case of immigrants, we do not estimate that they have higher probabilities of being Discontinuers. This means that they are more likely to end up classified as Long-Term Continuers.[15] Having kids under 18 also decreases both the probability of completion and discontinuation, meaning again that they increase the probability of being classified as a Long-Term Continuers. The sole positive impact on probabilities of completion comes from begin married. Married apprentices are 9% more likely to end up being classified as Completers in 2007.

HUMAN CAPITAL AND ABILITY

As we have shown earlier from the summary statistics, we estimate that apprentices with more education pre-apprenticeship are much more likely to be classified as Completers. For example, an individual who has completed high school is 44% more likely to be a Completer than an individual whose higher education levels is less than high school. However, it is possible that

[14] Desjardins and Fortin (2010) report that approximately 60% of apprentices are registered in 4-year programs, 20% in 3-year programs and 15% in 2-year programs. But they find no link between program duration and completion.

[15] Mangan and Trendle (2008) report a similar finding with respect to Indigenous Australians.

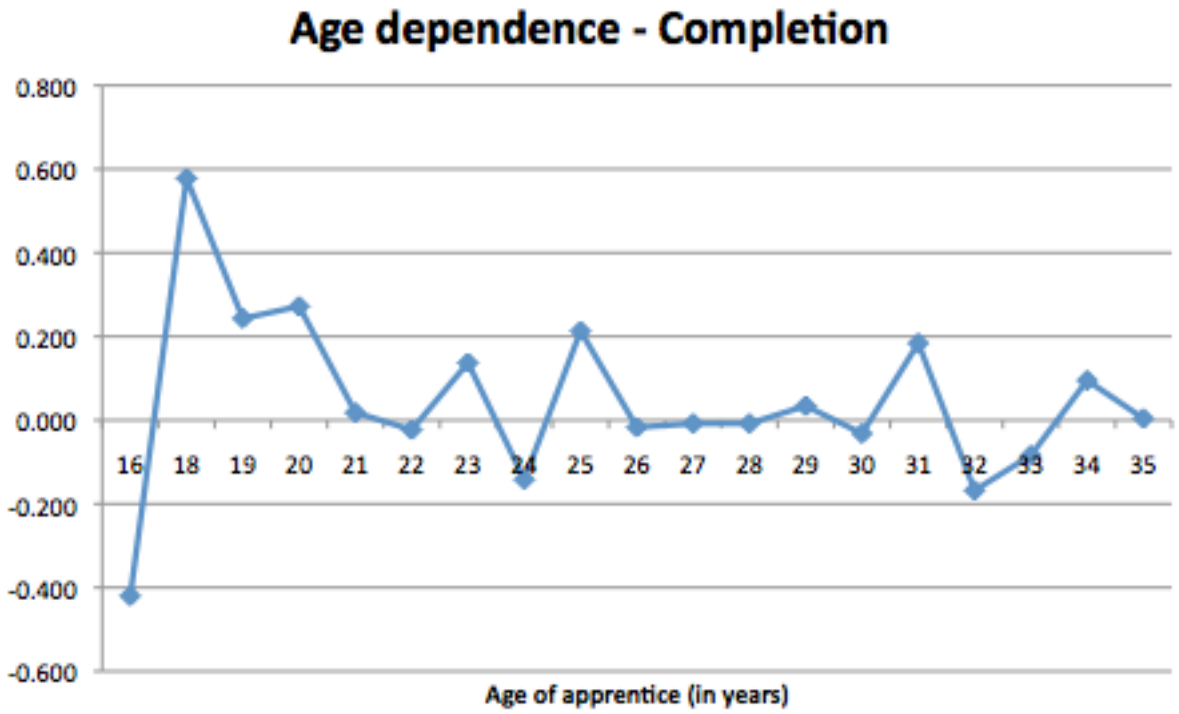

FIGURE 3

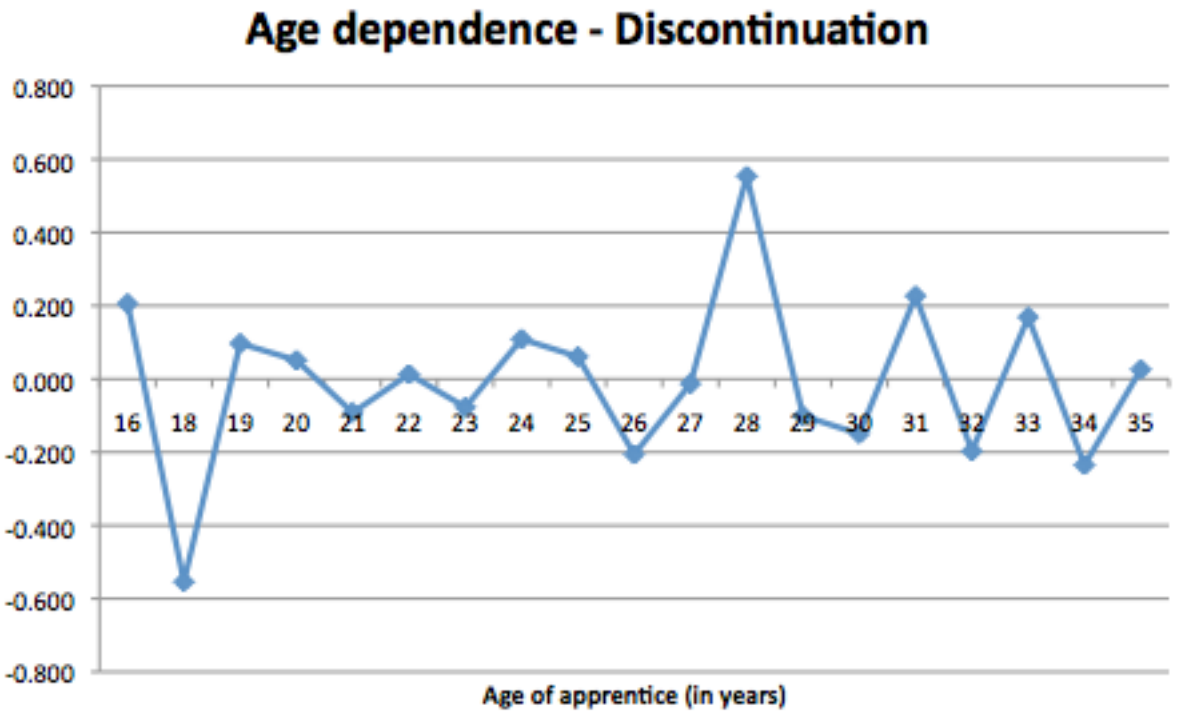

FIGURE 4

this positive association between higher levels of education and the probability of transiting to Completers is dues to unobserved ability, even though we try to take unobserved ability into account using GPA in last year of schooling. It is also possible that it reflects better decision-making behavior (Bessey and Backes-Gellner (2007)).

Quite interestingly, in the case of individuals who have some post high-school education, we estimate that they are both more likely to be classified as Completer and Discontinuer, thus less likely to be classified as Long-Term Continuers. Again, the positive association with the probability of completion could be caused by unobserved ability. The positive association with the probability of Discontinuation could reflect the fact that the opportunity cost of dropping out might be lower for individuals with higher levels of education.

In the case of ability, we also get the expected effects: more able individuals are more likely to complete and less likely to drop out. However, the magnitudes of the impact are smaller than in the case of education.

SUPPORT AND KNOWLEDGE OF APPRENTICESHIP

One puzzling finding is that individuals with former involvement in Youth Apprenticeship Programs are more likely to be classified as Discontinuers. This finding is however compatible with an explanation provided by Taylor and Watt-Malcolm (2007) who conclude that high-school programs do not provide sufficient preparation for apprenticeship.

We obtain negative impact on the probability of completion of having parents, relative or friends in the trade. Only in the case of co-workers is the impact on completion positive albeit small. However, in the case of parents, there is a strong negative impact on the probability of dropping out. This means these individuals are more likely to persevere and end up classified as Long-Term Continuers.

TYPE OF APPRENTICESHIP

We find no impact of membership in a union on the probability of completion but a large positive impact (almost +30%) on the probability transiting to being a Discontinuer. This results in particular is opposite to the one obtained by Bilginsoy (2003). This could indicate that, in Canada at least, unions act as barriers to entry to certain specific trades.

Apprenticeship involving technical training does not seem to foster completion. However, we see large negative impacts on the probability of dropping out, meaning that the technical requirement probably slows down apprentice who are then more likely to end up as Long-Term Continuers. This is true for both technical training in general and technical training by block.

Block-release training is often seen as a serious problem if it is associated with inflexibility in training arrangement, making it difficult to schedule or carry out normal operations (CAF (2006)). However, we estimate a negative impact on the probability of completion if the

technical training is taken through day release or self-paced. Hence our results mean that, contrary to the stated expectation, learning by block-release (one week or more) could help increase completion rates compared to day-release or self-paced learning.

Finally, we find that having more than one employer has the unambiguous impact of increasing the probability of end up being classified as a Long-Term Continuer, a similar finding to Mangan and Trendle (2008).

FIRM SIZE AND OTHER CONTROLS

Working in bigger firms increases the probability of completion and decreases the probability of discontinuation. However, the impact is no longer statistically significant for the biggest category (more than 500 employees).

Compared to Ontario, apprentices in the East are less likely to complete and more likely to drop out. However, apprentices in Central Canada or in BC are both more likely to complete and drop out, thus less likely to be Long-Term Continuers.

Comparing the different trades, the pattern is also clear as most trades compared to Construction have higher completion probabilities and lower probabilities of dropping out. This is true for all trades except the category Other trades that is more likely to be classified as Long-Term Continuers.

CONCLUSION

In this paper, we use a competing risk duration model to estimate the impact of various demographic and apprenticeship characteristics on the probabilities of being classified into each one of three status: (1) Long-Term Continuers, (2) Completer and (3) Discontinuer.

The use of a competing risk model allows us to estimate both age and duration dependence. In particular, we find older apprentices are less likely to transit toward completion after age 28. We also find duration dependence to be positive, meaning transition probabilities to completion increase with apprenticeship duration. However, we also estimate large increases in the probability of discontinuation around 3-4 years and 6-7 years.

In terms of demographic characteristics, our results are much in line with those of the literature. For example, we find that apprentice with disability, immigrant, aboriginal, and with kids below 18 are all less likely to complete. Also, even controlling for all other factors, we find that apprenticeship in Building, Construction, and apprentices from the East are all less likely to complete. We also find that individuals who completed high school are more likely to complete. This could mean that restricting entry into apprenticeship to individual with a high school degree would increase the completion rates.

Going into more detailed description of the type of training received by the apprentice, we find a negative impact on the probability of completion if the technical training is learned by day or self-paced. This could indicate that learning by block (one week or more) could help increase completion rates.

There are a number of extensions to the statistical model that would be worthwhile but are not allowed by the current structure of the data. For example, if we had detailed data on multiple apprenticeship spells per apprentice, we could extend the model to incorporate unobserved heterogeneity and calendar time dependence. Also, we had to rely on rather crude measures of duration. It would help if we had exact dates of entry in and out of apprenticeship programs.

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APPENDIX A

Table A1: Summary statistics - Explanatory variables

	ALL	2007 Status		
		LTC	C	D
Demographic characteristics				
1: French	0.01	0.01	0.01	0.01
1: married	0.33	0.31	0.34	0.33
1: immigrant	0.17	0.20	0.16	0.14
1: aboriginal	0.05	0.06	0.04	0.06
1: disability	0.07	0.10	0.06	0.09
Number of kids < 18	0.73	0.93	0.68	0.60
Human capital and ability				
1: less than high school	0.13	0.53	0.11	0.14
1: completed high school	0.53	0.31	0.54	0.52
1: some post high school	0.34	0.18	0.36	0.34
1: average GPA: A	0.20	0.18	0.21	0.18
1: average GPA: B or C	0.71	0.72	0.7	0.71
1: average GPA: D, E or F	0.04	0.04	0.04	0.05
Support and knowledge about apprenticeship				
1: YAP	0.09	0.11	0.07	0.11
1: parents in trade	0.20	0.23	0.20	0.17
1: relative in trade	0.30	0.33	0.30	0.28

1: friend in trade	0.39	0.4	0.38	0.4
1: co-workers in trade	0.23	0.22	0.23	0.23
Type of apprenticeship				
1: union	0.16	0.15	0.16	0.19
1: technical training	0.54	0.53	0.59	0.37
1: tech. training by block	0.4	0.36	0.45	0.29
1: tech. training by day	0.08	0.1	0.08	0.04
1: tech. training self-paced	0.07	0.09	0.07	0.04
1: journeyperson present	0.81	0.81	0.81	0.82
1: more than one employer	0.47	0.55	0.47	0.36
Firm size				
1: tiny (less than 20 empl.)	0.45	0.49	0.43	0.46
1: small (20 to 99)	0.31	0.28	0.33	0.31
1: medium (100 to 499)	0.16	0.15	0.17	0.16
1: big (500 and more)	0.07	0.07	0.07	0.07

LTC: Long-Term Continuer

C: Completer

D: Discontinuer

Table A2: Summary statistics - Other controls

	ALL	2007 Status		
		LTC	C	D
Province				
1: East	0.11	0.14	0.1	0.09
1: Ontario	0.37	0.48	0.37	0.22
1: Central	0.38	0.25	0.4	0.52
1: BC	0.14	0.13	0.13	0.17
Trade				
1: Building, construction	0.13	0.16	0.1	0.16
1: Electrical	0.17	0.16	0.18	0.17
1: Food and service	0.05	0.06	0.04	0.04
1: Industrial and mechanical	0.11	0.1	0.11	0.1
1: Metal fabrication	0.26	0.23	0.28	0.26
1: Motor vehicle	0.27	0.28	0.28	0.24
1: Other trades	0.01	0.01	0.01	0.02

LTC: Long-Term Continuer

C: Completer

D: Discontinuer

Table A3: Coefficient estimates - Duration spline

	C	D
Duration spline		
0-1 year	-0.565 ***	-1.233 ***
	(0.058)	(0.041)
1-2 year	1.207 ***	0.051
	(0.040)	(0.044)
2-3 year	0.951 ***	-0.033
	(0.025)	(0.050)
3-4 year	0.619 ***	0.329 ***
	(0.019)	(0.053)
4-5 year	-0.120 ***	-0.050
	(0.021)	(0.062)
5-6 year	-0.394 ***	-0.492 ***
	(0.027)	(0.081)
6-7 year	0.119 ***	0.503 ***
	(0.034)	(0.094)
7-8 year	-0.358 ***	-0.376 ***
	(0.043)	(0.112)
8-9 year	0.083	-0.198

	(0.053)	(0.144)
9-10 year	-0.312 ***	0.005
	(0.049)	(0.135)
10 years +	0.000	-0.037 **
	(0.005)	(0.014)

Standard error in parentheses

***: significant at 1%; **: 5%; *:10%

Table A4: Coefficient estimates - Age spline

	C	D
Age spline		
16-18 years old	-0.420 **	0.206 ***
	(0.169)	(0.069)
18-19 years old	0.578 ***	-0.554 ***
	(0.142)	(0.080)
19-20 years old	0.243 ***	0.097
	(0.078)	(0.079)
20-21 years old	0.272 ***	0.051
	(0.049)	(0.073)
21-22 years old	0.018	-0.092
	(0.037)	(0.071)
22-23 years old	-0.023	0.013
	(0.034)	(0.072)
23-34 years old	0.137 ***	-0.077
	(0.033)	(0.075)
24-25 years old	-0.142 ***	0.109
	(0.033)	(0.077)
25-26 years old	0.213 ***	0.061
	(0.033)	(0.078)
26-27 years old	-0.017	-0.206 **
	(0.034)	(0.086)
27-28 years old	-0.008	-0.013

	(0.036)	(0.094)
28-29 years old	-0.008	0.554 ***
	(0.038)	(0.089)
29-30 years old	0.034	-0.101
	(0.041)	(0.086)
30-31 years old	-0.032	-0.150
	(0.043)	(0.095)
31-31 years old	0.184 ***	0.227 **
	(0.045)	(0.100)
32-33 years old	-0.168 ***	-0.197 *
	(0.048)	(0.105)
33-34 years old	-0.084	0.169
	(0.053)	(0.111)
34-35 years old	0.095 **	-0.235 ***
	(0.041)	(0.084)
35 years old +	0.004 **	0.026 ***
	(0.002)	(0.004)

Standard error in parentheses

***: significant at 1%; **: 5%; *:10%

Table A5: Coefficient estimates - Demographic characteristics and Human Capital

	C	D
Demographic characteristics		
1: French	-0.189 ***	0.030
	(0.054)	(0.101)
1: married	0.086 ***	-0.018
	(0.013)	(0.028)
1: immigrant	-0.128 ***	-0.098 ***
	(0.014)	(0.030)
1: aboriginal	-0.154 ***	0.141 ***
	(0.025)	(0.043)
1: disability	-0.297 ***	0.123 ***
	(0.020)	(0.035)
Number of kids < 18	-0.210 ***	-0.247 ***
	(0.006)	(0.012)
Human capital and ability		
1: less than high school	-	-
1: completed high school	0.362 ***	0.033
	(0.017)	(0.031)
1: some post high school	0.439 ***	0.202 ***
	(0.017)	(0.033)
1: average GPA: A	-	-

1: average GPA: B or C	-0.068 ***	0.047 **
	(0.011)	(0.024)
1: average GPA: D, E or F	-0.088 ***	0.133 **
	(0.028)	(0.052)

Standard error in parentheses

***: significant at 1%; **: 5%; *:10%

Table A6: Coefficient estimates - Apprenticeship characteristics

	C	D
Support and knowledge about apprenticeship		
1: YAP	0.026	0.314 ***
	(0.019)	(0.037)
1: parents in trade	-0.055 ***	-0.295 ***
	(0.013)	(0.028)
1: relative in trade	-0.011	-0.076 ***
	(0.011)	(0.023)
1: friend in trade	-0.048 ***	0.089 ***
	(0.011)	(0.021)
1: co-workers in trade	0.037 ***	-0.124 ***
	(0.012)	(0.025)
Type of apprenticeship		
1: union	-0.017	0.240 ***
	(0.014)	(0.027)
1: technical training	0.046	-0.520 ***
	(0.030)	(0.081)
1: tech. training by block	0.011	-0.251 ***
	(0.029)	(0.081)
1: tech. training by day	-0.051 *	-0.314 ***
	(0.030)	(0.088)
1: tech. training self-paced	-0.181 ***	-0.288 ***
	(0.031)	(0.087)

1: journeyperson present	0.022 *	0.042
	(0.013)	(0.027)
1: more than one employer	-0.367 ***	-0.684 ***
	(0.010)	(0.023)
Firm size		
1: tiny (less than 20 empl.)	-	-
1: small (20 to 99)	0.113 ***	-0.044 *
	(0.012)	(0.024)
1: medium (100 to 499)	0.098 ***	-0.091 ***
	(0.014)	(0.031)
1: big (500 and more)	0.008	-0.023
	(0.021)	(0.042)

Standard error in parentheses

***: significant at 1%; **: 5%; *:10%

Table A7: Coefficient estimates - Other controls

	C	D
Province		
1: East	-0.240 ***	0.328 ***
	(0.019)	(0.041)
1: Ontario	-	-
1: Central	0.334 ***	1.001 ***
	(0.012)	(0.027)
1: BC	0.357 ***	0.812 ***
	(0.016)	(0.034)
Trade		
1: Building, construction	-	-
1: Electrical	0.060 ***	-0.214 ***
	(0.021)	(0.035)
1: Food and service	0.389 ***	-0.113 **
	(0.026)	(0.055)
1: Industrial and mechanical	0.185 ***	-0.207 ***
	(0.022)	(0.042)
1: Metal fabrication	0.262 ***	-0.157 ***
	(0.018)	(0.032)
1: Motor vehicle	0.268 ***	-0.217 ***
	(0.018)	(0.033)

1: Other trades	0.436 ***	0.266 ***
	(0.040)	(0.081)
Constant	2.596	-5.563 ***
	(2.960)	(1.214)

Standard error in parentheses

***: significant at 1%; **: 5%; *:10%

APPENDIX B

Formally, let Y(t) represent the state of the apprentice at time t=2007. Y(t) can take three values: (1) Long-Term Continuer, (2) Completer, and (3) Discontinuer. Transitions between states are determined by a vector of transition intensities that take the form

$$[\ h_1 \quad h_2 \quad h_3\ ]$$

where h_1 is the probability the apprentice is classified as a Long-Term Continuer, h_2 is the probability of being classified as a Completer and h_3 is the probability of being in the category Discontinuer. Equation \ref{matrix} should be seen as a description of the transition Table 4. Since $h_1 = 1 - h_2 - h_3$, we will focus in what follows on the probability of transiting to Completion (h_2) or to Discontinuation (h_3).

To build the likelihood function, we assume that the probability density function of the time spent in each apprenticeship state takes the generalized Gompertz form. We say that a duration variable t follows the Gompertz distribution when its density function takes the form:

$$f(t) = e^{(\lambda + \gamma t) - \frac{e^{\lambda}}{\gamma}(e^{\gamma t} - 1)}$$

The survivor function is

$$S(t) = e^{\frac{-e^{\lambda}}{\gamma}(e^{\gamma t} - 1)}$$

and the hazard rate is written as

$$h(t) = e^{\lambda} e^{\gamma t}$$

or

$$\ln h(t) = \lambda + \gamma t$$

The model is usually implemented by parameterizing $\lambda = \beta X$. Thus, in its most basic form, we write a Gompertz hazard as

$$\ln h(t) = \gamma T(t) + \beta X$$

The Gompertz distribution gives rise to a very convenient form for the hazard rates or transition intensities: the log-hazards are linear in the covariates of interest. This means that regression

coefficients indicate each variable's effect on the hazard function or the probability of transition. A positive coefficient increases this probability and therefore decrease expected duration.

Specifically, we let the transition to each destination status s take the following form:

$$\ln \lambda_s^i(t|x_i) = \gamma_0^s \text{ duration}_{it} + \gamma_1^s \text{ age}_{it} + \beta_0^s + \beta_1^s x_i, \quad s = 1,2,3$$

where the vector x_i includes person- or apprenticeship- specific variables as well as control variables.

We allow the effect of both types of duration dependence to be non-linear through the use of piecewise linear splines. For a duration spline T(s) with P nodes, we have

$$T(s) = \begin{pmatrix} \min[s, p_1] \\ \max[0, min[s - p_1, p_2 - p_1]] \\ \cdots \\ \max[0, min[s - p_{P-1}, p_P - p_{P-1}]] \\ \max[0, s - p_P] \end{pmatrix}$$

where $p_1,...,p_P\}$ represent the nodes. The apprenticeship duration and age profiles are represented by piecewise-linear splines with yearly nodes up to 10 years for state dependence and also with yearly nodes up to 35 for age dependence. The use of splines is crucial for an application such as this one where the effect of age may not be linear.

Then, for each apprentice, his or her contribution to the log likelihood will be

$$L_i = \sum_{s=1}^{3} \left[m_s^i \log \lambda_s^i(t^i) - \Lambda(t^i) \right]$$

where the integrated hazard takes the familiar form

$$\Lambda(t) = \int_0^t \sum_s \lambda_s(t) dt; \quad s = 1,2,3$$

and where m_s is defined as follow

$$m_s = \begin{cases} 1 & \text{if } s \text{ is the status at the end of the apprenticeship} \\ 0 & \text{otherwise} \end{cases}$$

This explicitly assumes that there is no censoring as we classify Long-Term Continuers as one of the final destination state.

Note that many studies that use duration models suffer from what is known as an initial-conditions problem. The problem lies in the fact that individuals (and their choices) are not observed prior to the point when data collection began (i.e., prior to the first observation). As a result, the likelihood function must be conditioned on the initial state as well as the individual's state history prior to the first observation. However, because the data we use are based on a retrospective questionnaire in which the year the individual started his apprenticeship program is given, there is no initial conditions problem.