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Romain **AEBERHARDT*** et Claire **MARBOT****

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Evolution of Instability on the French Labour Market during the Last Thirty Years

Abstract

We use a 30-year longitudinal matched employer-employee database to describe the evolution of job stability by studying the duration of employment spells. The paper proposes two different perspectives aiming at describing and characterizing this evolution.

Firstly, the analysis of survival rates and the modeling of the duration of the spells clearly show that instability increased in the last 30 years. Moreover there is a variety of situations depending on the characteristics of the employees and the firms. The increase in the instability is particularly strong in the first two years of the jobs. The youngest individuals are both the most unstable and the ones who have experienced the highest rise in instability. Executives are the most stable employees, and after a period of convergence between socio-occupational categories, the difference became larger, but in a different way among men and among women. The stability in service industry is lower than in other industries and it evolved in a less favourable way.

In a second part, we study time-invariant heterogeneity at both firm and individual levels with a double fixed effects model. Our estimates suggest in particular that the younger the cohort, the more their individual instability and the more frequently they work in firms which do not keep their employees long. Moreover, office clerks and service workers are the less stable socio-occupational categories in terms of individual stability, while blue-collar workers are the ones who work in the firms that keep their employees for the shortest periods of time.

Keywords : Cox models, double fixed effects, duration models, longitudinal data, DADS.

JEL Classification : D63, J20, J63

Évolution de l'instabilité sur le marché du travail français pendant les trente dernières années

Résumé

Nous utilisons le panel DADS sur 30 ans pour décrire l'évolution de la stabilité dans un emploi en étudiant la durée des périodes d'emploi. L'étude propose deux perspectives différentes qui visent à décrire et caractériser cette évolution.

Tout d'abord, l'analyse des taux de survie et la modélisation de la durée des périodes d'emploi montre clairement que l'instabilité a augmenté au cours des trente dernières années. De plus, il existe une variété de situations selon les caractéristiques des salariés et des entreprises. La hausse de l'instabilité est particulièrement prononcée avant la deuxième année des emplois. Les plus jeunes sont à la fois les plus instables et ceux qui ont connu la hausse la plus importante de l'instabilité en emploi. Les cadres sont les salariés les plus stables, et après une période de convergence entre catégories socio-professionnelles les différences se sont accrues, mais de manière différente parmi les hommes et parmi les femmes. La stabilité dans les entreprises du secteur des services est plus faible que dans les autres secteurs et son évolution est moins favorable.

Dans un second temps, nous étudions l'hétérogénéité fixe dans le temps, à la fois au niveau des salariés et au niveau des firmes, à l'aide d'un modèle à doubles effets fixes. Nos estimations suggèrent en particulier que, au fil des générations, l'instabilité individuelle augmente et les salariés travaillent de plus en plus dans des entreprises où la stabilité est moindre. De plus, les professions intermédiaires forment la catégorie socio-professionnelle la plus instable en termes de stabilité individuelle, tandis que les ouvriers travaillent dans les entreprises qui gardent leurs salariés le moins longtemps.

Mots-clés : Modèle de Cox, doubles effets fixes, modèles de durée, données longitudinales, DADS.

Classification JEL : D63, J20, J63

1 Introduction

The changes in wage inequalities since the 1970s are described and explained in numerous empirical studies. The most widespread approach is based upon the analysis of wage rates. Nevertheless, in France, the development of unstable types of contracts incites us to extend the analysis to yearly earnings, whose determinants are both wage rates and duration of employment spells along the year. Indeed, if work statuses were quite homogeneous up to the 1970s, the following period is marked by the development of part-time and temporary contracts until the end of the 1990's. Trajectories characterized by alternations between periods of employment and periods of unemployment or inactivity are more frequent. Because of this growing instability, duration at work has become a core parameter of earnings and their evolution in the past 30 years. The seventh report of the French CERC (Conseil de l'Emploi, des Revenus et de la Cohésion Sociale) precisely underlined the fact that the main factor of earnings inequality was now the number of days worked per year.

Studies on employment instability are far more recent than studies on wages. In the United States, employment instability was a recurrent topic of the 1996 presidential campaign and the media widely covered its important rise in the previous years. The envergure of this question entailed a series of empirical academic studies aimed at assessing the magnitude of the phenomenon, but no irrefutable stylized facts were brought to light. We may in particular mention the controversy between Swinnerton and Wial (1995, 1996) and Diebold, Neumark, and Polsky (1996, 1997). The former conclude that job stability decreased (though slightly, after taking into consideration their detractors' comments) while the latter rather find an overall stability – even if some populations seem to evolve toward more instability than others. However, Neumark, Polsky, and Hansen (1999) update their data to the early 1990s and show a fall of stability for workers with high seniority and a rise of stability for the low seniority ones. More recently, Neumark and Reed (2004) proposed a study of empirical links between instability and new technologies.

In the years following these American studies, a series of similar articles was published in Europe on this topic. The first studies focused on the UK and did not find any overall rising trend of instability but proved the existence of a certain elasiticity to the business cycle. On this topic, we may in particular mention Burgess and Rees (1996, 1998) and Nickell, Jones, and Quintini (2002). In France, we must wait until the early 2000s. Depending on the data, concepts and methodology, some authors conclude that stability decreased and others not, although they use the same database (the Labour Force Surveys). For example, Fougère (2003) or Auer and Cazes (2003) conclude that instability did not particularly increase, whereas Behaghel (2003) or Givord and Maurin (2004) rather find an upward trend. The latter establish that this phenomenon is especially noticeable in some fields of activity, and suggest the role of new technologies in the decrease of the duration of employment spells. We may equally refer to L'Horty (2004) for a survey of the main French articles on this topic and a tentative explanation of their divergences.

He finds that instability increased from 1969 until the mid 1990s then decreased until 2002.

But the presence of an upward trend of instability is not the unique pending question on this subject. Indeed, in the recent years, the availability of matched employer-employee data gave rise to new questions about potential links between the instability of the individuals and the one of the firms. Do some firms tend to have shorter employment spells than others? Are some individuals more or less "stable" than others? These questions, which were already in the foreground about wages with the seminal article of Abowd, Kramarz, and Margolis (1999), were recently the object of empirical studies about employment spells. Anderson and Meyer (1994) raise interesting questions about this topic and give a few empirical facts establishing the importance of both firm and individual effects. However, their analysis does not use a double fixed effects approach as we will do here, which limits the relevance of their results. Mumford and Smith (2004) find that firm effects and individual effects explain the duration of employment spells in almost equal proportions, and they do not find any correlation between these effects. But they do not estimate any model including both firm and individual fixed effects either. On the contrary, Cornelißen and Hübler (2011) find that "stable" workers tend to work in rather "unstable" firms. Their method is quite close to ours, but their data are on a shorter period of time and their sample of firms is far less rich.

We must notice that, except for Valletta (1999), very few articles try to use theoretical models to formalize the origin of the changes in employment stability. This question is nevertheless related to numerous fields of the labour economics theoretical literature. On the one hand, theories about the accumulation of specific human capital as well as search models predict that separations tend to decrease with experience on the job market and seniority in the firm. Instability may also be related to labour displacements due to globalization or biased technological change in favor of the most qualified (see Givord and Maurin, 2004). Some theories about strategies of human resources management have also been developed, opposing the workers of the heart of the firm, who are stable, to the workers at the periphery who suffer from workforce adjustments. Institutional changes may also be at stake, especially in European countries with the development of temporary contracts.

In a more normative perspective, these theoretical models bring light to the positive or negative aspects of job stability. On the one hand, if we consider instability as the result of a selection process of good matches between firms and individuals, instability may be considered as an evolution toward a more efficient situation. On the other hand, career interruptions and loss in (specific or general) human capital which are associated to them are inefficient in a general point of view and may send a bad signal to potential employers. It may penalize twice unstable individuals, which could in the end lead to a two-tier market.

Following these analyses, this paper aims at establishing stylized facts about the duration of employment spells. To our knowledge, the French studies about the evolution of employment

instability all used data from the Labour Force Surveys[1]. To measure instability, they estimate the proportion of people without a job among the ones who were employed at the last interview (that is to say one year before up to 2002 and 3 months before from 2002). Before 2002, these surveys only had one observation per year and the individuals could not be followed for more than 3 years. From 2002, they have one observation every 3 months during 15 months.

Although we restrict the analysis to the individuals who spent their entire career in the private sector, our 30-year longitudinal database allows us to get a more precise picture for at least three reasons. Firstly, we have daily information about employment status, so that we know exactly when employment spells begin and end. Secondly, we can follow individuals along the 1976-2006 period. Thirdly, we have matched employer-employee data, so that we also have information about the employing firms.

The purpose of this study is to give two different perspectives about instability on the labour market. Section 2 presents the data. Sections 3 and 4 study survival rates in order to determine whether instability has increased over the last thirty years and, if such is the case, which categories of workers were affected and in which kind of firms. To determine how employment stability has evolved in relation to the observable characteristics of workers and firms, section 5 focuses on time-invariant unobserved heterogeneity, both at the firm's level and at the worker's level and relate it to firm and worker observable characteristics.

2 The data

2.1 The statistical source

The data source we use is the "Déclaration Annuelle de Données Sociales" (DADS), an administrative database of matched employer-employee information collected by Insee (Institut National de la Statistique et des Études Économiques). The origin of these data is the mandatory report that employers have to send to administrations, which contains a nominative list of their workers and information about the latter. This document is used by social security administrations to calculate national insurance contributions for unemployment, retirement, healthcare and work accidents. The annual database therefore contains a list of employees and the following characteristics for each couple employee-job: employer, gender, date of birth, earnings, socio-occupational activity, number of days paid, date of beginning and end of the employment period and, since 1994, the number of hours worked. The database gives the firm where the worker is employed, along with its industry and its size bracket. From these annual data, information about employees born in October of even-numbered years (about 4% of employees) are extracted

[1] Leclair and Roux, 2005, use the DADS, but they study the characteristics of firms in relation to their use of unstable employment – which is defined as a job which lasts less than one year – and not the evolution of instability.

to build a longitudinal database. This database covers years from 1976 to 2006, but years 1981, 1983 and 1990 are missing, because the administrative reports were not handled these years.

Let us precise a few things about our database. Firstly, it does not give information about the contract under which the worker is employed (in particular fixed-term or permanent contract). Secondly, if the worker is employed by a temping agency, the firm where he really works (with the intermediary of the temping agency) is not reported, and so the duration of the employment spell is the total number of days worked as a temporary worker, no matter in which firm he effectively worked. As a consequence the stability of temporary workers is overestimated. Thirdly, we have no information about the cause of the end of the employment spell (dismissal, resignation, retirement). Fourthly, we do not have the industry variable in 1993 nor in 1994 because of quality issues. So for the survival rates by industry (Figures 10 and 12) and the whole Section 4 in which we estimate a model including an industry dummy, we imputed the 1993 and 1994 industry very basically, by calculating the weighted mean of 1992 and 1995. Lastly, the changes in socio-occupational categories over the career in our panel database are not very reliable – this was evaluated thanks to the comparison with another data source. That is why we choose to consider the socio-occupational category as an unchanging characteristic of the worker and use its most common value for each individual.

2.2 Coverage

Until the early 1980s, the French institute of statistics collected information only about private firms; since then, information about public firms, hospitals and local administration have been progressively included. Beside this database, we have a complementary data source including the same kind of variables for civil servants working for the national administration. Given that our purpose was to study employment instability and its evolution, we chose to restrict the scope of the study to the employees whose entire professional career from 1976 to 2006 was in the private sector. Our extract therefore excludes employees who entirely or partly worked in the civil service (for national or local administrations or in hospitals) or in the two main public firms ("La Poste" for mail carriage and "France Telecom" for telecommunications).

2.3 Creation of a database containing employment periods

Thanks to these annual data we constitute a database containing employment periods: an observation corresponds to an individual's employment spell in a firm, which is characterized by a duration – a number of days paid –, dates of beginning and end of the period, and some characteristics of the employee (gender, cohort of birth, age and socio-occupational activity) and of the firm (size bracket and industry). If a period ends on the last day of year 2006, we consider it is censored. We keep the periods if the employees' age is between 16 and 65 at each year of the period and if the date of beginning is 1977 or after to avoid the problem of left-censoring.

A specific treatment was implemented for the three missing years (1981, 1983 and 1990). Firstly, if the employees were in a firm before and after the year preceding the missing year, we consider they were in this firm during the missing year and we create the missing observation. We do the same thing if there is a lack of information about an individual lasting exactly one civil year (for years other than 1981, 1983 and 1990). Secondly, we try to deal with the remaining censoring problems: left-censoring for a large proportion of the spells whose starting date is January 1 of years 1982, 1984 and 1991 (which therefore begin in reality in 1981, 1983 and 1990 respectively) and right-censoring for a large proportion of the spells whose date of end is December 31 of years 1980, 1982 and 1989 (which end in reality in 1981, 1983 and 1990 respectively). To deal with these censoring issues, we implement a procedure of selection and imputation which is detailed in Appendix A.

3 Duration of employment spells and survival rates

3.1 General evolution

We firstly focus on a basic indicator of the duration of spells: the survival function. This cumulative function gives us the proportion, among workers who began their spell during the same year, of people whose employment spell is still uninterrupted after a certain period of time. Figures 1 and 2 show the shape of this curve: the decrease is important in the 500 first days then it is less and less pronounced, which means that the probability that an employment spell stops gets lower and lower when time goes by. Moreover, the comparison of these curves at different dates shows a progressive downward shift: the proportion of uninterrupted employment spell at a given date tends to decrease. But survival functions do not allow us to see clearly how employment duration has evolved. That is why we prefer to use another descriptive indicator: Kaplan-Meier estimators of the survival rate (see Appendix C) which are calculated for different terms. Globally, the survival rate decreased between 1977 and 2005 (see Figures 3 and 4). If we compare different terms more precisely (see Appendix E, Figures 37 to 42), the most important decrease is that of short-term survival rates – 3 months, 6 months and one year – whereas the decline was more moderate for 2-year, 3-year, and even more for 5-year survival rates. It is therefore mainly the probability to lose one's job in the first months which increased.

The survival function shows some discontinuities (Figures 1 and 2) for the durations which are multiples of 360 days. This is partly due to the fact that many temporary contracts have a precisely defined duration of one or several months. This is also partly imputable to measurement errors, since some firms declare all their workers for the entire year without giving the exact dates of start and end of the employment spells. Because of these measurement errors, we calculate the one-year (respectively 3-month, 6-month, 2-year, 3-year, 5-year) survival rate as the survival rate after one year + 1 day (respectively 3 months + 1 day, 6 months + 1 day, 2 years + 1 day, 3 years + 1 day, 5 years + 1 day): this choice allows us not to consider fake one-year periods, which are in fact shorter.

Survival function, all employees

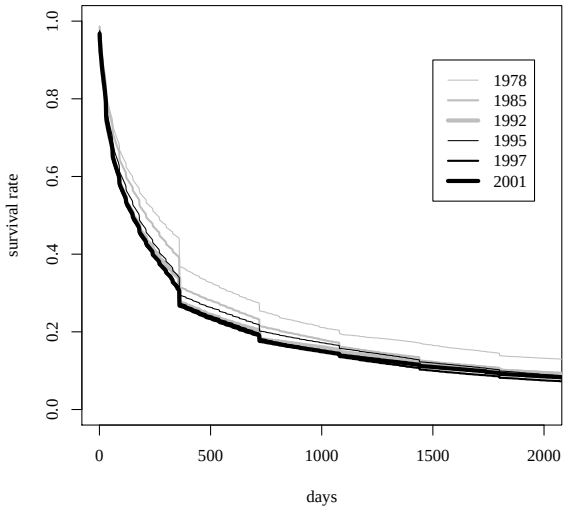

Fig. 1: Survival function, all male employees

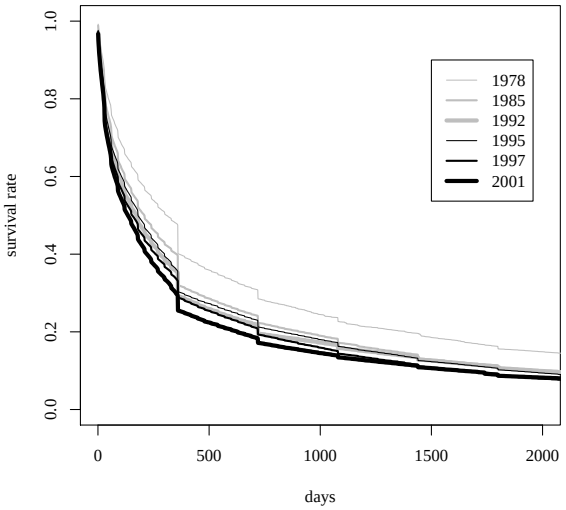

Fig. 2: Survival function, all female employees

Survival rate, all employees

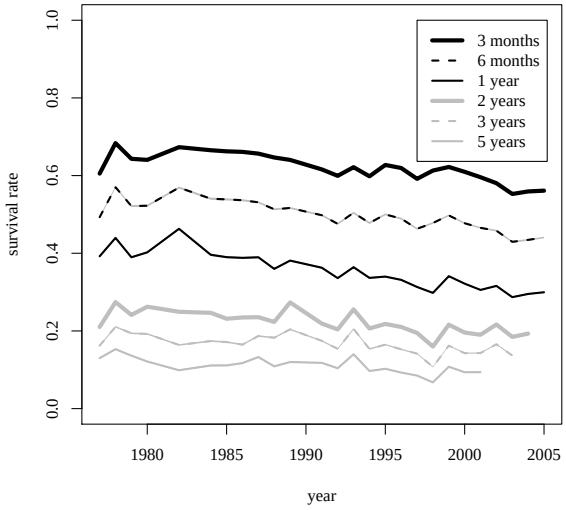

Fig. 3: Survival rate, all male employees

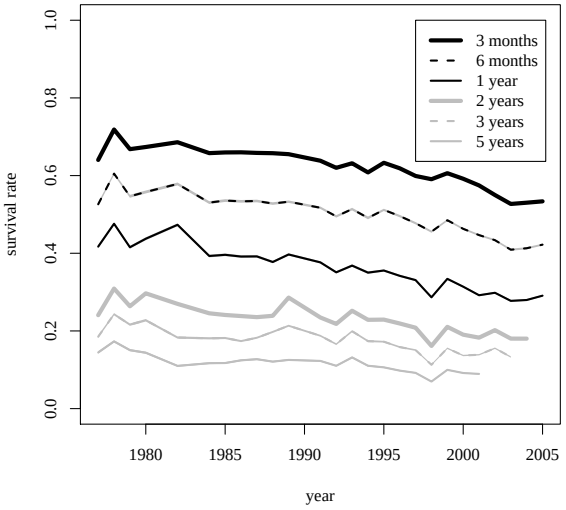

Fig. 4: Survival rate, all female employees

3.2 Survival rate and characteristics of the employees and the firms

We aim at studying if this downward trend of the survival rate is specific to some categories of employees or firms or if, on the contrary, it affects most employees and most firms of the private sector. For this purpose, we analyze the evolution of survival rates according to genders, age groups and socio-occupational categories of employees. Genders were analysed separately, because their survival rates and the evolutions of these rates turned out to be very differenciated in some cases.

Characteristics of the employees

Firstly, the global difference of survival rates between genders is small: the gap is generally lower or equal to one percentage point. However the survival rate of women continuously decreases at a quicker pace than the one of men: whereas it was greater than men's rate until the late 1990s, since then relative positions have reversed (see Figure 37 to 42 in Appendix E). This evolution is probably partly due to institutional changes (implementation of a paid-off parental leave, the "Allocation Parentale d'Éducation") or to possible differences of sensitivity toward the business cycle between jobs held by men and jobs held by women. This could also be explained by a composition effect in the population of employed women. Indeed, the female activity rate increased continuously during the considered period, possibly leading to a change in their average productivity and in the types of jobs they held.

If we now focus on the socio-occupational category of employees, we note that the downward trend of survival rates affects all categories (see Figure 5, 7 and, in Appendix E, Figures 43 to 54). The ranking between categories remains the same over the period. The survival rates of executives and technicians are constantly higher than the survival rates of office clerks and skilled and unskilled manual workers, which are quite close. Among women, the office clerks' survival rates are constantly higher than that of skilled and unskilled manual workers since the mid 1980s, but it is the contrary among men. If the ranking did not change, the gap between categories did. The difference between categories (quite big for men) was strongly reduced in the mid 1980s and as a consequence, a polarization has appeared between on the one hand, executives, technicians and associate professionals, and on the other hand office clerks and workers. There is nevertheless a great difference between men and women. If we focus on women, the survival rates of different socio-occupational categories were not very different at the beginning of the period and especially in the mid 1980s, then the decrease for workers and office clerks has widened the gap. On the contrary, for men, all categories experienced a decrease.

The survival rates are very differentiated between age groups (see Figure 6 and 8 and, in Appendix F, Figures 55 to 66). The ranking remains unchanged from 1977 to 2005: no matter which term we study, the survival rate increases with age, with the exception of the 5-year rate which is reduced by retirement or pre-retirement for the 46-55 age group. During the period, the evolutions are similar for 26-year old to 55-year old employees. However, the evolution of the

16-25 year old group's survival rate suddenly diverged in the early 1990s from that of other age groups, mainly for 3-month and 6-month survival rates. If the decrease of short-term survival rates is a general evolution, it is consequently more important at the beginning of the professional career. One must nevertheless take this result with caution for 16-25 year old employees, for a composition effect is probably part of the explanation. Because of the progressive rise in the level of qualification, the people who are already employed although they are only 18 or 20 years old, are indeed less and less numerous since 1976 and, as a consequence, they are on average less and less educated. Moreover the number of short term jobs held by students is likely to have risen in proportion for the same reason.

Characteristics of the firms

The differences between firms depending on their size are not very large, except for firms above 5,000 employees in which survival rates strongly decreased in the 1990s (Figures 9 and 11). The survival rates of these firms were the highest ones in the 1980s for men and comparable to the others for women, then it decreased and the stability is now the lowest for both genders. Givord and Maurin (2004) also note a specific rise in instability during the 1990s in firms with an above median use of computers and internet, which was likely to be the largest firms at that time. Let us nevertheless note that some characteristics of the data may partially explain this strong decrease in the 1990s. There were indeed many mergers and acquisitions of firms in the period, which often caused a change in the identification number (the SIREN number) of the firms. These restructurings mainly occurred in big firms, and they caused an interruption of the employment spells of the firm's workers in our database, which does not correspond to a real spell interruption.

On the contrary, the hierarchy between industries is almost unchanged. Construction and manufacturing industry display the highest survival rates, while the stability is lower in trade and services. The gap between industries has widened for women: their survival rates decreased since the 1990s while they increased for manufacturing industry. Their is no real evolution for men, but important differences between industries, with services far less stable than the other industries[2].

4 Analysis of the determinants of survival rates

We previously brought to light that some of the characteristics of the employees or the firms predisposed them more than others to be affected by a rise in instability as we define it here, with the survival rate calculated for different terms. To understand more precisely the role each determinant plays, we model duration of employment periods depending on age (with 5-year age groups, from 16 to 65 years), gender and socio-occupational category (executives, technicians and associate professionals, office clerks and service workers, skilled and unskilled workers) but

[2]As explained in Section 2, 1993 and 1994 are imputed by taking a weighted mean of 1992 and 1995

6-month survival rates - characteristics of the employee

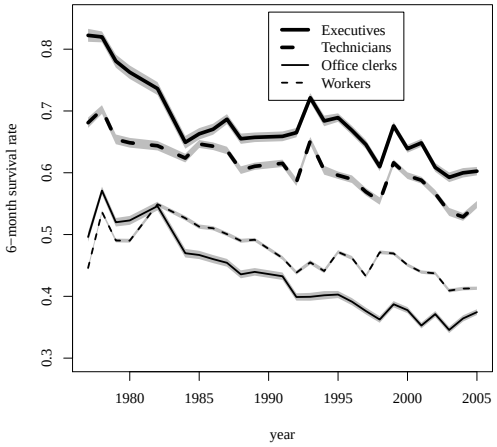

Fig. 5: 6-month survival rates depending on socio-occupational category, Men

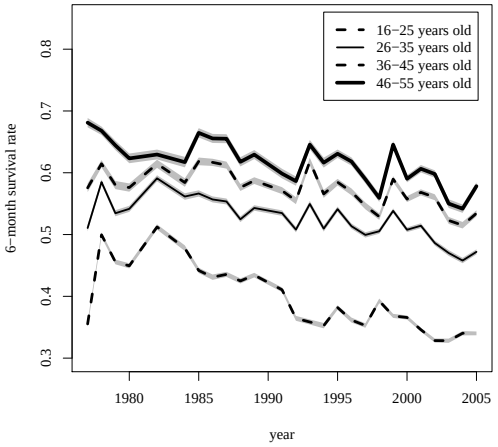

Fig. 6: 6-month survival rates depending on age, Men

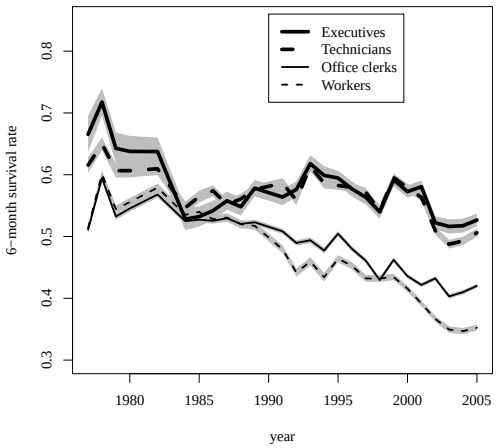

Fig. 7: 6-month survival rates depending on socio-occupational category, Women

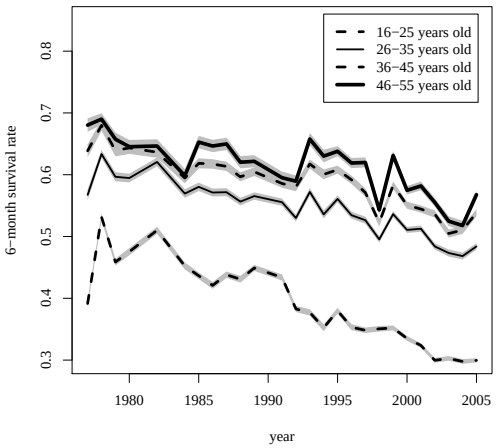

Fig. 8: 6-month survival rates depending on age, Women

6-month survival rates - characteristics of the firms

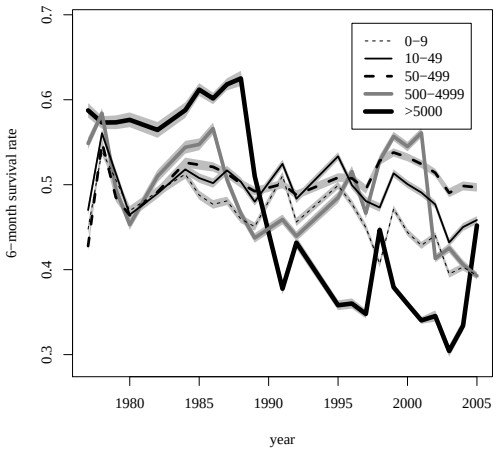

Fig. 9: 6-month survival rates depending on size of the firm, Men

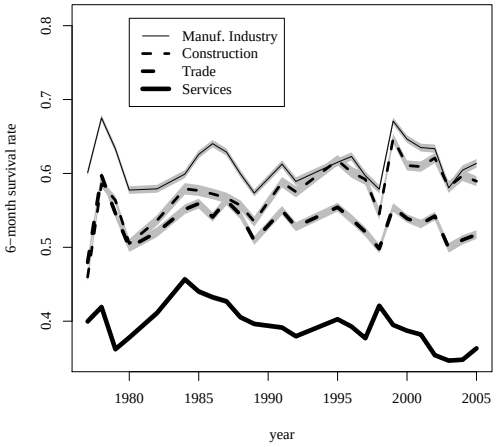

Fig. 10: 6-month survival rates depending on industry of the firm, Men

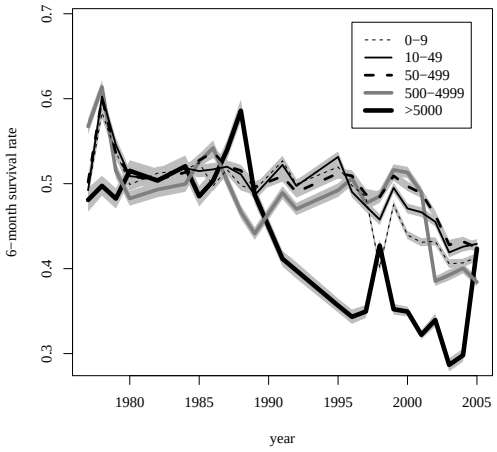

Fig. 11: 6-month survival rates depending on size of the firm, Women

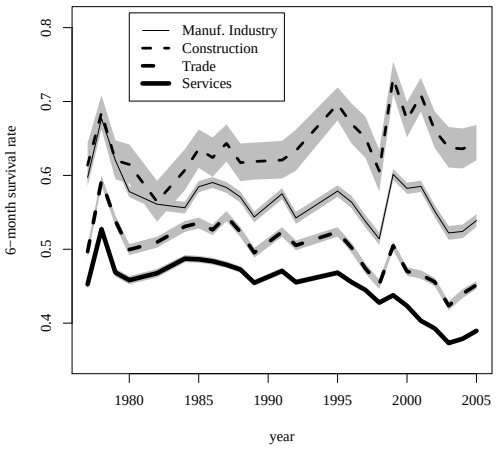

Fig. 12: 6-month survival rates depending on industry of the firm, Women

also depending on the size of the firm and its industry. In this context, the Cox model has the advantage not to impose a specification for the baseline hazard (see Appendix C). The baseline hazard rate is the hazard rate of an individual whose characteristics were chosen as the reference – here, a 36 to 45-year old skilled or unskilled manual worker who works for a manufacturing firm employing between 50 and 499 employees.[3] Figures 13 and 14 show the evolution of the survival rate as it is predicted by the model for an individual whose characteristics are the reference ones. In a second step, the hazard and the survival rates of any individuals are calculated on the basis of the baseline hazard or the baseline survival rates as well as the coefficients of the covariates.

The Cox model is indeed a proportional hazard model, which means that different values of the exogenous variables z give proportional values of the hazard rate. The coefficients exert a multiplicative effect on the predicted hazard.

In these models, the survival rate for the individuals whose characteristics are different from the reference ones are calculated according to the following formula - which is presented in more details in Appendix C:

$$h(t, y|z) = h_{0,y}(t).\phi_y(z, \beta) \tag{1}$$

where y is the starting year of the spell and $h_{0,y}(t)$ is the base hazard rate for year y.

We estimate separate models for each starting year of the spells. As a consequence, the coefficients β are different for spells whose starting year differ. The characteristics of the worker correspond to the ones at the beginning of the period.

We firstly focus on the evolution of the coefficients of the regression, which gives information about the influence a characteristic exerts on the probability of ending of the employment period.

Characteristics of the employees

The influence of the socio-occupational category evolved in a nonlinear way. What is more, there is a strong difference between men and women, which justifies our choice to analyse them separately. As far as men are concerned, the convergence between categories which we observed in the mid 1980s is illustrated here by a narrowing of the distance between the coefficients (see Figure 15) which is followed by a widening of it. At the end of the period, there is a polarization between, on the one hand, executives and technicians and, on the other hand, office clerks and workers. The evolution is very different for women (Figure 17). Indeed, coefficients of white-collar workers diverge from the ones of the blue-collar workers starting from the mid 1980s, and in the mid 2000s, being a worker is associated to a higher hazard rate than for all other categories, whose coefficients are quite close to each other. We also tested a specification introducing age $\times$ socio-occupational category interacted dummies, in order to test if the differences between socio-occupational categories are stable across age groups. We find that the difference in the coefficients between office clerks and workers decreases with age.

[3]Estimations for men and women are carried out separately.

Survival rate predicted by a Cox model

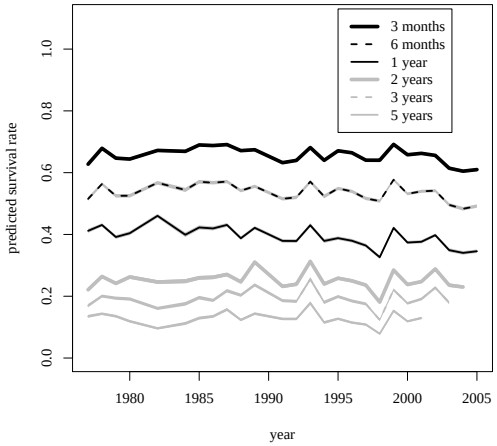

Fig. 13: 36 to 45-year old man, skilled or unskilled manual worker in a firm of manufacturing industry employing between 50 and 499 people

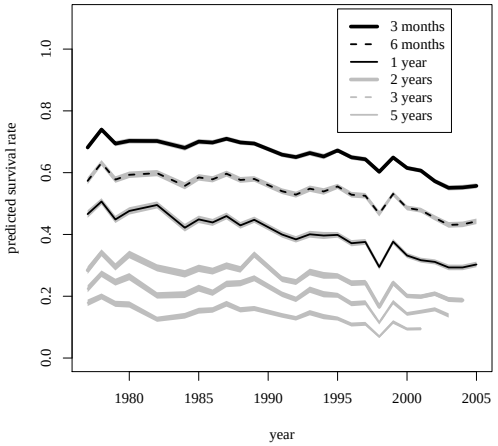

Fig. 14: 36 to 45-year old woman, skilled or unskilled manual worker in a firm of manufacturing industry employing between 50 and 499 people

Lastly, the analysis of the coefficients of age group dummies displays important changes for extreme ages (see Figures 16 and 18), which are at least partly due to their particularities (the 16-25 year old employees are on average less and less qualified and the 56-65 year-old employees' spells end because of earlier retirement). Age groups between 26 and 55 years do not exert very different effects at the beginning of the period, but there is a divergence, with a rise in the coefficient (which means an increased hazard rate) for 26-35 year old employees and a decrease for 46-55 year old employees (by comparison to the 36-45 year-old employees). As a robustness check, we tried to introduce dummies crossing socio-occupational activity and age in the model. We found that the effect of age is not very different between socio-occupational activities, except for 26-35 year-old executives who did not experience the rise that other socio-occupational categories between 26 and 35 experienced.

Characteristics of the firms

First of all, there is no clear hierarchy between the different sizes of firms: working in a bigger firm is not associated with a higher stability, for instance. For women, the link between firm size and instability remained more or less the same, except for firms above 5,000 employees, for which the stability decreased more since the 1990s, compared to firms employing 50 to 499 people. For men, stability decreased in the very big firms as well (above 5,000 employees), but also in the very small ones (under 10 employees), by comparison with firms employing 50 to 499 employees.

Concerning industries, instability followed different trends, especially since the 1990s. It

Coefficients of the Cox regression - Characteristics of the employee

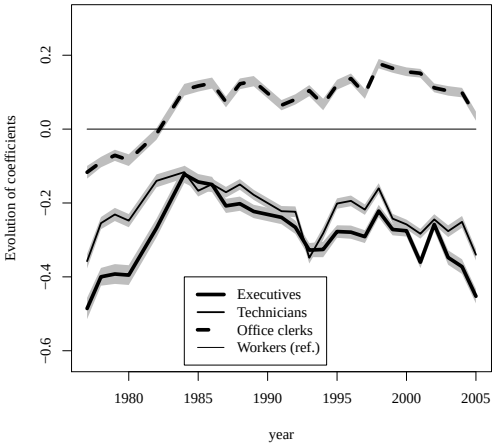

Fig. 15: Coefficients of socio-occupational category, Men

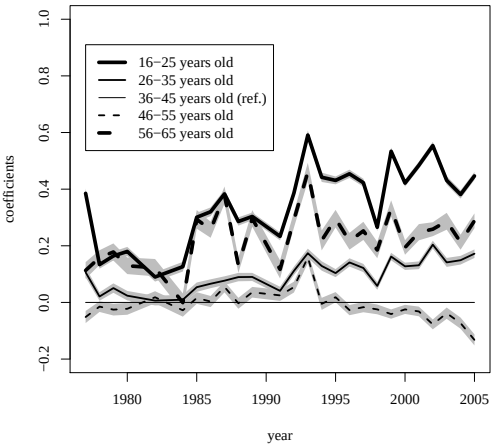

Fig. 16: Coefficients of age groups, Men

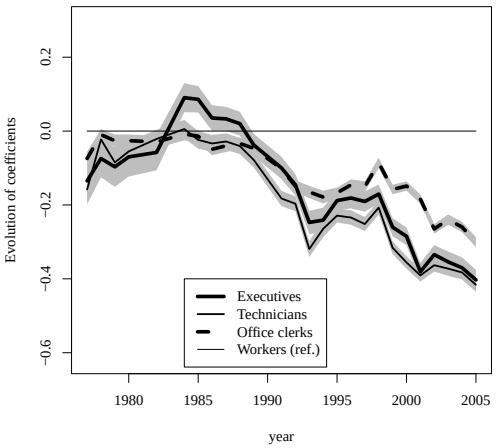

Fig. 17: Coefficients of socio-occupational category, Women

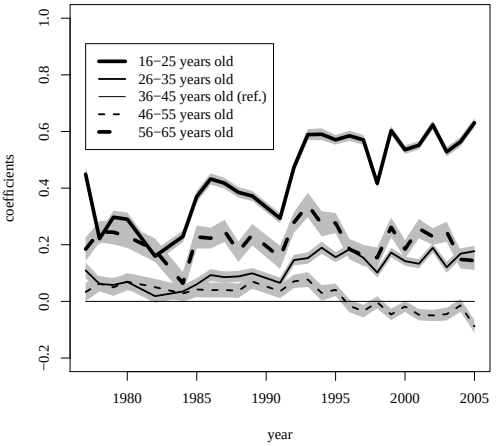

Fig. 18: Coefficients of age groups, Women

Coefficients of the Cox regression - Characteristics of the firms

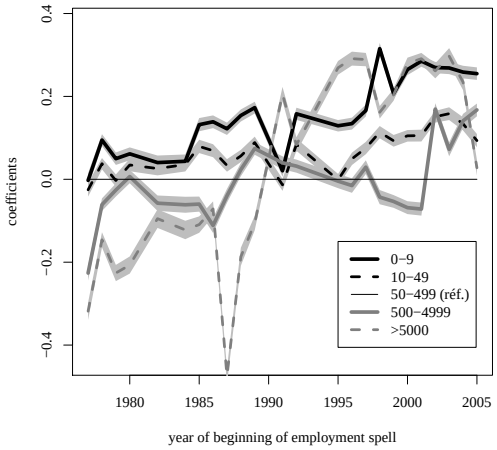

Fig. 19: Coefficients of size of the firm, Men

Fig. 20: Coefficients of industry, Men

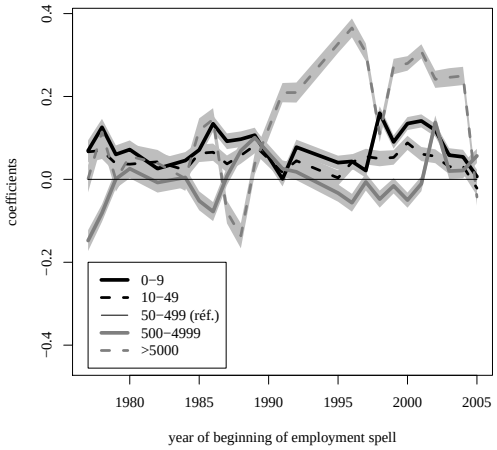

Fig. 21: Coefficients of size of the firm, Women

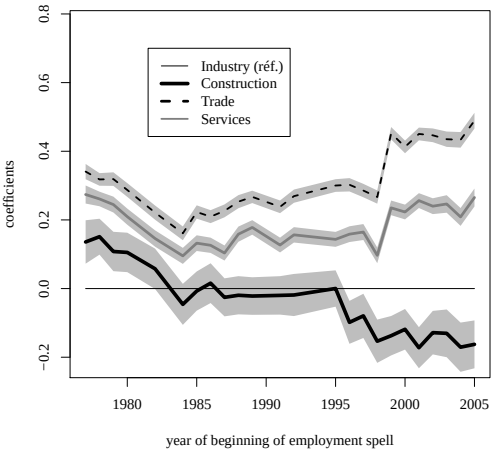

Fig. 22: Coefficients of industry, Women

6-month survival rate predicted by a Cox model - MEN

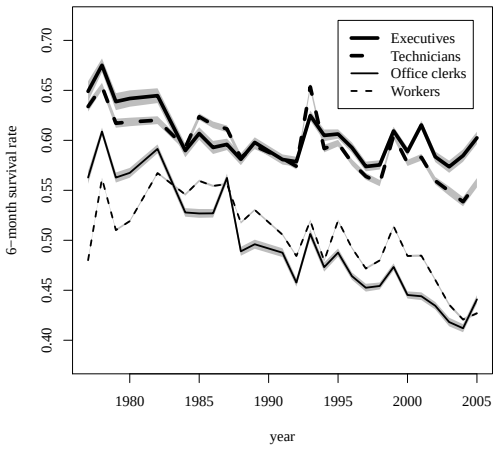

Fig. 23: 26-35-year-old man depending on socio-occupational category in a services firm employing between 50 and 499 people

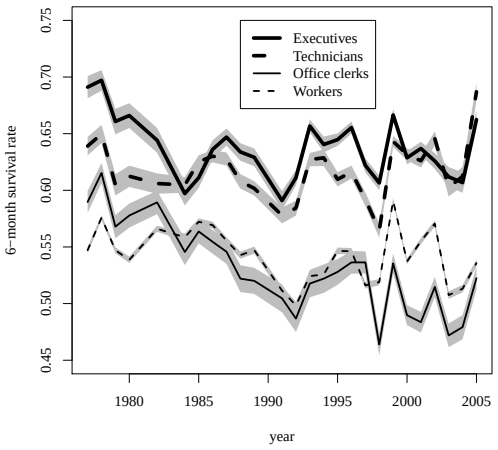

Fig. 24: 46-55-year-old man depending on socio-occupational category in a trade firm employing between 50 and 499 people

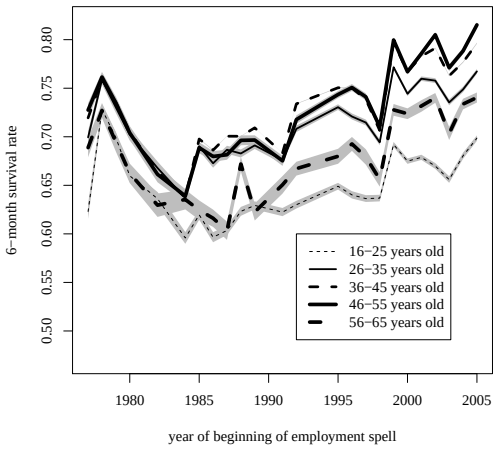

Fig. 25: Executive, man, depending on age group in a firm of manufacturing industry employing between 50 and 499 people

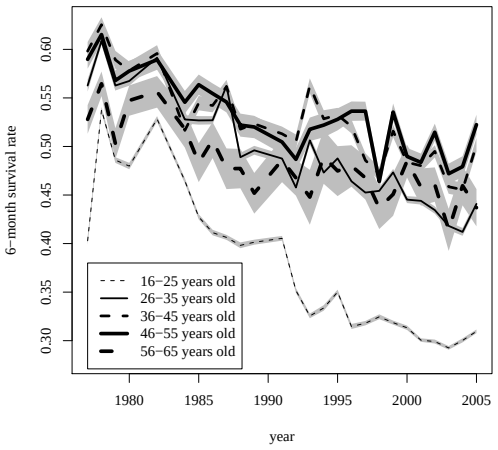

Fig. 26: Office clerk and service workers, man, depending on age group in a services firm employing between 0 and 9 people

6-month survival rate predicted by a Cox model - WOMEN

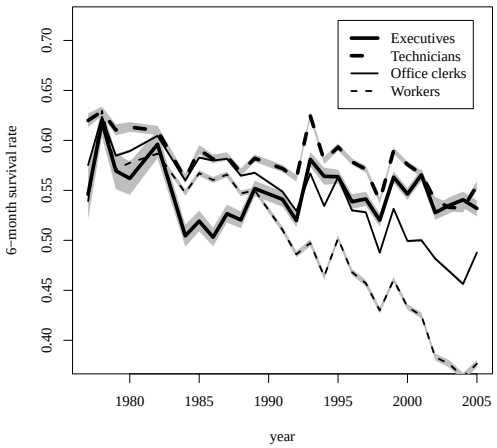

Fig. 27: 26-35-year-old woman depending on socio-occupational category in a services firm employing between 50 and 499 people

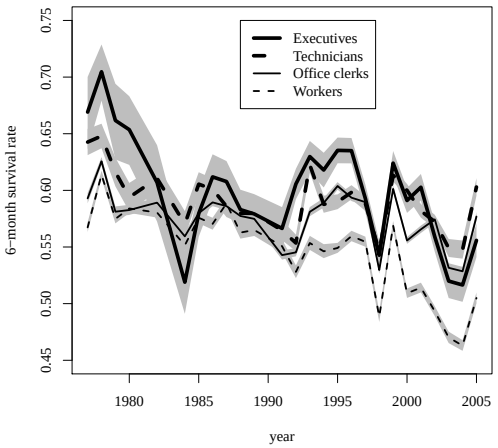

Fig. 28: 46-55-year-old woman depending on socio-occupational category in a trade firm employing more than 5,000 people

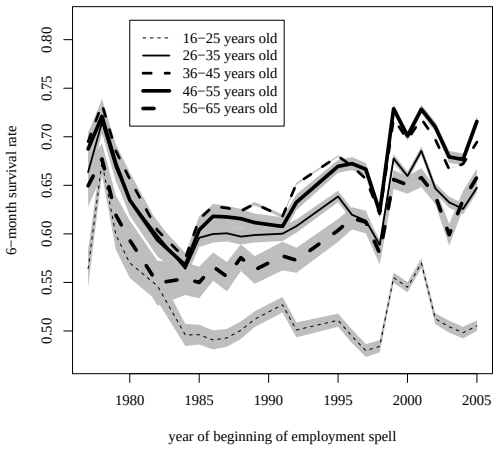

Fig. 29: Executive, woman, depending on age group in a firm of manufacturing industry employing between 50 and 499 people

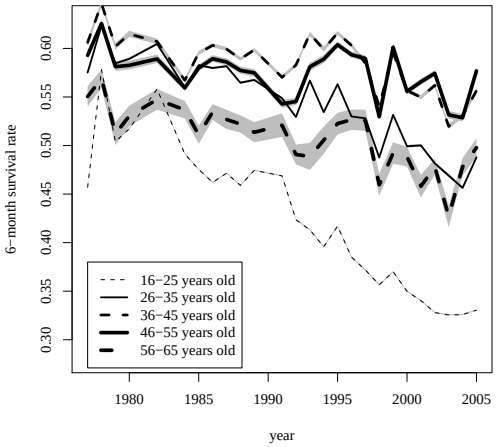

Fig. 30: Office clerk and service workers, woman, depending on age group in a services firm employing between 0 and 9 people

grew in services and trade compared to manufacturing and construction. For men the situation was already very differenciated between industries in the 1980s, while for women there was no important gap, then this gap widened a lot.

A few specific situations

After the analysis of coefficients, we study a few specific situations, for which we compare the evolutions of survival rates (see Figures 23 to 30). Indeed, coefficients are not sufficient to interpret the model in terms of evolution of instability for different categories of individuals and firms: in our proportional hazard model, the baseline hazard is different each year, so that we can only interpret the evolutions of coefficients as changes in instability for the category *by comparison to the reference category* - the latter being itself likely to have experienced changes in instability.

What is more, coefficients exert a non-linear influence on survival rates ($S(t|z) = [S_0(t)]^{\exp(z\beta)}$) which is not easy to understand without calculating them for specific characteristics of employees and firms. For example, if the survival rate of a 36-45-year-old worker in a firm of manufacturing industry employing between 50 and 499 people is $S_1(t)$, the one of the same kind of worker but in the upper age category will be $S_1(t)^{\exp(z_2\beta)}$ where z_2 is the coefficient of the 46-55 age category.

Therefore, to better understand the influence of coefficients, we present several specific situations, which take into account both the evolution of the baseline hazard and the influence of the coefficients. The results confirm a decrease of the duration of employment spells which is unequally distributed in the population, with some categories even experiencing a rise in the survival rates (for example executives of most ages in manufacturing industry firms employing 50-499 people, see Figure 25 and 29). The crucial role of age is confirmed, with an evolution of the survival rate which goes all the more toward higher instability as employees are younger (Figure 26 and 30). The 16-25 age group experienced an especially strong downward trend of stability, particularly for women. Another striking evolution is the strong decrease in the female blue-collar workers' predicted survival rate for the 26-35 age group (Figure 27). Female blue-collar workers experienced a strong decrease in their survival rate between 1977 and 2005, all other observable things considered equal, by comparison with other socio-occupational categories. Lastly, the decrease of stability in firms over 5,000 employees is confirmed when controlling for observable characteristics: no matter which socio-occupational group we consider, the decrease in the survival rate is important in the early 1990s, at least for the 46-55 group (Figure 24 and 28).

5 Firm effects and individual effects

In this section, we study time-invariant heterogeneity, at the individual level as well as at the firm level. More precisely, we intend to answer the following questions:

- Are some individuals more stable than others?
- Do some firms tend to keep their employees during longer periods of time than others?
- Is the labour market dual in the sense that the individuals who have a tendency to have short employment spells are more often hired by firms who keep their employees less?
- Do the distribution of time-invariant heterogeneity at firm and individual levels and the correlations between these two effects show differences depending on the characteristics of firms and employees and, in particular, is there an evolution across cohorts?

We may note that it could have been tempting to take into account individual heterogeneity in our Cox model – which only includes observable heterogeneity –, by introducing unobserved heterogeneity: indeed, some unobserved determinants may play a great role and the Cox model is an attractive framework. Nevertheless, the adaptability to our case is limited, as is explained in Appendix D. That is the reason why our analysis uses a very different framework in this section.

5.1 Model and estimation

In order to answer these questions, we adopt a linear framework inspired by Abowd, Kramarz, and Margolis (1999). This framework was originally used to study wages but we use it here to study the duration of employment spells. The estimated model is the following, where i represents an individual and j a firm:

$$\ln(T_{ij}) = C + x'_{ij}\beta + \alpha_i + \gamma_j + \varepsilon_{ij}$$

with T_{ij} the duration of the employment spell, C a constant term and x_{ij} containing dummies for the starting year of the spell and the age of the individual at the beginning of the spell, α_i are individual fixed effects and λ_j are firm fixed effects.

This specification makes sense when the data is complete (*i.e.* without censoring) and the underlying duration model is exponential, log-logistic or log-normal, which is quite general. In order to work on a dataset with as little censoring as possible, we will restrict our study to the spells that start in 2001 or before. The spells, which are censored in 2006, are truncated, but eventually few spells are in this case and they only represent 3% of the employment spells in our sample. A few spells are also undervalued when they begin or end during the years 1981, 1983 or 1990 for which data is missing. Note that, in this section, we do not use the imputed data from the previous sections, but rather keep the truncated spells. The main reason for this choice is that in the previous sections, all spells were considered independent whereas here, we specifically want to use the structure of the data which allows us to observe different spells for each individual. As reported in appendix, we also estimate a similar model that takes into account this censoring issue at the price of a more constrained specification of the error term. The results are

extremely similar to the ones presented here. This estimation is performed as a robustness check and is not presented as the main specification because it uses a maximum likelihood approach for which we do not provide any proof that the finite distance estimation of the individual and firm effects are unbiased.

As explained for example in Abowd, Creecy, and Kramarz (2002), in such a model the interpretation of the individual and firm fixed effects is only relevant within specific subgroups of the labour market for which we may find a relation between two employees or two firms. Indeed, individual and firm fixed effects are only defined up to an additive constant and their estimation requires some normalization for each separate subgroup (*e.g.* $\sum \alpha_i = 0$ and $\sum \gamma_j = 0$). It is therefore impossible, without further assumptions, to compare them between two separate subgroups.

More precisely, if we define the relation $\mathcal{R}$ such that:

- If x and y worked in the same firm (not necessarily at the same time), then $x\mathcal{R}y$
- If $x\mathcal{R}y$ and $y\mathcal{R}z$ then $x\mathcal{R}z$ (transitivity)

by construction, $\mathcal{R}$ is an equivalence relation and the firm and individual fixed effects can be defined on every equivalence class.

More intuitively, two individuals belong to the same equivalence class if and only if it is possible to find a (not necessarily unique) *chain* between them that would involve individuals *linked* to each other by the fact that each pair worked at some point in the same firm (not necessarily at the same time). The firms involved in each link do not have to be the same.

The same intuition applies to firms to define their classes of equivalence.

Practically, in our sample, the largest equivalence class represents 91% of individuals, 87% of firms and 97% of employment spells. We restrict the estimation of parameters α_i and γ_j to this equivalence class only. Moreover, for identification purposes we impose the restrictions: $\sum_i \alpha_i = 0$ and $\sum_j \gamma_j = 0$.

We estimate this double fixed-effect model with an iterative method (Gauss-Seidel algorithm) which consists in estimating the α_i, γ_j, and β successively and in repeating this procedure. The algorithm converges here after nearly 600 iterations (with a maximal gap between two successive values of the estimated coefficients of 10^{-4}). This way, we obtain 1,326,267 individual fixed effects and 965,695 firm fixed effects from our 5,628,028 employment periods. We may fear that, separately, each coefficient may be estimated quite imprecisely but here, we are not interested in their exact value but rather in summary statistics like means by subpopulations.

5.2 Results

We study the mean firm and individual fixed effects according to the characteristics of the firms and individuals.

Table 1: Mean fixed effects depending on firm size

Size group	Individual fixed effect (*)		Firm fixed effect	
	Estimate	95% confidence interval	Estimate	95% confidence interval
0	-0,43	[-0,44 ; -0,42]	-0,92	[-0,93 ; -0,90]
1–4	-0,29	[-0,29 ; -0,28]	0,00	[-0,01 ; 0,00]
5–9	-0,23	[-0,23 ; -0,22]	0,08	[0,07 ; 0,09]
10–19	-0,19	[-0,20 ; -0,19]	0,06	[0,05 ; 0,07]
20–49	-0,11	[-0,12 ; -0,11]	0,09	[0,08 ; 0,10]
50–99	-0,05	[-0,06 ; -0,04]	0,13	[0,12 ; 0,15]
100–249	0,02	[0,01 ; 0,03]	0,19	[0,17 ; 0,20]
250–499	0,04	[0,03 ; 0,06]	0,25	[0,24 ; 0,27]
500–999	0,12	[0,09 ; 0,14]	0,30	[0,27 ; 0,33]
1000–1999	0,13	[0,09 ; 0,16]	0,28	[0,24 ; 0,33]
2000–4999	0,13	[0,09 ; 0,18]	0,29	[0,23 ; 0,35]
5000 and more	0,22	[0,14 ; 0,29]	0,22	[0,11 ; 0,33]

Source: DADS, 1/25 panel
Careers only in the private sector.
(*) More precisely: Average individual fixed effect for the ones working in a firm of the size group.
Fixed effects are defined up to an additive constant.
Size of the firm is defined as the number of employees on December 31 of a given year. As this variable may change over the years, we consider here its most frequent value for each firm. Firms with size 0 have no permanent employee on December 31, either because of the nature of their activity or because they are closed.

On the one hand, we analyze the mean firm effect by firm size and industry, and the mean individual effect of the individuals who work in these firms. On the other hand, for each socio-occupational category and each cohort, we study the mean individual effect and the mean effect of the firms in which these employees work.

5.2.1 Firm size

The mean firm fixed effect increases with the size of the firm, but it is also true for the mean value of individual fixed effects.

The difference of mean fixed effects between the smallest firms and the biggest ones is of the same order of magnitude for individual and firm fixed effects. This suggests that the idea according to which employment spells are longer in larger firms is equally due to the firms themselves and to the employees who work in these firms.

Note that firms of size 0 on December 31 of a given year concentrate most of the negative firm fixed effects. Such a size corresponds either to firms that have a seasonal activity or to firms that closed during the year.

5.2.2 Industry

There are great disparities across industries. Manufacturing and trade industries tend to employ rather more stable individuals than the average, but the firms are themselves in the average, if we consider their fixed effects (see table 2 and 3).

On the contrary, some sectors like catering, the recreative sector and associative activities tend to have shorter employment spells, and it is explained in the same proportion by the firms and by the employees working for them.

Personal and domestic services are specific in the sense that they have firm fixed effects which are rather larger than the average but they also employ individuals who are rather more unstable than the average. This may probably be explained by the following: these firms offer secondary jobs for employees from other sectors who face difficulties to settle down in the labour market, but these firms allow employees to stay in the firm if they want to.

Lastly, financial activities have simultaneously individual and firm fixed effects which are higher than in the other sectors.

5.2.3 Socio-occupational categories

Executives as well as technicians and associate professionals tend to be more stable and to work in firms which keep their employees longer (see table 4). Quite the opposite, office clerks and service workers work in firms which keep their employees rather slightly less than the average, and they are individually far less stable. Lastly, blue-collar workers work in the firms which have the lowest stability but they are rather slightly over the average in terms of individual stability.

Note that individuals may experience changes in their social category. However, because theses changes are infrequent and also because of suspected coding errors we prefer focusing on its most frequent value for each individual.

5.2.4 Cohorts

Note that, although the age at the beginning of the spell partly controls for it, individuals are still observed during different periods of their careers. The cohort of individuals who were born in 1922 was 55 years old in 1977 and their individual fixed effects were consequently calculated on the basis of the end of the career only. On the contrary, the cohort born in 1976 was 25 years old in 2001 and their individual fixed effects were calculated with their very first employment periods. Moreover, our specification does not allow us to estimate age $\times$ cohort effects, and it could well be that the estimated cohort effect could be driven by an effect on the younger ages only.

It remains that both firm fixed effects and individual fixed effects tend to diminish very strongly from the cohort born in 1950, which suggests that the most recent cohorts tend to be less stable and to be hired in firms which keep their employees for the shortest periods of time (table 5).

Table 2: Mean individual fixed effects depending on the sector of the firm

Sector	Individual fixed effect (*)	95% confidence interval
Agriculture, forestry and fishing	0,19	[-0,07 ; 0,44]
Manufacturing of food products	-0,02	[-0,04 ; 0,00]
Manufacture of wearing apparel and leather	0,24	[0,21 ; 0,26]
Publishing, printing and reproduction	0,00	[-0,02 ; 0,03]
Manufacture of pharmaceutical products, perfumes and detergents	0,17	[0,11 ; 0,22]
Household facilities industries	0,21	[0,18 ; 0,24]
Manufacture of motor vehicles	0,15	[0,09 ; 0,21]
Shipbuilding, aircraft and railroad construction	0,13	[0,06 ; 0,20]
Manufacture of mechanical engineering	0,14	[0,12 ; 0,16]
Manufacture of electrical and electronical engineering	-0,04	[-0,07 ; -0,01]
Manufacture of mineral products	0,24	[0,21 ; 0,28]
Manufacture of textiles	0,36	[0,32 ; 0,39]
Manufacture of wood and paper	0,22	[0,18 ; 0,25]
Manufacture of chemicals, rubber and plastics products	0,15	[0,12 ; 0,18]
Manufacture of metallurgy and metal processing	0,18	[0,16 ; 0,20]
Manufacture of electrical and electronical components	0,00	[-0,05 ; 0,06]
Construction	0,05	[0,04 ; 0,06]
Trade and repair of motor vehicles	0,05	[0,03 ; 0,06]
Wholesale, agents involved in sale	0,20	[0,18 ; 0,21]
Retail trade, repair	-0,01	[-0,02 ; 0,00]
Transporting	0,03	[0,01 ; 0,04]
Financial activities	0,23	[0,19 ; 0,26]
Real estate activities	0,22	[0,20 ; 0,24]
Support service and consultancy activities	-0,01	[-0,03 ; 0,00]
Cleaning, human resource provision and other operational services	-0,09	[-0,11 ; -0,08]
Scientific research and development	0,04	[-0,08 ; 0,16]
Accommodation and food service activities	-0,31	[-0,32 ; -0,30]
Entertainments, cultural and sports activites	-0,29	[-0,31 ; -0,26]
Residential care and personal service activities	-0,29	[-0,32 ; -0,26]
Education	0,05	[0,01 ; 0,09]
Human health and social work activities	0,04	[0,02 ; 0,06]
Activities of membership organisations and extraterritorial activities	-0,08	[-0,11 ; -0,05]

Source: DADS, 1/25 panel

Careers only in the private sector.

(*) More precisely: Average individual fixed effect for the ones working in a firm of the sector.

Fixed effects are defined up to an additive constant.

Only the sectors for which we have a sufficient number of observations are displayed. As this variable may change over the years, we consider here its most frequent value for each firm.

Table 3: Mean firm fixed effects depending on the sector of the firm

Sector	Firm fixed effect	95% confidence interval
Agriculture, forestry and fishing	-0,76	[-1,12 ; -0,41]
Manufacturing of food products	-0,07	[-0,10 ; -0,05]
Manufacture of wearing apparel and leather	-0,14	[-0,17 ; -0,11]
Publishing, printing and reproduction	-0,18	[-0,21 ; -0,14]
Manufacture of pharmaceutical products. perfumes and detergents	-0,02	[-0,10 ; 0,06]
Household facilities industries	-0,05	[-0,09 ; -0,02]
Manufacture of motor vehicles	0,06	[-0,01 ; 0,14]
Shipbuilding, aircraft and railroad construction	-0,02	[-0,10 ; 0,07]
Manufacture of mechanical engineering	-0,15	[-0,18 ; -0,12]
Manufacture of electrical and electronical engineering	0,12	[0,08 ; 0,16]
Manufacture of mineal products	0,01	[-0,03 ; 0,06]
Manufacture of textiles	0,01	[-0,04 ; 0,06]
Manufacture of wood and paper	-0,12	[-0,17 ; -0,07]
Manufacture of chemicals. rubber and plastics products	-0,09	[-0,13 ; -0,05]
Manufacture of metallurgy and metal processing	-0,12	[-0,15 ; -0,09]
Manufacture of electrical and electronical components	0,09	[0,01 ; 0,16]
Construction	-0,14	[-0,15 ; -0,13]
Trade and repair of motor vehicles	0,06	[0,04 ; 0,08]
Wholesale, agents involved in sale	-0,16	[-0,17 ; -0,14]
Retail trade, repair	-0,10	[-0,11 ; -0,09]
Transporting	-0,25	[-0,28 ; -0,23]
Financial activities	0,15	[0,11 ; 0,19]
Real estate activities	-0,30	[-0,32 ; -0,27]
Support service and consultancy activities	-0,09	[-0,11 ; -0,07]
Cleaning, human resource provision and other operational services	-0,49	[-0,52 ; -0,47]
Scientific research and development	-0,07	[-0,21 ; 0,08]
Accommodation and food service activities	-0,42	[-0,44 ; -0,41]
Entertainments, cultural and sports activites	-0,72	[-0,76 ; -0,69]
Residential care and personal service activities	0,35	[0,31 ; 0,39]
Education	-0,22	[-0,27 ; -0,17]
Human health and social work activities	-0,15	[-0,17 ; -0,12]
Activities of membership organisations and extraterritorial activities	-0,48	[-0,53 ; -0,44]

Source: DADS, 1/25 panel

Careers only in the private sector.

Fixed effects are defined up to an additive constant.

Only the sectors for which we have a sufficient number of observations are displayed. As this variable may change over the years, we consider here its most frequent value for each firm.

Table 4: Mean fixed effects depending on the socio-occupational category

Socio-occupational activity	Individual fixed effect	95% confidence interval	Firm fixed effect (*)	95% confidence interval
Executives	0,24	[0,23 ; 0,25]	0,17	[0,16 ; 0,18]
Technicians and associate professionals	0,17	[0,17 ; 0,18]	0,10	[0,09 ; 0,10]
Office clerks and service workers	-0,22	[-0,23 ; -0,22]	-0,07	[-0,07 ; -0,06]
Skilled and unskilled workers	0,05	[0,04 ; 0,05]	-0,11	[-0,11 ; -0,11]

Source: DADS, 1/25 panel

Careers only in the private sector.

Fixed effects are defined up to an additive constant.

(*) More precisely: Average firm fixed effect for the firms employing workers of the socio-occupational activity.

Table 5: Mean fixed effects depending on birth cohort

Year of birth	Individual fixed effect	95% confidence interval	Firm fixed effect (*)	95% confidence interval
1922	1,85	[1,81 ; 1,88]	0,12	[0,09 ; 0,14]
1924	1,65	[1,62 ; 1,68]	0,09	[0,07 ; 0,11]
1926	1,55	[1,53 ; 1,58]	0,08	[0,06 ; 0,10]
1928	1,36	[1,34 ; 1,39]	0,08	[0,07 ; 0,10]
1930	1,29	[1,27 ; 1,31]	0,06	[0,05 ; 0,08]
1932	1,22	[1,20 ; 1,24]	0,07	[0,06 ; 0,09]
1934	1,10	[1,08 ; 1,12]	0,09	[0,07 ; 0,10]
1936	0,99	[0,97 ; 1,01]	0,08	[0,07 ; 0,09]
1938	0,90	[0,88 ; 0,92]	0,07	[0,05 ; 0,08]
1940	0,75	[0,73 ; 0,77]	0,06	[0,05 ; 0,08]
1942	0,70	[0,68 ; 0,72]	0,06	[0,05 ; 0,07]
1944	0,62	[0,60 ; 0,64]	0,06	[0,05 ; 0,07]
1946	0,54	[0,52 ; 0,55]	0,07	[0,06 ; 0,08]
1948	0,45	[0,44 ; 0,47]	0,05	[0,05 ; 0,06]
1950	0,32	[0,30 ; 0,33]	0,03	[0,02 ; 0,04]
1952	0,22	[0,21 ; 0,23]	0,02	[0,01 ; 0,03]
1954	0,14	[0,12 ; 0,15]	0,00	[-0,01 ; 0,00]
1956	0,02	[0,01 ; 0,04]	-0,04	[-0,05 ; -0,03]
1958	-0,05	[-0,06 ; -0,03]	-0,07	[-0,08 ; -0,06]
1960	-0,14	[-0,15 ; -0,13]	-0,07	[-0,07 ; -0,06]
1962	-0,24	[-0,25 ; -0,22]	-0,06	[-0,06 ; -0,05]
1964	-0,34	[-0,36 ; -0,33]	-0,08	[-0,09 ; -0,07]
1966	-0,46	[-0,47 ; -0,44]	-0,09	[-0,10 ; -0,08]
1968	-0,54	[-0,55 ; -0,53]	-0,09	[-0,10 ; -0,08]
1970	-0,68	[-0,69 ; -0,67]	-0,10	[-0,11 ; -0,09]
1972	-0,82	[-0,83 ; -0,80]	-0,12	[-0,13 ; -0,11]
1974	-0,94	[-0,95 ; -0,92]	-0,15	[-0,16 ; -0,14]
1976	-1,02	[-1,04 ; -1,01]	-0,18	[-0,18 ; -0,17]

Source: DADS, 1/25 panel

Careers only in the private sector.

Fixed effects are defined up to an additive constant.

(*) More precisely: Average firm fixed effect for the firms employing workers of the birth cohort.

6 Conclusion

These results clearly suggest that the stability on the labour market decreased during the last thirty years. Instability is unequally distributed among age groups, socio-occupational categories, and among sectors, and instability results both from firm and individual time-invariant factors. More precisely, the main lessons about employment instability we may draw from our analysis of survival rates are the following:

- Since the early 1990s, the employment survival rate has followed a downward trend;
- During this period, the probability of ending of an employment spell is constantly lower for executives or technicians and professional associates than for service workers and blue-collar workers, and for employees between 36 and 50 years old than for employees of other age groups;
- The stability gap between socio-occupational categories decreased in the mid 1980s before increasing again; female blue-collar workers' stability evolved in a less favourable way than other female categories while there is a polarization at the end of the period between male executives and technicians on the one hand, and workers and office clerks on the other hand;
- Women became more unstable than men in the 1990s, which may be explained by legislative changes and perhaps composition effects, but the difference remains small;
- The increase of the instability we observe at an aggregate level is not evenly distributed between age groups, it concerns employees all the more as they are younger, if we except employees older than 55 (in relation with earlier retirement).

Moreover, the implementation of a double fixed effect model allows us to understand more precisely the factors of instability. Our main findings are the following:

- The longer duration of employment spells we observe in bigger firms is equally due to the firms themselves and to the employees who work in these firms;
- There is a great variety of patterns across sectors;
- Office clerks and service workers are the individually less stable individuals, while blue-collar workers are the ones who are employed by the firms which keep their employees for the shortest periods of time;
- The younger a cohort, the lower the individual stability and the higher the probability to work in a firm with a low propensity to keep its employees.

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A Imputations

As it was exposed in the section presenting the data, the years 1981, 1983 and 1990 are missing in our database, because the administrative reports were not handled these years. A first treatment was applied to the spells which are concerned by these missing years: if the employees were in a firm before and after the year preceeding the missing year, we consider they were in this firm during the missing year and we create the missing observation.
There is still a problem of censoring, which exclusively affects the spells beginning in 1991 and before:

- *Left-censoring* : a large proportion of the spells whose starting date is January 1 of years 1982, 1984 and 1991 begin in reality in 1981, 1983 and 1990 respectively.
- *Right-censoring*: a large proportion of the spells ending on December 31 of years 1980, 1982 and 1989 end in reality in 1981, 1983 and 1990 respectively.

To deal with these censoring issues, we implement a procedure of selection and imputation of spells (except for Section 5):

- For left-censored data, in a first step we take a year which is not left-censored and calculate the proportion of spells beginning on January 1 in the total number of spells which begin in the previous year or January 1 of the current year. This figure is used to determine the proportion of spells of left-censored years which are supposed to really begin on January 1. In a second step, the lengths of these selected spells are imputed by randomly selecting spells among the ones which begin on January 1 of a non-censored year. The number of spells selected this way is presented in table 7.
- For right-censored data, the spells which end on December 31 of 1980, 1982 or 1989 are replaced by some spells which are randomly selected among the spells whose characteristics are the following: they begin on a particular year, as close as possible to the one of the replaced spell, and their duration is compatible with the one of the censored spell if it were not censored. For example, if we consider a spell whose starting date is February 5, 1989, and whose date of end is December 31, 1989, according to our data, this spell may be right-censored because 1990 is missing, so we randomly select a spell among spells beginning on the third period of fifteen days of 1988 and ending between December 31, 1988 and December 31, 1989.

As a result,

- Between 47% and 56% of spells are removed from the sample because of left-censoring in years 1982, 1984 and 1991 (table 7 and 8).
- The proportion of imputed spells because of right-censoring is highly variable according to the year (tables 7 and 8). The year 1982 is affected by both left and right censoring, that

Survival rates before and after imputations (Kaplan Meier estimator)

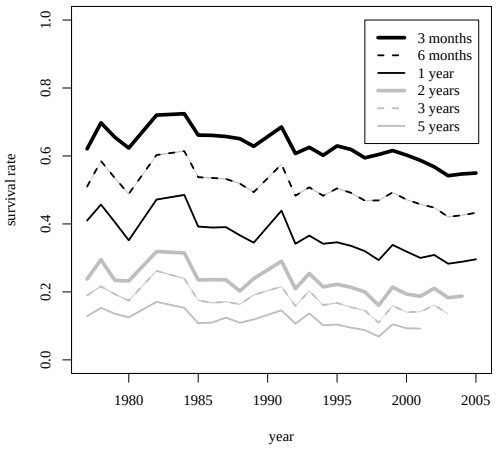

Fig. 31: Survival rates *before* imputations

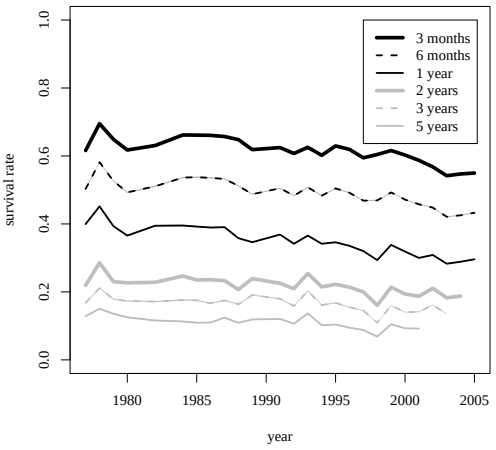

Fig. 32: Survival rates *after* imputations

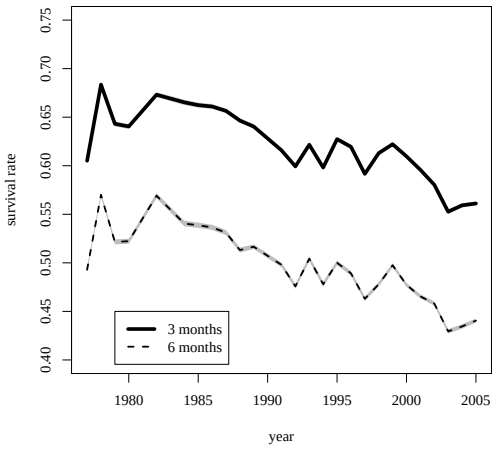

Fig. 33: Survival rates with imputations (Men)

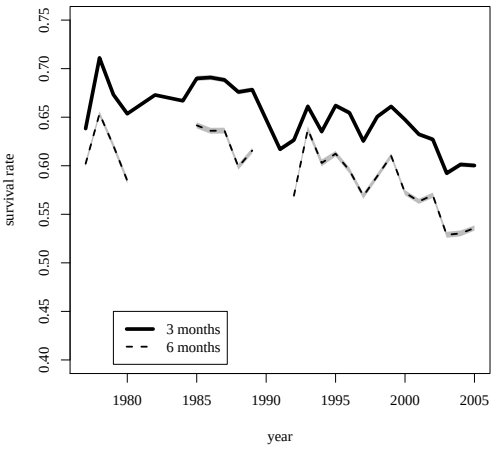

Fig. 34: Survival rates without any imputation (Men)

is why it displays the highest rate of imputed spells (74% of selected spells for men and 72% for women).

This procedure seems to produce quite satisfying results, if we consider its impact on final results (Figures 31 and 32). The irregularities of the figures which existed before imputations (Figure 31) mostly disappear after them (Figure 32), which suggests that our procedure significatively improves estimates.

To test the validity of our imputations, we also compare the estimated survival rates and their evolutions with the results of survival rates calculated without any imputations, for years without any censoring (every year except 1981, 1982, 1983, 1984, 1990, 1991). The result of this estimation is exposed in Figure 34, which must be compared to Figure 33. There is a difference in the level but the evolution seems coherent with our previous results, which tends to confirm the validity of our imputations.

The main effect of this procedure is to decrease the level of points 1982, 1984 and 1991, which were higher than the other ones around. One could be surprised by this effect, for we remove censored spells, whose length was consequently shorter due to the censoring. So one could expect that taking into account censoring would decrease the average duration (and therefore survival rates). In reality, by taking into account left censoring, we remove spells which seem to start on January 1 (1982, 1984 or 1991) but which in reality begin the year before (1981, 1983 or 1990). These spells are not randomly selected among the spells which begin a given year: they last until the beginning of the following year, which means that they reached a certain duration, and they are consequently longer, on average, than the spells which really begin in January. In a word, it is as if our selection of spells to be removed were conditional to a minimum duration.

Table 6: Statistics about imputed and removed spells

Main statistics		
(1)		Initial number of spells
(2)		Number of left-censored spells
(3)		Number of right-censored spells
(4)	=(1)-(7)	Final number of spells
(5)	=(9)+(10)	Number of imputed spells
(6)	=(5)/(4)	Proportion of imputed spells among remaining spells
Statistics about left-censoring		
(7)		Number of spells removed from sample because of left-censoring
(8)	=(7)/(2)	Proportion of spells removed from sample because of left-censoring
(9)	=(2)-(7)	Number of imputed spells because of left-censoring
Statistics about right-censoring		
(10)		Number of imputed spells because of right-censoring

Table 7: Statistics about imputed and removed spells - MEN

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1977	117 031	-	3 387	117 031	3 387	3%	-	-	-	3 387
1978	167 668	-	9 433	167 668	9 433	6%	-	-	-	9 433
1979	147 580	-	13 226	147 580	13 226	9%	-	-	-	13 226
1980	138 287	-	43 848	138 287	43 848	32%	-	-	-	43 848
1981	-	-	-	-	-	-	-	-	-	-
1982	161 420	81 951	49 887	115 470	85 888	74%	45 950	56%	36 001	49 887
1983	-	-	-	-	-	-	-	-	-	-
1984	157 787	85 006	-	118 106	45 325	38%	39 681	47%	45 325	-
1985	130 901	-	3 293	130 901	3 293	3%	-	-	-	3 293
1986	140 111	-	4 665	140 111	4 665	3%	-	-	-	4 665
1987	149 771	-	7 730	149 771	7 730	5%	-	-	-	7 730
1988	153 405	-	14 294	153 405	14 294	9%	-	-	-	14 294
1989	172 325	-	50 761	172 325	50 761	29%	-	-	-	50 761
1990	-	-	-	-	-	-	-	-	-	-
1991	213 412	99 210	-	166 179	51 977	31%	47 233	48%	51 977	-

Note : See table 6 for contents of columns

Table 8: Statistics about imputed and removed spells - WOMEN

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1977	53 377	-	1 935	53 377	1 935	4%	-	-	-	1 935
1978	80 170	-	5 506	80 170	5 506	7%	-	-	-	5 506
1979	69 411	-	6 934	69 411	6 934	10%	-	-	-	6 934
1980	67 270	-	21 861	67 270	21 861	32%	-	-	-	21 861
1981	-	-	-	-	-	-	-	-	-	-
1982	84 968	41 576	25 931	62 791	45 330	72%	22 177	53%	19 399	25 931
1983	-	-	-	-	-	-	-	-	-	-
1984	98 572	52 879	-	73 504	27 811	38%	25 068	47%	27 811	-
1985	78 989	-	2 150	78 989	2 150	3%	-	-	-	2 150
1986	81 098	-	2 688	81 098	2 688	3%	-	-	-	2 688
1987	86 048	-	4 717	86 048	4 717	5%	-	-	-	4 717
1988	88 298	-	8 238	88 298	8 238	9%	-	-	-	8 238
1989	98 894	-	29 591	98 894	29 591	30%	-	-	-	29 591
1990	-	-	-	-	-	-	-	-	-	-
1991	127 971	61 132	-	98 877	32 038	32%	29 094	48%	32 038	-

Note : See table 6 for contents of columns

B Kaplan-Meier estimator

Kaplan-Meier estimator is constructed in a quite similar way as the empirical cumulative function. But contrary to the latter, it takes into account right censoring. In case of right censoring, the parameter of interest is no longer the observed duration X, but the underlying duration T, which would be observed in case of no censoring.
We observe successive survivals at dates $t_0, t_1, \ldots, t_i, \ldots, t_N, \ldots, t_{K-1}$ which are characterized by $t_0 \leq t_1 \leq \ldots \leq t_i \leq \ldots \leq t_N \leq \ldots \leq t_K$. So we have grouped data, which means that several departures may occur during the time interval $I_j =]t_{j-1}, t_j[$. We know t_j for each date:

- $m_{j,K}$ number of departures during the time interval $I_j =]t_{j-1}, t_j[$.
- $c_{j,K}$ number of censored observations in the interval I_j.
- $n_{j,K}$ number of observations in the sample at date t_{j-1} in the time interval I_j, which have consequently neither been interrupted nor censored in t_{j-1}. It is the risk set in t_j.

$$\hat{S}_{K,N}(t) = \prod_{j/t_j \leq t} (1 - \frac{m_{j,K}}{n_{j,K} - c_{j,K}}) \tag{2}$$

C Cox models and semi-parametrical estimation

The Cox model is a proportional hazard model, which means that different values of the exogenous variables Z give proportional values of the hazard rate.
In these models, the hazard has the following form:

$$h(t|z) = h_0(t).\phi(z, \beta) \tag{3}$$

where $h_0(t)$ is the base hazard rate and z are the covariates.

The model may be interpreted this way: a covariate which makes function ϕ differ from the reference level generates a multiplicative effect of the same magnitude on the hazard rate, at every date t.
In this framework, the k-th coefficient of β measures the elasticity of the hazard rate to the k-th covariate (which is supposed to be constant over time):

$$\beta_k = \frac{\partial ln h(t|z)}{\partial z_k} \tag{4}$$

In a Cox model framework, ϕ is an exponential function such that $\phi(z\beta) = \exp(z, \beta)$ and the hazard function may then we written as:

$$h(t|z) = h_0(t). \exp(z\beta) \tag{5}$$

where $h_0(t)$ is the hazard rate and z are the covariates.

The coefficients β of the covariates can be estimated by maximum likelihood provided that we choose a specification of the baseline hazard. The specificity of the Cox model lies in the possibility to estimate β without specifying the baseline hazard h_0. To achieve this, one must use a particular semi-parametric method of resolution, based on maximization of a part of the likelihood of observations, the partial likelihood.

Let us assume that the duration T is continuous, and that exits happen at distinct moments $t_0 < t_1 < ... < t_i < ... < t_N$, with $t_0 = 0$. R_j is the set of indexes of individuals at risk just before the moment t_j .
Then the "Cox partial likelihood" may be written:

$$\ell_p = \prod_{1 \leq j \leq N} \frac{\exp(z_j(t_j)\beta)}{\sum_{k \in R_j}(\exp(z_k(t_j)\beta))} \tag{6}$$

Andersen et Gill (1982) proved that under some regularity conditions, the estimator obtained by the maximization of the partial likelihood is convergent and asymptotically normal.

The survival of an individual whose characteristics are z, predicted by the Cox model, may be inferred from the baseline survival function:

$$S(t|z) = [S_0(t)]^{\exp(z\beta)} \tag{7}$$

D Unobserved heterogeneity in duration models

The analysis of the determinants of durations in our Cox model is limited to the factors which are available in our dataset – gender, age, socio-occupational category, size and industry of the firm – which may seem restrictive since some unobserved determinants may play a great role. These factors may be pieces of information which are not in our data (like diploma) or characteristics of the individuals which are difficult to observe. Adding an unobserved heterogeneity variable then allows us in particular, by removing a source of bias, to evaluate more precisely the effect of observable characteristics.

In practice, introducing unobserved heterogeneity consists in adding an individual effect, which may be specified as a fixed effect or a random effect depending on the hypothesis we are willing to make about the possible correlation between covariates and unobserved heterogeneity.

Unfortunately, the implementation of a fixed effect model requires some conditions which do not hold here.

Next section presents the conditions required to implement this framework and their relevance for our particular case.

D.1 Fixed effects

The introduction of fixed effects in duration models supposes that some problems may have been solved. Yamaguchi (1986) presents the three issues that the implementation of this method raises:

1. Exogeneity: this condition assumes that the expectation of the dependent variable (here, duration) conditional on covariates at every date is equal to the expectation of the dependent variable conditional on covariates at the current date.

2. Right censoring: The date of censoring is not independent from the duration, since the longer the first spell, the more likely the next one to be censored. Horowitz and Lee (2004) propose a solution to handle this difficulty, but its implementation requires that the exogeneity condition holds.

3. The number of employment spells must be independent from the duration of each period of time. If this condition does not hold, Yamaguchi (1986) proposes to select two employments spells, either randomly or by taking the first ones.

Here the first condition (exogeneity) does not hold if the framework is an individual fixed effect model. Indeed, the starting date of a spell depends on the duration of the previous spell, which is itself related to unobserved heterogeneity. Given this heterogeneity element is also present in the current spell, a problem of endogeneity exists. So for example, the duration expectations of employment spells are different if we simply condition on the starting date of the current spell or if we condition also on the starting date of the next one. Because of this, the

Comparison between the simple model and the fixed effects models
Coefficient of the yearly dummy, men

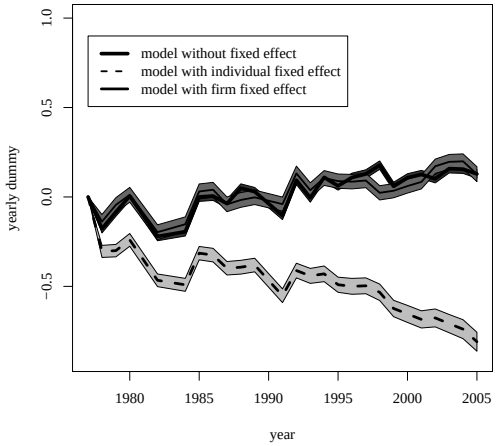

Fig. 35: All spells

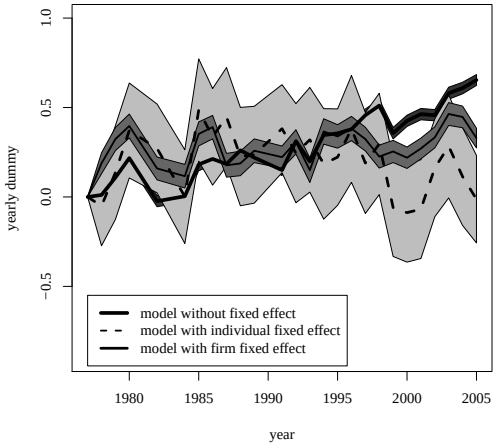

Fig. 36: Selection of two spells

right censoring problem cannot be handled with Horowitz and Lee (2004)'s method. The implementation of an individual fixed effects model therefore gives unreliable results. By the way, the comparison between models reveals that the diagnosis of this individual fixed-effect model about the effect of the date on the hazard rate strongly differs from that of other models (see Figure 35).

Moreover, the third criterion does not hold since we observe individuals during a period whose duration is fixed (30 years) and in which the number of spells and their duration are strongly linked. Indeed, the longer the first employment spell, the more likely the total number of spells to be low. The non-respect of this criterion is confirmed by an informal test with our data: when we implement the method proposed by Yamaguchi (1986) in our particular case by selecting two spells randomly, the diagnosis of the individual fixed effect model converges toward that of other models (see Figure 36). There is even no significative difference if we consider the large confidence intervals of the yearly coefficient of the model with fixed effects. If the number of spells were independent of the duration, selecting two spells would change nothing.

D.2 Random effects

The individual effect may also be specified as a random effect, which means that it is a random variable whose distribution has to be specified. But the main difference with the fixed effect specification lies in the core hypothesis of the two models: Independence between the covariates and the element of unobserved heterogeneity. Whereas the fixed effect specification does not assume anything in this domain, implementing a random effect model requires that this

condition holds.

This kind of model requires much processing time, that is why only simple tests were implemented. No notable difference with the model without unobserved heterogeneity were noticed, that is why no further investigation was made.

E Kaplan-Meier estimates of survival rates

Survival rate, by gender (separate estimates)

Fig. 37: 3-month survival rate

Fig. 38: 6-month survival rate

Fig. 39: 1-year survival rate

Fig. 40: 2-year survival rate

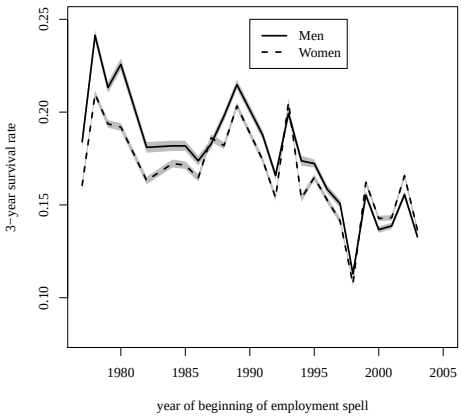

Fig. 41: 3-year survival rate

Fig. 42: 5-year survival rate

Survival rate, by socio-occupational category - MEN

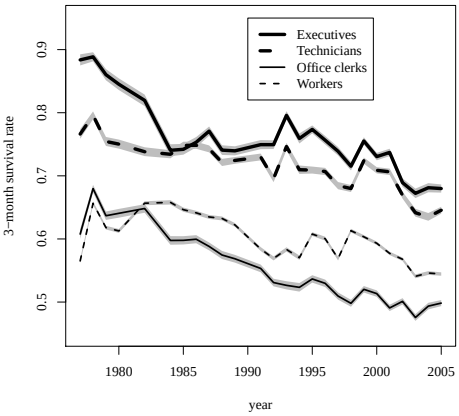

Fig. 43: 3-month survival rate

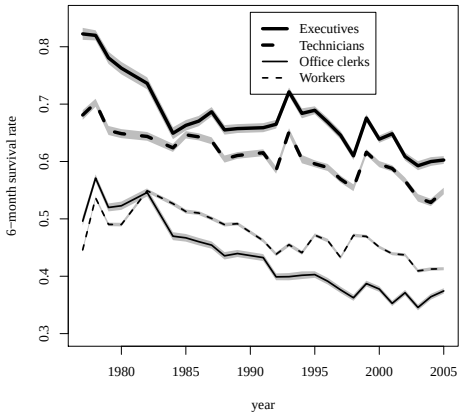

Fig. 44: 6-month survival rate

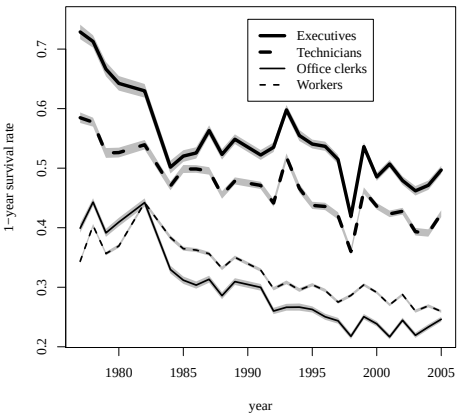

Fig. 45: 1-year survival rate

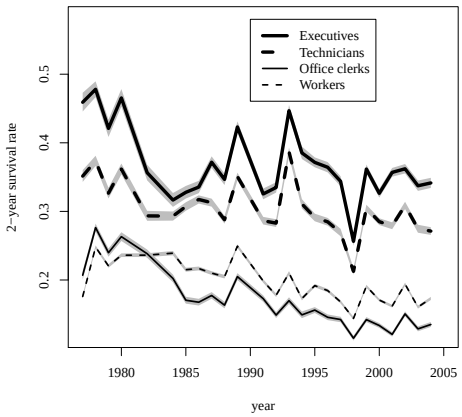

Fig. 46: 2-year survival rate

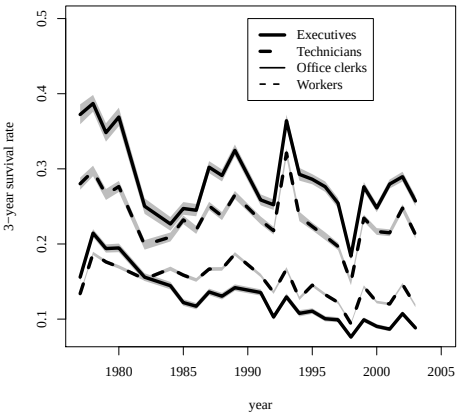

Fig. 47: 3-year survival rate

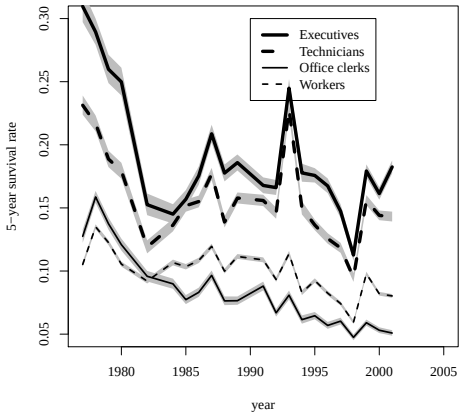

Fig. 48: 5-year survival rate

Survival rate, by socio-occupational category - WOMEN

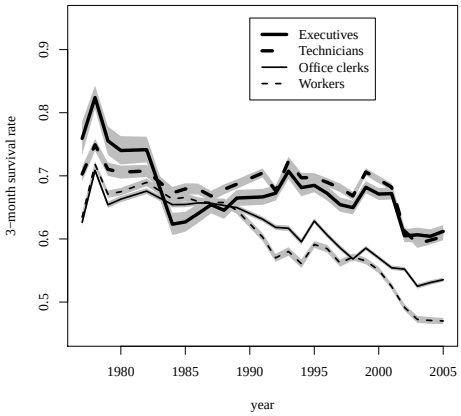

Fig. 49: 3-month survival rate

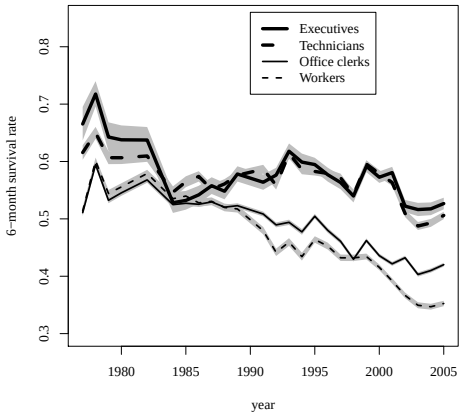

Fig. 50: 6-month survival rate

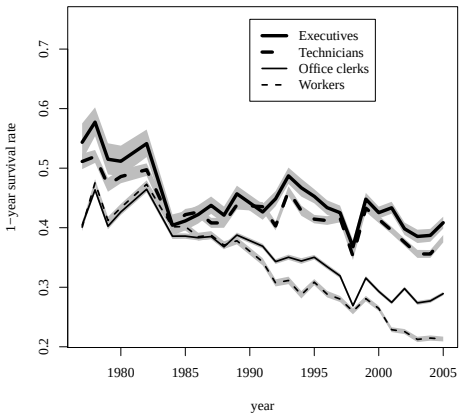

Fig. 51: 1-year survival rate

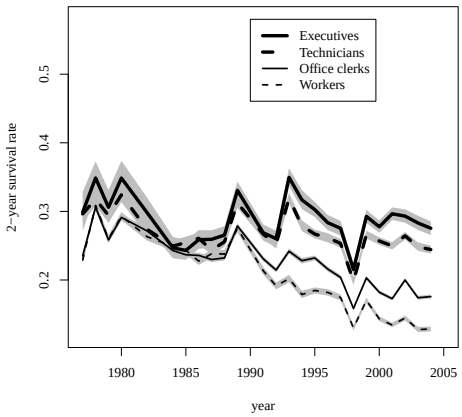

Fig. 52: 2-year survival rate

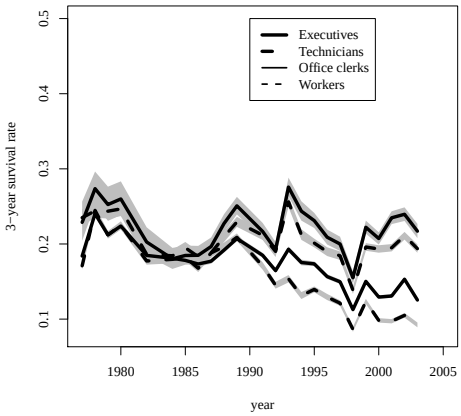

Fig. 53: 3-year survival rate

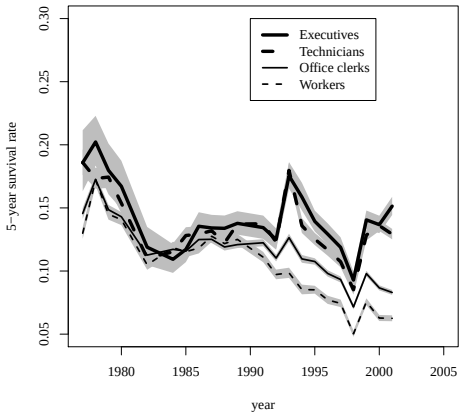

Fig. 54: 5-year survival rate

Survival rate, by age - MEN

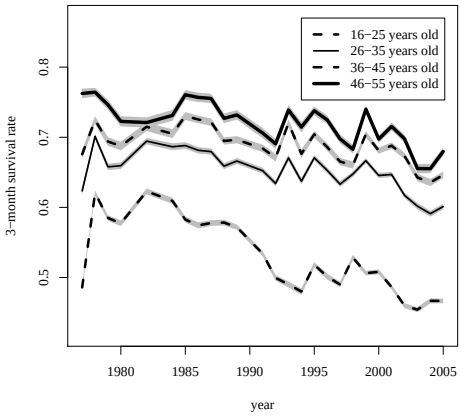

Fig. 55: 3-month survival rate

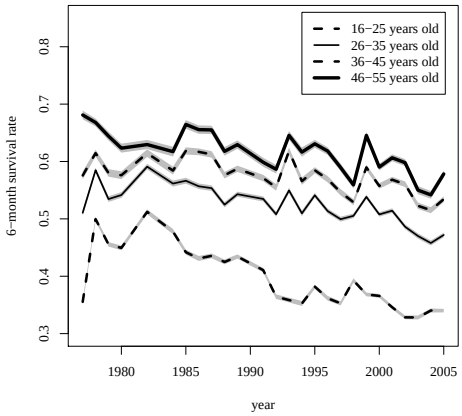

Fig. 56: 6-month survival rate

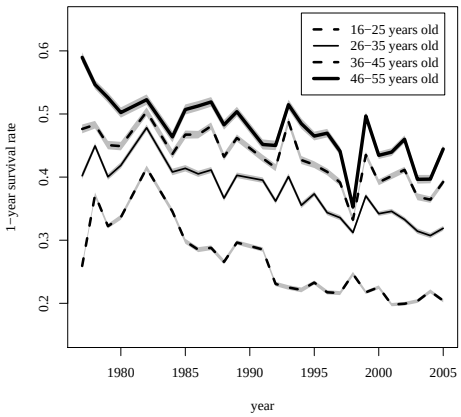

Fig. 57: 1-year survival rate

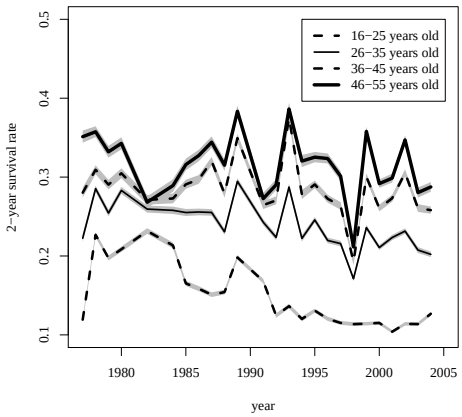

Fig. 58: 2-year survival rate

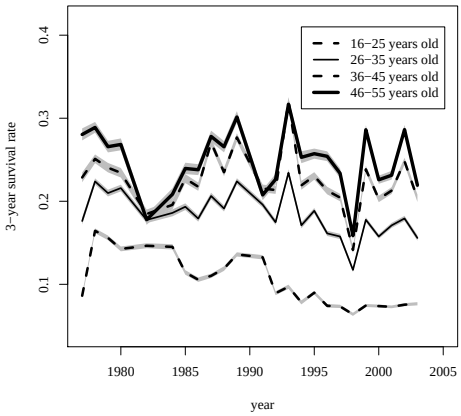

Fig. 59: 3-year survival rate

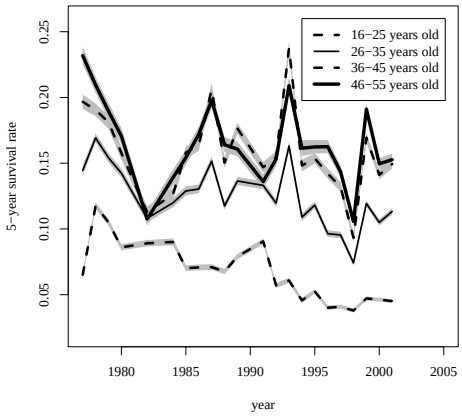

Fig. 60: 5-year survival rate

Survival rate, by age - WOMEN

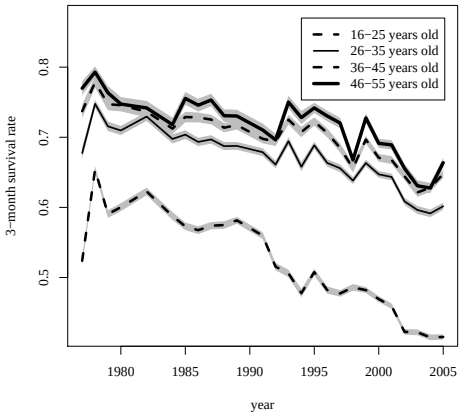

Fig. 61: 3-month survival rate

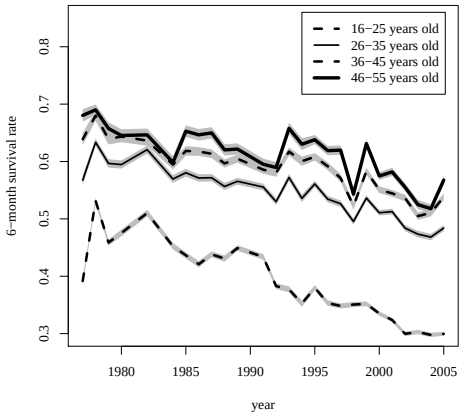

Fig. 62: 6-month survival rate

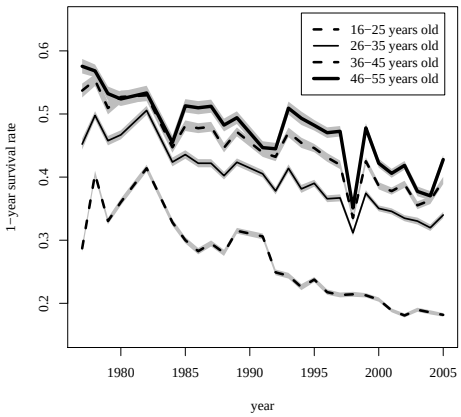

Fig. 63: 1-year survival rate

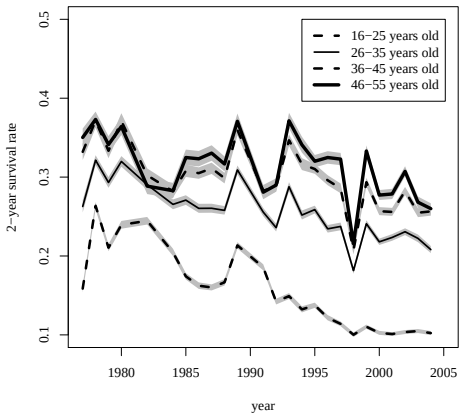

Fig. 64: 2-year survival rate

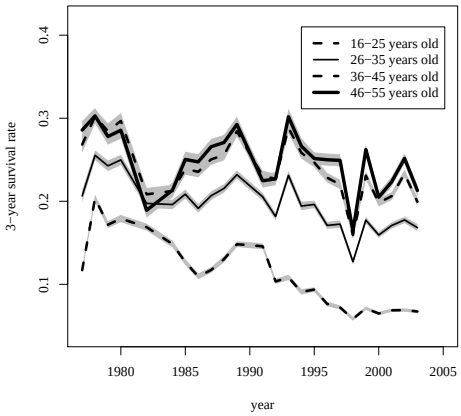

Fig. 65: 3-year survival rate

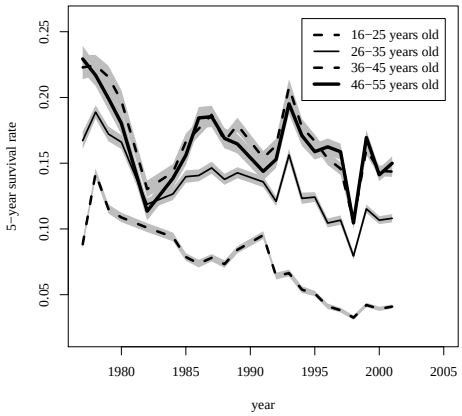

Fig. 66: 5-year survival rate

F Firm and individual effects with censoring

Here we estimate the following equation

$$\ln(T_{ij}^*) = C + x_{ij}'\beta + \alpha_i + \gamma_j + \varepsilon_{ij}$$

with C a constant term and x_{ij} containing dummies for the starting year of the spell and the age of the individual at the beginning of the spell. T_{ij}^* is either observed or bounded with known minimum and maximum values. When the spell starts or ends in 1981, 1983 or 1990 the data is naturally bounded, and when the spell is right censored (in 2006), we use the retiring age to construct an upper bound. ε_{ij} is assumed to be normally distributed with unknown constant variance (which is estimated). α_i and γ_j are centered.

The estimation method is in the same spirit as the one performed in Section 5, except that each step involves a maximum likelihood estimation instead of an OLS estimation. More precisely, we estimate sequentially the coefficients α_i, given the rest, the coefficients γ_j given the rest, the coefficient β given the rest, and the variance of ε_{ij} given the rest. This sequence of iterations is performed until convergence (this algorithm ensures that the likelihood always increases at each stage).

The results are extremely close to the ones obtained without censoring. The only difference concerns the individual effects by cohorts for which the differences seem slightly more pronounced. This is indeed a dimension in which the previous truncation of the data was more likely to have an impact.

Note that these estimations are only performed as a robustness check since there is no proof that the fixed effects are estimated without bias in this finite distance framework.

Table 9: Mean fixed effects depending on firm size – Taking censoring into account

Size group	Individual fixed effect		Firm fixed effect	
	Estimate	95% confidence interval	Estimate	95% confidence interval
0	-0,45	[-0,46 ; -0,44]	-0,94	[-0,96 ; -0,93]
1–4	-0,30	[-0,30 ; -0,29]	-0,01	[-0,01 ; 0,00]
5–9	-0,24	[-0,24 ; -0,23]	0,08	[0,07 ; 0,09]
10–19	-0,20	[-0,21 ; -0,20]	0,07	[0,06 ; 0,08]
20–49	-0,12	[-0,13 ; -0,11]	0,10	[0,09 ; 0,10]
50–99	-0,05	[-0,06 ; -0,04]	0,14	[0,13 ; 0,15]
100–249	0,02	[0,00 ; 0,03]	0,20	[0,18 ; 0,22]
250–499	0,04	[0,03 ; 0,06]	0,27	[0,25 ; 0,29]
500–999	0,12	[0,09 ; 0,14]	0,31	[0,28 ; 0,35]
1000–1999	0,13	[0,09 ; 0,16]	0,30	[0,26 ; 0,35]
2000–4999	0,14	[0,10 ; 0,18]	0,31	[0,25 ; 0,37]
5000 and more	0,23	[0,14 ; 0,31]	0,23	[0,12 ; 0,34]

Source: DADS, 1/25 panel

Careers only in the private sector.

Fixed effects are defined up to an additive constant.

Size of the firm is defined as the number of employees on December 31 of a given year. As this variable may change over the years, we consider here its most frequent value for each firm. Firms with size 0 have no permanent employee on December 31, either because of the nature of their activity of because they are closed.

Table 10: Mean individual fixed effects depending on the sector of the firm – Taking censoring into account

Sector	Individual fixed effect	95% confidence interval
Agriculture, forestry and fishing	0,19	[-0,06 ; 0,45]
Manufacturing of food products	-0,01	[-0,03 ; 0,00]
Manufacture of wearing apparel and leather	0,27	[0,24 ; 0,29]
Publishing, printing and reproduction	0,02	[-0,01 ; 0,05]
Manufacture of pharmaceutical products. perfumes and detergents	0,19	[0,13 ; 0,25]
Household facilities industries	0,23	[0,20 ; 0,26]
Manufacture of motor vehicles	0,16	[0,10 ; 0,22]
Shipbuilding, aircraft and railroad construction	0,15	[0,08 ; 0,21]
Manufacture of mechanical engineering	0,15	[0,13 ; 0,17]
Manufacture of electrical and electronical engineering	-0,04	[-0,07 ; -0,01]
Manufacture of mineral products	0,26	[0,23 ; 0,30]
Manufacture of textiles	0,39	[0,35 ; 0,43]
Manufacture of wood and paper	0,23	[0,20 ; 0,27]
Manufacture of chemicals. rubber and plastics products	0,17	[0,13 ; 0,20]
Manufacture of metallurgy and metal processing	0,19	[0,17 ; 0,21]
Manufacture of electrical and electronical components	0,02	[-0,04 ; 0,07]
Construction	0,07	[0,06 ; 0,08]
Trade and repair of motor vehicles	0,05	[0,04 ; 0,07]
Wholesale, agents involved in sale	0,22	[0,21 ; 0,23]
Retail trade, repair	0,00	[-0,01 ; 0,01]
Transporting	0,04	[0,03 ; 0,06]
Financial activities	0,25	[0,22 ; 0,28]
Real estate activities	0,25	[0,23 ; 0,27]
Support service and consultancy activities	0,00	[-0,01 ; 0,01]
Cleaning, human resource provision and other operational services	-0,08	[-0,10 ; -0,07]
Scientific research and development	0,06	[-0,06 ; 0,18]
Accommodation and food service activities	-0,31	[-0,32 ; -0,30]
Entertainments, cultural and sports activites	-0,28	[-0,30 ; -0,25]
Residential care and personal service activities	-0,31	[-0,34 ; -0,27]
Education	0,07	[0,03 ; 0,11]
Human health and social work activities	0,06	[0,04 ; 0,08]
Activities of membership organisations and extraterritorial activities	-0,07	[-0,11 ; -0,04]

Source: DADS, 1/25 panel

Careers only in the private sector.

Fixed effects are defined up to an additive constant.

Only the sectors for which we have a sufficient number of observations are displayed. As this variable may change over the years, we consider here its most frequent value for each firm.

Table 11: Mean firm fixed effects depending on the sector of the firm – Taking censoring into account

Sector	Firm fixed effect	95% confidence interval
Agriculture, forestry and fishing	-0,72	[-1,08 ; -0,37]
Manufacturing of food products	-0,07	[-0,09 ; -0,05]
Manufacture of wearing apparel and leather	-0,13	[-0,16 ; -0,10]
Publishing, printing and reproduction	-0,16	[-0,19 ; -0,12]
Manufacture of pharmaceutical products. perfumes and detergents	-0,02	[-0,10 ; 0,06]
Household facilities industries	-0,04	[-0,07 ; 0,00]
Manufacture of motor vehicles	0,07	[-0,01 ; 0,15]
Shipbuilding, aircraft and railroad construction	-0,01	[-0,09 ; 0,07]
Manufacture of mechanical engineering	-0,14	[-0,17 ; -0,12]
Manufacture of electrical and electronical engineering	0,14	[0,09 ; 0,18]
Manufacture of mineral products	0,02	[-0,03 ; 0,07]
Manufacture of textiles	0,02	[-0,03 ; 0,07]
Manufacture of wood and paper	-0,12	[-0,17 ; -0,08]
Manufacture of chemicals. rubber and plastics products	-0,09	[-0,13 ; -0,04]
Manufacture of metallurgy and metal processing	-0,11	[-0,14 ; -0,08]
Manufacture of electrical and electronical components	0,09	[0,02 ; 0,16]
Construction	-0,13	[-0,14 ; -0,12]
Trade and repair of motor vehicles	0,07	[0,05 ; 0,09]
Wholesale, agents involved in sale	-0,15	[-0,17 ; -0,14]
Retail trade, repair	-0,09	[-0,10 ; -0,08]
Transporting	-0,25	[-0,27 ; -0,23]
Financial activities	0,15	[0,11 ; 0,19]
Real estate activities	-0,28	[-0,31 ; -0,25]
Support service and consultancy activities	-0,07	[-0,09 ; -0,06]
Cleaning, human resource provision and other operational services	-0,49	[-0,51 ; -0,46]
Scientific research and development	-0,07	[-0,21 ; 0,08]
Accommodation and food service activities	-0,43	[-0,45 ; -0,41]
Entertainments, cultural and sports activites	-0,71	[-0,75 ; -0,67]
Residential care and personal service activities	0,37	[0,33 ; 0,41]
Education	-0,19	[-0,24 ; -0,15]
Human health and social work activities	-0,14	[-0,17 ; -0,12]
Activities of membership organisations and extraterritorial activities	-0,46	[-0,50 ; -0,42]

Source: DADS, 1/25 panel

Careers only in the private sector.

Fixed effects are defined up to an additive constant.

Only the sectors for which we have a sufficient number of observations are displayed. As this variable may change over the years, we consider here its most frequent value for each firm.

Table 12: Mean fixed effects depending on the socio-occupational category – Taking censoring into account

Socio-occupational activity	Individual fixed effect	95% confidence interval	Firm fixed effect	95% confidence interval
Executives	0,25	[0,23 ; 0,26]	0,18	[0,17 ; 0,19]
Technicians and associate professionals	0,18	[0,17 ; 0,19]	0,10	[0,10 ; 0,11]
Office clerks and service workers	-0,23	[-0,24 ; -0,23]	-0,07	[-0,07 ; -0,07]
Skilled and unskilled workers	0,05	[0,05 ; 0,05]	-0,11	[-0,11 ; -0,11]

Source: DADS, 1/25 panel
Careers only in the private sector.
Fixed effects are defined up to an additive constant.

Table 13: Mean fixed effects depending on birth cohort – Taking censoring into account

Year of birth	Individual fixed effect	95% confidence interval	Firm fixed effect	95% confidence interval
1922	2,03	[1,99 ; 2,06]	0,13	[0,11 ; 0,16]
1924	1,83	[1,80 ; 1,86]	0,10	[0,08 ; 0,12]
1926	1,72	[1,69 ; 1,75]	0,09	[0,07 ; 0,10]
1928	1,52	[1,49 ; 1,54]	0,09	[0,07 ; 0,10]
1930	1,41	[1,39 ; 1,44]	0,07	[0,05 ; 0,08]
1932	1,32	[1,30 ; 1,35]	0,08	[0,06 ; 0,09]
1934	1,19	[1,17 ; 1,21]	0,09	[0,07 ; 0,10]
1936	1,07	[1,05 ; 1,09]	0,08	[0,07 ; 0,09]
1938	0,96	[0,94 ; 0,98]	0,07	[0,06 ; 0,08]
1940	0,81	[0,79 ; 0,82]	0,07	[0,05 ; 0,08]
1942	0,74	[0,72 ; 0,76]	0,07	[0,05 ; 0,08]
1944	0,65	[0,63 ; 0,66]	0,06	[0,05 ; 0,08]
1946	0,56	[0,55 ; 0,58]	0,07	[0,06 ; 0,08]
1948	0,47	[0,46 ; 0,49]	0,06	[0,05 ; 0,07]
1950	0,34	[0,33 ; 0,35]	0,03	[0,02 ; 0,04]
1952	0,24	[0,23 ; 0,26]	0,03	[0,02 ; 0,04]
1954	0,16	[0,14 ; 0,17]	0,00	[-0,01 ; 0,01]
1956	0,04	[0,03 ; 0,05]	-0,04	[-0,05 ; -0,03]
1958	-0,03	[-0,05 ; -0,02]	-0,07	[-0,08 ; -0,06]
1960	-0,14	[-0,15 ; -0,13]	-0,07	[-0,08 ; -0,06]
1962	-0,24	[-0,25 ; -0,23]	-0,06	[-0,07 ; -0,05]
1964	-0,36	[-0,37 ; -0,35]	-0,08	[-0,09 ; -0,07]
1966	-0,48	[-0,49 ; -0,47]	-0,09	[-0,10 ; -0,08]
1968	-0,57	[-0,58 ; -0,56]	-0,09	[-0,10 ; -0,09]
1970	-0,73	[-0,74 ; -0,71]	-0,11	[-0,12 ; -0,10]
1972	-0,87	[-0,88 ; -0,86]	-0,13	[-0,14 ; -0,12]
1974	-1,00	[-1,01 ; -0,99]	-0,16	[-0,17 ; -0,15]
1976	-1,10	[-1,12 ; -1,09]	-0,19	[-0,20 ; -0,18]

Source: DADS, 1/25 panel

Careers only in the private sector.

Fixed effects are defined up to an additive constant.

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