A multistate demographic model for firms in the province of Gelderland

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ABSTRACT

In the last two decades researchers from various disciplines have made attempts to model and estimate developments in the size and structure of the population of firms. Although these attempts give useful insights into possible explanatory factors of firm dynamics, the explanatory value, and hence predictive power of these models is usually not very high. In this paper we follow a pure demographic approach for the modelling of firm survival. Important dimensions of the firm are firm age, firm size (in number of employees), economic activity and firm location. Using empirical firm level data for the region of Gelderland in the Netherlands over the period 1986-2002, developments in survival are described and analysed over time in an age-period-cohort perspective. In a later phase of the project, these (aggregated) scenarios will serve as a point of reference for comparisons to more extended model specifications using micro-simulation that include additional explanatory and spatial variables.

Keywords: demography of the firm, Age-Period-Cohort model, firm survival, closures

1 Introduction

There is a substantial body of literature dealing with the analysis and modelling of firm mortality and survival (for literature reviews: see e.g. Aldrich and Marsden, 1988, or Hannan et al., 1998). An important factor in these models is the age dependency of the mortality rate. This originates from the hypothesis, first stated in organizational research, about the liability of age (Stinchcombe, 1965): new organizations (firms) fail at a higher rate than old ones. This may be due to various underlying mechanisms. One asserts that young firms have not yet built up substantial internal strength, trust, tacit knowledge, networks with other firms and institutions, and are therefore more vulnerable for failure. As firms age, they learn, build up strength and trust, and know how to deal with difficulties. Another explanation is selection: as the cohort ages, the frail organizations die out, and the surviving population therefore become on average healthier). Although this age-dependence is a well-established stylised fact, various authors have proposed other, age-related ‘liabilities’. The liability of adolescence states that the mortality rate first increases, and next, after the period of adolescence, decreases over the rest of the life span (Brüderl and Schüssler, 1990). The liability of obsolescence states that there is a positive relationship between age and mortality. In this reasoning, organizational inertia leads to a position which is increasingly ‘out of sink’ with the environment, and hence to a larger vulnerability to failure (Barron et al., 1994). The liability of senescence asserts that organizations itself change as they age, becoming less and less flexible, more bureaucratic and less efficient, with a similar effect of increasing mortality with higher age (Carroll and Hannan, 2000). All these liability hypotheses are propositions about the form of the age curve of mortality. Empirical research has given overwhelming evidence for decreasing mortality with increasing age, thus –at least for most real-world situations- ruling out the obsolescence and senescence hypotheses.

The emphasis on age gives these types of research a strong demographic flavour. Yet, from a demographic point of view, these analyses are incomplete. In demography, time is the fundamental dimension. In fact, it is so fundamental, that it has been divided into a number of dimensions itself. The most common decomposition of time is in the dimensions age, period and cohort. Age is the amount of time elapsed since birth; Period is chronological or calendar time, and cohort is the chronological time during the formative period. An exclusive focus on age in the description of mortality gradients of firms may disregard important influences that are linked to specific historical events (e.g. economic recessions, wars) or that are related to specific cohort differentials. The demographic toolbox has a solution to this problem, which is called the age-period-cohort (APC) model. This model decomposes variations across age groups over time, into these three dimensions.

The dimension of calendar time as a source of variation in firm survival has also received some attention, most often in the form of analyses of the relation ship between the economic business cycle and survival. Indeed, there is a positive relationship between economic growth and firm survival (Siegfried and Evans, 1994, Caves, 1998). However, the relationship between calendar time and survival, without taking into account the possible impact of the age distribution of firms, may give biased results. For instance, in times of economic growth, entry will be high, and due to the short-lived nature of most firms, exit will be high as well. In order to solve this problem, age and time should be taken into account simultaneously. But even then, the cohort dimension may be important as well.

The concept of the cohort is also relevant in firm demography (van Wissen, 2002). According to Stinchcombe (1965) the circumstances at the time of founding of a firm have in imprint on the future behaviour of the firm. Firms have only limited capabilities to adapt to changing environments. Moreover, new generations of entrepreneurs of bring with them new ideas, technologies, innovations, and ways of doing things that reflect the level of technology, but also culture, institutions and socio-economic environment of that time.

This paper investigates the separate effects of the age, period and cohort dimension in decomposing time effects in firm mortality. It uses the demographic model of the age-period-cohort decomposition. The standard APC model does not have explanatory connotations: it is in essence an accounting framework that decomposes change over time in three dimensions. As will be discussed below, the model as specified here can be extended by introducing explanatory variables. This extension allows us to test if economic sector, geographical environment and size have any explanatory value for firm mortality.

The paper is organized as follows. In section 2 we introduce the APC model. Section 3 describes the data used, and section 4 deals with the results. The final section concludes.

2 The age-period-cohort model

Classical cohort analysis, or age-period-cohort (APC) analysis, is a method for exploring time series of demographic data and for the comparison of life courses of different cohorts. The time series generally consists of data classified by age and period (e.g. calendar year). Sometimes data are grouped by age and cohort. Variations in the age profiles are attributed to contemporary and historical factors. The contemporary factors are usually referred to as "period effects" and are generally approximated by the calendar year. The historical factors represent the influence of the past on current behaviour or experience and are usually referred to as "cohort effects". Cohort effects occur whenever the past history of individuals exerts an influence on their current experience or behaviour in a way that is not fully captured by the age variable. The main contribution of APC analysis is that the impact of societal and technological processes on demographic experience is conceptualized in its historical and contemporary dimensions.

The cohort or generation is an important concept in the study of changes in societal behaviour and experiences over time. Ryder recognized the cohort concept as the dominant agent of change in society (Ryder, 1965), and it was no coincidence that his similar article appeared in the sixties of the last century, at a time when the protest generation was about to stir large changes in society. The interest in cohort analysis is therefore particularly large when discontinuities occur in trends. Cohort analysis is expected to reveal and quantify the impact in time of these discontinuities.

In traditional APC analysis, the contemporary factors are approximated by the current period and the historical factors are represented by the year or period of birth. Current period and period of birth are not causal factors in the analysis. They are crude indications of the macro-setting that changes over time and in which demographic phenomena are embedded. In traditional analysis, the demographic rates, measured for a given age-group during a given period, are decomposed into an effect of age grouping (age effect), an effect of contemporary factors (period effect) and lasting effect of historical factors experienced by the group of people born during the same period; in APC analysis, it is interpreted as a group of people who lived through comparable historical or structural contexts (e.g. depression, war period, period of rapid technological change). They may be referred to as "contemporaries". Although the impact of past common experiences remaining at the time of observation is likely to differ for each member of the group, there is probably some effect that is still felt by all members of the group. That effect is the cohort effect. APC analysis attempts to unravel inter-cohort differences and intra-cohort variations.

APC analysis combines the two viewpoints traditionally distinguished by a demographer when analysing demographic data. One approach examines changes from year to year. Period analysis, as this approach is known, is particularly useful when rapid changes occur, such as technological or legal changes that directly affect the controllability of demographic processess, or a war or a revolution resulting in transitory behavioural changes such as the postponement of births. The other approach, cohort analysis, is better suited to the study of fundamental changes in behaviour such as an increase in health conditions and life expectancy. A comprehensive treatment of APC analysis in demographic and social research is given by Mason & Fienberg (1985).

The APC model is not an explanatory model but a statistical accounting scheme. To interpret the period and cohort effects, one must look for attributes of the historical contexts that brought about the effects; the age effect must be related to attributes of the firm development cycle over the lifespan. In moderns versions of the APC model, to be employed in this analysis, covariates may be included. These are factors, related to each combination of age-period-cohort, to test for level and/or slope differences among segments in the population.

In this paper, the APC model is presented as a special case of a generalized linear model (GLM). The number of deaths is a random variable associated with a stochastic process. Model fitting consists of three interrelated steps, following McCullagh and Nelder (1989); (i) model selections (model specification or identification); (ii) parameter estimation; and (iii) prediction.

The model relates the outcome of the random process to the parameters of the process. The outcome is the number of events (deaths) in a particular time interval. In this paper, we study the trend in death rates, defined as the ratio of the numbers of deaths and population at risk. The number and types of parameters are determined by the type of data that are available. One parameter is associated with each age, cohort and period. Models selected to represent the data belong to the family of generalized linear models (GLMs). An important characteristic of GLMs is that they assume independent observations. In case of non-independence, the variances will be larger than in the case of independent observations. It is assumed that deaths are generated by a Poisson process, hence the observed numbers of deaths follow a Poisson distribution. The Poisson assumption is justified when the death rate is low. In that case the Poisson assumption is an adequate approximation of the binomial distribution, which describes binary response data (e.g. deaths/survivors). The assumption that the number of deaths is an outcome of a Poisson process has become widely accepted in the literature and is implicit in the loglinear analysis of mortality rates. The dependent variable is the death rate, which is the ratio of the number of deaths and the total duration during which the population is exposed to the risk of dying. Since the exposure varies with the death rate, both the numerator and the denominator of the death rate are random variables and are interdependent. The dependence complicates the analysis substantially. Therefore it is generally assumed that the denominator is fixed, i.e. independent of the number of deaths. If the death rate is small, the assumption is realistic.

A major problem in model selection is the choice of variables to be included in the systematic part of the model. The strategy adopted in this paper is to associate one parameter with each age, period and cohort category.

Let n_{xtc} denote the observed numbers of death of age x, period t and cohort c. Let N_{xtc} denote independent random variables having Poisson distribution with positive parameters λ_{xtc}. λ_{xtc} is the product of the death rate and the duration of exposure to the risk of dying in year t by individual of age x and cohort c, which is assumed to be fixed (L_{xtc}). The true value consists of two components: a systematic component, predicted by the model to be specified, and a random component. To be precise, the random component must be separated into two parts. One is a part due to our ignorance, i.e. the absence of a complete observation; the other part is due to the fact that the outcome of any random process is inherently uncertain even if we have all the necessary data to predict the outcome. No distinction between the two parts is made in this paper.

Let λ_{xtc} denote the systematic component and ε_{xtc} the random component. The model is:

$$n_{xtc} = \lambda_{xtc} + \varepsilon_{xtc} \qquad (1)$$

With $E(n_{xtc}) = \lambda_{xtc}$
$E(\varepsilon_{xtc}) = 0$.

The parameter λ_{xtc} of the Poisson distribution and λ_{xtc} are assumed to satisfy a model that is loglinear in a set Θ of unknown parameters. One parameter is associated with each of the ages, cohorts and periods. The systematic component is

$$\lambda_{xtc}=L_{xtc}\kappa\alpha_x\beta_t\tau_c \exp \gamma Z_{xtc} \qquad (2)$$

where $\Theta = \{\kappa, \alpha_x, \beta_t, \tau_{c,} \gamma\}$, γ being a k-length vector, L_{xtc} is the duration of exposure assumed to be given, and Z_{xtc} is a vector of covariates $Z^{(k)}{}_{xtc}$, k=1,..,K. Model (2) is the multiplicative formulation of the loglinear model. The additive formulation is obtained by taking the natural logarithm of both sides. In that case, the ln of the dependent variable is linear in the parameters.

The unknown parameters must be determined from the data. This may be done using the method of maximum likelihood. To evaluate the goodness of fit of the model, we compare the likelihood achieved by the current model to the maximum of the likelihood achievable (i.e. the likelihood achieved by the full model). The logarithm of the ratio is known as the scaled deviance. The deviance is proportional to twice the difference between the loglikelihoods:

$$S(n, \lambda) = -2 \ln [L(\lambda,n)/L(n,n)] = 2[\ln L(n.n) – \ln L(\lambda,n)] \qquad (3)$$

Large values of S indicate low values of $L(\lambda,n)$ relative to the full model, increasing lack of fit. For the Poisson distribution, the deviance is

$$S(n,\lambda) = 2\sum_{xtc}\left[n_{xtc} \ln\left(n_{xtc} / \lambda_{xtc}\right) - \left(n_{xtc} - \lambda_{xtc}\right)\right] \qquad (4)$$

If a constant term Ø, which is known as the nuisance parameter, is included in the model it is generally the case that $\Sigma(n_{xtc}-\lambda_{xtc}) = 0$ so that

$$D(n,\lambda)=S(n, \lambda)\ Ø \qquad (5)$$

may be written in the more usual form of the loglikelihood ratio which is often used as a test in the analysis of contingency tables

$$D(n,\lambda) = 2\sum_{xtc} n_{xtc} \ln\left(n_{xtc} / \lambda_{xtc}\right) \qquad (6)$$

In order to determine the unknown Θ parameters with maximum likelihood, we need to maximize the loglikelihood function with respect to the parameters. This results in a set of normal equations which need to be solved for the unknown parameters. The GLIM package, which uses generalized weighted least squares, was applied. The weights are inversely related to the variances of the estimates. The algorithm uses the Fisher's scoring method and the Newton-Raphson method reduce to the same algorithm.

The expected death rate may be written as follows:

$$\lambda_{xtc} / L_{xtc} = \kappa \alpha_x \beta_t \tau_c \exp \gamma Z_{xtc} \tag{7}$$

where the parameters are restricted as follows: $\alpha_1=1$, $\beta_t=1$ and $\tau_c = 1$ and κ is an overall scale parameter. Alternative restrictions may be used.

3 Data

The PWE register of business establishments

The data used in this paper were obtained from the PWE (provincial employment inquiry) register of business establishments in the province of Gelderland (the Netherlands), which was provided by the province of Gelderland. The PWE is a regional subdivision of LISA (National Information System Labour Markets). LISA was originally set up as an administrative register for the implementation of social security laws. Currently it is a main source for socio-economic and spatial-economic analysis in the Netherlands. The PWE register holds information on all business establishments in Gelderland, where paid work is being performed. Besides firm establishments the PWE register also holds information on governmental establishments, educational establishments, public health services and establishments for free professions.

The basic unit in the PWE register is an establishment, which is defined as "a location of a firm, institute, or free profession (i.e. any factory, workplace, shop or other working accomodation, or a complex of these) in which or from where an aconomic activity or independent profession is performed by one or more employed persons (at least one person for 12 hours per week)".

Numbers of firms

For our research we were provided with PWE-data from 1986 up to 2002. Table 1 shows the number of establishments and number of employed per year.

Table 1: Number of establishments and number of employed in the province of Gelderland, 1986-2002

Year	Number of establishments	Number of employed (including parttime and agency staff)
1986	70,756	594,454
1987	71,887	608,595
1988	73,437	622,755
1989	73,242	637,286
1990	75,791	664,845
1991	76,609	696,554
1992	79,755	713,957
1993	81,749	722,556
1994	86,766	732,106
1995	90,375	751,207
1996	93,527	772,599
1997	96,113	795,361
1998	99,631	829,524
1999	102,855	856,658
2000	104,051	874,665
2001	105,693	892,064
2002	106,334	892,400

During the period 1986-2002 both the number of firms and the number of employed in Gelderland grew with fifty percent, or 2.6 percent per year. On average each establishment employed 8.5 persons (including parttime and agency staff).

The PWE files contain a lot of information per establishment. In this paper we used the following variables:

- SBI'93 code (5-digit);

- Startup year;
- Year of disappearance from the database;
- Reason of disappearance from the database;
- Number of employed (including parttime and agency staff);
- Whether or not a firm is located in the Economic Main Structure (EMS) of the province.

SBI'93 is the Dutch version of the 1993 European classification of economic activities. The European classification is called "Nomenclature générale des Activités économiques dans les Communautés Européennes (NACE)". The first four digits of SBI'93 correspond with the NACE. For national applications a fifth digit has been added (CBS, 1993). For the current analysis establishments were grouped into 4 main economic sectors. A list of the codes is given in the Appendix. Figure 1 shows the development of the number of firms by sector in the period 1986-2002. In 1986 the sector with the largest share of firms was the trade sector (33.7%). The share of firms performing activities in this sector decreased to 28.4 percent in 2002. The share of firms performing activities in the service sector grew from 27.7 to 39.4 percent, now being the largest sector. The share of industrial firms grew slightly from 12.3 to 15.1 percent, and the remaining firms had a share of 26.2 percent in 1986, declining to 17.2 percent in 2002.

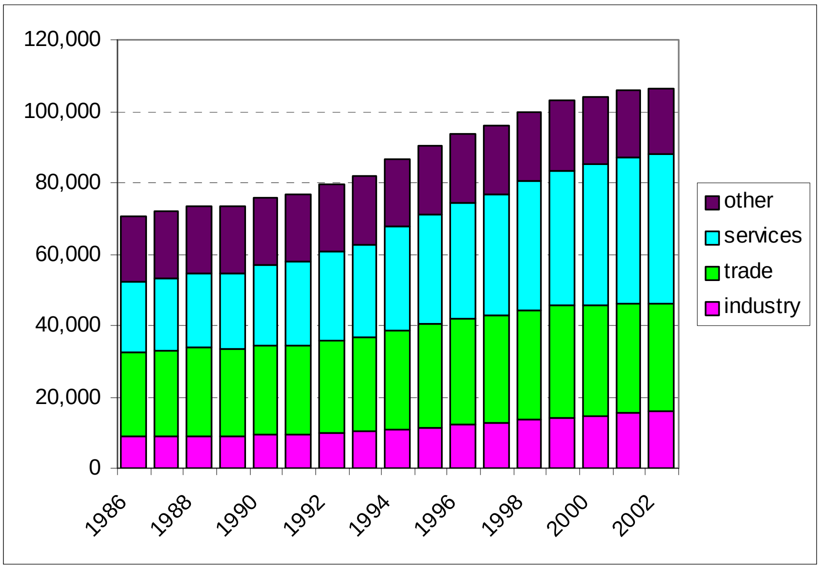

Figure 1 Number of firms in Gelderland, by sector, 1986-2002

In the Dutch national spatial policy plans, improvement of the international competition position plays a central role. Spatial investments will only take place where they contribute most to economic development. The National Spatial Economic Main Structure (EMS) determines where the state preferentially invests. The EMS refers to urban areas, mainports and infrastructure. To this Main Structure belong the six national urban systems: Randstad Holland, Brabantstad, Maastricht-Heerlen, Groningen-Assen, Arnhem-Nijmegen and Twente. Further it includes the national mainports Schiphol and the harbour of Rotterdam, a number of economic core-areas and greenports as can be found around Aalsmeer and in the Westland (Dekker, 2004).

The EMS covers 32 percent of the total Dutch area, 72 percent of the population aged 15 to 65, and 77 percent of all jobs (Louter, 2002).

The EMS in the province of Gelderland consists of

- an (inter-) national urban network: the junction Arnhem-Nijmegen;
- urban networks (with interprovincial aspects): urban triangle (Apeldoorn, Deventer, Zutphen) and WERV (Wageningen, Ede, Rhenen, Veenendaal);
- regional centres/formation of networks: Doetinchem and environs, Tiel and environs, Harderwijk and environs. (GS Gelderland, 2004).

In the province of Gelderland, the share of all establishments located in the EMS was constant in the period 1986-1996 (37 percent), and sligthly increased afterwards to 39 percent in 2002.

Closures

If a firm exists in year *t*, and no longer in year *t+1*, it is considered a closure during year *t*. In our dataset we also have information on the reason of disappearance of that firm from the dataset. If a firm no longer exists because it merged with another firm, it is not considered a closure. The same is true for firms that moved to either outside the province or abroad. All other reasons (owner-related, bankruptcy, reorganization, financial, or administrative) are considered to be real closures. The number of firms, disappearing from the dataset and not seen as closures, as a percentage of all disappearing firms, varies between zero and fifteen percent in the period 1986-2002.

In figure 2 the number of firms that closed down in the period 1986-2001 is shown, by main type of activity. The total number of closures ranges between 1,051 in 1986 4and 6,430 in 1999.

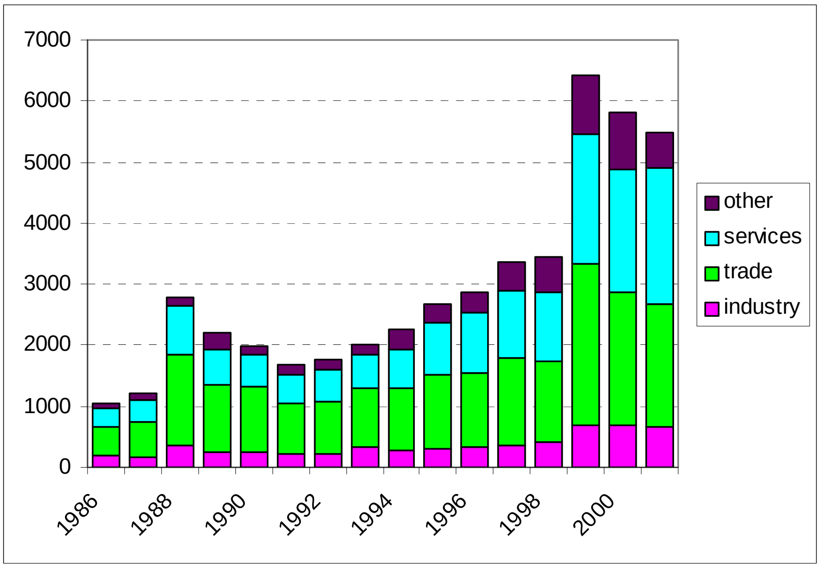

Figure 2 Number of closures in Gelderland, by sector, 1986-2001

The trade sector has a relatively high share of all closures. Between 1986 and 1993 about half of all closures were firms performing activities in the trade sector. Afterwards this share declined to 36 percent in 2001. Closures of firms in the services sector show a reversed trend: 28 percent in 1986 to 41 percent in 2001 of all closing firms concerned firms in the services sector.

Mortality rates

In demography (gross) mortality rates are calculated as a ratio between the number of deaths and the population. We used the same procedure for calculating mortality rates for the population of firms. Since we want to perform APC analysis on the data, we selected only those firms that started in 1986 (the 1986 birth cohort) or later. A firm born in 1986, did not exist in the beginning of 1986, but appears for the first time in the database at the beginning of 1987. A firm closing down cannot be observed until one year later. Our period dimension therefore starts in 1988. This selection reduces the number of firms and the number of deaths available to our analysis, substantially. We now have information on 9,615 existing firms in 1988 to 118,077 firms in 2001 and 397 to 7,753 firms closing down respectively. For each of the three time dimensions (age, period and cohort) mortality rates are plotted in figures 3 to 5. Figure 3 shows the mortality rates for the period dimension.

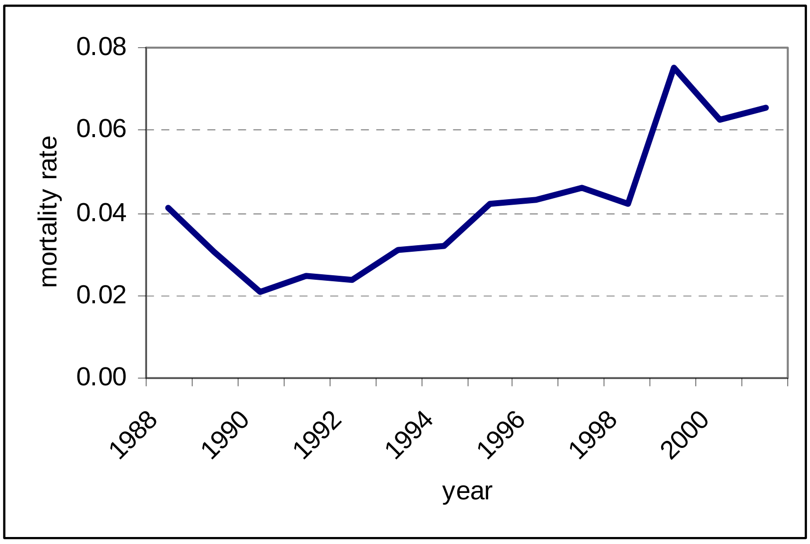

Figure 3 Mortality rates for firms in Gelderland by period, 1988-2001

In general the mortality rates show an increasing trend over time, with two peaks around 1988 and 1999. Not surprisingly, the mortality rates show a similar pattern as in figure 2, absolute numbers of deaths.

In figure 4 the mortality rates are shown by birth cohort. The picture is very clear: older cohorts have lower mortality rates than the younger cohorts do. Especially the most recent years (from 1998 onwards), were relatively speaking bad startup years. For firms that started in these years, mortality rates are the highest.

The last time dimension, age, is plotted in figure 5. As expected from the literature, younger firms show higher mortality rates than older firms do. Mortality rates very nicely decrease with age.

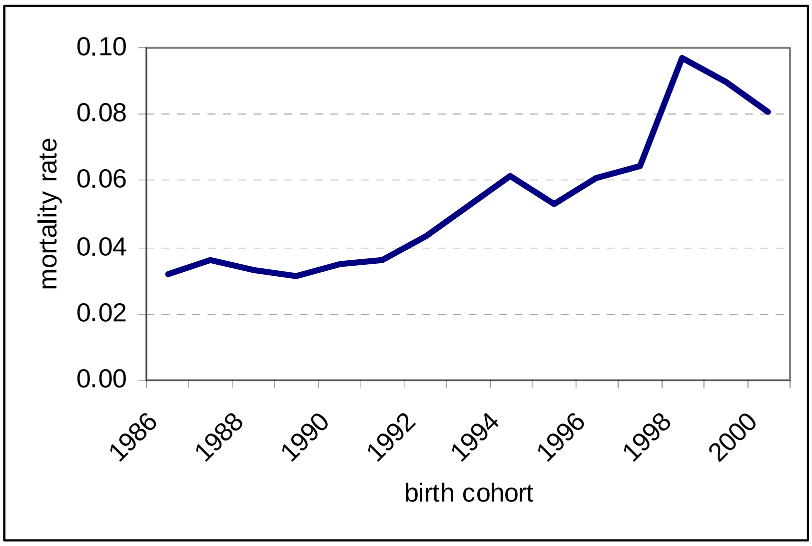

Figure 4 Mortality rates for firms in Gelderland by birth cohort, 1986-2000

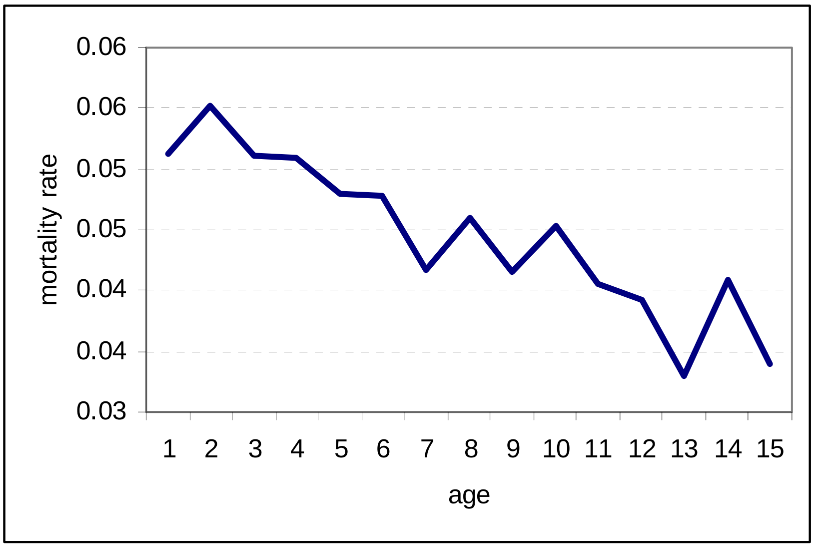

Figure 5 Mortality rates for firms in Gelderland by age

Mortality rates not only differ in each of the three time dimensions, but in the literarure it is also known that mortality may also differ by firm size, economic activity, and region. Each of these dimensions is included in our analysis as well. For economic activity we divided our data into four main groups: industry, trade, services, and other activities. See the Appendix for the way SBI codes were grouped. As shown in figure 6, firms performing activities in the trade sector show high mortality rates, firms in the industry sector the lowest.

As a spatial component we included the Economic Main Stucture in our analysis. For each firm we know whether it is located in the EMS or not. Apparantly firm dynamics are higher in the EMS, since mortality rates are lower outside the EMS than inside (figure 6).

And last but not least firm size (number of employees). Since differences in mortality are the largest between the lowest numbers of employees, we divided our firms once more into firms with zero employees (the owner is the only one working), firms with one employee, and firms with two or more employees. Again the literature is confirmed in our data: smaller firms have higher chances of dying than larger firms do (figure 6).

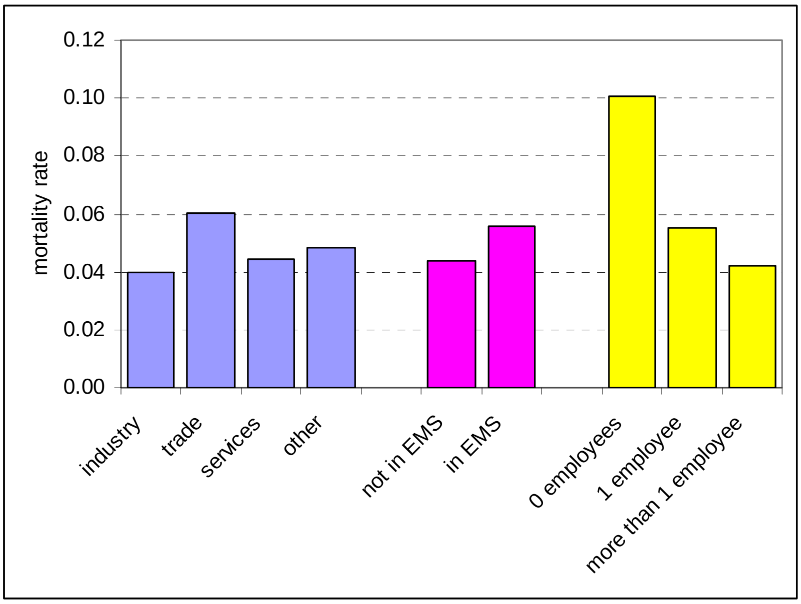

Figure 6 Mortality rates by economic activity, Economic Main Structure (EMS) and firm size, for firms in Gelderland.

4 Results of Loglinear analysis

In order to test for differences in mortality, loglinear models were formulated (using the software package GLIM 4.0 (Francis et al., 1993)). Loglinear analysis of demographic processes is a way to test hypotheses on connections between categorical variables in demographic processes. In the case of mortality numbers broken down by age (A), period (P), cohort (C), economic activity (SEC), economic main structure (EMS), and number of employed (EMPL) it is possible to test several associations.

As explained in section 2, this type of analysis yields a test criterium, the likelihood ratio, or deviation. Though this quantity does not follow a known distribution, and a formal statitical test is therefore impossible, it does give an indication of the relative importance of each of the variables in explaining the variation in mortality numbers. On the basis of this quantity one may decide whether mortality is for example sector-specific or not. Results of these analyses are shown in table 2.

Table 2 Results of loglinear analysis

Model	Scaled deviance	Residual degrees of freedom	% explained
1 -	17,112	2,855	0.00
2 EMS+EMPL+SEC	14,139	2,849	17.37
3 EMS+EMPL+SEC+A	13,849	2,835	19.07
4 EMS+EMPL+SEC+C	9,150	2,835	46.53
5 EMS+EMPL+SEC+P	9,230	2,836	46.06
6 EMS+EMPL+SEC+A+C	8,135	2,821	52.46
7 EMS+EMPL+SEC+A+P	7,774	2,822	54.57
8 EMS+EMPL+SEC+C+P	7,501	2,822	56.17
9 EMS+EMPL+SEC+A+P+C	**7,234**	**2,809**	**57.73**
10 EMS+EMPL+SEC+A+P+C+A*EMS	7,175	2,795	58.07
11 EMS+EMPL+SEC+A+P+C+A*EMPL	6,721	2,781	60.72
12 EMS+EMPL+SEC+A+P+C+A*SEC	7,208	2,767	57.88
13 EMS+EMPL+SEC+A+P+C+P*EMS	6,555	2,796	61.69
14 EMS+EMPL+SEC+A+P+C+P*EMPL	6,384	2,783	62.69
15 EMS+EMPL+SEC+A+P+C+P*SEC	7,176	2,770	58.07
16 EMS+EMPL+SEC+A+P+C+C*EMS	6,931	2,795	59.50
17 EMS+EMPL+SEC+A+P+C+C*EMPL	5,877	2,781	65.66
18 EMS+EMPL+SEC+A+P+C+C*SEC	7,188	2,767	57.99

Within loglinear analysis it is also possible to test for higher order interactions (for example A*P*C, but also interactions between each of the time dimesnions on the one hand and a factor on the other). We did test for such interactions, and results are shown in table 2, but the results were not satisfactory. Gains in scaled deviance were small, standard errors became too large and parameter values became uninterpretable. As an example figure 7 shows the parameter estimates for age by number of employed according to model 11. Values larger than zero indicate higher than average mortality chances and values smaller than zero lower than average chances of dying. Though the hypothesis that the more employees a firm has, the lower the chances of dying are, is confirmed by this model, mortality hardly decreases with age for firms with 1 or more employees. The decreasing age effect seems to be true (in this model) for zero-employees-firms only. This is clearly not what we expected.

Figure 7 Parameter estimates for age by number of employees, according to model 11

Based on the arguments mentioned above, we decided that model 9 is the optimal model, which includes a regional variable, a size-variable and economic activity variable, as well as the three time-dimensions.

Parameter estimates indicate whether mortality for certain characteristics is higher than average or lower. If a parameter value is higher than zero this means that mortality is higher, values lower than zero indicate the opposite. The more a value differs from zero, the stronger the effect is.
According to model 9 the first three explanatory variables behave exactly as hypothesized. Inside the EMS mortality rates are higher (0.24) than outside the EMS (0.0). Firms with no employees have the highest mortality rates (0.0), and with more than one employee the lowest (-0.89), firms with one employee fall in between (-0.66). For the sector variable the parameters also behave as expected: from the lowest to the highest mortality rates we find respectively industry (0.0), services (0.06), other (0.19) and trade (0.47).

In figure 8 the parameters and standard errors for age are plotted. Apart from the first age group, mortality rates clearly decrease with age. The impact of age on mortality is the strongest on the highest ages. With an increasing age also the standard errors increase.

Figure 9 shows parameter estimates and their standard errors for the period dimension. Indeed there seems to be a relation between the economic business cycle and survival of firms. Especially in the most recent years mortality chances are considerably higher, than in the beginning of the period. The period 1989-1993 shows relatively low mortality chances.

Parameter estimates for the cohort variable have the smallest, though still significant values (figure 10). The pattern is clear. In terms of mortality chances the periods 1988-

1992 and 1995-1997 were good birth cohorts. 1987 and 1998-2000 were bad start-up years.

Figures 11, 12 and 13 show combined parameter estimates for age, period, and cohort. In order to obtain these combined estimates, the original estimates were incremented with one, and subsequently we multiplied the concerned combinations of parameter estimates. The "average" mortality level has shifted upwards with one. The combined effect of cohort and age is demonstrated in figure 11. The three dimensional figure shows the product of cohort and age effects for each cohort and age. The other parameter estimates (period, employed, sector and EMS) are excluded from the chart. The figure reveals that cohort effects become especially pronounced in 1989-1991 and 1995-1997 and strongly suppress the age effects. The socio-economic environment in these years worked in favour of firms starting in those years. For the yougest ages the cohort effects are most pronounced.

Figure 12 is a very similar figure, but now the two dimensions age and period are combined. Especially in the most recent years the effect of period on the young ages is very strong (high mortality). Also the effect of early years on high ages is very large (very low mortality). As is evident from the product values, the effect of period on age is larger than the effect of cohorts.

Figure 13, finally, shows the combined effect of the dimensions year and cohort. As was said for the cohort-age combination, the cohort effects strongly suppress the period effects for cohorts 1989-1991 and 1995-1997. And also especially period 1999-2001 strongly reinforces the cohort effects.

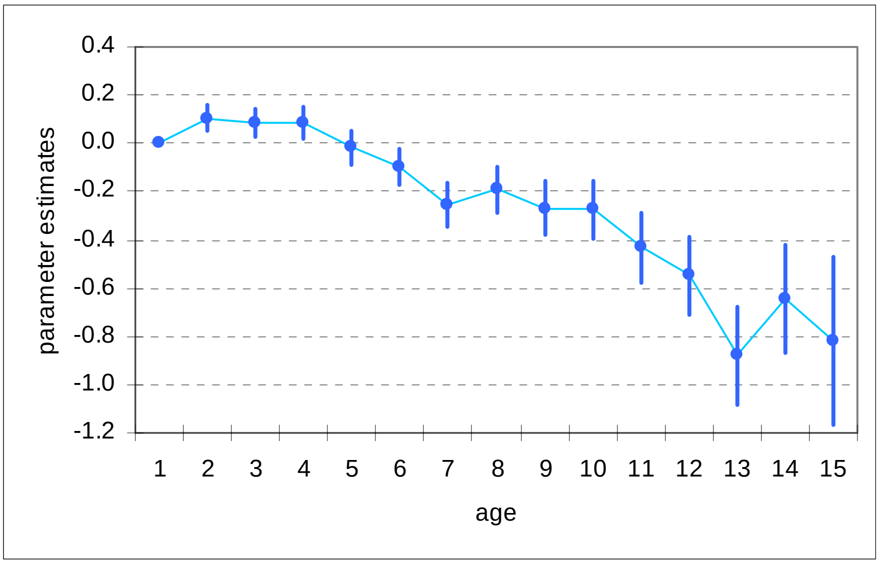

Figure 8 Parameter estimates and their standard errors for age in model 9.

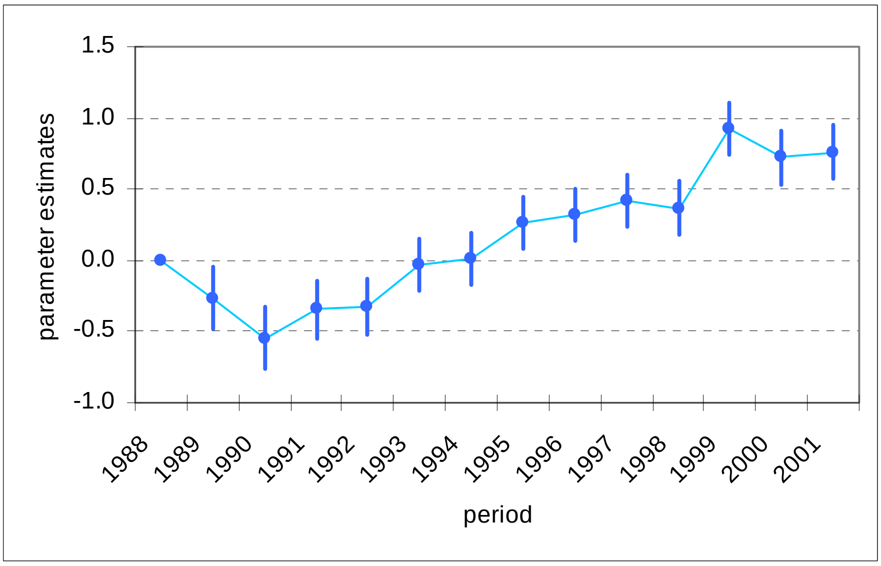

Figure 9 Parameter estimates and their standard errors for period in model 9

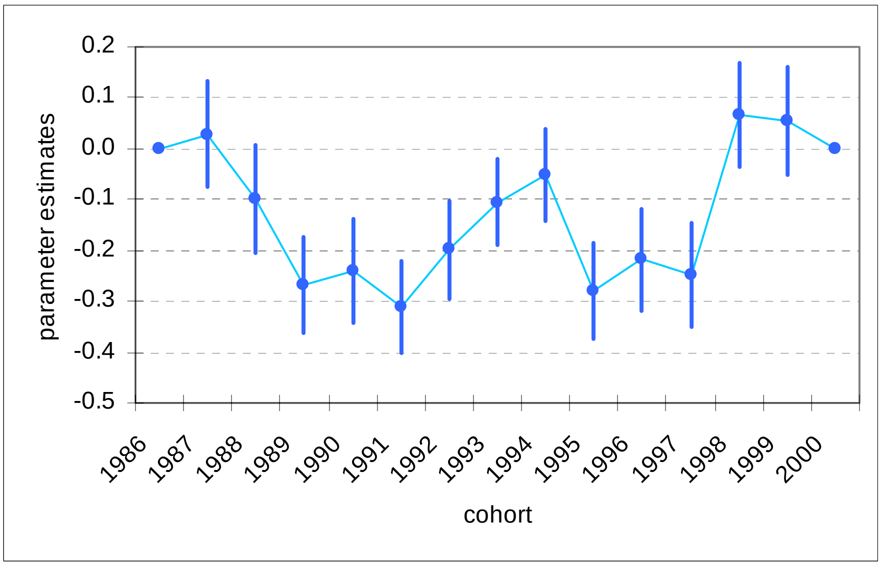

Figure 10 Parameter estimates and their standard errors for cohort in model 9

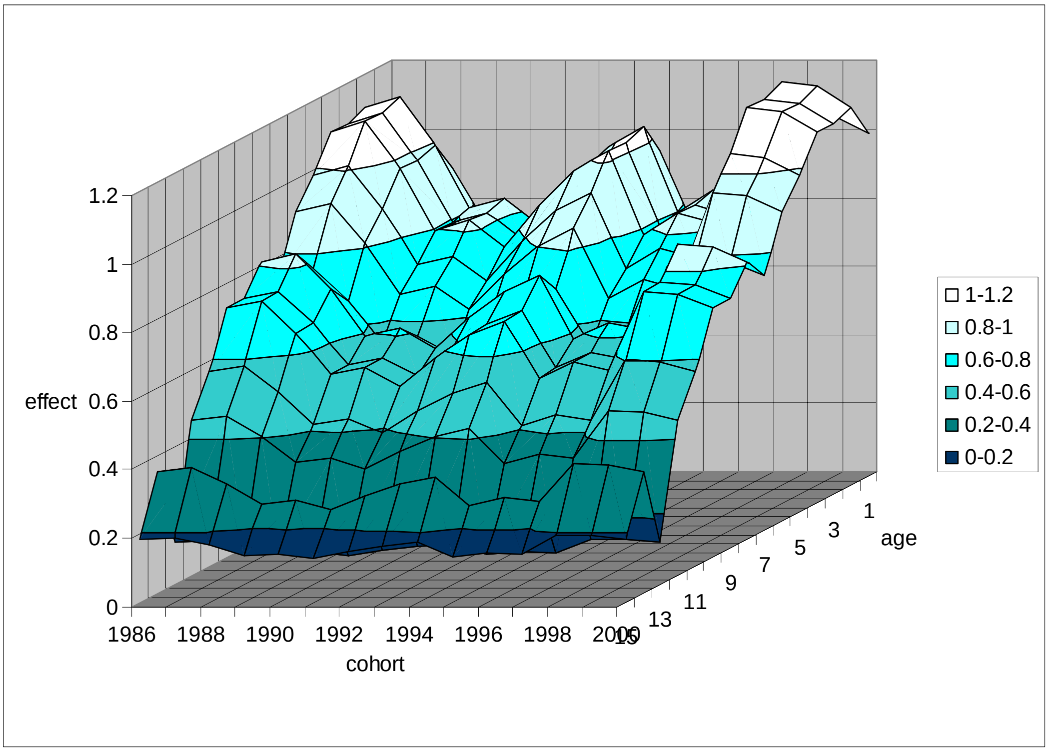

Figure 11 Combined parameter estimates for cohort and age in model 9

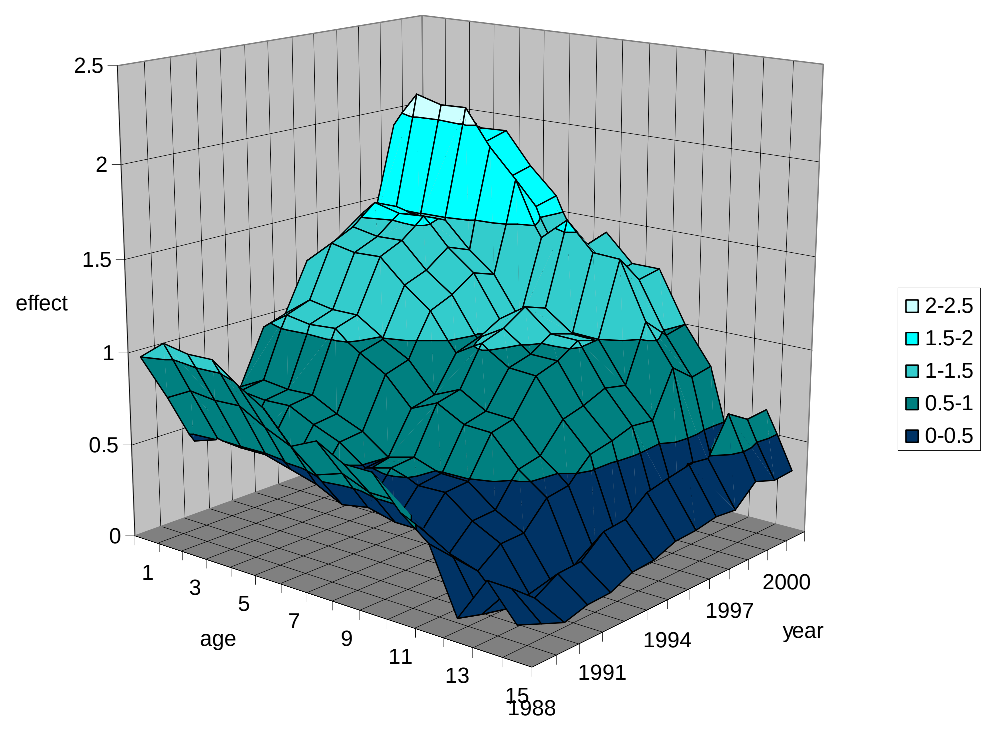

Figure 12 Combined parameter estimates for age and period (year) in model 9

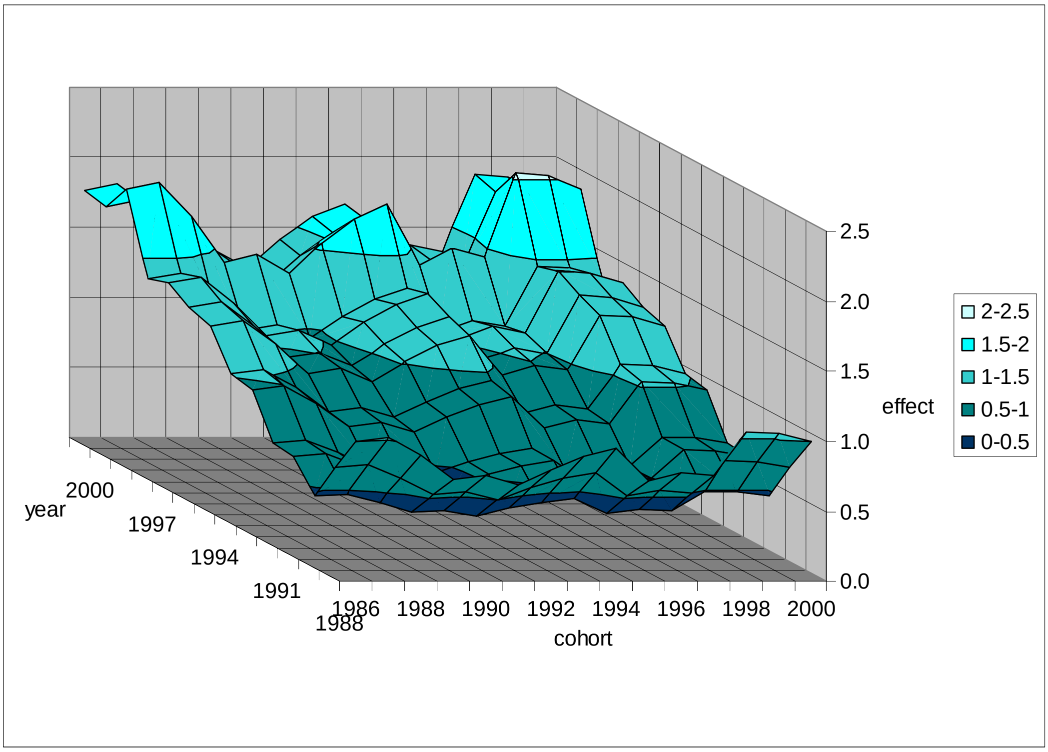

Figure 13 Combined parameter estimates for cohort and period (year) in model 9

5 Conclusions

In this paper we tried to investigate the separate effects of the age, period and cohort dimensions in decomposing time effects in firm mortality. The standard APC model was applied and was extended by introducing explanatory variables.

Decomposing time into three dimensions turned out to be a useful step. It removes the bias in the estimates of age effects, and gives additional information about the period and cohort structure in the mortality structure. Including a cohort variable in the analysis of mortality of firms, turned out to be a useful approach. Even though the effect of period on mortality is larger than the effect of cohorts, also cohorts explain a significant share of the variation in mortality of firms. The demographic concept of cohorts is therefore applicable to the population of firms as well.

The explanatory variables all worked as expected. Mortality rates inside the Economic Main Structure are higher than outside the EMS. Also the more employees a firm has, the lower the chances of mortality. Further, also economic activity matters. Lowest mortality rates were found in the industry sector, the highest in the trade sector.

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Appendix

Grouping of 1-digit economic activities into four main sectors

1-digit economic activity	Number of establishments		Main sector
	1986	2002	
A Agriculture-hunting-forestry	16,389	14,705	Other
B Fishery	13	20	Other
C Extracting minerals	27	25	Industry
D Manufacturing	4,261	6,938	Industry
E Public Services	90	39	Other
F Construction industry	4,426	9,058	Industry
G Repair of consumer goods and trade	19,992	25,363	Trade
H Catering industry	3,884	4,803	Trade
I Transport storage and communication	2,045	3,533	Other
J Financial institutions	1,991	2,762	Services
K Commercial services	6,119	20,653	Services
L Public administration and social security	855	562	Services
M Education	2,758	3,246	Services
N Health care and welfare	3,747	6,108	Services
O Culture recreation and other services	4,156	8,517	Services
P Household activities	2	0	Other
Q Extra-territorial bodies	1	2	Other
Total	70,756	106,334	Total