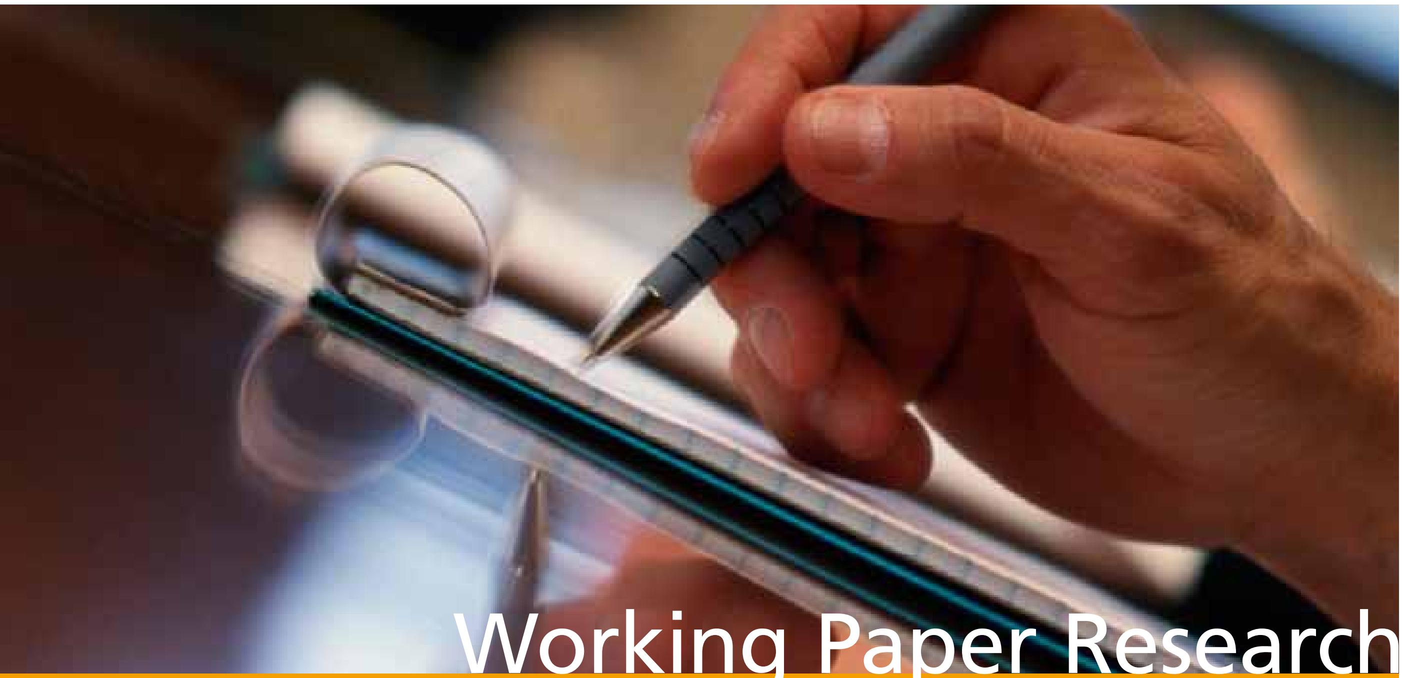
Analysis of business demography using markov chains : an application to Belgian data



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Abstract

This paper applies the theory of finite Markov chains to analyse the demographic evolution of Belgian enterprises. While other methodologies concentrate on the entry and exit of firms, the Markov approach also analyses migrations between economic sectors. Besides helping to provide a fuller picture of the evolution of the population, Markov chains also enable forecasts of its future composition to be made, as well as the computation of average lifetimes of companies by branch of activity.

The method is applied to Belgian data from the Crossroads Bank for Enterprises (CBE). To ensure compliance with Eurostat-OECD definitions, only 'active' enterprises, i.e. enterprises with a positive turnover and/or at least one employee, are considered. The forecasting method is applied to simulate the demographic evolution of the CBE population between 2000 and 2006. This simulation seems to match well the observed changes. Taking migrations into account yields better forecasts than if they are not considered. Moreover, several off-diagonal percentages in the transition matrix are sigificantly different from zero. A case study shows that these migrations are changes in main activity and not the consequence of corrections of wrongly classified firms.

Next, the average remaining lifetime and the average age of enterprises in a particular branch of activity is computed and analysed. These lifetimes and ages differ considerably across branches. As expected the life-times of public services are longer than average. Shorter lifetimes combined with an increasing number of enterprises is an indication of renewal inside the branch. A low average age is a sign of relatively new branches. Comparing age to total expected lifetime yields an indicator of closeness to extinction. This might be an indicator of the maturity of the branch.

The method is more generally applicable in the sense that it can be used to analyse other populations than those from the CBE and other partitions of the population.

JEL code: C81, M13, T11

Keywords: Business demography, Markov chains, Transition matrix

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INTRODUCTION

This study uses the theory of finite Markov chains to analyse the demographic evolution of Belgian enterprises over the period 2000-2006.

The literature overview in section 1 shows that most studies on business demography tend to concentrate on the births and deaths of enterprises. This paper has a broader perspective in the sense that it also looks at births and deaths by industry as well as migrations between industries. As such, for each industry, a distinction is made between a *newborn* enterprise in that industry and an enterprise that *migrates* into that industry. A migrating company is not new as it had already operated in another industry in the previous period. In the same way, companies can disappear from an industry, either by *'death'* or by *migrating to* another branch. A literature review in the first section shows that the segregation of enterprises that migrate between industries from the births and deaths is an approach which is not often used in demographic research.

The second section explains the Markov methodology and its advantages over other modelling techniques. It introduces concepts and notations used in Markov theory and summarises its relevant properties. The pre-requisites for the application of this theory are that a population of enterprises is known at different time intervals and that the population can be subdivided into several sub-groups. In this paper the subgroups are economic branches.

The next section describes the sources of enterprise data that are available in the National Bank of Belgium. It shows that the above-mentioned conditions are fulfilled for at least three sources: the Crossroads Bank for Enterprises (CBE), the National Accounts Database (NAD) and the Central Balance Sheet Office (CBSO). The section also describes whether and how the definitions used in this paper comply with Eurostat-OECD definitions. The last part of this chapter compares the three sources and argues that the Crossroads Bank for Enterprises has the most similar data (from a demographic point of view) to figures published by the Belgian National Bureau of Statistics. That is why this source is used in the remainder of the paper. It is worth noting that any of the other two data sources could have been used as an illustration.

The fourth chapter applies the methodology from section 2 to the CBE data. An example of the migration matrix for the years 2005-2006 is given and its properties are illustrated. Several off-diagonal percentages in the transition matrix are sigificantly different from zero. A case study shows that these migrations are changes in main activity and are not the consequence of corrections of wrongly classified firms.

The average transition matrix is used to forecast the composition of the population. Taking migrations into account yields better forecasts than when they are not considered. An application of the theory of absorbing Markov chains into the probability matrix also makes it possible to calculate the average lifetime and the age of enterprises by industry. Shorter lifetimes combined with an increasing number of enterprises is an indication of renewal inside the branch. Low ages characterise relatively young branches.

The last section summarises and concludes.

1 LITERATURE REVIEW

Demography is the study and description of developments within the *size* and *composition* of a certain population. The size of the population may change due to births, deaths or migration processes. The composition of a population may change due to variations in certain characteristics of the members of that population. Although the difference between the number of entries and exits and the internal changes within the surviving members of a population is usually studied in connection with human populations, it can be applied within a broader context to any type of population.

The demography of enterprises is an approach that deals with the dynamics of firms and industrial entities which has only recently been developed. Different methods and terms which are used to describe changes in human populations are also used to analyse changes in the population of enterprises. What is striking about this development is that it takes place within different, self-contained scientific areas at the same time.

So, the demography of enterprises has gained popularity within organisational sociology (Hannan and Freeman 1989; Carroll and Hannan 2000). This field of study classifies the dynamic processes involved in the creation, growth and disappearance of certain populations of organisations[1] and searches for the characteristics of organisations which are responsible for these demographic components. Organisations are regarded as inert in terms of their environment and consequently Darwinian selection largely determines which organisational forms are viable. Rational adjustments play a minor role. Adjustments to the environment are not made at the level of the individual organisation but through the growth or shrinkage of populations of organisations (Peli et al. 1994, Bruggeman 2001). In developing their theory of enterprise demography, a number of methods from population demography have been used, such as life expectancy tables and the search for connections between the age and probability of survival of enterprises. This area of study only looks at possible sociological explanations for developments relating to the creation of new organisations and the disappearance of older and less successful ones. It does not cover developments which can be attributed to migrations of enterprises between industries.

A second scientific area which looks closely at the demography of firms is economic geography: this is the study of the spatial dimensions of enterprise dynamics (Van Wissen and Gordijn 1992, Van Dijk and Pellenbarg 2000). Here, enterprise migration is analysed on the basis of composite components of birth, death, growth/decline and location with a view to being able to detect and extrapolate certain trends relating to the migration behaviour of enterprises (Van Wissen 2000). The internal characteristics of an enterprise (the industry in which it operates, the size of the enterprise and its age) have been found to be just as important as explanatory variables relating to the migration of an enterprise and as external factors such as the labour market, government policy or the specific characteristics of places of business (Pellenbarg, Van Wissen and Van Dijk 2002). Also, this area of study does not take account of the influence of enterprise migrations between different industries on the dynamic behaviour of firms.

Economic statistics is a scientific area which has seen a significant increase in interest in the demography of enterprises in recent years. Analysts are increasingly studying numerical data relating to the number of births and deaths of enterprises, their life expectancy and the important part which they play in respect of economic growth and productivity. In spite of the increasing importance of economic statistics, study of these data is being hindered by the lack of comparable international numerical data. There is no shortage of data as there are several statistical institutions producing numerical data relating to the above-mentioned domain (Eurostat 2004, Statec 2004, Bartelsman et al. 2003) but because of a lack of comparability and because the quality of the data is sometimes questionable, this can lead to confusion and contradictory conclusions. A number of studies have been published which have suggested a solution to this problem by proposing methods for creating more comparable indicators with regard to the demography of enterprises (Ahmad 2006, Eurostat-OECD 2007). In order to generate coherent and comparable data, it was

[1] The term "organisation" not only refers to enterprises but also to associations, schools, public utilities and local authorities.

decided that, for the purposes of this study, the Eurostat methodology (Eurostat-OECD 2007) would be used to generate demographic enterprise statistics.

The influence of enterprise dynamics on productivity and employment has been recognised in various studies (Caves 1998, Haltiwanger 2000, Bartelsman and Doms 2000, Ahn 2001). However, these studies are always limited to an analysis of the number of enterprise entries and exits without any distinction being made between "real" entries (e.g. the setting up of a new company) and exits (e.g. closure or failure) and enterprises being merged or taken over or continuing to operate within a different industry. Nevertheless, it has been found that this sub-group of exiting enterprises has different characteristics from those which stop production completely (Newman *et al.* 2007). Companies migrating between industries have a lower yield than those remaining within an industry but a significantly higher yield than new enterprises entering the industry.

A study by Bernard *et al.* (2006) shows how important it is in demographic research to take account of enterprises which make changes to their production activities. An analysis of an American dataset containing corporate data for the period from 1972 to 1997 inclusive shows that enterprises change their production activities extremely frequently by adding new products and dropping old ones. On average, 68 p.c. of the manufacturing sector in America changes its product range every five years, while 45 p.c. of the enterprises add at least one product and drop one product at the same time. As a result of these adjustments, on average 47 p.c. of the enterprises migrate between industries[2]. Switching production has been found to account for a substantially larger share of the growth of total productivity than the net result for enterprise births and deaths. For that reason, it was decided that, in this study, a distinction would be made between enterprises migrating from one industry to another and other enterprise entries and exits in order to avoid certain aggregation errors and thus provide a better insight into firm dynamics.

2 In the study carried out by Bernard *et al.* (2006), industries are classified using the 4-digit Standard Industrial Classification code (SIC). The SIC code is the American classification used for economic activities.

2 MODELLING THE DEMOGRAPHIC EVOLUTION OF FIRMS USING MARKOV CHAINS

2.1 Comparison to other methods

This paper models the demographic evolution of firms using Markov chains. Other widely-used techniques are descriptive statistics on enterprise entries and exits by economic activity, Probit or Logit models and survival analysis (also called duration analysis).

Probit and Logit models explain firm exits using a set of explanatory variables like age, size, branch characteristics, etc. They predict a probability of failure over a predefined horizon (e.g. probability of default within one year). Survival analysis does essentially the same but takes censored data into account, it estimates a 'survivorship function' i.e. the probability of surviving after a certain time *t*.

Firm demography should analyse the evolution of the *size and the composition* of the chosen population. Descriptive statistics on entries and exits, Logit/Probit models and methods based on survival analysis only study the evolution of the size of a population.

The Markov chain approach analyses both the size and the composition (i.e. the distribution of firms across economic branches) at the same time. As a consequence, the method described in this paper can be used for several purposes:

- Knowing the initial distribution of firms in the population considered over the different sectors of activity, one can forecast this distribution for the next year, within 2 years, 3 years, etc.
- This forecast also yields (for the population considered) an estimate of the number of exits after one year, 2 years, etc.
- It might also be used to forecast the sectoral distribution of value added and/or employment for the population.
- The method also computes the average age and remaining lifetime for companies in a particular sector. Sectors with shorter lifetimes might be an indication of the process of creative destruction.
- As population (branch) size is often used as an extrapolation factor, the forecast evolution of the composition of a population might also be used to reduce extrapolation errors. [3].

2.2 Data pre-requisites and the demographic evolution matrix

Modelling business demography using Markov chains requires, for a known population of enterprises, that the activity code (NACE) for each company is known in two consecutive years 't-1' and 't'.

The method is general in the sense that it can be used for any population of companies provided that the two above-mentioned conditions are met. For example, the population might be the set of companies that deposit annual accounts, it could also be the set of companies that are registered in the Crossroads Bank for Enterprises (CBE). Another possibility is to study the set of companies that are registered in the National Accounts Database (NAD).

It should also be mentioned that the method can be used for breaking down the data in other ways than by activity codes (e.g. regions, risk classes, etc.).

Once the population to analyse has been chosen, then for a particular enterprise, there are three possible scenarios:

1. The firm exists in year 't-1', but not in 't'. The firm has thus 'disappeared'. These companies are referred to as 'death'.

[3] A method often used in the NBB is the 'constant sample method', see e.g. Vivet D. (2008)

The number of companies with activity 'i' in 't-1' and that died in 't' is denoted $s_i^{(t)}$

2. The firm exists in 't-1' and 't'. For these firms, the activity code in both 't-1' and 't' is known. The number of such firms having activity code 'i' in 't-1' and 'j' in 't' is denoted as $m_{ij}^{(t)}$. This represents the number of companies that migrated from branch 'i' to branch 'j'.
3. The firm exists in the year 't', but does not exist in 't-1'. The firm is thus 'new'. In other words, we have a company 'birth'. The number of newborn firms that belong to branch 'j' in 't' is denoted $g_j^{(t)}$.

Using these numbers, three matrices can be defined:

$$M^{(t)} = \left(m_{ij}^{(t)}\right), \quad \text{i, j} \in \{1, 2, \ldots \text{N}\} \tag{1}$$

$$G^{(t)} = \left(g_j^{(t)}\right), \quad \text{j} \in \{1, 2, \ldots \text{N}\} \tag{2}$$

$$S^{(t)} = \left(s_i^{(t)}\right), \quad \text{i} \in \{1, 2, \ldots \text{N}\} \tag{3}$$

They can be grouped together into one matrix that represents the demographic evolution of the population between the years 't-1' and 't'. This matrix is called 'D':

$$D^{(t)} = \left(d_{ij}^{(t)}\right) = \begin{pmatrix} M^{(t)} & S^{(t)} \\ G^{T(t)} & O \end{pmatrix} \tag{4}$$

The zero in the lower right-hand corner means that, by definition, no company can migrate from 'new' to 'death'. The first N columns and the first N rows of this matrix represent economic activities. The row (N+1) corresponds to the 'new' enterprises and the (N+1)-th column corresponds to the 'deaths'. In order to simplify the text, the name 'state' will be used for 'activity', 'birth' or 'death'.

The element $d_{ij}^{(t)}$ is the number of enterprises that migrates from state 'i' to state 'j' between 't-1' and 't'.

By the construction of the matrices, it can easily be seen that:

1. the sum of the elements in a single row 'i' from matrix D equals the total number of enterprises belonging to industry 'i' in the year 't-1' (where $i \leq N$);
2. for row i = N+1, the row sum yields the number of new enterprises between 't-1' and 't';
3. the sum of the elements in column 'j' ($j \leq N$) from D equals the total number of enterprises within industry 'j' in year 't';
4. the difference between the sum of column 'j' and the sum of the row 'i' represents the net increase/decrease in the number of enterprises in industry 'i';
5. for column j = N+1, the sum yields the number of 'death' enterprises between 't-1' and 't';
6. elements with identical indices m_{11}, m_{22}, m_{33},..., m_{NN}, (diagonal elements) correspond to the number of enterprises that have remained within the same industry in both year 't-1' and year 't'.

As such, the migration matrix D contains all information on the evolution and the composition of the population of firms.

Remark that, in this paper, the elements of the matrix D are 'numbers of firms'. However, the method could also be applied if it were 'units of value added' or 'number of persons employed'.

2.3 The probability matrix of an absorbing Markov chain

The fraction of firms migrating from state 'i' to state 'j' between 't-1' and 't' is given by:

$$p_{ij}^{(t)} = \frac{d_{ij}^{(t)}}{\sum_{k=1}^{N+1} d_{ik}^{(t)}} \quad (5)$$

These fractions are the elements of a transition matrix $P^{(t)}$:

$$P^{(t)} = \left(p_{ij}^{(t)}\right) \quad (6)$$

From (4) and (6), it can be seen that the matrix $P^{(t)}$ is subdivided into four blocks (the prefix 'P' is added before the notation of the sub-matrices to indicate that the elements are percentages):

$$P^{(t)} = \begin{pmatrix} PM^{(t)} & PS^{(t)} \\ PG^{(t)} & 0 \end{pmatrix} \quad (7)$$

The row labels of the matrix $P^{(t)}$ are activity codes for the first 'N' rows, while the row (N+1) shows the 'new' firms. The first N column labels are also branches of activity, the (N+1)-th column represents 'death'. In order to have the same row and column labels, the matrix will be transformed. There is no column for 'new'. Under the definition of 'new', no firm can migrate to that state, so a column of zeroes is added.

The last column of $P^{(t)}$ is the 'death' column. There is no such row, so a new row is added. Under the definition of 'death', no firm can migrate from that state. There is one exception: if a firm died, then it will remain classified as 'death' forever, so a row of zeroes, except for the last element that is 1, is added. As such, an extended matrix $P_{ext}^{(t)}$ is defined as:

$$P_{ext}^{(t)} = \begin{pmatrix} PM^{(t)} & 0 & PS^{(t)} \\ PG^{(t)} & 0 & 0 \\ 0 & 0 & 1 \end{pmatrix} \quad (8)$$

The matrix $P_{ext}^{(t)}$ now has the same row and column labels. If the percentages in the matrix $P_{ext}^{(t)}$ are stable throughout time then this matrix is the transition matrix of a Markov Chain. A Markov chain models the evolution of a system of elements. Each element can be in one of N 'states'. The state of the system is determined by the state of each of its elements. In two consecutive periods, an element can move from its current state 'i' to any other state 'j'. The system is a Markov chain if the probability of moving from 'i' to 'j' is independent of time.

As mentioned above, once entered into, the state 'death' cannot be left again. It is an absorbing state and the Markov chain represented by $P_{ext}^{(t)}$ is an absorbing Markov chain (for more details on Markov chains, see Kemeny and Snell 1960).

The demography of firms will be studied using an average transition matrix over the years 2000-2006:

$$\overline{P} = \frac{1}{6} \sum_{t=2001}^{2006} P_{ext}^{(t)} \quad (9)$$

This matrix will be similar in block structure to the annual matrices in (8), i.e.

$$\overline{P} = \begin{pmatrix} PM & 0 & PS \\ PG & 0 & 0 \\ 0 & 0 & 1 \end{pmatrix} \quad (10)$$

2.4 The properties of an absorbing Markov chain

The theory of absorbing Markov chains (see e.g. Kemeny and Snell 1960) shows that the fundamental matrix F of this chain is given by (I is the unity matrix of order (N+1)):

$$F = \left(I - \begin{pmatrix} PM & 0 \\ PG & 0 \end{pmatrix} \right)^{-1} \qquad (11)$$

and that the sum of the elements in each row 'i' of F are equal to the average remaining lifetime of a firm entering the system in state 'i'. In this case, it is the average lifetime for companies in branch 'i' for i < N and the average lifetime for a new born company for i = N+1.

Another property of Markov chains (absorbing or non-absorbing) is that, knowing the distribution of firms in the initial period, the transition matrix can be used to forecast the distribution of firms in the next period.

Let us assume that the initial number of firms in branch 'i' is $a_i^{(0)}$ and that, each year, 'c' new firms are created. The vector representing the initial distribution of firms is represented as the row vector

$$A^{(0)} = \begin{pmatrix} a_1^{(0)} & a_2^{(0)} & .... & a_N^{(0)} & c & 0 \end{pmatrix} \qquad (12)$$

Then, in the next period, this distribution will be given by the row vector:

$$A^{(1)} = A^{(0)}.\overline{P} = \begin{pmatrix} a_1^{(1)} & a_2^{(1)} & .... & a_N^{(1)} & 0 & s^{(1)} \end{pmatrix} \qquad (13)$$

where $s^{(1)}$ is the number of company deaths after one year. If the number of new firms is again equal to 'c' the next year, then after two years, the distribution of firms will be given by

$$A^{(2)} = \begin{pmatrix} a_1^{(1)} & a_2^{(1)} & .... & a_N^{(1)} & c & s^{(1)} \end{pmatrix}.\overline{P} = \begin{pmatrix} a_1^{(2)} & a_2^{(2)} & .... & a_N^{(2)} & 0 & s^{(2)} \end{pmatrix} \qquad (14)$$

$s^{(2)}$ is the number of deaths after two years (including the ones that died after one year).

The matrix defined in (9) will be used to forecast the demographic evolution of Belgian firms. The forecasting power is verified by comparing the forecast composition to the observed one over the period 2000-2006. The annual number of new companies 'c' is taken as the average number of companies created over the period 2000-2006.

As $\overline{P}$ is computed as an average over the period 2000-2006, it can be seen as a 'through-the-cycle' transition matrix. Therefore, forecasting the sectoral distribution of firms over a long period using the matrix $\overline{P}$ seems reasonable. As the average lifetimes are computed over an infinite forecasting period (see e.g. Kemeny and Snell 1960), the use of $\overline{P}$ is justified in that case as well.

For short(er)-term forecasts, another matrix would probably give better predictions. In that case, it could be argued that it is better to use two (average) matrices: if the near future is expected to be a 'high' growth period, then the average transition matrix should be computed as an average of 'high' growth years only. Similarly, forecasts for the short term and for (expected) low-growth periods should use an average matrix that is computed using low-growth transition matrices only. Using two different matrices for high- and low-growth periods implicitly assumes that the migration percentages are time-dependent. In such cases, the condition for a Markov chain is violated but the future distribution can still be forecasted. Indeed, in the formulae (13) and (14), one has to decide upon which transition matrix to use (i.e. as to whether one expects a period of high/low growth). A time-dependent transition matrix models a Markov *process*.

2.5 Reverting the Markov chain - the average age of enterprises

The matrix $D^{(t)}$ defined in (4) models the migration of enterprises between 't-1' and 't'. As such, it describes the direction in which the system moves as time goes on.

Another way of analysing the evolution of the population is to look back in time, i.e. to analyse the origin of enterprises that are in a state 'j' in period 't'. In doing so, another Markov chain is found. It has the 'birth' state as an absorbing state and the fundamental matrix of this chain yields the average number of years since birth, or the average age of enterprises in a particular branch. The underlying assumption is that the transition matrix is constant in the past too.

Adding up average age and average remaining lifetime for each branch yields an estimate of the age at death. Comparing the age to the expected total life time is an indicator of closeness to extinction.

The average age will be computed in a similar way. The matrices for the reverse chain will be denoted using a prefix R (T means matrix transposition):

$$RD^{(t)} = \left(rd_{ij}^{(t)}\right) = \begin{pmatrix} M^{T(t)} & G^{T(t)} \\ S^{T(t)} & O \end{pmatrix} = D^{T(t)} \qquad (4')$$

The matrix $RD^{(t)}$ can be used to compute an extended transition matrix in a way similar as in (5) .. (10).

3 THE DATA SOURCES

3.1 Compliance with the Eurostat - OECD definition of an 'active' enterprise

In section 2, it was proposed to analyse the demographic evolution of enterprises using Markov chains. Sub-section 2.2. mentioned the preconditions for doing this, i.e. a population of enterprises at two different time periods 't-1' and 't', and in each year a sub-division of that population e.g. into activity branches.

In order to generate coherent and comparable data on the demographic processes of enterprises, this study will use the Eurostat methodology (Eurostat-OECD 2007) to generate demographic enterprise statistics. This methodology requires that

- only *active* enterprises are studied
- a correction is made to the set of 'new' enterprises
- a correction is made to the set of 'death' enterprises.

3.1.1 Active enterprises

The Eurostat methodology defines an enterprise as active if it realises turnover and/or employs at least one member of staff within a certain year. Information regarding the enterprise's turnover can be found in the VAT register of the Federal Public Service Finance (FPS Finance). Data on the number of members of staff employed within an enterprise is available at the National Accounts Institute (NAI) and in the annual accounts and social balance sheets filed with the Central Balance Sheet Office (CBSO).

3.1.2 New enterprises

The European Commission (EC) defines the number of enterprise births:

> *"A count of the number of births of enterprises registered to the population concerned in the business register corrected for errors. A birth amounts to the creation of a combination of production factors with the restriction that no other enterprises are involved in the event. Births do not include entries into the population due to mergers, takeovers, break-ups or restructuring of a set of enterprises. It does not include entries into a sub-population resulting only from a change of activity".*[4]

Within the group of 'new' enterprises defined in section 2.2., a number of corrections should be made so that this definition complies with the above-mentioned EC methodology because not all entries may be regarded as a 'birth'. Indeed,

- 'new' companies (in the sense of the definition in section 2.2) that result from a merger of two or more existing companies, should not be considered as a 'birth'.
- 'new' companies (in the sense of section 2.2) resulting from a break-up of an existing one, should not be counted as a 'birth'.

These corrections are made using information on associations between enterprises that can be found in the CBE. As it applies to only a small fraction (i.e. 0.001% of the 'new' enterprises or 0.00008 % of the total population), it was decided to remove them from our population in 't'. Moreover, the alternative solution of moving them into the M submatrix would have required a 'case-by-case' judgement.

- 'new' companies (in the sense of section 2.2) that changed identification number should not be considered as a birth.

[4] (EC) Commission Regulation No. 2700/98 dated 17 December 1998 concerning the definitions of characteristics for structural business statistics.

In order to identify these false 'new' companies, one should make a pairwise match of the companies in two consecutive years. The match should also be carried out in other identification fields like address, NACE code, for example. As this procedure is very time-consuming and error-prone, it has been decided not to use it. Tests on a sample of enterprises show that the number of pairwise matches with different ID-numbers is very limited (i.e. in the order of magnitude of one per mille).

An activity change is not considered as a new enterprise in the Markov approach.

3.1.3 Death enterprises

The EC defines the death of an enterprise as

> *"A count of the number of deaths of enterprises registered to the population concerned in the business register corrected for errors. A death amounts to the dissolution of a combination of production factors with the restriction that no other enterprises are involved in the event. Deaths do not include exits from the population due to mergers, takeovers, break-ups or restructuring of a set of enterprises. It does not include exits from a sub-population resulting only from a change of activity".*

According to this definition, for the purpose of creating demographic statistics, the death of an enterprise is regarded as an economic event completely separate from the legal death[5]. A death is only registered if no further concrete and easily measurable form of activity is carried out in a certain year in the form of turnover or staff.

Within the group of 'death' enterprises defined in section 2.2., a number of corrections should be made to the definition in order to ensure compliance with the above-mentioned EC methodology because not all entries may be regarded as a 'death'. Indeed,

- companies that disappear due to takeover or a merger should not be considered as 'deaths'.
- companies disappearing after a break-up should not be counted as 'deaths'.

These corrections are made using information on legal status that can be found in the CBE (the legal situation distinguishes between disappearance due to takeover, merger and break-up). The fraction was relatively low (i.e. 4,36% of the 'death' enterprises or 0.3% of the total population), so it was decided to remove them from the 'death' enterprises.

- 'death' companies (in the sense of section 2.2) that disappeared as a result of a change of identification number, should not be considered as a death.

It is the same sub-set that was discussed at the end of the previous section. It has been decided not to apply the pairwise match in this case either.

An activity change is not considered as an exit in the Markov approach.

3.2 Grouping the enterprises by economic activity

In order to classify enterprises according to their economic activity, it was decided to use the industry classification from the supply and use tables (SUT[6]) created by the National Accounts Institute (NAI). The SUT format was created by Eurostat and is a standard (European System of Accounts 1995 or ESA 1995) which must be followed in order to enable comparisons to be made between Member States at a European level. In the working format, the NAI groups categories from the NACE-BEL 2003 into 120 industries from the supply and use table. The reporting format includes 60 industries (A60) which correspond to the 2-digit NACE classification. In ESA 1995, the European industry classification is also aggregated further into 17 industries (A17), 6 industries (A6) and 3 industries (A3).

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[5] The legal death of an enterprise corresponds to the date on which the legal person is closed in the company register.
[6] Abbreviation of "Supply and Use Tables".

For this study of the demography of enterprises, it was decided that a migration table would be used in which all economic activities would be grouped into 120 industries. For the purpose of reporting the results, we have aggregated the migration tables to create the levels A120, A60, A17, A6 and A3.

For some enterprises, the activity code is unknown or wrong. These enterprises have been grouped in a separate class "Unknown industry". As soon as the enterprise is reclassified within a certain activity, it will migrate from the afore-mentioned class to an existing SUT class.

Each source (CBE, NAD, CBSO) has its own algorithm to assign activity codes. This implies that the preconditions described in section 2.2. can be fulfilled for the population of active enterprises in CBE, NAD, CBSO using the activity codes of that particular source. For each of these sources, annual time series covering the period 2000-2006 are available at the NBB. Demographic migration tables ($D^{(t)}, P_{ext}^{(t)}$) for each of these sources, as well as the average transition matrix ($\overline{P}$) can therefore be compiled for t = 2001, 2002, ... 2006.

Next follows a short description of the three sources of company data. The three sources are compared to publicly-available Belgian statistics on firm demography. For reasons mentioned below, it seems that the data derived from CBE matches these publicly-available statistics best. That is the reason why the CBE is used in the rest of the paper.

However, this does not mean that Markov chain theory is not useful for the compilation of transition matrices for the other sources. The opposite is true: if one wishes to make forecasts for the evolution of a particular population (read 'source') using the method described in section 2.4, then the transition matrices computed using that source should be used. This is the reason why migration matrices by source are published on the National Bank of Belgium's website (cfr. infra).

3.3 A short description of available sources for populations of enterprises

The National Bank of Belgium has access to several databases on business information. The most important ones are the Crossroads Bank for Enterprises, the population of enterprises in the National Accounts Database, the population of enterprises that file annual accounts with the Central Balance Sheet Office.

3.3.1 Main sources available at the National Bank of Belgium

3.3.1.1 The Crossroads Bank for Enterprises (CBE)

The CBE is a register containing all the basic data regarding natural entities, legal persons and associations carrying out an economic activity in Belgium. It incorporates data taken from the national register of legal persons, from the trade register, from the VAT register and from the National Social Security Office (NSSO) and loaded by the FPS Economy. The database is kept up to date by the organisations authorised to add data to it (Company Counters, the FPS Finance (VAT), the NSSO and the FPS Justice (Registry of the Commercial Court)). The CBE contains the identification data of every enterprise such as name, address, legal form and legal status.

The CBE contains an overview of the activities carried out by an enterprise. Besides distinguishing between main and secondary activities, it also records the history of the enterprise including its start-up date and end date. This allows us to generate statistics relating to the migrations of an enterprise between the different economic industries and within a certain period of time based on the main activity of the enterprise. Since there has been no uniformity at all regarding the use of activity codes at federal government level, they have been divided up by instrumenting department. This means that in the CBE one enterprise can have different activity codes depending on the data supplying department.For the purpose of studying the demography of enterprises, one of these codes will be selected as the enterprise's activity. For this selection, the order of priority for administrative sources that the NAI applies for the generation of the national accounts will be followed (see section 3.3.1.2).

The CBE currently does not include natural persons (self-employed) without staff not accountable for VAT (e.g. medical occupations, legal occupations, administrators).

3.3.1.2 The database of the National Accounts Institute (NAD)

The NAD enterprise database is created by the NAI[7] for generating the Belgian national accounts. It integrates various administrative datasets relating to enterprises in order to provide a complete picture of all the economic actors. The principal sources are datasets from the National Statistical Institute (DBRIS[8], Prodcom[9], the Company Structures survey, etc.), the NSSO (National Social Security Office) and NSSOPLG (National Social Security Office of the Provincial and Local Governments) and the NBB (annual accounts and foreign trade returns).

The NAI database contains all the enterprises taken from the DBRIS business register compiled by the NSI. The main sources for the DBRIS are VAT datasets (FPS Finance) and datasets from the National Office of Social Security (NSSO) which are linked via a concordance table drawn up by the NSI. Other inputs include the State register of legal persons (FPS Interior), the Central Balance Sheet Office, the dataset for company tax and social archives (NSSOPLG). Just like the CBE, the NAI does not include natural persons without staff not accountable for VAT[10].

The activity codes included in the DBRIS come from different data supplying departments. To assign a unique activity code to every enterprise, the following order of priority is used in the NAD enterprise database:

1. the National Office of Social Security (NSSO),
2. Provincial and Local Government (PLG),
3. the FPS Finance (VAT),
4. the Registries,
5. Company Counters,
6. the CBE,
7. FPS Finance (company tax).

It should be noted here that if the activity code for an enterprise in a certain year is missing or is not (yet) known, the last known activity code is taken. This is a difference with the CBE where the 'Unknown industry' code is assigned in that case.

3.3.1.3 Central Balance Sheet Office's database (CBSO)

The internal database of the Central Balance Sheet Office is consulted as a third source of information regarding enterprise activity codes. The Central Balance Sheet Office collects, processes and publishes all the annual accounts deposited with the NBB by Belgian companies. All Belgian enterprises whose legal form implies a limited liability to the shareholders or partners, are obliged to deposit annual accounts at the CBSO. Natural entities and legal persons or associations with unlimited liability do not file annual accounts. As a consequence, the size of the CBSO population is smaller than that of the two other sources.

The identification data for the enterprises in the database come from the CBE. Before the introduction of the CBE in 2003, the Central Balance Sheet Office based the assignment of activity codes on different sources: a data carrier from the VAT department and the NSSO, direct contacts with enterprises and bilateral contacts with the NSI for approving the allocation or modification of certain activity codes. Companies were systematically contacted and asked to provide information if

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[7] The NAI, set up under the Law of 21 December 1994, combines three institutions: the National Statistical Institute (NSI, now the FPS Economy, SMEs, Self-Employed and Energy – General Department of Statistics and Economic Information), the National Bank of Belgium and the Federal Planning Bureau. Amongst other things, the NAI generates real national accounts and input-output tables.

[8] DBRIS stands for Database of Statistical Reporting Population (DB des Redevables de l'Information Statistique) and is the enterprise register which the NSI uses to set up surveys.

[9] Prodcom is the monthly survey of industrial production carried out by the NSI. It mainly relates to the quantities and the values of products supplied during the month under report as well as a number of questions regarding employment.

[10] The activity of these professions is estimated via personal income tax returns.

it was found that the activity code assigned by the VAT department was different to the one assigned by the NSSO.

Ater the introduction of the CBE, the Central Balance Sheet Office has had a computerised dataset containing both the VAT and NSSO activity codes which has lead to the adjustment of the above-mentioned method of operation. In the case of new enterprises, the activity code from the NSSO or VAT department will be used automatically, with the NSSO code being given priority. Companies without staff and not accountable for VAT are contacted in writing by the Central Balance Sheet Office and asked to provide information on their activities. The activity code can also be adjusted manually if it is found that the information from the CBE does not correspond to reality (any longer).

3.3.2 *Comparison of demographic evolution by source*

From the description in 3.3.1, it follows that sources differ in their composition (i.e. the list of enterprises) and in the way the activity codes are assigned. All three sources have historical data covering the period 2000-2006. As explained in section 3.2, the activity codes can be aggregated into several levels of detail (A120, A60, A17, A6, A3).

The migration matrices $D^{(t)}$ have been computed for each source, for every two consecutive years, and for each aggregation of activity levels. As such, 3 x 6 x 5 = 90 matrices were computed. For practical reasons, it is impossible to show all these matrices. It was decided to illustrate the methodology using the evolution of active enterprises recorded in the CBE over the period 2000-2006. The aggregation level A6 was chosen, again for practical reasons.

The decision to analyse CBE data was taken because it is most similar to publicly-available statistics on Belgian business demography. This is argued in more detail below.

Table 1 contains an overview of the total number of active enterprises, the number of births, deaths and the net increase or reduction in the population of enterprises calculated on the basis of data from migration matrices generated by taking the CBE or NAD as a source. As only active enterprises are considered, the population size, entries and exits are the same for both sources[11]. As mentioned before, Table 1 contains only a part of the information that can be found in the full migration matrix (see Annex 1 for the full migration matrix). Table 2 provides the same overview based on the Central Balance Sheet Office as a source.

[11] The NAD and CBE only differ in the way that the activity codes are assigned. As a result, the total number of active enterprises, the total number of births and the total number of deaths are identical. The number of enterprises which remain active within an industry, the number of enterprises which migrate between two industries and the number of births and deaths by industry over two consecutive years will vary depending on the source selected.

Table 1: Births and deaths of enterprises in CBE/NAD data

	2000	2001	2002	2003	2004	2005	2006
Number of active enterprises	643,220	643,280	647,750	653,093	665,425	678,046	695,021
Births		50,059	52,763	50,258	57,197	58,034	64,021
p.c. of births compared with active enterprises		7.78%	8.20%	7.76%	8.76%	8.72%	9.44%
Deaths		49,999	48,293	44,915	44,865	45,413	47,046
p.c. death compared with active enterprises		7.77%	7.51%	6.93%	6.87%	6.82%	6.93%
Growth		60	4,470	5,343	12,332	12,621	16,975
p.c. growth compared with active enterprises		0.01%	0.69%	0.82%	1.89%	1.90%	2.50%

Source: CBE, Own calculations

Table 2: Births and deaths of enterprises in CBSO data

	2000	2001	2002	2003	2004	2005	2006
Number of active enterprises	302,178	310,163	321,428	331,013	339,842	348,946	358,447
Births		22,985	25,042	23,020	23,190	23,450	24,826
p.c. births compared with active enterprises		7.61%	8.07%	7.16%	7.01%	6.90%	7.11%
Death		15,000	13,777	13,435	14,361	14,346	15,352
p.c. death compared with active enterprises		4.96%	4.44%	4.18%	4.34%	4.22%	4.40%
Growth		7985	11,265	9585	8829	9104	9474
p.c. growth compared with active enterprises		2.64%	3.63%	2.98%	2.67%	2.68%	2.72%

Source: CBSO, Own calculations

The population of active enterprises in the CBSO is roughly half (between 47% and 52% depending on the year) of the one in CBE/NAD. As explained in 3.3.1.3, only some of the enterprises file annual accounts.

The fraction of newborn enterprises is very similar in both tables, although it increases faster in CBE/NAD from 2004 onwards as this year saw the start of an economic upturn. So, it seems that in an improved economic climate more enterprises are created in CBE/NAD than in CBSO. This means (see 3.3.1.3) more natural entities or legal forms with unlimited liability are created.

The ratio between the number of deaths and the number of active enterprises is lower in the CBSO than in the CBE data. This indicates that enterprises that deposit annual accounts (i.e. with limited liability) do not die as quickly as other enterprises. These enterprises clearly have a more stable legal form.

On balance, the growth in the number of active enterprises is higher in the Central Balance Sheet Office than in the Crossroads Bank for Enterprises due to the different figure for deaths.

The population of active enterprises is the same for the NAD and CBE. They only differ in the way they assign activity codes. In the migration matrices created on the basis of data from the NAI, a lot more enterprises appear to remain active within the same industry over two consecutive years (see Table 3). This can be attributed to manual corrections carried out by the NAI where the last known activity code is used for enterprises for which the activity code for one or more years is missing or not (yet) known.

From the full migration matrix in Tables 5 and 7 it will be seen that enterprises with unknown activity codes are more vulnerable than the other ones. Indeed, for all branches the proportion of 'death' companies is below 8%, while for the enterprises with unknown activity code this fraction is over 27%. Moreover, it can be seen in Table 7 that enterprises with a known activity sometimes migrate to the more vulnerable 'unknown' state.

Table 3: Companies within the same industry over two consecutive years

A6 Classification	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006
Agriculture						
NAD	26,761	26,865	26,934	27,085	27,841	28,271
CBE	26,165	26,374	26,333	26,518	27,179	27,830
Industry						
NAD	43,520	42,786	42,365	41,966	42,284	41,900
CBE	42,731	42,167	41,577	41,126	41,129	41,171
Construction						
NAD	65,564	65,526	65,591	65,841	67,197	68,650
CBE	65,718	65,763	65,566	66,072	67,513	69,822
Trade and transport						
NAD	232,656	227,953	225,988	224,078	226,077	223,722
CBE	229,481	225,057	221,537	220,678	220,974	220,326
Financial activities						
NAD	142,286	145,924	150,109	157,160	163,839	169,999
CBE	137,713	144,624	151,193	155,359	159,319	163,694
Other service activities						
NAD	69,343	70,116	71,054	74,392	83,382	84,826
CBE	70,519	72,754	75,645	79,958	82,565	84,592

Source: NAI, CBE, Own calculations

3.3.3 *Comparing the results to public available statistics on enterprise demography for Belgium*

Table 4 shows the numerical data published by the National Statistical Institute (NSI). These statistics on business demography are published at regular intervals on the website of the NSI (see: http://www.statbel.fgov.be - under "Statistics", select the option: "Economy and Finance" followed by the option "Enterprises"). It therefore makes sense to compare the results of this paper to NSI's.

The data on births, deaths and growth from the CBE/NAD (Table 1) and the results from the NSI can be regarded as similar and the similarity increases in the most recent years. The population size is slightly different. For the purpose of this paper, an enterprise is regarded as active if it realises turnover and/or employs at least one member of staff within a certain year. Our definition of 'active enterprise' is in line with Eurostat's. The NSI studies the population of enterprises that are registered at the VAT department. As some of them do not comply with their legal obligation, this population is broader than the population of active enterprises as defined by Eurostat-OECD (see enterprises accountable for VAT and submitting returns in Table 4).

This similarity between CBE and NSI demographic statistics, together with previous remarks made on the difference in assignment of activity codes between CBE and NAD and the indications of vulnerability of enterprises with an unknown activity, justify the use of CBE data as an illustration in the remainder of this paper.

Table 4: Births and deaths of enterprises (NSI)

	2000	2001	2002	2003	2004	2005	2006
Number of enterprises accountable for VAT	689,453	687,349	686,857	687,762	697,817	710,252	722,191
Companies accountable for VAT submitting returns	560,184	562,434	561,973	563,776	574,634	585,591	598,800
Companies accountable for VAT set up		49,750	48,708	48,033	58,427	61,402	65,324
		7.22%	7.09%	6.99%	8.50%	8.80%	9.20%
Companies accountable for VAT removed		51,296	48,625	46,676	48,137	48,402	51,264
		7.44%	7.07%	6.80%	7.00%	6.94%	7.22%
Growth		-2104	-492	905	10,055	12,435	11,939
		-0.31%	-0.07%	0.13%	1.46%	1.78%	1.68%

Source[12]: FPS Finance, VAT register and FPS Justice, Own calculations

12 Calculations by the General Department of Statistics and Economic Information (DBRIS enterprise register).

4 AN APPLICATION TO THE CROSSROADS BANK FOR ENTERPRISES

4.1 The demographic evolution matrix

The CBE will be used to illustrate the definitions given in section 2. The matrix $D^{(t)}$ is calculated for for the periods 2000-2001, 2001-2002, ... 2005-2006. Depending on the level of aggregation of the activity codes (A120, A60, A17, A6), matrices of different dimensions are obtained. For practical reasons, it was decided that this paper shows the results for a classification within seven industries (A6 industry classification along with the industry 'Unknown').

More detailed matrices are disseminated via Belgostat (see: http://www.belgostat.be - under "Multidimensional search", select the following option: "Business demography").

4.1.1 Descriptive illustration of the properties of the demographic matrix

The migration table D^{2006} is shown below in Table 5. This migration table is used as an example in order to clarify the information which such tables can provide regarding the demographic evolution of Belgian enterprises during the period 2005-2006.

Table 5: Enterprise migrations between 2005-2006, table $D^{(2006)}$

		State in 2006								
	A6 Classification - numbers	(1)	(2)	(3)	(4)	(5)	(6)	Unknow	Death	Total
State in 2005	Agriculture .... (1)	27,830	26	83	133	42	44	137	1,648	29,943
	Industry .... (2)	24	41,171	210	459	167	38	176	2,546	44,791
	Construction .... (3)	68	145	69,822	265	184	21	295	4,875	75,675
	Trade and transport .... (4)	135	397	447	220,326	980	274	1,372	18,975	242,906
	Financial activities .... (5)	70	176	271	804	163,694	216	868	10,297	176,396
	Other service activities ..... (6)	42	40	36	262	228	84,592	564	4,393	90,157
	Unknown	37	81	124	467	562	198	12,397	4,312	18,178
	Birth	2,893	3,166	8,326	19,887	16,994	7,199	5,556	0	*64,021*
	Total	31,099	45,202	79,319	242,603	182,851	92,582	21,365	*47,046*	

Source: CBE, Own calculations

The first row shows that, in the year 2005, there were 29,943 enterprises operating within the 'Agricultural' branch (this is the total from the first row of the table). Between 2005 and 2006, twenty-six enterprises migrated from this group of enterprises to the 'Industry' branch and 27,830 enterprises remained within the 'Agriculture' branch and were therefore still active within the 'Agricultural' branch in 2006. In 2006, 137 agricultural enterprises were classified within the 'Unknown' branch and 1,648 were found to be no longer economically active in 2006, as a result of which they were entered under the ‘Death' classification.

As can be seen from the first column, in 2006, 31,099 enterprises were active within the 'Agricultural' branch. Between 2005 and 2006, a net total of 1,156 agricultural enterprises were added. This net increase is the result of the 'addition' of 2,893 enterprise births together with 376 (24 + 68 + 135 + 70+ 42 + 37) enterprises which migrated to the 'Agricultural' branch between 2005 and 2006 and the 'removal' of 1,648 enterprise deaths together with 465 (26 + 83 + 133 + 42 + 44 + 137) enterprises that migrated from the 'Agricultural' branch to another branch.

The total in the last row of the table indicates that 64,021 new enterprises were created in 2006, while the total from the last column indicates that a total of 47,046 enterprises have disappeared. Consequently, on balance, the number of active enterprises increased between 2005 and 2006.

The total number of enterprises in each branch in the year 2005 can be found in the last column 'Total'. If all known branches and unknown branches are added up, this gives 678,046 enterprises in 2005. The total from the 'Birth' row (64,021) cannot be counted because, by definition, these new enterprises did not exist in 2005, they were created in 2006.

Similarly, the total number of enterprises in 2006 is found by adding together all the totals in the 'Total' row from the table without the total from the 'Death' column which cannot be counted because, by definition, these enterprises no longer existed in 2006. The total number of enterprises in 2006 amounts to 695,021. Consequently, the total number of enterprises increased by 695,021 - 678,046 = 16,975 enterprises between 2005 and 2006. This, of course, is also the difference between the total from the 'Birth' row and the total from the 'Death' column.

In each case, the differences between the row and column totals represent the net growth by industry. Therefore, by using this method, the increase of 16,975 enterprises can be split into the different branches: 16,975 = 1,156 + 411 + 3,644 - 303 + 6,455 + 2,425 + 3,187.

The main diagonal (from top left to bottom right) shows the total number of enterprises remaining within a branch between 2005 and 2006. The vast majority of enterprises do not seem to have migrated between branches during the two consecutive years.

The findings for all branches are summarised in Table 6 below.

Table 6: Demographic evolution of Belgian enterprises between 2005-2006

Changes 2005-2006	2005	Birth	Migrate-in	Migrate-out	Death	2006
Agriculture ....(1)	29,943	2,893	376	465	1,648	31,099
Industry ....(2)	44,791	3,166	865	1074	2,546	45,202
Construction ....(3)	75,675	8,326	1171	978	4,875	79,319
Trade and transport ....(4)	242,906	19,887	2390	3605	18,975	242,603
Financial activities ....(5)	176,396	16,994	2163	2405	10,297	182,851
Other service activities ....(6)	90,157	7,199	791	1172	4,393	92,582
Unknown	18,178	5,556	3412	1469	4,312	21,365
Total	678,046	64,021	-	-	47,046	695,021

Percentages of 2005	2005	Birth	Migrate-in	Migrate-out	Death	2006
Agriculture ....(1)	100.0%	9.7%	1.3%	1.6%	5.5%	103.9%
Industry ....(2)	100.0%	7.1%	1.9%	2.4%	5.7%	100.9%
Construction ....(3)	100.0%	11.0%	1.5%	1.3%	6.4%	104.8%
Trade and transport ....(4)	100.0%	8.2%	1.0%	1.5%	7.8%	99.9%
Financial activities ....(5)	100.0%	9.6%	1.2%	1.4%	5.8%	103.7%
Other service activities ....(6)	100.0%	8.0%	0.9%	1.3%	4.9%	102.7%
Unknown	100.0%	30.6%	18.8%	8.1%	23.7%	117.5%
Total	100.0%	9.4%	-	-	6.9%	102.5%

Source: CBE, Own calculations

Between 2005 and 2006, the population has grown by around 2.5% in total 6.9% of all registered companies died. The new companies represent around 9.4% of the population in 2005. Except for the 'unknown' activity codes, births represent between 7% and 11% of 2005's branch size, migrations into a branch are between 1% and 2% of the population size in 2005. Between 5% and 8% of each branch's active enterprises disappear from the population between 2005 and 2006. Between 1.3% and 2.5% migrate to another branch.

Matrix D^t has also been calculated for 2001-2002, 2002-2003, ... 2004-2005. These tables are contained in Annex 1.

4.1.2 An analysis of particular migrations between branches

In this study, only the activity code for the main activity of an enterprise registered in a particular source is taken into account for the analysis of migrations of enterprises between various industries. It is obvious that a registration error with regard to the main activity of an enterprise can have an influence on the results of this paper. An analysis of all migrations between 2005 and 2006 from the "Financial, real estate, renting and business activities" industry to the "Agriculture, hunting and foresty; fishing and operation of fish hatcheries and fish farms" industry indicates that, without any exception, they can all be attributed to an alteration in the main activity of the enterprise and not to an administrative rectification of an incorrect activity code attributed in the past. The result of the afore-mentioned analysis is described below.

One can read in Table 5 that 70 enterprises migrated between the two industries mentioned above. Within the group of 'enterprises registered as legal persons', 41% migrates through the adjustment at the VAT department of their main activity. In two out of three cases, this modification of the company objectives is published in the annexes of the Belgian Law Gazette. In some cases, besides the activity, the name is changed too, the domicile moves and a new statutory business manager is appointed. This indicates that some enterprises migrate between industries because a complete new business is developed within an existing legal form. In cases where there is no publication of an amendment to the articles of association, both activities can always be found in the memorandum of association of the enterprise.

The rest of the group of 'enterprises registered as legal persons' migrate between the two industries because, up to and including 2005, they are registered at only one particular department (e.g. NSSO, VAT, company tax, etc.). An enterprise that exercises for example a main activity accountable for VAT without any employment (e.g. NACE code 74142 Business and management consultancy activities) will only be registered at the VAT department. When, in 2006, this enterprise recruits personnel as a part of one of its other activities[13] (e.g. NACE code 01220 Horse-breeding), the company will have to be registered at the NSSO department. This department records as a main activity the NACE code for which personnel is employed. As in this paper a certain order of priority is followed for the attribution of activity codes coming from different instrumenting departments (see section 3.3.1.2 The database of the National Accounts Institute), in this particular case, the enterprise will migrate from the "Financial, real estate, renting and business activities" industry to the "Agriculture, hunting and forestry; fishing and operation of fish hatcheries and fish farms" industry. The afore-mentioned priority rule is adopted from the NAI which applies it for generating national accounts. The NAI gives priority to an activity code attributed by the NSSO department because the enterprise in question will employ personnel. As the application of labour means a larger contribution to prosperity and to the national income, one can assume that this enterprise is no longer the same as before.

Within the group of 'enterprises natural persons', 23% of them migrate through the adjustment of their main activity at the VAT department. This always concerns businesses run by one person who has had a particular main activity (e.g. NACE code 74402 Management of publicity carriers) for a number of years and subsequently switches over to a new activity (e.g. NACE-code 01410 Construction and maintenance of gardens and parks). Moreover, in the majority of cases, the new main activity was registered as a sideline business before. This indicates that the importance of one of the sideline businesses increased during the years and became a main activity as from 2006. This excludes the theory that some of these migrations can be attributed to an administrative rectification of an incorrect activity code.

The remaining enterprises natural persons migrate between the two industries because, up to and including 2005, they are only registered at the VAT department as landscape architects (NACE code 74201). As they recruit personnel to construct and maintain gardens in 2006, they are registered for the first time with the NSSO department for the activity with personnel (NACE-code 01410) which causes a migration between industries. This proves that also for these particular cases migration is dictated by an economic reality.

[13] This is usually an activity that is registered as a sideline business at the VAT department and is always mentioned in the memorandum of association of the enterprise published in the annexes of the Belgian Law Gazette.

4.2 Forecasting demographic change: an in-sample test

As explained in section 2.4, the (average) extended transition matrix given by (8) can be used to forecast the demographic evolution over the next few years. The formulae in (12), (13) and (14) were applied to the matrix $\overline{P}$ in Table 7.

The annual matrices $P_{ext}^{(t)}$ can be found in annex 2. A hypothesis test based on the Binomial distribution shows that most off-diagonal elements are significantly different from zero.

Table 7: Average matrix $\overline{P}$ in percentages

	A6 Classification - numbers	(1)	(2)	(3)	(4)	(5)	(6)	Unknow	Birth	Death
					State in t					
State in t-1	Agriculture .... (1)	**93.51**	0.03	0.13	0.27	0.08	0.09	0.46	-	5.43
	Industry .... (2)	0.02	**92.73**	0.22	0.59	0.21	0.07	0.47	-	5.68
	Construction .... (3)	0.05	0.11	**92.21**	0.21	0.15	0.02	0.51	-	6.72
	Trade and transport .... (4)	0.04	0.10	0.10	**91.09**	0.24	0.08	0.69	-	7.67
	Financial activities .... (5)	0.02	0.06	0.10	0.36	**92.85**	0.10	0.42	-	6.10
	Other service activities ..... (6)	0.02	0.02	0.02	0.19	0.17	**94.30**	0.42	-	4.87
	Unknown	0.25	0.49	0.93	3.42	5.85	3.51	58.16	-	27.39
	Birth	3.86	4.71	11.23	32.90	27.49	11.79	8.01	-	-
	Death	-	-	-	-	-	-	-	-	100

Source: CBE, Own calculations

The main diagonal of the one-year transition matrix shows that between 91.1% (Trade and Transport) and 94.3% (Other service activities) stay in the same branch from one year to another.

The probability of dying the next year is between 4.9% (Other service activities) and 7.7% (Trade and Transport). That is the average (one-year) default rate for all the enterprises in that particular branch. At a lower level of aggregation (e.g. A60), the spread is higher: it ranges from around 10% for 'Post and telecommunication services' (13.4%), 'Water transport services' (9.3%), 'Hotel and restaurant services (9.2%)' to around 4% for 'Manufacture of motor vehicles, trailers and semi-trailers' (4.3%), 'Manufacture of rubber and plastic products' (4.2%), 'Real estate services' (4.1%), and 'Manufacture of pulp, paper and paper products' (4.0%).

Public service branches show even lower failure rates: 'Health and social work services' (2.9%), 'Public administration and defence services; compulsory social security services' (2.9%).

Note that firms with an unknown activity code have a significantly higher risk (27.39% fail the next year). Only 14.5% of enterprises with an unknown activity move to an identified branch the year after, 58.2% remain unknown, and the others disappear. Moreover, it can be seen that between 0.4% and 0.7% of the enterprises with a known branch move to the unknown branch the next year.

This vulnerability of the unknown branch is not observed in the CBSO enterprises; since 2005 less than 1.5% of the CBSO enterprises have an unknown activity code. They are not more vulnerable than firms with a known activity. There are only a few migrations to the unknown column, meaning that, in most cases, the activity code 'unknown' exists for new companies.

The probalities of failure after *n* years can be obtained from the powers of the transition matrix: $\overline{P}^n$.

These default fractions are the average default rates for all the enterprises in that particular branch. The default probability of an individual firm in that branch is to be estimated using other techniques like Logistic Regression or survival analysis (see e.g. ECCBSO 2007).

Around 33% of all the new companies are set up in 'Trade and Transport', 27.5% in 'Financial Activities', 11.8% in 'Other service activities' and 11.2% in 'Construction'

The extended transition matrix can be used to forecast the long-term behaviour of a Markov chain. From an initial distribution of the firms, the state of enterprises can be calculated during subsequent years. Within the framework of this study, the demographic evolution of Belgian enterprises for the period 2000-2006 will be simulated and this simulation will be taken from the starting distribution of the enterprises in the year 2000. The result of this simulation will be compared with the actual distribution and evaluated.

The distribution of enterprises in the year 2000 can be calculated using the data from the CBE. If, for example, it is assumed that the number of births remains constant each year, then the distribution of enterprises across the different industry classes and the 'Death' class can be calculated for subsequent years (2001, 2002, 2003, ...) based on the average transition matrix. On average, 55,000 new enterprises per year were created. As a very simple proxy c = 55,000 is taken for simulating the demographic evolution between 2000 and 2006. Other possibilities might be to use a constant growth factor for the births (it could e.g. be derived from Table 1) or estimating the number 'c' using GDP forecasts.

The initial distribution of enterprises $A^{(0)}$ (see (12)) was computed from CBE data from the year 2000 and for 6 economic branches and the 'unknown' branch, so N = 7 and

$$A^{(0)} = \begin{pmatrix} 27{,}882 & 45{,}904 & 71{,}256 & 252{,}537 & 149{,}209 & 75{,}021 & 21{,}330 & 55{,}000 & 0 \end{pmatrix}$$

.

Table 8 provides an overview of the forecasts based on the starting state of the enterprises in 2000 and these results are compared with the actual demographic distribution of enterprises for the period 2000-2006 based on the CBE as a source.

The forecast was made using two different methodologies:

- *Markov estimate*: this estimate is computed using the technique explained in section 2.4 (see (13), (14))

- *Estimate average Entry/exit rate*: in this case, the annual composition of entries and exits is based on entry and exit rates by branch. It does not take migrations between sectors into account. Within each branch the entry and exit rates are the average entry and exit rate over the period 2000-2006. The entry rates multiplied by 'c' yield the annual number of entries. The exit rates multiplied by the branch sizes give the number of exits. In line with the Eurostat OECD methodology (Eurostat-OECD 2007) migrations are thus not considered as 'birth' or 'death'.

Numbers in bold are observed counts, e.g. in 2001, there were 28,118 active enterprises in the agricultural branch. The row entitled 'Markov estimate' shows the relative error of the estimate made using the Markov method described in this paper. The 'estimate average entry/exit rate' row shows the forecast using the method that does not take migrations between sectors into account.

It can be seen that the Markov chain approach gives better forecasts than the other method. For each year the RMSE (root mean squared error)[14] is lower for the Markov estimate. The same holds for RMSE over all the years together. Other measures for comparing the forecasting power, like MAPE (mean absolute percentage error), MAE (mean absolute error), 'percentage better' (Makridakis et. al 2000)) - lead to similar conclusions.

The Markov simulation performs well for all branches except for the 'Unknown' industry and for the 'Death' state. The relatively poor performance on the 'Unknown' state stems from the heterogeneity

[14] Considering n observations o_i that are estimated by the values $\hat{o}_i$ then the root mean squared error is defined as

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(o_i - \hat{o}_i)^2}$$

of the enterprises in this branch. Since more than a quarter of the enterprises in the 'Unknown' state die the next year (see Table 7), estimation errors in that class are propagated to the 'Death' state.

The transition matrix used was an average matrix over the period 2000-2006. This is justified by the fact that the simulation in Table 8 spans a longer period. However, it also implies that for some years that deviate strongly from the average, the predictions for that year will also deviate more than over the whole period. That is why, for short-term forecasts, one should make use of two different transitions matrices, one for high growth and one for low growth, together with a forecast of the business cycle (see also the remark made at the end of section 2.4). If a year of low growth is expected, the low-growth matrix should be used and vice versa.

Table 8: Forecast of the number of enterprises by industry for 2000-2006

	2001	2002	2003	2004	2005	2006
Agriculture ....(1)	**28,118**	**28,321**	**28,217**	**29,063**	**29,943**	**31,099**
Markov-estimate..........................	1.2%	2.4%	4.5%	3.1%	1.6%	-0.9%
Estimate average entry/exit rate...	1.4%	2.7%	5.0%	3.8%	2.4%	0.1%
Industry ....(2)	**45,404**	**44,807**	**44,176**	**44,625**	**44,791**	**45,202**
Markov-estimate..........................	0.7%	1.6%	2.7%	1.3%	0.6%	-0.6%
Estimate average entry/exit rate...	1.1%	2.4%	3.9%	2.8%	2.4%	1.5%
Construction ....(3)	**71,369**	**71,418**	**71,222**	**73,326**	**75,675**	**79,319**
Markov-estimate..........................	1.8%	3.5%	5.4%	3.9%	2.0%	-1.5%
Estimate average entry/exit rate...	1.8%	3.6%	5.6%	4.1%	2.3%	-1.2%
Trade and transport ....(4)	**247,539**	**243,747**	**239,863**	**242,402**	**242,906**	**242,603**
Markov-estimate..........................	1.0%	1.7%	2.5%	0.7%	-0.2%	-0.7%
Estimate average entry/exit rate...	1.5%	2.7%	3.9%	2.4%	1.8%	1.6%
Financial activities ....(5)	**155,813**	**162,695**	**166,801**	**171,287**	**176,396**	**182,851**
Markov-estimate..........................	0.1%	-0.3%	0.6%	1.0%	0.9%	-0.2%
Estimate average entry/exit rate...	-0.3%	-1.0%	-0.2%	0.1%	-0.1%	-1.2%
Other service activities ....(6)	**77,147**	**80,267**	**84,321**	**87,379**	**90,157**	**92,582**
Markov-estimate..........................	1.7%	1.6%	0.3%	-0.1%	-0.2%	-0.2%
Estimate average entry/exit rate...	0.9%	0.4%	-1.4%	-2.0%	-2.4%	-2.6%
Unknown	**17,890**	**16,495**	**18,493**	**17,343**	**18,178**	**21,365**
Markov-estimate..........................	11.8%	16.7%	2.0%	7.6%	2.1%	-13.2%
Estimate average entry/exit rate...	10.1%	12.2%	-4.6%	-1.9%	-8.9%	-24.0%
Death	**49,999**	**48,293**	**44,915**	**44,865**	**45,413**	**47,046**
Markov-estimate..........................	-6.2%	-2.6%	5.3%	6.1%	5.6%	2.7%
Estimate average entry/exit rate...	-6.2%	-2.7%	5.0%	5.7%	5.1%	2.1%

Source: CBE, Own calculations

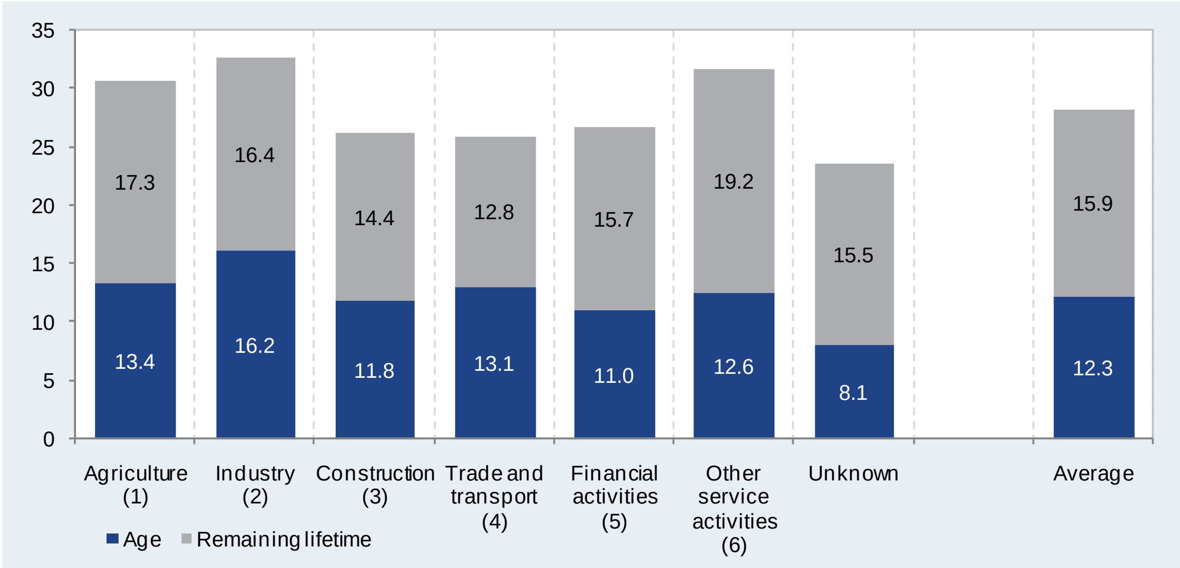
We can conclude from this that the extended average transition matrix makes it possible to carry out extrapolations across the demographic evolution of Belgian enterprises. However, it should be noted here that, in Table 8, calculations are carried out for years for which the actual demographic distribution was also counted when calculating the average transition matrix. This ensures that there are no excessive differences between the data calculated and the actual data. If an average transition matrix is used to generate forecasts for the year after the period 2000-2006, the bigger the forecast horizon, the bigger the difference will be. If that is the case, then in order to ensure optimum results, a new average transition matrix will need to be calculated whereby the years which are used to do this must follow as closely as possible after the year for which extrapolation is required[15].

4.3 Computation and analysis of the average lifetimes and ages

In section 2.4, it was argued that the fundamental matrix of the absorbing Markov chain can be used to compute the average lifetime of enterprises in a particular economic branch. Table 9 shows the results for the different industries at A6 level.

The extended matrix $\overline{P}$ in Table 7 shows that an enterprise in the 'Agriculture branch' has a 5.43% chance of dying after one year. Some of the enterprises in that branch have a remaining lifetime of only one year. Some die after two, three, ... years. Table 9 shows that 'on average' a farming enterprise will have a lifetime of 17.33 years. In a similar way the average age by branch can be computed. The results are shown in chart 1 and chart 1bis.

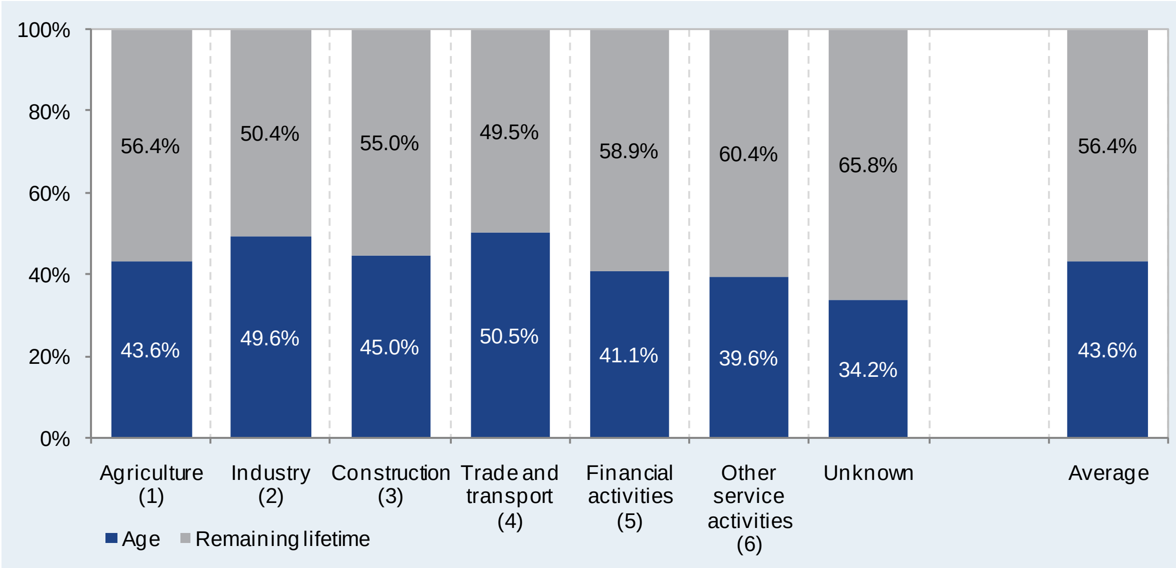
Chart 1: Average remaining lifetime and age at A6 level



Source: CBE, Own calculations

15 The number of years used to create an average transition matrix will depend on the economic cycle. The average transition matrix makes it possible for extrapolations to be made for the future based on the assumption that the past is representative of this. Above all, that means that a year like 2008 in which the credit crisis had an extraordinarily negative effect on economic growth cannot be included in the calculation of an average migration matrix. Instead, this year is to be regarded as a break. Therefore, it is not possible to make accurate predictions for this exceptional period and the best way to calculate extrapolations for the future is by taking as a basis a new migration matrix created based on demographic developments during 2009, 2010, etc.

Chart 1bis: Average remaining lifetime and age at A6 level (percentages)



Source: CBE, Own calculations

The chart shows the age, the remaining lifetime and the sum of the two (the total lifetime) for each branch. The average over all branches is also shown. The total lifetime of Agriculture, Industry and Other service activities are above average. For Agriculture and Other service activities the age is close to the average value. Industry's enterprises are older than average. Comparing age with total expected lifetime is an indicator of closeness to extinction. Agriculture is at 44%, Industry at 51% and Other services is at 40%.

Construction, Trade and Transport and Financial Activities have below average total lifetimes. Construction and Financial Activities have younger enterprises. Trade and transport is closer to extinction (51%) than Construction (45%) and Financial Activities (41%).

The 'Unknown' branch is a particular case. Enterprises starting as 'Unknown' die sooner (even if they migrate to a known branch later on). Their age is low compared to their total lifetime. This is because many new enterprises start in the 'Unknown' state. It is far from extinction (34%), meaning that there will be unknown activities for a long time in the future.

In order to be able to establish possible connections between the industry in which an enterprise operates and the average remaining lifetime, the result needs to be viewed at a lower aggregation level. Annex 3 contains an overview of the average lifetime of enterprises by industry at A120 level. Table 10 contains a summary of the average remaining lifetime and average age of enterprises operating within the main types of industry (at A120 level) in terms of their share of the value added in GDP.

Table 10: Average remaining lifetime and average age within the main industries (A120 level)

SUT	Description	Remaining Lifetime	Age	Total Lifetime
40A1	Electricity, gas, steam and hot water supply.................................	12.37	7.70	20.1
45B1	General construction of buildings and civil engineering works, erection of roof covering and frames	14.76	12.59	27.3
50A1	Sale, maintenance and repair of motor vehicles and motorcycles, sale of motor vehicle parts and accessories............	16.14	17.40	33.5
51A1	Wholesale trade and commission trade.......................................	13.26	13.91	27.2

SUT	Description	Remaining Lifetime	Age	Total Lifetime
52A1	Retail trade; repair of personal and household goods	13.62	14.68	28.3
63B1	Cargo handling and storage; supporting and auxiliary transport activities	15.41	12.36	27.8
64B1	Telecommunications	9.21	5.70	14.9
65A2	Financial intermediation	16.32	13.44	29.8
70A1	Real estate activities	21.69	14.96	36.6
72A1	Computer and related activities	12.34	7.16	19.5
74A1	Legal, accounting, book-keeping and auditing activities; tax consultancy; market research and public opinion polling	17.30	15.18	32.5
74B1	Business and management consultancy activities, management activities of holding companies and coordination centres	16.78	8.39	25.2
74E1	Labour recruitment and provision of personnel	15.03	7.60	22.6
74F1	Investigation and security activities, industrial cleaning, miscellaneous business activities	12.10	9.68	21.8
75A3	Public administration except defence and compulsory social security	29.03	10.41	39.4
85A1	Human health activities	31.05	12.99	44.0
85C1	Social work activities	44.63	17.07	61.7

Source: CBE, Own calculations

Companies operating within the "Telecommunications" industry have a total lifetime of just 14.9 years, a figure which is well below the average of 33.8 years. Enterprises from that branch 64B1 tend to die younger than the average enterprise, and in the absence of new entries, this branch would be threatened with extinction. However, over the period 2000-2006, the total number of enterprises in the telecommunications branch almost doubled (+98%). A short lifetime and a large number of entries are an indication of renewal processes inside the branch. The average age of enterprises (5.7 years) in that branch is the lowest of all branches.

The energy branch's (40A1) total average lifetime is relatively short (20.1 years), and the same holds for the computer branch (72A1, 19.5 years). Their size grew by 49% and 58% respectively. They also show constant renewal of enterprises inside the branch. The enterprises in these two branches are relatively young.

Branches 51A1 and 52A1 also have lifetimes that are lower than but close to the average. Their number of enterprises has decreased between 2000-2006 (-8.1% and -6.6% respectively). Early deaths are thus not compensated by new entries in these branches. The average age within these branches is also less than but close to the overall average.

Then comes the "Real estate activities" sector with a lifetime (36.6) which is longer than the average and where age is lower than average. Here, the large number of enterprises which belong to this industry (number of enterprises in the average transition matrix: 34,403) is striking. The affiliation of real estate activities (development, management, etc.) to enterprises from various industries, the common practice of setting up temporary enterprises for individual development projects and the emergence of issuers of real estate securities are undoubtedly elements which explain this number. However, all this points to the possibility that the main reason for the high number of enterprises within this industry are the patrimonial enterprises set up with a view to achieving fiscal optimisation. This last category where an enterprise is only set up for a private property or a company property for the purpose of managing real estate could explain the low figures for deaths (on average 4.08%) and the high average lifetime within this industry.

As one would expect, the industries "Public administration, except defence and compulsory social security", "Human health activities" and "Social work activities" have a long lifetime. These are industries where operating resources are partly or completely funded by the government as a result of which these enterprises cannot be compared with commercial enterprises.

5 CONCLUSION

This study applies the mathematical theory of Markov chains to the demographic evolution of Belgian enterprises over the period 2000-2006. Other frequently-used techniques to analyse business demography are descriptive statistics on entries/exits by branch and duration analysis. None of these methods takes migrations between economic branches into account. Markov chains account for changes in economic activity and, as a consequence, the so-called migration matrix gives a more complete picture of the demographic evolution of a population of enterprises.

This paper uses Belgian data from the Crossroads Bank for Enterprises (CBE) to illustrate this. Other sources of business data that are available are the National Accounts Database (NAD) and the Central Balance Sheet Office (CBSO). The migration matrices for the three data sources are available on the National Bank's website.

The CBE was chosen because of its comparability to other, publicly-available, statistics: the number of enterprises, the fraction of entries and the fraction of exits computed using the CBE are very similar to those published by the National Statistical Institute (NSI). The differences are due to another definition of 'active enterprise'. This paper's definition is more in line with the international methodology outlined by Eurostat/OECD.

The CBE and NAD populations are the same, even though in some cases they assign different activity codes to an enterprise. The size of the population, the entry rates and the exit rates are thus the same for both sources, but migrations between branches are different. The main difference lies in the treatment of 'unknown' activity codes: the NAD copies the activity code from the previous year while, for the CBE, this paper classified them in an 'unknown' branch.

The number of active enterprises in the register of the Central Balance Sheet Office is roughly half the number in the other two sources. The birth rate in CBSO is lower, the difference increases in times of economic upturn. The average difference in birth rate is 1.1%. The death rate in the CBSO data is also lower, the average difference being 2.7%. This shows that limited liability enterprises tend to be more stable. Moreover, the CBSO has relatively few enterprises with an unknown activity on its books.

A descriptive analysis of the migration matrix for CBE enterprises reveals additional information compared to other techniques: besides the number of births and deaths by branch, one can also derive the migrations to and from other branches. Row and column totals show the total number of enterprises in the two consecutive years. The elements of each row and column break this total down into migrations into (column) and out of (row) the branch, as well as new enterprises (column) and death enterprises (row). As such, this matrix gives a complete picture of the population and and any changes in it from one year to the next.

The transition matrix in counts can be transformed into a migration matrix in percentages by dividing each element by the row total. This is done for all the years between 2000 and 2006, resulting in six transition matrices. An average matrix of these six matrices is then computed. This matrix shows that firms with an unknown activity code have a significantly higher death rate than other enterprises. This shows that (for the CBE) a missing activity code indicates a higher risk of failure.

It should be pointed out that this is different for the population of enterprises in the CBSO, where the number of enterprises with an unknown activity code is relatively low compared to the CBE and the enterprises with unknown activity have a similar risk to the firms with a known activity code.

Many off-diagonal elements are sigficantly different from zero, so it makes sense to take migrations between branches into account. A detailed analysis of particular cases of migrations shows that they represent enterprises changing their main activity, i.e. they are not corrections of wrongly classified firms.

It is argued that this average matrix can be seen as the transition matrix of a Markov chain, i.e. the percentages are relatively stable over the period. This stability-argument is justified by checking the forecasting performance of the matrix.

The forecasting test shows that the average transition matrix can be used to model the demographic evolution over an 'average' business cycle. As this matrix can be seen as a 'through-the-cycle' migration matrix, it can be used to forecast the future evolution of the population. Taking into account changes in activity codes leads to better forecasts. For short-term forecasts, it is better to take the business cycle into account and to make the computations with two different transition matrices - one for a period of low growth and one for a period of high growth. As many variable's forecasts use the population structure and its size as an extrapolation factor (a method often used in the NBB is the 'constant sample method', see e.g. Vivet D. (2008)), the Markov-based forecasts might be used to make better predictions. This is a topic for future research.

The theory of absorbing Markov chains shows that the average transition matrix can also be used to compute average remaining lifetimes and ages of enterprises in a particular branch. This property was applied to the CBE average transition matrix. It shows that the remaining lifetimes and ages can differ considerably across industries. Moreover, short lifetimes combined with an increasing population size is a sign of renewal inside the branch. Relatively new branches are characterised by a low average age. As such the average lifetime and age are useful indicators in the study of innovation and renewal within branches. They yield additional information compared to other existing indicators like entries and exits that are set out by international methodologies.

LIST OF ABBREVIATIONS

CBE	Crossroads Bank for Enterprises
CBSO	Central Balance Sheet Office
DBRIS	Database of Statistical Reporting Population
	(DB des Redevables de l'Information Statistique)
ESA	European System of Accounts
FPS	Federal Public Service
NACE	Nomenclature statistique des Activités économiques dans la Communauté Européenne
NAD	National Accounts Database
NAI	National Accounts Institute
NBB	National Bank of Belgium
NSI	National Statistical Institute
NSSO	National Social Security Office
NSSOPLG	National Social Security Office of the Provincial and Local Governments
SUT	Supply and Use Table
VAT	Value Added Tax

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ANNEX 1: ANNUAL MIGRATION MATRICES $D^{(2001)}$ .. $D^{(2006)}$

Table A1.1 Enterprise migrations between 2000-2001, table $D^{(2001)}$

		State in 2001								
	A6 Classification - numbers	(1)	(2)	(3)	(4)	(5)	(6)	Unknow	Death	Total
State in 2000	Agriculture .... (1)	26,165	6	13	42	13	12	104	1,527	27,882
	Industry .... (2)	2	42,731	48	148	50	29	183	2,713	45,904
	Construction .... (3)	18	60	65,718	55	53	7	310	5,035	71,256
	Trade and transport .... (4)	171	151	77	229,481	280	104	1,434	20,839	252,537
	Financial activities .... (5)	23	63	55	321	137,713	100	536	10,479	149,290
	Other service activities ..... (6)	4	6	4	59	96	70,519	226	4,107	75,021
	Unknown	46	70	166	497	2,310	314	12,628	5,299	21,330
	Birth	1,689	2,317	5,288	16,936	15,298	6,062	2,469	0	50,059
	Total	28,118	45,404	71,369	247,539	155,813	77,147	17,890	49,999	693,279

Source: CBE, Own Calculations

Table A1.2 Enterprise migrations between 2001-2002, table $D^{(2002)}$

		State in 2002								
	A6 Classification - numbers	(1)	(2)	(3)	(4)	(5)	(6)	Unknow	Death	Total
State in 2001	Agriculture .... (1)	26,374	6	14	37	8	23	112	1,544	28,118
	Industry .... (2)	4	42,167	57	157	55	47	184	2,733	45,404
	Construction .... (3)	16	64	65,763	77	51	17	337	5,044	71,369
	Trade and transport .... (4)	42	145	86	225,057	257	99	1,466	20,387	247,539
	Financial activities .... (5)	24	82	73	376	144,624	107	557	9,970	155,813
	Other service activities ..... (6)	6	14	3	87	79	72,754	219	3,985	77,147
	Unknown	39	65	177	510	1,163	335	10,971	4,630	17,890
	Birth	1,816	2,264	5,245	17,446	16,458	6,885	2,649	0	52,763
	Total	28,321	44,807	71,418	243,747	162,695	80,267	16,495	48,293	696,043

Source: CBE, Own Calculations

Table A1.3 Enterprise migrations between 2002-2003, table $D^{(2003)}$

		State in 2003								
	A6 Classification - numbers	(1)	(2)	(3)	(4)	(5)	(6)	Unknow	Death	Total
State in 2002	Agriculture .... (1)	26,333	6	27	61	16	26	193	1,659	28,321
	Industry .... (2)	7	41,577	74	195	84	35	324	2,511	44,807
	Construction .... (3)	20	68	65,566	122	74	24	687	4,857	71,418
	Trade and transport .... (4)	67	183	170	221,537	411	198	3,112	18,069	243,747
	Financial activities .... (5)	25	105	133	549	151,193	169	886	9,635	162,695
	Other service activities ..... (6)	9	26	16	122	109	75,645	496	3,844	80,267
	Unknown	28	73	121	499	1,017	2,199	8,218	4,340	16,495
	Birth	1,728	2,138	5,115	16,778	13,897	6,025	4,577	0	50,258
	Total	28,217	44,176	71,222	239,863	166,801	84,321	18,493	44,915	698,008

Source: CBE, Own Calculations

Table A1.4 Enterprise migrations between 2003-2004, table $D^{(2004)}$

	A6 Classification - numbers	State in 2004 (1)	(2)	(3)	(4)	(5)	(6)	Unknow	Death	Total
State in 2003	Agriculture .... (1)	26,518	10	33	65	25	16	125	1,425	28,217
	Industry .... (2)	6	41,126	107	287	122	33	175	2,320	44,176
	Construction .... (3)	32	68	66,072	172	109	17	320	4,432	71,222
	Trade and transport .... (4)	84	268	267	220,678	669	231	1,398	16,268	239,863
	Financial activities .... (5)	27	112	208	621	155,359	195	605	9,674	166,801
	Other service activities ..... (6)	14	28	30	195	145	79,958	247	3,704	84,321
	Unknown	64	133	226	935	670	414	9,009	7,042	18,493
	Birth	2,318	2,880	6,383	19,449	14,188	6,515	5,464	0	57,197
	Total	29,063	44,625	73,326	242,402	171,287	87,379	17,343	44,865	710,290

Source: CBE, Own Calculations

Table A1.5 Enterprise migrations between 2004-2005, table $D^{(2005)}$

	A6 Classification - numbers	State in 2005 (1)	(2)	(3)	(4)	(5)	(6)	Unknow	Death	Total
State in 2004	Agriculture .... (1)	27,179	19	61	108	37	39	111	1,509	29,063
	Industry .... (2)	22	41,129	165	403	172	60	189	2,485	44,625
	Construction .... (3)	50	111	67,513	230	177	26	273	4,946	73,326
	Trade and transport .... (4)	134	317	357	220,974	873	248	1,343	18,156	242,402
	Financial activities .... (5)	50	173	245	793	159,319	226	629	9,852	171,287
	Other service activities ..... (6)	11	30	43	226	183	82,565	299	4,022	87,379
	Unknown	64	100	208	836	692	378	10,622	4,443	17,343
	Birth	2,433	2,912	7,083	19,336	14,943	6,615	4,712	0	58,034
	Total	29,943	44,791	75,675	242,906	176,396	90,157	18,178	45,413	723,459

Source: CBE, Own Calculations

Table A1.6 Enterprise migrations between 2005-2006, table $D^{(2006)}$

	A6 Classification - numbers	State in 2006 (1)	(2)	(3)	(4)	(5)	(6)	Unknow	Death	Total
State in 2005	Agriculture .... (1)	27,830	26	83	133	42	44	137	1,648	29,943
	Industry .... (2)	24	41,171	210	459	167	38	176	2,546	44,791
	Construction .... (3)	68	145	69,822	265	184	21	295	4,875	75,675
	Trade and transport .... (4)	135	397	447	220,326	980	274	1,372	18,975	242,906
	Financial activities .... (5)	70	176	271	804	163,694	216	868	10,297	176,396
	Other service activities ..... (6)	42	40	36	262	228	84,592	564	4,393	90,157
	Unknown	37	81	124	467	562	198	12,397	4,312	18,178
	Birth	2,893	3,166	8,326	19,887	16,994	7,199	5,556	0	64,021
	Total	31,099	45,202	79,319	242,603	182,851	92,582	21,365	47,046	742,067

Source: CBE, Own Calculations

ANNEX 2: ANNUAL MIGRATION MATRICES $P^{(2001)}$ .. $P^{(2006)}$

The tables A2.1 .. A2.6 show the transition matrices for every two consecutive years in the period 2000-2006. For each element in the table a Binomial test is performed for the null-hypthesis that the percentage is greater than 0.02%. The test uses the cumulative binomial distribution. Numbers in gray indicate cells that are not significantly greater than 0.02% (at the 5% confidence level).

Table A2.1 Enterprise migrations between 2000-2001, table $P^{(2001)}$

	State in 2001							
State in 2000 — A6 Classification - p.c.	(1)	(2)	(3)	(4)	(5)	(6)	Unknow	Death
Agriculture .... (1)	**93.84**	0.02	0.05	0.15	0.05	0.04	0.37	5.48
Industry .... (2)	0.00	**93.09**	0.10	0.32	0.11	0.06	0.40	5.91
Construction .... (3)	0.03	0.08	**92.23**	0.08	0.07	0.01	0.44	7.07
Trade and transport .... (4)	0.07	0.06	0.03	**90.87**	0.11	0.04	0.57	8.25
Financial activities .... (5)	0.02	0.04	0.04	0.22	**92.25**	0.07	0.36	7.02
Other service activities ..... (6)	0.01	0.01	0.01	0.08	0.13	**94.00**	0.30	5.47
Unknown	0.22	0.33	0.78	2.33	10.83	1.47	59.20	24.84
Birth	3.37	4.63	10.56	33.83	30.56	12.11	4.93	-

Source: CBE, Own Calculations

Table A2.2 Enterprise migrations between 2001-2002, table $P^{(2002)}$

	State in 2002							
State in 2001 — A6 Classification - p.c.	(1)	(2)	(3)	(4)	(5)	(6)	Unknow	Death
Agriculture .... (1)	**93.80**	0.02	0.05	0.13	0.03	0.08	0.40	5.49
Industry .... (2)	0.01	**92.87**	0.13	0.35	0.12	0.10	0.41	6.02
Construction .... (3)	0.02	0.09	**92.15**	0.11	0.07	0.02	0.47	7.07
Trade and transport .... (4)	0.02	0.06	0.03	**90.92**	0.10	0.04	0.59	8.24
Financial activities .... (5)	0.02	0.05	0.05	0.24	**92.82**	0.07	0.36	6.40
Other service activities ..... (6)	0.01	0.02	0.00	0.11	0.10	**94.31**	0.28	5.17
Unknown	0.22	0.36	0.99	2.85	6.50	1.87	61.32	25.88
Birth	3.44	4.29	9.94	33.06	31.19	13.05	5.02	-

Source: CBE, Own Calculations

Table A2.3 Enterprise migrations between 2002-2003, table $P^{(2003)}$

	State in 2003							
State in 2002 — A6 Classification - p.c.	(1)	(2)	(3)	(4)	(5)	(6)	Unknow	Death
Agriculture .... (1)	**92.98**	0.02	0.10	0.22	0.06	0.09	0.68	5.86
Industry .... (2)	0.02	**92.79**	0.17	0.44	0.19	0.08	0.72	5.60
Construction .... (3)	0.03	0.10	**91.81**	0.17	0.10	0.03	0.96	6.80
Trade and transport .... (4)	0.03	0.08	0.07	**90.89**	0.17	0.08	1.28	7.41
Financial activities .... (5)	0.02	0.06	0.08	0.34	**92.93**	0.10	0.54	5.92
Other service activities ..... (6)	0.01	0.03	0.02	0.15	0.14	**94.24**	0.62	4.79
Unknown	0.17	0.44	0.73	3.03	6.17	13.33	49.82	26.31
Birth	3.44	4.25	10.18	33.38	27.65	11.99	9.11	-

Source: CBE, Own Calculations

Table A2.4 Enterprise migrations between 2003-2004, table $P^{(2004)}$

	A6 Classification - p.c.	(1)	(2)	(3)	(4)	(5)	(6)	Unknow	Death
		State in 2004							
State in 2003	Agriculture .... (1)	**93.98**	0.04	0.12	0.23	0.09	0.06	0.44	5.05
	Industry .... (2)	0.01	**93.10**	0.24	0.65	0.28	0.07	0.40	5.25
	Construction .... (3)	0.04	0.10	**92.77**	0.24	0.15	0.02	0.45	6.22
	Trade and transport .... (4)	0.04	0.11	0.11	**92.00**	0.28	0.10	0.58	6.78
	Financial activities .... (5)	0.02	0.07	0.12	0.37	**93.14**	0.12	0.36	5.80
	Other service activities ..... (6)	0.02	0.03	0.04	0.23	0.17	**94.83**	0.29	4.39
	Unknown	0.35	0.72	1.22	5.06	3.62	2.24	48.72	38.08
	Birth	4.05	5.04	11.16	34.00	24.81	11.39	9.55	-

Source: CBE, Own Calculations

Table A2.5 Enterprise migrations between 2004-2005, table $P^{(2005)}$

	A6 Classification - p.c.	(1)	(2)	(3)	(4)	(5)	(6)	Unknow	Death
		State in 2005							
State in 2004	Agriculture .... (1)	**93.52**	0.07	0.21	0.37	0.13	0.13	0.38	5.19
	Industry .... (2)	0.05	**92.17**	0.37	0.90	0.39	0.13	0.42	5.57
	Construction .... (3)	0.07	0.15	**92.07**	0.31	0.24	0.04	0.37	6.75
	Trade and transport .... (4)	0.06	0.13	0.15	**91.16**	0.36	0.10	0.55	7.49
	Financial activities .... (5)	0.03	0.10	0.14	0.46	**93.01**	0.13	0.37	5.75
	Other service activities ..... (6)	0.01	0.03	0.05	0.26	0.21	**94.49**	0.34	4.60
	Unknown	0.37	0.58	1.20	4.82	3.99	2.18	61.25	25.62
	Birth	4.19	5.02	12.20	33.32	25.75	11.40	8.12	-

Source: CBE, Own Calculations

Table A2.6 Enterprise migrations between 2005-2006, table $P^{(2006)}$

	A6 Classification - p.c.	(1)	(2)	(3)	(4)	(5)	(6)	Unknow	Death
		State in 2006							
State in 2005	Agriculture .... (1)	**92.94**	0.09	0.28	0.44	0.14	0.15	0.46	5.50
	Industry .... (2)	0.05	**91.92**	0.47	1.02	0.37	0.08	0.39	5.68
	Construction .... (3)	0.09	0.19	**92.27**	0.35	0.24	0.03	0.39	6.44
	Trade and transport .... (4)	0.06	0.16	0.18	**90.70**	0.40	0.11	0.56	7.81
	Financial activities .... (5)	0.04	0.10	0.15	0.46	**92.80**	0.12	0.49	5.84
	Other service activities ..... (6)	0.05	0.04	0.04	0.29	0.25	**93.83**	0.63	4.87
	Unknown	0.20	0.45	0.68	2.57	3.09	1.09	68.20	23.72
	Birth	4.52	4.95	13.01	31.06	26.54	11.24	8.68	-

Source: CBE, Own Calculations

ANNEX 3: AVERAGE REMAINING LIFETIMES AT THE A120 BRANCHES LEVEL

Table A3.1 Average lifetime (A120 classification)

Nace	Description	Remaining Lifetime	Age	Total Lifetime
01A1	Agriculture, hunting and related service activities	17.89	13.21	31.10
02A1	Forestry, logging and related service activities	14.52	16.31	30.82
05A1	Fishing, operation of fish hatcheries and fish farms	17.14	24.92	42.06
14A1	Other mining and quarrying industries	18.47	25.40	43.86
15A1	Production, processing and preserving of meat and meat products	15.42	16.16	31.58
15B1	Processing and preserving of fish and fish products	21.75	21.97	43.72
15C1	Processing and preserving of fruit and vegetables	22.42	15.09	37.51
15D1	Manufacture of vegetable and animal oils and fats	24.00	24.00	48.00
15E1	Manufacture of dairy products	17.29	18.17	35.46
15F1	Processing of grain mill products, fabrication of starches and starch products	18.85	52.97	71.82
15G1	Manufacture of prepared animal feeds	23.47	31.79	55.26
15H1	Manufacture of bread; manufacture of fresh pastry goods and cakes	16.96	24.42	41.38
15I1	Manufacture of cocoa; chocolate and sugar confectionery	19.19	17.62	36.81
15J1	Manufacture of pasta, coffee and tea, and other food products	16.77	16.61	33.38
15K1	Manufacture of beverages, except mineral waters and soft drinks	18.00	16.59	34.59
15L1	Production of mineral waters and soft drinks	13.33	17.97	31.30
17A1	Preparation and spinning of textile fibres, weaving and finishing of textiles	15.73	25.46	41.19
17B1	Manufacture of made-up textile articles, except apparel and other textiles	19.28	17.90	37.18
18A1	Manufacture of apparel; dressing and dyeing of fur	13.40	19.23	32.63
19A1	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	13.85	18.80	32.65
20A1	Manufacture of wood and of products made of wood and cork; manufacture of articles of straw and plaiting materials	17.14	13.46	30.59
21A1	Manufacture of paper and paperboard	20.89	31.66	52.55
22A1	Publishing	13.92	11.88	25.80
22B1	Printing and service activities related to printing; reproduction of recorded media	15.05	11.79	26.84
23A1	Manufacture of coke, refined petroleum products and nuclear fuel	11.65	15.00	26.65
24A1	Manufacture of basic chemicals	15.96	17.86	33.83
24C1	Manufacture of paints, varnishes and printing ink	21.32	65.50	86.82
24D1	Manufacture of pharmaceuticals	15.90	13.86	29.76
24E1	Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations	14.43	17.97	32.40
24F1	Manufacture of other chemical products	18.66	18.29	36.95
24G1	Manufacture of man-made fibres	13.00	37.00	50.00
25A1	Manufacture of rubber products	23.20	28.75	51.95
25B1	Manufacture of plastic products	21.32	22.67	43.99
26A1	Manufacture of glass and glass products	16.05	21.12	37.17
26B1	Manufacture of ceramic products	13.78	17.83	31.60
26C1	Manufacture of cement, lime and plaster	15.00	15.00	30.00
26D1	Manufacture of articles of concrete, plaster and cement, stone and other non-metallic mineral products	19.48	23.18	42.66
27A1	Manufacture of basic iron and steel and of ferro-alloys (ECSC)	14.66	21.69	36.36
27B1	First processing of steel, production of non-ECSC ferro-alloys and non-ferrous metals	15.48	28.53	44.01
28A1	Manufacture of structural metal products, tanks, reservoirs, central heating radiators and boilers	16.37	14.72	31.09
28B1	Treatment and coating of metals; general mechanical engineering	19.08	12.97	32.05
28C1	Manufacture of cutlery, tools and general hardware	20.02	23.72	43.75
29A1	Manufacture of engines and turbines, except aircraft, vehicle and cycle engines	18.62	15.10	33.73
29B1	Manufacture of other general purpose machinery	16.81	15.82	32.63
29C1	Manufacture of agricultural and forestry machinery and machine tools	18.36	18.51	36.86
29D1	Manufacture of domestic appliances n.e.c.	20.53	16.03	36.56
30A1	Manufacture of office machinery and computers	11.92	8.89	20.81

Nace	Description	Remaining Lifetime	Age	Total Lifetime
31A1	Manufacture of electric motors, generators and transformers, distribution and control apparatus, insulated wire and cable	18.42	21.15	39.57
31B1	Manufacture of accumulators, primary cells and primary batteries, electric lamps and lighting equipment	14.95	17.03	31.98
32A1	Manufacture of radio, television and communication equipment and apparatus	12.99	16.11	29.09
33A1	Manufacture of medical, precision and optical instruments, watches and clocks	19.48	18.43	37.91
34A1	Manufacture of motor vehicles	12.92	14.48	27.40
34B1	Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers, parts and accessories for motor vehicles	22.64	22.96	45.60
35A1	Building and repairing of ships and boats, manufacture of railway and tramway locomotives and rolling stock, aircraft and spacecraft	14.99	12.53	27.52
35B1	Manufacture of motorcycles and bicycles and other transport equipment n.e.c.	13.09	13.50	26.59
36A1	Manufacture of furniture	17.98	17.69	35.67
36B1	Manufacture of jewellery and related articles	13.64	14.26	27.89
36C1	Manufacture of musical instruments, sports goods, games and toys, other manufacturing n.e.c.	15.22	14.19	29.42
37A1	Recycling	21.28	12.22	33.49
40A1	Electricity, gas, steam and hot water supply	12.37	7.70	20.08
41A1	Collection, purification and distribution of water	13.96	14.33	28.29
45A1	Site preparation	13.86	7.57	21.44
45B1	General construction of buildings and civil engineering works, erection of roof covering and frames	14.76	12.59	27.35
45C1	Construction of highways, roads, airfields and sport facilities, water projects; other construction work involving special trades	12.77	9.68	22.45
45D1	Building installation	15.19	12.73	27.92
45E1	Building completion, renting of construction or demolition equipment with operator	15.02	12.80	27.82
50A1	Sale, maintenance and repair of motor vehicles and motorcycles, sale of motor vehicle parts and accessories	16.14	17.40	33.54
50B1	Retail sale of automotive fuel	12.43	15.13	27.56
51A1	Wholesale trade and commission trade	13.26	13.91	27.17
52A1	Retail trade; repair of personal and household goods	13.62	14.68	28.30
55A1	Hotels and other provision of short-stay accommodation	19.36	15.16	34.52
55B1	Restaurants, bars, canteens and catering	10.79	10.14	20.93
60A1	Transport via railways	15.30	10.50	25.80
60B1	Scheduled passenger land transport, taxi operation, and other land passenger transport	16.36	16.91	33.27
60C1	Freight transport by road, furniture removal by road and transport via pipelines	14.40	15.52	29.92
61A1	Sea and coastal water transport	13.02	9.33	22.35
61B1	Inland water transport	10.18	8.41	18.59
62A1	Air transport	15.75	9.72	25.47
63A1	Travel agencies and tour operators	17.59	14.34	31.93
63B1	Cargo handling and storage; supporting and auxiliary transport activities	15.41	12.36	27.77
64A1	Post and courier activities	7.87	6.59	14.46
64B1	Telecommunications	9.21	5.70	14.91
65A2	Financial intermediation	16.32	13.44	29.76
66A2	Insurance	18.60	19.92	38.52
67A1	Activities auxiliary to financial intermediation and insurance	21.07	15.92	36.99
70A1	Real estate activities	21.69	14.96	36.65
71A1	Renting of automobiles and other transport equipment	13.74	11.99	25.73
71B1	Renting of other machinery and equipment and other household goods	14.74	11.66	26.40
72A1	Computer and related activities	12.34	7.16	19.51
73A1	Research and development	16.56	9.01	25.57
74A1	Legal, accounting, book-keeping and auditing activities; tax consultancy; market research and public opinion polling	17.30	15.18	32.48
74B1	Business and management consultancy activities, management activities of holding companies and coordination centres	16.78	8.39	25.17
74C1	Architectural and engineering activities and related technical consultancy, technical testing and analysis	15.66	11.26	26.91

Nace	Description	Remaining Lifetime	Age	Total Lifetime
74D1	Advertising	12.80	12.59	25.39
74E1	Labour recruitment and provision of personnel	15.03	7.60	22.63
74F1	Investigation and security activities, industrial cleaning, miscellaneous business activities	12.10	9.68	21.78
75A3	Public administration except defence and compulsory social security	29.03	10.41	39.44
75C3	Compulsory social security activities	64.00	28.00	92.00
80A1	Education	22.59	13.47	36.06
85A1	Human health activities	31.05	13.00	44.04
85B1	Veterinary activities	24.35	16.44	40.79
85C1	Social work activities	44.63	17.07	61.71
90A1	Sewage and refuse disposal, sanitation and similar activities	19.30	12.13	31.43
91A1	Activities of membership organisations n.e.c.	39.31	12.73	52.05
92A1	Motion picture and video activities, radio and television activities	13.69	10.31	24.00
92B1	Other entertainment activities	11.96	8.77	20.73
92C1	News agency activities and other cultural activities	13.65	8.31	21.96
92D1	Sporting activities and other recreational activities	15.22	10.49	25.72
93A1	Other service activities	17.05	15.24	32.29
95A4	Private households with employed persons	59.99	6.73	66.73

Source: CBE, Own Calculations

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