Constructing Occupation-Specific Life Tables for China

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Executive Summary

This report documents the “Constructing Occupation-Specific Life Tables for China” project commissioned by the Society of Actuaries under the “China Research Topics” proposal. The purpose of the project is to construct the most up-to-date occupational life tables for male and female urban employees in China based on administrative data from the Beijing Public Pension System for the period 2005–2009.

The project deliverables include the following:

1. Develop a generalized linear model (GLM) framework to model the different transition intensities.

2. Using the estimated transition intensities, compute life tables for a number of different industrial classifications including but not limited to low-skilled manufacturing/construction workers, high-skilled professionals/technicians, service and administrative workers, inter-province migrant workers and public-owned/non-for-profit enterprise employees.

3. The following datasets used and computed in the project:

    - Categorized and formatted birth, mortality and retirement data for different industrial occupation groups;
    - Crude transition rates computed for each occupation group (considered in this project) at different ages;
    - Smoothed transition rates based on the Generalized Linear Models developed in this project for each occupation group at different ages;
    - Life expectancy computed based on the smoothed transition rates for each occupation group.

This report consists of five sections. Section 1 provides a literature review and an overview on different types of life tables developed in the last few decades for China based on different data sources and population samples. Section 2 describes the two datasets used from the Beijing Urban Public Pension Scheme. Moreover, we document the data cleaning procedure and the assumptions made in the calculation of death and exposure numbers. Section 3 presents the occupation-specific life tables as well as the total life tables for both male and female urban employees. In Section 4, we develop generalized linear models for transition intensities between four states, namely “Contributing”, “Non-contributing”, “Retired” and “Dead”. Conclusions are drawn in Section 5.

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Section 1

Introduction

A life table is a table showing the expected number of future life years at each age for a group of lives. The first known life table was created around A.D. 200 by the Roman judge Ulpian, who is often considered as the first actuary (Wilson, 2015). Since then, life tables have been frequently used to determine the premiums of life insurance products, to monitor population health and to assess the effectiveness of social security policies. Broadly speaking, there are two types of life tables considered in actuarial science, namely period life tables and cohort life tables. Period life tables are based on mortality rates from a certain time period, assuming that those rates will apply to a person's remaining lifetime thus ignoring the future changes in mortality rates. On the other hand, cohort life tables incorporate future mortality improvement/deterioration. However, since cohort life tables use a combination of observed mortality rates and future mortality projections, the uncertainty involved with cohort life tables is much higher. In this report, we focus on constructing the period life tables rather than cohort life tables for China.

The first recorded life table for China was developed during 1929–1933 by an academic from the University of Nanking. Since then, various types of life tables have been developed based on different data sources and population samples. Life tables developed in the last few decades include Jiang (1990), Lin (1991), People's Bank of China (1996), Cai (2005), Ding (2008), and China Insurance Regulatory Commission (2016). Most of these lifetables focused on the differences in life expectancy across regions and genders, and some also considered health behaviors such as smoking status. However, due to the substantial degree of heterogeneity in the mortality experience of different sub-populations in China (Kaneda *et al.*, 2005; Congdon, 2007; Zhao *et al.*, 2013; Li *et al.*, 2017), decomposed life tables are needed to accurately assess the level of longevity improvements across different population subgroups. Occupation is a good indicator of an individual's socioeconomic and health status (see, for example, Alonso *et al.*, 1997; Fujishiro *et al.*, 2010; Fong *et al.*, 2015a). Moreover, in China different occupations generally have different effective contribution rates into the pension scheme. Therefore, understanding variations in occupation-specific life expectancies is crucial for policy makers, insurance companies and healthcare service providers.

The Ministry of Human Resources and Social Security (1994) published the "Chinese Working Population Life Table" based on the 1990 population census, which provided life tables for broad occupational groups for the period 1989–1990. To date, these life tables are still considered as the most comprehensive occupation-specific life tables for China. However, the dramatic developments in the Chinese economy over the past 20 years have substantially altered the occupational structure of the labor force. Therefore, new life tables for an up-to-date grouping of occupations are needed. To address this gap, in this project we compute occupation-specific period life tables for the period 2006–2009 based on administrative data collected by the Urban Public Pension Scheme for Beijing. We develop life tables for major occupational groups including private-sector high-skilled professionals, low-skilled workers, service sector workers, and government or state-owned enterprise employees.

1.1 Literature review

1.1.1 Official life tables for China

In this subsection we present a number of official life tables developed and released in the last few decades reflecting the changes in longevity levels of different population groups in China. A selection of life table statistics is presented in Table 1.1 for an overview. We report the life expectancy at age 20 together with the organization that published the life table, the name of the life table, and the data that was used to construct the life table.

Table 1.1 shows that life expectancy in China has substantially increased from 51.52 (male) and 55.44 (female) during 1989–1990 to 62.94 (male) and 67.83 (female) during 2010–2013. Since the 1990s, different life tables have been developed for different population groups based on insurance data. For example, in 2005 the China Insurance Regulatory Commission (CIRC) published the "China Life Insurance Mortality Table (2000–2003)" (CL(2000–2003)) for annuity and non-annuity insurance businesses. 11 years later, the CIRC published the most recent life insurance mortality tables in December 2016. These tables are referred to as the "China Life Insurance Mortality Table (2010–2013)", or CL(2010–2013). Based on Table 1.1 we can compare the life expectancy at age 20 from the CL(2000–2003) and the CL(2010–2013) tables. For the Pension business, the increase in life expectancy is 2.2 years for males and 4.3 years for females. For the Non-pension business, the values in the CL(2000–2003) table are close to the values for the Protection business in the CL(2010–2013) tables.

The CL(2010-2013) were developed by the CIRC together with the China Association of Actuaries. The life tables were constructed using data on 340 million policies from nine insurance companies, accounting for 93% of the whole industry. The data was collected for the period January 2010 - December 2013 (Zhang and Zhang, 2016). The CL(2010–2013) consists of 6 sets of life tables based on 3 types of life insurance business:

- Protection (Non-aged care) business - Male (CL1) and Female (CL2)
- Saving (Non-nursing) business - Male (CL3) and Female (CL4)
- Annuity (Pension) business - Male (CL5) and Female (CL6)

Table 1.1: *Official life tables for China*

Organization	Name	Data used	Future life years at age 20	
			Male	Female
Ministry of Labour and Social Security	China Population Life Table	1989–1990 Population census data	51.52	55.44
People's Bank of China	China Life Insurance Mortality Table (1990–1993): Non-annuity business	1990–1993 Life insurance industry data	54.91	58.7
	China Life Insurance Mortality Table (1990–1993): Annuity business	1990–1993 Life insurance industry data	56.07	59.80
China Insurance Regulatory Commission	China Life Insurance Mortality Table (2000–2003): Non-annuity business	2000–2003 Life insurance industry data	56.76	59.73
	China Life Insurance Mortality Table (2000–2003): Annuity business	2000–2003 Life insurance industry data	60.77	63.51
China Insurance Regulatory Commission	China Life Insurance Mortality Table (2010–2013): Protection (Non-aged care) business	2010–2013 Life insurance industry data	56.43	61.55
	China Life Insurance Mortality Table (2010–2013): Saving (Non-nursing) business	2010–2013 Life insurance industry data	60.24	65.18
	China Life Insurance Mortality Table (2010–2013): Annuity business	2010–2013 Life insurance industry data	62.94	67.83

Table 1.1 shows that life expectancy at age 20 is highest in the Annuity tables (CL1, CL2) and lowest in the Protection tables (CL5, CL6). The difference between the Annuity and the Protection table is 6.5 years for males and 6.3 years for females. Life expectancies based on the Saving business tables exceed those based on the Protection table by 2.7 years for males and 2.6 years for females. The difference between female and male life expectancies is about 5 years for all three types of business, Protection, Saving and Annuity. Insurers are suggested to use the tables as follows: (i.) Businesses other than whole-life annuity should use 100% of the non-pension life table. (ii.) Whole-life annuity providers are required to use a maximum of 80% or 120% of the pension life table. For pricing purposes, insurance companies are allowed to use their own assumptions with some adjustments on the published tables (OECD, 2014, Ch. 2).

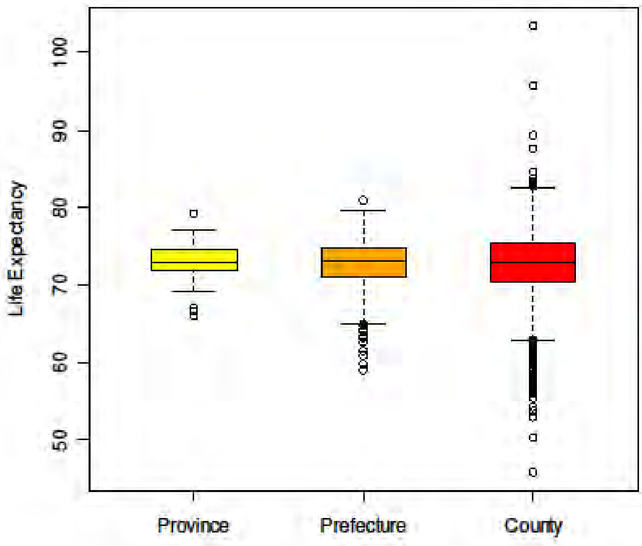
1.1.2 Mortality and life expectancy heterogeneity in China

Despite the remarkable improvements in longevity and health in China during recent decades, the health inequalities across different regions and socio-economic groups are still large. In this subsection we provide a brief review of previous studies analyzing the heterogeneity in mortality and life expectancy in China. We begin with studies focusing on regional heterogeneity and then summarize studies looking at socio-economic differences.

Regional heterogeneity

Cai (2005) used data from the 2000 Chinese national census to construct sex-specific life tables for all 2,870 county-level units, as well as 345 prefectural-level units, 31 provincial-level units and the national totals of China. His results showed a large degree of heterogeneity in life expectancy, in particular at the county level. Figure 1.1 summarizes the estimated life expectancies at birth in Cai's research. County-level life expectancies for males and females combined vary between 45.8 years and 103.5 years, with a standard deviation of 4.4 years. At the province level, the range is 66.1 to 79.3 years, with a standard deviation of 3 years.

Figure 1.1: *Distribution of estimated life expectancies for both sexes at three different administrative levels (box plots), 2000. Source: Cai (2005).*



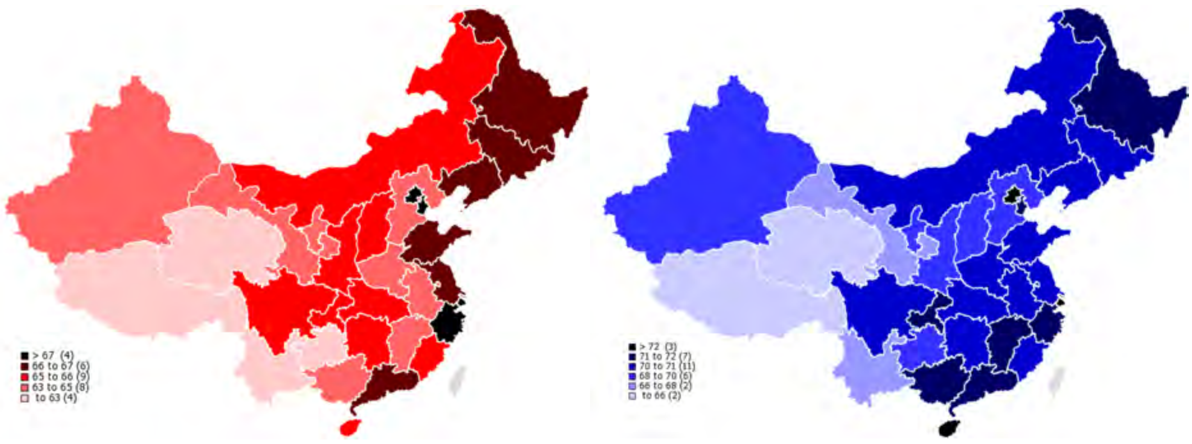
Congdon (2007) also used data from the 2000 Chinese census to develop a model for spatial variations in life expectancy in China. The model features age-area interactions that are modeled in a similar way as the age-time structure in the Lee-Carter model. Congdon (2007) documented large inter-province and urban-rural contrasts in mortality risks and life expectancy. It has been found that (for both males and females) the regional differences in life expectancy are larger within the rural sub-divisions than the urban sub-divisions of the 31 province-level regions. For example, for females, the range in urban subdivisions is from 72.4 years (Yunnan) to 80.1 years (Shanghai), while for rural subdivisions, the range is from 64.5 years (Yunnan) to 75.2 years (Shanghai).

Zhao *et al.* (2013) modeled the sex-age-specific mortality rates of sub-populations at different administrative levels of China (cities, towns and counties) based on data from the China Population Statistics Yearbooks (1988–2009) using a modified Lee-Carter model. A similar analysis is provided in Huang (2017) using a modified CMI (Continuous Mortality Investigation) mortality projections model and data from the China Population Statistics Yearbooks (1998–2006) and the China Population and Employment Statistics Yearbooks (2007–2012). The two research papers both concluded that urban residents have lower mortality rates and higher mortality improvement rates than people living in towns and counties for most ages.

Moreover, recent studies on healthy life expectancy in China by Liu *et al.* (2010) and Li *et al.* (2017) also confirmed the results in Congdon (2007). Healthy life expectancy is a popular indicator of population health which takes into account both the quantity and the quality of life. It quantifies the future lifetime of an individual in healthy condition. Liu *et al.* (2010) estimated the disability-free life expectancy at age 60 for China's provinces in 2006. Their estimates vary between 11.2 and 20.8 years across provinces and reflect the patterns in regional economic developments in China. Li *et al.* (2017) focused on the regional disparities in healthy life expectancy at birth in China. They estimated healthy life expectancy at birth in 2015 for both males and females. They found that healthy life expectancy varies by more than ten years across Chinese provinces for both males and females (see Figure 1.2).

Figure 1.2: *Province-level healthy life expectancy at birth, 2015. Source: Li* et al. *(2017).*

(a) *Males* (b) *Females*



Socio-economic heterogeneity

Kaneda *et al.* (2005) compared life and active life expectancy estimates across indicators of socioeconomic status (SES) for a cohort of older adults in Beijing using survey data from 1992, 1994 and 1997. The SES indicators include education, income, occupation and household-level ownership of selected household possessions. They distinguished two occupational categories: light physical and heavy physical labor in the occupation held longest by the individual. Kaneda *et al.* (2005) reported that men in light physical labor occupation group were living 27%–40% longer. For women, significant differences by occupation were only found for life expectancy at ages 55 and 60.

Luo and Xie (2014) analyzed socio-economic disparities in mortality among the elderly in China. They considered three different socioeconomic status (SES) indicators–education, economic independence, and household income per head. They used data from 2005 and 2008 waves of the Chinese Longitudinal Healthy Longevity Survey (CLHLS). They found significant differences for economic independence and household income per head, but not for education.

1.1.3 Occupation-specific mortality and life expectancy in other countries

In this subsection, we summarize the results of recent research on differences in mortality and life expectancy by occupation across different countries. Note that we include studies published in the last ten years in this review.

United Kingdom

In 1842, Edwin Chadwick's published the now famous "Report on the Sanitary Conditions of the Labouring Population of Great Britain". In this report he documented large social and spatial inequalities in health and insanitary conditions. Green *et al.* (2018) repeated the same analysis using data from the Office of National Statistics on individual mortality records by occupation (2010–2012) and population data from the 2011 Census. Green *et al.* (2018) focused on premature mortality in the age group 16–74 due to data restrictions. They used three occupational categories to match the categories in Chadwick's report: "Higher" (e.g. managerial and professional professions), "Intermediate" (e.g. clerical, sales and small employers), and "Lower" (e.g. routine and semi-routine occupations). Green *et al.* (2018) found that mortality rates still vary considerably geographically between occupational groups. For example, Table 1.2 shows that mortality rates in the "intermediate" occupational group in Rutland were in fact lower than those in the "higher" occupational group in the other locations, among both males and females.

Table 1.2: *Directly standardised premature (ages 16–74) mortality rates per 100,000 population by occupation group, 2010–12. Source: Green* et al. *(2018).*

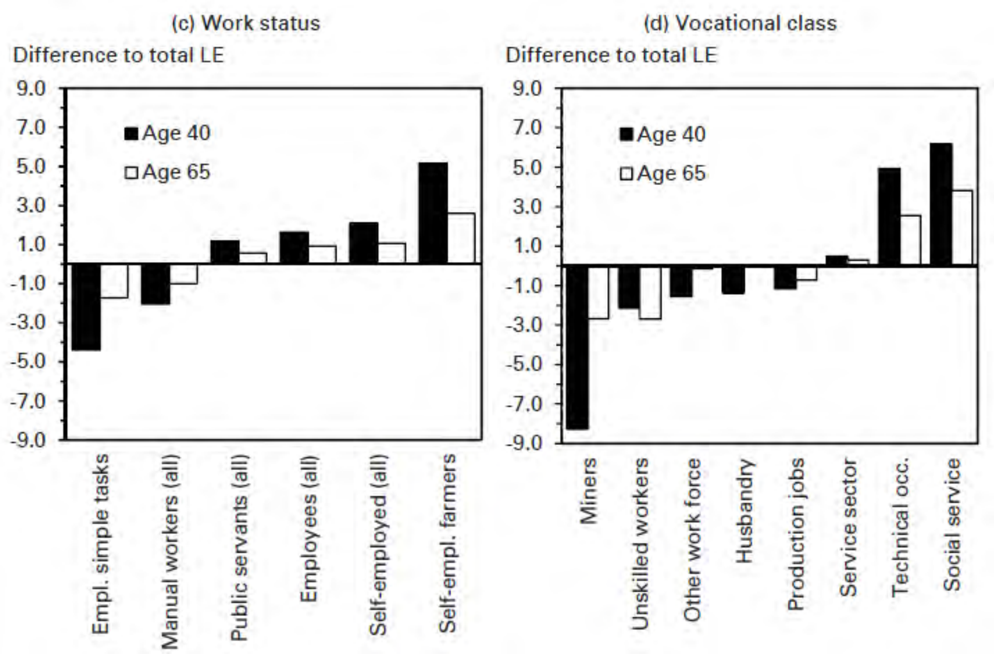
Location	Males			Females		
	Higher	Intermediate	Lower	Higher	Intermediate	Lower
Rutland	88.0	127.6	420.7	46.1	77.3	106.0
Leeds	254.5	358.7	631.5	123.2	189.7	341.4
Liverpool	271.0	330.6	635.7	141.0	155.5	267.0
Manchester	307.0	372.0	998.5	200.6	204.6	339.0
Bolton	254.6	296.5	560.8	153.8	163.5	274.3
England	213.6	309.9	447.0	132.8	156.4	220.9

In a related study, Katikireddi *et al.* (2017) analyzed patterns of mortality by occupation in the UK based on linked census and mortality records. They focused on adults of working age (20–59 years) and coded individuals' main occupation into more than 60 groups in the 2001 census, with mortality follow-up until 2011. They found that mortality rates by occupation differed by more than three times between the lowest and highest observed rates for both men and women.

Germany

Luy *et al.* (2015) estimated differences in life expectancy by education, household income, work status and vocational class using panel data from two surveys conducted in 1984–86 and 1998. They classified work status into four main groups (manual workers, employees, public servants and self-employed workers), with two or three specific work status subgroups, such as unskilled and skilled workers or employees in simple, qualified and highly qualified tasks. The definition of vocational class was based on the German Classification of Professions published by the Federal Statistical Office of Germany. Luy *et al.* (2015) found that among men, life expectancy at age 40 ranges by around ten years across the work status groups and almost 15 years across the vocational classes. They found smaller differences for females. Figure 1.3 illustrates these results.

Figure 1.3: *Deviation of life expectancy at ages 40 and 65 of subpopulations defined by work status and vocational class from the total population, German men. Source: Luy* et al. *(2015).*

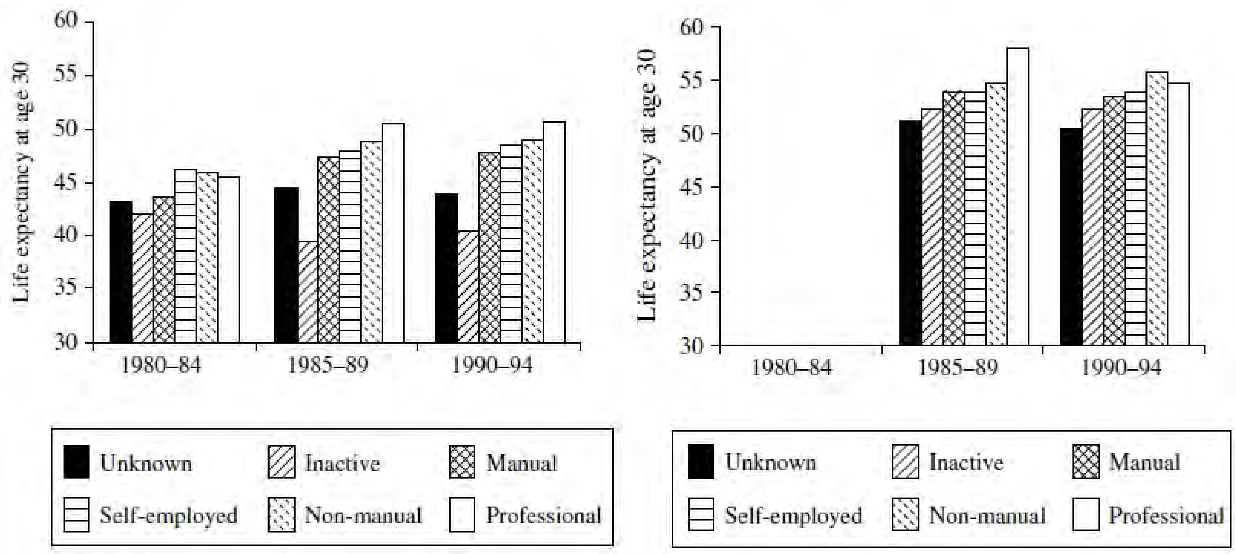


Italy

Luy *et al.* (2011) analyzed the differences in life expectancy by education and occupation in Italy over the period 1980–1994. They classified occupations into five groups: (1) economically inactive; (2) manual workers; (3) non-manual workers; (4) self-employed; and (5) professionals. Figure 1.4 shows their estimates of life expectancy at age 30 by occupation for men and women. Overall, Luy *et al.* (2011) found that the mortality differences between the highest social class and the other socio-economic status groups increased among men and decreased among women.

Figure 1.4: *Estimates of life expectancy at age 30 by occupation for Italian men and women, periods 1980–1984, 1985–1989, and 1990–1994. Source: Luy et al. (2011).*

(a) *Men* (b) *Women*



1.2 Life table construction

1.2.1 Notation

Before going into the details of life table construction, we first introduce some notation which will be used throughout this report. Formally, define the following:

- p_x, one-year survival probability for a person aged x.
- q_x, one-year death probability for a person aged x, which is $1 - p_x$.
- l_x, number of people alive at the beginning of the year aged x out of 100,000.
- d_x, number of deaths at age x among l_x people.
- L_x, the total number of years lived by l_x people between age x and $x + 1$.
- T_x, the total number of years lived by l_x people after age x.
- e_x, life expectancy at age x, which is the average number of years lived after age x.

Note that in this report, the age definition adopted is "aged last birthday", which corresponds to the exact age $(x, x + 1)$.

1.2.2 Formulae

Assuming on average deaths happen in the middle of the year, L_x is given by:

$$L_x = l_x - \frac{1}{2}d_x. \tag{1.2.1}$$

The one-year death probability q_x is calculated by:

$$q_x = \frac{d_x}{l_x} = \frac{l_x - l_{x+1}}{l_x}, \tag{1.2.2}$$

which corresponds to the death probability at the beginning of the year.

We can thus calculate the life expectancy at age x as:

$$e_x = \sum_{t=0}^{\infty} t \times_t p_x q_{x+t}, \tag{1.2.3}$$

note that we set ω to be the upper age limit, and thus the formula of life expectancy becomes:

$$e_x = \sum_{t=0}^{\omega - x} t \times_t p_x q_{x+t}. \tag{1.2.4}$$

T_x is then calculated as:

$$T_x = l_x \times e_x. \tag{1.2.5}$$

1.2.3 Smoothing of crude mortality rates

Due to the limitation of the sample size, in some cases the variability in the crude (unsmoothed) mortality rates is large. Moreover, anomalies in the data may also affect the calculation of the life tables. Therefore, in this project after the computation of crude mortality rates, we apply smoothing techniques including both parametric linear interpolation or smoothing and non-parametric smoothing methods. The two main methods adopted in this project are:

- Linear interpolation (parametric smoothing for missing data), and
- Loess regression (non-parametric smoothing to reduce variability).

Following these smoothing procedures, the life tables are constructed based on the formulae in 1.2.2.

Section 2

Data

2.1 Description

The Urban Public Pension Scheme is an important pillar of the pension system in China. The basic public pension schemes for urban employees were reformed and unified in 1997 (Jin and Fung, 2011). By the end of 2015, 353.6 million people were enrolled in this scheme, which was roughly a quarter of the total population in China (Ministry of Human Resources and Social Security, 2016). Under this scheme, eligible urban employees who have reached the retirement age can receive an annuity payment in the form of monthly pension benefits. The current official retirement age is 60 for most males; for females, it is 55 for party cadres, civil servants, and state enterprise employees and 50 for other females. There is no penalty for early retirement.

To construct occupation-specific life tables for China, we consider the administrative data collected by the Urban Public Pension Scheme in Beijing over the period 2005–2009. As Beijing is one of the most populous cities in China, the data used is a good representation of the Chinese urban population. The data come from two administrative databases:

1. Working-age (aged 20–60 years) database. This is an annual database over the period 2005–2009;

2. Retirement (males aged 60+ and females aged 50+) database. This is a cumulative database over the period 1994–2009.

In this project, our variables of interest include *Gender*, *Occupation*, *DoB* and *Status* which are described in Table 2.1.

Variables	Data type	Description
Gender	Binary	Male or Female
Occupation	Categorical	Occupation of the individual
DoB	Date	Date of birth of the individual
Status	Categorical	Recorded status in the pension scheme

Table 2.1: *Description of the variables.*

2.2 Working-age database

For the working-age database, we first present the percentage of missing data for each variable across the years 2005–2009 in Table 2.2. The overall quality of data is quite good: There is no missing information on the gender and status, very few missing observations on the date of birth and an improvement of quality for occupation records over time.

Table 2.2: *Percentage of missing data across variables for the 5-year period.*

Variables	Year				
	2005	2006	2007	2008	2009
Gender	0.00	0.00	0.00	0.00	0.00
Occupation	16.53	3.29	0.60	1.48	1.57
DoB	≈ 0.00 (56)	≈ 0.00 (54)	≈ 0.00 (54)	≈ 0.00 (51)	≈ 0.00 (52)
Status	0.00	0.00	0.00	0.00	0.00

Note: Numbers in bracket are the exact number of missing observations.

Table 2.3 shows the number of observations for each gender from 2005 to 2009. We can see that the number of pension scheme participates increased steadily during the period 2005–2009 from around 4.4 million to just above 7 million people. For each year, there are more male participates in the working-age pension scheme than females, which is reasonable given that as the female labour participate rate is in general lower than that of males across China (Maurer-Fazio *et al.*, 2011; Liu, 2012; Meng, 2012). Although the number of observations for both males and females has increased over time, the differences in numbers seem to remain at a constant level.

Table 2.3: *Number of observations in each gender.*

Gender	2005	2006	2007	2008	2009
Female	1785877	2056909	2388014	2844630	2994316
Male	2612708	2939061	3327329	3861184	4045340
Total observations	4398585	4995970	5715343	6705814	7039656

2.2.1 Data mining procedure

In order to construct life tables and conduct further analyses, we first merge the five years of data into a single dataset and only include those observations with a complete and consistent record over all five annual datasets. We perform cleaning on the merged data and extract useful information to form new variables which can be directly used for the calculation of mortality rates. Below is a list of tasks performed in the data mining procedure:

- Define category "Unknown" for the missing observation for *Occupation*;
- Merge the five years of data by system ID and ensure that the variables such as *Gender* and *DoB* are recorded correctly (consistent across five datasets);

- Exclude observations for those with Status "Dead" in year 2005 (those who are dead prior to 2006);
- Create a new variable *Birthyear* which identify the birth year of the individuals based on *DoB*;
- Based on the yearly *Status* variable for each individual, define a new variable *Deathyear* which records the year of death of an individual. An individual is assumed to have died in year T if the status in year T is "Dead" and status in previous year $(T-1)$ is not "Dead";
- Remove observations with inconsistent records, for example, observations with changing date of birth or gender over time.

Note that we did not filter out any "NA's" from the variable *Deathyear* since in most cases, we are still able to determine the death year as long as we know there is a transition from "Not dead" to "Dead". The "NA's" in the variable *Occupation* are recorded as "Unknown".

2.2.2 Summarized results

After the data mining procedure, there are 4,320,405 individuals left in the sample, of which 2,561,324 are males and 1,759,081 are females. The pie chart below illustrates the percentages of males and females in our sample.

Figure 2.1: *Percentages of males and females in the working-age sample*

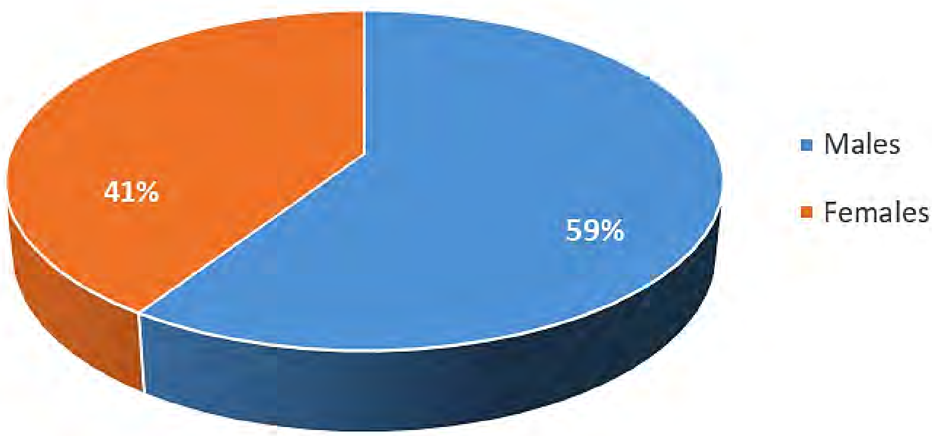


Table 2.4: *Number of observations for 21 occupations in working-age dataset*

	Occupations	2005	2006	2007	2008	2009
1	Transportation, warehousing and postal services	353273	347015	334643	334300	342745
2	Accommodation and catering industry	118999	115339	114176	111112	109367
3	Information transmission, computer services and software development	113152	108664	103433	102021	99292
4	Public administration and social organization	99144	262349	310343	303502	30187
5	Agriculture, forestry, animal husbandry and fishery	31997	28341	24419	23778	23576
6	Manufacturing	763000	723962	690464	663426	648817
7	Health, social security and social welfare	94105	288549	286131	263429	269610
8	International organization		38680	26664	26161	43997
9	Residential services and other services	804416	911651	967256	935001	922090
10	Construction	168722	169381	165675	163401	165247
11	Real estate industry	130931	130244	128999	129496	128715
12	Wholesale and retail trade	398706	390157	382640	378939	377848
13	Education	1632	50909	52414	52795	52467
14	Culture, sports and entertainment	15025	22378	23242	24266	24689
15	Water, environmental and public facilities management	8599	12577	12864	13534	13620
16	Electricity, gas and water production and supply	66329	116380	115817	116453	116229
17	Scientific research, technical services and geological exploration	18808	26859	35231	46919	50938
18	Leasing and business services	269555	268095	269876	277427	275178
19	Mining	19071	28670	27981	27723	27093
20	Financial industry	136047	138996	139691	139966	142631
21	Unknown	708894	143262	28961	81428	86425
	Total	4320405	4283778	4252936	4215580	4204615

Note: International organization was a new job category introduced in 2007.

A summary of the variables *Occupation*, *Birthyear* and *Status* is given in Table 2.4, 2.5 and 2.6 respectively. There are 21 categories of occupation (including "Unknown") being recorded in the working-age dataset as shown in Table 2.4. This occupation classification covers all jobs undertaken by urban employees in Beijing during 2005–2009. Due to missing data, certain occupations have low numbers of observations in the first two years. For example, in 2005 the number of individuals in job category "Education" was only 1,632, while in 2006 the number increased to 50,909. However, in later years as the quality of data improves, the number of observations in each occupation group are consistent and more reliable. From the table we can see that the occupations "Residential services and other services", "Wholesale and retail trade" and "Manufacturing" have the largest number of observations in our sample. However, as the pension database is for urban employees in Beijing, occupations that belong to the so-called "primary industry" such as "Agriculture, forestry, animal husbandry and fishery", "Water, environmental and public facilities management" and "Mining" have relatively small numbers of exposure in the sample. Therefore, in this project we will further classify the original 20 occupations into a smaller number of groups to ensure sufficient sample size for each broad occupation category.

In Table 2.5 we present the distribution of birth-year for the 4,320,405 working-age urban pension scheme participants. The table shows that the majority of the workforce was aged between 18 and 55 during the period 2005–2009. The mode of the birth-year distribution is 1960–1964 (40 to 50 years old in 2005–2009). It is worth noting that at both age extremes, we observe some participants in the pension scheme. The youngest urban employee in the sample is aged 10 years old while the oldest one is aged 94 in the year 2005. We do not attempt to conduct further investigations on these observations as this is beyond the scope of the project. When constructing the life tables, we set the starting age to be 20-year-old, again to ensure that each age group has a sufficient number of exposures. We combine observations for individuals who have reached their official retirement age but are still in the workforce with the observations in the retirement database.

Table 2.5: *Distribution of birth-year*

	Birth-year	Frequency
1	1901–1944	8394
2	1945–1949	92485
3	1950–1954	317806
4	1955–1959	559354
5	1960–1964	709280
6	1965–1969	555959
7	1970–1974	641035
8	1975–1979	661113
9	1980–1987	770143
10	1988–1995	4836

Table 2.6 reports the frequency of status in the working-age dataset. The four status considered in this project are "Contributing", "Non-contributing", "Dead" and "Retirement". If a person has a "Contributing" status, that means the person is alive and contributing to the urban pension scheme. A "Non-contributing" person is someone who is also alive but currently not contributing to the pension scheme. This could be caused by multiple reasons such as unemployment, change of residency and injury. "Dead" is an absorbing state in our analysis and there are no possible transitions from "Dead" to other status. Finally, the "Retirement" status shows a person is retired but does not specify the life status of that person. Therefore, we will need to refer to the retirement dataset for information on the life status for the retirees. As the working-age dataset covers ages mainly between 20 and 60, we can see that the numbers of deaths are relatively low over the period 2005–2009. We also present the crude death rates by age groups in Table 2.7. It can be seen that the overall trend of death rate increases with age.

Table 2.6: *Frequency of status*

	Status	2005	2006	2007	2008	2009
1	Contributing	3550017	3307898	3125449	2998735	2941602
2	Non-contributing	628245	740861	790568	772659	770087
3	Dead		3221	6461	9622	11169
4	Retirement	142143	231798	330458	434564	481757
	Total	4320405	4283778	4252936	4215580	4204615

Note: Number of deaths is not available for year 2005 as we use the life status in 2005 as a starting point to determine deaths for the following years.

To get an initial impression of the differences in mortality experience across different occupations, in Table 2.8 we present total deaths, total exposure and death rate per 1,000 people for 20 job categories (excluding "Unknown"). In our sample, the "top" 3 job categories with the lowest death rate are "Information transmission, computer services and software development", "Education" and "Scientific research, technical services and geological exploration". These three job categories share some common features such as none of them generally involve physical tasks and they all require high levels of education. On the other hand, there are four job categories with a death rate (per 1,000) larger than one, namely "Agriculture, forestry, animal husbandry and fishery", "International organization", "Water, environmental and public facilities management" and "Mining". The result is not very surprising as most of these jobs require a great amount of manual labor, and are therefore exposed to higher health and safety hazards. However, it is worth noting that the occupation "International organization" has the highest death rate (around 1.9 per 1,000 people) among all occupations. This result is potentially due to the randomness in our data and the limitation of the sample size. However, without further clarifications of the job descriptions we tend not to make any definite conclusions on these results.

Table 2.7: *Mortality rate (per thousand individuals) by age group.*

Age Range	Total Death	Total Exposure	Death rate × 1,000
11–19	1	21239	0.0471
20	6	51602	0.1163
21	19	96134	0.1976
22	20	153708	0.1301
23	41	236419	0.1734
24	49	358176	0.1368
25	72	472434	0.1524
26	82	565778	0.1449
27	87	616245	0.1412
28	80	606390	0.1319
29	78	570488	0.1367
30	85	529541	0.1605
31	90	488287	0.1843
32	98	450846	0.2174
33	114	453056	0.2516
34	122	470034	0.2596
35	154	489330	0.3147
36	194	507734	0.3821
37	199	505909	0.3934
38	223	507692	0.4392
39	220	470837	0.4673
40	253	435490	0.5810
41	263	416811	0.6310
42	316	415646	0.7603
43	404	511227	0.7903
44	482	568207	0.8483
45	504	541123	0.9314
46	483	553023	0.8734
47	520	488592	1.0643
48	529	459151	1.1521
49	649	473579	1.3704
50	674	396857	1.6983
51	547	417869	1.3090
52	565	398264	1.4187
53	641	354012	1.8107
54	589	308909	1.9067
55	517	217946	2.3721
56	280	206298	1.3573
57	274	179830	1.5237
58	237	142044	1.6685
59	235	105692	2.2234
60	159	53062	2.9965
61	4	49152	0.0814
>61	9	105546	0.0853

Table 2.8: *Death rate (per thousand people) by occupation*

	Occupation	Total Deaths	Total Exposure	Death rate × 1,000
1	Transportation, warehousing and postal services	1241	1310378	0.9471
2	Accommodation and catering industry	189	428806	0.4408
3	Information transmission, computer services and software development	74	410112	0.1804
4	Public administration and social organization	993	1148511	0.8646
5	Agriculture, forestry, animal husbandry and fishery	104	96563	1.0770
6	Manufacturing	1927	2598490	0.7416
7	Health, social security and social welfare	1022	1063933	0.9606
8	International organization	180	90033	1.9993
9	Residential services and other services	1868	3625755	0.5152
10	Construction	563	640597	0.8789
11	Real estate industry	348	503180	0.6916
12	Wholesale and retail trade	842	1485462	0.5668
13	Education	60	199531	0.3007
14	Culture, sports and entertainment	43	92135	0.4667
15	Water, environmental and public facilities management	53	50870	1.0419
16	Electricity, gas and water production and supply	439	454911	0.9650
17	Scientific research, technical services and geological exploration	56	157897	0.3547
18	Leasing and business services	383	1070064	0.3579
19	Mining	119	107150	1.1106
20	Financial industry	294	555108	0.5296

2.3 Retirement database

The retirement dataset is a cumulative database for Beijing urban retirees from year 1994 up to year 2009, comprising of 1,945,402 observations. The percentages of missing data for our variables of interest are presented in Table 2.9. We only have a few missing records for the variable occupation. Overall, the quality of data is very good.

Table 2.9: *Percentages of missing values*

	Percentages
Gender	0.0000
DoB	0.0000
Occupation	0.0689 (1340)
Status	0.0000

Note: Figures in bracket are the exact number of missing observations.

2.3.1 Data mining procedure

We first perform a list of data cleaning tasks listed as follows:

- Define category "Unknown" for the missing observation for *Occupation*;
- Recode the *Status* of those who are dead but the *Status* shows otherwise;
- Create a new variable *Birthyear* identifying the birth year of the individuals based on *DoB*;
- Create a new variable *Deathyear* identifying the death year of the individuals;
- Filter out observations where death occurred before 2006.

2.3.2 Summarized results

After filtering out those who are dead prior to 2006, there are 1,908,398 observations left in the retirement dataset, of which 792,334 are males and 1,116,064 are females. The pie chart in Figure 2.2 illustrates the percentages of males and females in our retirement sample.

A summary of the variables *Occupation* and *Deathyear* is given in Table 2.10 and Table 2.11 respectively. From Table 2.10 we see that the occupation "Manufacturing" by far has the largest number of observations in the retirement dataset, followed by "Wholesale and retail trade" and "Residential services and other services". This result reflects the industrial history of China in manufacturing (Banister, 2005). We also find that there are less observations in those occupations which require substantial education such as "Information transmission, computer services and software development", "Education" and "Scientific research, technical services and geological exploration".

Figure 2.2: *Percentages of males and females in the retirement sample*

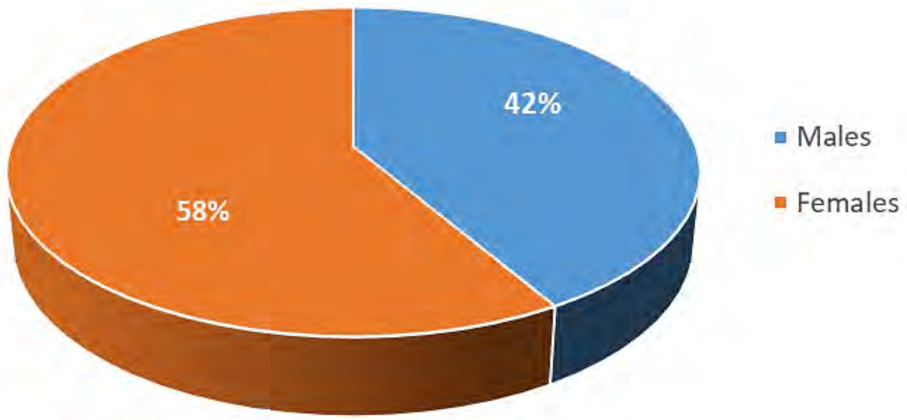


Table 2.10: *Number of observations for 21 occupations in the retirement dataset*

Occupation	Frequency
Transportation, warehousing and postal services	132028
Accommodation and catering industry	34356
Information transmission, computer services and software development	5178
Public administration and social organization	77646
Agriculture, forestry, animal husbandry and fishery	16996
Manufacturing	698846
Health, social security and social welfare	103902
International organization	454
Residential services and other services	236450
Construction	120540
Real estate industry	34942
Wholesale and retail trade	261154
Education	6712
Culture, sports and entertainment	2420
Water, environmental and public facilities management	4560
Electricity, gas and water production and supply	43560
Scientific research, technical services and geological exploration	5456
Leasing and business services	64168
Mining	26674
Financial industry	31544
Unknown	812
Total	1908398

From Table 2.11 we can see that the observed number of deaths during the sample period from the retirement dataset is much higher than those from the working-age dataset reported in Table 2.6.

Table 2.11: *Distribution of death-year*

Death-year	Frequency
Alive	1780738
2006	32560
2007	33954
2008	31642
2009	29504
Total	1908398

Finally, we present the combined number of observations and deaths by occupation from both the working-age dataset and the retirement dataset in Table 2.12.

2.4 Remarks

2.4.1 Assumptions

For the construction of the occupation-specific life tables, we made the following assumptions:

- As we do not have information on the exact date of death for an individual, it is assumed that the person died in the middle of that particular calendar year.
- As we do not have information on the exact date of retirement for an individual, it is also assumed that the person retired in the middle of that particular calendar year.
- For those people who retired during the investigation period, it is not possible to return to the workforce.
- For those people who changed jobs during the investigation period, we assume the changes happened in the middle of the calendar year and a half-year exposure is counted for both occupations. However, when a person dies, the death will be counted as one in his/her last recorded occupation regardless of job changes.

2.4.2 Software

To handle the large sample size in each year during 2005–2009, we created an ephemeral in-memory RSQLite database to store the datasets using the "RSQlite" package in **R**. Interface for communication between **R** and the database is established using the "DBI" package. This resolves the issue of **R** running low on memory.

Table 2.12: *Number of observations and deaths (combined) by occupations*

	Occupation	Total observations	Total deaths
1	Transportation, warehousing and postal service	1545193	11907
2	Accommodation and catering industry	479894	2779
3	Information transmission, computer services and software development	376771	274
4	Public administration and social organization	1241347	4527
5	Agriculture, forestry, animal husbandry and fishery	137511	1094
6	Manufacturing	4425285	51553
7	Health, social security and social welfare	1258960	3508
8	International organizations	78693	194
9	Resident services and other services	3902783	14252
10	Construction	927277	10707
11	Real estate industry	547097	2712
12	Wholesale and retail trade	2097500	21378
13	Education	194377	314
14	Culture, sports and entertainment	87367	187
15	Water, environmental and public facilities management	58118	405
16	Electricity, gas and water production and supply	532124	3059
17	Scientific research, technical services and geological exploration	149644	248
18	Leasing and business services	1131878	3907
19	Mining	174818	2781
20	Financial industry	581365	2416

Section 3

Occupation-specific life tables

In this section, we present the occupation-specific life tables constructed based on the combined deaths and exposures data from the working-age dataset and retirement dataset described in Section 2. Two grouping options are considered in our project, in which the 20 occupations (excluding "Unknown") are combined into four and five boarder groups respectively. Details of these grouping choices and the resulting occupation-specific life tables are presented in Section 3.2 and Section 3.3. We also compute and compare the life expectancy for the local urban employees and the migrant urban workers employees in Beijing during the same time period.

3.1 Occupation-combined life tables

To provide an overview of the life expectancy of the urban population in Beijing, we first present a gender-combined all-occupation life table in Table 3.1 below. Note that we set the upper age limit in this table and all subsequent life tables to be 105 years old which is a common practice in many life tables.

Table 3.1: *Period life table 2006–2009.*

Age	p_x	q_x	l_x	d_x	L_x	T_x	e_x
20	0.99991	0.00009	100000	9	99996	6091622	60.92
21	0.99990	0.00010	99991	10	99986	5991627	59.92
22	0.99989	0.00011	99981	11	99976	5891641	58.93
23	0.99988	0.00012	99970	12	99964	5791665	57.93
24	0.99986	0.00014	99958	14	99951	5691701	56.94
25	0.99985	0.00015	99944	15	99937	5591750	55.95
26	0.99983	0.00017	99929	17	99921	5491813	54.96
27	0.99982	0.00018	99913	18	99904	5391892	53.97
28	0.99980	0.00020	99894	20	99884	5291988	52.98
29	0.99977	0.00023	99874	23	99863	5192104	51.99
30	0.99975	0.00025	99851	25	99839	5092242	51.00
31	0.99972	0.00028	99826	28	99812	4992403	50.01
32	0.99969	0.00031	99798	31	99783	4892590	49.02
33	0.99966	0.00034	99767	34	99750	4792808	48.04

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Table 3.1 – *Continued from previous page*

Age	p_x	q_x	l_x	d_x	L_x	T_x	e_x
34	0.99962	0.00038	99733	38	99714	4693057	47.06
35	0.99958	0.00042	99695	42	99674	4593343	46.07
36	0.99953	0.00047	99653	47	99630	4493669	45.09
37	0.99948	0.00052	99606	52	99581	4394039	44.11
38	0.99942	0.00058	99555	57	99526	4294459	43.14
39	0.99936	0.00064	99497	64	99465	4194933	42.16
40	0.99929	0.00071	99433	71	99398	4095467	41.19
41	0.99921	0.00079	99363	79	99323	3996069	40.22
42	0.99912	0.00088	99284	87	99240	3896746	39.25
43	0.99902	0.00098	99197	97	99148	3797506	38.28
44	0.99892	0.00108	99100	107	99046	3698358	37.32
45	0.99880	0.00120	98992	119	98933	3599312	36.36
46	0.99866	0.00134	98873	132	98807	3500379	35.40
47	0.99851	0.00149	98741	147	98668	3401572	34.45
48	0.99835	0.00165	98594	163	98513	3302904	33.50
49	0.99816	0.00184	98431	181	98340	3204392	32.55
50	0.99794	0.00206	98250	202	98149	3106051	31.61
51	0.99770	0.00230	98048	225	97935	3007902	30.68
52	0.99742	0.00258	97822	252	97696	2909967	29.75
53	0.99711	0.00289	97570	282	97429	2812271	28.82
54	0.99676	0.00324	97288	315	97131	2714842	27.91
55	0.99636	0.00364	96973	353	96797	2617711	26.99
56	0.99591	0.00409	96620	395	96422	2520914	26.09
57	0.99540	0.00460	96225	443	96004	2424492	25.20
58	0.99483	0.00517	95782	495	95535	2328488	24.31
59	0.99418	0.00582	95287	554	95010	2232954	23.43
60	0.99346	0.00654	94733	620	94423	2137944	22.57
61	0.99264	0.00736	94113	693	93766	2043521	21.71
62	0.99172	0.00828	93420	773	93033	1949755	20.87
63	0.99071	0.00929	92646	861	92216	1856722	20.04
64	0.98958	0.01042	91786	957	91307	1764506	19.22
65	0.98832	0.01168	90829	1061	90298	1673199	18.42
66	0.98691	0.01309	89768	1175	89180	1582901	17.63
67	0.98534	0.01466	88593	1299	87943	1493721	16.86
68	0.98359	0.01641	87294	1433	86578	1405777	16.10
69	0.98162	0.01838	85861	1578	85072	1319200	15.36
70	0.97940	0.02060	84283	1736	83415	1234128	14.64
71	0.97691	0.02309	82547	1906	81594	1150713	13.94
72	0.97409	0.02591	80641	2089	79597	1069119	13.26
73	0.97102	0.02898	78552	2277	77414	989522	12.60
74	0.96776	0.03224	76275	2459	75046	912108	11.96
75	0.96431	0.03569	73816	2635	72499	837063	11.34
76	0.96063	0.03937	71181	2803	69780	764564	10.74
77	0.95668	0.04332	68379	2962	66897	694784	10.16
78	0.95240	0.04760	65416	3114	63859	627886	9.60

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Table 3.1 – *Continued from previous page*

Age	p_x	q_x	l_x	d_x	L_x	T_x	e_x
79	0.94772	0.05228	62302	3257	60673	564027	9.05
80	0.94253	0.05747	59045	3393	57348	503354	8.52
81	0.93671	0.06329	55651	3522	53890	446006	8.01
82	0.93011	0.06989	52129	3644	50308	392116	7.52
83	0.92273	0.07727	48486	3746	46613	341808	7.05
84	0.91471	0.08529	44739	3816	42831	295195	6.60
85	0.90597	0.09403	40923	3848	38999	252364	6.17
86	0.89644	0.10356	37075	3839	35156	213364	5.75
87	0.88603	0.11397	33236	3788	31342	178209	5.36
88	0.87464	0.12536	29448	3692	27602	146867	4.99
89	0.86214	0.13786	25757	3551	23981	119264	4.63
90	0.84840	0.15160	22206	3366	20523	95283	4.29
91	0.83323	0.16677	18839	3142	17269	74760	3.97
92	0.81646	0.18354	15698	2881	14257	57492	3.66
93	0.79783	0.20217	12816	2591	11521	43235	3.37
94	0.77737	0.22263	10225	2276	9087	31714	3.10
95	0.75517	0.24483	7949	1946	6976	22627	2.85
96	0.73106	0.26894	6003	1614	5196	15651	2.61
97	0.70484	0.29516	4388	1295	3741	10455	2.38
98	0.67629	0.32371	3093	1001	2592	6715	2.17
99	0.64514	0.35486	2092	742	1721	4122	1.97
100	0.61109	0.38891	1350	525	1087	2401	1.78
101	0.57380	0.42620	825	351	649	1314	1.59
102	0.53284	0.46716	473	221	363	665	1.41
103	0.48738	0.51262	252	129	188	303	1.20
104	0.43750	0.56250	123	69	88	115	0.94
105	0.00000	1.00000	54	54	27	27	0.50

According to Table 3.1, the average future lifespan for a 20-year-old urban employee in Beijing is around 60.92 years. This result is in line with the figures in the official life tables presented in Table 1.1 in Section 1. Compared to the China Life Insurance Mortality Table (2010–2013) (CL(2010–2013)), our result is the closest to the life expectancy at age 20 based on CL(2010–2013) male mortality experience for the "Saving (Non-nursing) business".

In Table 3.2 we present the gender-specific all-occupation life table. The table shows that male life expectancy is lower than female life expectancy for all age groups. Life expectancy at age 20 is 59.33 years for males, while for females it is 63.09 years, which is 3.76 years higher. The gap becomes narrower as age increases: at age 50, the difference is 3.36 years; at age 85, the difference is only 0.93 years. Overall, when comparing our results with the figures from the official life tables presented in Table 1.1, the closest benchmark is the China Life Insurance Mortality Table (2000–2003) mortality experience for the "Annuity business" for both males and females.

Table 3.2: *Period life table 2006–2009 by gender*

Age	Male			Female		
	q_x	l_x	e_x	q_x	l_x	e_x
20	0.00011	100000	59.33	0.00006	100000	63.09
21	0.00012	99989	58.34	0.00007	99994	62.09
22	0.00014	99976	57.35	0.00007	99987	61.10
23	0.00015	99962	56.35	0.00008	99980	60.10
24	0.00017	99947	55.36	0.00009	99972	59.10
25	0.00019	99930	54.37	0.00010	99963	58.11
26	0.00021	99911	53.38	0.00011	99953	57.12
27	0.00023	99890	52.39	0.00012	99942	56.12
28	0.00026	99867	51.40	0.00013	99930	55.13
29	0.00029	99841	50.42	0.00015	99916	54.14
30	0.00032	99812	49.43	0.00017	99901	53.14
31	0.00036	99780	48.45	0.00018	99885	52.15
32	0.00040	99744	47.47	0.00020	99866	51.16
33	0.00044	99705	46.48	0.00022	99846	50.17
34	0.00049	99661	45.50	0.00025	99824	49.18
35	0.00054	99612	44.53	0.00027	99799	48.20
36	0.00060	99558	43.55	0.00030	99772	47.21
37	0.00067	99498	42.58	0.00034	99741	46.22
38	0.00074	99432	41.60	0.00037	99708	45.24
39	0.00082	99358	40.63	0.00041	99670	44.26
40	0.00092	99276	39.67	0.00046	99629	43.27
41	0.00102	99185	38.70	0.00051	99583	42.29
42	0.00113	99084	37.74	0.00057	99532	41.31
43	0.00126	98971	36.78	0.00063	99476	40.34
44	0.00140	98847	35.83	0.00070	99413	39.36
45	0.00156	98708	34.88	0.00077	99344	38.39
46	0.00173	98554	33.93	0.00086	99267	37.42
47	0.00193	98384	32.99	0.00095	99182	36.45
48	0.00214	98194	32.05	0.00106	99087	35.49
49	0.00239	97984	31.12	0.00119	98982	34.52
50	0.00266	97750	30.20	0.00134	98864	33.56
51	0.00296	97490	29.27	0.00151	98732	32.61
52	0.00331	97201	28.36	0.00170	98583	31.66
53	0.00370	96880	27.45	0.00192	98416	30.71
54	0.00414	96521	26.55	0.00216	98227	29.77
55	0.00464	96121	25.66	0.00245	98015	28.83
56	0.00520	95675	24.78	0.00277	97775	27.90
57	0.00583	95177	23.91	0.00313	97505	26.98
58	0.00654	94622	23.04	0.00355	97199	26.06
59	0.00732	94003	22.19	0.00403	96854	25.15
60	0.00820	93315	21.35	0.00458	96464	24.25
61	0.00917	92550	20.52	0.00520	96022	23.36
62	0.01024	91702	19.71	0.00590	95523	22.48

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Table 3.2 – *Continued from previous page*

Age	Male			Female		
	q_x	l_x	e_x	q_x	l_x	e_x
63	0.01143	90762	18.91	0.00669	94959	21.61
64	0.01274	89725	18.12	0.00758	94324	20.75
65	0.01419	88581	17.35	0.00858	93610	19.91
66	0.01580	87324	16.59	0.00970	92807	19.07
67	0.01759	85944	15.85	0.01098	91906	18.26
68	0.01958	84433	15.12	0.01242	90898	17.45
69	0.02180	82779	14.42	0.01405	89769	16.67
70	0.02429	80975	13.73	0.01589	88508	15.90
71	0.02708	79008	13.05	0.01799	87101	15.14
72	0.03023	76868	12.40	0.02031	85534	14.41
73	0.03367	74544	11.78	0.02279	83797	13.70
74	0.03730	72034	11.17	0.02545	81888	13.01
75	0.04116	69347	10.58	0.02833	79803	12.34
76	0.04527	66493	10.01	0.03146	77542	11.68
77	0.04967	63483	9.47	0.03487	75103	11.04
78	0.05444	60330	8.93	0.03864	72484	10.43
79	0.05966	57045	8.42	0.04285	69683	9.82
80	0.06541	53642	7.92	0.04760	66697	9.24
81	0.07184	50133	7.44	0.05302	63522	8.68
82	0.07912	46531	6.98	0.05911	60154	8.14
83	0.08721	42850	6.54	0.06579	56599	7.62
84	0.09600	39113	6.11	0.07315	52875	7.12
85	0.10558	35358	5.71	0.08125	49007	6.64
86	0.11600	31625	5.32	0.09019	45025	6.18
87	0.12738	27957	4.96	0.10008	40965	5.75
88	0.13982	24395	4.61	0.11104	36865	5.33
89	0.15343	20985	4.27	0.12323	32771	4.93
90	0.16838	17765	3.96	0.13683	28733	4.55
91	0.18482	14774	3.66	0.15205	24802	4.20
92	0.20295	12043	3.37	0.16893	21031	3.86
93	0.22300	9599	3.11	0.18747	17478	3.54
94	0.24497	7458	2.85	0.20782	14201	3.25
95	0.26878	5631	2.62	0.23019	11250	2.97
96	0.29461	4118	2.40	0.25478	8660	2.70
97	0.32267	2905	2.19	0.28184	6454	2.46
98	0.35318	1967	1.99	0.31165	4635	2.23
99	0.38642	1273	1.81	0.34453	3190	2.01
100	0.42268	781	1.64	0.38085	2091	1.80
101	0.46234	451	1.47	0.42139	1295	1.60
102	0.50580	242	1.30	0.46623	749	1.40
103	0.55389	120	1.12	0.51585	400	1.19
104	0.60654	53	0.89	0.57076	194	0.93
105	1.00000	21	0.50	1.00000	83	0.50

3.2 Grouping option 1

We first combine the 20 occupations into four groups, namely primary, secondary, tertiary and quaternary. The 4 occupation sectors are defined as follows:

- Primary jobs involve getting raw materials from the natural environment such as mining, farming and fishing.
- Secondary jobs involve making things (manufacturing) such as construction and manufacturing.
- Tertiary jobs involve providing a service to general population and businesses and include transportation, electric, gas and sanitary services, wholesale trade, retail trade, real estate, entertainment, and health care.
- Quaternary jobs involve knowledge based services, research and development such as IT, finance, insurance, public administration, teaching, and nursing.

The result of this grouping is shown in Table 3.3. Each of the 20 occupation is classified into one of the four sectors. We present the total number of observations and deaths of the four sectors in Table 3.4.

Table 3.3: *Occupation grouping (four sectors)*

Occupation	Sector
Transportation, warehousing and postal services	T
Accommodation and catering industry	T
Information transmission, computer services and software development	Q
Public administration and social organization	Q
Agriculture, forestry, animal husbandry and fishery	P
Manufacturing	S
Health, social security and social welfare	T
International organizations	Q
Resident services and other services	T
Construction	S
Real estate industry	T
Wholesale and retail trade	T
Education	T
Culture, sports and entertainment	T
Water, environmental and public facilities management	T
Electricity, gas and water production and supply	T
Scientific research, technical services and geological exploration	Q
Leasing and business services	T
Mining	P
Financial industry	Q

Note: P: Primary; S: Secondary; T: Tertiary; Q: Quaternary.

Table 3.4: *Summary statistics of 4 occupation sectors*

	Sector	Total observations	Total deaths
1	Primary	312329	3875
2	Secondary	5352562	62260
3	Tertiary	11288194	64408
4	Quaternary	2974917	7659

From Table 3.4 we can see that the Primary Sector has the smallest number of observations and the Tertiary Sector has the largest number of observations among the four sectors. In fact, the number of observations in the Tertiary Sector is greater than the summation of number of observations in the other three sectors.

Based on this grouping method, we compute life expectancy at age 20, 50 and 80 for the four different sectors and present the results in Table 3.5. We find that the Primary Sector has the lowest life expectancy among the four sectors, at all ages. While the Secondary Sector has the second lowest life expectancy at all ages, we find mixed results for the Tertiary Sector and the Quaternary Sector. At age 20 and 50, the Tertiary Sector has the highest life expectancy among all four sectors. However, the Quaternary Sector has a higher life expectancy at age 80. Overall, we find that the largest deviations in life expectancies are 1.55 years at age 20, 1.32 years at age 50, and 1.12 years at age 80.

Table 3.5: *Summary table of life expectancies for a 20-year old based on 4-sector grouping*

Sector	Average future life years at age		
	20	50	80
Primary	59.70	30.61	7.50
Secondary	60.18	30.93	8.04
Tertiary	61.25	31.93	8.60
Quaternary	60.96	31.64	8.62

3.2.1 Occupation-specific life tables based on Grouping 1

In this section we present the occupation-specific life tables for the four sectors described in Grouping 1. The life tables are shown in Table 3.6, 3.7, 3.8 and 3.9.

Table 3.6: *Period life table 2006–2009 for the Primary Sector.*

Age	p_x	q_x	l_x	d_x	L_x	T_x	e_x
20	0.99967	0.00033	100000	33	99983	5969894	59.70
21	0.99967	0.00033	99967	33	99950	5869910	58.72
22	0.99967	0.00033	99934	33	99917	5769960	57.74
23	0.99967	0.00033	99901	33	99884	5670042	56.76
24	0.99967	0.00033	99868	33	99851	5570158	55.78
25	0.99967	0.00033	99835	33	99818	5470306	54.79
26	0.99967	0.00033	99802	33	99786	5370488	53.81
27	0.99967	0.00033	99769	33	99753	5270702	52.83
28	0.99967	0.00033	99736	33	99720	5170950	51.85
29	0.99964	0.00036	99703	36	99685	5071230	50.86
30	0.99961	0.00039	99667	39	99648	4971545	49.88
31	0.99958	0.00042	99629	42	99608	4871897	48.90
32	0.99954	0.00046	99587	45	99564	4772289	47.92
33	0.99951	0.00049	99541	49	99517	4672725	46.94
34	0.99946	0.00054	99492	53	99465	4573209	45.97
35	0.99942	0.00058	99439	58	99410	4473743	44.99
36	0.99937	0.00063	99381	63	99350	4374334	44.02
37	0.99931	0.00069	99318	68	99284	4274984	43.04
38	0.99925	0.00075	99250	74	99213	4175700	42.07
39	0.99918	0.00082	99176	81	99135	4076487	41.10
40	0.99911	0.00089	99094	89	99050	3977352	40.14
41	0.99903	0.00097	99006	96	98958	3878302	39.17
42	0.99894	0.00106	98910	105	98857	3779344	38.21
43	0.99885	0.00115	98805	114	98748	3680487	37.25
44	0.99875	0.00125	98692	123	98630	3581739	36.29
45	0.99864	0.00136	98568	134	98501	3483109	35.34
46	0.99851	0.00149	98434	147	98360	3384608	34.38
47	0.99836	0.00164	98287	161	98206	3286248	33.44
48	0.99819	0.00181	98126	177	98037	3188042	32.49
49	0.99801	0.00199	97949	195	97851	3090005	31.55
50	0.99783	0.00217	97754	212	97648	2992153	30.61
51	0.99763	0.00237	97541	231	97426	2894506	29.67
52	0.99741	0.00259	97310	252	97184	2797080	28.74
53	0.99717	0.00283	97059	275	96921	2699895	27.82
54	0.99688	0.00312	96784	302	96633	2602974	26.89
55	0.99653	0.00347	96482	335	96314	2506342	25.98
56	0.99608	0.00392	96146	377	95958	2410028	25.07
57	0.99555	0.00445	95770	426	95557	2314070	24.16
58	0.99496	0.00504	95344	481	95103	2218513	23.27
59	0.99429	0.00571	94863	541	94592	2123410	22.38
60	0.99354	0.00646	94322	609	94017	2028817	21.51
61	0.99269	0.00731	93713	685	93370	1934800	20.65
62	0.99172	0.00828	93028	770	92643	1841430	19.79
63	0.99061	0.00939	92258	866	91825	1748787	18.96

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Table 3.6 – *Continued from previous page*

Age	p_x	q_x	l_x	d_x	L_x	T_x	e_x
64	0.98933	0.01067	91392	975	90904	1656962	18.13
65	0.98786	0.01214	90416	1097	89868	1566058	17.32
66	0.98622	0.01378	89319	1231	88703	1476191	16.53
67	0.98437	0.01563	88088	1377	87399	1387488	15.75
68	0.98230	0.01770	86711	1534	85944	1300088	14.99
69	0.98000	0.02000	85176	1704	84325	1214145	14.25
70	0.97742	0.02258	83473	1884	82530	1129820	13.54
71	0.97456	0.02544	81588	2076	80550	1047290	12.84
72	0.97138	0.02862	79513	2276	78375	966740	12.16
73	0.96785	0.03215	77237	2483	75995	888365	11.50
74	0.96400	0.03600	74754	2691	73408	812370	10.87
75	0.95983	0.04017	72062	2895	70615	738961	10.25
76	0.95530	0.04470	69167	3091	67622	668347	9.66
77	0.95037	0.04963	66076	3279	64436	600725	9.09
78	0.94497	0.05503	62797	3456	61069	536289	8.54
79	0.93899	0.06101	59341	3620	57531	475220	8.01
80	0.93234	0.06766	55721	3770	53836	417689	7.50
81	0.92486	0.07514	51951	3904	49999	363853	7.00
82	0.91652	0.08348	48047	4011	46042	313854	6.53
83	0.90733	0.09267	44036	4081	41996	267812	6.08
84	0.89719	0.10281	39955	4108	37902	225817	5.65
85	0.88600	0.11400	35848	4087	33804	187915	5.24
86	0.87361	0.12639	31761	4014	29754	154111	4.85
87	0.85989	0.14011	27747	3888	25803	124357	4.48
88	0.84464	0.15536	23859	3707	22006	98554	4.13
89	0.82767	0.17233	20152	3473	18416	76548	3.80
90	0.80886	0.19114	16680	3188	15086	58132	3.49
91	0.78811	0.21189	13492	2859	12062	43046	3.19
92	0.76522	0.23478	10633	2496	9385	30984	2.91
93	0.73997	0.26003	8136	2116	7079	21600	2.65
94	0.71210	0.28790	6021	1733	5154	14521	2.41
95	0.68135	0.31865	4287	1366	3604	9367	2.18
96	0.64739	0.35261	2921	1030	2406	5763	1.97
97	0.60984	0.39016	1891	738	1522	3357	1.77
98	0.56829	0.43171	1153	498	904	1835	1.59
99	0.52231	0.47769	655	313	499	930	1.42
100	0.47144	0.52856	342	181	252	431	1.26
101	0.41515	0.58485	161	94	114	179	1.11
102	0.35287	0.64713	67	43	45	65	0.97
103	0.28395	0.71605	24	17	15	20	0.84
104	0.20770	0.79230	7	5	4	5	0.71
105	0.00000	1.00000	1	1	1	1	0.50

Table 3.7: *Period life table 2006–2009 for the Secondary Sector.*

Age	p_x	q_x	l_x	d_x	L_x	T_x	e_x
20	0.99991	0.00009	100000	9	99995	6017563	60.18
21	0.99989	0.00011	99991	11	99985	5917568	59.18
22	0.99988	0.00012	99980	12	99974	5817582	58.19
23	0.99987	0.00013	99968	13	99962	5717608	57.19
24	0.99986	0.00014	99955	14	99948	5617647	56.20
25	0.99984	0.00016	99941	16	99933	5517699	55.21
26	0.99982	0.00018	99925	18	99916	5417766	54.22
27	0.99980	0.00020	99907	20	99897	5317850	53.23
28	0.99978	0.00022	99887	22	99876	5217953	52.24
29	0.99975	0.00025	99865	25	99853	5118077	51.25
30	0.99973	0.00027	99840	27	99827	5018225	50.26
31	0.99970	0.00030	99813	30	99798	4918398	49.28
32	0.99966	0.00034	99783	34	99766	4818600	48.29
33	0.99963	0.00037	99749	37	99730	4718834	47.31
34	0.99958	0.00042	99712	42	99691	4619104	46.32
35	0.99954	0.00046	99670	46	99647	4519413	45.34
36	0.99949	0.00051	99624	51	99598	4419766	44.36
37	0.99943	0.00057	99573	57	99544	4320168	43.39
38	0.99936	0.00064	99516	63	99484	4220623	42.41
39	0.99929	0.00071	99453	70	99417	4121139	41.44
40	0.99921	0.00079	99382	78	99343	4021722	40.47
41	0.99913	0.00087	99304	87	99261	3922379	39.50
42	0.99903	0.00097	99217	97	99169	3823118	38.53
43	0.99892	0.00108	99121	107	99067	3723949	37.57
44	0.99879	0.00121	99013	119	98954	3624882	36.61
45	0.99866	0.00134	98894	133	98827	3525929	35.65
46	0.99851	0.00149	98761	148	98687	3427101	34.70
47	0.99834	0.00166	98614	164	98531	3328414	33.75
48	0.99815	0.00185	98449	182	98358	3229883	32.81
49	0.99793	0.00207	98267	203	98165	3131524	31.87
50	0.99770	0.00230	98064	226	97951	3033359	30.93
51	0.99743	0.00257	97838	251	97712	2935408	30.00
52	0.99713	0.00287	97587	280	97447	2837696	29.08
53	0.99680	0.00320	97307	312	97151	2740249	28.16
54	0.99642	0.00358	96995	347	96822	2643097	27.25
55	0.99599	0.00401	96648	387	96455	2546275	26.35
56	0.99551	0.00449	96261	432	96045	2449821	25.45
57	0.99497	0.00503	95829	482	95588	2353776	24.56
58	0.99437	0.00563	95347	537	95079	2258188	23.68
59	0.99368	0.00632	94810	599	94511	2163109	22.82
60	0.99291	0.00709	94211	668	93877	2068598	21.96
61	0.99205	0.00795	93544	744	93172	1974720	21.11
62	0.99108	0.00892	92800	827	92386	1881549	20.28
63	0.99001	0.00999	91973	918	91513	1789162	19.45

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Table 3.7 – *Continued from previous page*

Age	p_x	q_x	l_x	d_x	L_x	T_x	e_x
64	0.98882	0.01118	91054	1018	90545	1697649	18.64
65	0.98750	0.01250	90037	1125	89474	1607104	17.85
66	0.98603	0.01397	88911	1242	88290	1517630	17.07
67	0.98439	0.01561	87669	1369	86985	1429339	16.30
68	0.98255	0.01745	86301	1506	85548	1342354	15.55
69	0.98050	0.01950	84795	1654	83968	1256806	14.82
70	0.97819	0.02181	83141	1813	82235	1172838	14.11
71	0.97559	0.02441	81328	1985	80335	1090604	13.41
72	0.97266	0.02734	79343	2169	78258	1010269	12.73
73	0.96943	0.03057	77173	2359	75994	932011	12.08
74	0.96597	0.03403	74814	2546	73541	856017	11.44
75	0.96225	0.03775	72268	2728	70904	782476	10.83
76	0.95824	0.04176	69540	2904	68088	711571	10.23
77	0.95389	0.04611	66636	3073	65100	643483	9.66
78	0.94913	0.05087	63563	3233	61947	578383	9.10
79	0.94391	0.05609	60330	3384	58638	516437	8.56
80	0.93811	0.06189	56946	3524	55184	457799	8.04
81	0.93162	0.06838	53422	3653	51595	402615	7.54
82	0.92428	0.07572	49768	3768	47884	351020	7.05
83	0.91610	0.08390	46000	3859	44070	303135	6.59
84	0.90715	0.09285	42141	3913	40184	259065	6.15
85	0.89734	0.10266	38228	3924	36266	218881	5.73
86	0.88658	0.11342	34303	3891	32358	182615	5.32
87	0.87476	0.12524	30413	3809	28508	150257	4.94
88	0.86175	0.13825	26604	3678	24765	121749	4.58
89	0.84739	0.15261	22926	3499	21177	96984	4.23
90	0.83151	0.16849	19427	3273	17791	75807	3.90
91	0.81390	0.18610	16154	3006	14651	58017	3.59
92	0.79433	0.20567	13148	2704	11796	43366	3.30
93	0.77273	0.22727	10444	2374	9257	31570	3.02
94	0.74912	0.25088	8070	2025	7058	22313	2.76
95	0.72331	0.27669	6045	1673	5209	15256	2.52
96	0.69506	0.30494	4373	1333	3706	10046	2.30
97	0.66412	0.33588	3039	1021	2529	6340	2.09
98	0.63020	0.36980	2018	746	1645	3812	1.89
99	0.59297	0.40703	1272	518	1013	2166	1.70
100	0.55204	0.44796	754	338	585	1153	1.53
101	0.50698	0.49302	416	205	314	568	1.36
102	0.45694	0.54306	211	115	154	254	1.20
103	0.40181	0.59819	96	58	68	100	1.04
104	0.34109	0.65891	39	26	26	33	0.84
105	0.00000	1.00000	13	13	7	7	0.50

Table 3.8: *Period life table from 2006–2009 for the Tertiary Sector.*

Age	p_x	q_x	l_x	d_x	L_x	T_x	e_x
20	0.99991	0.00009	100000	9	99996	6125325	61.25
21	0.99990	0.00010	99991	10	99986	6025329	60.26
22	0.99989	0.00011	99981	11	99976	5925343	59.26
23	0.99988	0.00012	99970	12	99964	5825367	58.27
24	0.99987	0.00013	99958	13	99952	5725402	57.28
25	0.99985	0.00015	99945	15	99938	5625451	56.29
26	0.99984	0.00016	99930	16	99922	5525513	55.29
27	0.99982	0.00018	99914	18	99905	5425590	54.30
28	0.99980	0.00020	99896	20	99886	5325685	53.31
29	0.99978	0.00022	99876	22	99865	5225799	52.32
30	0.99975	0.00025	99854	24	99842	5125934	51.33
31	0.99973	0.00027	99830	27	99816	5026092	50.35
32	0.99970	0.00030	99803	30	99788	4926276	49.36
33	0.99967	0.00033	99773	33	99756	4826488	48.37
34	0.99963	0.00037	99739	37	99721	4726732	47.39
35	0.99959	0.00041	99703	41	99682	4627011	46.41
36	0.99955	0.00045	99662	45	99639	4527329	45.43
37	0.99950	0.00050	99617	50	99592	4427690	44.45
38	0.99945	0.00055	99567	55	99539	4328098	43.47
39	0.99938	0.00062	99512	61	99481	4228558	42.49
40	0.99932	0.00068	99451	68	99417	4129077	41.52
41	0.99924	0.00076	99383	75	99345	4029660	40.55
42	0.99916	0.00084	99307	84	99265	3930315	39.58
43	0.99907	0.00093	99224	93	99177	3831050	38.61
44	0.99896	0.00104	99131	103	99080	3731873	37.65
45	0.99885	0.00115	99028	114	98972	3632793	36.68
46	0.99873	0.00127	98915	126	98852	3533821	35.73
47	0.99859	0.00141	98789	140	98719	3434970	34.77
48	0.99843	0.00157	98649	155	98572	3336251	33.82
49	0.99825	0.00175	98494	172	98408	3237679	32.87
50	0.99805	0.00195	98322	192	98226	3139271	31.93
51	0.99782	0.00218	98130	214	98023	3041045	30.99
52	0.99756	0.00244	97916	239	97797	2943022	30.06
53	0.99726	0.00274	97677	267	97544	2845225	29.13
54	0.99693	0.00307	97410	299	97260	2747682	28.21
55	0.99655	0.00345	97111	335	96943	2650421	27.29
56	0.99612	0.00388	96776	375	96588	2553478	26.39
57	0.99564	0.00436	96400	420	96190	2456890	25.49
58	0.99509	0.00491	95980	471	95744	2360700	24.60
59	0.99448	0.00552	95509	527	95245	2264955	23.71
60	0.99379	0.00621	94982	590	94687	2169710	22.84
61	0.99302	0.00698	94392	659	94062	2075023	21.98
62	0.99215	0.00785	93733	736	93365	1980961	21.13
63	0.99119	0.00881	92997	819	92587	1887596	20.30

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Table 3.8 – *Continued from previous page*

Age	p_x	q_x	l_x	d_x	L_x	T_x	e_x
64	0.99012	0.00988	92177	911	91722	1795009	19.47
65	0.98892	0.01108	91266	1011	90761	1703287	18.66
66	0.98758	0.01242	90255	1121	89695	1612526	17.87
67	0.98609	0.01391	89134	1240	88514	1522831	17.08
68	0.98441	0.01559	87894	1370	87209	1434317	16.32
69	0.98252	0.01748	86524	1512	85768	1347109	15.57
70	0.98040	0.01960	85011	1666	84178	1261341	14.84
71	0.97800	0.02200	83345	1834	82428	1177163	14.12
72	0.97528	0.02472	81512	2015	80504	1094734	13.43
73	0.97230	0.02770	79497	2202	78396	1014230	12.76
74	0.96914	0.03086	77295	2386	76102	935834	12.11
75	0.96576	0.03424	74909	2565	73627	859732	11.48
76	0.96215	0.03785	72345	2738	70976	786104	10.87
77	0.95827	0.04173	69607	2905	68154	715129	10.27
78	0.95404	0.04596	66702	3066	65169	646974	9.70
79	0.94940	0.05060	63636	3220	62026	581805	9.14
80	0.94425	0.05575	60416	3368	58732	519779	8.60
81	0.93847	0.06153	57048	3510	55293	461047	8.08
82	0.93188	0.06812	53538	3647	51714	405754	7.58
83	0.92452	0.07548	49891	3766	48008	354040	7.10
84	0.91648	0.08352	46125	3853	44199	306032	6.63
85	0.90768	0.09232	42273	3902	40321	261833	6.19
86	0.89806	0.10194	38370	3911	36414	221512	5.77
87	0.88751	0.11249	34459	3876	32521	185097	5.37
88	0.87592	0.12408	30582	3795	28685	152577	4.99
89	0.86318	0.13682	26788	3665	24955	123892	4.62
90	0.84912	0.15088	23123	3489	21378	98936	4.28
91	0.83357	0.16643	19634	3268	18000	77558	3.95
92	0.81633	0.18367	16366	3006	14863	59558	3.64
93	0.79717	0.20283	13360	2710	12005	44695	3.35
94	0.77607	0.22393	10650	2385	9458	32690	3.07
95	0.75308	0.24692	8265	2041	7245	23232	2.81
96	0.72803	0.27197	6224	1693	5378	15987	2.57
97	0.70069	0.29931	4532	1356	3853	10609	2.34
98	0.67081	0.32919	3175	1045	2653	6756	2.13
99	0.63812	0.36188	2130	771	1745	4103	1.93
100	0.60228	0.39772	1359	541	1089	2358	1.74
101	0.56290	0.43710	819	358	640	1270	1.55
102	0.51954	0.48046	461	221	350	630	1.37
103	0.47134	0.52866	239	127	176	280	1.17
104	0.41829	0.58171	113	66	80	104	0.92
105	0.00000	1.00000	47	47	24	24	0.50

Table 3.9: *Period life table from period 2006 to 2009 for the Quaternary Sector.*

Age	p_x	q_x	l_x	d_x	L_x	T_x	e_x
20	0.99991	0.00009	100000	9	99995	6095598	60.96
21	0.99991	0.00009	99991	9	99986	5995602	59.96
22	0.99990	0.00010	99981	10	99976	5895616	58.97
23	0.99988	0.00012	99971	12	99965	5795640	57.97
24	0.99987	0.00013	99959	13	99953	5695675	56.98
25	0.99986	0.00014	99947	14	99940	5595722	55.99
26	0.99984	0.00016	99932	16	99925	5495782	54.99
27	0.99982	0.00018	99917	18	99908	5395858	54.00
28	0.99981	0.00019	99899	19	99889	5295950	53.01
29	0.99978	0.00022	99880	22	99869	5196060	52.02
30	0.99976	0.00024	99858	24	99846	5096191	51.03
31	0.99973	0.00027	99834	27	99821	4996345	50.05
32	0.99970	0.00030	99807	30	99792	4896525	49.06
33	0.99967	0.00033	99778	33	99761	4796732	48.07
34	0.99963	0.00037	99745	37	99726	4696971	47.09
35	0.99959	0.00041	99708	41	99687	4597245	46.11
36	0.99955	0.00045	99667	45	99644	4497558	45.13
37	0.99949	0.00051	99622	50	99597	4397913	44.15
38	0.99944	0.00056	99571	56	99543	4298317	43.17
39	0.99938	0.00062	99516	62	99484	4198773	42.19
40	0.99930	0.00070	99453	69	99419	4099289	41.22
41	0.99923	0.00077	99384	77	99346	3999870	40.25
42	0.99914	0.00086	99307	86	99264	3900524	39.28
43	0.99904	0.00096	99221	95	99174	3801260	38.31
44	0.99893	0.00107	99126	106	99073	3702086	37.35
45	0.99881	0.00119	99020	118	98961	3603013	36.39
46	0.99868	0.00132	98902	131	98837	3504052	35.43
47	0.99853	0.00147	98772	145	98699	3405215	34.48
48	0.99836	0.00164	98626	162	98545	3306516	33.53
49	0.99817	0.00183	98464	180	98374	3207971	32.58
50	0.99795	0.00205	98284	201	98184	3109596	31.64
51	0.99771	0.00229	98083	225	97971	3011413	30.70
52	0.99743	0.00257	97858	252	97733	2913442	29.77
53	0.99711	0.00289	97607	282	97466	2815710	28.85
54	0.99676	0.00324	97325	316	97167	2718244	27.93
55	0.99635	0.00365	97009	354	96832	2621077	27.02
56	0.99590	0.00410	96656	396	96457	2524244	26.12
57	0.99539	0.00461	96259	444	96037	2427787	25.22
58	0.99481	0.00519	95815	498	95566	2331749	24.34
59	0.99415	0.00585	95318	557	95039	2236183	23.46
60	0.99341	0.00659	94760	624	94448	2141144	22.60
61	0.99258	0.00742	94136	698	93787	2046696	21.74
62	0.99165	0.00835	93438	780	93048	1952909	20.90
63	0.99062	0.00938	92658	869	92224	1859861	20.07

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Table 3.9 – *Continued from previous page*

Age	p_x	q_x	l_x	d_x	L_x	T_x	e_x
64	0.98947	0.01053	91789	966	91306	1767637	19.26
65	0.98819	0.01181	90823	1072	90286	1676331	18.46
66	0.98677	0.01323	89750	1188	89156	1586045	17.67
67	0.98517	0.01483	88562	1313	87906	1496889	16.90
68	0.98339	0.01661	87249	1450	86524	1408983	16.15
69	0.98138	0.01862	85800	1598	85001	1322458	15.41
70	0.97912	0.02088	84202	1758	83323	1237458	14.70
71	0.97656	0.02344	82444	1932	81477	1154135	14.00
72	0.97376	0.02624	80511	2112	79455	1072657	13.32
73	0.97080	0.02920	78399	2289	77254	993202	12.67
74	0.96767	0.03233	76110	2461	74880	915948	12.03
75	0.96432	0.03568	73649	2627	72335	841068	11.42
76	0.96074	0.03926	71022	2788	69628	768733	10.82
77	0.95687	0.04313	68233	2943	66762	699106	10.25
78	0.95264	0.04736	65291	3092	63745	632344	9.69
79	0.94797	0.05203	62199	3236	60581	568599	9.14
80	0.94275	0.05725	58963	3375	57275	508018	8.62
81	0.93684	0.06316	55587	3511	53832	450744	8.11
82	0.93029	0.06971	52076	3630	50261	396912	7.62
83	0.92321	0.07679	48446	3720	46586	346651	7.16
84	0.91555	0.08445	44726	3777	42837	300065	6.71
85	0.90724	0.09276	40948	3798	39049	257228	6.28
86	0.89820	0.10180	37150	3782	35259	218179	5.87
87	0.88833	0.11167	33368	3726	31505	182920	5.48
88	0.87751	0.12249	29642	3631	27826	151415	5.11
89	0.86560	0.13440	26011	3496	24263	123588	4.75
90	0.85242	0.14758	22515	3323	20854	99325	4.41
91	0.83778	0.16222	19192	3113	17636	78472	4.09
92	0.82168	0.17832	16079	2867	14645	60836	3.78
93	0.80425	0.19575	13212	2586	11919	46191	3.50
94	0.78536	0.21464	10625	2281	9485	34272	3.23
95	0.76487	0.23513	8345	1962	7364	24787	2.97
96	0.74264	0.25736	6383	1643	5561	17423	2.73
97	0.71848	0.28152	4740	1334	4073	11862	2.50
98	0.69218	0.30782	3406	1048	2881	7789	2.29
99	0.66353	0.33647	2357	793	1961	4908	2.08
100	0.63221	0.36779	1564	575	1276	2947	1.88
101	0.59797	0.40203	989	398	790	1670	1.69
102	0.56042	0.43958	591	260	461	880	1.49
103	0.51883	0.48117	331	159	252	419	1.26
104	0.47330	0.52670	172	91	127	167	0.97
105	0.00000	1.00000	81	81	41	41	0.50

3.3 Grouping option 2

Extending the works in Section 3.2, we re-group the 20 occupations into five sectors, by combining smaller groups together and splitting up larger groups into smaller sectors. The results of the new grouping method by occupations are tabulated in Table 3.10. The five occupation sectors are defined as follows:

- Sector 1: Production related occupations including farmers, construction workers, transportation, warehousing and postal services workers.
- Sector 2: Manufacturing, which is the same as in the original 20 occupation classification.
- Sector 3: Business services related occupations such retailers, financial services workers and real estate agents.
- Sector 4: Public services related occupations such as residential service workers and public facilities managers.
- Sector 5: Intellectual services related occupations such as educators, scientific researchers and IT workers.

Table 3.10: *Occupation grouping (five sectors)*

Occupation	Sector
Transportation, warehousing and postal services	1
Accommodation and catering industry	3
Information transmission, computer services and software development	5
Public administration and social organization	5
Agriculture, forestry, animal husbandry and fishery	1
Manufacturing	2
Health, social security and social welfare	5
International organizations	5
Resident services and other services	4
Construction	1
Real estate industry	3
Wholesale and retail trade	3
Education	5
Culture, sports and entertainment	5
Water, environmental and public facilities management	4
Electricity, gas and water production and supply	4
Scientific research, technical services and geological exploration	5
Leasing and business services	3
Mining industry	1
Financial industry	3

A summary of the total number of observations and deaths for the five occupation sectors is shown in Table 3.11. We can see from Table 3.11 that the five sectors have quite evenly distributed number of observations which is desirable when constructing occupation-specific life tables.

Table 3.11: *Summary statistics of five occupation sectors.*

Sector	Total observations	Total deaths
1	2784799	26489
2	4425285	51553
3	4837734	33192
4	4493025	17716
5	3387159	9252

We also provide a summary table of life expectancies at different ages for each of the five sectors. We observe that at age 20 and age 50, life expectancy increases from Sector 1 to Sector 5. Sector 1 has the lowest life expectancy at both age 20 and 50: for a 20-year-old person, the average future life expectancy is 59.83 years; for a person aged 50 years old, the average future life years is 30.66 years. The difference between the highest and lowest life expectancy is 2.63 years at age 20, and 2.55 years at age 50. At age 80, there is no clear trend found in average future life years across the 5 sectors. The deviation between the highest and lowest life expectancy at age 80 is 1.28 years.

Table 3.12: *Summary table of life expectancies for a 20-year old based on 5-sector grouping*

Sector	Average future life years at age		
	20	50	80
1	59.83	30.66	8.35
2	60.28	31.02	8.07
3	61.42	32.02	8.61
4	61.54	32.15	8.40
5	62.46	33.21	9.35

We conclude that, compared to occupation Grouping 1, this new grouping method provides a clearer picture of the heterogeneity in longevity across different occupation groups. It classifies occupations into five broader groups of similar size without losing too much information on the distinct characteristics of the original 20 occupations. We are able to differentiate the level of longevity among the five occupation groups. Therefore, in the rest of this report we will focus on the five occupation groups based on occupation Grouping 2.

3.3.1 Occupation-specific life tables based on Grouping 2

Based on this 5-sector grouping, the occupation-specific life tables are constructed and shown in Table 3.13, 3.14, 3.15, 3.16 and 3.17, respectively.

Table 3.13: *Period life table 2006–2009 for Sector 1.*

Age	p_x	q_x	l_x	d_x	L_x	T_x	e_x
20	0.99987	0.00013	100000	13	99994	5982746	59.83
21	0.99987	0.00013	99987	13	99981	5882753	58.84
22	0.99986	0.00014	99974	14	99967	5782772	57.84
23	0.99984	0.00016	99960	16	99952	5682805	56.85
24	0.99983	0.00017	99944	17	99936	5582853	55.86
25	0.99981	0.00019	99927	19	99917	5482917	54.87
26	0.99979	0.00021	99908	21	99897	5383000	53.88
27	0.99977	0.00023	99886	23	99875	5283103	52.89
28	0.99974	0.00026	99863	26	99850	5183228	51.90
29	0.99971	0.00029	99837	29	99823	5083378	50.92
30	0.99968	0.00032	99809	32	99793	4983555	49.93
31	0.99965	0.00035	99777	35	99759	4883762	48.95
32	0.99961	0.00039	99742	39	99723	4784003	47.96
33	0.99957	0.00043	99703	43	99682	4684280	46.98
34	0.99952	0.00048	99660	47	99637	4584598	46.00
35	0.99947	0.00053	99613	52	99587	4484962	45.02
36	0.99942	0.00058	99561	58	99532	4385375	44.05
37	0.99936	0.00064	99503	64	99471	4285843	43.07
38	0.99929	0.00071	99439	71	99403	4186372	42.10
39	0.99921	0.00079	99368	78	99329	4086969	41.13
40	0.99913	0.00087	99290	87	99246	3987640	40.16
41	0.99903	0.00097	99203	96	99155	3888393	39.20
42	0.99893	0.00107	99107	106	99054	3789238	38.23
43	0.99881	0.00119	99001	118	98942	3690184	37.27
44	0.99868	0.00132	98883	130	98818	3591242	36.32
45	0.99854	0.00146	98753	144	98681	3492424	35.37
46	0.99838	0.00162	98609	159	98529	3393744	34.42
47	0.99821	0.00179	98449	177	98361	3295215	33.47
48	0.99801	0.00199	98273	195	98175	3196854	32.53
49	0.99779	0.00221	98077	217	97969	3098679	31.59
50	0.99754	0.00246	97860	240	97740	3000710	30.66
51	0.99726	0.00274	97620	267	97486	2902970	29.74
52	0.99695	0.00305	97353	297	97204	2805484	28.82
53	0.99659	0.00341	97056	331	96890	2708279	27.90
54	0.99619	0.00381	96725	369	96540	2611389	27.00
55	0.99574	0.00426	96356	411	96150	2514849	26.10
56	0.99523	0.00477	95945	458	95716	2418699	25.21
57	0.99465	0.00535	95487	510	95232	2322983	24.33
58	0.99401	0.00599	94976	569	94692	2227751	23.46
59	0.99327	0.00673	94407	635	94090	2133059	22.59
60	0.99244	0.00756	93772	709	93418	2038970	21.74
61	0.99150	0.00850	93064	791	92668	1945552	20.91
62	0.99043	0.00957	92273	883	91831	1852883	20.08
63	0.98922	0.01078	91389	985	90897	1761052	19.27

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Table 3.13 – *Continued from previous page*

Age	p_x	q_x	l_x	d_x	L_x	T_x	e_x
64	0.98789	0.01211	90404	1095	89857	1670156	18.47
65	0.98641	0.01359	89309	1214	88702	1580299	17.69
66	0.98477	0.01523	88095	1341	87425	1491597	16.93
67	0.98296	0.01704	86754	1478	86015	1404173	16.19
68	0.98095	0.01905	85276	1625	84463	1318158	15.46
69	0.97871	0.02129	83651	1781	82760	1233695	14.75
70	0.97621	0.02379	81870	1948	80896	1150935	14.06
71	0.97341	0.02659	79922	2125	78859	1070039	13.39
72	0.97028	0.02972	77797	2312	76641	991180	12.74
73	0.96676	0.03324	75485	2509	74231	914539	12.12
74	0.96298	0.03702	72976	2702	71625	840308	11.51
75	0.95908	0.04092	70274	2876	68836	768683	10.94
76	0.95505	0.04495	67398	3030	65884	699846	10.38
77	0.95087	0.04913	64369	3163	62788	633962	9.85
78	0.94648	0.05352	61206	3276	59568	571175	9.33
79	0.94182	0.05818	57930	3371	56245	511607	8.83
80	0.93678	0.06322	54560	3449	52835	455362	8.35
81	0.93124	0.06876	51110	3515	49353	402527	7.88
82	0.92503	0.07497	47596	3568	45812	353174	7.42
83	0.91795	0.08205	44028	3612	42221	307362	6.98
84	0.91009	0.08991	40415	3634	38598	265141	6.56
85	0.90167	0.09833	36781	3617	34973	226543	6.16
86	0.89265	0.10735	33164	3560	31384	191570	5.78
87	0.88294	0.11706	29604	3465	27871	160185	5.41
88	0.87247	0.12753	26139	3333	24472	132314	5.06
89	0.86113	0.13887	22805	3167	21222	107842	4.73
90	0.84880	0.15120	19638	2969	18154	86620	4.41
91	0.83532	0.16468	16669	2745	15296	68467	4.11
92	0.82052	0.17948	13924	2499	12674	53171	3.82
93	0.80417	0.19583	11425	2237	10306	40496	3.54
94	0.78642	0.21358	9187	1962	8206	30190	3.29
95	0.76747	0.23253	7225	1680	6385	21984	3.04
96	0.74724	0.25276	5545	1402	4844	15599	2.81
97	0.72558	0.27442	4143	1137	3575	10755	2.60
98	0.70234	0.29766	3006	895	2559	7180	2.39
99	0.67734	0.32266	2112	681	1771	4621	2.19
100	0.65037	0.34963	1430	500	1180	2850	1.99
101	0.62116	0.37884	930	352	754	1670	1.80
102	0.58941	0.41059	578	237	459	916	1.58
103	0.55435	0.44565	341	152	265	457	1.34
104	0.51629	0.48371	189	91	143	192	1.02
105	0.00000	1.00000	97	97	49	49	0.50

Table 3.14: *Period life table 2006–2009 for Sector 2*

Age	p_x	q_x	l_x	d_x	L_x	T_x	e_x
20	0.99991	0.00009	100000	9	99995	6028097	60.28
21	0.99990	0.00010	99991	10	99986	5928102	59.29
22	0.99989	0.00011	99981	11	99975	5828116	58.29
23	0.99987	0.00013	99970	13	99963	5728141	57.30
24	0.99986	0.00014	99957	14	99950	5628178	56.31
25	0.99984	0.00016	99943	15	99935	5528228	55.31
26	0.99983	0.00017	99928	17	99919	5428292	54.32
27	0.99981	0.00019	99910	19	99901	5328373	53.33
28	0.99979	0.00021	99891	21	99880	5228473	52.34
29	0.99976	0.00024	99870	24	99858	5128592	51.35
30	0.99974	0.00026	99846	26	99833	5028734	50.36
31	0.99971	0.00029	99820	29	99805	4928901	49.38
32	0.99967	0.00033	99790	33	99774	4829096	48.39
33	0.99964	0.00036	99758	36	99740	4729322	47.41
34	0.99960	0.00040	99721	40	99701	4629583	46.43
35	0.99955	0.00045	99681	45	99659	4529881	45.44
36	0.99950	0.00050	99636	50	99611	4430223	44.46
37	0.99944	0.00056	99586	55	99559	4330611	43.49
38	0.99938	0.00062	99531	62	99500	4231052	42.51
39	0.99931	0.00069	99470	68	99435	4131552	41.54
40	0.99923	0.00077	99401	76	99363	4032117	40.56
41	0.99915	0.00085	99325	85	99282	3932754	39.59
42	0.99905	0.00095	99240	94	99193	3833472	38.63
43	0.99894	0.00106	99146	105	99093	3734279	37.66
44	0.99882	0.00118	99041	117	98982	3635186	36.70
45	0.99869	0.00131	98924	130	98859	3536203	35.75
46	0.99853	0.00147	98794	145	98721	3437345	34.79
47	0.99837	0.00163	98649	161	98568	3338624	33.84
48	0.99818	0.00182	98488	179	98398	3240055	32.90
49	0.99797	0.00203	98308	200	98209	3141657	31.96
50	0.99773	0.00227	98109	222	97998	3043448	31.02
51	0.99747	0.00253	97887	247	97763	2945451	30.09
52	0.99718	0.00282	97639	276	97501	2847688	29.17
53	0.99685	0.00315	97364	307	97210	2750186	28.25
54	0.99647	0.00353	97056	343	96885	2652976	27.33
55	0.99605	0.00395	96714	382	96523	2556091	26.43
56	0.99558	0.00442	96332	426	96119	2459569	25.53
57	0.99504	0.00496	95906	476	95668	2363450	24.64
58	0.99444	0.00556	95430	531	95165	2267782	23.76
59	0.99377	0.00623	94899	592	94604	2172617	22.89
60	0.99301	0.00699	94308	660	93978	2078014	22.03
61	0.99215	0.00785	93648	735	93281	1984036	21.19
62	0.99120	0.00880	92913	817	92505	1890755	20.35
63	0.99015	0.00985	92096	907	91642	1798250	19.53

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Table 3.14 – *Continued from previous page*

Age	p_x	q_x	l_x	d_x	L_x	T_x	e_x
64	0.98897	0.01103	91189	1006	90686	1706608	18.72
65	0.98767	0.01233	90183	1112	89627	1615922	17.92
66	0.98621	0.01379	89071	1228	88457	1526295	17.14
67	0.98459	0.01541	87843	1354	87166	1437838	16.37
68	0.98277	0.01723	86489	1490	85744	1350673	15.62
69	0.98073	0.01927	84998	1637	84180	1264929	14.88
70	0.97845	0.02155	83361	1796	82463	1180750	14.16
71	0.97588	0.02412	81564	1967	80581	1098287	13.47
72	0.97298	0.02702	79597	2151	78521	1017706	12.79
73	0.96978	0.03022	77446	2340	76276	939185	12.13
74	0.96635	0.03365	75106	2527	73842	862909	11.49
75	0.96266	0.03734	72578	2710	71223	789067	10.87
76	0.95867	0.04133	69868	2887	68425	717843	10.27
77	0.95435	0.04565	66981	3058	65452	649419	9.70
78	0.94962	0.05038	63923	3220	62313	583967	9.14
79	0.94442	0.05558	60703	3374	59016	521654	8.59
80	0.93864	0.06136	57329	3518	55570	462638	8.07
81	0.93218	0.06782	53811	3650	51986	407068	7.56
82	0.92487	0.07513	50161	3769	48277	355082	7.08
83	0.91672	0.08328	46393	3864	44461	306805	6.61
84	0.90779	0.09221	42529	3922	40568	262344	6.17
85	0.89801	0.10199	38607	3938	36639	221775	5.74
86	0.88727	0.11273	34670	3908	32716	185137	5.34
87	0.87546	0.12454	30761	3831	28846	152421	4.95
88	0.86245	0.13755	26930	3704	25078	123576	4.59
89	0.84809	0.15191	23226	3528	21462	98498	4.24
90	0.83220	0.16780	19698	3305	18045	77036	3.91
91	0.81458	0.18542	16392	3039	14873	58991	3.60
92	0.79498	0.20502	13353	2738	11984	44118	3.30
93	0.77334	0.22666	10615	2406	9412	32134	3.03
94	0.74967	0.25033	8209	2055	7182	22722	2.77
95	0.72377	0.27623	6154	1700	5304	15540	2.53
96	0.69540	0.30460	4454	1357	3776	10236	2.30
97	0.66431	0.33569	3097	1040	2578	6460	2.09
98	0.63019	0.36981	2058	761	1677	3883	1.89
99	0.59272	0.40728	1297	528	1033	2205	1.70
100	0.55151	0.44849	769	345	596	1173	1.53
101	0.50611	0.49389	424	209	319	577	1.36
102	0.45567	0.54433	215	117	156	257	1.20
103	0.40008	0.59992	98	59	68	101	1.04
104	0.33882	0.66118	39	26	26	33	0.84
105	0.00000	1.00000	13	13	7	7	0.50

Table 3.15: *Period life table 2006–2009 for Sector 3*

Age	p_x	q_x	l_x	d_x	L_x	T_x	e_x
20	0.99993	0.00007	100000	7	99996	6141931	61.42
21	0.99992	0.00008	99993	8	99989	6041935	60.42
22	0.99991	0.00009	99985	9	99981	5941946	59.43
23	0.99990	0.00010	99976	10	99971	5841965	58.43
24	0.99989	0.00011	99967	11	99961	5741994	57.44
25	0.99988	0.00012	99956	12	99950	5642033	56.45
26	0.99987	0.00013	99944	13	99937	5542083	55.45
27	0.99985	0.00015	99930	15	99923	5442146	54.46
28	0.99983	0.00017	99916	17	99907	5342223	53.47
29	0.99982	0.00018	99899	18	99890	5242315	52.48
30	0.99979	0.00021	99881	21	99870	5142426	51.49
31	0.99977	0.00023	99860	23	99849	5042555	50.50
32	0.99975	0.00025	99837	25	99825	4942707	49.51
33	0.99972	0.00028	99812	28	99798	4842882	48.52
34	0.99968	0.00032	99784	31	99768	4743084	47.53
35	0.99965	0.00035	99752	35	99735	4643316	46.55
36	0.99961	0.00039	99717	39	99698	4543582	45.56
37	0.99957	0.00043	99678	43	99657	4443884	44.58
38	0.99952	0.00048	99635	48	99611	4344227	43.60
39	0.99946	0.00054	99587	54	99560	4244616	42.62
40	0.99940	0.00060	99533	60	99503	4145056	41.65
41	0.99933	0.00067	99473	67	99440	4045553	40.67
42	0.99925	0.00075	99406	74	99369	3946114	39.70
43	0.99917	0.00083	99332	83	99291	3846744	38.73
44	0.99907	0.00093	99249	92	99203	3747454	37.76
45	0.99897	0.00103	99157	102	99106	3648251	36.79
46	0.99885	0.00115	99055	114	98998	3549145	35.83
47	0.99872	0.00128	98941	127	98877	3450147	34.87
48	0.99857	0.00143	98814	141	98743	3351270	33.92
49	0.99840	0.00160	98672	158	98593	3252527	32.96
50	0.99820	0.00180	98514	177	98426	3153934	32.02
51	0.99798	0.00202	98337	199	98238	3055508	31.07
52	0.99772	0.00228	98139	223	98027	2957271	30.13
53	0.99743	0.00257	97915	251	97790	2859244	29.20
54	0.99710	0.00290	97664	283	97522	2761454	28.28
55	0.99673	0.00327	97381	319	97222	2663932	27.36
56	0.99630	0.00370	97062	359	96883	2566710	26.44
57	0.99582	0.00418	96704	404	96502	2469827	25.54
58	0.99528	0.00472	96300	454	96073	2373325	24.65
59	0.99467	0.00533	95846	511	95590	2277252	23.76
60	0.99398	0.00602	95335	574	95048	2181662	22.88
61	0.99321	0.00679	94761	644	94439	2086614	22.02
62	0.99234	0.00766	94117	721	93757	1992175	21.17
63	0.99137	0.00863	93396	806	92993	1898419	20.33

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Table 3.15 – *Continued from previous page*

Age	p_x	q_x	l_x	d_x	L_x	T_x	e_x
64	0.99029	0.00971	92590	899	92141	1805426	19.50
65	0.98908	0.01092	91691	1001	91191	1713285	18.69
66	0.98773	0.01227	90690	1112	90134	1622094	17.89
67	0.98622	0.01378	89578	1234	88961	1531960	17.10
68	0.98453	0.01547	88344	1367	87660	1443000	16.33
69	0.98263	0.01737	86977	1511	86221	1355339	15.58
70	0.98049	0.01951	85466	1668	84632	1269118	14.85
71	0.97807	0.02193	83798	1838	82879	1184486	14.14
72	0.97535	0.02465	81960	2021	80950	1101607	13.44
73	0.97236	0.02764	79940	2210	78835	1020658	12.77
74	0.96919	0.03081	77730	2395	76532	941823	12.12
75	0.96581	0.03419	75335	2575	74047	865291	11.49
76	0.96220	0.03780	72759	2750	71384	791243	10.87
77	0.95832	0.04168	70009	2918	68550	719859	10.28
78	0.95410	0.04590	67091	3080	65551	651309	9.71
79	0.94947	0.05053	64012	3235	62394	585757	9.15
80	0.94433	0.05567	60777	3384	59085	523363	8.61
81	0.93855	0.06145	57393	3527	55630	464278	8.09
82	0.93198	0.06802	53866	3664	52034	408648	7.59
83	0.92462	0.07538	50202	3784	48310	356614	7.10
84	0.91659	0.08341	46418	3872	44482	308304	6.64
85	0.90781	0.09219	42546	3922	40585	263822	6.20
86	0.89820	0.10180	38624	3932	36658	223237	5.78
87	0.88767	0.11233	34692	3897	32743	186579	5.38
88	0.87611	0.12389	30795	3815	28887	153836	5.00
89	0.86338	0.13662	26980	3686	25137	124949	4.63
90	0.84935	0.15065	23294	3509	21539	99812	4.28
91	0.83384	0.16616	19785	3287	18141	78273	3.96
92	0.81665	0.18335	16497	3025	14985	60132	3.64
93	0.79752	0.20248	13472	2728	12108	45147	3.35
94	0.77647	0.22353	10745	2402	9544	33039	3.07
95	0.75354	0.24646	8343	2056	7315	23495	2.82
96	0.72857	0.27143	6287	1706	5433	16180	2.57
97	0.70132	0.29868	4580	1368	3896	10747	2.35
98	0.67155	0.32845	3212	1055	2685	6851	2.13
99	0.63899	0.36101	2157	779	1768	4166	1.93
100	0.60329	0.39671	1378	547	1105	2398	1.74
101	0.56408	0.43592	832	363	650	1293	1.56
102	0.52090	0.47910	469	225	357	643	1.37
103	0.47290	0.52710	244	129	180	286	1.17
104	0.42008	0.57992	116	67	82	106	0.92
105	0.00000	1.00000	49	49	24	24	0.50

Table 3.16: *Period life table 2006–2009 for Sector 4*

Age	p_x	q_x	l_x	d_x	L_x	T_x	e_x
20	0.99992	0.00008	100000	8	99996	6153741	61.54
21	0.99992	0.00008	99992	8	99988	6053745	60.54
22	0.99991	0.00009	99984	9	99979	5953757	59.55
23	0.99990	0.00010	99975	10	99969	5853777	58.55
24	0.99988	0.00012	99964	12	99958	5753808	57.56
25	0.99987	0.00013	99953	13	99946	5653850	56.57
26	0.99986	0.00014	99940	14	99933	5553903	55.57
27	0.99984	0.00016	99926	16	99918	5453970	54.58
28	0.99983	0.00017	99910	17	99901	5354052	53.59
29	0.99981	0.00019	99893	19	99883	5254151	52.60
30	0.99978	0.00022	99873	21	99863	5154268	51.61
31	0.99976	0.00024	99852	24	99840	5054405	50.62
32	0.99973	0.00027	99828	26	99815	4954566	49.63
33	0.99971	0.00029	99801	29	99787	4854751	48.64
34	0.99967	0.00033	99772	33	99756	4754964	47.66
35	0.99964	0.00036	99740	36	99721	4655208	46.67
36	0.99960	0.00040	99703	40	99683	4555487	45.69
37	0.99955	0.00045	99663	44	99641	4455803	44.71
38	0.99951	0.00049	99619	49	99594	4356162	43.73
39	0.99945	0.00055	99570	55	99542	4256568	42.75
40	0.99939	0.00061	99515	61	99485	4157025	41.77
41	0.99932	0.00068	99454	68	99420	4057540	40.80
42	0.99924	0.00076	99387	75	99349	3958120	39.83
43	0.99916	0.00084	99311	84	99269	3858771	38.86
44	0.99906	0.00094	99227	93	99181	3759502	37.89
45	0.99896	0.00104	99134	103	99083	3660321	36.92
46	0.99884	0.00116	99031	115	98974	3561238	35.96
47	0.99871	0.00129	98916	128	98852	3462265	35.00
48	0.99856	0.00144	98788	143	98717	3363413	34.05
49	0.99839	0.00161	98645	159	98566	3264696	33.10
50	0.99819	0.00181	98486	178	98397	3166130	32.15
51	0.99798	0.00202	98308	199	98209	3067733	31.21
52	0.99773	0.00227	98110	223	97998	2969524	30.27
53	0.99745	0.00255	97887	250	97762	2871526	29.34
54	0.99713	0.00287	97637	280	97497	2773764	28.41
55	0.99677	0.00323	97357	314	97200	2676267	27.49
56	0.99637	0.00363	97042	352	96866	2579068	26.58
57	0.99592	0.00408	96690	395	96493	2482201	25.67
58	0.99541	0.00459	96295	442	96074	2385709	24.77
59	0.99484	0.00516	95853	495	95606	2289634	23.89
60	0.99420	0.00580	95358	553	95082	2194028	23.01
61	0.99349	0.00651	94806	617	94497	2098946	22.14
62	0.99270	0.00730	94189	688	93845	2004449	21.28
63	0.99181	0.00819	93501	765	93118	1910605	20.43

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Table 3.16 – *Continued from previous page*

Age	p_x	q_x	l_x	d_x	L_x	T_x	e_x
64	0.99082	0.00918	92735	851	92310	1817487	19.60
65	0.98971	0.01029	91884	945	91412	1725177	18.78
66	0.98846	0.01154	90939	1049	90414	1633765	17.97
67	0.98706	0.01294	89890	1163	89308	1543351	17.17
68	0.98547	0.01453	88726	1289	88082	1454043	16.39
69	0.98367	0.01633	87437	1428	86723	1365961	15.62
70	0.98163	0.01837	86009	1580	85220	1279238	14.87
71	0.97937	0.02063	84430	1742	83559	1194018	14.14
72	0.97689	0.02311	82688	1911	81732	1110459	13.43
73	0.97418	0.02582	80777	2085	79734	1028727	12.74
74	0.97122	0.02878	78691	2265	77559	948993	12.06
75	0.96795	0.03205	76426	2449	75202	871434	11.40
76	0.96434	0.03566	73977	2638	72658	796233	10.76
77	0.96034	0.03966	71339	2829	69924	723575	10.14
78	0.95586	0.04414	68510	3024	66998	653650	9.54
79	0.95083	0.04917	65486	3220	63876	586652	8.96
80	0.94513	0.05487	62266	3416	60558	522776	8.40
81	0.93874	0.06126	58850	3605	57047	462219	7.85
82	0.93164	0.06836	55244	3776	53356	405172	7.33
83	0.92377	0.07623	51468	3924	49506	351815	6.84
84	0.91502	0.08498	47544	4040	45524	302309	6.36
85	0.90529	0.09471	43504	4120	41444	256785	5.90
86	0.89447	0.10553	39384	4156	37306	215341	5.47
87	0.88242	0.11758	35228	4142	33157	178035	5.05
88	0.86899	0.13101	31086	4073	29049	144878	4.66
89	0.85399	0.14601	27013	3944	25041	115829	4.29
90	0.83722	0.16278	23069	3755	21191	90788	3.94
91	0.81855	0.18145	19314	3505	17561	69597	3.60
92	0.79785	0.20215	15809	3196	14211	52035	3.29
93	0.77491	0.22509	12613	2839	11194	37824	3.00
94	0.74948	0.25052	9774	2449	8550	26630	2.72
95	0.72127	0.27873	7326	2042	6305	18080	2.47
96	0.68998	0.31002	5284	1638	4465	11776	2.23
97	0.65526	0.34474	3646	1257	3017	7311	2.01
98	0.61670	0.38330	2389	916	1931	4294	1.80
99	0.57387	0.42613	1473	628	1159	2363	1.60
100	0.52607	0.47393	845	401	645	1203	1.42
101	0.47290	0.52710	445	234	328	558	1.26
102	0.41377	0.58623	210	123	149	231	1.10
103	0.34801	0.65199	87	57	59	82	0.94
104	0.27486	0.72514	30	22	19	23	0.77
105	0.00000	1.00000	8	8	4	4	0.50

Table 3.17: *Period life table 2006–2009 for Sector 5*

Age	p_x	q_x	l_x	d_x	L_x	T_x	e_x
20	0.99989	0.00011	100000	11	99994	6246023	62.46
21	0.99988	0.00012	99989	12	99983	6146029	61.47
22	0.99987	0.00013	99977	13	99970	6046046	60.47
23	0.99985	0.00015	99963	15	99956	5946076	59.48
24	0.99984	0.00016	99948	16	99940	5846121	58.49
25	0.99982	0.00018	99932	18	99923	5746181	57.50
26	0.99980	0.00020	99914	20	99904	5646257	56.51
27	0.99978	0.00022	99894	22	99884	5546353	55.52
28	0.99976	0.00024	99873	24	99861	5446469	54.53
29	0.99974	0.00026	99849	26	99836	5346608	53.55
30	0.99971	0.00029	99823	29	99809	5246772	52.56
31	0.99968	0.00032	99795	31	99779	5146963	51.58
32	0.99965	0.00035	99763	35	99746	5047184	50.59
33	0.99962	0.00038	99729	38	99710	4947438	49.61
34	0.99958	0.00042	99691	42	99670	4847729	48.63
35	0.99954	0.00046	99649	46	99626	4748059	47.65
36	0.99950	0.00050	99604	50	99579	4648432	46.67
37	0.99945	0.00055	99553	55	99526	4548854	45.69
38	0.99939	0.00061	99498	60	99468	4449328	44.72
39	0.99933	0.00067	99438	66	99405	4349859	43.74
40	0.99926	0.00074	99372	73	99335	4250455	42.77
41	0.99919	0.00081	99299	80	99258	4151119	41.80
42	0.99911	0.00089	99218	88	99174	4051861	40.84
43	0.99902	0.00098	99130	97	99081	3952687	39.87
44	0.99892	0.00108	99033	107	98979	3853606	38.91
45	0.99881	0.00119	98926	117	98867	3754626	37.95
46	0.99869	0.00131	98809	129	98744	3655759	37.00
47	0.99856	0.00144	98679	142	98608	3557015	36.05
48	0.99841	0.00159	98537	156	98459	3458407	35.10
49	0.99825	0.00175	98381	172	98295	3359947	34.15
50	0.99806	0.00194	98209	190	98114	3261653	33.21
51	0.99785	0.00215	98018	210	97913	3163539	32.27
52	0.99762	0.00238	97808	233	97692	3065626	31.34
53	0.99735	0.00265	97575	258	97446	2967934	30.42
54	0.99705	0.00295	97317	287	97173	2870488	29.50
55	0.99671	0.00329	97030	319	96870	2773315	28.58
56	0.99634	0.00366	96711	354	96534	2676445	27.67
57	0.99592	0.00408	96357	393	96160	2579912	26.77
58	0.99545	0.00455	95963	437	95745	2483752	25.88
59	0.99493	0.00507	95526	484	95284	2388007	25.00
60	0.99436	0.00564	95042	536	94774	2292723	24.12
61	0.99372	0.00628	94505	593	94209	2197950	23.26
62	0.99302	0.00698	93912	656	93584	2103741	22.40
63	0.99224	0.00776	93257	724	92895	2010157	21.56

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Table 3.17 – *Continued from previous page*

Age	p_x	q_x	l_x	d_x	L_x	T_x	e_x
64	0.99136	0.00864	92533	799	92133	1917262	20.72
65	0.99039	0.00961	91734	881	91293	1825129	19.90
66	0.98930	0.01070	90852	972	90366	1733836	19.08
67	0.98808	0.01192	89880	1071	89344	1643470	18.29
68	0.98671	0.01329	88809	1181	88218	1554125	17.50
69	0.98516	0.01484	87628	1301	86978	1465907	16.73
70	0.98341	0.01659	86328	1432	85611	1378929	15.97
71	0.98147	0.01853	84895	1573	84109	1293318	15.23
72	0.97938	0.02062	83322	1718	82463	1209209	14.51
73	0.97710	0.02290	81604	1869	80670	1126746	13.81
74	0.97462	0.02538	79735	2023	78724	1046076	13.12
75	0.97191	0.02809	77712	2183	76620	967352	12.45
76	0.96893	0.03107	75529	2347	74356	890732	11.79
77	0.96563	0.03437	73182	2515	71925	816376	11.16
78	0.96196	0.03804	70667	2688	69323	744452	10.53
79	0.95784	0.04216	67979	2866	66546	675129	9.93
80	0.95319	0.04681	65113	3048	63589	608583	9.35
81	0.94796	0.05204	62065	3230	60450	544994	8.78
82	0.94216	0.05784	58835	3403	57134	484544	8.24
83	0.93571	0.06429	55432	3564	53650	427410	7.71
84	0.92854	0.07146	51868	3706	50015	373760	7.21
85	0.92058	0.07942	48162	3825	46249	323745	6.72
86	0.91174	0.08826	44337	3913	42380	277495	6.26
87	0.90192	0.09808	40424	3965	38442	235115	5.82
88	0.89102	0.10898	36459	3973	34473	196673	5.39
89	0.87892	0.12108	32486	3933	30519	162201	4.99
90	0.86549	0.13451	28553	3841	26632	131682	4.61
91	0.85061	0.14939	24712	3692	22866	105049	4.25
92	0.83415	0.16585	21020	3486	19277	82183	3.91
93	0.81596	0.18404	17534	3227	15921	62906	3.59
94	0.79582	0.20418	14307	2921	12846	46986	3.28
95	0.77355	0.22645	11386	2578	10097	34139	3.00
96	0.74891	0.25109	8808	2212	7702	24042	2.73
97	0.72162	0.27838	6596	1836	5678	16341	2.48
98	0.69141	0.30859	4760	1469	4025	10663	2.24
99	0.65793	0.34207	3291	1126	2728	6637	2.02
100	0.62081	0.37919	2165	821	1755	3909	1.81
101	0.57966	0.42034	1344	565	1062	2154	1.60
102	0.53406	0.46594	779	363	598	1093	1.40
103	0.48327	0.51673	416	215	309	495	1.19
104	0.42694	0.57306	201	115	143	186	0.93
105	0.00000	1.00000	86	86	43	43	0.50

3.4 Migrant workers

In this subsection we compute the life tables for migrant workers in Beijing. Since in the retirement dataset there is no residential status available to identify migrant workers, we use the information in the working-age dataset only, and interpolate mortality rates for ages 60 to 105. The period life table for migrant workers (with local Beijing workers as a comparison) is presented in Table 3.18.

Table 3.18: *Period life table 2006–2009 for migrant workers.*

Age	Local workers			Migrant workers		
	q_x	l_x	e_x	q_x	l_x	e_x
20	0.00015	100000	64.35	0.00007	100000	63.70
21	0.00016	99985	63.36	0.00008	99993	62.71
22	0.00017	99970	62.37	0.00008	99985	61.71
23	0.00018	99953	61.38	0.00009	99977	60.72
24	0.00019	99936	60.39	0.00010	99968	59.72
25	0.00020	99917	59.40	0.00011	99957	58.73
26	0.00021	99897	58.41	0.00012	99946	57.74
27	0.00023	99876	57.42	0.00014	99934	56.74
28	0.00024	99853	56.43	0.00015	99920	55.75
29	0.00026	99829	55.45	0.00017	99905	54.76
30	0.00028	99804	54.46	0.00018	99889	53.77
31	0.00030	99776	53.48	0.00020	99871	52.78
32	0.00032	99747	52.49	0.00022	99850	51.79
33	0.00034	99715	51.51	0.00024	99828	50.80
34	0.00036	99681	50.53	0.00027	99804	49.81
35	0.00040	99645	49.54	0.00030	99777	48.83
36	0.00044	99606	48.56	0.00034	99747	47.84
37	0.00048	99562	47.58	0.00038	99713	46.86
38	0.00053	99515	46.61	0.00043	99675	45.87
39	0.00058	99462	45.63	0.00049	99632	44.89
40	0.00064	99405	44.66	0.00055	99583	43.92
41	0.00070	99341	43.69	0.00062	99528	42.94
42	0.00077	99271	42.72	0.00070	99466	41.97
43	0.00085	99194	41.75	0.00078	99397	41.00
44	0.00093	99110	40.78	0.00087	99319	40.03
45	0.00102	99018	39.82	0.00097	99233	39.06
46	0.00110	98917	38.86	0.00108	99136	38.10
47	0.00119	98808	37.90	0.00118	99030	37.14
48	0.00127	98691	36.95	0.00129	98913	36.18
49	0.00136	98566	35.99	0.00140	98785	35.23
50	0.00146	98431	35.04	0.00153	98647	34.28
51	0.00158	98287	34.09	0.00167	98496	33.33
52	0.00169	98132	33.15	0.00182	98331	32.38
53	0.00182	97966	32.20	0.00198	98152	31.44
54	0.00196	97788	31.26	0.00216	97957	30.50
55	0.00210	97596	30.32	0.00235	97745	29.57

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Table 3.18 – *Continued from previous page*

Age	Local workers			Migrant workers		
	q_x	l_x	e_x	q_x	l_x	e_x
56	0.00226	97391	29.38	0.00256	97515	28.64
57	0.00242	97171	28.45	0.00278	97266	27.71
58	0.00260	96936	27.52	0.00301	96995	26.79
59	0.00278	96684	26.59	0.00327	96703	25.87
60	0.00299	96415	25.66	0.00355	96387	24.95
61	0.00340	96127	24.74	0.00402	96045	24.04
62	0.00387	95800	23.82	0.00456	95659	23.13
63	0.00440	95430	22.91	0.00517	95223	22.23
64	0.00501	95010	22.01	0.00586	94731	21.35
65	0.00570	94534	21.12	0.00664	94176	20.47
66	0.00648	93996	20.23	0.00753	93551	19.60
67	0.00738	93386	19.36	0.00853	92847	18.75
68	0.00839	92697	18.50	0.00967	92054	17.91
69	0.00955	91919	17.66	0.01096	91164	17.08
70	0.01087	91041	16.82	0.01243	90165	16.26
71	0.01237	90051	16.00	0.01409	89044	15.46
72	0.01408	88938	15.19	0.01597	87790	14.67
73	0.01602	87686	14.40	0.01810	86388	13.90
74	0.01822	86281	13.63	0.02052	84824	13.15
75	0.02074	84709	12.87	0.02326	83083	12.41
76	0.02360	82952	12.14	0.02637	81151	11.70
77	0.02685	80995	11.42	0.02989	79011	11.00
78	0.03056	78820	10.72	0.03388	76650	10.32
79	0.03477	76411	10.04	0.03841	74053	9.67
80	0.03956	73755	9.38	0.04354	71209	9.03
81	0.04502	70836	8.75	0.04935	68108	8.42
82	0.05123	67647	8.14	0.05594	64747	7.83
83	0.05830	64182	7.55	0.06341	61125	7.27
84	0.06633	60440	6.99	0.07188	57249	6.73
85	0.07548	56431	6.45	0.08149	53134	6.21
86	0.08589	52171	5.93	0.09237	48804	5.72
87	0.09774	47690	5.45	0.10471	44296	5.25
88	0.11122	43029	4.98	0.11869	39658	4.80
89	0.12655	38244	4.54	0.13454	34951	4.38
90	0.14401	33404	4.13	0.15251	30249	3.98
91	0.16387	28593	3.74	0.17288	25635	3.61
92	0.18647	23908	3.37	0.19598	21203	3.26
93	0.21218	19450	3.03	0.22215	17048	2.93
94	0.24144	15323	2.71	0.25182	13261	2.63
95	0.27474	11623	2.42	0.28546	9921	2.35
96	0.31263	8430	2.14	0.32358	7089	2.08
97	0.35575	5794	1.89	0.36680	4795	1.84
98	0.40481	3733	1.66	0.41579	3036	1.62
99	0.46063	2222	1.44	0.47133	1774	1.41

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Table 3.18 – *Continued from previous page*

Age	Local workers			Migrant workers		
	q_x	l_x	e_x	q_x	l_x	e_x
100	0.52416	1198	1.25	0.53428	938	1.22
101	0.59644	570	1.07	0.60564	437	1.05
102	0.67870	230	0.90	0.68653	172	0.89
103	0.77230	74	0.76	0.77823	54	0.75
104	0.87880	17	0.62	0.88217	12	0.62
105	1.00000	2	0.50	1.00000	1	0.50

Table 3.18 shows that, overall, migrant workers in Beijing have a slightly lower life expectancy compared to local Beijing workers. However, we also observe that at younger ages (early 20s to late 40s), the mortality rates of migrant workers are actually lower than those of local workers. After age 50, the mortality rates of migrant workers start to exceed those of local workers.

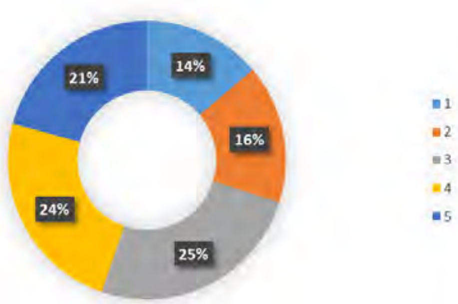
To further investigate on this finding, we look into the decomposition of the occupation for both local workers and migrant workers. We first present the decomposition of occupations for local and migrant works for the age range 20–50, according to occupation Grouping 2. The results are illustrated in Table 3.19 and Figure 3.1. For migrant workers, we note a large number of exposure in occupation Sector 3 and 4. Sector 1 has the lowest number of exposure among the five occupation sectors. On the other hand, the exposure seems to be more evenly distributed among sectors for local workers. Figure 3.1 shows that Sector 1 and 2 together account for 30% of the total exposure for local workers, while the figure is 27% for migrant workers. Compared to local workers, migrant workers have a larger percentage exposure in Sector 3 and 4, but a smaller one in Sector 5. Therefore, we conclude that the decomposition of occupations may have contributed to the differences in mortality rates between local workers and migrant workers for ages 20–50, and may have led to slightly better mortality experience for migrant workers. However, there maybe other factors that contribute to this heterogeneity, such as level of education, which are not observable in our dataset.

Table 3.19: *Decomposition of occupations for local and migrant works (ages 20–50)*

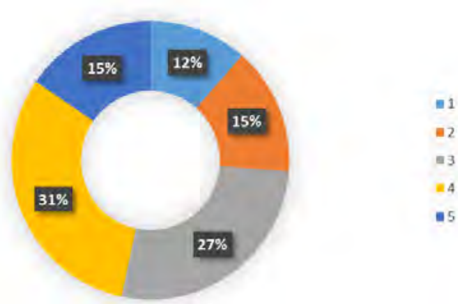
Sector	Total exposure	
	Local workers	Migrant workers
1	1125325	437968
2	1319359	566234
3	2075700	1034717
4	1957270	1192886
5	1698263	589296

Figure 3.1: *Percentages of occupation decomposition for local and migrant workers (ages 20–50)*

(a) *Local workers*



(b) *Migrant workers*



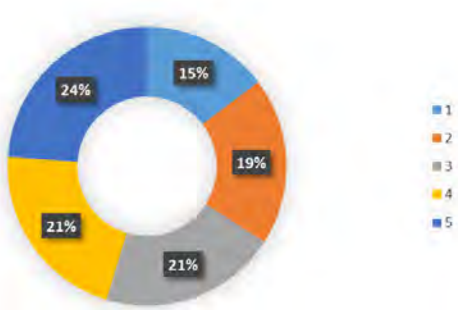
We also present the results for ages over 50 in Table 3.20 and Figure 3.2. Table 3.20 shows that the total exposures for migrant workers are substantially smaller than local workers, for all occupation sectors. Figure 3.2 illustrates that migrant workers have a larger percentage exposure in Sector 1 and 4, but smaller percentage exposure in Sector 2, 3 and 5. In particular, for Sector 5, the percentage of exposure is only 13% for migrant workers, while the figure is 11% higher (24%) for local workers. Again, we conclude that the occupation decomposition contributes to the heterogeneity in mortality between local and migrant workers in older age groups, but it might not be the only factor.

Table 3.20: *Decomposition of occupations for local and migrant works (over 50-year-old)*

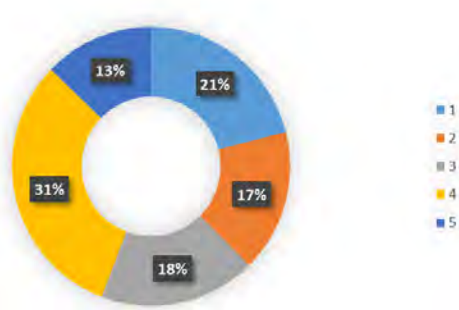
Sector	Total exposure	
	Local workers	Migrant workers
1	271592	45010
2	358826	35211
3	381665	38997
4	394858	67126
5	442493	27328

Figure 3.2: *Percentages of occupation decomposition for local and migrant workers (over 50-year-old)*

(a) *Local workers*



(b) *Migrant workers*

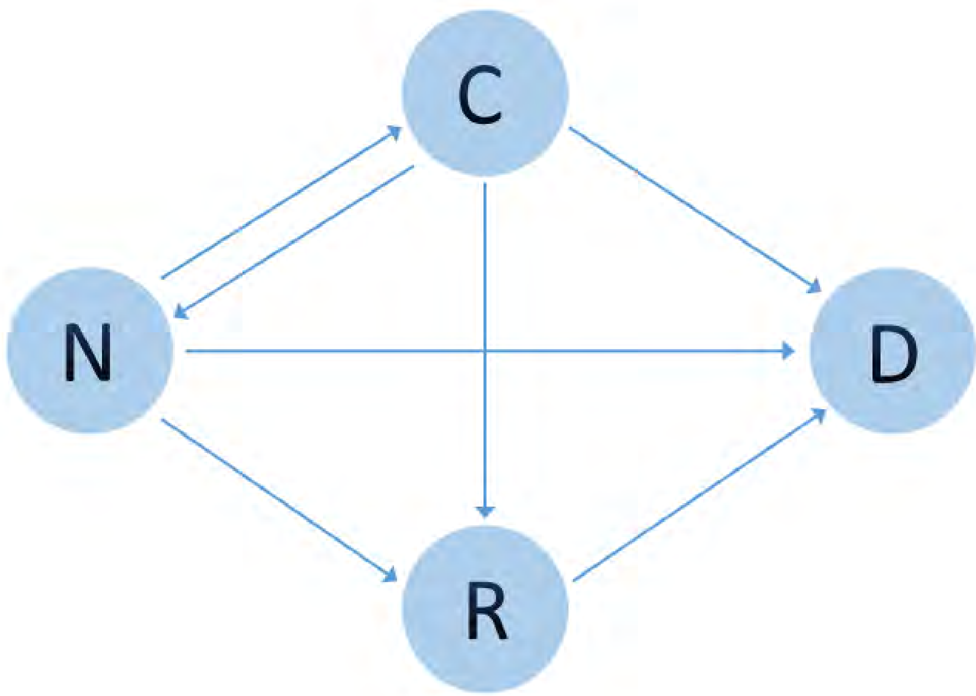


Section 4

GLM framework

In this section, we calculate the crude transition intensities between different states for the occupation groups considered in this project. Generalized linear models will then be developed based on these transition intensities. We first introduce a four-state Markov process illustrated in Figure 4.1 below.

Figure 4.1: *Four-state transition model*



The process has three transient states, "C" (working-age and contributing into the pension scheme), "N" (working-age, but not contributing into the pension scheme) and "R" (retired), and one absorbing state, "D" (dead). It allows for seven different transitions:

- $\sigma_{C,N}$: C $\rightarrow$ N, the transition intensity from contributing to non-contributing.
- $\sigma_{C,R}$: C $\rightarrow$ R, the retirement intensity from the contributing state.
- $\sigma_{C,D}$: C $\rightarrow$ D, the mortality intensity for a contributing person.
- $\sigma_{N,C}$: N $\rightarrow$ C, the transition intensity from non-contributing to contributing.
- $\sigma_{N,R}$: N $\rightarrow$ R, the retirement intensity from the non-contributing state.
- $\sigma_{N,D}$: N $\rightarrow$ D, the mortality intensity for a non-contributing person.
- $\sigma_{R,D}$: R $\rightarrow$ D, the mortality intensity for a retiree.

We assume that these transitions follow a Markov process, and we define the following probabilities and transition intensities:

$$P_{i,j}(x,t,h) = \text{Pr}(S(x+h,t+h) = j | S(x,t) = i), \tag{4.0.1}$$
$$\sigma_{i,j}(x,t) = \lim_{h \to 0^+} P_{i,j}(x,t,h)/h, \tag{4.0.2}$$

where x represents age in years, t represents time with $h \geq 0$. $S(x)$ represents the stochastic status of an individual who is aged x at time t, and $i,j \in \{N,C,R,D\}$. $P_{i,j}(x,t,h)$ denotes the transition probability from state i to j, from time t to $t+h$ for a person aged x. $\sigma_{i,j}(x,t)$ denotes the corresponding transition intensity at time t. As the primary aim of the project is to produce period occupation-specific life tables, we assume that all transition intensities remain constant over the sample period 2006–2009.

4.1 Model specification

Following works by Renshaw and Haberman (1995), Fong *et al.* (2015b) and Hanewald *et al.* (2018), we develop a GLM framework to model the transition intensities presented in Table 4.1. We extend these previous studies by considering a larger number of transition states and by tailoring the model design to different occupations. The GLM framework employed consists three components, namely the link function, the linear predictor and the probability distribution.

4.1.1 Link function

A log-link function $g(\cdot)$ is adopted and defined as:

$$g(\sigma_{i,j}(x)) = \text{ln}(\sigma_{i,j}(x)) = \eta_{i,j}(x), \tag{4.1.1}$$

where $\sigma_{i,j}(x)$ is the transition intensity from state i to state j, for age x at time t. $\eta_(x)$ is a linear predictor of regressors.

4.1.2 Linear predictor

We model each transition intensity as a function of age, so the linear predictor is given by:

$$\eta(x) = \beta_0 + \beta_1 x + \beta_2 x^2, \tag{4.1.2}$$

where β_k's are unknown coefficients that need to be estimated. The model structure is flexible in the sense that some of these coefficients might be set to zero in the model selection process. We include age factors up to the quadratic effect which is line with earlier studies by Dowd *et al.* (2010), Fong *et al.* (2015b) and Hanewald *et al.* (2018).

4.1.3 Probability distribution

The Poisson assumption on the number of health and mortality transitions is commonly used in actuarial research (see, for example Brouhns *et al.*, 2002; Cairns *et al.*, 2006). In this project, we assume that the number of transitions follows a Poisson distribution with a mean equal to the product of the exposure and the corresponding transition intensity. Let $n_{i,j}(x)$ be the number of transitions from state i to j at age x, we have:

$$n_{i,j}(x) \sim \text{Poisson}(e^i(x) \times \sigma_{i,j}(x)) \ \ \forall\ x, \tag{4.1.3}$$

where $e^i(x)$ is the exposure to risk in state i for age x.

4.2 Estimation and model selection

Separate GLMs are estimated for each transition intensity using the maximum likelihood estimation (MLE). Define Φ as the parameter set. The log-likelihood function is given by:

$$l(\Phi; n, e) = \sum_x \left\{ n_{i,j}(x)\text{ln}[e^i(x)\sigma_{i,j}(x)(\Phi)] - e^i(x)n_{i,j}(x)(\Phi) - \text{ln}(n_{i,j}(x)!)\right\}. \tag{4.2.1}$$

We adopt the Akaike information criterion (AIC) to select the optimal models for each transition intensity and each occupation. AIC is a widely used model selection criterion in statistics and has several desirable asymptotically properties (Akaike, 1974). We will compare and choose from the following three models:

$$\eta(x) = \beta_0, \tag{4.2.2}$$
$$\eta(x) = \beta_0 + \beta_1 x, \tag{4.2.3}$$
$$\eta(x) = \beta_0 + \beta_1 x + \beta_2 x^2. \tag{4.2.4}$$

4.3 Occupation-combined age-specific transition rates

We present the crude occupation-combined age-specific transition rates in Table 4.1. For transitions from states "C" and "N", we only report the transition intensities for ages below 60, as the sample size becomes very small beyond age 60 due to retirement. For transitions from state "R", we start reporting the transition intensities beyond age 50. This is because the earliest official retirement age is 50-year-old for most female urban employees. Table 4.1 shows that all mortality intensities increase with age regardless of the initial state of transition (whether it is from "C", "N" or "R"). We also observe that the mortality intensities from state "N" are higher than those from "C" for the age groups below 40; while for age groups above 40, the mortality intensities from "N" are lower than those from "C". For retirement transitions, individuals who transit from the non-contributing state ("N") always have a higher rate than those who transit from the contributing state ("C"), except for ages 51–55. Between states "C" and "N", most transitions happen in younger working age groups between ages 21–30. We do not observe a strong trend in transition intensities from "C" to "N", although there seems to be a slight increase over ages. For transition intensities from "N" to "C", we observe a slight decreasing trend over ages.

Table 4.1: *Crude age-specific transition intensities*

Age group	Transition intensities						
	C→ N	C→ D	C→ R	N→ C	N→ R	N→ D	R→ D
21–25	0.14553	0.00006	0.00000	0.13381	0.00001	0.00020	N/A
26–30	0.17825	0.00011	0.00000	0.09138	0.00002	0.00018	N/A
31–35	0.16637	0.00020	0.00006	0.06555	0.00010	0.00030	N/A
36–40	0.16950	0.00048	0.00032	0.04805	0.00046	0.00052	N/A
41–45	0.20033	0.00105	0.02311	0.04740	0.02518	0.00088	N/A
46–50	0.23109	0.00205	0.05261	0.04608	0.06574	0.00149	N/A
51–55	0.20427	0.00288	0.10787	0.04924	0.08206	0.00243	0.00271
56–60	0.16043	0.00450	0.14136	0.03727	0.15541	0.00351	0.00459
61–65	N/A	N/A	N/A	N/A	N/A	N/A	0.00862
66–70	N/A	N/A	N/A	N/A	N/A	N/A	0.01748
71–75	N/A	N/A	N/A	N/A	N/A	N/A	0.03469
76–80	N/A	N/A	N/A	N/A	N/A	N/A	0.05804
81–85	N/A	N/A	N/A	N/A	N/A	N/A	0.10294
86–90	N/A	N/A	N/A	N/A	N/A	N/A	0.16595
91–95	N/A	N/A	N/A	N/A	N/A	N/A	0.24828
96–100	N/A	N/A	N/A	N/A	N/A	N/A	0.30683
101–105	N/A	N/A	N/A	N/A	N/A	N/A	0.12428

Based on the GLM framework described in Section 4.1 and 4.2, we estimate the parameters for the selected model by MLE. The results are shown in Table 4.2 below. Except for transition intensities from "N" to "D", all selected models include both linear and quadratic age effects in the GLM predictor. Note that all coefficients are significant at the 1% level.

Table 4.2: *GLM parameter estimates of selected models*

Coefficient	C→N	C→D	C→R	N→C	N→R	N→D	R→D
β_0	-2.3964	-15.4520	-40.1519	0.9246	-33.9253	-11.2445	-16.4100
β_1	0.0278	0.2725	1.3552	-0.1675	1.1252	0.0979	0.2384
β_2	-0.0002	-0.0017	-0.0121	0.0017	-0.0099		-0.0008
AIC	3234.3	71.2	1923.2	2854.9	24438.0	137.5	486.0
Age range	20–60	20–60	20–60	20–60	20–60	20–60	50–105

4.4 Age-occupation-specific transition rates

In this section we present the crude transition rates for each of the five occupation sectors in Table 4.3, 4.5, 4.7, 4.9 and 4.11. The corresponding GLM parameter estimates are reported in Table 4.4, 4.6, 4.8, 4.10 and 4.12 respectively. Note that all estimated coefficients are significant at the 1% level.

Table 4.3: *Crude age-specific transition intensities for Sector 1*

Age group	Transition intensities						
	C→ N	C→ D	C→ R	N→ C	N→ R	N→ D	R→ D
21–25	0.13513	0.00020	0.00000	0.07920	0.00000	0.00022	N/A
26–30	0.13028	0.00026	0.00000	0.05300	0.00001	0.00023	N/A
31–35	0.10926	0.00038	0.00000	0.04197	0.00007	0.00048	N/A
36–40	0.10804	0.00059	0.00008	0.03106	0.00026	0.00071	N/A
41–45	0.11636	0.00098	0.00131	0.01841	0.01172	0.00116	N/A
46–50	0.12630	0.00120	0.00917	0.01148	0.04509	0.00167	N/A
51–55	0.09751	0.00274	0.02167	0.00806	0.07491	0.00270	0.00308
56–60	0.05213	0.00332	0.05555	0.01084	0.13775	0.00427	0.00506
61–65	N/A	N/A	N/A	N/A	N/A	N/A	0.01048
66–70	N/A	N/A	N/A	N/A	N/A	N/A	0.02127
71–75	N/A	N/A	N/A	N/A	N/A	N/A	0.04294
76–80	N/A	N/A	N/A	N/A	N/A	N/A	0.06880
81–85	N/A	N/A	N/A	N/A	N/A	N/A	0.11203
86–90	N/A	N/A	N/A	N/A	N/A	N/A	0.18349
91–95	N/A	N/A	N/A	N/A	N/A	N/A	0.30760
96–100	N/A	N/A	N/A	N/A	N/A	N/A	0.26340
101–105	N/A	N/A	N/A	N/A	N/A	N/A	0.20930

Table 4.4: *GLM parameter estimates of selected models for Sector 1*

Coefficient	C→N	C→D	C→ R	N→C	N→R	N→ D	R→ D
β_0	-1.8361	-10.7492	-42.1538	-1.3219	-36.6200	-10.6440	-17.5784
β_1	-0.0086	0.0880	1.2608	-0.0454	1.1790	0.0892	0.2770
β_2			-0.0101	-0.0004	-0.0101		-0.0011
AIC	298.3	41.5	47.7	514.6	1445.6	63.9	197.7
Age range	20–60	20–60	20–60	20–60	20–60	20–60	50–105

Table 4.5: *Crude age-specific transition intensities for Sector 2*

Age group	Transition intensities						
	C→ N	C→ D	C→ R	N→ C	N→ R	N→ D	R→ D
21–25	0.06610	0.00003	0.00000	0.14291	0.00002	0.00020	N/A
26–30	0.08575	0.00009	0.00000	0.08166	0.00003	0.00024	N/A
31–35	0.07935	0.00016	0.00005	0.05597	0.00016	0.00033	N/A
36–40	0.07878	0.00043	0.00009	0.03395	0.00059	0.00065	N/A
41–45	0.09297	0.00074	0.00442	0.01633	0.04478	0.00097	N/A
46–50	0.10373	0.00169	0.01015	0.01115	0.06014	0.00162	N/A
51–55	0.09630	0.00264	0.02805	0.00755	0.10165	0.00259	0.00297
56–60	0.06183	0.00435	0.07273	0.01109	0.18466	0.00348	0.00500
61–65	N/A	N/A	N/A	N/A	N/A	N/A	0.00940
66–70	N/A	N/A	N/A	N/A	N/A	N/A	0.01818
71–75	N/A	N/A	N/A	N/A	N/A	N/A	0.03478
76–80	N/A	N/A	N/A	N/A	N/A	N/A	0.06001
81–85	N/A	N/A	N/A	N/A	N/A	N/A	0.10645
86–90	N/A	N/A	N/A	N/A	N/A	N/A	0.16799
91–95	N/A	N/A	N/A	N/A	N/A	N/A	0.24740
96–100	N/A	N/A	N/A	N/A	N/A	N/A	0.35880
101–105	N/A	N/A	N/A	N/A	N/A	N/A	0.04068

Table 4.6: *GLM parameter estimates of selected models for Sector 2*

Coefficient	C→N	C→D	C→R	N→C	N→R	N→D	R→D
β_0	-3.3877	-12.9927	-31.8702	0.6425	-25.7067	-10.8423	-15.7614
β_1	0.0419	0.1341	0.8941	-0.1194	0.8118	0.0914	0.2231
β_2	-0.0004		-0.0068	0.0003	-0.0069		-0.0007
AIC	310.0	41.5	95.4	759.5	8139.9	67.5	223.1
Age range	20–60	20–60	20–60	20–60	20–60	20–60	50–105

Table 4.7: *Crude age-specific transition intensities for Sector 3*

Age group	Transition intensities						
	C→ N	C→ D	C→ R	N→ C	N→ R	N→ D	R→ D
21–25	0.15142	0.00004	0.00000	0.13650	0.00000	0.00022	N/A
26–30	0.16800	0.00008	0.00000	0.09326	0.00001	0.00015	N/A
31–35	0.15636	0.00015	0.00004	0.06479	0.00008	0.00024	N/A
36–40	0.16101	0.00024	0.00011	0.03991	0.00033	0.00041	N/A
41–45	0.17887	0.00062	0.00262	0.02124	0.01514	0.00078	N/A
46–50	0.20588	0.00129	0.01249	0.01392	0.06562	0.00125	N/A
51–55	0.19186	0.00207	0.02831	0.01107	0.05941	0.00217	0.00251
56–60	0.09828	0.00377	0.06402	0.01413	0.13317	0.00303	0.00449
61–65	N/A	N/A	N/A	N/A	N/A	N/A	0.00819
66–70	N/A	N/A	N/A	N/A	N/A	N/A	0.01620
71–75	N/A	N/A	N/A	N/A	N/A	N/A	0.03352
76–80	N/A	N/A	N/A	N/A	N/A	N/A	0.05579
81–85	N/A	N/A	N/A	N/A	N/A	N/A	0.10159
86–90	N/A	N/A	N/A	N/A	N/A	N/A	0.16971
91–95	N/A	N/A	N/A	N/A	N/A	N/A	0.23838
96–100	N/A	N/A	N/A	N/A	N/A	N/A	0.28091
101–105	N/A	N/A	N/A	N/A	N/A	N/A	0.15238

Table 4.8: *GLM parameter estimates of selected models for Sector 3*

Coefficient	C→N	C→D	C→R	N→C	N→R	N→D	R→D
β_0	-2.0690	-13.2230	-39.2757	-0.1882	-39.8085	-10.6700	-16.6100
β_1	0.0106	0.1336	1.1846	-0.0726	1.3521	0.0629	0.2414
β_2	-0.0001		-0.0096	-0.0002	-0.0122	0.0004	-0.0008
AIC	637.3	43.2	71.2	1163.3	7336.0	98.6	225.6
Age range	20–60	20–60	20–60	20–60	20–60	20–60	50–105

Table 4.9: *Crude age-specific transition intensities for Sector 4*

Age group	Transition intensities						
	C→ N	C→ D	C→ R	N→ C	N→ R	N→ D	R→ D
21–25	0.18885	0.00006	0.00000	0.13658	0.00000	0.00016	N/A
26–30	0.22637	0.00010	0.00000	0.09811	0.00001	0.00013	N/A
31–35	0.21676	0.00021	0.00003	0.07072	0.00009	0.00024	N/A
36–40	0.22833	0.00038	0.00043	0.04800	0.00044	0.00045	N/A
41–45	0.26677	0.00089	0.02884	0.04175	0.02252	0.00077	N/A
46–50	0.28421	0.00227	0.08822	0.03948	0.07328	0.00149	N/A
51–55	0.27048	0.00251	0.15930	0.03634	0.07866	0.00228	0.00237
56–60	0.18617	0.00484	0.22854	0.02945	0.16063	0.00361	0.00411
61–65	N/A	N/A	N/A	N/A	N/A	N/A	0.00745
66–70	N/A	N/A	N/A	N/A	N/A	N/A	0.01514
71–75	N/A	N/A	N/A	N/A	N/A	N/A	0.02976
76–80	N/A	N/A	N/A	N/A	N/A	N/A	0.04884
81–85	N/A	N/A	N/A	N/A	N/A	N/A	0.09069
86–90	N/A	N/A	N/A	N/A	N/A	N/A	0.14571
91–95	N/A	N/A	N/A	N/A	N/A	N/A	0.23100
96–100	N/A	N/A	N/A	N/A	N/A	N/A	0.35036
101–105	N/A	N/A	N/A	N/A	N/A	N/A	0.00000

Table 4.10: *GLM parameter estimates of selected models for Sector 4*

Coefficient	C→N	C→D	C→R	N→C	N→R	N→D	R→D
β_0	-2.2314	-15.1435	-43.6069	0.6502	-37.1195	-11.7189	-15.2900
β_1	0.0330	0.2492	1.5020	-0.1424	1.2522	0.1064	0.2028
β_2	-0.0003	-0.0014	-0.0134	0.0013	-0.0112		-0.0006
AIC	799.3	56.6	552.0	553.3	7134.8	82.5	132.3
Age range	20–60	20–60	20–60	20–60	20–60	20–60	50–105

Table 4.11: *Crude age-specific transition intensities for Sector 5*

Age group	Transition intensities						
	C→ N	C→ D	C→ R	N→ C	N→ R	N→ D	R→ D
21–25	0.17044	0.00008	0.00000	0.14409	0.00000	0.00023	N/A
26–30	0.20253	0.00018	0.00000	0.10569	0.00002	0.00020	N/A
31–35	0.18893	0.00023	0.00018	0.08296	0.00014	0.00033	N/A
36–40	0.18829	0.00076	0.00066	0.08315	0.00072	0.00048	N/A
41–45	0.21999	0.00147	0.04180	0.13002	0.03469	0.00081	N/A
46–50	0.25153	0.00240	0.06270	0.14222	0.08062	0.00151	N/A
51–55	0.20840	0.00325	0.12592	0.17271	0.09665	0.00248	0.00260
56–60	0.19542	0.00479	0.15059	0.11973	0.16453	0.00329	0.00388
61–65	N/A	N/A	N/A	N/A	N/A	N/A	0.00574
66–70	N/A	N/A	N/A	N/A	N/A	N/A	0.01331
71–75	N/A	N/A	N/A	N/A	N/A	N/A	0.02689
76–80	N/A	N/A	N/A	N/A	N/A	N/A	0.04334
81–85	N/A	N/A	N/A	N/A	N/A	N/A	0.08570
86–90	N/A	N/A	N/A	N/A	N/A	N/A	0.11593
91–95	N/A	N/A	N/A	N/A	N/A	N/A	0.17212
96–100	N/A	N/A	N/A	N/A	N/A	N/A	0.11858
101–105	N/A	N/A	N/A	N/A	N/A	N/A	0.18462

Table 4.12: *GLM parameter estimates of selected models for Sector 5*

Coefficient	C→N	C→D	C→ R	N→C	N→R	N→D	R→D
β_0	-2.2888	-15.7510	-32.5429	-0.8769	-34.6580	-11.1807	-14.4000
β_1	0.0306	0.3130	1.0899	-0.0828	1.1811	0.0964	0.1791
β_2	-0.0003	-0.0023	-0.0097	0.0012	-0.0107		-0.0004
AIC	1056.3	58.5	1571.3	7925.2	5643.4	77.8	207.2
Age range	20–60	20–60	20–60	20–60	20–60	20–60	50–105

Section 5

Conclusion

In this report we construct the most up-to-date occupation-specific life tables for China based on the data from the Beijing Urban Public Pension Scheme for the period 2005–2009. Based on the status recorded in the database, we also develop a four-state Markov process and compute the transition intensities between states, and then model these transition intensities in a GLM framework. In this section, we will first discuss the major findings from the project, and then address the limitations of the research.

5.1 Summary of major findings

The following provides a summary of the major findings from the project:

- The gender-combined period life table 2006–2009 indicates a total life expectancy of 80.92 years for a Beijing urban employee aged 20-year-old. This shows a substantial improvement in longevity in China since the early 1990s. The gender-specific life tables for the same time period shows an average life span of 79.33 years for males and 83.09 years for females. Our results are very comparable and consistent with the China Life Insurance Mortality Table (2010–2013), in which life expectancy at age 20 is estimated to be 76.43–82.94 years for males and 81.55–87.83 years for females.
- The working-age database mainly contains urban employees aged 20–60 years old. There are in total 20 occupations recorded in the system. Our research finds that the overall death rate in the working-age urban population is quite low across all occupations. However, we still observe some occupations having higher death rates than others, for example "agriculture, forestry, animal husbandry and fishery", "Water, environmental and public facilities management" and "Mining". On the other hand, "Information transmission, computer services and software development", "Education", and "Scientific research, technical services and geological exploration" have the lowest death rates among all occupations in the working-age database.
- The retirement database mainly contains urban retirees aged above 50-year-old and also follows the same occupation classification as in the working-age database. However, there is a noticeable difference in the occupation structure between the working-age database and the retirement database: There are a larger proportion of observations in physical occupations such as "Manufacturing" and a smaller proportion of observations in highly intellectual

occupations such as “Education”. This result reflects the industrial structure changes and revolutions in China over the last decades.

- Due to the small number of observations for some occupation groups, we perform two grouping methods to form broader occupation sectors based on the 20 occupation groups. We conclude the second method (Occupation grouping 2) is better and produces more interpretable results. Based on the five-sector grouping described in Section 3.3, we construct occupation-specific life tables and compare the heterogeneity in life expectancy across the five sectors. Sector 1 has the lowest life expectancy which reflects the mortality experience of production related occupations including farming, mining and construction. Sector 5 has the highest life expectancy which reflects the mortality experience of intellectual occupations such as information technology, scientific research and education. Across the five occupations, the difference between the highest and lowest life expectancy is 2.63 years at age 20, 2.55 years at age 50 and 1.28 years at age 80.

- We investigate the differences in the mortality experience between inter-province migrant workers and local workers based on the information in the working-age database. We observe an overall lower life expectancy for migrant workers compared to local workers in Beijing. Moreover, we find that for younger age groups (20–50), migrant workers have similar or even slightly lower mortality rates than local workers. However, after age 50, the mortality rates of migrant workers start to increase at a faster rate than those of local workers. We argue that the decomposition of occupations within the younger and older age groups have contributed to these results, but acknowledge that there might be other contributing factors.

- We develop a four-state Markov process and calculate the crude transition rates between states “Contributing” (“C”), “Non-contributing” (“N”), “Retired” (“R”) and “Dead” (“D”). A GLM framework is then employed to model and estimate the transitions rates, for both occupation-combined transition rates and occupation-specific transition rates based on the five-sector grouping. For the occupation-combined case, all transition rates are found to be increasing with age expect for transitions from “N” to “C”. The occupation-specific rates show similar trends, with one exception: for Sector 1, the transition rates from “C” to “N” decrease with age. In the selected GLM, most transition rates include age effects up to the quadratic effect, with a few exceptions in the cases of transitions from “N” to “D”. Our investigation age range is 20–60 for transitions from state “C” or “N”, and 50–105 for transitions from state “R”.

5.2 Limitations

For readers of this report, in particular those who would like to apply the results produced by this research project, it is important to understand the following limitations:

- The occupation-combined life tables constructed and reported in this project are based on the mortality experience of Beijing urban population who are enrolled in the Urban Public Pension Scheme during the period 2005–2009. Therefore, the tables may not accurately represent the longevity level for China on the national level or in other specific scenarios. As the regional heterogeneity in life expectancy is quite substantial across China, it is more sensible to apply the underlying results to reflect the longevity level in more developed areas in China.

- Similarly, the occupation-specific life tables are constructed based on the occupation structure in Beijing urban population. Therefore, the calculations are subject to different sample sizes for each occupation included in this study. For example, agriculture related occupations are less represented in the sample compared to business related occupations. Therefore, we acknowledge that the figures in the reported occupation-specific life tables are not always appropriate to be applied directly and adjustment may be needed.

- Even though the overall data quality is relatively high for both the working-age database and the retirement database, there are some minor issues which could potentially affect the accuracy of our results. In the working-age database, we suspect that when a person stops contributing to the pension scheme, sometimes the information on their life status may not be reported or updated on time in the system. However, we are unable to quantify the amount or proportion of these cases. We acknowledge that this may have led to an underestimation of mortality rates at some ages. In the retirement database, only individuals who are eligible for pension payments are included in the database. As a result, we do not have information on those individuals who are not eligible for pension payments such as some inter-province migrant works. Therefore, the estimated mortality rates based on the retirement data are subject to this limitation.

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