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Towards the development of a three-state Markov Chain model of working life expectancy in South Africa

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ABSTRACT
Courts are able to exercise broad discretion when they assess the quantum of damages due to loss of earning capacity and have considerable discretion in making an award. South African courts have adopted the approach that an actuarial computation is a valuable basis for establishing the quantum of damages. Actuarial calculations, by their nature, account for certain contingency factors such as inflation, income tax, mortality and the retirement age. It is commonplace to deduct a general contingency where the actuarial calculation makes no explicit allowance. General contingencies cover many considerations that vary from case to case. The only real difference between mortality and other contingencies is that more evidence is available in statistical form to show mortality rates. Despite various data limitations that do not currently allow for a full implementation of the model, this paper seeks to develop a three state Markov Chain model of working life expectancy in South Africa by gender and broad education level. Working life expectancy is inextricably linked to general contingency deductions and the results of this paper challenge some common law conventions and the level of general contingency deductions that have been adopted by South African courts.

KEYWORDS
Working life expectancy, Markov Chain model, actuarial evidence, common law, general contingency deductions, labour force statistics

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1. INTRODUCTION

1.1 Background

1.1.1 The basic principle underlying an award of damages for bodily or fatal injury is that compensation must be assessed so as to place the plaintiff, as far as possible, in the same position had the unlawful act or delict not been committed (Corbett et al., 1995). Damages recoverable in delict are either classified as special damages or general damages (Visser & Potgieter, 2004).

1.1.2 Special damages include all monetary loss actually incurred up to the date of trial such as past medical expenses and past loss of income. General damages include non-monetary loss such as pain and suffering, loss of amenities of life and disfigurement. General damages also include monetary loss which, up to the date of trial, have not yet materialised, such as future medical expenses and future loss of income (Corbett et al., 1995).

1.1.3 Du Plessis (2012) notes that South African courts readily consult and rely on actuarial opinion when determining monetary compensation, and concludes that such reliance is rational. Where the actuarial approach is adopted in future loss of income claims, a four-stage procedure can be derived from Koch (1984):

1.1.3.1 STEP (I): Ascertain the likely career path of the plaintiff had the accident or incident that caused the loss not occurred. In so doing, assessments are conducted to ascertain the plaintiff's academic qualifications, vocational qualifications, career history, historic job roles, available job roles and the chances of promotion, historic earnings and the remuneration package including fringe benefits at the date of the accident, working life expectancy and likely retirement age.

1.1.3.2 STEP (II): The actuary is provided with the raw data set out in Step (i) and then proceeds to calculate the present value of future income had the accident or incident not occurred. The actuary is required to make assumptions concerning the after-tax rate of interest that would be earned on the investment of the award, future rates of consumer price inflation, an allowance for general productivity increases, an allowance for mortality by selecting an appropriate mortality table and an assumption concerning future tax rates.

1.1.3.3 STEP (III): Step (i) and Step (ii) above are repeated for the situation now that the accident or incident has occurred.

1.1.3.4 STEP (IV): On completion of the above steps, a final adjustment is made for general contingency deductions (other than life contingencies). Such adjustment is made in respect of both income streams. Once a deduction for general contingencies is made, the plaintiff's net loss of income can be determined by subtracting the value of income now that the incident has occurred from the value of income had the accident not occurred. This is referred to as the differencing rule (Du Plessis, 2012).

1.1.4 The above four-stage procedure is followed whenever compensation by way of a lump sum is to be calculated. It has been, and still is, possible, however, for the parties to a claim in terms of the Road Accident Fund Act to agree to compensation for loss of income by way of instalments.[1]

1 Section 17(4)(b) of the *Road Accident Fund Act* 56 of 1996

1.1.5 This paper concerns itself with an element of Step (i) of the above procedure which is the determination of working life expectancy. Working life expectancy (WLE) can be defined as the expected number of years an individual will be in paid employment, or the expected number of years an individual will be economically active. With respect to the latter definition, WLE calculations consider time spent in employment and unemployment. This paper concerns itself with the former definition. To date no expert evidence has been presented in South African courts concerning WLE. The WLE is in turn inextricably linked to Step (iv) of the above procedure which is the determination of the level of general contingency deductions that may be applied in a claim for future loss of income. To date the courts have applied various approaches in determining contingency deductions as discussed in Section 2.

1.2 Importance of this research

1.2.1 There has been no contribution from the actuarial community concerning an empirical basis for determining WLE and in turn general contingency deductions in South Africa. In the landmark case of *Southern Insurance Association* v *Bailey*,[2] the court favoured an actuarial computation in the determination of damages on the basis that it represented an attempt to ascertain the loss of income on a logical basis. Despite common law conventions, aspects of general contingency deductions lend themselves to actuarial computation. A review of this principle means developing the common law as envisaged by the Constitution. Aside from applications in the assessment of damages setting, WLE tables are essential for the analysis of work force progression, retirement trends and educational planning (Hoem, 1977). WLE tables can also be used to measure the success of labour market policy.

1.2.2 The common law convention of referring to prior case law in deciding general contingency deductions, coupled with the court's general impressions of a case, must be tested against available empirical evidence.

1.3 Aims

1.3.1 The aim of this paper is to develop tables of WLE by gender and broad levels of education using available panel data. In turn, these estimates can be used to test the level of general contingency deductions applied by the courts.

1.3.2 Whilst fulfilling this aim, the paper also seeks to fulfil the following aims:

- Describe the principles underlying general contingency deductions in the legal context.
- Investigate the methodology involved in constructing WLE tables.
- Construct a WLE table for South Africa from available panel data.
- Determine the general contingency deductions that can be derived from the WLE tables.

1.4 Plan of development

1.4.1 The paper unfolds as follows: Section 2 provides an overview of relevant case law and Section 3 provides a literature review. Section 4 provides an overview of the data and Section 5 describes the methodology used to construct the WLE tables. Section 6

2 *Southern Insurance Association Ltd* v *Bailey* 1984 1 SA 98 (A)

discusses the results of the analysis and Section 7 discusses the limitations of the model. The paper concludes in Section 8.

2. RELEVANT CASE LAW

A court is not a casino.[3]

2.1 Boberg (1964) notes that the term "general contingencies" traditionally denotes all the uncertainties, hazards and vicissitudes of life, and its introduction into the assessment of damages is based on the fact that the courts are required to speculate on the future as it would have been but for the accident and now having regard to the accident. In *Hulley* v *Cox*,[4] the court noted that:

> It is at any rate desirable to test the result of an actuarial calculation by a consideration of the general equities of the case.

2.2 Many cases involving actuarial evidence require determining the actuarial value of income from employment. As noted in *Road Accident Fund* v *GSO Guedes*,[5] the court exercises a broad discretion when it assesses the quantum of damages due to loss of earning capacity and has a considerable discretion to award what it considers appropriate. South African courts have adopted the approach that in order to assist in such a calculation, an actuarial computation is a valuable basis for establishing the quantum of damages.

2.3 The authoritative case with respect to actuarial calculations is *Southern Insurance Association Ltd* v *Bailey*[6] in which it was held that:

> All that the Court can do is to make an estimate, which is often a very rough estimate, of the present value of the loss. It has open to it two possible approaches. One is for the Judge to make a round estimate of an amount which seems to him to be fair and reasonable. That is entirely a matter of guesswork, a blind plunge into the unknown. The other is to try to make an assessment, by way of mathematical calculations, on the basis of assumptions resting on the evidence. The validity of this approach depends of course upon the soundness of the assumptions, and these may vary from the strongly probable to the speculative. It is manifest that either approach involves guesswork to a greater or lesser extent. But the Court cannot for this reason adopt a non possumus attitude and make no award… In a case where the Court has before it material on which an actuarial calculation can usefully be made, I do not think that the first approach offers any advantage over the second. On the contrary, while the result of an actuarial computation may be no more than an 'informed guess' it has the advantage of an attempt to ascertain the value of what was lost on a logical basis; whereas the trial Judge's 'gut feeling' (to use the words of appellant's counsel) as to what is fair and reasonable is nothing more than a blind guess.

3 Judge Willis in *NK obo ZK* v *Member of the Executive Council for Health of the Gauteng Provincial Government* (216/2017) [2018] ZASCA 13; 2018 (4) SA 454 (SCA)
4 *Hulley* v *Cox* [1923] AD
5 *Road Accident Fund* v *GSO Guedes* [2006] SCA 18
6 *Southern Insurance Association Ltd* v *Bailey* 1984 1 SA 98 (A)

2.4 In *Dlamini* v *Road Accident Fund*[7] it was noted that the court's historic wide discretion in assessing awards for past and future loss of earnings has been attenuated by the practice of obtaining actuarial input.

2.5 However, where a court assesses that there is uncertainty regarding a plaintiff's pre-accident employment history and the evidence on which to base calculations is not credible, actuarial calculations may be rejected in favour of a globular award, such as in *January* v *The Minister of Police.*[8]

2.6 In *Smit* v *Road Accident Fund*,[9] it was noted that actuarial calculations by their nature take into account certain contingency factors such as inflation, income tax, mortality and the retirement age. It is commonplace for a deduction to be made for general contingencies for which no explicit allowance has been made in the actuarial calculation.

2.7 As noted in *RAF* v *C K*,[10] general contingencies cover many considerations that vary from case to case. These include the possibility of errors in the estimation of future life expectancy and retirement age; the likelihood of illness and unemployment which would have occurred in any event; savings in relation to work travel; other contingencies which would have affected earning capacity in any event; loss of pension benefits from frequent changing of employment; economic adversity; and other unforeseen events.

2.8 Despite actuaries being well versed in statistics concerning, for example, morbidity risks, a rigorous application of these types of statistics to compensation cases has met resistance. For example, in *Shield Insurance Co Ltd* v *Hall,*[11] the court expressed the view that the actuary giving evidence in the matter was in no position and not qualified to give evidence as to the hazards and contingencies applicable to any particular type of work.

2.9 Further, in *Oosthuizen* v *Road Accident Fund*:[12]

> But the Court emphasised that provision for contingencies falls squarely within the subjective discretion of the court as to what is reasonable and fair. This will depend upon the underlying assumptions made which are not the domain of the actuary.

2.10 As correctly noted in *RAF* v *Sweatman*,[13] the only real difference between mortality and other contingencies is that more evidence is available in statistical form to show mortality rates.

7 *Dlamini* v *The Road Accident Fund* (21375/2019) [2022] ZAGPJHC 657
8 *January* v *Minister of Police* [2022] ZANCHC 51
9 *Smit* v *Road Accident Fund* (1820/10) [2013] ZAECGHC 57
10 *RAF* v *C K* (1024/2017) [2018] ZASCA 151
11 *Shield Insurance Co Ltd* v *Hall* 1976 (4) SA 431 (A)
12 *Oosthuizen* v *Road Accident Fund* (2014/04972) [2015] ZAGPJHC 172
13 *RAF* v *Sweatman* (162/2014) [2015] ZASCA 22

2.11 In *Goodall* v *President Insurance*,[14] it was held that:

> When assessing damages for future loss of earnings, in an action for damages for personal injuries sustained, in the assessment of a proper allowance for contingencies arbitrary considerations must inevitably play a part, for the art or science of foretelling the future, so confidently practised by ancient prophets and soothsayers, and by modern authors of a certain type of almanack, is not numbered among the qualifications for judicial office.

2.12 Despite no empirical evidence, in some matters such as *Oosthuizen* v *Road Accident Fund*,[15] *Pierre* v *Road Accident Fund*,[16] and *Coetzee* v *Road Accident Fund*,[17] the courts have adopted the so-called sliding scale approach. Under that approach the contingency deduction is determined on the basis of ½% for each year from the calculation date to the age of retirement. For example, a 35-year-old that would have retired at age 65 would attract a general contingency deduction of 15% (30 years until retirement multiplied by ½% a year). In *Dlamini* v *Road Accident Fund*,[18] the court stated that:

> The authorities indicate that a sliding scale approach of 0.5% per annum for every year over the period that income must be determined should be applied, to achieve the best estimate of the plaintiff's damages.

2.13 Koch (1984) notes that recognition has been given to the principle that a short period of exposure to the risk of adversity justifies a lower deduction than a longer period, or the so-called widening funnel of doubt principle as set out in *Haigh* v *Road Accident Fund*.[19]

2.14 In *NK obo ZK* v *MEC for Health, Gauteng*[20] it was noted that whilst conjecture may be required in making a contingency deduction, it should not be done whimsically. In particular the approach of splitting a contingency deduction down the middle (in other words, simply taking the average between what respective parties contend should be the contingency deduction), without explanation, is devoid of any rational connection between the means by which the decision was made and the result of the decision-making process.

2.15 In *Mokone* v *Road Accident Fund*,[21] determination of contingency deductions involves:

> … the manner in which the plaintiff, given her particular circumstances, would fare as compared the established norm … These are applied by the court dealing with the case in order to adjust the loss to reflect as closely as possible the real circumstances of the plaintiff. This is a delicate exercise which is an important judicial function.

14 *Goodall* v *President Insurance* 1978 1 SA 389 (W)
15 Ibid 12
16 *Pierre* v *Road Accident Fund* (44981/2013) [2015] ZAGPJHC 159
17 *Coetzee* v *Road Accident Fund* (2871/2018) [2021] ZAFSHC 193
18 Ibid 7
19 *Haigh* v *Road Accident Fund* (25947/2016) [2019] ZAGPPHC 945
20 Ibid 3
21 *Mokone* v *Road Accident Fund* (22403/2015) [2022] ZAGPPHC 702

2.16 With the exception of *Nienaber* v *Road Accident Fund*[22] and *Njoko* v *Minister of Safety and Security and Another*,[23] the concept of WLE has rarely been mentioned by South African courts. The literature on WLE is well developed internationally as discussed in Section 3. Knowledge of WLE would provide the court with a further tool in establishing norms and assisting with the important judicial function of setting contingency deductions.

3. LITERATURE REVIEW

3.1 Conventional model

3.1.1 First proposed by Wolfbein (1949), the conventional WLE model is computed as the joint probability of age-specific rates of survival from population mortality tables and assumed stationary labour force participation rates by age. The joint probability of survival from time to time coupled with the labour force participation rate for each age is summed from each age x until the assumed terminal age so as to obtain the conventional WLE estimate. The classical working life table is static in nature because it is based on data from a single point in time, such as census data.

3.1.2 The conventional WLE model, as with all life table methodology, is based on the concept of a stationary population (Smith, 1982). Stationarity of the labour market means that there is only one transition into and out of the labour force (Verrall et al., 2005). The conventional WLE model is also characterised by the assumption of unimodality. That is, there is a single peak in the distribution of the mobility of the population which is a consequence of the stationarity assumption. Bloomfield & Haberman (1990) note that unimodality is observed in the graph of participation rates against the age of individuals in the labour force, where a single peak is evident around the ages of 16 to the early 20s which is when most individuals enter the labour market.

3.1.3 A number of limitations are inherent in the conventional WLE model. Given the assumption of stationarity, the model does not consider the numerous entries and exits from the labour force of an individual, which is not realistic. The conventional WLE model does not account for an individual's current labour force status which would control his/her labour force participation in the future (Skoog & Ciecka, 2001). Hence, an individual presently in the labour force and an individual of the same age and gender outside of the labour force, will be treated in the same manner.

3.1.4 Whilst unimodality may be considered normal for male participation rates, bimodality is seen to be more accurate for female participation rates, where bimodality refers to the distribution of mobility of females in and out of the workforce exhibiting two peaks (Krueger, 2004). Based on Smith (1982), females present bimodal patterns as their entries and exits out of the workforce may be a result of changes in their parental or marital status. Bloomfield & Haberman (1990) state that even if bimodality was incorporated into the classical approach, for example, by splitting the population by marital status, the comparison

22 *Nienaber* v *Road Accident Fund* (A5012/11) [2011] ZAGPJHC 150

23 *Njoko* v *Minister of Safety and Security and Another* (2011 (5) SA 512 (KZP)) [2011] ZAKZPHC 25; 1565/09

of results for the two genders would be made difficult due to the application of different techniques for each gender. However, these alterations to incorporate bimodality would still require the assumption of stationarity (Bloomfield & Haberman, 1990).

3.1.5 Information on workforce participation is collected at one point in time, such as from a census. It would be more appropriate to identify the dynamic nature of workforce participation and use labour force survey data that relates to the entries and exits from the workforce. Hence, the classical approach suffers a major structural flaw as the workforce participation rates on which it is based are static in nature. It would be better to use cohort-based data instead of the cross-sectional data which is utilised by this approach (Bloomfield & Haberman, 1990).

3.1.6 The conventional WLE model is artificial, in the sense that the WLE table provides a summary of workforce participation behaviour for all ages in the population over a specified period and does not track the individuals through their lifetimes. Hence, it provides a synthetic overview of the inherent decrements which may give deceptive ideas of the trends in the inherent workforce participation rates and become outdated over time (Bloomfield & Haberman, 1990).

3.2 Markov Chain model

3.2.1 The Markov Chain model is built on the foundation of the multi-state life table, also known as the increment-decrement approach (Krueger, 2004). The earliest published study of the multi-state life table is due to du Pasquier (1913), and the model allows for movement back and forth between at least two states, as well as movement into an absorbing state, commonly known as the death state (Krueger, 2004).

3.2.2 Built on the foundation of the multi-state life table, the earliest published WLE tables using that method are accredited to Hoem & Fong (1976). The WLE tables were derived from panel labour force surveys of the Danish male population from 1972–1974. A Markov Chain model was undertaken in this study, resulting in more credible and realistic results based on the data capture of labour force mobility. The WLE table modelled the transition probabilities for labour force participation based on active participation, inactive participation and exit to death, by age. Hoem & Fong (1976) defined an individual as 'active' if he/she is either employed or actively seeking employment, whereas an individual is defined to be 'inactive' if he/she is not employed and not actively seeking employment. The raw transition probabilities were smoothed using a moving average.

3.2.3 The Markov Chain framework models the labour force as a dynamic process (Smith, 1982). It considers the transition of individuals into and out of the workforce over an individual's working lifetime as well as his/her initial labour force status (Bloomfield & Haberman, 1990). It permits the calculation of the time spent in various activity states (Verrall et al., 2005). The Markov Chain model is an improvement on the classical approach, as it is based on data that considers the labour flows of the workforce and it is not from a single point in time (Hoem & Fong, 1976).

3.2.4 The first use of the Markov Chain model for constructing WLE tables in the United States was that by Schoen & Woodrow (1980). That study used Current

Population Survey (CPS) data from 1972 and 1973 for labour force activity and the 1972 US Life Tables for mortality data. The CPS dataset was ideal for the purpose of capturing the dynamics of the labour force, because it was designed as an aggregate rotating survey of the population, meaning that it overcame the difficulty of maintaining a high response rate, which arises from permanent sample surveys, and overcame the limitation of using a new sample each period, which can result in a higher variance in estimates of change (Krueger, 2004). Although the sizes of the samples were not recorded, it was noted that transition probabilities were smoothed using a 9th-order centred moving average for males and a 7th-order centred moving average for females. The study did not report the WLE for individuals whose initial state was inactive in the labour force (Krueger, 2004).

3.2.5 The Markov Chain model became the paradigm utilised when calculating WLE after its publication in the Bureau of Labour Statistics Bulletin by Smith (1982) and Smith (1986), which publicised the change from the conventional models (Skoog et al., 2011). The 1986 WLE tables by Smith are credited as the first time that WLE tables were extended to include WLE by race and education for each gender but not race and education simultaneously (Millimet et al., 2003). In both years, Smith used the 1970 and 1971 CPS labour force data, and the US life tables for mortality data (Smith, 1986). The method of smoothing the transitional probabilities was not reported in the 1982 research, however in the 1986 tables, it was reported that transition probabilities were smoothed using a 9th-order centred moving average (Krueger, 2004).

3.2.6 Further attempts to improve the WLE tables for the US population were undertaken by Ciecka et al. (1995), Skoog & Ciecka (2001) and Abele & Richards (1999), however, the differences in comparable results were found to be minimal (Krueger, 2004).

3.2.7 Millimet et al. (2003) attempted to improve the WLE tables published by Smith (1986) using the same methodology with the exception of adopting a logit model to estimate transitional probabilities instead of the more traditionally used relative frequency method (Krueger, 2004). This study was based on nine years of CPS data from 1992 to 2000, which meant that the results were not as sensitive to economic conditions as the results of Smith (1986) which were based on one year of data. Whilst previous WLE models were based on only the employed and unemployed state, this model was enhanced by categorising individuals into three states, namely the employed, unemployed and inactive. The transition between states was modelled as a function of age, race, sex, marital status, number of children, and occupation. Although Millimet et al. (2003) concluded that their WLE tables produced significantly more precise estimates, Krueger (2004) remarks that the differences in the results when compared to Smith (1986) were negligible.

3.2.8 In 2004, Krueger extended the Markov Chain model of constructing WLE tables to incorporate age-based economic characteristics such as earning capacity. These tables were based on the US population and used 1998 to 2004 CPS data and US life tables for labour force activity and mortality rates, respectively. These were the first WLE tables that presented labour force participation probability projections that could be connected to age-specific earning capacity forecasts.

3.2.9 As described above, extensive research on and publication of WLE tables have been carried out in the United States following the work done by Smith in 1982 and 1986. As noted in Watt et al. (2019), the Australian Actuary Department has only produced life expectancy tables in the past, and there is no published WLE table for the Australian population by the department. However, the Australian Bureau of Statistics (ABS) and the Household, Income and Labour Dynamics in Australia (HILDA) acts as an alternative source of data regarding calculations pertinent to WLE. Although it was not the purpose of the Watt et al. (2019) paper to construct WLE tables for the Australian population, they stated that the data could be sourced for the population and a Markov Chain model was viable.

3.2.10 In Asia, the Markov Chain model has been applied to Vietnamese data in research performed by Samaniego & Viegelahn (2021). The research was based on workforce participation data collected in the Vietnamese labour force surveys for 2011 to 2019. These surveys are also performed in a rotating panel manner, where individuals can be tracked across different quarters in a year, but not across years (ILO, 2021). This study was similarly based on the increment-decrement approach and considered transitions between three states, namely employed, unemployed and inactive; transitions between the formality of the job, the economic sector and the different occupation types were looked at as well (ILO, 2021).

3.2.11 In the United Kingdom (UK), the Government Actuary’s Department (2022) publishes actuarial tables for use in personal injury and fatal accident cases. Included in the so-called Ogden tables are tables of contingencies other than mortality. The reduction factors adjust the baseline multiplier in the Ogden tables to reflect the average pre-injury and post-injury contingencies according to the employment risks associated with the age, sex, employment status, disability status and educational attainment of the claimant when calculating awards for loss of earnings. The method of calculation, based as it is on three broadly defined characteristics, will not capture all the factors which might be expected to affect the claimant’s future earnings.

3.2.12 As noted by Hoem & Fong (1976), the Markov Chain model requires fewer assumptions. As noted in Verrall et al. (2005), this model makes use of one process for both genders and all ages, thus the consequential variation in group rates may be ascribed to actual variation in the behaviour of the workforce, instead of bias created by the model. Hence, the Markov Chain model does not suffer from the issues surrounding the use of a bimodal curve of workforce participation rates (Verrall et al., 2005).

3.2.13 The main limitation of the model is that it requires more data, as it uses longitudinal data which is meant to improve the quality of results. As a result, the Markov Chain model requires greater standards of data processing procedures (Bloomfield & Haberman, 1990). Additionally, the complex nature of the required datasets might lead to reliability issues within the datasets as there is a greater chance for misreporting of workforce status, especially regarding temporary and part-time employees, as described by Hoem (1977).

4. DATA SOURCES

4.1 General comments

4.1.1 The Markov Chain model of WLE requires three fundamental data inputs that in turn require derivation from a variety of sources. This is because the three fundamental inputs are not covered by one survey in South Africa.

4.1.2 The first input into the model is in respect of the labour force. In particular, for those alive at each age x, an estimate is required of the number of persons who are either active or inactive in the labour force. To this end the Quarterly Labour Force Survey (QLFS) covering the second quarter of 2022 was used. That survey contained a sample of 57,244 individuals. Sample weights are used to estimate the number of individuals in the active state at every age (${}^{a}N_x$) and the number of individuals in the inactive state at every age (${}^{i}N_x$), giving a total population size at each age of N_x. The numbers of individuals in the active and inactive states were determined across gender and broad educational level. Persons with no schooling, Grade R to Grade 11, an N1 or N2, and those who did not know their schooling level were coded as having less than a Grade 12. The balance of the population was coded as having a Grade 12 or higher level of education.

4.1.3 The second input required for the model is an estimate of transition rates between states. In particular, for those alive at age x and at age $x+1$ who are active in the labour force at age x, what proportion of those persons are still active in the labour force at age $x+1$? Similarly, for those alive at age x and age $x+1$ who are inactive in the labour force at age x, what proportion of those persons are still inactive in the labour force at age $x+1$? Discussion surrounding suitable data for estimating transition probabilities is set out in Section 4.2 and Section 4.3.

4.1.4 Lastly, an appropriate mortality table is required in order to estimate the proportion of persons who are still alive at age $x+1$ out of living persons at age x. A discussion regarding a suitable mortality table is set out in Section 4.4.

4.2 Labour market dynamics in South Africa

4.2.1 Statistics South Africa (StatsSA) produces an annual Labour Market Dynamics in South Africa publication (LMD) that contains an amalgamation of data from the QLFS for each quarter in the calendar year, but only covers the labour market activities of persons aged 15–64 years.

4.2.2 The QLFS makes it possible to track individuals from one quarter to the next and hence panel data can be constructed so as to analyse transition rates between various states in the labour market. In each edition of the LMD, panel data summaries are provided that measure quarterly rates of transition between various starting states, such as the transition of employed individuals to employed individuals. The results reported in the LDS panel are after the application of sample weights.

4.2.3 The quarterly rates of transition for Quarter 3 to Quarter 4 from employed to employed, and for not employed to employed, is shown in Figure 1. It can be observed that transition rates have remained fairly stable from 2012 to 2020 when examining flows from Quarter 3 to Quarter 4 of each year:

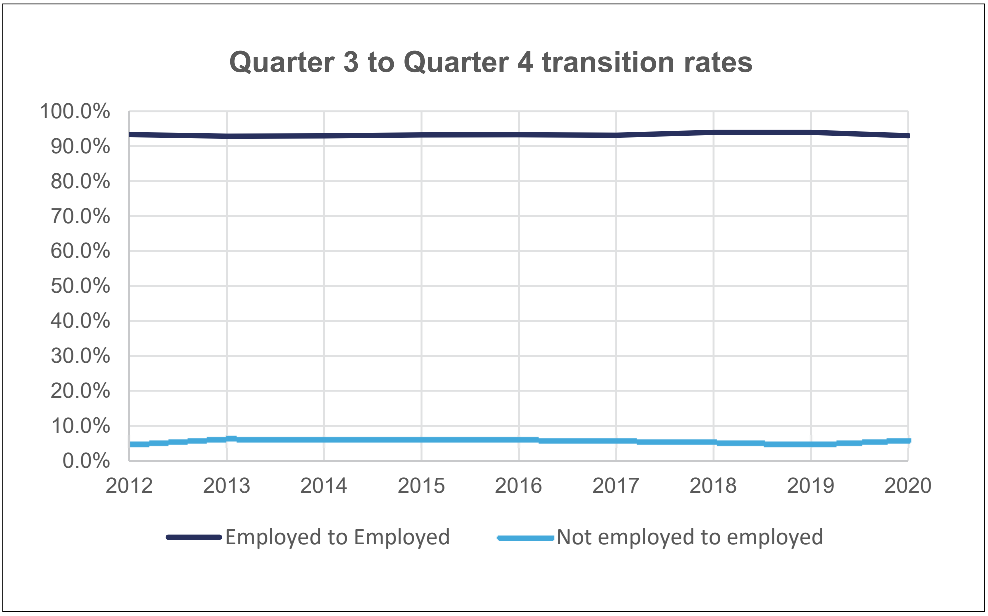

FIGURE 1. Quarterly transitions from 2012–2020

4.2.4 The only time that quarterly transition rates from employed to employed were less than 90% was for Quarter 1 of 2020 to Quarter 2 of 2020. This coincides with the COVID-19 pandemic and the government announcement of a national lockdown commencing on 27 March 2020. On 21 April 2020, a R500 billion stimulus package was announced in response to the pandemic, with the lockdown level reducing to Level 4 from 1 May 2020 and Level 3 from 1 June 2020.

4.2.5 StatsSA have only once released panel data which were for Quarter 3 of 2013 to Quarter 4 of 2013. That survey contained a sample of 35,744 individuals between the age of 15 and 64. The quality of the QLFS panel is tested by StatsSA and a report on quality diagnostics for the panel data is produced.

4.2.6 Data were recoded to reflect those who are active (employed) and those who are inactive (unemployed or not economically active). The same process as noted in 4.1.2 above was used to split the sample between those with less than a Grade 12 and those with a Grade 12 or higher level of education. Eight separate groups were determined based on a combination of gender, active or inactive status at the beginning of the quarter, and broad education level. The education level was assumed to remain constant over the quarter based on the education level at the beginning of the quarter. Raw rates of transition were determined by age for each group after applying sample weights.

4.2.7 The definition of those employed was not altered from the definition used by StatsSA. In particular, employed persons were considered to be those persons between the ages of 15 and 64 who, during the reference week, did any work for at least one hour, or had a job or business but were temporarily absent. Definitions of unemployment and not economically active were not considered, as an individual was simply classified as employed (active) or not employed (inactive).

4.2.8 The panel dataset reflected the whole age of each survey participant. Once raw quarterly transition rates were determined, these were projected for a whole year such that an estimate of transition rates for each age was obtained as follows:

$$P_{x:x+¼} = \begin{bmatrix} p_{11,\ x:x+¼} & p_{12,x:x+¼} \\ p_{21,x:x+¼} & p_{22,x:x+¼} \end{bmatrix} \quad (1)$$

$$P_{x:x+1} = P^4_{x:x+¼} \quad (2)$$

where:

$P_{x:x+¼}$ = the transition matrix from age x to age $x+¼$.

$p_{11,x+¼}$ = the probability that an individual aged x who was employed at age x, remains employed at age $x+¼$.

$p_{12,x+¼}$ = the probability that an individual aged x who was employed at age x, is not employed at age $x+¼$.

$p_{21,x+¼}$ = the probability that an individual aged x who was not employed at age x, becomes employed at age $x+¼$.

$p_{22,x+¼}$ = the probability that an individual aged x who was not employed at age x, remains not employed at age $x+¼$.

$P_{x:x+1}$ = the estimated transition matrix from age x to age $x+1$.

4.2.9 On request, StatsSA provided a further panel data file that has not been previously released, covering the period from Quarter 3 of 2019 to Quarter 4 of 2019 (just prior to the COVID-19 pandemic). That panel dataset contained data in respect of 28,137 individuals that were matched across both quarters and provided weights applicable for Quarter 4 of 2019. The coding of education was the same as for the 2013 panel data. Hence, the same recoding of data was undertaken as for the Quarter 3 to Quarter 4 of 2013 panel dataset. Raw transition rates were derived for each age for the same groupings by gender and broad level of education. The level of education at the beginning of Quarter 3 of 2019 was assumed to remain constant over the ensuing quarter.

4.2.10 Raw transition rates were smoothed using a 9th-order centred moving average. Favour is found in this approach in Smith (1986), Ciecka et. al. (1995) and Krueger (2004). Smoothing is necessary as sample size problems, such as samples being small at older ages, make for irregular transition curves. Moving averages are simple to apply and personal communication with Krueger confirms that these still provide satisfactory results. Other techniques such a non-parametric localised regression were not considered.

4.2.11 The smoothed transition rates from Quarter 3 of 2013 to Quarter 4 of 2013, and Quarter 3 of 2019 to Quarter 4 of 2019, were averaged and then applied to each age so as to determine the number of persons who were:

${}^{i}N_x^{i}$ = inactive at age x and inactive at age $x+1$

${}^{i}N_x^{a}$ = inactive at age x and active at age $x+1$

${}^{a}N_x^{i}$ = active at age x and inactive at age $x+1$

${}^{a}N_x^{a}$ = active at age x and active at age $x+1$

4.3 National Income Dynamics Study

4.3.1 The National Income Dynamics Study (NIDS) is a face-to-face longitudinal survey of individuals living in South Africa and their households. It is funded by the Department of Planning, Monitoring and Evaluation. The study commenced in 2008 with a nationally representative sample of approximately 28,000 individuals in approximately 7,300 households. The survey was repeated every two years between 2008 and 2017. Five waves of the survey were released over that period.

4.3.2 A set of files was released on request for each wave of NIDS and these files can be combined across waves using a unique identifier for the individual, using the variable name *pid*. For each wave, the *pid* and date of interview was extracted from the *Adult* file using Stata software. This was matched to the *indderived* file. The *indderived* file contained data in respect of gender, year and month of birth, educational level and employment status. The educational levels were broadly similar to those used in the QLFS and were recoded into those with less than a Grade 12 and those with a Grade 12 or higher level of education.

4.3.3 Care had to be taken to match employment status as in the first two waves only three categories were provided but in later waves four categories were provided in the data. Data were matched from wave 1 to wave 2, wave 2 to wave 3 and so on. An individual who was matched across all five waves was treated as a separate individual with their own characteristics and would contribute four separate data points to the survival analysis. The educational level at the beginning of each wave was assumed to apply until the date of the next survey interview.

4.3.4 A survival analysis was conducted on individuals matched across at least two waves using the Kaplan–Meier method. The Kaplan–Meier method is well known and a relatively simple way of calculating survival time. The survival probability across two waves is calculated as the number of individuals who were still employed at the second interview date, having been employed at the first interview date. However, given that the survey dates were approximately two years apart, it is not possible to directly estimate one-year transition rates. Consideration can be given to taking the square root of the two-year transition matrix derived from the survival analysis undertaken above. However, the square root of a non-scalar 2 times 2 matrix has four square roots if the square of the trace of the matrix does not equal 4 times the determinant of the matrix, and the determinant is non-zero. In addition, the survival rates derived from such an analysis would be unweighted and not representative of the general population. Estimation of one-year transition rates from the NIDS data was therefore considered to be inappropriate.

4.3.5 Cichello et. al. (2014) estimated that between wave 1 and wave 2, the probability of remaining in employment was 70% using post-stratification weights. Projecting the quarterly transition matrix averaged over Quarter 3 to Quarter 4 of 2013 and Quarter 3 to Quarter 4 of 2019 results in a two-year survival rate of approximately 66%. The results are not directly comparable as the estimate made by Cichello et. al. was for ages 20 to 55, whereas our estimate is based on ages 15 to 64.

4.3.6 A further issue that arose is that it was not possible to derive the exact date of exit from employment or the exact date of entry into employment for many individuals, with the result that exposures will be overstated.

4.3.7 Log rank tests applied to the various groupings of gender and educational level confirmed that there were statistically significant differences in survival rates for the groupings adopted (where the failure variable was taken as being not employed at the date of second interview having been employed at the date of first interview).

4.4 Mortality table

4.4.1 Various estimates are available concerning life expectancy at birth in South Africa as shown in Table 1.

TABLE 1. Life expectancy at birth in 2019

Report	Males	Females
World Health Organization	62.2	68.3
Dorrington et al. (2021)[1]	62.4	68.2
Statistics South Africa (2019)	62.0	67.8
Johnson et. al. (2017)[2]	62.2	66.1

[1] Rapid Mortality Surveillance Report
[2] Thembisa model

4.4.2 By way of comparison, the South African Life Tables (SALT) 1984/1986 for the white population group provides an estimate of life expectancy of birth of 68.4 years for males and 75.8 years for females. SALT 1984/1986 for the coloured population group provide an estimate of life expectancy of birth of 57.9 years for males and 65.5 years for females.

4.4.3 Some practitioners rely on mortality tables set out in Koch (2022) that are computed according to broad income levels. For high-income earners, Life Table 2 is adopted which is essentially the same as the SALT 1984/1986 for the white population group. For low-income earners and sometimes for citizens of other African countries claiming from the Road Accident Fund such as in *Langa* v *Road Accident Fund*,[24] Life Table 5 is adopted which is essentially the same as the SALT 1984/1986 for the coloured population group.

4.4.4 If Life Table 2 is applied to those with Grade 12 and higher; and Life Table 5 is applied to those with less than a Grade 12; the mortality rates weighted by population size result in an estimate of life expectancy of 45.9 additional years for males at age 20, and 52.7 additional years for females at age 20. This compares favourably with the World Health Organization (WHO) (2022) estimate of 45.5 additional years for males at age 20 and 51.5 additional years for females at age 20. At age 40, the WHO estimates of future life expectancy are slightly higher than the blended approach noted above. Substituting the WHO rates for all levels of education does not have a material impact on the results. Calculations proceeded using the tables set out in Koch (2022) as these tables are familiar to practitioners and have been cited in various judgments such as Life Table 2 in *Singh and Another* v *Ebrahim*[25] and Life Table 5 in *Seme* v *Road Accident Fund*.[26] Research is however required to examine mortality rates by level of education in South Africa.

4.4.5 Kaplan et. al. (2014) note that education is one of the best predictors of life expectancy, however it is not known whether the relationship is causal. Montez & Berkman (2014) show a difference in life expectancy of between 10 and 12 years between those with less than a high school level of education and those with an advanced degree.

5. MODEL AND NOTATION

5.1 Possible transitions considered in the model are illustrated in Figure 2.

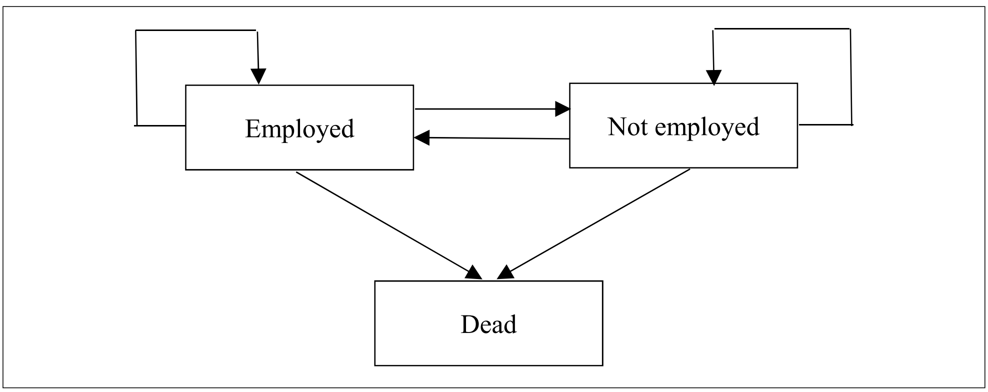

FIGURE 2. Transitions model

5.2 The model adopted is the one period Markov increment-decrement life table (MID_1) for three states as discussed by Krueger (2004). The MID_1 is an important model in the

24 *Langa* v *Road Accident Fund* (645/2017) [2022] ZAMPMBHC 6
25 *Singh and Another* v *Ebrahim* (413/09) [2010] ZASCA 145
26 *Seme* v *Road Accident Fund* (13917/04) [2008] ZAKZHC 79

forensic economic literature used to calculate WLE. The states within this model include the active and inactive states of labour force participation which are annotated by a and i respectively, and the absorbing death state with annotation d. The state of being inactive in this paper means not earning an income or not employed and the state of active means earning an income or employed.

5.3 In the MID_1 WLE model, the labour force status depends only on the current status. The transition probability from a state at age x to a state at age $x+1$ is dependent on the current state, not on historical states (Foster & Skoog, 2004). Hence, for a WLE table, the Markovian assumption implies that the probability that an individual in the given cohort will be active next year is solely dependent on whether the individual was either active or inactive in the current year (Foster & Skoog, 2004). Throughout a synthetic population lifespan, the MID_1 model controls the fluxes between active and inactive labour force participation. Before exiting to the absorbing stage of death, population members of the active and inactive labour force states are considered to migrate back and forth between participating and not-participating in the labour force based on age-specific transition probabilities. The number of people active and inactive in the labour force at each age after x can be used to generate labour force attachment probabilities by age, and the sum of those probabilities by age yields lifetime WLE in total years of labour force attachment. The algebra for computing the MID_1 model in discrete single-age-interval time is presented below.

5.4 We define the transition probability that an individual will be in state t at age $x+1$ exact given that he/she was in state s at age x exact to be ${}^{s}p_x^t$ where $s \in \{a,i\}$ and $t \in \{a,i,d\}$. According to Skoog et al. (2019) mortality is accounted for within the transition probability and transitions are assumed to occur half-way between ages. In addition, the states are mutually exhaustive such that:

$${}^{a}p_x^a + {}^{a}p_x^i + {}^{a}p_x^d = 1 \tag{3}$$

$${}^{i}p_x^i + {}^{i}p_x^a + {}^{i}p_x^d = 1 \tag{4}$$

5.5 As mortality data by state is unavailable, we assume that:

$${}^{a}p_x^d = {}^{i}p_x^d = {}^{\bullet}p_x^d \tag{5}$$

The values for ${}^{\bullet}p_x^d$ are obtained from the SALT 1984/1986 as discussed in Section 4.4 and the • denotes either the active or inactive state.

5.6 It should be noted that the age accounted for in population activity data is based on that recorded from the survey and are reported in single-digit values. Hence, the mean value of the age in the data is $x+\frac{1}{2}$. Thus, the survey data should be re-centred to exact ages when the computation of the transition probabilities is completed. This is done by averaging the surveyed population size data across the range $x \pm \frac{1}{2}$ by combining two ages from survey data.

Hence, we compute ${}^{i}p_x^{i}$ and ${}^{a}p_x^{a}$. using the following formulae:

$$ {}^{i}p_x^{i} = \left[\frac{{}^{i}N_{x-1}^{i} + {}^{i}N_x^{i}}{{}^{i}N_{x-1} + {}^{i}N_x} \right] * \left(1 - {}^{\bullet}p_x^{d}\right) \tag{6} $$

and

$$ {}^{a}p_x^{a} = \left[\frac{{}^{a}N_{x-1}^{a} + {}^{a}N_x^{a}}{{}^{a}N_{x-1} + {}^{a}N_x} \right] * \left(1 - {}^{\bullet}p_x^{d}\right). \tag{7} $$

5.7 The number of active and inactive labour force survivors at age x exact are calculated recursively using:

$$ Total\, l_x = l_{x-1}\left(1 - {}^{\bullet}p_x^{d}\right) \tag{8} $$

or $x = 19, \ldots, 70+$ and we set $Total\, l_{18}$ = the radix which is obtained from the relevant South African Life Table 1984/1986.

$Total\ l_x$ denotes the number of survivors (individuals alive) at age x and is also equal to:

$$ Total\, l_x = {}^{a}l_x + {}^{i}l_x \tag{9} $$

where ${}^{a}l_x$ are those active and ${}^{i}l_x$ are those who are inactive.

5.8 The values of ${}^{a}l_{19}$ and ${}^{i}l_{19}$ are computed by the product of the number of individuals alive at age 19 and proportion of individuals in the population who are active and inactive at age 19, respectively, as follows:

$$ {}^{a}l_{19} = Total\, l_{19} * \left(\frac{{}^{a}N_{19}}{N_{19}} \right) \tag{10} $$

$$ {}^{i}l_{19} = Total\, l_{19} * \left(\frac{{}^{i}N_{19}}{N_{19}} \right) \tag{11} $$

5.9 For $x > 19$,

$$ {}^{a}l_x = {}^{a}l_{x-1} + {}^{i}p_{x-1}^{a}\, {}^{i}l_{x-1} - {}^{a}p_{x-1}^{i}\, {}^{a}l_{x-1} - {}^{\bullet}p_{x-1}^{d}\, {}^{a}l_{x-1} \tag{12} $$

$$ {}^{i}l_x = {}^{i}l_{x-1} + {}^{a}p_{x-1}^{i}\, {}^{a}l_{x-1} - {}^{i}p_{x-1}^{a}\, {}^{i}l_{x-1} - {}^{\bullet}p_{x-1}^{d}\, {}^{i}l_{x-1} \tag{13} $$

5.10 Equation (12) above implies that the number of survivors active at exact age x is equal to the number of individuals active at age $x-1$ plus those transitioning from the inactive state to the active state less those leaving the active state to either the inactive or dead state by age x. Equation (13) illustrates the number of inactive survivors at exact age x which is found using a similar methodology as equation (12).

5.11 It is assumed that transitions occur uniformly throughout the year, thus:

$$Total\, L_x = \frac{Total\, l_x + Total\, l_{x+1}}{2} \tag{14}$$

$${}^{a}L_x = \frac{{}^{a}l_x + {}^{a}l_{x+1}}{2} \tag{15}$$

$${}^{i}L_x = \frac{{}^{i}l_x + {}^{i}l_{x+1}}{2} \tag{16}$$

where equation (14) represents the number of living years, and equations (15) and (16) represent the active years and inactive years lived by individuals currently aged x respectively.

5.12 The total remaining number of years still to be lived by those aged 70+ are manually set, such that $Total\, L_{70+}$ *is* taken directly from the appropriate South African Life Table 1984/1986. $Total\, L_{70+} = {}^{i}L_{70+}$ as we assume that all individuals are inactive at the "closing" age, thus ${}^{a}L_{70+} = 0$.

5.13 Let $\overset{\bullet}{e}_x$ represent the expected years to be lived by an individual aged exact age x and is calculated by adding the total number of active years to be lived throughout all future ages by those currently aged x and dividing it by the number of people alive at age x.

$$\overset{\bullet}{e}_x = \frac{\sum_x^{70+} Total\, L_x}{Total\, l_x} \tag{17}$$

5.14 Based on Foster & Skoog (2004), WLE at age x is the average number of years that a cohort of age x will be in the labour force, before retiring permanently or dying. The expected remaining inactive years to be lived by an individual currently aged x exact and the expected remaining active years to be lived by an individual currently aged x is given in equation (18) and equation (19):

$$e_x^i = \frac{\sum_x^{70+} {}^{i}L_x}{Total\, l_x} \tag{18}$$

$$e_x^a = \frac{\sum_x^{70+} {}^{a}L_x}{Total\, l_x} \tag{19}$$

5.15 It follows that:

$$e_x^{\bullet} = e_x^a + e_x^i \tag{20}$$

5.16 If the radix values are changed such that ${}^a l_x = {}^{\bullet} l_x$ and ${}^i l_x = 0$, then an estimate can be made of WLE conditional on a commencement status of active at age x. Similarly, if the radix values are changed such that ${}^i l_x = {}^{\bullet} l_x$ and ${}^a l_x = 0$, then an estimate can be made of WLE conditional on a commencement status of inactive at age x.

5.17 The estimated contingency deductions set out in the Appendices have been determined on the basis of a commencement status of active at age x. In addition, the contingency deductions only hold if income remains constant in real terms from age x until retirement at age 65. The contingency deduction has been estimated as an approximation to:

$$\textit{Contingency deduction at age } x = 1 - \frac{\int_x^{65} {}_t p'_x \, v^t \, dt}{\int_x^{65} {}_t p_x v^t \, dt} \tag{21}$$

where ${}_t p_x$ is determined on a mortality only basis and ${}_t p'_x$ is determined on a mortality and active status basis conditional on a commencement status of active. A net discount rate of 2.5% per annum compound is assumed in all calculations and represents the net rate of investment return after taxation and inflation.

6. RESULTS AND DISCUSSION

6.1 Results

6.1.1 Appendix A reflects results for females with less than a Grade 12 level of education, Appendix B reflects results for females with a Grade 12 level of education or greater, Appendix C reflects results for males with less than a Grade 12 level of education, and Appendix D reflects results for males with a Grade 12 level of education or greater.

6.1.2 Each appendix shows details of transition probabilities, active life expectancy and inactive life expectancy from age 20 to age 65. In addition, an estimate is provided of the contingency deduction that would be applicable to an individual who is employed and is injured from age 20 to age 60, if normal retirement is assumed to be at age 65. With respect to each table of contingency deductions, earnings are assumed to increase in line with inflation only until retirement at age 65.

6.1.3 From age 20 to age 40, the ratio of active life expectancy to total life expectancy is around 30% for females with less than a Grade 12, compared to 60% for males with at least a Grade 12. Active WLE for males with at least a Grade 12 exceeded those for males with less than a Grade 12. The same pattern holds for females. Females with at least a Grade 12 had higher working life expectancies than males with less than a Grade 12.

6.1.4 General contingency deductions are lowest for males with at least a Grade 12 level of education, with the deduction being 25% or less between age 27 and age 47. At older ages the contingency deductions counter the rule of thumb that shorter future periods should attract lower contingency deductions. This could be due to factors such as early retirement, however more data are required at older ages in order to confirm this. Our results are nevertheless consistent with those in the Ogden tables where higher contingency deductions are applicable at older ages.

6.2 Discussion

6.2.1 Compensation for future loss of income in South Africa is primarily a function of earnings. Higher income earners will receive more compensation than lower income earners for the same injury. The compensation system for Road Accident Fund claims is not redistributive. The findings in this paper would arguably exacerbate the situation where the more educated and by association higher income earners would attract lower contingency deductions. The defined benefit system of compensation envisaged in the Road Accident Benefit Scheme Bill would have to some extent narrowed the gap in compensation between high-income earners and low-income earners. It is unclear if the courts would make a distinction between contingency deductions for males compared to contingency deductions for females, despite the significant gap in WLE estimated in this paper.

6.2.2 In more advanced jurisdictions such as the United States that have considered such issues, Ben-Zion & Visser (2021) note that numerous implementation questions arise and to date there are no appellate decisions illuminating the implementation of California Senate Bill 41 that provides that:

> Estimations, measures, or calculations of past, present, or future damages for lost earnings or impaired earning capacity resulting from personal injury or wrongful death shall not be reduced based on race, ethnicity, or gender.

6.2.3 Ireland (2010) notes that most of the difference between male and female WLE can be explained by the role that females play in child care and elder care. The import of this is that some forensic economists use male WLE for females who have shown consistent labour force attachment.

6.2.4 Palamuleni (2007) constructed what he refers to as working life tables for the South African population based on census data for 1996 and 2001. However, the estimates derived are representative of the expectation of economically active life and are not comparable to the results in this paper. In particular, based on the 2001 census, Palamuleni (2007) obtains an estimate of 36 years in active status and 8 years in inactive status for a male age 15. His estimates are therefore of economically active life where an economically active individual is one who is either employed or unemployed but is trying to obtain employment. The results do not measure time earning an income, but rather time earning an income plus time available for employment for those who want employment.

6.2.5 Lower levels of education are correlated with lower active working life expectancies, but the results must not be interpreted as causative. For example, better educated individuals tend to be less likely to be unemployed, but this could be due to ability in that more intelligent individuals are simultaneously more likely to obtain more education and to have more successful careers. Hence, providing additional education will not necessarily improve an individual's labour market prospects.

6.2.6 Secondary to the development of WLE tables, it is important to understand the relationship between education and life expectancy in South Africa. In addition, more sophisticated models may be developed that examine differences in mortality between active and inactive states.

6.2.7 The WLE tables produced in this paper summarise the average behaviour of individuals grouped in the same cohort. However, care must be taken when forecasting the labour force behaviour of an individual. This is especially important when the individual in question is not an ideal representative of the class considered. This limitation arises due to the heterogeneity in the class, introducing bias into the WLE of an individual (Foster & Skoog, 2004). Nevertheless, the results in this paper reflect the economic realities of South Africa and could find application in many claims for future loss of income.

6.2.8 Table 2 and Table 3 provide a comparison between active WLE as a percentage of total life expectancy derived from this paper and the corresponding results derived by Smith (1986). Smith (1986) provided results for those with less than high school, high school to 14 years of education and individuals with 15 or more years of education.

TABLE 2. Active WLE as a percentage of total life expectancy (lowest education category)

Results from	This study	Smith (1986)
30-year-old males in lowest education category	54%	59%
30-year-old females in lowest education category	32%	32%

TABLE 3. Active WLE as a percentage of total life expectancy (highest education category)

Results from	This study	Smith (1986)
30-year-old males in highest education category	62%	75%
30-year-old females in highest education category	46%	49%

6.2.9 Table 4 provides a comparison between the contingency deductions applicable for various ages for individuals who would have retired at age 65 derived from this paper and the corresponding results in the Ogden tables in the United Kingdom. It must be noted however that the Ogden tables make a distinction between non-disabled lives and disabled lives. The results below are in respect of non-disabled lives.

TABLE 4. Contingency deductions for various ages

Educational level Grade 12 or higher in South Africa/GCSE A level in UK	This study	Ogden tables
30-year-old male employed at accident date	23%	10%
40-year-old male employed at accident date	23%	13%
50-year-old male employed at accident date	28%	17%

7. LIMITATIONS

7.1 Ideally, a large dataset such as the Current Population Survey produced by the Census Bureau in the United States would permit a more detailed analysis of WLE by more granular levels of education. The choice of less than Grade 12 and Grade 12 or higher provided a convenient split of the population between two groups of similar size once weightings were applied (approximately 21.4 million people in the former group and 19.3 million people in the latter group at Quarter 2 of 2022). Nevertheless, dividing the data into two distinct groups could be indicative of occupations for which a certain level of competency or training is required.

7.2 The WLE tables assume that the probabilities of transition estimated over a one-year period will remain unchanged in the future. The assumed stability of probabilities of transition mirror those assumed with respect to the stability of mortality over time embedded in cross sectional population life tables. However, the framework set up in this paper will allow for annual updates of the transition rates which in turn will provide a useful measure of the success of labour market policies. In addition, the model easily makes allowance for exploratory analysis such as the impact on WLE and consequently contingency deductions should transition probabilities for certain age groups improve or worsen.

7.3 There are a number of factors that can have an impact on finding employment other than the level of education of an individual, such as prior work experience, an individual's network, their province of residence and marital status. Given the memoryless property of the Markov process, these factors were not considered in this paper, but this could be an area for future research.

7.4 Shibata (2019) notes that a first-order Markov Chain model does not cater for differences in unobservable characteristics such as human capital and observable characteristics such as labour force histories. Given the relatively small sample sizes available for the 2013 and 2019 panels, further stratification of the sample by length of current employment for example was not feasible. Should Statistics South Africa increase the size of their panel survey, this may become possible.

7.5 As with any panel data from a statistical agency, the data are subject to classification error, where participants misreport their labour market status. No adjustment was made for classification errors in this paper. As the WLE were generated from sample data, a further area of research would be to examine the impact of sample variation.

7.6 The paper makes no distinction between formal sector employment and informal sector employment, or measuring transitions between formal sector and informal sector employment. Further research could be conducted using the techniques in this paper. Alternatively econometric models could be used to predict the probability of transition between various states taking into account factors such as age, occupation, marital status, number of children and gender. Consideration can also be given to determining deductions by broad income bands.

8. CONCLUSION

8.1 Despite various limitations identified in the data that do not permit a full implementation of the model, empirical data shows that WLE for females is less than males irrespective of level of education. Consequently, the implied contingency deduction by broad level of education would be higher for females compared to males. Consideration could be given to using male rates for females who have shown consistent labour force attachment. Legal arguments around differential contingency deductions between males and females have not materialised as to date there have been no reliable WLE tables.

8.2 Out of the four broad classification groups of the working population, males with a Grade 12 or higher had the highest WLE. More data are required so as to stratify the population into more detailed educational levels, but given the very low proportion of degreed individuals in South Africa, this may not be feasible. Unfortunately, subjective adjustments may then be required for degreed or higher degreed individuals. In line with international literature, it is expected that an individual with a degree or higher degree would have a higher WLE and hence lower general contingency deductions would probably be indicated.

8.3 This paper highlights the importance of extending the work done by statistical agencies. The NIDS dataset followed up participants roughly every two years. Ideally, Statistics South Africa should release an annual panel dataset which is reweighted to the population. This dataset could be used to test the one-year rates derived from projecting quarterly transition rates. A significantly larger data set could also give rise to a more granular analysis.

8.4 This paper highlights the importance of measuring WLE using a Markov Chain model and it is an essential tool, not only in the compensation space, but in broader planning and decision-making. A more detailed analysis is required of the impact of education on life expectancy and, in turn, education can be used as a lever to shape health policy. Statistical agencies should strive to produce tables of WLE along with publications such as the mid-year population estimate. This can clearly indicate trends in employment by age group and education levels.

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APPENDIX A1
Females with less than Grade 12

Age	Population counts at age x			Population transitions age x to $x+1$				Probability transitions age x to $x+1$		
x	Population$_x$ N_x	Inactive$_x$ ^iN_x	Active$_x$ ^aN_x	Inactive$_x$ Inactive$_{x+1}$ $^iN^i_x$	Inactive$_x$ Active$_{x+1}$ $^iN^a_x$	Active$_x$ Inactive$_{x+1}$ $^aN^i_x$	Active$_x$ Active$_{x+1}$ $^aN^a_x$	Living$_x$ Dead$_{x+1}$ $^*p^d_x$	Inactive$_x$ Inactive$_{x+1}$ p^i_x	Active$_x$ Active$_{x+1}$ $^ap^a_x$
20	166,932	158,717	8,215	146,384	12,333	4,847	3,368	0.00133	0.90073	0.39840
21	174,839	164,286	10,553	148,635	15,651	5,570	4,983	0.00146	0.91203	0.44429
22	242,764	219,782	22,982	194,999	24,783	10,742	12,240	0.00160	0.89329	0.51275
23	188,023	169,367	18,656	146,811	22,556	7,950	10,706	0.00173	0.87683	0.55012
24	174,058	147,412	26,646	125,419	21,993	12,545	14,101	0.00187	0.85777	0.54656
25	186,324	143,942	42,382	121,101	22,841	18,971	23,411	0.00199	0.84443	0.54235
26	185,843	151,020	34,823	126,630	24,390	14,970	19,853	0.00211	0.83810	0.55920
27	211,898	170,867	41,031	140,204	30,663	17,054	23,977	0.00223	0.82712	0.57653
28	222,184	171,399	50,785	139,198	32,201	20,738	30,047	0.00236	0.81441	0.58701
29	189,328	146,415	42,913	118,047	28,368	16,595	26,318	0.00247	0.80742	0.60008
30	207,012	148,662	58,350	118,926	29,736	22,047	36,303	0.00259	0.80101	0.61680
31	232,851	172,452	60,399	135,768	36,684	22,246	38,153	0.00272	0.79100	0.62530
32	253,630	164,808	88,822	127,023	37,785	30,827	57,995	0.00288	0.77695	0.64248
33	226,410	148,590	77,820	113,737	34,853	25,187	52,633	0.00308	0.76586	0.66183
34	210,366	151,082	59,284	114,187	36,895	18,546	40,738	0.00331	0.75806	0.67877
35	198,287	130,482	67,805	97,636	32,846	19,670	48,135	0.00359	0.74961	0.69679
36	215,258	140,760	74,498	104,891	35,869	20,567	53,931	0.00390	0.74375	0.71445
37	214,662	154,010	60,652	114,514	39,496	16,029	44,623	0.00425	0.74117	0.72612
38	216,567	146,980	69,587	109,181	37,799	17,123	52,464	0.00462	0.73976	0.74201
39	229,131	152,591	76,540	113,392	39,199	18,010	58,530	0.00502	0.73924	0.75576
40	205,867	104,211	101,656	78,028	26,183	24,156	77,500	0.00545	0.74134	0.75921
41	208,593	127,108	81,485	96,872	30,236	20,601	60,884	0.00590	0.75164	0.75116
42	209,361	125,020	84,341	96,047	28,973	22,143	62,198	0.00638	0.76028	0.73750
43	166,258	107,871	58,387	81,587	26,284	15,067	43,320	0.00689	0.75748	0.73420
44	171,400	105,407	65,993	78,378	27,029	16,428	49,565	0.00742	0.74446	0.74124
45	187,825	113,708	74,117	86,643	27,065	18,543	55,574	0.00798	0.74711	0.74441
46	188,971	107,227	81,744	82,125	25,102	19,672	62,072	0.00857	0.75733	0.74835
47	222,750	149,954	72,796	115,112	34,842	17,614	55,182	0.00918	0.75988	0.75176
48	184,545	105,549	78,996	81,154	24,395	20,145	58,851	0.00981	0.76062	0.74387
49	201,602	127,155	74,447	98,364	28,791	18,872	55,575	0.01047	0.76337	0.73791
50	147,245	71,297	75,948	55,219	16,078	18,125	57,823	0.01116	0.76527	0.74558

Age	Population counts at age x			Population transitions age x to $x+1$				Probability transitions age x to $x+1$		
x	Population$_x$ N_x	Inactive$_x$ ${}^iN_x$	Active$_x$ ${}^aN_x$	Inactive$_x$ Inactive$_{x+1}$ ${}^iN^i{}_x$	Inactive$_x$ Active$_{x+1}$ ${}^iN^a{}_x$	Active$_x$ Inactive$_{x+1}$ ${}^aN^i{}_x$	Active$_x$ Active$_{x+1}$ ${}^aN^a{}_x$	Living$_x$ Dead$_{x+1}$ ${}^*p^d{}_x$	Inactive$_x$ Inactive$_{x+1}$ $p^i{}_x$	Active$_x$ Active$_{x+1}$ ${}^ap^a{}_x$
51	174,403	96,541	77,862	75,636	20,905	19,385	58,477	0.01189	0.77038	0.74713
52	160,671	98,471	62,200	79,740	18,731	15,316	46,884	0.01268	0.78665	0.74270
53	205,412	117,819	87,593	97,466	20,353	22,447	65,146	0.01363	0.80813	0.73770
54	162,714	101,862	60,852	85,081	16,781	14,743	46,109	0.01445	0.81896	0.73864
55	154,654	93,795	60,859	79,709	14,086	15,751	45,108	0.01545	0.82923	0.73788
56	164,732	116,857	47,875	100,936	15,921	13,411	34,464	0.01652	0.84338	0.71971
57	171,461	111,942	59,519	98,727	13,215	16,091	43,428	0.01768	0.85723	0.71247
58	169,998	116,677	53,321	104,621	12,056	15,855	37,466	0.01891	0.87264	0.70333
59	159,285	111,459	47,826	101,865	9,594	14,602	33,224	0.02023	0.88679	0.68474
60	175,954	145,070	30,884	134,654	10,416	10,517	20,367	0.02160	0.90208	0.66615
61	158,586	145,513	13,073	135,536	9,977	4,676	8,397	0.02302	0.90842	0.63932
62	154,872	137,566	17,306	129,852	7,714	6,376	10,930	0.02445	0.91458	0.62064
63	154,475	145,780	8,695	138,204	7,576	3,557	5,138	0.02588	0.92155	0.60199
64	145,152	136,357	8,795	129,976	6,381	3,694	5,101	0.02731	0.92457	0.56945
65	156,376	149,728	6,648	142,721	7,007	2,792	3,856	0.02884	0.92571	0.56326

APPENDIX A2
Females with less than Grade 12

Age	Probability transitions age x to $x+1$				Stationary population in each status			Person years lived in each status		
x	Inactive$_x$ Inactive$_{x+1}$ $^ip^i{}_x$	Inactive$_x$ Active$_{x+1}$ $^ip^a{}_x$	Active$_x$ Inactive$_{x+1}$ $^ap^i{}_x$	Active$_x$ Active$_{x+1}$ $^ap^a{}_x$	Total l_x	Inactive ^il_x	Active ^al_x	Total L_x	Inactive ^iL_x	Active ^aL_x
20	0.90073	0.09795	0.60028	0.39840	92,923	82,106	10,817	92,861	81,277	11,584
21	0.91203	0.08651	0.55425	0.44429	92,800	80,448	12,351	92,732	80,333	12,399
22	0.89329	0.10511	0.48565	0.51275	92,664	80,217	12,447	92,590	78,959	13,631
23	0.87683	0.12144	0.44815	0.55012	92,516	77,702	14,814	92,436	76,236	16,200
24	0.85777	0.14037	0.45157	0.54656	92,356	74,770	17,585	92,269	73,423	18,846
25	0.84443	0.15357	0.45566	0.54235	92,183	72,077	20,107	92,091	71,051	21,040
26	0.83810	0.15979	0.43869	0.55920	91,999	70,026	21,974	91,902	69,177	22,725
27	0.82712	0.17065	0.42124	0.57653	91,805	68,328	23,477	91,703	67,366	24,336
28	0.81441	0.18324	0.41064	0.58701	91,600	66,405	25,195	91,492	65,416	26,077
29	0.80742	0.19011	0.39745	0.60008	91,384	64,427	26,958	91,271	63,580	27,691
30	0.80101	0.19640	0.38061	0.61680	91,159	62,734	28,425	91,041	61,902	29,139
31	0.79100	0.20628	0.37198	0.62530	90,923	61,069	29,853	90,799	60,240	30,559
32	0.77695	0.22017	0.35464	0.64248	90,675	59,410	31,264	90,544	58,328	32,216
33	0.76586	0.23106	0.33510	0.66183	90,413	57,246	33,167	90,274	56,102	34,173
34	0.75806	0.23863	0.31791	0.67877	90,135	54,957	35,178	89,986	53,901	36,085
35	0.74961	0.24680	0.29962	0.69679	89,837	52,844	36,992	89,676	51,770	37,905
36	0.74375	0.25235	0.28165	0.71445	89,514	50,696	38,818	89,340	49,668	39,672
37	0.74117	0.25459	0.26963	0.72612	89,165	48,639	40,526	88,976	47,808	41,168
38	0.73976	0.25562	0.25337	0.74201	88,787	46,977	41,810	88,582	46,161	42,421
39	0.73924	0.25574	0.23922	0.75576	88,377	45,345	43,031	88,155	44,580	43,575
40	0.74134	0.25321	0.23534	0.75921	87,933	43,815	44,118	87,693	43,340	44,354
41	0.75164	0.24246	0.24294	0.75116	87,454	42,865	44,589	87,196	42,958	44,238
42	0.76028	0.23334	0.25612	0.73750	86,938	43,051	43,887	86,661	43,511	43,149
43	0.75748	0.23563	0.25891	0.73420	86,383	43,971	42,412	86,086	44,130	41,956
44	0.74446	0.24812	0.25134	0.74124	85,788	44,288	41,500	85,470	43,845	41,625
45	0.74711	0.24491	0.24761	0.74441	85,152	43,401	41,750	84,812	43,082	41,729
46	0.75733	0.23410	0.24309	0.74835	84,472	42,763	41,709	84,110	42,644	41,466
47	0.75988	0.23094	0.23906	0.75176	83,748	42,525	41,223	83,364	42,347	41,017
48	0.76062	0.22957	0.24631	0.74387	82,979	42,169	40,811	82,572	42,148	40,425
49	0.76337	0.22616	0.25162	0.73791	82,165	42,126	40,039	81,735	42,179	39,556
50	0.76527	0.22357	0.24326	0.74558	81,305	42,232	39,073	80,851	42,028	38,823

Age	Probability transitions age x to $x+1$				Stationary population in each status			Person years lived in each status		
x	Inactive$_x$ Inactive$_{x+1}$ ${}^ip^i{}_x$	Inactive$_x$ Active$_{x+1}$ ${}^ip^a{}_x$	Active$_x$ Inactive$_{x+1}$ ${}^ap^i{}_x$	Active$_x$ Active$_{x+1}$ ${}^ap^a{}_x$	Total l_x	Inactive ${}^il_x$	Active ${}^al_x$	Total L_x	Inactive ${}^iL_x$	Active ${}^aL_x$
51	0.77038	0.21773	0.24097	0.74713	80,397	41,824	38,574	79,919	41,670	38,250
52	0.78665	0.20067	0.24462	0.74270	79,441	41,515	37,926	78,938	41,725	37,212
53	0.80813	0.17824	0.24867	0.73770	78,434	41,935	36,499	77,900	42,450	35,449
54	0.81896	0.16659	0.24691	0.73864	77,365	42,966	34,400	76,806	43,323	33,483
55	0.82923	0.15532	0.24667	0.73788	76,247	43,680	32,567	75,658	43,967	31,691
56	0.84338	0.14009	0.26377	0.71971	75,069	44,254	30,815	74,449	44,853	29,596
57	0.85723	0.12509	0.26985	0.71247	73,829	45,451	28,377	73,176	46,036	27,141
58	0.87264	0.10845	0.27776	0.70333	72,524	46,620	25,904	71,838	47,249	24,589
59	0.88679	0.09298	0.29503	0.68474	71,152	47,877	23,275	70,432	48,600	21,832
60	0.90208	0.07632	0.31224	0.66615	69,713	49,324	20,389	68,960	50,092	18,868
61	0.90842	0.06856	0.33767	0.63932	68,207	50,860	17,347	67,422	51,460	15,962
62	0.91458	0.06097	0.35491	0.62064	66,637	52,059	14,577	65,822	52,423	13,399
63	0.92155	0.05256	0.37213	0.60199	65,007	52,786	12,221	64,166	52,990	11,176
64	0.92457	0.04812	0.40324	0.56945	63,325	53,193	10,131	62,460	53,230	9,230
65	0.92571	0.04545	0.40790	0.56326	61,595	53,266	8,329	60,707	52,986	7,720

APPENDIX A3
Females with less than Grade 12

Age	Various whole life expectancies			Present value of 1 to age 65		
x	Life expectancy	Inactive life expectancy	Active life expectancy	Mortality only basis	Active basis	Implied contingency deduction
20	50.32	35.25	15.06	25.14	8.93	64%
21	49.38	34.43	14.96	24.79	8.88	64%
22	48.45	33.61	14.84	24.43	8.93	63%
23	47.53	32.81	14.72	24.07	9.00	63%
24	46.61	32.04	14.57	23.70	9.05	62%
25	45.70	31.30	14.39	23.33	9.09	61%
26	44.79	30.59	14.19	22.94	9.10	60%
27	43.88	29.91	13.98	22.55	9.10	60%
28	42.98	29.24	13.74	22.16	9.08	59%
29	42.08	28.59	13.49	21.75	9.04	58%
30	41.18	27.96	13.22	21.34	8.98	58%
31	40.29	27.36	12.93	20.91	8.90	57%
32	39.40	26.77	12.63	20.48	8.81	57%
33	38.51	26.20	12.31	20.04	8.69	57%
34	37.63	25.66	11.97	19.59	8.56	56%
35	36.75	25.14	11.61	19.13	8.39	56%
36	35.88	24.65	11.23	18.67	8.20	56%
37	35.02	24.19	10.82	18.19	7.99	56%
38	34.17	23.76	10.41	17.71	7.76	56%
39	33.32	23.35	9.98	17.22	7.50	56%
40	32.49	22.96	9.53	16.73	7.23	57%
41	31.66	22.59	9.08	16.23	6.93	57%
42	30.85	22.23	8.62	15.71	6.63	58%
43	30.04	21.87	8.18	15.19	6.34	58%
44	29.25	21.50	7.74	14.67	6.05	59%
45	28.46	21.15	7.31	14.13	5.75	59%
46	27.69	20.81	6.88	13.58	5.44	60%
47	26.92	20.48	6.44	13.03	5.12	61%
48	26.17	20.16	6.01	12.46	4.80	61%
49	25.42	19.85	5.57	11.88	4.47	62%
50	24.69	19.54	5.15	11.29	4.14	63%

Age	Various whole life expectancies			Present value of 1 to age 65		
x	Life expectancy	Inactive life expectancy	Active life expectancy	Mortality only basis	Active basis	Implied contingency deduction
51	23.96	19.24	4.72	10.68	3.80	64%
52	23.24	18.94	4.30	10.06	3.45	66%
53	22.53	18.65	3.88	9.43	3.10	67%
54	21.84	18.36	3.47	8.77	2.76	69%
55	21.15	18.06	3.09	8.11	2.43	70%
56	20.47	17.76	2.71	7.42	2.10	72%
57	19.81	17.45	2.36	6.71	1.78	73%
58	19.16	17.13	2.03	5.98	1.48	75%
59	18.52	16.80	1.72	5.23	1.20	77%
60	17.89	16.45	1.44	4.44	0.94	79%

APPENDIX B1
Females with Grade 12 or more

Age	Population counts at age x			Population transitions age x to $x+1$				Probability transitions age x to $x+1$		
x	Population$_x$ N_x	Inactive$_x$ ^iN_x	Active$_x$ ^aN_x	Inactive$_x$ Inactive$_{x+1}$ $^iN^i_x$	Inactive$_x$ Active$_{x+1}$ $^iN^a_x$	Active$_x$ Inactive$_{x+1}$ $^aN^i_x$	Active$_x$ Active$_{x+1}$ $^aN^a_x$	Living$_x$ Dead$_{x+1}$ $^*p^d_x$	Inactive$_x$ Inactive$_{x+1}$ $^ip^i_x$	Active$_x$ Active$_{x+1}$ $^ap^a_x$
20	311,577	274,093	37,484	184,380	89,713	18,741	18,743	0.00062	0.63571	0.48098
21	308,672	272,849	35,823	208,289	64,560	15,091	20,732	0.00065	0.71747	0.53815
22	312,939	257,760	55,179	220,747	37,013	18,471	36,708	0.00067	0.80803	0.63078
23	344,540	250,665	93,875	208,001	42,664	33,245	60,630	0.00069	0.84270	0.65259
24	347,291	256,696	90,595	208,066	48,630	27,520	63,075	0.00071	0.81948	0.67012
25	355,700	228,039	127,661	179,571	48,468	32,628	95,033	0.00073	0.79910	0.72388
26	334,522	216,041	118,481	167,939	48,102	29,245	89,236	0.00075	0.78195	0.74807
27	331,237	186,753	144,484	142,164	44,589	31,769	112,715	0.00077	0.76928	0.76738
28	331,537	183,827	147,710	137,676	46,151	28,302	119,408	0.00080	0.75454	0.79378
29	293,474	161,277	132,197	119,679	41,598	23,668	108,529	0.00083	0.74511	0.81366
30	273,638	130,937	142,701	95,961	34,976	23,215	119,486	0.00086	0.73732	0.82874
31	290,648	159,563	131,085	117,742	41,821	20,672	110,413	0.00090	0.73498	0.83895
32	298,406	148,442	149,964	109,333	39,109	23,445	126,519	0.00094	0.73655	0.84223
33	260,086	119,536	140,550	87,398	32,138	20,455	120,095	0.00099	0.73340	0.84804
34	241,083	88,021	153,062	64,409	23,612	22,392	130,670	0.00105	0.73063	0.85317
35	266,479	114,775	151,704	85,186	29,589	21,006	130,698	0.00113	0.73683	0.85663
36	257,786	103,896	153,890	78,748	25,148	19,694	134,196	0.00122	0.74878	0.86576
37	232,986	105,516	127,470	79,197	26,319	16,188	111,282	0.00132	0.75324	0.87132
38	244,045	105,006	139,039	81,534	23,472	18,152	120,887	0.00143	0.76239	0.86990
39	227,215	99,336	127,879	75,653	23,683	16,201	111,678	0.00157	0.76803	0.86994
40	221,648	76,267	145,381	57,616	18,651	17,227	128,154	0.00172	0.75761	0.87616
41	235,799	87,765	148,034	65,763	22,002	16,560	131,474	0.00190	0.75073	0.88317
42	221,891	77,220	144,671	58,956	18,264	15,253	129,418	0.00212	0.75434	0.88943
43	201,461	82,687	118,774	62,596	20,091	11,217	107,557	0.00236	0.75834	0.89740
44	169,596	57,292	112,304	42,452	14,840	10,113	102,191	0.00265	0.74847	0.90529
45	171,544	66,420	105,124	49,850	16,570	9,894	95,230	0.00296	0.74389	0.90529
46	188,574	66,316	122,258	49,979	16,337	10,531	111,727	0.00330	0.74960	0.90717
47	168,832	47,910	120,922	34,589	13,321	9,904	111,018	0.00366	0.73765	0.91261
48	165,126	54,141	110,985	40,910	13,231	8,174	102,811	0.00403	0.73684	0.91833
49	157,941	55,255	102,686	41,175	14,080	8,048	94,638	0.00440	0.74705	0.92002
50	159,772	50,183	109,589	38,889	11,294	9,718	99,871	0.00478	0.75571	0.91193

Age	Population counts at age x			Population transitions age x to $x+1$				Probability transitions age x to $x+1$		
x	Population$_x$ N_x	Inactive$_x$ ^iN_x	Active$_x$ ^aN_x	Inactive$_x$ Inactive$_{x+1}$ $^iN^i_x$	Inactive$_x$ Active$_{x+1}$ $^iN^a_x$	Active$_x$ Inactive$_{x+1}$ $^aN^i_x$	Active$_x$ Active$_{x+1}$ $^aN^a_x$	Living$_x$ Dead$_{x+1}$ $^*p^d_x$	Inactive$_x$ Inactive$_{x+1}$ $^ip^i_x$	Active$_x$ Active$_{x+1}$ $^ap^a_x$
51	144,763	42,898	101,865	33,483	9,415	9,759	92,106	0.00519	0.77348	0.90318
52	145,544	66,593	78,951	54,413	12,180	8,924	70,027	0.00563	0.79825	0.89163
53	113,324	36,043	77,281	29,631	6,412	9,843	67,438	0.00611	0.81386	0.87450
54	112,151	35,014	77,137	28,388	6,626	8,953	68,184	0.00664	0.81109	0.87245
55	97,591	37,883	59,708	32,057	5,826	7,985	51,723	0.00723	0.82318	0.86989
56	101,394	31,655	69,739	27,365	4,290	9,349	60,390	0.00790	0.84777	0.85924
57	87,934	48,035	39,899	42,045	5,990	6,194	33,705	0.00867	0.86346	0.85079
58	69,480	34,587	34,893	31,300	3,287	5,302	29,591	0.00953	0.87926	0.83823
59	80,420	38,815	41,605	35,324	3,491	5,418	36,187	0.01051	0.89812	0.85084
60	58,924	40,904	18,020	37,699	3,205	3,196	14,824	0.01158	0.90540	0.84563
61	77,609	51,303	26,306	47,048	4,255	4,601	21,705	0.01273	0.90739	0.81360
62	54,269	32,726	21,543	30,681	2,045	3,717	17,826	0.01395	0.91213	0.81462
63	62,960	47,918	15,042	45,867	2,051	2,828	12,214	0.01522	0.93477	0.80860
64	38,683	28,881	9,802	27,397	1,484	1,879	7,923	0.01652	0.93821	0.79715
65	67,745	62,888	4,857	59,657	3,231	931	3,926	0.01788	0.93167	0.79386

APPENDIX B2
Females with Grade 12 or more

Age	Probability transitions age x to $x+1$				Stationary population in each status			Person years lived in each status		
x	Inactive$_x$ Inactive$_{x+1}$ $^ip^i_x$	Inactive$_x$ Active$_{x+1}$ $^ip^a_x$	Active$_x$ Inactive$_{x+1}$ $^ap^i_x$	Active$_x$ Active$_{x+1}$ $^ap^a_x$	Total l_x	Inactive ^il_x	Active ^al_x	Total L_x	Inactive ^iL_x	Active ^aL_x
20	0.63571	0.36367	0.51840	0.48098	98,461	56,755	41,705	98,430	57,227	41,203
21	0.71747	0.28188	0.46120	0.53815	98,400	57,700	40,700	98,368	58,934	39,433
22	0.80803	0.19130	0.36855	0.63078	98,336	60,169	38,167	98,303	61,426	36,876
23	0.84270	0.15660	0.34672	0.65259	98,270	62,684	35,585	98,236	63,923	34,312
24	0.81948	0.17981	0.32917	0.67012	98,202	65,163	33,039	98,167	64,719	33,448
25	0.79910	0.20017	0.27539	0.72388	98,132	64,275	33,857	98,096	62,480	35,616
26	0.78195	0.21730	0.25118	0.74807	98,060	60,686	37,374	98,023	58,763	39,260
27	0.76928	0.22994	0.23184	0.76738	97,986	56,841	41,145	97,949	55,054	42,895
28	0.75454	0.24466	0.20542	0.79378	97,911	53,266	44,645	97,871	51,314	46,557
29	0.74511	0.25406	0.18551	0.81366	97,832	49,362	48,470	97,792	47,567	50,225
30	0.73732	0.26182	0.17040	0.82874	97,751	45,772	51,979	97,709	44,189	53,520
31	0.73498	0.26413	0.16015	0.83895	97,667	42,606	55,061	97,624	41,369	56,254
32	0.73655	0.26251	0.15683	0.84223	97,580	40,133	57,447	97,534	39,351	58,183
33	0.73340	0.26561	0.15096	0.84804	97,488	38,569	58,919	97,440	37,875	59,565
34	0.73063	0.26832	0.14578	0.85317	97,391	37,181	60,210	97,340	36,562	60,778
35	0.73683	0.26204	0.14224	0.85663	97,289	35,943	61,346	97,234	35,576	61,658
36	0.74878	0.25001	0.13302	0.86576	97,179	35,210	61,969	97,120	34,909	62,211
37	0.75324	0.24544	0.12736	0.87132	97,061	34,608	62,453	96,997	34,315	62,682
38	0.76239	0.23617	0.12866	0.86990	96,933	34,022	62,911	96,864	34,027	62,836
39	0.76803	0.23040	0.12850	0.86994	96,794	34,033	62,762	96,719	34,118	62,601
40	0.75761	0.24066	0.12212	0.87616	96,643	34,203	62,440	96,559	33,870	62,689
41	0.75073	0.24736	0.11493	0.88317	96,476	33,537	62,939	96,384	32,974	63,410
42	0.75434	0.24354	0.10846	0.88943	96,292	32,411	63,881	96,191	31,894	64,296
43	0.75834	0.23930	0.10024	0.89740	96,089	31,377	64,711	95,975	30,830	65,146
44	0.74847	0.24889	0.09206	0.90529	95,862	30,282	65,580	95,735	29,492	66,243
45	0.74389	0.25315	0.09174	0.90529	95,608	28,702	66,906	95,466	28,096	67,370
46	0.74960	0.24709	0.08953	0.90717	95,325	27,490	67,835	95,167	27,085	68,083
47	0.73765	0.25869	0.08373	0.91261	95,010	26,679	68,330	94,836	26,040	68,796
48	0.73684	0.25913	0.07764	0.91833	94,662	25,401	69,261	94,472	24,748	69,724
49	0.74705	0.24855	0.07558	0.92002	94,281	24,094	70,187	94,074	23,699	70,374
50	0.75571	0.23950	0.08329	0.91193	93,866	23,304	70,562	93,642	23,396	70,245

Age	Probability transitions age x to $x+1$				Stationary population in each status			Person years lived in each status		
x	Inactive$_x$ Inactive$_{x+1}$ ${}^ip^i{}_x$	Inactive$_x$ Active$_{x+1}$ ${}^ip^a{}_x$	Active$_x$ Inactive$_{x+1}$ ${}^ap^i{}_x$	Active$_x$ Active$_{x+1}$ ${}^ap^a{}_x$	Total l_x	Inactive ${}^il_x$	Active ${}^al_x$	Total L_x	Inactive ${}^iL_x$	Active ${}^aL_x$
51	0.77348	0.22133	0.09163	0.90318	93,417	23,488	69,929	93,175	24,032	69,143
52	0.79825	0.19612	0.10275	0.89163	92,932	24,575	68,357	92,671	25,608	67,063
53	0.81386	0.18004	0.11939	0.87450	92,410	26,641	65,769	92,128	28,087	64,040
54	0.81109	0.18227	0.12092	0.87245	91,845	29,534	62,311	91,541	30,512	61,029
55	0.82318	0.16958	0.12288	0.86989	91,236	31,489	59,746	90,906	32,376	58,530
56	0.84777	0.14433	0.13286	0.85924	90,576	33,263	57,313	90,218	34,539	55,679
57	0.86346	0.12788	0.14055	0.85079	89,860	35,814	54,046	89,471	37,167	52,304
58	0.87926	0.11121	0.15224	0.83823	89,081	38,520	50,562	88,657	40,043	48,614
59	0.89812	0.09137	0.13866	0.85084	88,232	41,566	46,666	87,769	42,684	45,085
60	0.90540	0.08302	0.14280	0.84563	87,306	43,802	43,503	86,800	44,836	41,964
61	0.90739	0.07987	0.17367	0.81360	86,295	45,871	40,424	85,745	47,257	38,488
62	0.91213	0.07392	0.17143	0.81462	85,196	48,643	36,553	84,602	49,639	34,963
63	0.93477	0.05002	0.17618	0.80860	84,007	50,635	33,372	83,368	51,923	31,445
64	0.93821	0.04527	0.18633	0.79715	82,729	53,212	29,517	82,046	54,318	27,728
65	0.93167	0.05045	0.18826	0.79386	81,362	55,424	25,939	80,635	55,972	24,663

APPENDIX B3
Females with Grade 12 or more

Age	Various whole life expectancies			Present value of 1 to age 65		
x	Life expectancy	Inactive life expectancy	Active life expectancy	Mortality only basis	Active basis	Implied contingency deduction
20	56.94	31.17	25.77	26.34	14.61	45%
21	55.98	30.61	25.37	26.00	14.57	44%
22	55.02	30.03	24.98	25.65	14.54	43%
23	54.05	29.43	24.62	25.30	14.53	43%
24	53.09	28.80	24.29	24.94	14.55	42%
25	52.13	28.16	23.97	24.56	14.58	41%
26	51.16	27.54	23.62	24.18	14.59	40%
27	50.20	26.96	23.24	23.79	14.56	39%
28	49.24	26.42	22.82	23.40	14.50	38%
29	48.28	25.92	22.36	22.99	14.39	37%
30	47.32	25.45	21.87	22.57	14.24	37%
31	46.36	25.02	21.34	22.14	14.05	37%
32	45.40	24.62	20.78	21.70	13.83	36%
33	44.44	24.24	20.20	21.25	13.59	36%
34	43.49	23.88	19.61	20.79	13.32	36%
35	42.53	23.53	19.01	20.32	13.04	36%
36	41.58	23.19	18.39	19.84	12.74	36%
37	40.63	22.85	17.78	19.35	12.42	36%
38	39.68	22.53	17.15	18.84	12.10	36%
39	38.74	22.21	16.53	18.33	11.76	36%
40	37.80	21.89	15.91	17.80	11.42	36%
41	36.86	21.58	15.28	17.27	11.06	36%
42	35.93	21.28	14.65	16.72	10.69	36%
43	35.01	20.99	14.02	16.16	10.31	36%
44	34.09	20.72	13.37	15.59	9.90	36%
45	33.18	20.47	12.71	15.01	9.48	37%
46	32.28	20.23	12.04	14.41	9.03	37%
47	31.38	20.01	11.37	13.81	8.56	38%
48	30.49	19.81	10.68	13.19	8.07	39%
49	29.62	19.63	9.99	12.56	7.55	40%
50	28.74	19.46	9.28	11.92	7.02	41%

Age	Various whole life expectancies			Present value of 1 to age 65		
x	Life expectancy	Inactive life expectancy	Active life expectancy	Mortality only basis	Active basis	Implied contingency deduction
51	27.88	19.31	8.57	11.26	6.47	43%
52	27.02	19.15	7.87	10.58	5.91	44%
53	26.17	18.98	7.19	9.90	5.36	46%
54	25.33	18.79	6.54	9.19	4.82	48%
55	24.50	18.58	5.91	8.47	4.29	49%
56	23.67	18.36	5.31	7.72	3.78	51%
57	22.86	18.12	4.73	6.96	3.28	53%
58	22.05	17.86	4.19	6.18	2.79	55%
59	21.26	17.58	3.68	5.38	2.33	57%
60	20.48	17.28	3.20	4.56	1.89	58%

APPENDIX C1
Males with less than Grade 12

Age	Population counts at age x			Population transitions age x to $x+1$				Probability transitions age x to $x+1$		
x	Population$_x$ N_x	Inactive$_x$ ${}^iN_x$	Active$_x$ ${}^aN_x$	Inactive$_x$ Inactive$_{x+1}$ ${}^iN^i_x$	Inactive$_x$ Active$_{x+1}$ ${}^iN^a_x$	Active$_x$ Inactive$_{x+1}$ ${}^aN^i_x$	Active$_x$ Active$_{x+1}$ ${}^aN^a_x$	Living$_x$ Dead$_{x+1}$ ${}^*p^d_x$	Inactive$_x$ Inactive$_{x+1}$ ${}^ip^i_x$	Active$_x$ Active$_{x+1}$ ${}^ap^a_x$
20	242,136	223,435	18,701	198,713	24,722	9,422	9,279	0.00365	0.87420	0.46248
21	248,476	191,221	57,255	163,149	28,072	29,701	27,554	0.00405	0.86915	0.48297
22	244,524	199,573	44,951	162,039	37,534	19,880	25,071	0.00440	0.82846	0.51263
23	221,991	169,364	52,627	132,691	36,673	23,411	29,216	0.00472	0.79510	0.55372
24	248,098	167,693	80,405	127,159	40,534	32,295	48,110	0.00498	0.76710	0.57836
25	252,023	162,825	89,198	118,556	44,269	32,646	56,552	0.00520	0.73956	0.61389
26	243,310	158,484	84,826	111,426	47,058	28,209	56,617	0.00536	0.71193	0.64683
27	234,893	146,548	88,345	101,285	45,263	28,436	59,909	0.00547	0.69352	0.66921
28	230,938	120,835	110,103	80,919	39,916	32,320	77,783	0.00558	0.67763	0.68997
29	252,779	148,161	104,618	99,598	48,563	29,260	75,358	0.00563	0.66730	0.70920
30	257,119	138,733	118,386	91,982	46,751	30,614	87,772	0.00567	0.66399	0.72737
31	271,141	166,166	104,975	112,435	53,731	26,122	78,853	0.00573	0.66660	0.74172
32	293,128	169,458	123,670	115,590	53,868	27,963	95,707	0.00584	0.67544	0.75900
33	273,158	154,748	118,410	105,703	49,045	25,559	92,851	0.00602	0.67846	0.77422
34	249,765	141,619	108,146	95,740	45,879	22,901	85,245	0.00630	0.67543	0.78116
35	209,258	104,496	104,762	70,065	34,431	21,474	83,288	0.00665	0.66921	0.78631
36	246,823	126,559	120,264	86,227	40,332	23,257	97,007	0.00707	0.67165	0.79555
37	234,688	111,692	122,996	77,601	34,091	23,496	99,500	0.00753	0.68245	0.80173
38	263,290	124,715	138,575	85,090	39,625	27,365	111,210	0.00800	0.68268	0.79911
39	208,381	101,164	107,217	70,414	30,750	21,089	86,128	0.00848	0.68260	0.79606
40	207,704	106,514	101,190	72,327	34,187	20,944	80,246	0.00898	0.68115	0.79115
41	225,069	102,462	122,607	70,080	32,382	27,795	94,812	0.00951	0.67497	0.77478
42	246,246	122,250	123,996	85,853	36,397	28,311	95,685	0.01011	0.68691	0.76468
43	169,813	80,198	89,615	56,754	23,444	20,766	68,849	0.01079	0.69681	0.76195
44	176,196	77,879	98,317	55,491	22,388	22,739	75,578	0.01156	0.70185	0.75963
45	198,422	85,011	113,411	59,743	25,268	25,119	88,292	0.01243	0.69864	0.76435
46	193,675	82,411	111,264	58,899	23,512	26,269	84,995	0.01340	0.69915	0.76095
47	196,309	83,492	112,817	61,099	22,393	25,976	86,841	0.01446	0.71285	0.75576
48	170,171	80,461	89,710	60,273	20,188	21,347	68,363	0.01561	0.72873	0.75437
49	192,778	87,953	104,825	67,623	20,330	23,180	81,645	0.01686	0.74662	0.75811
50	148,962	65,971	82,991	49,946	16,025	16,556	66,435	0.01819	0.74992	0.77409

Age	Population counts at age x			Population transitions age x to $x+1$				Probability transitions age x to $x+1$		
x	Population$_x$ N_x	Inactive$_x$ ^iN_x	Active$_x$ ^aN_x	Inactive$_x$ Inactive$_{x+1}$ $^iN^i{}_x$	Inactive$_x$ Active$_{x+1}$ $^iN^a{}_x$	Active$_x$ Inactive$_{x+1}$ $^aN^i{}_x$	Active$_x$ Active$_{x+1}$ $^aN^a{}_x$	Living$_x$ Dead$_{x+1}$ $^*p^d{}_x$	Inactive$_x$ Inactive$_{x+1}$ $^ip^i{}_x$	Active$_x$ Active$_{x+1}$ $^ap^a{}_x$
51	138,087	75,334	62,753	56,155	19,179	11,757	50,996	0.01959	0.73615	0.78995
52	152,513	72,201	80,312	54,158	18,043	15,592	64,720	0.02107	0.73195	0.79179
53	158,244	83,646	74,598	64,643	19,003	14,852	59,746	0.02262	0.74505	0.78530
54	112,274	49,159	63,115	37,663	11,496	12,777	50,338	0.02423	0.75169	0.78001
55	128,418	67,124	61,294	51,833	15,291	11,891	49,403	0.02590	0.74971	0.78095
56	107,672	64,898	42,774	51,523	13,375	9,320	33,454	0.02766	0.76121	0.77416
57	138,838	75,395	63,443	59,444	15,951	12,822	50,621	0.02952	0.76762	0.76818
58	118,771	62,737	56,034	51,074	11,663	13,512	42,522	0.03148	0.77491	0.75504
59	130,738	76,274	54,464	63,312	12,962	13,109	41,355	0.03356	0.79524	0.73360
60	101,642	72,771	28,871	61,648	11,123	8,394	20,477	0.03577	0.80842	0.71543
61	117,584	94,302	23,282	81,636	12,666	6,683	16,599	0.03810	0.82494	0.68382
62	115,987	92,360	23,627	80,071	12,289	7,003	16,624	0.04057	0.83116	0.67951
63	111,502	97,864	13,638	88,016	9,848	4,242	9,396	0.04319	0.84547	0.66810
64	115,129	103,730	11,399	94,225	9,505	3,620	7,779	0.04595	0.86246	0.65448
65	119,874	106,360	13,514	96,614	9,746	4,291	9,223	0.04886	0.86398	0.64911

APPENDIX C2
Males with less than Grade 12

Age	Probability transitions age x to $x+1$				Stationary population in each status			Person years lived in each status		
x	Inactive_x Inactive_{x+1} ${}^ip^i{}_x$	Inactive_x Active_{x+1} ${}^ip^a{}_x$	Active_x Inactive_{x+1} ${}^ap^i{}_x$	Active_x Active_{x+1} ${}^ap^a{}_x$	Total l_x	Inactive ${}^il_x$	Active ${}^al_x$	Total L_x	Inactive ${}^iL_x$	Active ${}^aL_x$
20	0.87420	0.12215	0.53387	0.46248	91,404	78,830	12,574	91,238	77,228	14,009
21	0.86915	0.12680	0.51299	0.48297	91,071	75,626	15,445	90,887	74,640	16,247
22	0.82846	0.16714	0.48297	0.51263	90,702	73,653	17,049	90,503	71,453	19,050
23	0.79510	0.20019	0.44156	0.55372	90,303	69,253	21,050	90,090	66,805	23,285
24	0.76710	0.22792	0.41666	0.57836	89,877	64,357	25,519	89,653	62,179	27,474
25	0.73956	0.25524	0.38091	0.61389	89,429	60,001	29,428	89,197	57,793	31,404
26	0.71193	0.28271	0.34782	0.64683	88,965	55,584	33,380	88,726	53,383	35,343
27	0.69352	0.30100	0.32532	0.66921	88,488	51,182	37,306	88,246	49,407	38,839
28	0.67763	0.31679	0.30445	0.68997	88,004	47,632	40,371	87,758	46,100	41,658
29	0.66730	0.32707	0.28518	0.70920	87,513	44,568	42,945	87,267	43,278	43,989
30	0.66399	0.33034	0.26696	0.72737	87,021	41,987	45,033	86,774	40,944	45,830
31	0.66660	0.32767	0.25255	0.74172	86,528	39,901	46,626	86,280	39,138	47,142
32	0.67544	0.31872	0.23517	0.75900	86,032	38,374	47,658	85,781	37,751	48,030
33	0.67846	0.31552	0.21976	0.77422	85,530	37,127	48,403	85,272	36,477	48,796
34	0.67543	0.31828	0.21255	0.78116	85,015	35,826	49,189	84,748	35,240	49,508
35	0.66921	0.32414	0.20703	0.78631	84,480	34,653	49,827	84,199	34,080	50,119
36	0.67165	0.32128	0.19738	0.79555	83,918	33,506	50,412	83,621	32,980	50,641
37	0.68245	0.31002	0.19075	0.80173	83,325	32,454	50,870	83,011	32,153	50,858
38	0.68268	0.30932	0.19289	0.79911	82,698	31,852	50,846	82,367	31,702	50,665
39	0.68260	0.30892	0.19546	0.79606	82,036	31,552	50,484	81,688	31,479	50,210
40	0.68115	0.30988	0.19988	0.79115	81,341	31,405	49,935	80,975	31,389	49,587
41	0.67497	0.31552	0.21571	0.77478	80,610	31,372	49,238	80,227	31,584	48,642
42	0.68691	0.30298	0.22521	0.76468	79,844	31,797	48,047	79,440	32,229	47,211
43	0.69681	0.29240	0.22727	0.76195	79,036	32,662	46,374	78,610	32,980	45,630
44	0.70185	0.28659	0.22882	0.75963	78,184	33,299	44,885	77,732	33,470	44,262
45	0.69864	0.28893	0.22323	0.76435	77,280	33,641	43,639	76,800	33,443	43,357
46	0.69915	0.28746	0.22566	0.76095	76,320	33,245	43,075	75,809	33,104	42,705
47	0.71285	0.27270	0.22978	0.75576	75,298	32,963	42,334	74,753	33,094	41,659
48	0.72873	0.25566	0.23002	0.75437	74,209	33,226	40,984	73,630	33,432	40,197
49	0.74662	0.23653	0.22503	0.75811	73,051	33,639	39,411	72,435	33,812	38,623
50	0.74992	0.23189	0.20772	0.77409	71,819	33,985	37,835	71,166	33,665	37,501

Age	Probability transitions age x to $x+1$				Stationary population in each status			Person years lived in each status		
x	Inactive$_x$ Inactive$_{x+1}$ ${}^ip^i{}_x$	Inactive$_x$ Active$_{x+1}$ ${}^ip^a{}_x$	Active$_x$ Inactive$_{x+1}$ ${}^ap^i{}_x$	Active$_x$ Active$_{x+1}$ ${}^ap^a{}_x$	Total l_x	Inactive ${}^il_x$	Active ${}^al_x$	Total L_x	Inactive ${}^iL_x$	Active ${}^aL_x$
51	0.73615	0.24425	0.19046	0.78995	70,513	33,345	37,168	69,822	32,485	37,337
52	0.73195	0.24698	0.18713	0.79179	69,131	31,626	37,506	68,403	30,896	37,506
53	0.74505	0.23233	0.19208	0.78530	67,674	30,167	37,507	66,909	29,924	36,985
54	0.75169	0.22408	0.19577	0.78001	66,144	29,680	36,463	65,343	29,565	35,778
55	0.74971	0.22439	0.19315	0.78095	64,541	29,449	35,093	63,706	29,152	34,553
56	0.76121	0.21112	0.19818	0.77416	62,870	28,856	34,014	62,000	28,781	33,219
57	0.76762	0.20286	0.20230	0.76818	61,130	28,706	32,424	60,228	28,651	31,577
58	0.77491	0.19361	0.21348	0.75504	59,326	28,595	30,731	58,392	28,657	29,735
59	0.79524	0.17120	0.23284	0.73360	57,458	28,719	28,740	56,494	29,124	27,370
60	0.80842	0.15581	0.24881	0.71543	55,530	29,530	26,000	54,537	29,936	24,601
61	0.82494	0.13696	0.27808	0.68382	53,544	30,342	23,202	52,524	30,912	21,612
62	0.83116	0.12826	0.27992	0.67951	51,504	31,482	20,022	50,459	31,627	18,832
63	0.84547	0.11134	0.28872	0.66810	49,414	31,771	17,643	48,347	31,863	16,484
64	0.86246	0.09159	0.29957	0.65448	47,280	31,955	15,325	46,194	32,053	14,141
65	0.86398	0.08716	0.30203	0.64911	45,108	32,151	12,957	44,006	31,921	12,085

APPENDIX C3
Males with less than Grade 12

Age	Various whole life expectancies			Present value of 1 to age 65		
x	Life expectancy	Inactive life expectancy	Active life expectancy	Mortality only basis	Active basis	Implied contingency deduction
20	43.02	24.30	18.72	23.59	11.34	52%
21	42.18	23.54	18.64	23.26	11.32	51%
22	41.35	22.81	18.53	22.92	11.40	50%
23	40.53	22.12	18.40	22.58	11.50	49%
24	39.72	21.48	18.23	22.24	11.57	48%
25	38.91	20.90	18.02	21.90	11.61	47%
26	38.11	20.36	17.76	21.55	11.60	46%
27	37.32	19.86	17.45	21.19	11.55	45%
28	36.52	19.41	17.11	20.82	11.46	45%
29	35.72	18.99	16.73	20.45	11.33	45%
30	34.92	18.60	16.32	20.06	11.17	44%
31	34.12	18.24	15.88	19.67	10.97	44%
32	33.31	17.89	15.42	19.26	10.76	44%
33	32.50	17.55	14.95	18.84	10.52	44%
34	31.70	17.23	14.47	18.41	10.27	44%
35	30.89	16.92	13.98	17.98	10.00	44%
36	30.10	16.63	13.47	17.54	9.72	45%
37	29.31	16.35	12.96	17.09	9.41	45%
38	28.53	16.08	12.44	16.63	9.10	45%
39	27.75	15.83	11.93	16.17	8.78	46%
40	26.99	15.57	11.41	15.69	8.45	46%
41	26.23	15.33	10.90	15.22	8.11	47%
42	25.47	15.08	10.39	14.73	7.78	47%
43	24.73	14.82	9.90	14.23	7.45	48%
44	23.99	14.56	9.43	13.73	7.13	48%
45	23.27	14.30	8.97	13.22	6.81	48%
46	22.55	14.04	8.51	12.70	6.50	49%
47	21.85	13.79	8.06	12.18	6.18	49%
48	21.17	13.55	7.62	11.64	5.85	50%
49	20.49	13.31	7.19	11.10	5.54	50%
50	19.84	13.06	6.77	10.55	5.23	50%

Age	Various whole life expectancies			Present value of 1 to age 65		
x	Life expectancy	Inactive life expectancy	Active life expectancy	Mortality only basis	Active basis	Implied contingency deduction
51	19.19	12.83	6.36	10.00	4.92	51%
52	18.57	12.62	5.95	9.43	4.60	51%
53	17.96	12.43	5.53	8.85	4.25	52%
54	17.36	12.27	5.09	8.26	3.89	53%
55	16.78	12.11	4.67	7.65	3.53	54%
56	16.21	11.97	4.24	7.02	3.16	55%
57	15.66	11.84	3.82	6.37	2.78	56%
58	15.12	11.72	3.40	5.70	2.40	58%
59	14.60	11.60	3.00	5.01	2.01	60%
60	14.09	11.48	2.61	4.28	1.63	62%

APPENDIX D1
Males with Grade 12 or more

Age	Population counts at age x			Population transitions age x to $x+1$				Probability transitions age x to $x+1$		
x	Population$_x$ N_x	Inactive$_x$ ^iN_x	Active$_x$ ^aN_x	Inactive$_x$ Inactive$_{x+1}$ $^iN^i_x$	Inactive$_x$ Active$_{x+1}$ $^iN^a_x$	Active$_x$ Inactive$_{x+1}$ $^aN^i_x$	Active$_x$ Active$_{x+1}$ $^aN^a_x$	Living$_x$ Dead$_{x+1}$ $^*p^d_x$	Inactive$_x$ Inactive$_{x+1}$ $^ip^i_x$	Active$_x$ Active$_{x+1}$ $^ap^a_x$
20	259,489	228,250	31,239	139,402	88,848	14,678	16,561	0.00204	0.58167	0.50411
21	274,858	218,206	56,652	149,256	68,950	21,855	34,797	0.00220	0.64513	0.58306
22	284,702	233,419	51,283	175,800	57,619	15,198	36,085	0.00231	0.71809	0.65520
23	271,738	201,440	70,298	148,385	53,055	19,983	50,315	0.00237	0.74373	0.70895
24	285,706	167,711	117,995	117,317	50,394	31,545	86,450	0.00238	0.71805	0.72461
25	325,679	200,054	125,625	135,310	64,744	29,756	95,869	0.00236	0.68530	0.74661
26	275,503	152,002	123,501	101,140	50,862	25,315	98,186	0.00231	0.67007	0.77714
27	312,686	156,408	156,278	100,215	56,193	29,282	126,996	0.00226	0.65141	0.80304
28	289,837	149,322	140,515	91,106	58,216	22,784	117,731	0.00218	0.62442	0.82277
29	277,370	128,016	149,354	77,566	50,450	23,941	125,413	0.00215	0.60687	0.83700
30	255,484	137,192	118,292	81,611	55,581	16,432	101,860	0.00216	0.59890	0.84732
31	302,422	137,638	164,784	83,261	54,377	21,592	143,192	0.00219	0.59859	0.86378
32	239,169	101,735	137,434	60,163	41,572	15,642	121,792	0.00224	0.59782	0.87483
33	242,351	79,196	163,155	46,004	33,192	17,530	145,625	0.00232	0.58542	0.88758
34	237,625	81,313	156,312	49,753	31,560	15,146	141,166	0.00240	0.59515	0.89556
35	229,861	78,663	151,198	48,643	30,020	13,944	137,254	0.00250	0.61353	0.90314
36	259,967	97,417	162,550	62,400	35,017	16,718	145,832	0.00263	0.62899	0.89990
37	270,203	80,096	190,107	52,611	27,485	18,676	171,431	0.00278	0.64611	0.89714
38	195,302	80,464	114,838	52,397	28,067	10,081	104,757	0.00295	0.65208	0.90303
39	259,161	77,475	181,686	49,241	28,234	15,647	166,039	0.00316	0.64149	0.91035
40	200,737	50,859	149,878	31,675	19,184	11,632	138,246	0.00340	0.62837	0.91461
41	230,996	59,773	171,223	39,122	20,651	12,711	158,512	0.00367	0.63758	0.92080
42	241,503	57,475	184,028	38,554	18,921	13,080	170,948	0.00398	0.65985	0.92371
43	202,027	44,639	157,388	28,218	16,421	12,127	145,261	0.00433	0.65106	0.92215
44	184,212	40,406	143,806	26,710	13,696	11,209	132,597	0.00473	0.64282	0.91816
45	186,815	50,101	136,714	32,647	17,454	8,022	128,692	0.00518	0.65244	0.92662
46	185,647	55,078	130,569	35,009	20,069	7,444	123,125	0.00568	0.63959	0.93679
47	170,242	46,553	123,689	31,102	15,451	6,316	117,373	0.00625	0.64643	0.93997
48	166,333	31,197	135,136	22,854	8,343	7,553	127,583	0.00689	0.68918	0.93990
49	113,240	18,526	94,714	13,238	5,288	5,029	89,685	0.00761	0.72033	0.93807
50	132,776	31,866	100,910	22,613	9,253	5,696	95,214	0.00841	0.70545	0.93722

Age	Population counts at age x			Population transitions age x to $x+1$				Probability transitions age x to $x+1$		
x	Population$_x$ N_x	Inactive$_x$ ${}^iN_x$	Active$_x$ ${}^aN_x$	Inactive$_x$ Inactive$_{x+1}$ ${}^iN^i_x$	Inactive$_x$ Active$_{x+1}$ ${}^iN^a_x$	Active$_x$ Inactive$_{x+1}$ ${}^aN^i_x$	Active$_x$ Active$_{x+1}$ ${}^aN^a_x$	Living$_x$ Dead$_{x+1}$ ${}^*p^d_x$	Inactive$_x$ Inactive$_{x+1}$ ${}^ip^i_x$	Active$_x$ Active$_{x+1}$ ${}^ap^a_x$
51	135,238	42,007	93,231	30,809	11,198	6,088	87,143	0.00931	0.71643	0.93056
52	135,077	25,502	109,575	19,660	5,842	6,854	102,721	0.01031	0.73989	0.92653
53	133,982	38,346	95,636	28,818	9,528	5,736	89,900	0.01141	0.75062	0.92793
54	106,039	22,608	83,431	17,537	5,071	5,992	77,439	0.01263	0.75089	0.92270
55	107,923	23,975	83,948	19,464	4,511	5,430	78,518	0.01397	0.78321	0.91875
56	78,741	17,530	61,211	14,363	3,167	4,960	56,251	0.01542	0.80243	0.91411
57	102,575	28,642	73,933	23,467	5,175	7,526	66,407	0.01699	0.80541	0.89219
58	70,367	24,513	45,854	21,231	3,282	5,904	39,950	0.01868	0.82520	0.87130
59	66,455	25,745	40,710	22,700	3,045	6,313	34,397	0.02051	0.85619	0.84126
60	51,369	34,454	16,915	30,566	3,888	2,659	14,256	0.02246	0.86496	0.82534
61	59,205	33,425	25,780	29,723	3,702	4,377	21,403	0.02455	0.86638	0.81469
62	56,861	28,551	28,310	25,952	2,599	5,237	23,073	0.02680	0.87426	0.80021
63	58,029	31,218	26,811	28,620	2,598	5,156	21,655	0.02920	0.88639	0.78776
64	55,204	40,100	15,104	37,423	2,677	3,395	11,709	0.03176	0.89662	0.77071
65	50,569	38,081	12,488	35,539	2,542	2,807	9,681	0.03449	0.90106	0.74846

APPENDIX D2
Males with Grade 12 or more

Age	Probability transitions age x to $x+1$				Stationary population in each status			Person years lived in each status		
x	Inactive$_x$ Inactive$_{x+1}$ $^ip^i{}_x$	Inactive$_x$ Active$_{x+1}$ $^ip^a{}_x$	Active$_x$ Inactive$_{x+1}$ $^ap^i{}_x$	Active$_x$ Active$_{x+1}$ $^ap^a{}_x$	Total l_x	Inactive ^il_x	Active ^al_x	Total L_x	Inactive ^iL_x	Active ^aL_x
20	0.58167	0.41629	0.49385	0.50411	97,503	51,351	46,152	97,404	52,006	45,397
21	0.64513	0.35267	0.41475	0.58306	97,304	52,662	44,643	97,197	52,575	44,622
22	0.71809	0.27960	0.34249	0.65520	97,090	52,489	44,601	96,978	52,728	44,250
23	0.74373	0.25390	0.28868	0.70895	96,866	52,967	43,899	96,751	52,517	44,235
24	0.71805	0.27957	0.27301	0.72461	96,636	52,066	44,570	96,521	50,810	45,711
25	0.68530	0.31234	0.25103	0.74661	96,406	49,554	46,852	96,292	47,637	48,655
26	0.67007	0.32761	0.22055	0.77714	96,178	45,721	50,458	96,067	43,743	52,325
27	0.65141	0.34633	0.19470	0.80304	95,956	41,765	54,191	95,848	39,761	56,087
28	0.62442	0.37340	0.17505	0.82277	95,739	37,757	57,982	95,635	35,741	59,894
29	0.60687	0.39098	0.16085	0.83700	95,531	33,726	61,805	95,428	32,067	63,361
30	0.59890	0.39894	0.15052	0.84732	95,325	30,409	64,917	95,222	29,196	66,027
31	0.59859	0.39922	0.13403	0.86378	95,119	27,983	67,136	95,015	26,866	68,149
32	0.59782	0.39993	0.12293	0.87483	94,911	25,749	69,162	94,805	24,822	69,983
33	0.58542	0.41226	0.11010	0.88758	94,698	23,895	70,803	94,589	22,840	71,749
34	0.59515	0.40245	0.10204	0.89556	94,479	21,784	72,695	94,366	21,084	73,282
35	0.61353	0.38397	0.09436	0.90314	94,252	20,383	73,870	94,134	19,929	74,205
36	0.62899	0.36839	0.09747	0.89990	94,016	19,476	74,541	93,893	19,496	74,397
37	0.64611	0.35112	0.10009	0.89714	93,769	19,515	74,254	93,639	19,778	73,861
38	0.65208	0.34497	0.09402	0.90303	93,509	20,041	73,468	93,371	20,008	73,363
39	0.64149	0.35535	0.08649	0.91035	93,233	19,976	73,257	93,086	19,563	73,523
40	0.62837	0.36824	0.08199	0.91461	92,939	19,150	73,788	92,781	18,617	74,164
41	0.63758	0.35875	0.07553	0.92080	92,623	18,084	74,539	92,453	17,622	74,831
42	0.65985	0.33617	0.07231	0.92371	92,283	17,160	75,123	92,100	16,958	75,142
43	0.65106	0.34460	0.07351	0.92215	91,916	16,755	75,161	91,717	16,595	75,122
44	0.64282	0.35245	0.07711	0.91816	91,518	16,434	75,084	91,301	16,394	74,907
45	0.65244	0.34239	0.06820	0.92662	91,085	16,354	74,731	90,849	16,060	74,789
46	0.63959	0.35473	0.05753	0.93679	90,613	15,767	74,847	90,356	15,079	75,277
47	0.64643	0.34732	0.05378	0.93997	90,099	14,390	75,708	89,817	13,882	75,935
48	0.68918	0.30393	0.05322	0.93990	89,536	13,374	76,162	89,227	13,322	75,905
49	0.72033	0.27206	0.05433	0.93807	88,919	13,270	75,649	88,581	13,469	75,112
50	0.70545	0.28614	0.05437	0.93722	88,243	13,669	74,574	87,872	13,683	74,189

Age	Probability transitions age x to $x+1$				Stationary population in each status			Person years lived in each status		
x	Inactive$_x$ Inactive$_{x+1}$ ${}^ip^i{}_x$	Inactive$_x$ Active$_{x+1}$ ${}^ip^a{}_x$	Active$_x$ Inactive$_{x+1}$ ${}^ap^i{}_x$	Active$_x$ Active$_{x+1}$ ${}^ap^a{}_x$	Total l_x	Inactive ${}^il_x$	Active ${}^al_x$	Total L_x	Inactive ${}^iL_x$	Active ${}^aL_x$
51	0.71643	0.27426	0.06013	0.93056	87,501	13,697	73,804	87,093	13,974	73,119
52	0.73989	0.24980	0.06316	0.92653	86,686	14,251	72,435	86,239	14,685	71,554
53	0.75062	0.23797	0.06065	0.92793	85,792	15,119	70,673	85,303	15,377	69,926
54	0.75089	0.23647	0.06467	0.92270	84,813	15,635	69,178	84,277	15,924	68,353
55	0.78321	0.20283	0.06729	0.91875	83,742	16,214	67,528	83,157	16,728	66,429
56	0.80243	0.18215	0.07048	0.91411	82,572	17,243	65,330	81,936	17,841	64,094
57	0.80541	0.17760	0.09082	0.89219	81,299	18,440	62,859	80,609	19,501	61,108
58	0.82520	0.15612	0.11002	0.87130	79,918	20,561	59,357	79,171	22,029	57,142
59	0.85619	0.12330	0.13823	0.84126	78,425	23,497	54,928	77,621	25,604	52,017
60	0.86496	0.11258	0.15220	0.82534	76,817	27,711	49,106	75,954	29,577	46,377
61	0.86638	0.10907	0.16076	0.81469	75,091	31,443	43,649	74,170	32,851	41,319
62	0.87426	0.09894	0.17299	0.80021	73,248	34,258	38,989	72,266	35,477	36,789
63	0.88639	0.08441	0.18304	0.78776	71,285	36,696	34,589	70,244	37,777	32,467
64	0.89662	0.07162	0.19753	0.77071	69,203	38,858	30,346	68,104	39,846	28,258
65	0.90106	0.06445	0.21705	0.74846	67,005	40,835	26,170	65,850	41,655	24,195

APPENDIX D3
Males with Grade 12 or more

Age	Various whole life expectancies			Present value of 1 to age 65		
x	Life expectancy	Inactive life expectancy	Active life expectancy	Mortality only basis	Active basis	Implied contingency deduction
20	49.95	20.09	29.86	25.43	17.32	32%
21	49.05	19.59	29.46	25.10	17.34	31%
22	48.16	19.09	29.06	24.77	17.34	30%
23	47.27	18.59	28.67	24.44	17.36	29%
24	46.38	18.10	28.28	24.09	17.37	28%
25	45.49	17.61	27.88	23.74	17.37	27%
26	44.59	17.16	27.44	23.38	17.33	26%
27	43.70	16.74	26.95	23.00	17.25	25%
28	42.79	16.36	26.43	22.62	17.13	24%
29	41.89	16.03	25.86	22.22	16.97	24%
30	40.97	15.72	25.25	21.81	16.75	23%
31	40.06	15.45	24.61	21.39	16.51	23%
32	39.15	15.20	23.95	20.96	16.23	23%
33	38.24	14.97	23.26	20.52	15.93	22%
34	37.32	14.77	22.56	20.07	15.59	22%
35	36.41	14.58	21.83	19.61	15.23	22%
36	35.50	14.40	21.10	19.13	14.85	22%
37	34.59	14.23	20.36	18.65	14.46	22%
38	33.69	14.06	19.63	18.15	14.07	23%
39	32.79	13.89	18.90	17.65	13.66	23%
40	31.89	13.72	18.17	17.13	13.25	23%
41	31.00	13.57	17.43	16.61	12.82	23%
42	30.11	13.43	16.68	16.07	12.36	23%
43	29.23	13.30	15.93	15.52	11.90	23%
44	28.35	13.17	15.18	14.97	11.41	24%
45	27.48	13.05	14.43	14.40	10.92	24%
46	26.63	12.95	13.68	13.82	10.42	25%
47	25.77	12.85	12.92	13.23	9.89	25%
48	24.93	12.78	12.16	12.63	9.35	26%
49	24.10	12.72	11.39	12.02	8.78	27%
50	23.28	12.66	10.62	11.40	8.21	28%

Age	Various whole life expectancies			Present value of 1 to age 65		
x	Life expectancy	Inactive life expectancy	Active life expectancy	Mortality only basis	Active basis	Implied contingency deduction
51	22.48	12.61	9.86	10.77	7.63	29%
52	21.68	12.57	9.11	10.12	7.04	30%
53	20.90	12.53	8.37	9.47	6.44	32%
54	20.14	12.49	7.65	8.80	5.85	34%
55	19.39	12.46	6.93	8.11	5.24	35%
56	18.66	12.44	6.22	7.41	4.63	37%
57	17.94	12.41	5.53	6.70	4.03	40%
58	17.24	12.38	4.86	5.96	3.42	43%
59	16.56	12.34	4.23	5.21	2.84	45%
60	15.90	12.26	3.64	4.42	2.28	48%