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National Centre for Social and Economic Modelling  
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## **APPSIM – Modelling the Labour Force**

**Marcia Keegan**

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## **About NATSEM**

The National Centre for Social and Economic Modelling was established on 1 January 1993, and supports its activities through research grants, commissioned research and longer term contracts for model maintenance and development with the federal departments of Families, Community Services and Indigenous Affairs, Employment and Workplace Relations, Treasury, and Education, Science and Training.

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## Abstract

This paper has been prepared as the fourth in a series of papers associated with the development of the Australian Population and Policy Simulation Model (APPSIM). The APPSIM dynamic population microsimulation model is being developed as part of an Australian Research Council (ARC) Linkage grant (LP0562493), and will be used by Commonwealth Government policy makers and other analysts to assess the social and fiscal policy implications of Australia's ageing population.

This paper is intended to guide the development of the labour market module of APPSIM. It considers the future aggregate impacts on the labour market that have been projected by the Australian Treasury and the Productivity Commission, and reviews the features of dynamic microsimulation models that have been developed over the last 20 years. Based on this research, the paper discusses the features necessary for the labour market module to effectively meet the goals of APPSIM – in particular, the need for the labour market module to ultimately include a system of behavioural responses to personal or policy changes.

## Author note

Marcia Keegan is a doctoral candidate at the National Centre for Social and Economic Modelling at the University of Canberra.

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# 1 Introduction

## 1.1 Why dynamic microsimulation?

The Australian Treasury and the Productivity Commission have undertaken large modelling projects to estimate the likely fiscal and social impacts of the ageing population (Treasury 2002 and 2007, Productivity Commission 2005). These reports have found that, over the next 50 years:

- the proportion of retired people in the population will increase,
- the average age of the population will increase;
- the ratio of people in the labour force to the overall population will decrease, resulting in fewer workers supporting a larger number of non-workers; and
- as a result of these factors and assuming current policy remains unchanged, a ‘fiscal gap’ in the Federal Government’s budget will develop, due to the increase in expenditures on pensions and healthcare and slowing growth in taxation revenue due to relatively fewer people in the labour market.

The social and fiscal difficulties likely to face Australia over the next 40-50 years are already well known, so why is there the need for yet another model?

Dynamic microsimulation modelling (DMSM) has become a popular methodological tool for governments and academics. It was pioneered by Guy Orcutt (1957), who proposed a model of interacting individuals to address some of the shortcomings of macroeconomic models. Its use has increased as Western nations face ageing populations and declining birthrates, as it allows modellers to predict the likely future distributional impacts of social and fiscal policies, such as future pensions and healthcare costs (Harding et al. 2007). The focus of DMSM is on how fiscal and social policies affect the future distributional outcomes of individuals, which can then be aggregated to determine overall economic effects, rather than simply focusing on aggregate data. The major benefit of DMSM over conventional modelling is that it can demonstrate the heterogeneity of future populations and the distributional impact of policy, economic and social changes (Klevmarken 2005). In other words, DMSM can measure the impact of changes on specific groups in a population, such as the poor, single parents, the retired etc.

DMSM involves using statistical data on a country’s population to develop a model subset of individuals and households and their characteristics, such as age, education, employment status, marital status and health. The lives of this subset of individuals are updated as time passes in the model. Moving from one characteristic

to another is called an event, and events can include commencing or finishing education, becoming unemployed, finding a new job, getting married or divorced, having a child, moving out of the parental home or retiring. Using existing datasets, modellers can estimate the probability that an individual or household will change one of their characteristics in a certain period of time. A DMSM can then model the lives of hundreds of thousands of individuals over decades into the future as they gain an education, start work, earn and save money, marry, have children, divorce, become unemployed, retire and die.

## 1.2 APPSIM

In collaboration with 13 government agencies, NATSEM is developing the Australian Population and Policy Simulation Model (APPSIM), a model of the Australian population until 2050, to be used in evaluating the impact of future social and fiscal policies. Because the main development driver of the model is to provide a decision support tool for policy makers which will allow them to develop policy that will minimise the costs and maximise the benefits of the ageing population, it must be tailored to represent the particular concerns that arise from the ageing population.

King and Bækgaard noted (1997, p7): “the most fundamental lesson for a dynamic microsimulation modelling exercise is the need for design and development to be clearly related to the purpose of the modelling exercise in terms of intended applications.” The labour market module for APPSIM should therefore be developed to demonstrate how the ageing population will affect the labour market. Retirement, the labour supply decision in a labour-scarce environment and workforce age range must be clearly and accurately modelled.

This paper reviews the labour market modules of existing DMSMs, particularly the elements that are useful in modelling an ageing population. The aim is to determine what form the labour market module should take within APPSIM.

## 2 Expectations on future labour market trends

Three major government reports have been issued over the last five years highlighting the difficulties Australia is likely to face as the percentage of the population over the age of 65 increases, usually referred to as ‘the ageing population’. The Treasury’s first *Intergenerational Report* (IGR) was released in 2002, the second IGR was released in 2007 and the Productivity Commission’s *Economic Implications of an Ageing Australia* was released in 2005. The findings of these reports were similar. The Treasury found that the aged dependency ratio (ratio of people

aged 65+ to people aged 15-64) would increase, from 19 percent in 2002 to almost 42 percent by 2050 (Treasury 2007). As a result, there will be a smaller percentage of the population paying taxes to support a larger percentage of the population who are retired, most of whom will be on full or part pensions. In addition, the greater number of the old (aged 65+) and the oldest old (85+) elderly people is expected to increase the costs of health and aged care (Productivity Commission 2005). Fewer workers paying taxes and more people relying on government support for pensions, aged care and health care means that, if the Australian Government's revenue and expenditure patterns fail to adapt, by 2047 an adjustment to taxes and spending of or 3.5 percent of GDP, will be needed to avoid a budget deficit (Treasury 2007), a reduction in the first IGR's projection of five percent. This estimate was upgraded to 6.4 percent of GDP in the Productivity Commission's report (2005, p321). This is commonly referred to as the fiscal gap. These fiscal pressures are expected to become increasingly apparent as more and more of the baby boomers enter retirement.

## **2.1 Findings of the Intergenerational Report**

The Intergenerational Report projected that male participation trends would continue downward and stabilise, and that female participation rates would increase. People under the age of 20 are more likely now than in the past to work part-time rather than full-time, probably reflecting increased participation in education. Labour force participation rates for both sexes are projected to increase in the 60-64 and 65-69 age groups, reflecting better health among older members of the population and an ability to work longer. Overall, participation rates for people aged 15-64 are expected to rise from 76 percent in 2006-07 to 78 percent by 2046-47 due to an increase in participation of older workers. Participation rates for all persons over 15 are expected to decline from 2008-09 to 57 percent in the latter 2046-47, reflecting the increase in the proportion of the population over 65 and the low participation rates of this group (Treasury 2007).

IGR1 recommended a number of policy directions that could assist in minimising the fiscal gap. These included restraining the Pharmaceutical Benefits Scheme, promoting private saving for retirement, balanced budgets and efficient medical care. Labour force policies designed to promote participation were also strongly recommended in two forms: ensuring the social security safety net does not discourage working age people from working and promoting mature age participation in the workforce (Treasury 2002). IGR2 reports that many of these measures have been undertaken since IGR1 was released.

As a result, the projections from IGR2 are different from those in IGR1. IGR1 was published in 2002, at the very end of a long, steady downward trend in fertility rates from 2.95 in 1971 to 1.73 in 2001. Based on this downward trend, Treasury and the

ABS forecast Australia's fertility rate to decline from 1.75 in 2000 to 1.6 in 2042. However, since 2002 birth rates have rebounded, with the fertility rate reaching 1.81 in 2005 (ABS 2006). As a result, IGR2 projected a fertility rate of 1.7 births per woman (Treasury 2007). Also, since IGR1, the Federal Government has delivered budget surpluses, eliminated net debt, established the Future Fund and made changes to the PBS, so IGR2 contains more positive projections for future government spending. Furthermore, some measures to increase migration, improve productivity and raise labour force participation have been put in place.

## **2.2 Findings of *Economic Implications of an Ageing Australia***

The Productivity Commission's report *Economic Implications of an Ageing Australia* (2005) found that the ageing population is likely to trigger significant changes to the workforce in the future. In addition, some trends that have become apparent over the latter half of the 20th century are projected to continue.

Part-time employment has grown over the last 25 years and is expected to continue to grow as older workers, who have a greater tendency to work part-time, make up an increasing percentage of the labour market. However, adult participation rates will decrease as the population ages from 63.5 percent to 56.3 percent in 2044-45 (Productivity Commission 2005, p47).

Unemployment is likely to be slightly lower due to relatively fewer younger people (who have high unemployment rates) and more older people (who have the option of retiring if they lose their job, so have low unemployment rates). It is expected that there will be labour shortages as the population ages, concentrated in specific industries such as the health profession. These labour shortages are expected to be short term, as the higher wages triggered by a shortage of labour will encourage people back into the labour force from child rearing and retirement, and employers will accept unemployed people for positions they would have previously rejected (Productivity Commission 2005, p69).

Education levels are positively correlated with participation rates (Productivity Commission 2005, p71). Older people are projected to become more educated, as throughout the last half century each generation has been more educated than the one before it. Therefore when today's young become tomorrow's old, they will be more educated than the old of today. Furthermore, people acquire additional education as they age. So if the old in 20 years' time will be more educated than the old of today, it is likely they will have higher participation rates than the old of today (Productivity Commission 2005, p74).

Female participation rates have grown significantly over the last century, while male participation rates have declined. These trends are expected to continue, and it is predicted that female workforce participation patterns will become increasingly similar to those of men.

The number of people unable to participate in the labour force due to disability has increased significantly in recent years. In 1989 there were 307,795 people receiving Disability Support Pension (DSP) (FaCS (Department of Family and Community Services) 2001), while 15 years later in 2004 the number of DSP recipients had more than doubled to 696,742 (FaCSIA (Department of Families Community Services and Indigenous Affairs) 2006). Despite this strong upward trend, the Productivity Commission expects the number of DSP recipients to stabilise and possibly decline due to changes in DSP tests and improved health technology (Productivity Commission 2005, p82).

The Productivity Commission's report was based on population growth assumptions that were slightly different to those in IGR1. The additional two years of data available to the Commission led them to assume that the fertility rate would increase from 1.75 to 1.8 babies per woman by 2013, and that net internal migration would stabilise at higher levels, around 115 000 per annum (p xvi).

The report considered which policies would be significant in minimising the fiscal gap in future decades. It found that population policies such as increasing the birthrate and immigration rate would have little effect on the fiscal gap, and that improving productivity would have a very positive effect. The most relevant finding to this paper was that policies to increase participation rates among all age groups, not just people over 55, are likely to have an appreciable impact on fiscal difficulties associated with the ageing population.

### **2.3 Implications for APPSIM**

The trends projected and the policy changes recommended in these three reports provide guidance for the features that will be required in the labour market module of APPSIM. We believe that overall participation rates are likely to decrease, part-time workers will increase as a share of total workers, female participation is likely to rise relative to male participation, and people over the age of 60 are more likely to continue working, relative to the picture today. We also know that the decisions of individuals about whether or not to participate in the labour force could have a significant impact on the fiscal gap. It is therefore important that the labour market module of APPSIM can appropriately reflect the impact of policies to improve participation rates among both 15-64 year olds and those aged over 65.

### **3 Dynamic microsimulation models of the labour market**

#### **3.1 Characteristics of DMSMs**

##### *Cohort or full cross section*

A cohort model focuses on the entire lives of one or a handful of birth cohorts - for example, the baby boomer cohort born between 1946 and 1961. These models tend to be open, so new individuals are created to support the cohort simulation (eg husbands and wives are simulated for individuals within the cohort). It is also more common for cohort models to simulate their individuals longitudinally - that is, the entire life of an individual is simulated before the next individual's simulation starts. This prevents interaction between individuals in the model, but this is usually not simulated in cohort models (eg Canada's Lifepaths model).

A full cross-section model focuses on a representative cross-section of a whole population at a given time, and models the population from the base year to some fixed year in the future. These models are more likely to be closed (new individuals only enter the model through birth and immigration, and can only leave through death or emigration), and the entire population is simulated for one time period before moving to the next time period, allowing microunits in the model to interact (O'Donoghue 2001).

A major advantage of simulating the entire population is the flexibility. The baby boomer cohort is a major focus of government policy today but that focus could quickly change to another cohort in the future. A full population model could easily handle this change whereas the cohort model could require extensive redevelopment.

##### *Discrete vs continuous time*

Discrete time models age their populations by stepping them through time using a certain time period, such as a month or a year. The probability that a microunit will change characteristics is calculated for that time period, and the population is updated accordingly. The probability that a microunit will change particular characteristics, such as marital or labour force status, from one time period to the next is called the transition probability (O'Donoghue 2001). A common method of using these transition probabilities to update the model from year to year is the

Monte Carlo technique. The computer generates a random number between 0 and 1, and if this number is smaller than the transition probability, the transition occurs. Using the Monte Carlo method to apply this vector of transition probabilities to the population at time  $t$  provides a model of what the population is likely to look like at time  $t+1$  (van Imhoff et al. 1998).

For example, suppose we found from longitudinal Australian data that the probability of a 55 year old male retiring between time period  $t$  and  $t+1$  is 0.1, given his characteristics. If the randomly generated number for this person in period  $t$  is greater than 0.1, he continues to work in period  $t+1$ ; if it is less than 0.1, he retires in period  $t+1$ .

Essentially, a discrete time model considers a person at time  $t+1$  and how their characteristics differ from those at time  $t$ , without consideration at the individual level for the order in which characteristics changed (Galler 1997).

Rather than calculating the likelihood of an event such as change in workforce status or marriage occurring at a given stage in a given year, a continuous time model contains survival functions that determine how long an individual will remain in his current state. The survival functions estimate waiting times for each possible event; that is, how long it will take for an individual to experience a change in one of their characteristics. Once a change in any one of the characteristics occurs, the individual is updated with new characteristics and the time periods until another change in characteristics are recalculated (Statistics Canada 2006).

Consider a 29 year old employed woman in a continuous time model. Given her characteristics, the model calculates that it will be seven years until she changes her labour force status, fourteen months until she gets married and five years until she has a premarital pregnancy. The first event to occur is marriage. Once she marries, the time until she changes any of her characteristics is recalculated. She can no longer have a premarital pregnancy - and because of her change in characteristics she is now due to have a marital pregnancy in 18 months and change her employment status in three years.

One of the claimed advantages of continuous time models is that there is no need for 'tie-breaking', ie calculating which of two events occurs first in a discrete-time simulation (Statistics Canada 2006). For example, if a birth occurs in the same year as a marriage, a continuous time model can clearly simulate which happens first. However, whether this adds a great deal to the simulation is uncertain, as most discrete time models allocate a logical order in which events occur within the time period. If the time period is short enough, it is unlikely that two events will regularly happen to one individual in one time period.

It is acknowledged that the usefulness of continuous time modelling may depend on the subject to be analysed. For example, modelling the use/accumulation of sick leave or annual leave is more accurate in a continuous time model. When measuring things like the decision about when to give up work/go back to work due to a baby's birth, a discrete time model with one month as a time unit may be more useful. For a model to analyse the public pension system, in which pensions are accumulated over a person's whole employment life, a discrete time approach with one year as the time unit appears to be satisfactory. Supporting this conclusion is the recent international literature review by Cassells et al (2006), which found that the most widely used dynamic population microsimulation models in the world today use a discrete time approach.

A major limitation of continuous models relative to discrete time models is that the former have greater data requirements (van Imhoff et al. 1998). Longitudinal data are required for both continuous and discrete time models. However, some longitudinal datasets may not show the duration of an event, which is necessary to develop survival functions in continuous time models. For example, a longitudinal dataset collected annually might show an individual was married in 2001 and separated in 2003, and that he became employed in 2002 and left that job in 2003. One may conclude that his marriage lasted longer than his job. But if he married in December 2001 and separated in January 2003, and took his job in January 2002 and left it in December 2003, his job lasted longer than his marriage. Such a dataset would be sufficient for an annual discrete time model, but more detailed information on the duration of events would be needed for a continuous time model. The Australian data needed to estimate survival functions are relatively limited (as discussed below).

### *Behavioural vs arithmetic or probabilistic*

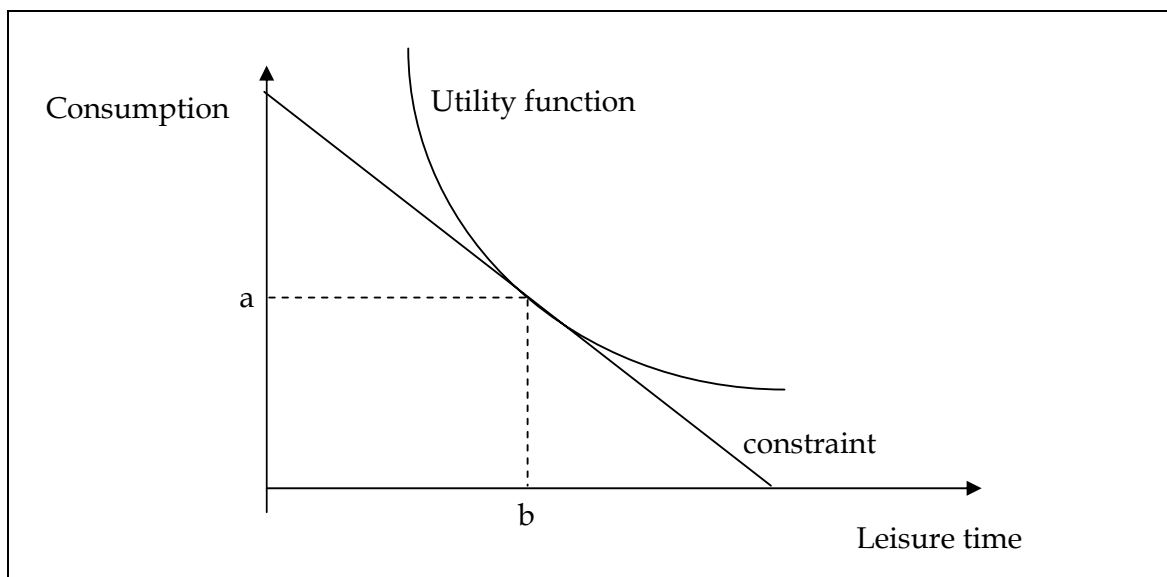
An arithmetic or probabilistic model applies changes in policy to the circumstances of the individuals in the model. Based on each individual or household's socio-demographic profile, it arithmetically derives each unit's new situation based on the change in policy. What it does not do is simulate how individuals might change their behaviour as a result of that change in policy (Bourguignon et al. 2006).

A behavioural approach to microsimulation uses economic theory to determine how changes in the economy or society affect particular behaviours of individuals in the model (O'Donoghue 2001). This approach results in policy and parameter changes having first and second round effects: the immediate impacts of the change that can be calculated arithmetically, and the second round behavioural effects when individuals change their behaviour as a result of the impact of the first round change. Take as an example the experience of an employed mother with two children who

also receives a welfare payment, when the government significantly tightens the means-test for the welfare payment. The first round effect is that she experiences a reduction in her disposable income. A second round effect may occur if she reduces her working hours because the means-tested welfare benefit means her disposable income declines very little when she works less. The labour supply decision is the most common application of the behavioural approach (Klevmarken 1997).

Developing a behavioural model of labour supply is based on the treatment of leisure time<sup>1</sup> as a consumption good that must be paid for like any other. Instead of the individual using earnings to directly purchase a consumption good, he indirectly pays for leisure by choosing to spend fewer hours working and forgoing wages. The budget constraint is then determined not only by his income, but by the hours available for work (Becker 1965). The individual then chooses his hours of work, and implicitly his consumption level, to maximise his utility. Figure 1 shows the utility function and budget constraint of an individual who consumes  $a$  and has  $b$  hours of leisure.

Figure 1 **Utility Function and Budget constraint on an Individual**



Data source: (Becker 1965)

This is a stylised version of the utility function and the constraint. Note the gradient of the constraint (called the marginal return on labour) is constant – this can only occur if the individual's only income is wages and they are subject to no tax or a

<sup>1</sup> Leisure is classified as any time not spent in paid employment. It includes time spent in unpaid work, such as housework, voluntary work and childcare; activities essential for wellbeing such as eating and sleeping and time spent on activities incidental to work, such as getting dressed and transporting oneself to work.

universal flat tax system. In a modern welfare state, the marginal return on the individual's labour changes frequently as they are subject to a progressive tax system, welfare benefits that reduce as income rises and possible receipt of passive income (Creedy et al. 2002).

In most OECD countries, family status has a great impact on the level of benefits an individual is entitled to. Therefore a DMSM behavioural labour supply module needs to establish utility functions and constraints at the household level (Pylkkanen 2000). Different functions are derived for couple households, single individuals and single parent households.

For example, the arithmetic or probabilistic approach would determine the hours worked of a tertiary-educated married couple with two school age children by examining the data records of actual tertiary-educated married couples with school age children and creating a distribution of hours worked for couples with those characteristics. A behavioural approach would establish the husband and wife's initial working hours this way, but would also contain a model of their preferences for income and leisure. If a change in either partner's wage, their non-wage income or childcare availability occurred, the model would estimate the changes in hours worked, childcare used etc in response to this change.

Most 'behavioural' DMSMs will have behavioural components only for certain events in the model. These are usually the events that are most responsive to the policies that the model is intended to evaluate. Labour supply and the retirement decision are popular targets for behavioural modelling, as policy can have a significant impact on these individual decisions. On the other hand, events such as disability and couple formation are largely exogenous with respect to policy and economic events, so no benefit is gained from using behavioural modelling of these events.

### *Links to macro models*

For a range of reasons, the summed total of various types of behaviour in a DMSM may not match other external aggregate data. This may be because the longitudinal sample survey microdata from which the behavioural equations were estimated contained sampling and other errors, because behaviour has changed somewhat since the longitudinal microdata was collected, or due to Monte Carlo variability. For this reason, some micro models choose to align certain aggregate outcomes with those of either an internal or external macro model, to ensure simulations replicate known benchmarks such as the age structure and distribution of the population.

One of the simplest ways to align a DMSM to a macro model is to select aggregate projections that have already been generated by a macro model and align the

outcomes of the DMSM to that model. For example, the outcomes from the demographic module could be aligned with pre-existing demographic projections. Alternatively, a DMSM and a macro model could be run side by side, with the output of each model feeding back into the other. A more complicated method would involve incorporating firms and other institutions into the DMSM.

Although aligning the DMSM to a macro model adds an additional layer of complexity, it can have some benefits. Firstly, the lack of microdata relative to macrodata means that often a DMSM must be created based on only a few years of microdata. A macro model, however, may have decades of reliable data from which to draw its projections. In this scenario, the macro model is perceived to project aggregate data more accurately. Secondly, Monte Carlo variation in a purely micro model can result in macro outcomes that differ with each run of the model (van Imhoff et al. 1998). Aligning the outcomes to macro aggregates reduces this problem.

Table 1 summarises some of the main features of the models reviewed in the following sections of this paper.

Table 1 Selected Features of Major Dynamic Microsimulation models

	Explanatory variables	Labour force states	Micro/ macro link	Time unit for labour force	Other labour force distinctions	Retirement age	Basis of initial population
<b>DYNAMOD</b>	Age, sex, education, marital status, presence and ages of children, current studies, season	FT, PT, NILF, UE	Can be aligned with exogenous labour market aggregates	Monthly (hours per year for full-time students)	Public/private sector, industry, occupation, employment status (wage earner, self employed etc)	45+	Based on 1% of the population from 1986 census
<b>DYNASIM3</b>	Age, sex, education, race, South, disability, marital status, children, studentship, spouse earnings	Hours per year plus UE	Employment rates aligned with OASDI Trustees Report	Hours per year	Tenure, industry, pension coverage	50-80	Based on a sample of 100 000 people from Survey of Income and Program Participation (SIPP) panels
<b>DYNACAN</b>	Age, sex, education, disability, family structure, work history, retirement status	0, 1-47 or 48+ weeks worked per year	Macro outcomes are aligned with those of ACTUCAN, a macro model for pension plans	Weekly	Employee or self employed	60+	Based on 1% of 1971 Census Public Use Files (Families and Individuals)
<b>Lifepaths</b>	Current job duration, age, sex, province, education, children, spouse, spouse's employment	Employed, self employed, not employed	Micro only	Monthly	Student employment, career employment, maternity leave	60+	Synthetic
<b>SAGE</b>	Age, sex, family status, children, employment history, job type, industry, health status, sector, occupation, industry	FT, PT, UE, NILF	Micro only	Quarterly	Industry, sector, employee or self employed, occupation	64	Based on 0.1% of the population from the 1991 Census
<b>MOSART</b>	Age, sex, children, marital status, education, pension status, disability, previous year's LF participation	No status, only labour force participation rate	Micro only initially, has been linked to Norwegian CGE model	Hours per year	None	67	Real based on 1% of population from administrative data from National Insurance Scheme
<b>SESIM</b>	Age, sex, education, children, spouse's employment, preferences for leisure, size of town, nation of	0-3000 hours of work per year, choice of 250-hr brackets, UE, sick	Can implement exogenous assumptions and forecasts, eg unemployment and	Hours per year	Blue/white collar, private/government/ self employed (for earnings calculations only)	Up to 65	Based in 3.5% of population drawn from longitudinal dataset Linda (based on administrative records)

	birth, work/UE in previous year	leave	demography				
<b>PENSIM (USA)</b>	Age, sex, education, prior job characteristics	FT, PT, UE, NILF	Macro link with SSASIM macro model and GEMINI social security and pension taxes model	continuous	Industry, unionisation, job hours, initial job earnings, firm size, employer pension sponsorships	62-68	1996-98 establishment data from Bureau of Labour Statistics Employee Benefit Survey, on which synthetic lives are based

Source: See section 3.2 – 3.9

### 3.2 DYNAMOD

DYNAMOD is a dynamic microsimulation model of the Australian population developed by the National Centre for Social and Economic Modelling (NATSEM). It has been through three stages of development. The first stage commenced in 1992, and its purpose was to assess the impact of income-contingent student loans from the Federal Government. It simulated the life of one percent of the Australian population, or 150 000 people, for fifty years. It used the 1986 Census of Population and Housing as its base data (Antcliff 1993).

DYNAMOD is a female dominant closed model. It incorporates mortality, fertility, couple formation and dissolution, education, migration, labour force participation and income. It uses a pseudocontinuous time approach, in which events such as mortality are modelled continuously, while events such as labour force participation are modelled monthly and education is modelled annually.

Due to a short timeframe for development and staffing issues, development in the first version of DYNAMOD stalled in 1995. A review of the plans for DYNAMOD and hiring of new staff allowed development to continue, and DYNAMOD-2 was completed in 1997. It used 1986 census data to develop a population of around 150000. The older data set was used so more recent censuses could be used to calibrate the model (King et al. 1999). Since then, it has been updated further to include wealth, superannuation, taxes and government transfers. Demographic and labour force alignments, and accounting of labour force and earnings has been improved (Cassells et al. 2006). The latest version is DYNAMOD-3.

Individuals in DYNAMOD-3 can fall into one of four labour force states: full-time employed (at least 35 hours per week) part-time employed (less than 35 hours per week), unemployed or not in the labour force. Individuals in the model go through labour force transitions every month. First DYNAMOD-3 calculates whether an individual will be employed, unemployed or not in the labour force. If the individual is deemed to be employed, the model then calculates whether she will work full-time or part-time.

Those individuals who are employed are further classified according to the following criteria:

- Sector of employment (public or private)
- Industry (manufacturing, agriculture or services)
- Occupation (manager, professional, trade, sales, labourer)
- Employment status (wage or salary earner, employer, other self employed, unpaid family helper) (King et al. 1999)

These classifications are allocated when a person enters the labour force, and do not change throughout the individual's life. The model assumes that all self employed workers are full-time. Six labour force transition equations are used, for males and females aged 15-24, 25-44 and 45+. There are only two classifications for hours worked due to the absence of data on exact hours worked.

The factors that affect transitions from one labour force status to another can vary with age. They include age, sex, marital status, presence and ages of children, current studies, education level, the season, the industry or occupation of the person, whether they are an employee or self employed, the proportion of people working part-time and unemployment rates at the time (Kelly 2003).

The employment characteristics of full-time students are different to those of other workers. For each full-time student, the model simulates whether or not the individual works, and if he does, simulates the average hourly wage and the annual number of hours worked.

The data on which the model is based can only provide accurate estimates of the future labour force in similar economic conditions – eg if the data was collected during a period of fast growth, without manipulation it cannot provide an accurate view of what the labour market would be like in a recession. DYNAMOD-3 contains a facility to align labour force employment, unemployment and NILF levels according to exogenously specified aggregates. The labour market aggregates used are male and female participation rates and unemployment rates.

Individuals within DYNAMOD-3 are considered for retirement from age 45 onwards. The decision to retire is considered by each individual once per year in July. It is based on superannuation data from the ABS and eligibility for the age pension (65 for men and 60-65 for women). However, within the model it is possible for people to continue working past pension age (Kelly 2003). An individual is forced to retire if they spent 10 months out of the labour force in the previous year. Once a person retires they are considered retired forever.

### 3.3 DYNASIM

The first version of DYNASIM was built at the Urban Institute in the 1970s. It was updated and developed into DYNASIM-2 in the early 1980s to model future retirement incomes. DYNASIM3 is the most recent version of the model and it is a closed, discrete-time arithmetic model with a standard time unit of one year.

DYNASIM3 updated the previous version by using newer data from the 1990-93 Survey of Income and Program Participation Panels (SIPP). The base dataset included over 100 000 individuals and 44 000 families. The model is broken down into three sectors; demographics, economics and taxes and benefits. The demographic sector covers population growth, family formation, education and health; the economic sector includes labour force participation, earnings, job changes, pension and asset accumulation; the taxes and benefits sector includes pension benefits, old age and disability insurance and payroll taxes (Favrealt et al. 2004).

The labour force module of DYNASIM3 first allocates a labour force participation status to all individuals between 16 and 80. For those individuals allocated to work, the model then estimates annual hours worked and the hourly wage rate. Labour force participation, hours worked and wage estimates are based on transition probabilities derived from the Panel Study of Income Dynamics (PSID) and the National Longitudinal Survey of Youth (NLSY). The module uses separate equations for sex, age groups and race (black and non-black). In addition to these, factors that are deemed to affect labour force participation in DYNASIM3 are marital status, education levels, whether one is from the South or not, disability status, current educational activities and the presence and ages of children (Anderson 2001). An individual's job tenure has an effect on how long they are likely to remain in that job in the future and their type of pension coverage, but it does not have an impact on hours worked or unemployment (Zaidi et al. 2001). No distinction between employees and self-employed is modelled explicitly.

Since pensions in the United States depend on labour force participation, synthetic employment histories for those already in the labour market need to be modelled. Synthetic work histories are taken from PENSIM, which are assigned based on characteristics at the time of the SIPP interview (when the base data was collected): age, gender, industry, tenure, pension coverage and pension type. Employment rates generated by DYNASIM3 are aligned with the projections from the OASDI Trustees Report (Favrealt et al. 2004). The probability of an individual being unemployed is based on unemployment probabilities from a cross-tabulation of PSID pooled data (Zedlewski 1990).

At age 50, individuals are subject to the possibility of retirement, and they remain so up to 80 years of age (Favrealt et al. 2004). This makes DYNASIM3 one of the most

flexible of the DMSMs considered here in modelling retirement decisions, with a 30 year window in which retirement is possible but not mandatory (in contrast with other DMSMs, which have a window of as little as 4-5 years in which individuals can require.) Unlike most other models in which retirement is considered a permanent state, an individual who retires may re-enter the workforce at any time up to age 80.

### 3.4 DYNACAN

DYNACAN commenced development in 1994 in Canada's Office of the Superintendent of Financial Institutions. It was built to generate policy and fiscal analyses of the Canada Pension Plan (CPP), a mandatory, public, pay as you go pension scheme. It was a derivative of the CORSIM model from the United States, created at Cornell University.

DYNACAN is a discrete-time, open, probabilistic full cross-section model of the Canadian population. The base population is derived from one per cent of the population recorded in the 1971 census. It models mortality, fertility, couple formation and dissolution, education, disability, labour force participation, earnings, pension contributions and migration. Migration is classified as external migration, moving in and out of Canada; and internal migration, moving to and from the Canadian province of Quebec and the rest of Canada (Quebec has a separate pension plan system). The basic units of the model are individuals and families. It simulates the population from 1971 – 1997, and can project it forward to 2100, although it is more common to project until 2030.

DYNACAN consists of three stages. DYNACAN-A assembles data from the census into a single hierarchical database that can be used for longitudinal projection. This data feeds into DYNACAN-B, which applies transition probabilities to the base population to create projections for each individual. Based on the lives of the simulated individuals, DYNACAN-C calculates CPP coverage, CPP contributions and retirement and disability pensions (Morrison et al. 2000).

The outcomes of DYNACAN are aligned with a macroeconomic model of CPP, called ACTUCAN. The Chief Actuary uses ACTUCAN for valuation of the CPP. These two models have companion status, and are closely coordinated to ensure that they are based on common assumptions.

Each year, the labour force participation module in DYNACAN makes three decisions for each individual: firstly, whether the individual will work and if he will be an employee or self-employed; secondly, how many weeks that individual will work during the year and, finally, what the earnings from that work will be. Factors that affect the individual's working pattern include age, sex, educational attainment,

disability, family structure, previous work and earnings history and retirement status. In addition, to ensure that the model did not solely predict earnings within an ordinary range, certain individuals were assigned a 'permanent luck' variable which allowed their earnings to diverge from values that would otherwise be predicted (Anderson 2001).

There is no distinction in DYNACAN between the unemployed and those not in the labour force. Instead, the annual weeks worked and wages for all individuals are dependent on the overall unemployment rate.

DYNACAN is unique in that it assumes a certain portion of women spend most of their lives outside the labour force. When a woman turns 21, she faces a probability of being excluded from future labour force participation. Whether she is one of those women excluded depends on her marital status, children and labour force participation up to that point in her life. This represents women who choose marriage and children over labour force participation. The likelihood of exclusion from the labour force declines over time to reflect the increasing participation of women in the labour market (Morrison et al. 2000).

When an individual reaches age 60, he faces the option of retiring for pension purposes, and begins drawing a pension. Each simulation year from 60 to 64 the individual faces a choice to retire or keep working. By age 65, all individuals are considered retired for pension purposes. Those on a disability pension are assumed to convert their disability pension to a retirement pension at age 65. These figures are aligned with the output of ACTUCAN for age, gender, retirement status and simulation year (Anderson 2001).

### **3.5 PENSIM**

The Office of Policy and Research in the United States Department of Labor commenced work on PENSIM in September 1997. The sole purpose of PENSIM was to analyse the effects of government policy towards employer-sponsored pension plans. For this reason, private savings and social security are not considered in PENSIM.

PENSIM used the Lifepaths method of continuous time simulation, and is capable of simulating the lives of a birth cohort of any given year from 1935. Its base data is drawn from 1996-98 establishment data from Bureau of Labour Statistics Employee Benefit Survey, and synthetic life paths are developed based on that data (Holmer et al. 2006).

PENSIM can be combined with two other models, SSASIM, which simulates macro-demographic and macroeconomic variables against which PENSIM outcomes can be

constrained, and GEMINI, which incorporates social security taxes and benefits into the results.

Employment in PENSIM is calculated to reflect the number of jobs an individual has over their lifetime, not just how much time they spent being employed. There are hazard functions for the time it takes to find the first job, the duration of that job, the waiting period between jobs and the duration of any subsequent jobs. All of these, except for the time taken to find the first job, are continuous time functions. The duration of a job is expressed in terms of the individual's age at commencement and conclusion of the job (eg the individual starts a job at age 25.463 and finishes it at age 31.452.) Individual factors affecting labour market participation include age, sex, schooling, family history, disability, job history and pension participation.

Beginning with the first job, all jobs are imbued with one of six characteristics:

- employer industry (agriculture, mining and construction; product manufacturing; equipment manufacturing; transportation and communication; wholesale trade; retail trade; finance, insurance, real estate and personal services; professional services; government);
- job unionisation (if an individual is covered by a union work agreement or not);
- job hours (less than 35 hours, at least 35 hours per week);
- initial job earnings (continuous);
- employer firm size (1-24 employees, 25-99 employees, 100+ employees);
- and employer pension sponsorship (if the employer provides a pension plan or not) (Holmer et al. 2006).

Each simulated job characteristic is a covariate in the model for future job characteristics. An individual's sex, age and educational attainment at the time of taking their first job.

If an individual becomes disabled (defined in PENSIM as receiving disability insurance), their employment is immediately terminated.

Earnings are adjusted on the anniversary of the commencement of the current job. The adjustment is dependent on macroeconomic variables from SSASIM.

Within the model, individuals begin to consider retiring from age 62. If an individual chooses not to retire at 62, he will reconsider again a year later, and every year after that until he retires. The latest he can retire is age 68. The likelihood of deferring retirement is dependent on age and sex, but not the generosity of pension entitlements (Holmer et al. 2006).

### 3.6 Lifepaths

Lifepaths is significantly different to the other DMSMs considered here in that it is an open (simulates new persons when needed for purposes such as marriage, rather than choosing an individual already in the model), continuous time, cohort-based model based on a synthetic population. Most other DMSMs are closed, discrete time, full cross-section models with populations based on actual data.

Although the model cohorts are synthetic, Lifepaths uses data from censuses, birth registrations and immigration records from 1921 to 1998 to create its population as a basis for creating each cohort. Likewise, waiting times within the model are based on data such as the Labour Force Survey, the 1984 Family History Survey, the General Social Survey and National Graduate Surveys 2006. The oldest cohort represented in the model is born in 1872, so that in the year 1971 Lifepaths would have a complete simulation of all cohorts alive at the time (Gribble, Hicks et al. 2003).

Lifepaths has three employment classifications: student employment, career employment and maternity leave (Statistics Canada 2006).

Pregnant women make decisions about their labour market participation four months before they are due to give birth. Women who are unemployed and due to have a child withdraw from the labour force. Women who are employed at this stage face three decisions: a) whether to take maternity leave or quit; b) when to start maternity leave or quit; and c) when to return from maternity leave.

Students are classified as either not employed or employed, and the employed are divided into self employment and paid employment. The chances and timing of moving into or out of employment are recalculated monthly. Variables influencing the likelihood of taking up or quitting student employment include sex, province, status in the parental home, seasonal employment patterns and time trends.

Certain people cannot be employed: retirees (retirement is considered a permanent state in Lifepaths) and persons who never work in their life (such as poorly educated women, children and people in institutions) (Statistics Canada 2006).

Employment status for career workers is classified into three categories: paid employee, self-employed and not employed. Note there is no distinction between 'unemployed' and 'not in the labour force'. The chances of moving from one state to another are re-assessed monthly. Variables influencing employment transitions are duration of current job/not working, age, sex, province, education, presence and ages of children, presence of spouse and spouse's employment (Zaidi 2004).

Each year after a person reaches 60, they face a retirement process. The likelihood of retiring is affected by age, sex, region and education level. An institutionalised person is automatically retired.

### 3.7 SESIM

SESIM commenced development in 1997 by the Swedish Ministry of Finance in consultation with Swedish academics. It was originally created to evaluate the Swedish education financing system. Since 2000 it has been adapted to assessing the impacts of the ageing population (eg the Swedish pension system, health care costs, elder care, housing etc) (Flood et al. 2005).

SESIM is a closed, discrete-time DMSM with a one year time unit. Its primary data source is Linda, a longitudinal data set drawn from administrative records, representing about 3.5 percent of the Swedish population. The model's base year is 1999 and the base population is a random sample of 100 000 individuals from Linda. The outcomes of SESIM can be aligned with exogenous demographic and economic projections (Flood et al. 2005).

SESIM was originally designed to use a behavioural approach to estimate the labour supply of households, based on neoclassical consumer demand theory. The initial labour force module considers four types of households: single men, single women, single mothers and husband/wife households. Each person in a household has preferences for consumption (wages earned, other income and government benefits minus taxes) and leisure time (number of hours in the week not spent working). The amount of leisure and consumption a household can enjoy is constrained by the number of hours available in the week and the household's budget constraint. In couple households, it is assumed that the husband and wife make a joint labour supply decision, and that the wife's labour is a substitute for the husband's labour. In SESIM, individuals can work from 0 to 3000 hours per year, in 250 hour increments (eg 250 hours per year, 500 hours, 750 hours etc).

Households maximise their total utility according to their budget constraint and hours available per week. Utility increases with consumption and decreases with the hours worked. Housework and caring for children are classified as leisure rather than work. The preferences for consumption and leisure are measured separately for a husband and wife. Factors affecting preferences are age, education and the number and ages of children (Pylkkanen 2000). The relationship between hours worked and income is not linear due to tax and transfer systems, which can make calculation of the budget constraint difficult.

A similar model is involved for the retirement decision. Individuals in SESIM are forced to retire at age 65, but may choose to retire early. When facing the option to retire early, individuals calculate the NPV of their retirement benefits for retiring immediately, and compare this to the increased utility gained from retiring early (Flood et al. 2005).

All individuals are considered to be in the labour force for SESIM's purposes unless they are children, pensioners, students or mothers with a newborn. If an individual is neither working nor looking for work, they are classified as a person in the labour force who chooses to work 0 hours given their utility function.

Any individuals in the labour force are subject to becoming unemployed. An individual is defined as unemployed if unemployment insurance is a major part of their income. SESIM allocates a probability of becoming unemployed to each individual within the labour market. This probability is compared to a number between 0 and 1 to determine whether the individual will become unemployed or not, and the value of this number depends on the unemployment rate used for alignment. Without alignment, any individual with a probability of becoming unemployed of greater than 0.5 will become unemployed (Ericson 2000).

SESIM's proposed labour force module was quite advanced and proposed a level of analysis that had not been developed in other DMSMs. However the module described here was not incorporated into SESIM.

The outcomes of SESIM can be aligned with exogenous demographic and economic projections.

### **3.8 MOSART**

The first version of the MOSART model started in 1988 and was completed in 1991, comprising demographic events, marriage, education and labour supply. A revision of this model began in 1991, and incorporated labour market earnings and public pension benefits, and was tested against actual income distribution from 1967 to 1989. These first two models were designed to project public pension benefits until 2020 (Fredriksen 1998).

The latest version of the model includes demographics, education, labour force, public pension benefits, labour market earnings, household formation and a simple representation of other forms of income, taxation, savings and wealth. Some of the underlying assumptions, such as net immigration, life expectancy at birth and propensity to study have been increased. Projection starts in 1989 and goes beyond 2050.

MOSART uses a one percent sample of the Norwegian population from their National Insurance Scheme data. It is based in discrete time with the calendar year as the time unit. Events that may occur each year are migration, deaths, births, household formation, educational activities, retirement, labour force participation, income and wealth. From these, an individual's likely pension benefits are calculated. It uses cross sectional simulation – all the people's transitions throughout the year are calculated before moving on to the next year, rather than calculating each individual's entire life before moving on to simulating the next individual. This requires more computer resources but allows people in the model to interact, eg marry, and allows external restrictions to be placed on each year's outcomes, eg total employment (Fredriksen 2003).

The labour force is modelled in MOSART by projecting the number of persons in the labour force and man-years worked, based on a logistic regression of data from Statistics Norway's Labour Force Sample Surveys from 1985-1988 and 1991. There is no distinction between unemployment and not in labour force, only a participation rate of zero. Then each individual's income from working is calculated so that the number of income recipients and their earnings are consistent with the projected labour force. Factors affecting transition probabilities are sex, age, children, marital status, educational activities and attainment, pension status and previous year's labour force participation.

The effects of engaging in study or claiming the disability pension on labour force participation are estimated by joining the Labour Force Sample Surveys with administrative data. This captures the fact that some people work part-time because of student or disability status (Fredriksen 1998).

The Norwegian retirement pension scheme sets the pension age at 67. Early retirement is allowed at age 64. From age 67, pension entitlements are means-tested against earnings until age, 70, when many employees are subject to mandatory retirement (Fredriksen 1998). In MOSART, all individuals are deemed to retire at age 67 (Zaidi et al. 2001).

### **3.9 SAGE**

In 1999 the Economic and Social Research Council (ESRC) was granted funding for five years to carry out social research for the ageing society, including the development of SAGE, a DMSM model to project the impact of the ageing population on pensions, health costs and the need for long-term care.

SAGE is a partially closed, discrete-time, full cross-section model. The model's population is based on a 0.1 percent sample of the British population from the 1991

Census. Additional data used comes from the Family and Working Lives survey, the Quarterly Labour Force Survey (QLFS), the British Household Panel Survey (BHPS) and the ONS Longitudinal Survey. The time period for the model is 1991-2031. The time unit for each simulation is one year with a specific simulation order in which events occur:

- Fertility
- Dissolution of marriage/relationships
- Partnership – creation of new marriage/cohabitation
- Labour Market
- Calculation of pensions
- Writing cross-sectional population characteristics to file
- Aging the population one year to calculate new births and education transitions
- Mortality and widowhood
- Health (Scott 2004)

SAGE uses data from the QLFS and the BHPS to determine the percentage of people who are employed, unemployed or inactive in the labour market at any time in the model, and the likelihood that their labour force status would change in the next period. Although a person's labour market status is updated annually, each year four transitions of employment status are performed, so quarterly employment data is calculated. This allows individuals to be recorded as being employed for only part of the year. Employment by full-time students is excluded, as they are placed in the 'education' life stage.

Individuals have a labour market status in the model after they leave education (between ages 16 and 22) until the year they are 64, effectively imposing a mandatory retirement age within the model.

There are four possible employment statuses, full-time employed, part-time employed, unemployed and not in the labour force (NILF). Movement between each status is modelled as a simultaneous polychotomous choice. SAGE uses a multinomial logit function to determine the probability that a person will change their employment status from one quarter to the next, given their age, sex, family status, number and age of children, employment history, job type and industry type (Zaidi 2004). In addition, SAGE projects health status for individuals and this has an impact on labour force participation. The impact of disability on labour force participation, and therefore pension accumulation, can be measured.

There are four separate models for participation in the labour market, one each for men with/without advanced qualifications, and women with/without advanced qualifications.

Once the regressions had been run, the labour market equations were tested by using them to project the labour market from 1990 to 2000, to establish the accuracy of their projections.

## **4 Lessons for the labour market in APPSIM**

### **4.1 What must be taken into account**

It can be tempting for modellers to try and develop models that capture a very large range of influences on behaviour. Often these plans can be too optimistic or grandiose for implementation in a DMSM. Inevitably, this results in the model running over time and over budget, being difficult to use or failing to do what it was supposed to do (Cassells et al. 2006). A model that does not have a clear vision of its intended purpose and users is likely to be difficult to use and produce irrelevant or inaccurate results. Conversely, modellers should not become too conservative and build a model that is too simple to create projections of any probative value.

The major factors that must be taken into account when designing a DMSM are:

- The purpose of the model – what is it being built for, what policy is it designed to assess? Only features that are relevant and useful to the purpose of the model should be included.
- Data availability – if a feature is desired and likely to be useful, it must be backed up by reliable data, or at least some basis for creation of synthetic data. If part of the model is based on unreliable data, it will not add to the predictive value of the model.
- Time, funding and staffing constraints – when developing a plan for a model, it is important not to underestimate the resources needed to produce the model when promised.

### **4.2 Model assumptions**

A number of DMSMs reviewed in the previous section have imposed constraints on the behaviour of individuals that, if imposed in real life, would be detrimental to the

individual and could limit the availability of policy solutions (with such constraints being imposed, no doubt, as part of pragmatic tradeoffs between accuracy and other modelling issues such as simplicity and data availability, or a reflection of existing policies and practices).

### *The retirement age*

One such issue is the imposition of a mandatory retirement age in several of the models. Individuals are completely barred from working after age 64 in SAGE, after 65 in SESIM and DYNACAN, and after 68 in PENSIM. Granted, this does reflect mandatory retirement policies in some of the countries modelled. Australia has no universal mandatory retirement age, but the pension age and superannuation rules strongly encourage retirement between ages 60 and 65.

Building APPSIM so that all individuals in the model are forced to retire at age 65 would be detrimental for two reasons. Firstly, the Productivity Commission found that the proportion of people working past the age of 65 is increasing and this trend is likely to continue, possibly with people in their 70s becoming increasingly likely to remain in the labour market. Data from the Household, Income and Labour Dynamics in Australia (HILDA)<sup>2</sup> survey backs up this finding, with statistically significant numbers of HILDA respondents working past the age of 65 and into their 70s. Secondly, if increasing the participation rate is to be a useful tool in reducing the fiscal gap, APPSIM should be able to model the impact of policies designed to increase the participation rate among over-65s.

The question is then whether APPSIM should force all individuals to retire at a certain age, and if so, what should that age be?

On one hand, as population health continues to improve, it is quite feasible that some people may continue to work until their late 70s or even their 80s. Imposing a high mandatory retirement age such as 75 would prevent this trend from appearing in APPSIM. On the other hand, without a mandatory retirement age, peculiar and unlikely outliers may appear in the model results, such as individuals working full-time in their 90s. HILDA data shows that although working beyond age 65 is not rare, very few individuals are still in paid employment past the age of 75. For this reason, in the short term it will be assumed that all individuals will have retired by their 75<sup>th</sup> birthday. If further data comes to light that suggests a different mandatory retirement age more accurately reflects Australian working patterns, this will be changed.

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<sup>2</sup> The Household, Income and Labour Dynamics in Australia (HILDA) is a longitudinal panel survey of Australians collected by the Melbourne Institute on behalf of the Department of Families, Community Services and Indigenous Affairs.

### *Impact of children on labour force participation*

Some of the models listed above implicitly assume that only a child's mother can take on child-rearing duties. SESIM's proposed labour force module, for example, assumed that there are four types of households: couples, single men, single women, and single mothers – there are no single father households. In SAGE, the number and age of children in a household is a factor in the labour supply equation for women but not men, so it is impossible for the presence of children to directly impact male participation in the labour force.

Although these assumptions would have been perfectly sensible in decades past and might be easier for simplicity's sake in the present, current trends suggest that an accurate projection of Australia's labour market should consider having provision for males in the model to have their labour force status affected by children. Examples of these trends include the increase in the number of women earning more than their male partners (Drago, Black et al. 2004), making it economically sensible for men to reduce their working hours to rear children, and a small percentage of fathers taking on primary child-rearing duties (Lumby 2004). In addition, the recently announced reforms to Australia's child support scheme are specifically designed to encourage shared custody of children.

APPSIM's labour market module should be able to measure the impact of children on the father's labour market participation as well as the mother's.

### **4.3 Household labour supply: arithmetic or behavioural?**

To date, no DMSM has incorporated a behavioural labour supply response module in its final form, although some such modules have been developed for use in DMSMs. The reasons given by O'Donoghue (2001) for this are:

- estimates of the value of relevant elasticities vary a great deal across the studies used to estimate them;
- predictions based on behavioural models tend to have wide confidence intervals, creating uncertainty in the results; and
- feedback loops from tax-benefit algorithms can substantially increase the time required to run the simulation.

In addition, behavioural models may require more detailed data to produce a reasonably accurate model.

However, this does not mean that a labour supply response module should be ruled out for APPSIM. Essentially, a behavioural model of the labour supply is likely to be

far more complicated than an arithmetic method, will take longer to simulate and will require more data analysis. The advantage of the behavioural approach is it allows individuals within the model to react to policy changes.

Whether one approach is better than another for a DMSM depends on the purpose of the model – specifically, whether the policy or policies to be analysed by the DMSM are likely to result in behavioural responses of interest to policy analysts. If they are, then the modellers must consider whether the extra effort involved in a behavioural component (data, analysis, simulation time, wide confidence intervals) will be outweighed by the benefits of a model that better reflects real life.

### *Purpose of the model*

It seems inescapable that APPSIM’s labour market module would benefit from a behavioural component. Several of the arithmetic DMSMs assessed in the previous chapter had specific purposes, such as PENSIM, whose sole purpose was to evaluate employer pension plans. However APPSIM’s purpose is stated very broadly: to “assess the future distributional and revenue consequences of changes in tax and outlay programs” (NATSEM 2005).

The range of policies intended to be evaluated by APPSIM is likely to include pension, tax, education, immigration and labour market policies. The IGRs and *Economic Implications of an Ageing Australia* argued for policies to improve labour market participation among both the working age population and those aged 65 and over as tools to minimise the fiscal gap. Such policies will involve fiscal and other incentives to encourage individuals to change their labour supply decisions.

Anderson (2001) identified DYNACAN’s inability to depict the labour force participation decision, as opposed to imputing labour supply from transition probabilities, as a shortcoming of DYNACAN in modelling broader retirement policy issues beyond the CPP. Using a probabilistic approach to simulate labour force participation would, in the longer term, make APPSIM of less use for analysing policies designed to increase labour force participation.

### *Feasibility of a behavioural component*

One of the most important questions when considering whether to undertake a behavioural model is whether data availability is sufficient to create a model that is a reasonable reflection of an individual’s labour supply decisions.

The creators of SESIM had the benefit of a comprehensive longitudinal dataset spanning decades, in the form of Linda. Australia has no such dataset. The closest

Australia has to a comprehensive longitudinal dataset is HILDA<sup>3</sup> which has only been collected for six years to date. Other surveys which may be of use are the Survey of Income and Housing Costs (SIHC) and the Household Expenditure Survey (HES).

The Melbourne Institute has created the Melbourne Institute Tax and Transfer Simulator (MITTS), a static behavioural microsimulation model focusing on the effects of tax and welfare changes on labour supply. It is currently based on data from the Survey of Income and Housing Costs (SIHC) (Creedy and Kalb 2004), although the Melbourne Institute is considering updating MITTS with HILDA data.

HILDA is a more suitable dataset to use than SIHC for a DMSM as the data contains more detail; is more recent; is longitudinal; and contains questions on opinions and values that are likely to be relevant to the labour supply decision, such whether individuals would prefer to work more or fewer hours. However, HILDA has some shortcomings compared to the Swedish data source Linda - namely that HILDA's sample size is much smaller. The subset of Linda used in SESIM to derive the labour market module is around 2.5 times size of HILDA and runs from 1992 – 1996 (Pylkkanen 2000).

The author will undertake further examination of HILDA, SIHC and HES to determine whether these datasets will be sufficient for the development of a behavioural model of the labour supply decision. It may be desirable for APPSIM's labour market module to contain two behavioural models for the decision to participate in the labour market - one for the labour supply decision when retirement is not an option, and a second for the retirement decision.

#### **4.4 Discrete vs continuous time**

If labour force transitions within a DMSM are to be based on real data, which is the case with APPSIM, the decision of whether to model the labour force in discrete or continuous time can be easily made on the basis of what data are available. Labour participation in PENSIM was measured in continuous time because administrative data on exactly how long an individual worked in a job for was available from Social Security; on the other hand, Lifepaths used continuous time because it was based on synthetic data (so the lack of specific data on event duration was not a barrier to using continuous time). All the other models considered in the previous chapter used discrete time, with the time unit dependent on the data available. For example

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<sup>3</sup> The Household, Income and Labour Dynamics in Australia (HILDA) is a longitudinal panel survey of Australians collected by the Melbourne Institute on behalf of FACS.

the time unit for modelling labour force participation in SAGE was three months, because the dataset on which the labour force was based contained quarterly data.

An option for APPSIM is to model the labour force in discrete time with a one year time unit because the HILDA and SIHC surveys, upon which the module is likely to be based, are collected annually at best (although HILDA does gather some limited data on labour force participation over the previous 12-18 months). In addition, the policies dealing with the ageing of the population are likely to have long-term impacts rather than short-term impacts. Using continuous time, or time intervals shorter than one year, may not add a great deal of value to the outputs of APPSIM.

#### **4.5 Alignment with a macro model**

The transition probabilities in APPSIM's labour market module will be drawn from HILDA, which has produced six years of longitudinal data. Although the HILDA data are valuable, it would be risky to base 50 years' worth of labour force projections solely on a mere six years of microdata, particularly since those six years capture continuous healthy economic conditions and declining unemployment. The labour force module for APPSIM will be aligned with projections of labour force participation rates and unemployment rates by age and sex, using the estimates created by the Federal Treasury for the second Intergenerational Report.

### **5 The first version of the labour market module**

The APPSIM project requires the rapid development of a functional labour market module. The purpose of this initial module is partly to allow modules which are dependent on labour force participation, such as earnings and wealth, to function and to allow the overall model to produce reasonably realistic outcomes. In the development of the initial labour market module, the main concern is adequate functionality rather than a full level of projection ability that incorporates behavioural responses. Therefore, it will be a less complex version than that proposed in the previous section. The most significant difference will be that this initial version will not include a behavioural component for the labour supply decision.

It is expected that the first version of the labour force module will be estimated using HILDA data. However, it may be necessary to use other data sets for specific groups of individuals, such as full-time students and the unemployed. The four potential labour market statuses will be full-time employed (35+ hours per week), part-time employed (up to 35 hours per week), unemployed and not in the labour force. It is

expected that the parameters of the model will be age, sex, current education activities, education level, marital status, presence and age of children, disability in the previous period and labour force status in the previous two periods.

To determine the desirable time unit for labour force participation, an assessment of HILDA's variables has been undertaken. Each year, HILDA asks individuals detailed questions about their current employment and the most recent job undertaken since the previous interview, not including the position held at the last interview. The questions include average hours worked over the last month, and usual hours worked in the position. In addition, HILDA asks respondents to fill out a calendar of their work and study patterns over at least the previous year. Respondents state what job they worked at, or whether they were unemployed, not in the labour force or studying at the start, middle and end of each month.

A person's labour force status in time period  $t$  will be calculated based, among other things, on their labour force status in time periods  $t-1$  and  $t-2$ . Then the person's quarterly transitions during the year from  $t-1$  to  $t$  will be calculated.

Part-timers will be classified into two groups according to hours worked: 1-14 hours per week and 15-34 hours per week.

However, two major gaps remain in the data, for which assumptions must be made.

1. Calculating transitions between full-time and part-time employment may be impossible for some individuals due to the fact that the calendar data from HILDA does not distinguish between full-time and part-time employment. If a person only had one or two jobs during the year, full-time or part-time status can be gleaned from other parts of the survey. However if a person switched jobs several times throughout the year, or sometimes held more than one job at a time, reporting part-time or full-time status is impossible. It is proposed that if a person is employed during the year between  $t-1$  and  $t$ , their full-time/part-time status will be based on their status in periods  $t-1$  and  $t$ .
2. If an individual is working more than one job at the time of the interview, he or she will be asked about their total hours worked and total income earned, but will only be asked for details on their main job (that is, the job from which they receive the most pay). It will be assumed that the other jobs have similar characteristics to the main job.

Based on these assumptions, the APPSIM modellers will calculate quarterly labour force states for each of the preceding 12 months for each HILDA respondent captured in one of four particular labour force states as at 30 June each year. A breakdown of labour force status for HILDA respondents is provided in Appendix A. The labour force transition equations will be derived from this microdata. Tables 11, 12 and 13 in the Appendix show the 2001-2002 unweighted transition

probabilities between labour force states for males (table 11) and females (table 12); and the transition probabilities between types of employment (table 13).

These labour force transition equations will generate labour force status for each individual at June 30 of each year, and provide details of their labour force status by quarter *within that financial year*. APPSIM can then align its participation rate at June 30 over the year with projections of labour force participation rates over the financial year from the Treasury's Intergenerational Report.

The labour market participation of full-time students and the severely disabled will be modelled separately from the rest of the population (although it is likely that the severely disabled will be excluded from the labour force altogether). The tables in the Appendix provide some initial estimates on these issues. As table 3 indicates, there are relatively few cases in the base data where at later ages in the lifecycle students are engaged in full-time study and work. This suggests that it will be most important to undertake modelling of the study status of full-time students only for those in their teens and 20s. Table 4 suggests that there is almost no labour force participation among those with severe disability.

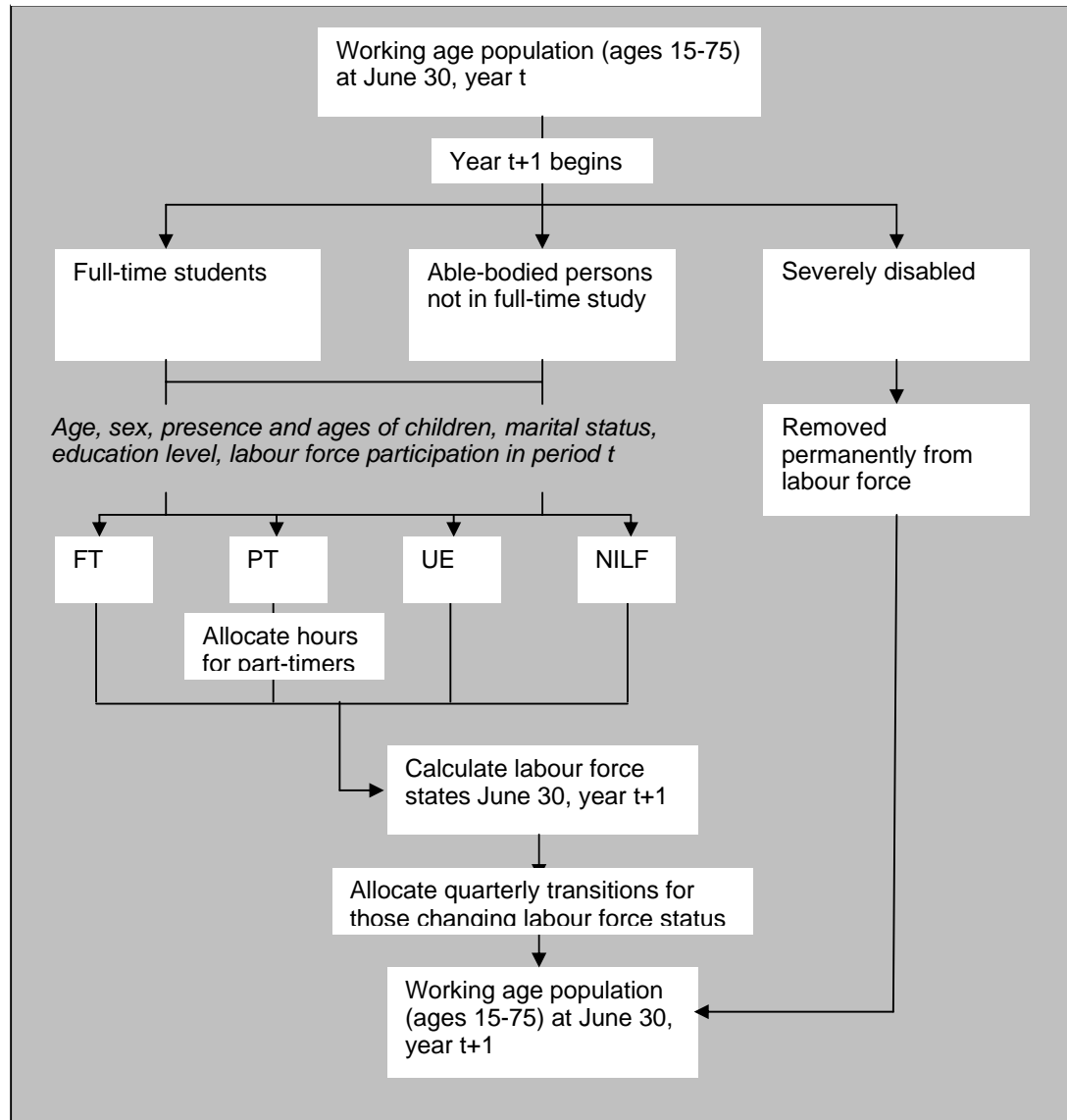
Separate equations will be estimated for men and women, and for persons aged 15-24, aged 25-49, aged 50-64 and aged 65+.

For this first version of the module, we expect to retire all individuals within APPSIM by age 75. This reflects the evidence presented in tables 2, 5, and 8 suggesting that very few individuals are in the labour force after age 75. Individuals will face a risk of retirement from age 50 onwards. Men and women who are unemployed or not in the labour force will be assumed to enter retirement when they reach their respective pension ages.

This first module will reflect current international practice in dynamic microsimulation modelling. After it is completed, the author will go on to examine whether it is feasible to include labour supply response within an enhanced APPSIM labour market module, given the Australian data limitations.

Figure 2 represents the proposed transitions in the APPSIM labour force module.

Figure 2: Flow diagram of APPSIM labour force module



## 6 Conclusions

DMSM has the potential to provide a unique perspective on the distribution of the impacts of fiscal and social policies to mitigate the costs of the ageing population. Existing projections of changes to the labour force over the next 50 years suggest that policies designed to increase participation rates are likely to have an appreciable impact on the fiscal gap.

In order for the labour market module to provide the maximum benefit, the following features are recommended:

- incorporation of behavioural responses to policy change;
- labour force participation to be measured in discrete time, with labour force status updated once a year, but providing monthly data on participation;
- ability of parenthood to affect the labour force participation of both mothers and fathers;
- mandatory retirement age within the model to be tentatively set at 75; and
- alignment with projected exogenous labour force participation and unemployment rates (such as those developed by Treasury for the second Intergenerational Report).

In the first stage, the author will develop an arithmetic labour market module consistent with established practice for DMSMs, to be inserted into APPSIM for calibration with the other modules. In the second stage, the author will then examine the feasibility of building a behavioural response mechanism into the model, to be inserted into APPSIM in 2009.

## A HILDA Observations

Table 2 Labour force status –not in full-time study

	Males				Females			
	Full-time	Part-time	Unemploy ed	Not in labour force	Full-time	Part-time	Unemploy ed	Not in labour force
15-19	78	31	21	18	54	48	12	28
20-24	206	35	30	17	148	70	26	57
25-29	340	30	19	15	228	104	22	118
30-34	443	43	14	24	231	184	25	190
35-39	466	47	24	33	195	266	24	185
40-44	542	40	19	48	235	277	18	159
45-49	447	35	18	50	252	215	15	122
50-54	358	37	12	72	187	156	10	145
55-59	217	44	18	100	116	106	9	217
60-64	102	61	7	187	36	52	3	258
65-69	37	25	0	216	7	26	2	271
70-74	12	19	0	233	1	10	0	265
75-79	2	9	0	157	1	1	0	235
80+	2	1	0	126	1	1	0	208
Total	3252	457	182	1296	1692	1516	166	2458

a

Note: This table is generated from unweighted data.

Source: HILDA Wave 2, Release 4

Table 3 Labour force status – full-time students

	Males				Females			
	Full-time	Part-time	Unemploy ed	Not in labour force	Full-time	Part-time	Unemploy ed	Not in labour force
15-19	15	118	7	97	15	130	27	90
20-24	17	47	5	22	3	67	3	18
25-29	7	9	1	9	10	10	2	12
30-34	4	4	1	9	5	8	2	11
35-39	4	3	2	9	1	6	1	10
40-44	2	2	2	5	3	3	3	6
45-49	1	3		6	2	2	0	5
50-54				1	2	1	1	1
55-59				2			0	2
60-64							0	1
65-69				1			0	1
70-74							0	0
75-79				1			0	1
80+							0	0
Total	50	186	37	143	41	227	39	158

a

Note: This table is generated from unweighted data.

Source: HILDA Wave 2, Release 4

**Table 4 Labour force status – severe disability**

	Males				Females			
	Full-time	Part-time	Unemploy ed	Not in labour force	Full-time	Part-time	Unemploy ed	Not in labour force
15-19							1	
20-24				1				
25-29							1	
30-34				1				1
35-39				1				2
40-44			1	4				1
45-49				2				2
50-54				5				9
55-59		1		14		1		2
60-64		1		8				1
65-69				2				2
70-74				4				2
75-79				7				1
80+				7		1		7
Total		2	1	56		2	2	30

a

Note: For the purposes of this table, respondents are classified as severely disabled if they gave a response of 10 when asked the extent to which their disability affected their ability to work on a scale of 1 to 10. This table is generated from unweighted data.

Source: HILDA Wave 2, Release 4

**Table 5 Labour force status (weighted) –not in full-time study**

	Males				Females			
	Full-time	Part-time	Unemploy ed	Not in labour force	Full-time	Part-time	Unemploy ed	Not in labour force
15-19	92504	42905	23309	19228	51790	54506	8295	32274
20-24	272402	48577	48041	24905	200415	98458	33447	80371
25-29	459271	44385	21905	26112	277511	128376	31358	150975
30-34	567648	58373	19841	31170	275449	213245	27053	211601
35-39	529588	56524	30640	45180	192213	261395	29011	184923
40-44	599160	46136	22524	53672	239497	277035	16830	180215
45-49	506108	36104	27825	57225	267835	246748	14547	150580
50-54	435608	43876	12719	100668	204830	181196	10415	179858
55-59	254492	51788	23725	135038	124181	123014	3450	272394
60-64	115768	67485	8655	243222	38923	59826	2258	296643
65-69	35677	22800	0	261135	6702	26515	2078	301602
70-74	9393	17643	0	260564	946	9695	0	299761

75-79	1344	8448	0	208160	798	1200	0	294629
80+	2664	1293	0	166804	365	969	0	264023
Total	3881626	546337	239185	1633083	1881454	1682178	178743	2899848

a

Note:

Source: HILDA Wave 2, Release 4

Table 6 Labour force status (weighted) – full-time students

	Males				Females			
	Full-time	Part-time	Unemploy ed	Not in labour force	Full-time	Part-time	Unemploy ed	Not in labour force
15-19	19840	144247	37212	132889	17910	159660	27181	114321
20-24	24051	66753	13876	31385	2968	98674	5005	33575
25-29	13220	13606	1092	15175	11999	10479	7001	15073
30-34	6577	6162		4118	5643	9200	3515	15457
35-39	3191	3095	1659	2932	417	5961	2413	9373
40-44	2125	1652		1502	3248	3559	3366	4991
45-49	851	3208		7555	1967	1567	2471	6016
50-54				1051	1986	609	2079	1208
55-59				509				2427
60-64				1007				1242
65-69								2509
70-74								
75-79								1510
80+								
Total	69856	238724	53838	198123	46139	289708	53032	207702

a

Note:

Source: HILDA Wave 2, Release 4

Table 7 Labour force status (weighted) – severe disability

	Males				Females			
	Full-time	Part-time	Unemploy ed	Not in labour force	Full-time	Part-time	Unemploy ed	Not in labour force
15-19							553	
20-24				2891				
25-29							748	
30-34				1925				1257
35-39				607				1826
40-44			849	6452				809
45-49				3911				1756
50-54				7092				9541
55-59		1128		18079		710		3136
60-64		970		8327				1543
65-69				2120				2909

70-74				4210				2287
75-79				10930				1209
80+				8566		1167		9769
Total	0	2098	849	75110	0	1878	1302	36043

a

Note: For the purposes of this table, respondents are classified as severely disabled if they gave a response of 10 when asked the extent to which their disability affected their ability to work on a scale of 1 to 10.

Source: HILDA Wave 2, Release 4

**Table 8 Labour force status (percentage by age group) –not in full-time study**

	Males				Females			
	Full-time	Part-time	Unemploy ed	Not in labour force	Full-time	Part-time	Unemploy ed	Not in labour force
15-19	52.7	20.9	14.2	12.2	38.0	33.8	8.5	19.7
20-24	71.5	12.2	10.4	5.9	49.2	23.3	8.6	18.9
25-29	84.2	7.4	4.7	3.7	48.3	22.0	4.7	25.0
30-34	84.5	8.2	2.7	4.6	36.7	29.2	4.0	30.2
35-39	81.8	8.2	4.2	5.8	29.1	39.7	3.6	27.6
40-44	83.5	6.2	2.9	7.4	34.1	40.2	2.6	23.1
45-49	81.3	6.4	3.3	9.1	41.7	35.6	2.5	20.2
50-54	74.7	7.7	2.5	15.0	37.6	31.3	2.0	29.1
55-59	57.3	11.6	4.7	26.4	25.9	23.7	2.0	48.4
60-64	28.6	17.1	2.0	52.4	10.3	14.9	0.9	73.9
65-69	13.3	9.0		77.7	2.3	8.5	0.7	88.6
70-74	4.5	7.2		88.3	0.4	3.6	0.0	96.0
75-79	1.2	5.4		93.5	0.4	0.4	0.0	99.2
80+	1.6	0.8		97.7	0.5	0.5	0.0	99.0

a

Note: This table is generated from unweighted data.

Source: HILDA Wave 2, Release 4

**Table 9 Labour force status (percentage by age group)– full-time students**

	Males				Females			
	Full-time	Part-time	Unemploy ed	Not in labour force	Full-time	Part-time	Unemploy ed	Not in labour force
15-19	5.8	45.6	10.8	37.8	5.7	49.6	10.3	34.4
20-24	18.3	50.5	7.5	23.7	3.3	73.6	3.3	19.8
25-29	30.4	39.1	4.3	26.1	29.4	29.4	5.9	35.3
30-34	33.3	33.3		33.3	19.2	30.8	7.7	42.3
35-39	36.4	27.3	9.1	27.3	5.6	33.3	5.6	55.6
40-44	33.3	33.3		33.3	20.0	20.0	20.0	40.0
45-49	11.1	33.3		55.6	22.2	22.2		55.6
50-54				100.0	40.0	20.0	20.0	20.0
55-59				100.0				100.0
60-64				100.0				100.0

65-69	100.0
70-74	
75-79	100.0
80+	

a

Note: This table is generated from unweighted data.

Source: HILDA Wave 2, Release 4

**Table 10 Labour force status (percentage by age group) – severe disability**

	Males				Females			
	Full-time	Part-time	Unemploy ed	Not in labour force	Full-time	Part-time	Unemploy ed	Not in labour force
15-19							100.0	
20-24				100.0				
25-29							100.0	0.0
30-34				100.0				100.0
35-39				100.0				100.0
40-44			20.0	80.0				100.0
45-49				100.0				100.0
50-54				100.0				100.0
55-59		6.7		93.3		33.3		66.7
60-64		11.1		88.9				100.0
65-69				100.0				100.0
70-74				100.0				100.0
75-79				100.0				100.0
80+				100.0		12.5		87.5

a This table is generated from unweighted data.

Note: For the purposes of this table, respondents are classified as severely disabled if they gave a response of 10 when asked the extent to which their disability affected their ability to work on a scale of 1 to 10. This table is generated from unweighted data.

Source: HILDA Wave 2, Release 4

**Table 11 Transitions between employment states for males aged 15-49**

	FT in 2002	PT in 2002	UE in 2002	NILF in 2002	% with same employment status over both periods
FT in 2001	1891	61	32	25	94
PT in 2001	74	98	11	14	50
UE in 2001	38	25	47	22	36
NILF in 2001	25	10	15	108	68

a

Note: This table is generated from unweighted data.

Source: HILDA waves 1 and 2, Release 4

**Table 12 Transitions between employment states for females aged 15-49**

	FT in 2002	PT in 2002	UE in 2002	NILF in 2002	% with same employment status over both periods
FT in 2001	867	120	14	19	85
PT in 2001	145	670	22	80	73
UE in 2001	21	22	26	22	29
NILF in 2001	20	116	41	456	72

a

Note: This table is generated from unweighted data.

Source: HILDA waves 1 and 2, Release 4

**Table 13 Transitions between types of employment for persons aged 15-49**

	Not employed in 2002	Employee in 2002	Employee of own business in 2002	Self employed in 2002	Unpaid family worker in 2002	% with same type of employment over both periods
Not employed in 2001	835	254	7	29	8	74
Employee in 2001	226	3225	37	71	1	91
Employee of own business in 2001	3	18	146	20	1	78
Self employed in 2001	29	75	45	326	2	68
Unpaid family worker in 2001	9	3	3	3	3	14

a

Note: This table is generated from unweighted data.

Source: HILDA waves 1 and 2, Release 4

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