Chapter 7: The Labour Market

The labour market is highly dynamic. There are large flows in and out of work and between employers. It is also highly diverse: both employers and workers are heterogeneous. This Chapter discusses the UK labour market and then develops a simple model of a local labour market. It starts with a model to generate the distribution of wages. It then adds the interaction between employers and workers as employers try to fill vacancies and workers seek jobs. Finally, the various flows of workers between employers and into and out of the labour force are added to produce a simple, but interesting, model of the Guildford labour market.

Key words: employment, employers, labour supply, labour demand, economic activity, power law distributions, unemployment, verification, wage distribution, wage flexibility.
Introduction

Since the end of the Second World War unemployment has been a prime concern of the UK Government. Its White Paper, *Employment Policy*, published in 1944 said: ‘The Government accept as one of their primary aims and responsibilities, the maintenance of a high and stable level of employment after the war.’

Nearly 70 years later, the Bank of England (2013) announced that it intended ‘not to raise Bank Rate from its current level of 0.5% at least until the Labour Force Survey headline measure of the unemployment rate has fallen to a threshold of 7%’.

Understanding of the workings of the labour market is therefore a priority for policy-makers and has been a major strand of academic work. In this Chapter, we build a simple labour market model loosely based on our home town of Guildford. But first, by way of introduction, we present key features of the UK labour market.

The labour force

The UK follows conventions used throughout the European Union and by OECD to define people’s labour force status. People are categorised as in employment, unemployed or economically inactive.

- Employed people do at least one hour a week of paid work.
- Unemployed people are not in employment, and have been looking for work in the last four weeks and are able to start work within the next two weeks. It does not matter whether they are seeking full-time or part-time work or whether they are claiming social security benefits.
- Economically inactive people are neither in employment nor counted as unemployed. This includes those who are students, caring for dependents, retired, or unable to work due to sickness or disability.

These definitions are mutually exclusive: a given person can only have one status at a time. The numbers in each category are estimated on a quarterly basis using a survey of households, *The Labour Force Survey* (LFS). For more details, see Box 7.1.
Box 7.1: The Labour Force Survey (LFS).

The LFS is a major survey of households designed to produce estimates of employment, unemployment, economic inactivity and other labour market data on a quarterly basis. A nationally representative sample of approximately 100,000 people aged 16 and over is interviewed in each three-month period. Because it is based on quarters, rather than months, for reason of costs, some short term changes in labour market status will not be recorded. For example, if someone moves from employment to unemployment and then back into employment within the quarter, their unemployment spell will be missed.

The ONS publishes figures for rolling three month average time periods. For example, the ONS estimated that there were 2,625 million unemployed in January to March 2012. There had been 2,671 million unemployed in the previous quarter, October to December 2011; and so ONS reported that unemployment had fallen 45,000 on the previous quarter.

Sources: Clegg (2012a and 2012b), ONS (2013c).

Three key ratios – by convention incorrectly called ‘rates’ – are derived from these data:

- The employment rate: the percentage of all people who are in employment.
- The participation rate: the percentage of all people who are economically active i.e. either in employment or unemployed.
- The unemployment rate: the percentage of the economically active who are unemployed.

Box 7.2 presents recent UK labour force data on this basis.
Box 7.2: Employment, participation and unemployment rates: 2013, Q2, UK.

<table>
<thead>
<tr>
<th></th>
<th>Millions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Economically active</strong></td>
<td></td>
</tr>
<tr>
<td>In employment</td>
<td>29.98</td>
</tr>
<tr>
<td>Unemployed</td>
<td>2.51</td>
</tr>
<tr>
<td>Total economically active</td>
<td>32.49</td>
</tr>
<tr>
<td><strong>Economically inactive</strong></td>
<td></td>
</tr>
<tr>
<td>Students</td>
<td>2.31</td>
</tr>
<tr>
<td>Looking after family/home</td>
<td>2.24</td>
</tr>
<tr>
<td>Long-term sick</td>
<td>2.05</td>
</tr>
<tr>
<td>Retired</td>
<td>1.37</td>
</tr>
<tr>
<td>Other</td>
<td>1.03</td>
</tr>
<tr>
<td>Total economically inactive</td>
<td>8.99</td>
</tr>
<tr>
<td><strong>Total population aged 16-64</strong></td>
<td>41.48</td>
</tr>
</tbody>
</table>

**Employment rate**

\[
\frac{\text{In employment}}{\text{Total population}} \times 100 = \frac{29.98}{41.48} \times 100 = 72.3\%
\]

**Participation rate**

\[
\frac{\text{Economically active}}{\text{Total population}} \times 100 = \frac{32.49}{41.48} \times 100 = 78.3\%
\]

**Unemployment rate**

\[
\frac{\text{Unemployed}}{\text{Economically active}} \times 100 = \frac{2.51}{32.49} \times 100 = 7.7\%
\]

Note that these rates are based on the population aged 16 to 64. Rates based on all people aged 16 and over will differ.

Source: ONS (2013a).
It is, however, the unemployment rate that is the key policy variable. The unemployment rate may rise because more people become unemployed, or because fewer people leave unemployment for jobs or leave the labour force. Much work has been done to identify which of these flows is the most important: see Gomes (2009) and Smith (2011) for example. Elsby et al (2011) argued that

…the leading contribution to UK unemployment cyclicality since 1975 has, in fact, been the substantial rise in rates of job loss in times of recession, accounting for approximately two-thirds of the fluctuations in the unemployment rate over each cycle. Declines in unemployed workers’ job-finding prospects, while undeniably important, explain just over one-quarter of the cyclical change in unemployment in each of the recessions we examine. The remaining 10 per cent is attributed to flows involving non-participation.

Using US data, Rogerson and Shimer (2010) found that ‘recessions are typically characterized by a sharp, short-lived increase in the inflow rate of workers from employment into unemployment and a large, prolonged decline in the outflow rate of workers from unemployment into employment’. In short, a lot of people get fired and few get hired.

Figure 7.1 confirms these views. The top part of Figure 7.1 shows unemployment in the UK since 2001. Until 2008, around 1½ million people were unemployed at any one time and, as shown in the lower part of the figure, the gross inflows to and outflows from unemployment were some 700 to 800 thousand each quarter. Then in the third quarter of 2008 the gross inflow into unemployment rose sharply and this was not matched by an increase in outflow until a year later. The level of unemployment has since been around 2½ million with the gross inflow and outflow between 900 thousand and 1 million each quarter. Thus at the macro level, the total number unemployed may appear to change little, because the inflows are similar to the outflows, while at the micro level large changes are occurring: many workers are becoming unemployed while many unemployed are at the same time, finding work. This means that to understand the labour market, it is necessary to examine the flows into and out of work.
Figure 7.1: Unemployment flows and the unemployment level in the UK: 2001 to 2013.

Source: ONS (2013c).
Figure 7.2 illustrates the flows in the UK labour market between the first and second quarters of 2013. (See Box 7.1 for an explanation of how these flows are measured.) One third of those who were unemployed in the first quarter had left unemployment in the second quarter, either for work or to become inactive. The probabilities of moving between the three possible states of economic activity are called hazard rates. Examples are shown in Box 7.3. Figure 7.3 shows the hazard rates of moving between the three basic employment states in the UK from the start of the series in 2001.

**Figure 7.2: Labour market flows in the UK: comparing Q1 to Q2, 2013 (1).**

Source: ONS (2013c, p.3).

(1) See Box 7.1 for definitions.
### Box 7.3: Examples of hazard rates, UK: Q1 2013 to Q2 2103.

<table>
<thead>
<tr>
<th>Event</th>
<th>Numbers</th>
<th>2013 (%)</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of people who moved from employment to unemployment</td>
<td>404 thousand / 28.7 million = 1.4%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of people employed in Q1 2013</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of people who moved from unemployment to employment</td>
<td>545 thousand / 2.5 million = 21.8%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of people unemployed in Q1 2013</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: ONS (2013c, p.7 & p. 11).

These examples are based on data from the UK Labour Force Survey (LFS) and reflect the changes between one quarter and the next as explained in Box 7.1. But the LFS does not record all the changes. First, as noted in Box 7.1, changes within a quarter will be missed (ONS, 2013c). US data miss fewer such shifts because it is based on month to month changes. (See Box 7.4 for more information on the differences between UK and US data.) Second, it does not allow for those who move directly from one job to another without becoming unemployed. Using LFS data between 1996 and 2007, Gomes (2009) estimated that on average 2.9 per cent of those in employment changed jobs directly each quarter; over the same period, 1.3 per cent became unemployed.
Figure 7.3: Hazard rates, UK: 2001-2013.

Source: derived from ONS data.
Box 7.4: The US labour market.

In the USA unemployment is measured in several different ways, not all of which are consistent with the measures used in the UK and elsewhere in Europe. International comparisons must be made very carefully.

For example, in the US long-term unemployment is defined as being out of work for 27 weeks or more while in the UK, it is a year.

A more subtle difference arises because of different measurement techniques. So a simple comparison of US and UK data suggests that the US labour market is more fluid. However, the US data are monthly, and therefore, according to Gomes (2009), not comparable because the shorter time period means the more transitions into and out of employment are recorded.


The probability of becoming unemployed and once unemployed, of returning to work, vary significantly between people. For instance, in the first part of 2013, unemployed people had a 38 per cent chance of leaving unemployment, either for work or to become economically inactive (as shown in Figure 7.3). Yet, if all the unemployed had such a high probability of leaving unemployment only 2 per cent of a given cohort would be continuously unemployed over two years. (The maths are: \((1 - 0.38)^8\) which equals 0.02.) But in the second quarter of 2013, one in five of those unemployed in the UK (19 per cent) had been continuously unemployed for over two years (Table 7.1). The longer someone is unemployed, the less likely they are to get a job. ONS (2013c) reported that:

Over the year from April-June 2012 to April-June 2013, if one had been unemployed for less than three months one was 3.2 times more likely to move from unemployment into employment compared with someone who has been unemployed for over two years, and 1.9 times more likely compared with someone who has been unemployed for between six and 12 months.
Table 7.1: Unemployment rate and duration of unemployment by age: April – June 2013, UK, seasonally adjusted.

| Age Group | Rate Up to 6 months | Over 6 and up to 12 months | Over 12 and up to 24 months | All over 24 months | All
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>16-17</td>
<td>38.1</td>
<td>70</td>
<td>18</td>
<td>12</td>
<td>* 100</td>
</tr>
<tr>
<td>18-24</td>
<td>19.2</td>
<td>51</td>
<td>16</td>
<td>18</td>
<td>14 100</td>
</tr>
<tr>
<td>25-49</td>
<td>6.0</td>
<td>43</td>
<td>18</td>
<td>18</td>
<td>22 100</td>
</tr>
<tr>
<td>50+</td>
<td>4.7</td>
<td>38</td>
<td>16</td>
<td>18</td>
<td>27 100</td>
</tr>
</tbody>
</table>

| All       | 7.8                 | 47                          | 17                          | 17                | 19 100 |

Source: (ONS, 2013d)

*By definition, those under 18 cannot be unemployed for over 2 years.

Other indicators of the heterogeneity of the unemployed include:

- Younger workers are more likely to be unemployed. The unemployment rate is much higher for younger workers than for older workers (Table 7.1); in the year to June 2013 workers under 25 were three times more likely to become unemployed than older workers (ONS, 2013c).

- Employment history matters. Those who have experienced recent unemployment are more likely to become unemployed again. ONS (2013c) reported that between April-June 2012 and April-June 2013, one was 8.5 times more likely to move from employment into unemployment if one had been employed for less than six months compared with someone who has been employed for between 5 and 10 years.

Furthermore, those who are unemployed at one point in time were more likely to have been unemployed previously and are likely to remain unemployed for longer.

- Those with recent employment are less likely to become unemployed: in 2007 the probability of an employed person becoming unemployed was 10% if they had been unemployed in the previous period but only 6% if inactive and 1% if employed (Gomes, 2009).

- Those with recent employment who do become unemployed are more likely to find another job. ‘The job-finding rate is 46% if two quarters earlier the person was employed, 23% if the person was inactive and 18.6% if the person was unemployed’ (Gomes, 2009).
• Qualifications and job skills are also important. However, gender is less so: ‘The employment hazard rates for men and women have followed fairly similar patterns to one another’ although the hazard rates are higher for men. For example, from ‘the second quarter of 2008 to the second quarter of 2013 the average unemployment hazard rate for men was 1.9% compared with 1.4% for women’ (ONS, 2013c).

Employers

Employers are highly heterogeneous too. In particular, there are a few very large employers and many small employers. Axtell (2001) observed that in the United States the probability that a firm is larger than a given size is inversely proportional to that size e.g. one in a million firms will employ more than 1 million people. Mathematically, this is known as a power law distribution. (For more on power laws, see Box 7.5).

Simple analysis suggests that the same holds for the UK. At the start of 2013, the Department for Business and Skills (BIS, 2013) estimated there were almost 5 million organisations in the UK, all but about 90 thousand in the private sector. They employed 31 million people. However, 3.9 million, or nearly 80 per cent, were one person businesses. Yet 40 per cent of people were employed in large organisations with 500 or more employees. (Details in the top panel of Box 7.6.) The National Health Service (NHS), which is the largest employer in the UK, employs 1.3 million people in England alone: allowing for Wales, Scotland and Northern Ireland probably brings the total to around 1.5 million. The supermarket firm, Tesco, is thought to be the largest private employer in the UK, with ‘over 310,000’ employees. Plotting this data on logarithmic scale produces the straight line that is a characteristic of power law distributions and an exponent of -1, as shown in the bottom panel of Box 7.6.
Box 7.5: Power law distributions.

A power law distribution is said to exist if ‘the probability of measuring a particular value of some quantity varies inversely as a power of that value’ (Newman, 2005). Power law distributions are observed in many contexts, although often only over the higher values. In economics, it has been long-established that the distribution of wealth follows a power law distribution.

Example: imagine there are 1 000 agents, with some item distributed between them very inequitably so that the majority of agents have only 1 item, but a few agents have significantly more, as shown in the table. The graph plots the data on a logarithmic scale giving the straight line that is characteristic of a power law distribution. The line has an exponent of -1.

<table>
<thead>
<tr>
<th>Number of items</th>
<th>Number of agents with that number of items</th>
<th>Total number of items</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 000</td>
<td>1</td>
<td>1 000</td>
</tr>
<tr>
<td>500</td>
<td>2</td>
<td>1 000</td>
</tr>
<tr>
<td>150</td>
<td>8</td>
<td>1 200</td>
</tr>
<tr>
<td>10</td>
<td>90</td>
<td>900</td>
</tr>
<tr>
<td>1</td>
<td>899</td>
<td>899</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1 000</strong></td>
<td><strong>4 999</strong></td>
</tr>
</tbody>
</table>

If the exponent is less than 2, ‘the mean is not a well-defined quantity, because it can vary enormously from one measurement to the next, and indeed can become arbitrarily large’ (Newman, 2005). While the average can be calculated from any given sample, it may vary considerably between samples. This can be illustrated with the example above. If all 1 000 agents are included, then the average number of items per agent is 5. If the agent with 1 000 items is excluded, the average over the remaining 999 drops to 4. And if the top three agents are excluded, the average drops to 3.

When the exponent is -1, the distribution is often said to follow Zipf’s Law. But strictly Zipf’s Law applies to ranked data. For example, the event with the highest probability occurs twice as often as the event with the next highest probability, and three times as often as the third ranking item and so on.

For more on power law distributions, see Newman, 2005.
### Box 7.6: UK organisations by size: 2013.

<table>
<thead>
<tr>
<th>Size</th>
<th>Organisations</th>
<th>Total Employment</th>
<th>Average Employment* (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Per cent</td>
<td>Thousands</td>
</tr>
<tr>
<td>1 **</td>
<td>3,877,795</td>
<td>77.8</td>
<td>4,421</td>
</tr>
<tr>
<td>2-4</td>
<td>614,985</td>
<td>12.3</td>
<td>1,839</td>
</tr>
<tr>
<td>5-9</td>
<td>244,635</td>
<td>4.9</td>
<td>1,679</td>
</tr>
<tr>
<td>10-19</td>
<td>130,715</td>
<td>2.6</td>
<td>1,806</td>
</tr>
<tr>
<td>20-49</td>
<td>70,950</td>
<td>1.4</td>
<td>2,157</td>
</tr>
<tr>
<td>50-99</td>
<td>22,840</td>
<td>0.5</td>
<td>1,579</td>
</tr>
<tr>
<td>100-199</td>
<td>11,020</td>
<td>0.2</td>
<td>1,540</td>
</tr>
<tr>
<td>200-249</td>
<td>2,260</td>
<td>0.04534</td>
<td>503</td>
</tr>
<tr>
<td>250-499</td>
<td>4,290</td>
<td>0.08607</td>
<td>1,484</td>
</tr>
<tr>
<td>500-300,000</td>
<td>4,593</td>
<td>0.09215</td>
<td>12,522</td>
</tr>
<tr>
<td>Tesco</td>
<td>1</td>
<td>0.000002</td>
<td>310</td>
</tr>
<tr>
<td>NHS</td>
<td>1</td>
<td>0.000002</td>
<td>1,500</td>
</tr>
<tr>
<td>Total</td>
<td>4,984,085</td>
<td>100</td>
<td>31,340</td>
</tr>
</tbody>
</table>

*Employment divided by number of organisations.

**Includes self-employed owner-managers.

Source: based on data from Department for Business and Skills (2013: Table 2 – whole economy), NHS Confederation (2014) and Tesco (2014).
The average size of all organisations is 21 in the UK. But, as shown in Box 7.6, only about 2 per cent of organisations have 20 or more people: the majority of firms have less than five. What then is a ‘representative firm’? The skewness of the distribution casts doubt on Marshall’s assertion (1890/1920, Book IV, Chapter XIII.9) that

..a representative firm is in a sense an average firm. But there are many ways in which the term "average" might be interpreted in connection with a business. And a Representative firm is that particular sort of average firm, at which we need to look in order to see how far the economies, internal and external, of production on a large scale have extended generally in the industry and country in question. We cannot see this by looking at one or two firms taken at random: but we can see it fairly well by selecting, after a broad survey, a firm, whether in private or joint-stock management (or better still, more than one), that represents, to the best of our judgment, this particular average.

It also casts doubt on the validity of using a representative firm in modern models.

We noted in Chapter 6 that about 10 per cent of retailers go out of business and are replaced each year. While the proportions vary between industry groups, as some sectors grow and others decline, this is also broadly true for all businesses. So while the macro picture of the number of employers may appear constant, once again there is a great deal of change at the micro level.

Summary

To sum up, while the labour market may appear fairly stable at the macro level, there is much activity at the micro level. Many people move between employment, unemployment and inactivity even though the total number in each group changes little. Firms close and are replaced by new ones. Both labour and organisations are highly heterogeneous. There is no ‘average employer’ and it is tempting to say there is no ‘average worker’ either. The importance of dynamics and heterogeneity suggest agent-based modelling may provide insights into the labour market.
A simple labour market model

The labour market is dynamic and there is great diversity among the participants, both workers and employers. To capture this diversity in full, very large scale agent-based models are being built. For example, Guerrero & Axtell (2013) built a model of the Finnish labour market with a ‘one-to-one scale with the Finnish labor force’; that is, 2.5 million agents. And Axtell is currently working on a model of the US labour market comprising over 100 million agents and drawing on ‘three dozen’ data sources (Axtell, 2013). Such models are beyond the scope of this book.

So in this Section we present a simple labour market model, using 1 000 agents and 100 employers, as used by the French WORKSIM model (Lewkovicz et al., 2009). However, rather than addressing a particular policy issue, as Lewkovicz et al. do, our model aims simply to capture the essential features of the labour market, making minimal assumptions. It illustrates the basic dynamics and shows how small imbalances due to heterogeneity in both the supply of and the demand for labour can generate cycles in unemployment.

To add some realism, where possible, this simple model is broadly based on our home town of Guildford. Box 7.7 provides information about the labour supply and demand in Guildford
To keep the model simple, many details – such as that many workers commute out of Guildford – are overlooked. In this model, agents either work full-time or are unemployed. This is in contrast to the classic micro textbook treatments which focus on the number of hours worked, with the implicit assumption that workers can choose their hours. (See for example Begg et al. (2011, pp.230-234) and Varian (2010, pp.174-178)). This standard assumption is rather surprising given the evidence to the contrary (such as Tam, 2010) and so this simplification of our model seems quite justifiable.
Box 7.7: Guildford: labour supply.

Guildford is a town of about 150 000 inhabitants about 30 miles to the south west of London. Some 70 000 or nearly 80 per cent of the working age population are economically active.

<table>
<thead>
<tr>
<th>Economic activity in Guildford (October 2012-September 2013)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Economically active</td>
<td>77.1%</td>
</tr>
<tr>
<td>In employment</td>
<td>69.8%</td>
</tr>
<tr>
<td>Employees</td>
<td>55.7%</td>
</tr>
<tr>
<td>Self employed</td>
<td>13.3%</td>
</tr>
<tr>
<td>Unemployed</td>
<td>5.8%</td>
</tr>
</tbody>
</table>

While as many as half the workers travel out of Guildford to work – 1 in 8 commuting to London, which is a 35 minute train journey – others come in to Guildford to work from the surrounding area.

Thirty per cent of the employee jobs were in ‘Public admin., education and health’ in 2012. In comparison with the rest of the UK, a higher than average proportion of workers is in the higher occupational groups: 38 per cent are managers, directors, senior officials or in professional occupations. One third of the employees are part-timers.

There are about 6 500 employers and some 65 000 in employment so each employer on average employs about 10 people. However, the three largest employers – the University, the hospital and local government – together account for about 13 per cent of employees. Combining data from various sources suggests that the power law distribution noted in Box 7.6 for the whole of the UK applies locally too, although possibly with a slightly higher exponent because there are no very large employers.

![Graph showing the power law distribution with equation y = 22 719x^{-1.2} and R^2 = 0.97](image)

Sources: ONS (2014), Guildford Borough Council (2009, pp.8-9), University of Surrey (2013, p.26), Royal Surrey County Hospital (2013, p.26).
We build the model in three stages. In the first stage, we establish the distribution of wages. In the second, we model job search, matching employers with vacancies and unemployed workers. Finally, we add the labour market flows described in the Introduction, basing the model on our home town of Guildford.

**Stage 1: Wages**

There are 100 employers and 1000 employees. Workers are either employed or unemployed. Those who become inactive drop out of the model and are replaced by new workers joining the labour force. So there are always 1000 workers and 1000 jobs.

As we have noted, workers are heterogeneous in many respects. In this model, we assume that this heterogeneity is entirely reflected in their wages. The distribution of wages is based on that of full-time workers in Guildford (see Box 7.8). We built a model to generate a log-normal distribution with a mean normalised to 100. (See Appendix A7.1 for details.) Figure 7.5 shows an example of the wage distribution based on this method that best meets the stylised facts set out in Box 7.8.
Box 7.8: Distribution of wages in the Guildford and Aldershot travel-to-work area, 2012.

In 2012, the average gross weekly pay of full-time workers was £624 per week. But about 60 per cent earned less than this average. The median was lower, £505, or about 80 per cent of the average. In other words, half of workers earned less than 80 per cent of the average wage. Only workers in the top decile earned more than around twice average pay as shown the bottom line of the table below.

<table>
<thead>
<tr>
<th>Percentiles</th>
<th>Pay £ per week</th>
<th>As % of average pay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottom decile</td>
<td>125</td>
<td>20</td>
</tr>
<tr>
<td>Lower quintile</td>
<td>238</td>
<td>40</td>
</tr>
<tr>
<td>Middle quintile</td>
<td>419</td>
<td>67</td>
</tr>
<tr>
<td>Median</td>
<td>505</td>
<td>80</td>
</tr>
<tr>
<td>Upper quintile</td>
<td>606</td>
<td>100</td>
</tr>
<tr>
<td>Top quintile</td>
<td>875</td>
<td>140</td>
</tr>
<tr>
<td>Top decile</td>
<td>1 181</td>
<td>190</td>
</tr>
</tbody>
</table>

Source: ONS, 2013b.

Figure 7.4: Results of model: an example of the distribution of wages generated by the model.

1 000 agents. 100 runs.

The average wage is set equal to 100 and standard deviation of the log-normal distribution is set to 0.7. This distribution is consistent with the observed distribution shown in Box 7.8: 64% of workers have wages below the average and the top decile – the top 10 per cent of workers – earned more than twice the average wage. (The plots show only 99.6% of workers because 0.4% have wages more than 5 times the average and are therefore off the end of the plot.)
Stage 2: Job search

On average, each employer has 10 employees, to reflect the observed average in Guildford, but the size of employers is distributed according to a power distribution of about (minus) one, as shown in Box 7.9.

Box 7.9: Guildford: labour demand.

<table>
<thead>
<tr>
<th>Model assumptions</th>
<th>Number of employers</th>
<th>Average no. of employees per employer</th>
<th>Total employees</th>
<th>Per cent of employers</th>
<th>employees</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>100</td>
<td>100</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>97</td>
<td>97</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>50</td>
<td>150</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>30</td>
<td>120</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>15</td>
<td>405</td>
<td>27</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>64</td>
<td>2</td>
<td>128</td>
<td>64</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>10.0</td>
<td>1 000</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
So we now have workers to whom wages have been allocated and employers who want a given number of workers. All the workers are allocated at random to employers, so that there is no unemployment. The modeller selects the number of job-seekers – workers looking to find another job – and the extent of wage flexibility. The number of jobs and the number of vacancies are fixed and equal there are always 100 employers and 1 000 workers, although individual employers and workers the number of job-seekers also equals the number of vacancies. This simplifying assumption means that there is no cyclical unemployment, but as we shall show, frictional and structural unemployment can arise. (See Box 7.10 for information on the types of unemployment.) Note that job-seekers are not counted as unemployed until they have been through the job search procedure and failed to find work. This means that workers can move from one job to another without being unemployed.

**Box 7.10: Types of unemployment.**

<table>
<thead>
<tr>
<th>Three types of unemployment are generally recognised.</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Frictional unemployment. Workers may leave their jobs voluntarily in order to find something ‘better’. This is called frictional unemployment and is seen as a sign of a healthy economy with a mobile work-force. It explains why there is always unemployment, even when vacancies exist.</td>
</tr>
<tr>
<td>• Structural unemployment arises when workers’ skills do not match the job opportunities.</td>
</tr>
<tr>
<td>• Cyclicl unemployment or demand deficient unemployment arises when output is below full capacity i.e. unemployment is due to a general fall in demand.</td>
</tr>
</tbody>
</table>

For more see Begg et al., 2011, pp. 531-533.

The employers want to fill their vacancies and the job seekers want a new job. How can they be brought together in the model? Job search can be initiated in two ways: by employers with vacancies or by job-seeking workers. In this simple example, we have adopted an employer-led process: employers in effect advertise their vacancies at the same wage that they paid to the worker who left the job. The reasons for choosing this approach are essentially technical: the programming is somewhat simpler and it is easier to add employer preferences, such as favouring those who have been unemployed for a shorter time.

Employers do not adjust the wages they offer and workers have to take what is offered or remain unemployed. Workers are ‘price-takers’, that is, they have to accept the wage offered and cannot negotiate. However, workers can only accept wages within a given range of their past wage. The extent of this wage flexibility is set by the modeller specifying the maximum wage increase and the maximum wage decrease any job-seeker can accept. This chosen wage
bracket is the same for all workers. So, for example, if both are set at 0 per cent, there is no wage flexibility and the worker can only accept a job at exactly the same pay as they received in their previous job. But if both are set at 10 per cent, then workers can accept jobs offering wages between 90 per cent and 110 per cent of their last wage. There may be many reasons why workers would take a job paying a lower wage than they previously earned: a lower paid job may be preferred because it is closer to home, reducing travel costs, or is better work in some sense. Setting the maximum wage decrease to zero could be regarded as analogous to the ‘wage stickiness’ that is a key feature of ‘new Keynesian’ models, which refers to the failure of wages to fall so that the labour market clears and all seeking work obtain it.

The process starts with the employer with the highest paid vacancy looking at all the workers seeking jobs within the wage range in which that vacancy lies. The employer then selects the worker whose last wage was the highest, on the basis that this is the only indicator of quality available to the employer. But the employer pays the wage offered, not the previous wage the worker received. Depending on circumstances, this could be more or less than the worker’s previous wage. Then the next-best paid vacancy is filled and so on. Considering the highest paid first may seem an odd assumption. However, given the shape of the wage distribution – as illustrated in Figure 7.5 – the highest paid workers will have a smaller selection of jobs to choose from than lower paid workers, and so to maximise the chances of the top paid finding jobs, they are considered first. Other assumptions could be made. Because the model notionally reflects the labour market in a single town, any worker can take a job with any employer except their last one, thus ensuring that job-seekers do not simply return to their last employer.

The details are in Appendix A7.2, together with some suggestions about how to verify a model with such complicated interaction.

**Results**

The model repeats the process 100 times, each time with a new set of data, and then reports the averages over the 100 runs. Despite the simplicity of the model the results are rather interesting.
A selection of results are shown in the top panel of Figure 7.10: a high rate of unemployment is associated with small changes in the mean wages of those who move to new jobs. Further investigation shows that when there is no downward flexibility of wages permitted:

- The relationship between the maximum wage increase permitted, set by the modeller, and the resulting increase in mean wages of those who move to new jobs follows a semi-logarithmic relationship, as shown in the left middle panel.
- The relationship between the maximum wage increase permitted, set by the modeller, and the resulting unemployment rate follows a power law relationship, as shown in the right middle panel and
- The relationship between the unemployment rate and the observed changes in the mean wages of those who move to new jobs follows a semi-logarithmic distribution, as shown in bottom panel.

These results make sense in that greater wage flexibility results in less unemployment. Thus the model is validated against theory in broad terms. Whether the precise relationships implied between wage flexibility and unemployment are valid is another question. The point of this model is to understand the basic process before incorporating it into a more realistic model, to which we now turn.
Figure 7.5: Results from the job search model.

No downward flexibility in wages

\[ y = 1.58 \ln(x) - 0.41 \]
\[ R^2 = 0.98 \]

\[ y = 6.56x^{0.834} \]
\[ R^2 = 0.99 \]

\[ y = -1.89 \ln(x) + 3.15 \]
\[ R^2 = 0.99 \]

(1) Of those who have moved to new jobs.
Stage 3: The Guildford Labour Market

So far, we have simply allowed the modeller to decide how many workers become job-seekers, thus creating vacancies. Now we extend the model so that vacancies are created by employers closing or workers retiring or quitting. The time period used is a quarter of a year.

Business demographics
When employers close they are replaced by new employers of the same size, and offer wages drawn at random from the log normal distribution. These may be significantly different from those of the employer who closed, so there is no guarantee that those made redundant by the closing employers will be able to take jobs with the new employers. Consistent with the observed ‘business demographics’, two employers ‘die’ each quarter (ONS, 2012). Only small employers die as the mortality rate falls with increasing size and it would be unrealistic to allow one of the three major employers to close. The resulting unemployment could be regarded as structural (see Box 7.10).

Worker demographics
Workers are aged from 20 to 59. This range is used for simplicity as in reality those going to University will start work later and many will retire later too. Age is included only to ensure that workers do not live forever. When workers retire at age 60, they are replaced by new workers aged 20 who are allocated a wage level they expect drawn at random from the log normal distribution. (This does mean that there is a chance that a 20 year old could get a very high wage but it avoids the need to make more complicated assumptions about the profile of lifetime earnings.) So, again, there is no guarantee the retired workers will be replaced by similar workers. Only those in the labour force are explicitly modelled. Retired workers do not appear in the model. As the initial age of workers is distributed randomly between 20 and 59 and three quarters, and workers retire at 60, on average 6 will retire each quarter i.e. 0.6 per cent of the workforce.

Other worker changes
To allow for the other reasons for leaving the labour force, the modeller sets two percentages: for moving from employment to inactivity and from unemployment to inactivity. These can be disabled by setting the rates to zero.
Due to heterogeneity, the demand and supply may not always match as imbalances may occur as retiring workers and closing employers are replaced. However, there is no change in total labour demand or total supply. The model is summarised by a simplified activity diagram in Figure 7.11. Following the Unified Mark-up Language (UML) conventions:

- the workers’ states are shown by a rounded rectangle, e.g. unemployed;
- a decision is shown by a diamond with the options labelled e.g. to seek work or leave the labour force;
- an activity is shown by a narrower, more rounded rectangle e.g. entering the labour force;
- a transition is shown by an arrow e.g. employed leave labour market.

(For more on the use of UML in agent-based modelling, see Bersini, 2012.)

At the start of the quarter some of the employed leave their jobs voluntarily to seek other work, some are made redundant due to employers closing and some become inactive due to retirement or for some other reason. Those unemployed already decide whether to seek work or leave the labour force. All those leaving the labour force – from employment or unemployment – leave the model and are replaced by new workers, who are seeking work. New employers replace those who have gone out of business and they create vacancies. Other employers create vacancies to replace those who have left. So total labour supply equals total labour demand. Employers then fill their vacancies from the jobseekers, as described above.

When this matching process is complete, some job-seekers will have found new jobs but others will be unemployed. As before, job-seekers are not counted as unemployed until the matching process is complete and they have failed to find a new job. This means that, as in the Labour Force Survey flow data, a move from employment to unemployment and back into employment within the quarter will not appear in the unemployment statistics.
Figure 7.6: Simple labour market model.

The dynamic processes have to be allowed to ‘run-in’ to settle. In addition to the number of quarters, the run-in time and the number of runs, the modeller sets the wage flexibility as before plus the value of three probabilities:

- The probability of a worker leaving their job.
- The probability of an employed worker leaving the labour force.
- The probability of an unemployed worker leaving the labour force.

The probability of a worker leaving their job is in addition to redundancies but includes those moving between jobs without becoming unemployed and should therefore probably be higher than shown in Figure 7.3. As noted above, Gomes (2009) estimated that on average 2.9 per cent of those in employment changed jobs directly each quarter. However, this was based on data before the 2008 crisis and it is believed that people are less likely to leave jobs voluntarily when unemployment is high. The probability of a worker leaving the labour force – either from employment or unemployment – is in addition to retirement and the employer closing should therefore probably be lower than shown in Figure 7.3.

Even though wage flexibility is restricted, this model does allow workers to be mobile over several job changes. For example, if a worker changes jobs three times and each time increases their wage by 10 per cent, their wage would be one third higher than initially. But the overall average across all employed workers will remain near 100.

The details of the model are in Appendix A7.3.

Results

After some testing, the run-in period was selected to be 100 quarters to be sure that the system has settled. The results are then based on the averages taken over the next 100 quarters. So the model was run for 200 quarters.

In order to test the model to ensure that it is working as desired it incorporates a ‘homogeneous’ scenario. In this scenario, all employers are identical, all with the average size of 10 employees, and all workers are identical. However, workers retire and employers close. But everyone finds a job during the quarter and so the unemployment rate is zero.
For a more realistic scenario, we sought to replicate unemployment in the south-east of England during a period of relative stability and we have chosen to focus on the period between 2009 and 2013 as shown in Figure 7.12 and Box 7.11.
Figure 7.7: Unemployment rate in south east England: 1992-2013.

Source: ONS (2014)

Box 7.11: Unemployment data since 2009.

Unemployment rate (%): south-east England*: May 2009 – October 2013

<table>
<thead>
<tr>
<th>No. of quarters</th>
<th>21</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>6.1</td>
</tr>
<tr>
<td>Maximum</td>
<td>6.6</td>
</tr>
<tr>
<td>Minimum</td>
<td>5.2</td>
</tr>
<tr>
<td>Range</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Source: Figure 7.12

*Not available for Guildford.

Hazard rates per quarter (%): UK: Q2 2009 to Q2 2013

<table>
<thead>
<tr>
<th>From</th>
<th>Employment</th>
<th>Unemployment</th>
<th>Inactivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>To</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employment</td>
<td>22.2</td>
<td>(1.2)</td>
<td>4.8</td>
</tr>
<tr>
<td>Unemployment</td>
<td>1.5</td>
<td>(0.1)</td>
<td>5.7</td>
</tr>
<tr>
<td>Inactivity</td>
<td>1.8</td>
<td>(0.2)</td>
<td>15.9</td>
</tr>
</tbody>
</table>

Source: Figure 7.3

*Not available for Guildford or south-east England.
An example of key results over 30 runs, with the underlying assumptions, is shown in Table 7.2. The greater the wage flexibility, the lower is the rate of unemployment, the lower the proportion of unemployed who are long-term unemployed and the greater the probability of moving from unemployment into work. That is all as would be expected. But, in this model, the fewer workers who leave their job, the higher the rate of unemployment. This is because there is less activity in the job market and thus fewer job opportunities and less likelihood of finding a suitable job. The results for limited wage flexibility combined with 2% to 3% leaving employment seems to be closest to the observations in Box 7.11: an unemployment rate of about 6 per cent and an unemployment to employment hazard rate of about a fifth. But the model produces a lower proportion of long-term unemployed than observed.
Table 7.2: Results from the simple labour market model.

<table>
<thead>
<tr>
<th>Assumptions</th>
<th>Key results (over 30 runs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Per cent of employees leaving jobs (1)</td>
</tr>
<tr>
<td></td>
<td>Mean (sd)</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Wage flexibility: max wage increase: 5%, max wage reduction: 0%</td>
<td>Unemployment rate (%)</td>
</tr>
<tr>
<td></td>
<td>% of unemployed long-term</td>
</tr>
<tr>
<td></td>
<td>Hazard rate: U to E %</td>
</tr>
<tr>
<td>Wage flexibility: max wage increase: 10%, max wage reduction: 10%</td>
<td>Unemployment rate (%)</td>
</tr>
<tr>
<td></td>
<td>% of unemployed long-term</td>
</tr>
<tr>
<td></td>
<td>Hazard rate: U to E %</td>
</tr>
</tbody>
</table>

(1) In addition to retiring and due to employers closing.
Discussion

We have presented a simple model in order to illustrate the key dynamic processes underlying the labour market. Nevertheless, the explicit assumptions required are many:

- demand and supply, in terms of the number of jobs and the number of workers, are fixed and initially balance so that there is full employment
- wages are distributed log-normally to reflect the distribution observed in the Guildford area
- the distribution of the size of employers is determined by a power law distribution with an exponent of -1, reflecting the distribution observed in the Guildford area
- the ‘death rate’ of employers is two per quarter, selected randomly
- workers are evenly distributed between the ages of 20 and 60 and those aged 60 retire and are replaced by workers aged 20
- other than for retirement and as a result of the ‘death’ of employers, workers are selected at random to leave their jobs
- job-search is initiated by employers, who fill the best paid jobs first
- employers do not change their wage offers
- workers are only differentiated by their wage in the job search process
- workers accept the wages offered.

In addition there are implicit assumptions. For instance:

- the fact that workers can choose not to work implies that they have some means of support, either private resources or Government benefits.
- the labour market is isolated so that workers have to find jobs within it.
- there is no cyclical unemployment.

The modeller sets the values of just five parameters:

- the probability of leaving employment to seek a new job
- the probabilities of leaving employment or unemployment for inactivity
- the extent of wage flexibility: the maximum wage increase and the maximum wage reduction allowed.

Neither employers nor workers are explicitly optimising. Employers are simply trying to maintain their desired labour force and workers to obtain a wage within the specified range.
Yet despite this simplicity, it is possible to replicate the kind of unemployment seen in Guildford and south-east England in recent years. Furthermore, examination of example runs shows (Figure 7.13) that the unemployment rate fluctuates too, in a way that suggests cycles even though there is no change in the total number of workers demanded. These fluctuations are not the ‘cyclical unemployment’ that results from changes in demand, but cyclical unemployment in the sense of ‘occurring in cycles’. The unemployment observed is frictional and structural and entirely due to mismatch, to heterogeneity.
Figure 7.8: Results: examples of the unemployment rate (%) based on maximum wage increase of 5% (as illustrated in Box 7.12).

Thin lines show the observed range of unemployment rates (see Box 7.11)
Of course the results of the model do not match the observations very closely because this is a simple model. The workers only differ in one characteristic, namely, wages. There is no allowance for age, gender, education or time spent unemployed. In particular, given that the model did not take into account that the long-term unemployed are less likely to return to work than others, it is hardly surprising that the model underestimates the proportion of unemployed who are long-term unemployed. Adding such characteristics would complicate the model immensely and require many more assumptions. The purpose here was to create the simplest model that could reflect the basic dynamics of the labour market.

It could be said that the model has produced a straight line with some random variation and that a much simpler model would match the data just as well. But a simpler model would not be emulating the complicated flows that comprise the labour market. Think of a swan – black or white – gliding across a lake. The turbulence created by its paddling is not visible but without understanding the dynamics of the paddling, you would not be able to understand how the swan is able to glide.

Despite our aim to ‘keep it simple’, the programming has been quite complicated and illustrates just how much detail is required to model the labour market. It is vital to establish what the model is actually doing. This is not just a matter of verification and validation, but also assessing properly the implications of taking different approaches to modelling any given economic activity. It is not sufficient simply to say ‘we can match these observations’. There are usually many ways a given set of observations can be matched. We have shown in Figure 7.10 how the simple approach we have taken to modelling job search results in a specific set of relationships between wage increases and the unemployment rate. The power law and semi-logarithmic relationships between unemployment and wage flexibility were not programmed in but emerged from the behavioural rules used. These relationships may or may not be acceptable, or realistic. But they need to be explored before the model is used to answer bigger questions. This is an important lesson for agent-based modellers who are understandably so keen to do exciting policy-orientated work that they neglect to explore and understand the modelling of basic economic processes. Building blocks that are based on agreed assumptions, and have been fully tested and understood need to be created so that those using them for policy analysis can be clear on what exactly their models are doing.
Returning to the three main themes of the book, even this simple model demonstrates the importance of modelling heterogeneity, dynamics and interaction.

- Both employers and workers are highly diverse. This heterogeneity causes a mismatching that results in unemployment.
- The labour market is highly dynamic: there are large flows into and out of work and into and out of the labour force.

Again, we have shown how the micro and macro can be brought together effectively using agent-based modelling. This is especially important in the labour market, because relative stability is observed at the macro despite a great deal of activity at the micro level. In contrast, traditional textbooks separate micro and macro (e.g. Begg et al., Chapters 10 & 23).

To sum up, again we have demonstrated the importance of modelling heterogeneity, dynamics and direct interaction and how agent-based modelling can bring together the micro and macro.
References


Appendix to Chapter 7

A7.1: Wage distribution model.

*Purpose:* The aim of the model is to produce a log-normal wage distribution.

*Entities:* Agents represent people.

*Stochastic processes:* Random allocation of wages using a log normal distribution.

*Outputs:* Results are displayed on the screen and printed to a csv file.

The pseudo-code is in Box A7.1 and a screenshot in Figure A7.1. For the full code see the website: *Chapter 7 – Wage Distribution Model.*

---

**Box A7.1: Pseudo-code for the wage distribution model.**

Create 1 000 workers  
Repeat 100 times  
Allocate wages  
Allocate a wage drawn randomly from a log-normal distribution to workers.  
Calculate the average wage and normalise it to 100.  
Recalculate workers’ wages.

Data collection  
Record the key points on the wage distribution: bottom decile, bottom 20%, bottom 40%, median, bottom 60%, bottom 80% and top decile.  
For each, calculate the cumulative difference squared from the target (to measure goodness-of-fit.)  
Collect the data for each run.

Take the averages over the 100 runs.  
Plot the wage distribution for all runs.  
Plot the results of the model against the target over 100 runs.  
Send the output to a csv file.
Figure A7.1: Screenshot of wage distribution model.

Things to try using the wage distribution model

Use the slider to generate different distributions.
A7.2: Job search model

Purpose: The aim is to model job search.

Entities: There are two types of agents: employers and workers.

Stochastic processes: Wage distribution, allocation of workers to employers and selection of job-seekers.

Initialisation: The modeller selects the number of job-seekers and the extent of wage flexibility (by specifying the maximum wage increase and the maximum wage decrease any job-seeker can accept).

Outputs: Results are shown on the interface and sent to a csv file.

The pseudo-code is in Box A7.2. There is some very complicated programming involved in this job-search model, so how can we be sure that it is working as we intended? Box A7.3 explains how the model has been verified. Figure A7.2 shows a screenshot. For the full code see the website: Chapter – Job Search Model.

Box A7.2: Pseudo-code for the job search model.

Create a world 315 x 315
Create 1 000 agents to represent workers and 100 to represent employers and distribute them randomly across the world.

For each run:
Allocate a wage to each worker.
Allocate a firm size to each employer.
Allocate workers to employers.
Select the required number of workers to seek new jobs.
The employers of the job-seekers create vacancies.

Vacancies are filled, starting with the best paid and working down the wage distribution. Employers fill their vacancies with the highest paid eligible worker.

Verification checks are carried out (see Box 7.A3).

Data from each run is collected
Means over all the runs are calculated and shown on the screen and printed to a csv file.
Box A7.3: Notes on verification of the job-search model.

To test that the model is working as intended, it includes a range of checks at both the micro and macro level:

At the micro level:

Workers
- Do any job-seekers receive wage increases outside the specified range? If so, then the wage restrictions have not been modelled correctly.
- Have any workers been re-employed by their last employer? This is not supposed to happen as if it did all the job-seekers could simply slot back into the jobs they have just left.

Employers
- Does the sum of the number of employees and the number of vacancies equal the employer’s size? Are there any employers for whom the sum of their unfilled vacancies and new recruits not equal their total initial vacancies? If not, then the recruitment process has not been modelled correctly.

At the macro level:
- Do the total vacancies equal the total number of workers with no employers? If not, there is an error because the overall demand for labour is set to equal the overall supply.
- Do the total new recruits equal the total number of workers who have found jobs? If not, then the recruitment process has not been modelled correctly.
Things to try using the job search model

Use the sliders to examine the effect of different levels of wage flexibility.

Advanced, requiring programming

- What is the effect of not starting with the highest paid vacancies or job-seekers?
- Devise different job search mechanisms.
A7.3: Guildford labour market model

Purpose: A simple labour market model based on Guildford.

Entities: There are two types of agents: employers and workers.

Stochastic processes: Wage distribution, the age distribution, allocation of workers to employers and selection of job-seekers and selection of workers to leave the labour force.

Initialisation:

- Wage flexibility as in the job-search model.
- The probability of a worker leaving their job in addition to redundancies but including those moving between jobs without becoming unemployed.
- The probability of an employed worker leaving the labour force in addition to retirement.
- The probability of an unemployed worker leaving the labour force in addition to retirement.
- The number of quarters and the run-in time.
- The number of runs.

Outputs: Results are shown on the interface and sent to a csv file, Plots for the first run are sent to another csv file.

The pseudo-code is in Box A7.3 and a screenshot in Figure A7.3. For the full code see the website: Chapter 7 – Guildford Labour Market model.
Box A7.3: Pseudo-code for the Guildford labour market model

Create a world 315 x 315.

Each run:
Create 1 000 agents to represent workers and 100 to represent employers and distribute them randomly across the world.
Workers are allocated
- a wage – see Wage Distribution model above
- an age, distributed evenly between 20 and 59.75.
Allocate a firm size to each employer.
Allocate workers to employers.

Dynamics:
Clear past records as appropriate.
Employers ‘die’ making their workers redundant.
New employers are created with vacancies at wages selected from the log-normal distribution.
Workers age and retire if aged 60, and are replaced by 20 year olds.
Workers leave their job to seek new jobs: number set by slider.
Workers leave the labour force: numbers set by sliders.
All those who leave the labour force are replaced by new workers, who are allocated a wage at random from the log-normal distribution.
Employers create vacancies to replace the workers who have left, offering the same wage as paid to those who have left.
Employers fill vacancies, as in the job search model. (see Appendix A7.2.)

Data collection at the end of the quarter
- the unemployment rate and various flows are measured.
- the overall wage level is also monitored
- averages collected.

Data from each run is collected

When all runs are completed, means over all the runs are calculated and shown on the screen and printed to a csv file.
Things to try using the Guildford labour market model

Use the sliders to examine the effect of different levels of wage flexibility and flows.

Advanced, requiring programming

- Allow employers to give preference to job-seekers who have only recently left their jobs and discriminate against the long-term unemployed.
- Make the probabilities of leaving a job dependent on age.
- Add education.
- Replace the employer-led job search mechanism with the worker-led mechanism.
- Allow workers to search for jobs before giving notice i.e. so that there is a time lag in the creation of vacancies.