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The Macroeconomics of Unemployment in the Treasury Macroeconomic (TRYM) Model

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Abstract

The paper is essentially in three parts. (A) First it outlines and documents the labour market framework in TRYM and attempts to validate the framework by showing how it can explain certain historical facts such as why unemployment is now much more cyclical than in the 1960s. To further validate the framework, it is compared and reconciled with the labour market specifications in a recent paper by the RBA (Debelle and Vickery 1998). (B) The paper then turns to some of the implications of the framework and what it says about the linkages between wages and unemployment. An important aspect of how a wage change impacts on unemployment under our current monetary policy framework is via the interest rate reaction to the inflation generated by higher nominal wages. The paper therefore compares the monetary policy response in TRYM with that in other Australian macro models. It then looks at the full model response to a wage shock and demonstrates that the interest rate reaction is important in generating the short-term employment response. (C) The paper then looks at the macroeconomic consequences of reducing unemployment, including implications for living standards and macroeconomic aggregates such as national saving and investment. Inter alia the paper touches on what the model has to say about the sources of the increase in unemployment in the 1980s and 1990s. While it is impossible to be precise, the evidence from the model suggests that the observed increase in structural unemployment was only partly due to search effectiveness factors. It seems macroeconomic wage setting and price setting factors (eg institutional/bargaining factors, the fall in productivity growth, decline in the terms of trade, and perverse feedback such as to taxation and to the cyclicality of unemployment itself) played an important role in explaining the level and persistence of unemployment in the late 1980s early 1990s.

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Background on the TRYM Model

The TRYM model is a small macroeconomic model developed in the Australian Treasury for macroeconomic forecasting, policy analysis and sensitivity analysis. The model has a core of key macroeconomic relationships that are estimated using quarterly time series data. The estimated equations are linked together by a larger number of accounting identities. The model could be described as broadly new Keynesian in its dynamic structure but with an equilibrating long run. Activity is demand determined in the short run but supply determined in the long run. There are 29 estimated equations, 3 financial market identities, and about 20 behavioural identities with 60 accounting identities linking these key behavioural relationships. In constructing TRYM, effort has been directed towards ensuring consistency between and within sectors, with 19 of the model's 29 behavioural equations being jointly estimated with other equations. Care has also been taken to identify separate demand and supply curves where possible. Most equations are estimated with either error correction or partial adjustment specifications with an identifiable long run. This allows the construction of a steady-state representation of the model's equations. The steady-state version of the model is simulated to provide model-consistent future values for forward looking variables such as the exchange rate. Optimal control algorithms are used for policy control simulations in deriving forward looking monetary and fiscal policy settings, and there are also simple default monetary and fiscal policy response mechanisms which are used when the fiscal or monetary policy response is not the key feature of the simulation. Details of the model are contained in Commonwealth Treasury (1996a) "Documentation of the TRYM Model" and (1996b) "The Macroeconomics of the TRYM Model".

The model is designed to mesh in with other analytical systems within the Treasury and where possible it exploits information from those other systems. For example, it employs detailed population projections from the Retirement Income Modelling Unit's POPMOD which, in turn, are aggregated into variables which feed into the equations for household consumption, dwelling investment and the labour supply. The department also has an input-output price incidence model PRISMOD which is used to derive coefficients for weighted demand terms for imports and non-farm stocks in TRYM as well as deriving revenue bases for various indirect taxes.

The model is extensively used in forecasting where its output forms an aggregate consistency check on the output of the far more detailed National Accounts Forecasting Framework (NAFF), an interlinked system of spreadsheets used to forecast national accounts aggregates and related variables. Over the years, the more disaggregated forecasting systems have also served as a consistency check on the specification of the TRYM equations.

The Treasury has been involved in macroeconomic modelling since 1970. The original NIF model, authored by Chris Higgins and Vince FitzGerald, was published in the first issue of the Journal of Econometrics in 1973. Documentation of the first version of the TRYM model was published in 1992. Since then the model has evolved as a result of both its use for forecasting and policy analysis and explicit research and development. It has also been subject to extensive scrutiny and validation, including via conferences examining the model itself (1992, 1993, and 1997) and by the examination of results at model comparison conferences (1994 Productivity, 1996 Monetary Policy, 1998 Asian Crisis).

The model continues to be the subject of research and development.

Overview

The aim in this paper is to provide a reasonably non-technical description of the labour market framework in TRYM and the linkages that exist between wages and unemployment in the model. Some equations and derivations are included in Sections 3.1 to 3.6, but in the main the technical material is relegated to appendixes. The descriptions of the intuition behind the specifications and results is hopefully readily understood. The paper is designed to trace through the linkages between wages and unemployment and where possible to validate the linkages by reference to:

- empirical evidence;
- predictions of the framework; and
- comparison with other empirical work and model responses.

Section 1 provides a brief overview of theories of unemployment which the model needs to encompass.

Section 2 outlines the labour market framework in TRYM, and the factors it highlights as possible explanations for the rise in unemployment in Australia, and briefly discusses the evidence for the alternative explanations.

Section 3 looks at the empirical evidence on the relationships outlined in the framework; surveys the evidence on employment demand and wages; and, provides details of the specifications in TRYM for: employment; output prices, wages; vacancies; labour supply and average hours worked. It provides details of the latest econometric estimates for each of these equations from the model; and, a brief analysis of the dynamic properties of the labour market equations taken as a whole — as a cross check on the estimates from individual estimation of the equations.

Section 4 attempts to validate the model's labour market framework first by looking at two predictions of the framework:

- That unemployment will become more volatile as the economy moves further from a full employment equilibrium (as trend unemployment rises); and
- That the response of employment to wage changes rose in the 1970s and 1980s as unemployment increased.

These two predictions are also a cross check on the conclusion drawn from analysis of the Beveridge curve - that the rise in unemployment reflects mainly macroeconomic factors and that the long-run equilibrium level of unemployment may be well below the current rate.

Section 5 deals with further validation by attempting to reconcile the framework with previous studies, in particular the RBA study by Debelle and Vickery, and briefly discusses their macroeconomic results and how they relate to the full model results presented in this paper.

Section 6 looks at the monetary policy response in the model. This is in two parts. The first part covers the response of the economy to a change in interest rates, briefly comparing the response in TRYM to that of other models. The second part covers the modelled response of

interest rates to developments in the economy — in particular the control procedure used for determining monetary policy in the wage sensitivity analysis for the Wages Safety Net Review..

Section 7 looks at the full-model response to a wage shock again comparing a number of models and the work with previous work such as that of Debelle and Vickery, and the Committee on Employment Opportunities, EPAC, and Access Economics. One of the interesting features of the results in TRYM is that large reductions in real wages are not required in the model to reduce unemployment. The logic behind the TRYM result conforms closely to the Layard, Nickell and Jackman (1991) description (p 384) that, with mark-up pricing, an increase in wage pressure has very little impact on real wages in the medium-run. If there is no abatement in wage pressure, the only medium-run result is higher unemployment. Everybody is worse off. As taxes need to be raised to pay for the unemployed, and the revenue base has shrunk, real after-tax wages can actually fall in the medium run as a result of an increase in wage pressure. Moreover, because of the turnover characteristics of the labour market the distribution of the losses is concentrated among the poor — the equity implications are extremely negative. The rise in unemployment also has adverse consequences for other economic variables often thought to be important such as National Saving, the CAD and the PSBR.

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1 Introduction — Theories of Unemployment

Unemployment is a macroeconomic phenomenon with microeconomic foundations. There are many things that might be done at a microeconomic level to reduce unemployment. But ultimately no microeconomic policy will work unless it leads to a change in the relationship between aggregate unemployment and aggregate wages. For example, a program that improved the skills, motivation and search effectiveness of the unemployed would have little or no impact on aggregate unemployment unless the greater competition for jobs that resulted reduced nominal wage growth at a given rate of unemployment.[1] It is possible for a microeconomic program to change the distribution of unemployment — to shuffle the queue — without reducing unemployment at the aggregate macroeconomic level. The reduction of unemployment at the aggregate level ultimately depends on the response of aggregate wages and aggregate prices. The failure of nominal wages to respond to unemployment at the aggregate level generates a large problem for economic policy makers. As the Employment White Paper put it in 1945.

> "To prevent the waste of resources which results from higher unemployment is the first and greatest step to higher living standards."

The consequences for equity and social welfare are equally disturbing.

> "A central theme of the [Henderson] Commission into Poverty of 1973 was that the dominant factor which determines poverty is whether or not the head of the income unit is in the 'work-force'."[2]

It is stating the obvious to say that it is an important problem. Perhaps what is not so obvious is the theoretical problem that it presents for macroeconomics. It is a central macroeconomic phenomenon. Any model that hopes to describe the Australian economy must provide a coherent explanation for the rise in unemployment in the 1970s and 1980s.

So what is the theoretical problem? On the simplest view, in a perfectly operating market, competing workers would bid down the wage until the market cleared — there would be no unemployment. The perfect-competition, market-clearing model is a spot market with: full information; homogenous goods; no uncertainty or risk aversion; no social welfare system or moral hazard; no institutional rigidities or monopolies; and no discrete reaction lags or adjustment costs. Such a market is characterised by instantaneous, real time adjustment of prices. Commodity and financial markets are often cited as examples where the market clears

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1 Or, to be more precise, the tendency of nominal wage growth to increase relative to productivity growth at a given rate of unemployment. Note that greater skills would increase productivity. Also this paragraph is not meant to imply that microeconomic policies or programs have no effect on unemployment (cf *The Age*, Saturday 2 October 1999 P14) . It is simply a statement of the aggregate test. The solution to unemployment must have both macro and micro aspects and it is the interaction between the two which is perhaps the most interesting part of the problem. Neither is it intended to belittle distributional aspects of policies and programs. Micro policies and programs can obviously have quite important impacts on individuals and on individual groups and regions.

2 Gregory and Sheehan, (1998) "Poverty and the Collapse of Full Employment", in Fincher and Nieuwenhuysen *Australian Poverty — Then and Now*, Melbourne University Press. See also Harding and Richardson (1998) and Borland and Kennedy (1998) in Debelle and Borland (1998). The Committee on Employment Opportunities (1993b) Background Paper "The Social and Economic Consequences of Unemployment" also provides a useful survey.

almost instantaneously.[3] Let us imagine for a moment that such a market existed for labour. In such a market there would be no unemployment. Theories of unemployment can therefore be classified by the reasons why the market clearing model does not work. They include:

- Search models — these relax the assumptions of full information and homogeneity. As each worker is different and each job is different, and the job market is characterised by turnover, then the process of matching jobs is characterised by search as in the models by Diamond. As a result, there will always be some level of frictional and mismatch unemployment. The level of frictional and mismatch unemployment will be a function of the level of turnover, the degree of structural change in employment (e.g. dispersion of growth rates), the nature of the social welfare system (many studies for example find the duration of benefits as a significant contributor), the efficiency of the education and training system, the responsiveness of relative wages, and the characteristics of the unemployed themselves (for example level of motivation and search intensity which falls with duration).

  There are a number of factors that might lead to reductions in the effectiveness of the unemployed in filling available jobs and hence explain the rise in unemployment. Increases in long-term unemployment may lead to deterioration of skill levels or morale problems which reduce search intensity. Structural change (particularly in the face of relative wage rigidities) can increase the mismatch between the skills of the unemployed and available jobs. Increases in welfare benefits can reduce the incentive to seek employment. In all cases unfilled vacancies should rise for a given unemployment rate. The unemployed would be less search effective and the unemployment rate would be higher at the point where the market clears.

  - Within this model cyclical fluctuations in unemployment might be explained by the industrial churning caused by recession as in Liliens findings.[4]

- Efficiency wage theories. These relax the assumption of perfect information and introduce monitoring costs and or psychological theories of human motivation. The essential idea is that work effort is related to relative pay. These models have the important property that they provide a reason why the wage setting relationship may diverge in the long run from the labour supply relationship. If wages reflect labour supply then the only unemployment that is possible in the long run is frictional and mismatch unemployment.

  - One prediction is that higher turnover should be associated with higher unemployment. A country like Japan with a tradition of life time employment would be associated with low unemployment.[5]

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3 Although there is some doubt whether the efficient market hypothesis holds even for the financial markets.

4 Lilien (1982) advanced the idea that fluctuations in unemployment could be attributed to sectoral specific shocks. He consequently used a measure of the industry dispersion of employment growth to explain fluctuations in unemployment over the cycle. Later work by Abraham and Katz (1986) and Murphy and Topel (1987) challenged his findings — particularly the direction of causality between his explanatory measure and the cycle.

5 On the other hand the US and Canada have roughly twice the turnover compared to Europe and yet unemployment has been lower in the US in the 1980s and 1990s than in Europe (although the reverse was true in the 1960s). Other factors may be at work. Countries with low turnover also tend to generate high levels of long term and mismatch unemployment i.e. may be more susceptible to insider hysteresis for a given shock.

- They provide a reason why relative wages might differ from relative productivity across industry as shirking behaviour is potentially more costly in high capital cost industries.

- They provide a reason why wages might be slow to react to changes in labour market conditions (e.g. a given firm may not want to be the first to lower wages).

- The models however, do not provide a strong reason why unemployment rose suddenly in the 1970s, but they do provide reasons why the adjustment process might be slow following wage shocks or negative supply side shocks

One important aspect of the of the efficiency wage theories are their implications when combined with the menu cost idea of Ackerlof and Yellen. The menu cost idea is that small adjustment costs provide a reason for sticky prices and sticky wages when a firm is near its profit maximisation position. For a firm near its profit maximization position the short-term loss of profits from not adjusting is small (second order) compared to the potentially larger short-term adjustment costs. Efficiency wage theories suggest another reason why adjustment of wages might be costly at the level of the individual firm (ie another reason why the short term costs might outweigh the short term benefits). In combination with the menu cost ideas they therefore provide a basis for explaining slow reaction of wages and prices to changes in output demand in the product market, and employment demand in the labour market. The lack of adjustment at the firm level due to the fact that the short term benefits may be small (second order) paradoxically leads to first order losses (e.g. increases in unemployment) at the economy wide level. From an economy-wide point of view, explaining the reasons for the slow price and wage adjustment is absolutely crucial. Without that slow adjustment, unemployment would be due purely to frictions and mismatch and cyclical fluctuations in sectoral churning as argued by Lillien.

- Bargaining models — these introduce legal and institutional factors and/or risk aversion and uncertainty into the picture. There are a number of different forms. One is the implicit contracts model which is based on the premise that workers are risk averse and firms have a greater capacity to cope with fluctuations in activity (engage in risk spreading). Another is the right to manage model where the union bargains over the wage and the firm chooses the level of employment. Like the efficiency wage model, these models introduce a reason for the wage setting relationship to be separate from the labour supply relationship. In combination with firm specific skills on the part of workers, the implicit contract models supply a reason for adjustments of employment to lag, and/or not fully reflect, fluctuations in activity (labour hoarding). They also suggest reasons why the wage setting curve may shift over time — i.e. due to: changes in union power; changes in the degree of centralisation of the wage bargaining process; fluctuations in bargaining power with sector specific shocks in combination with centralised arrangements (ie the leading sector problem); and, changes in productivity growth, taxes or the change in the terms of trade driving a wedge between producer and consumer wages (ie changes in the wedge). [6]

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[6] The theoretical bargaining models are not without their problems in terms of the implications for cyclical fluctuations in employment and the real wage, and also because of the possibility of efficient contracts. The insider-outsider models go some way to solving these problems.

- Insider/outsider models or membership models of Gregory (1985), Blanchard and Summers (1986) and Lindbeck and Snower (1986) — these are an outgrowth of bargaining models. The crucial distinction in these models is between insiders or members who play a role in the bargaining process and outsiders (the unemployed) who do not participate. As the wage bargainer is only concerned about the insiders the unemployment level may have little effect on the bargain. Rather, wage restraint will only occur when employment is falling and insiders feel threatened. If the unemployed exert little effect on wages then changes in unemployment will be the main influence on wage developments. In that case unemployment will exhibit *path dependence*. In the extreme case, where the unemployment level exerts no influence, unemployment would exhibit *hysteresis*.

Perhaps an additional model that might be added to those above at the macroeconomic level are the constrained equilibrium models associated with Clower, Leijonhvud and Barro and Grossman — which deal with the implications of constraints in one market for other markets. How prices and wages adjust in different markets relative to each other can have important and sometimes counterintuitive effects at the aggregate level. Perhaps an example of this is the US economy in the seventies / early eighties where the relatively strong performance was attributed by some authors (e.g. Bruno and Sachs 1985) to a high level of nominal wage inflexibility (e.g. from overlapping contracts) in the face of rising prices associated with supply side shocks and expansionary demand policies. That is, with supply side shocks and rapid price adjustment in the goods (commodity) market, nominal wage inflexibility implies real wage flexibility (Jackman 1989).[7]

In summary, there are explanations for unemployment persistence from both the wage setting/price setting and search effectiveness points of view, i.e. from both the insider and outsider point of view. Unemployment might rise because of changes in the characteristics of the unemployed themselves (the outsiders) and their search behaviour, or it could persist because of changes in wage setting behaviour or price setting behaviour and the factors that can drive a wedge between the two and hence the wage demanded by insiders.

- On the search effectiveness side, a common argument is that higher unemployment leads to higher levels of long-term unemployment. Higher long-term unemployment leads to deterioration in skill levels and possible morale problems which reduce search intensity. The loss of human capital and reduction in search effectiveness associated with long periods of unemployment will lessen the potential competition from the unemployed leading to higher wage pressures at a given rate of unemployment. Thus, the equilibrium rate of unemployment increases.

- On the wages setting side, the insider-outsider or membership theory provides a reason why unemployment may be path dependent. The essential idea here is that the number of insiders will fall during a recession. As only insiders participate in the wage bargaining process (the welfare of the unemployed does not enter the equation), insiders will bid up wages as the economy comes out of recession and before unemployment falls back to its original levels. Unemployment will tend to ratchet up after each recession. Necessary

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7 Another example might be the mid to late 1990s in Australia where nominal wages continued to grow at between 4 and 5 per cent when, with higher productivity growth, inflation had dropped to between 1 and 2 per cent. The consequence is that insiders have cornered the benefits of higher productivity growth in the form of higher real wages, while unemployment has only fallen slightly despite strong output growth.

adjustments to the capital stock can amplify this process — see Bean (1990). In its extreme form, the insider theory leads to the conclusion that there is no unique equilibrium rate of unemployment, even in the long term.

Bean (1994) provides a useful summary of the theories and the evidence for Europe and concludes that European unemployment is mainly explained on the outsider side.[8] Blanchard, in a 1989 study, also concluded that UK and US unemployment was largely a function of search effectiveness factors but that wage setting / price setting factors explained the rise in German unemployment.

The challenge for the model is to encompass the different theories but to do it in a parsimonious manner focussing on recursive factors (feedback), but with sufficient detail to allow judgements based on more comprehensive microeconomic work to be fed in.[9] It is not the role of the model to be at the cutting edge of economic research (although work on the model often involves constructing solutions to problems in areas where there is little in the way of academic literature). Rather, it codes in what might be called mainstream economic theory and hopefully contains something close to the consensus on the empirical evidence. What we are attempting to do is to reflect mainstream economic theory.

However, the theories outlined above are not mutually exclusive. Efficiency wage considerations, implicit contracts, bargaining and membership will be of varying importance in different firms and industries. Behaviour at the aggregate level is likely to reflect a mix of factors. Similarly, it seems likely that the behaviour of unemployment is due to a range of factors both on the wage bargaining, price-setting side and the search effectiveness side.

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8 Romer (1996), Blanchard and Fisher (1989) provide useful surveys of the various models with worked examples of implications.

9 In other words the model does not need to contain detail that is not recursive i.e. does not have feedback implications. For example, Economic Group maintains detailed and extensive spreadsheets to prepared detailed forecasts of the economy. The disaggregated methodologies involved can be used as a cross check on the aggregate relationships contained in TRYM, and provide information for example on whether structural changes may be occurring in particular relationships. If such a conclusion is reached from examination of the detail the aggregate relationship can be adjusted.

2 Labour Market Framework in TRYM

2.1 Basic Framework

This section attempts to outline the basic labour market framework in TRYM so that the more detailed specifications presented in parts 4.2 to 4.6 can be seen in context. The framework bears many similarities with the system outlined in the influential book by Layard, Nickell and Jackman (1991).[10] In particular by Layard, Nickell and Jackman went to some length to develop an encompassing explanation of unemployment, with unemployment benefits, search effectiveness, the wedge between producer and consumer prices, union power and wage bargaining institutions all playing a role. The aim in TRYM is to have a framework that allows us to similarly capture a variety of influences that can lead to higher unemployment. Again the aim is not to be at the cutting edge but to reflect what is now a reasonably widely accepted view of how the labour market works.

The labour market framework consists of five broad components shown in Figure 1 below. These are as follows:

- Short Run Labour Demand Curve — this is downward sloping with an elasticity of around 0.84[11]. It is important to note that this elasticity and the curve as drawn represents a partial relationship — i.e. holding other things constant.

- Price Setting or Long Run Labour Demand Correspondence Curve — this could be thought of as the long-run labour demand curve when all other relationships in the model are allowed to adjust.[12] In TRYM it is close to horizontal in the long run. The level of this curve is largely determined by productivity, which is, in turn determined by technology. Real wages can move away from this level in the short term but as any increase in wages is eventually passed on in the form of a price rise, real wages must return to the equilibrium level in the long run. A fall in the terms of trade or productivity would imply a fall in this line and an equivalent fall in the labour demand curve.

- A Beveridge Curve — this relates unemployment to vacancies. As unemployment rises the number of job seekers per available job increases and the number of unfilled vacancies falls. This relationship is shown relative to the labour demand and labour supply lines in the diagram below. An unfilled vacancy is an unfilled demand. It is the difference between observed employment given by BC and employment demand (LD). Similarly, unemployment is the difference between observed employment (BC) and

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10 See the system developed in Chapter 8, "The Macroeconomics of Unemployment".

11 Strictly speaking this is the elasticity of factor substitution σ. The own wage constant output elasticity of labour would be around 0.25, i.e. $(1-s).\sigma$ with s being the wage share of GDP. However, whether the own wage constant output elasticity (i.e. the movement around the isoquant) requiring a fall in the capital stock to allow a rise in employment is particularly relevant in an applied sense is a moot point. The simulation results attached show that the capital stock rises as a result of a negative wage shock even in the very short term. Another short-term concept is the imaginary response when capital is controlled for and output allowed to adjust its desired level — in this case the elasticity of employment with respect to the real wage is 2.5 (i.e. $\sigma/(1-s)$).

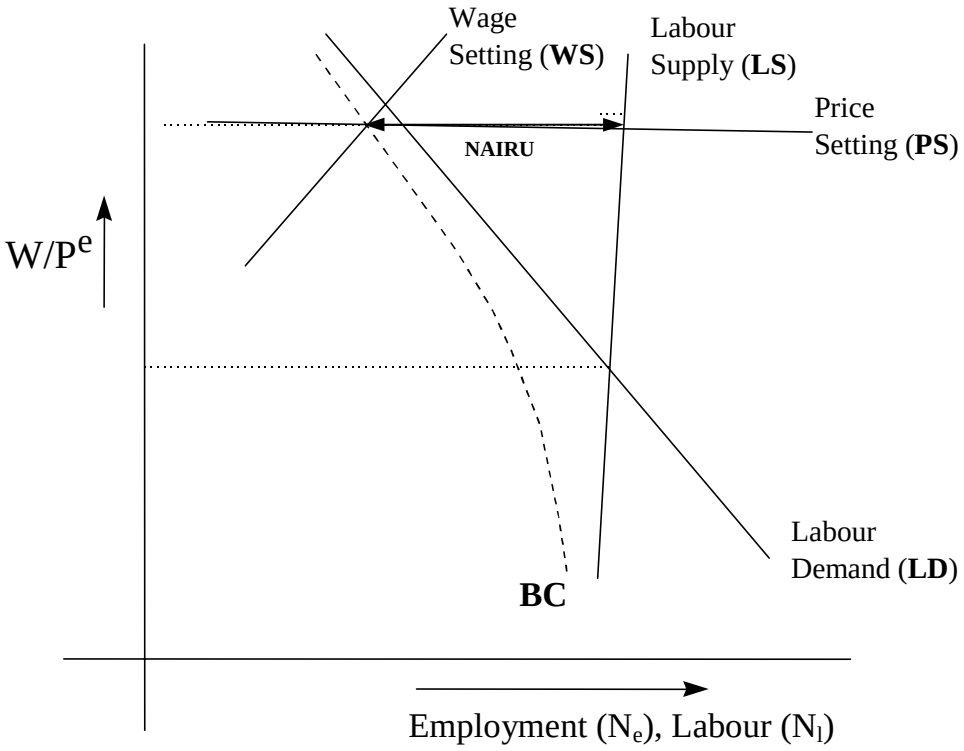
12 That is, the total differential while the short-run labour demand curve LD is the partial differential. The total differential involves all of the models equations and is derived numerically rather than analytically given the number of equations in the model.

labour supply (LS). A shift to the left in BC represents a decrease in search effectiveness of the part of the unemployed (i.e. an increase in frictional and mismatch unemployment). The way the TRYM framework is set up is that the information from the Beveridge curve is fed into the wage setting curve (WC). A reduction in search effectiveness increases the NAIRU. A shift in the BC curve to the left shifts the WS curve by the same amount. It is a sufficient but not a necessary condition for the WS curve to shift. The wage setting curve can shift for its own reasons, independent of BC. For example, it could shift to the left as a result of institutional factors (e.g. 1974, 1981) independent of any change in search effectiveness. Thus vacancies are used in two ways — to help identify the labour demand curve, and to help identify movements in the wage setting curve.

- Labour Supply Curve (LS) — this is deliberately drawn vertical as there is very little evidence of a long-run response to real wages. Neither does there appear to be significant evidence of inter-temporal substitution and hence a purely short-run response to fluctuations in real wages. Rather, the dominant features are the encouraged/discouraged worker effect, and social and demographic trends.

- Wage Setting Curve (WS) this is linked to the Beveridge Curve (BC) but can also move independently of BC due to bargaining factors. As mentioned above, it is separate from the labour supply curve and reflects efficiency wage, wage bargaining and insider-outsider factors. It will also move relative to the Price Setting Curve as a result of changes in wedge factors such as the terms of trade, changes in trend productivity growth, and change in taxation levels or tax efficiency or the efficiency of the delivery of government services.

Figure 1: Labour Market Framework



Equilibrium is where the Price Setting and Wage Setting Curves intersect, or as by Layard, Nickell and Jackman describe it — 'where peace is found in the battle of the mark ups — prices over wages and wages over prices'.

The framework allows unemployment to be decomposed. Short-term cyclical fluctuations in unemployment can be explained by reference to fluctuations in labour demand or labour supply. The secular rise in unemployment and persistence in unemployment at a high level can be explained with reference to the outward movement in the Beveridge Curve in the mid 1970s and movements in the wage setting and price setting curves in the 1970s, 1980s and 1990s. Following are some examples of how the curves might shift and interact to result in higher unemployment:

- Higher or open-ended benefit payments: reduce search effectiveness, shifting the Beveridge Curve (BC) to the left; raise the reservation wage, shifting the Wage Setting Curve up; and, need to be funded by increased taxes shifting the Price Setting Curve down. (When the PS curve falls, the LD and BC curves also fall.) All three shifts increase the NAIRU. As unemployment increases tax rates increase (a combination of higher benefit pay-outs and a smaller revenue base) driving a further wedge between the Wage Setting and Price Setting Curves.

- Relative wage rigidities in the face of sectoral shocks might: reduce matching and search effectiveness and hence move BC to the left; create leading sector problems shifting the WS up; and reduce productivity at the firm level, lowering the Price Setting Curve.

- Falling terms of trade: shifts the Price Setting Curve down raising the NAIRU

- Falling trend productivity growth: shifts the Price Setting Curve down raising the NAIRU

- Increasing tax wedges due to higher unemployment: shift the Price Setting Curve down and may be a cause of persistence as unemployment benefit and associated payments rise and the tax base shrinks. Wage setting behaviour is relative to consumer prices, whereas the price setting curve is defined in terms of producer prices. Taxation drives a wedge between the two – an increase in the tax wedge (see Figure 8) shifts the Price Setting Curve down relative to the Wage Setting curve.

- Institutional factors (the wage explosions of 1974 and 1981) and other shocks shifting the Wage Setting Curve to the left. Insider-outsider factors causing persistence in the Wage Setting Curve — that is once it has moved out it is slow to move back.

The system provides a reasonably flexible framework within which unemployment can be examined. It allows us to explain unemployment within the context of what is now mainstream theory. What remains is an empirical question of the nature of the various relationships shown.

3 Labour Market Evidence and Specifications

3.1 Employment Demand

Employment demand in the model is estimated jointly with the investment and business output price equations. In common with most other equations in the model the equation is estimated in an error correction format. The long run elasticities are estimated directly using non linear least squares. The form of the long run is derived from a constant elasticity of substitution (CES) production function, as are the private business investment equation and the business output price equation. These are joint decisions on the part of the firm and hence the equations are estimated jointly with common coefficients to ensure internal consistency. In other words, information from the other equations helps inform the estimated long-run elasticity.

Because business investment is defined for the private sector in the national accounts, the employment demand equation is also defined for the private business sector to allow joint estimation. General government employment is treated as exogenous and public enterprise employment is endogenous but mainly dependant on public enterprise investment which, in turn, is exogenous. Quite clearly estimating a wage elasticity including employment from the public sector is problematic. The large movements in public sector employment in the 1970s and 1980s, shown in Figure 18, below need to be excluded. The swings in general government employment also have quite significant effects on productivity growth given that the ABS imputes labour productivity to be lower in the general government sector than the private sector.

3.1.1 Review of Empirical Evidence — Comparison of Elasticities of Substitution

The empirical literature on the effects of wages on employment can be usefully divided into two parts — that which looks at the employment response at the aggregate level — and the part that which looks at the employment response at the disaggregated level, (i.e. for individual groups of workers or for individual firms, industries or regions). (The well known Krueger and Card study, for example, is for a particular group of workers (teenagers) in a particular industry (fast food) in a particular region (New Jersey)).

This section looks at the evidence at the aggregate level. Research at the aggregate level could be further divided into two kinds:

- firstly, partial analysis focussing on one feedback — the direct wage effects on employment demand by itself; and
- secondly, full model or full system analysis where all feedbacks are allowed to operate.

The studies referred to below focus only on the **direct** impact of real wages via the labour demand relationship, (i.e. they represent partial analysis). That is, the responses are estimated abstracting from other feedbacks. The total effect on employment of a change in wages and wage inflation involves a range of other responses as well. The direct employment demand response is only one component of the total response where capital, output and prices are other variables are allowed to adjust as in the full model results in Section 7 below.

The response of employment demand to changes in real wages is depicted in different ways in the literature depending on what factors are being held constant. For example, some authors might refer to the "constant output, own-wage elasticity" of labour demand (e.g. Hamermesh (1986)), which is derived by holding output constant and measured as if capital and labour reach their equilibrium levels. This gives a small apparent response from employment to a change in the real wage. Another methodology is to derive the employment demand curve in terms of capital and the real wage (e.g. Layard and Nickell (1986)) and measure the response as if output adjusted to its ideal level — this gives a large apparent response from employment to a change in the real wage.[13] However, these are simply different ways of expressing and measuring the same thing — the measure depends on what else is held constant. Other things need to be held constant to simplify the description. The complex reality is that output, prices and the capital stock all have their own responses — they are determined by other relationships in the economy — or put another way their adjustment path is determined by other equations. The only real point of interest from the labour demand studies from an aggregate point of view is the estimated elasticity of substitution between capital and labour. The elasticity of substitution effectively defines the partial employment demand relationship. It also provides a useful point for cross study comparisons. The full economy, or full model, employment response depends on the response of other variables.

3.1.2 Aggregation Issue

It is important to note that the elasticity of substitution at the aggregate level is not the same as the elasticity of substitution at the firm or industry level. It should normally be a little higher. This is because a real wage rise will favour capital intensive firms over labour intensive firms (which have a higher proportion of labour costs). For example, Houthakker (1956) demonstrates that it is possible to derive a Cobb-Douglas production function with an elasticity of substitution equal to 1.0, via the aggregation of substitution effects between individual firms each of which has a different, but fixed, capital to labour ratio (i.e. each of which has an elasticity of substitution equal to zero). That does not mean that the elasticity of labour demand (as opposed to the elasticity of factor substitution) is necessarily lower at the level of the firm or industry. Rather, the reverse is the case — the partial elasticity of demand at the industry or firm level or for individual groups of workers is generally higher than the partial elasticity of demand at the aggregate level. This is because at the disaggregated level there is not only the possibility of capital for labour substitution, but also the possibility of substitution between one firm's output and another firm's output (scale effects), and the possibility of substitution between one group of workers and another groups of workers (cross wage or labour for labour substitution effects). These other forms of substitution (scale and cross wage effects) tend to net out at the aggregate level.[14]

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13 The constant output, own-wage elasticity is: $(1-s)\sigma$ where s is the wage share and σ is the elasticity of substitution. When the capital stock rather than output is held constant the long run coefficient on real wages is $\sigma/(1-s)$.

14 Similar logic applies to what might be called the proportion of wage costs argument. It is sometimes argued that wage changes have little effect at the firm level on pricing, output or employment decisions because wage costs only form a small proportion of overall costs (made up of wage costs, capital costs and costs of inputs). However at the aggregate level the inputs from other industries net out. While the wage share at the firm level may be one third, at the national level it is two thirds. Hence the argument is a non sequitur, small changes at the firm level cascade up through the production chain to larger changes at the aggregate level.

3.1.3 Empirical Evidence

Estimates of the elasticity of substitution between labour and capital in Australian aggregate employment demand studies range between 0.32 and 1.04 with most studies giving an estimate close to 0.7 to 0.8. This implies that, for a given level of output growth, each 1 per cent increase in real wages employment will decline by between 0.7 and 0.8 per cent.

An elasticity of 0.7 to 0.8 is also around the level that the international evidence suggests. International results drawn from Hamermesh (1994) are shown in Table 1. Similar estimates for a variety of countries are contained in the OECD Jobs Study (1994). Hamermesh in fact ends his comprehensive survey of the literature with the conclusion that the vast majority of evidence points to an elasticity somewhat higher, at around 1.0.

> "The immense literature that estimates the constant-output demand elasticity for labour in the aggregate has truly led us to 'arrive where we started and know the place for the first time' [with an estimate where the implied elasticity of substitution is equal to 1.0]."[15]

The results of the aggregate Australian studies are also shown in Table 1. Some early models of employment demand such as that employed in the Treasury NIF10 model simply assumed an elasticity of substitution of 1.0. Murphy et al (1986), in estimating the employment equation for the EPAC AMPS model based on a CES production function, found an elasticity of substitution substantially lower at 0.32 for the period 1966 to 1985. Their low elasticity appears to be due to a problem in identifying the labour demand relationship, with movements in employment in the earlier period 1966 to 1972 often constrained by labour supply (see Commonwealth Treasury (1996)). Pissarides (1987) in a study over the same period which includes an equation for labour supply, finds a much higher elasticity at 0.79.[16] Lewis and Kirby (1988) examine the effect of wage restraint under the wage freeze and Accord on employment. They estimate an elasticity of substitution of 0.79, somewhat higher than Lewis in 1985.[17] These results are also consistent with estimates in the major macroeconomic models of the Australian economy including TRYM, the Access Economics Model (AEM) and the Murphy model (MM2), estimates from each of which give elasticities of substitution around 0.7 to 0.8.

A good summary of the various Australian employment demand studies conducted until 1993 is provided in the Committee on Employment Opportunities 1993 Green Paper, *Restoring Full Employment*. The committee concluded that:

> "There is now a widespread acceptance that the experience of the last twenty years has demonstrated that employment is sensitive to real wages. The consensus is that for

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15 Hamermesh (1993) P92 and in turn T.S. Eliot, (1942), *Little Gidding.* Many early studies simply assumed an elasticity of substitution of 1 and proceeded from there.

16 C.Pissarides, 'Real Wages and Employment Growth in Australia', Discussion Paper No 286, (Centre for Labour Economics, London School of Economics, 1987).

17 P.E.T.Lewis and M.G.Kirby, 'A New Approach to Modelling the Effects of Income Policies', *Economic Letters*, (No 28, 1988).

> Australia a reduction of one per cent in the level of real wages would have a direct effect on employment over time of around three-quarters of one percent."[18]

Dungey and Pitchford (1998), Debelle and Vickery (1998) [19] and the TRYM results below provide more recent estimates of the elasticity of substitution in Australia. Dungey and Pitchford estimate an elasticity of substitution of 0.40. Debelle and Vickery provide two estimates one for the 1969 to 1997 period of 0.67 and one for the more recent period from 1979 of 0.41. This leads them to speculate that the elasticity may have fallen in the 1980s and 1990s. However, there is no explanation for the decline, and the result sits a little oddly with other evidence. For example it does not appear to be apparent in the overseas evidence, and there is no particular reason why the elasticity of substitution would have declined over time. The fall in the elasticity appears to be partly definitional and partly related to data problems. The Debelle and Vickery equation is re-estimated in Section 5 below using private sector hours worked and the estimated elasticity of substitution rises to 1.04. The reason for the difference is mainly found in the fact that the elasticity in TRYM is defined for effective labour demand (employment plus vacancies) and for the private business sector alone rather than the whole economy. Elasticities estimated for the total economy rather than the private sector alone and without the vacancy adjustment should be substantially lower than that for TRYM by definition (Section 5.3 below contains a more detailed discussion). Sharp swings in public employment in Australia over the 1970s, 1980s and 1990s further cloud the comparison. There was a sharp lift in public sector employment in the mid 1970s relative to private sector employment and large relative falls in the 1980s (see Figure 18 below).

Government employment is a result of explicit policy decisions and is treated as being pre determined in most macroeconomic models. Because public employment is largely pre determined most overseas studies have focussed on private employment. Private sector employment is also the focus below. In the results below the elasticity is relatively high at around 0.82. The elasticity is insignificantly different when estimated over shorter more recent sample periods, if anything, is slightly higher. As mentioned employment demand is measured as employment plus vacancies (to avoid the effect of periods when labour supply partly constrained or otherwise influenced the employment response). If adjusted back to be comparable to the other measures it would be squarely within the 0.7 to 0.8 range. Hence, in TRYM the short run (first-year) employment elasticity is around 0.3 to 0.4, rising to around 0.75 over two to three years. Translating it back to total employment, given that there is no response from public employment to wages in TRYM, would give something even lower (around 0.6).

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18 Committee on Employment Opportunities 1993, *Restoring Full Employment: A Discussion Paper*, (AGPS, Canberra), cited in P.Dawkins and J.Freebairn, 'Towards Full Employment', *Australian Economic Review*, (December 1997), page 54.

19 G.Debelle and J.Vickery, 'Macroeconomics of Australian Unemployment', *Unemployment and the Australian Labour Market*, (Reserve Bank of Australia, 1998).

Table 1: Estimated Elasticities of Substitution Between Labour and Capital

Study	Employment Definition	Estimation Sample Period	Elasticity of Substitution
INTERNATIONAL*			
Brown and de Cani (1963)	Private, Hours	1933-1958	0.47
David and van de Klundert (1965)	Private, Hours	1899-1960	0.32
Dhrymes(1969)	Private, Hours	1948-1960	0.75
Lucas and Rapping (1970)	Total, Hours	1930-1965	1.09
Black and Kelejian (1970)	Private, Hours	1948-1965	0.36
Liu and Hwa (1974)	Private, Hours	1961-1971	0.67
Hamermesh (1983)	Private, Heads	1955-1975	0.47
Rudebusch (1986)	Total, Hours	1952-1981	1.16
Quandt and Rosen (1988)	Private, Hours	1932-1983	0.69
AUSTRALIAN **			
EPAC (AMPS Model) (1986)=	Total, Heads	1966-1985	0.32
Pissarides (1987)~	Total, Hours	1966(3)-1986(2)	0.79
Lewis and Kirby (1988)~	Total, Heads	1967(3)-1987(1)	0.78
Russell and Tease (1991)~	Total (male), Heads	1969(3)-1987(4)	0.61
Murphy and Powell (MM2) (1996)=	Total, Heads	1970(3)-1992(4)	0.77
Dungey and Pitchford (1998)~	Total, Heads	1984(4)-1997(1)	0.40
Debelle and Vickery (1998) I~	Total, Hours	1978(1)-1997(4)	0.41
" " II~	Total, Hours	1969(1)-1997(4)	0.67
" " III #~	Private, Hours	1969(1)-1997(4)	1.04
TRYM (1999)=	Private, Hours	1971(2)-1999(2)	0.82
TRYM (1999)=	Private, Hours	1982(2)-1999(2)	0.83+
TRYM (1999)	Total, Heads	1971(2)-1999(2)	0.6

* from Hamermesh (1993) Pages 78-79.

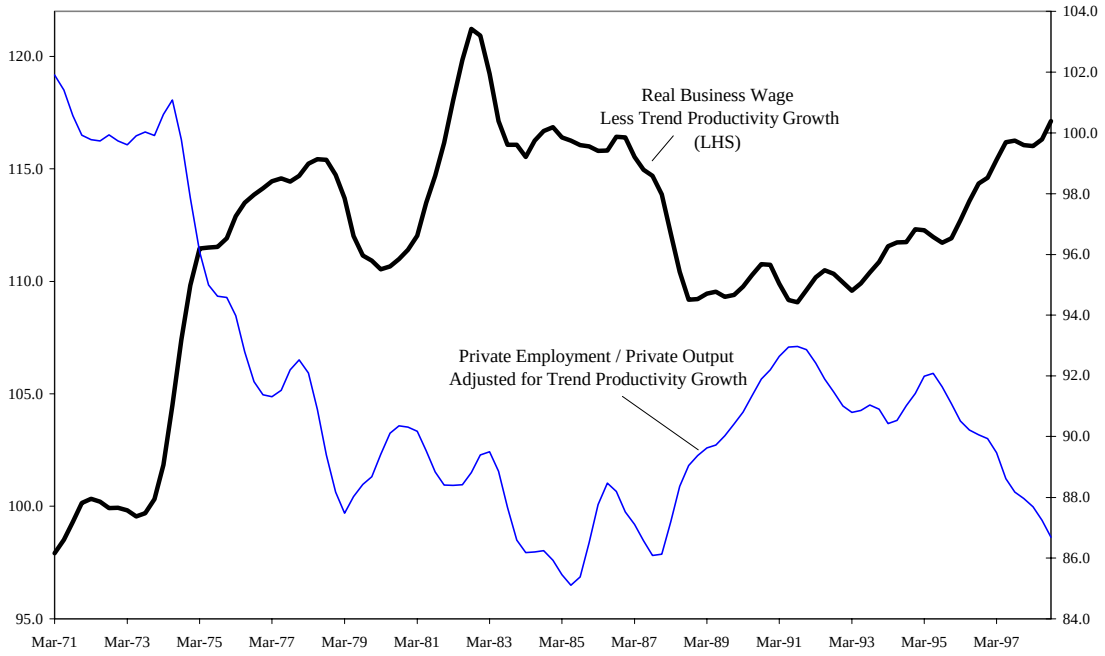
** The Australian studies marked with an = tag can be directly interpreted as factor elasticities of substitution. The interpretation on the studies marked ~ is a little looser. They appear similar to those that would be derived from a first order condition and should be reasonably close to an elasticity of substitution. To have the direct interpretation as an elasticity of substitution, strictly speaking, some underlying process for technical progress (Hicks, Harrod or Solow neutral) needs to be assumed. If Harrod neutral (consistent with a constant output to capital ratio over time), then employment needs to be defined in efficiency units in the long run and the long-run coefficient on output set to one for the long run coefficient on the real wage term to be interpreted as an elasticity of substitution. In both the Debelle and Vickery study and the Dungey and Pitchford study, the reported long run elasticities on output are greater than 1 while, that from Russell and Tease is lower than 1. The depiction of the results above as elasticities of substitution rather than as simply long-run (econometric) elasticities (as the author's describe them) is therefore a little loose. In other words, to place a precise structural definition on the reduced form econometric coefficients requires a prior structural specification or form for the production function. However, other aspects of the equations are also different, so the best that can be said about any of the results above is that they are broadly comparable.

\# Debelle and Vickery equation re-estimated in Section 5 below using private employment and output data

\+ As noted in last year's hearings, and the subject of some discussion, this estimate assumes unchanged trend productivity growth in both periods (pre and post 1982) for ease of estimation (Joint Governments (1999), cet par, page 229) Allowing trend productivity growth estimate to differ between the two periods yields an estimate for the elasticity of 0.86 for the second period.

The link between real wages and employment can also be seen in Figure 2 below.

Figure 2: Real Producer Wages and Private Employment to Private Output Ratio



Private employment is measured on an hours worked basis. Both series are indexes 1971-72=100
See Section 3.2 below, particularly the long run component of the employment equation, and Figure 8.

3.1.4 Derivation of Labour Demand Equation

Appendix A sets out the full derivation of the functional form of the long-run components of the employment, investment and output price equations. To tie these equations together first requires a choice of a functional form for the production function — in this case a constant elasticity of factor substitution (CES) function. The first order condition for profit maximisation requires that the marginal product of labour ($\partial Y/\partial L$) is equal to the real wage (W/P), and this is assumed to hold in the long run. Given the CES production function specified in TRYM, this implies that in the long run:

$$\frac{W}{P} = \alpha\left(\frac{L}{Y}\right)^{(\rho-1)}$$

Rearranging to obtain the equilibrium level of labour demand as a function of output and real wages gives:

$$\ln(L) = \ln(Y) + \sigma\ln(\alpha) - \sigma\ln\left(\frac{W}{P}\right)$$

Hamermesh (1986) and (1993) both contain derivations of the same functional form from the CES production function. Firms can alter their labour input by either changing the number of people they employ or by altering the number of hours worked by existing employees. The labour demand equation is therefore specified using average hours worked (NH) in addition to the number of people demanded (NEBD). This approach helps to capture, for example, the effect of the trend decline in average hours worked over the 1970s and 1980s, related to the 35 hour week campaign in the mid seventies and the shift over time towards part time work. Technical progress is assumed to be both labour and capital augmenting, however, post-

sample capital productivity is assumed to equal zero in order to achieve a constant capital-output ratio and sensible steady state. The marginal product of labour is adjusted for the rate of Harrod neutral technical progress (or the underlying growth in private sector labour productivity, λ_1) to determine the equilibrium relationship for labour demand. Harrod neutral technical progress is consistent with the observed long-term constancy of the capital-output ratio.

To help to identify the labour demand curve, unfilled vacancies (NVA) are added to observed business employment (NEB) to form effective employment demand (NEBD). Unfilled vacancies are the difference between the labour demanded by firms and the people actually employed. Without this adjustment, the significant movements in vacancy levels over time would tend to bias the estimate on the elasticity of substitution of labour for capital (σ) downwards. Put another way the vacancy data helps to identify the labour demand relationship (see Figure 1) adjusting for the fact that some employment, wage points would reflect or be influenced by the labour supply relationship.

The real wage faced by producers is given by the hourly nominal wage (RWH) adjusted for payroll and fringe benefits taxes (RTPRB) and deflated by the price of business sector output (PGB). This gives the following long run relationship for labour demand by the private business sector (QTIME is a time trend):

$$\ln(NEBD) = \ln(GBA) - \ln(NH) - \lambda \times QTIME + \sigma \ln(\alpha) - \sigma\left[\ln\left(\frac{RWH \times RTPRB}{PGB}\right) - \lambda \times QTIME\right]$$

The (producer) real wage, ln(RWH x RTPRB/PGB), adjusted for underlying productivity (λ_1) can be interpreted as a measure of real hourly wages adjusted for efficiency. As labour efficiency improves, with unchanged real wages, the real wage per unit of production declines. The above equilibrium relationship defines the labour demand of profit maximising firms, given real wages and the level of private business output (GBA). The equation implies that if real wages grow in line with underlying productivity, employment, on an average hours worked basis, will grow in line with output less underlying productivity growth.

This relationship will not necessarily hold in the short run. An error correction specification has been used to incorporate both the dynamic and long-run responses (see Section 2.2.3 of *The Macroeconomics of TRYM).*

The estimated equation is adjusted for population growth to ensure that steady state bias is not introduced into the model. Average adult population (NPAD) growth over two years is used to smooth out short-term fluctuations in population growth.

$$
\begin{aligned}
\Delta \ln(NEBD) = {} & \frac{\Delta_8 \ln(NPAD)}{8} - a_1 \times \sigma \times \left[\Delta \ln\left(\frac{RWH \times RTPRB}{PGB} \right) - \frac{\lambda_1}{4} \right] \\
& - (1 - a_2) \times \Delta \ln(NH) \\
& + a_3 \times \left[\Delta \ln(GBA) - \frac{\Delta_4 \ln(NPAD)}{4} - \frac{\lambda_1}{4} \right] \\
& + a_4 \times \left[\Delta \ln(GBA(-1)) - \frac{\Delta_4 \ln(NPAD(-1))}{4} - \frac{\lambda_1}{4} \right] \\
& + a_5 \times \left[\Delta \ln(GBA(-2)) - \frac{\Delta_4 \ln(NPAD(-2))}{4} - \frac{\lambda_1}{4} \right] \\
& + a_6 \times QPRIV \\
& - a_0 \times \left[\begin{array}{l} \left(\ln\left(\frac{NEBD(-1)}{GBA(-1)} \right) + \ln(NH(-1)) + \lambda_1 \times QTIME(-1) \right) - \sigma \ln(\alpha) + \\ \sigma \times \left[\ln\left(\frac{RWH(-1) \times RTPRB(-1)}{PGB(-1)} \right) - \lambda_1 \times QTIME(-1) \right] \end{array} \right]
\end{aligned}
$$

Results (from joint estimation of business employment, investment and price of non-commodities equations)

Sample: 1970(4) to 1999(2)

Parameter	Interpretation	Estimate	t-Statistic
a_0	error correction	0.198	6.42
a_1	real wages	0.150	3.16
a_2	hours worked	0.713	6.48
a_3	output	0.240	5.37
a_4	output lagged 1 qtr	0.106	2.28
a_5	output lagged 2 qtrs	0.085	1.89*
a_6	privatisation dummy	0.000001	2.30
σ	elasticity of substitution	0.817	14.88
λ_1	trend labour productivity	0.012	8.40

Diagnostic Statistics

$R^2 = 0.55$	
SE = 0.66%	
DW = 1.67	
Box-Pierce Q (1-8th order auto correlation)	7.71
Jarque-Bera Test for Normality	0.90
Chow Test for Parameter Stability	1.00
Ramsey's Reset Test	0.08
Breusch-Pagan Heteroscedasticity Tests:	
Trend	2.62
Y-Hat	4.66*
Joint	5.93

* Indicates the test has failed at the 5% confidence level.

Economic Interpretation

The adjustment toward equilibrium is fairly quick, with around 20 per cent of any difference between actual and desired labour demand eliminated each quarter. Other elasticities in this equation imply the following:

- A one per cent increase in private business output leads to an increase in the level of labour demanded of 0.24 per cent initially and 0.43 per cent after 3 quarters. However, this short-term direct response will be offset to some extent by the response of hours worked to the increase in activity (see the hours worked equation in Section 5). The response of employment to output builds to 1 per cent in the long run (in accordance with the constant returns to scale assumption). Employment here is defined in efficiency units.

- A one per cent increase in real wages would decrease the level of labour demanded by 0.15 per cent initially, building to 0.82 per cent in the long run. The direct effects on private employment and total employment are smaller (as discussed in Section 3.1).

- A one per cent increase in average hours worked would decrease the number of employees demanded (in terms of the number of people required) by about 0.71 per cent in the short run. That is, average hours worked play an important role in the adjustment of employment to any shock. Average hours worked, however, has no effect on unemployment in the long run since, in the model, the equilibrium unemployment level is determined by wage adjustment in the labour market and, hence, the NAIRU (see Section 5). Wage adjustments lead back to changes in interest rates and output and, hence, in labour demand.

Estimating the system of production function equations over a shorter period 82(3) to 98(3) and assuming no difference in trend productivity (i.e. holding λ constant) indicates a very slight increase in the estimate for σ. The estimate appears reasonably stable over a range of estimation periods. That is there does not appear to be strong evidence for a decline in the elasticity as discussed in Section 3.1. Estimating the equation as a part of a system using FIML (see Appendix B) also had little effect on the estimates.

3.2 Non-Commodity Business Output Prices — Price Setting

As mentioned above, the employment demand equation is estimated jointly with the investment and price equations. Like the employment equation, the price equation is defined for the private business sector. As the business sector has little control over commodity prices, output prices are modelled on a non-commodity basis. Also note from Section 2.4 below that the wage setting relationship is defined in terms of consumer prices. The business output price equation outlined in this section forms the main foundation for a system that builds up to consumer prices. Business non-commodity output prices combined with public enterprise output prices determine domestic supply prices (PD). Domestic supply prices, import prices plus custom duties and indirect taxes determine total supply prices (PT). PT in turn determines consumer prices with an adjustment for import content and pass through. Anything that drives a wedge between the business output price and the consumer price (such as the terms of trade or the tax wedge) will drive a wedge between the price setting and wage setting curves.

3.2.1 Derivation

The long run level of non-commodity prices is derived from the CES production function and the first order conditions for labour. Expressing equilibrium labour demand as a function of wages and output and substituting into the production function allows prices to be written as a function of nominal wages, capital stock and output.

$$P = \left[\frac{W}{\alpha}\right] \times \left[\frac{1}{\alpha} - \frac{\beta}{\alpha} \times \left(\frac{K \times e^{\lambda_2 t}}{Y}\right)^{\left(\frac{\sigma-1}{\sigma}\right)}\right]^{\left(\frac{1}{\sigma-1}\right)}$$

The price equation in the private business sector only relates to non-commodity prices. The price of commodities is determined by the price Australian exporters receive on world markets and is analysed in Section 6. This distinction is made because, in the TRYM model, non-commodity prices are sticky while commodity prices are assumed to be flexible and to clear the market for commodities.

Adjusting the above equation to take account of underlying productivity, and rewriting for the private business sector gives the following long run relationship:

$$PNC = \left[\frac{RWH \times RTPRB}{\alpha \times \exp(\lambda_1 \times QTIME)}\right] \times \left[\frac{1}{\alpha} - \frac{\beta}{\alpha} \times \left(\frac{K \times e^{\lambda_2 \times QTCAP}}{Y}\right)^{\left(\frac{\sigma-1}{\sigma}\right)}\right]^{\left(\frac{1}{\sigma-1}\right)}$$

The business sector is assumed to have little control over commodity prices. Therefore, the equilibrium relationship is defined for non-commodity output prices alone. This is done by removing the price effects of commodity exports (XC) and farm stocks (SFM) from the price of business sector output to form PNC (the price on non-commodity output). Using the suffix 'Z' to indicate nominal variables gives the long run relationship for the equilibrium price of non-commodities (PSTAR):

$$PSTAR = PNC = \frac{PGB \times GB - XCZ - SFMZ}{GB - XC - SFM}$$

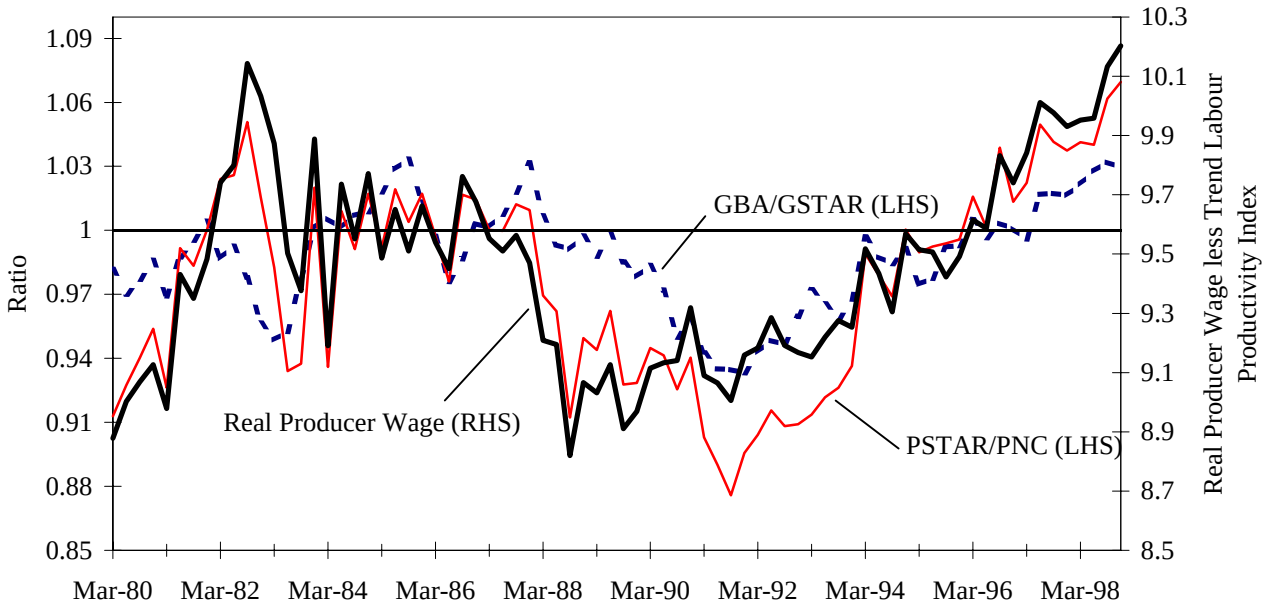
The two essential elements of PSTAR are the nominal wage adjusted for trend productivity and the output to capital ratio, which moves closely with capacity utilisation. PSTAR could loosely be defined as desired output prices given wages, productivity and the utilisation of capital. It is closely related to GSTWK (hypothetical output given current wages, prices, productivity and capital) - see Sections 3.1.1 and 5.8 of *The Macroeconomics of TRYM*. When non-commodity prices (PNC) reach their equilibrium level (PSTAR) derived from the first order conditions for profit maximisation, prices will have fully adjusted to any wage movement and GBA will equal GSTWK. However, the labour market and the financial market will not necessarily be in equilibrium at this point. Figure 1 shows that movements in PSTAR relative to PNC are closely related to movements in real wages and short run capacity utilisation, GBA/GSTAR.

As can be seen, PNC does not equal PSTAR in the short run. Non-commodity prices are assumed to adjust slowly toward their equilibrium level. In the short run, PNC is assumed to be driven by:

- a weighted average of current and past growth in PSTAR, with contemporaneous and lagged changes from one through to four quarters;
- short run movements in import prices PMGS (note that any effects are assumed to be unwound in the next quarter); and
- any disequilibrium between actual PNC and the desired level PSTAR, with a lag of five quarters, to ensure that prices are in equilibrium in the long run.

In order to ensure that the equation exhibits homogeneity with respect to inflation, the sum of the changes in the equilibrium growth of non-commodity prices is constrained to one.

3.2.1.1 Figure 1: PSTAR/PNC, Producer Real Wages and Capacity Utilisation (GBA/GSTAR)



The price of non-commodities equation is specified in error correction form as follows:

$$\begin{aligned}\Delta \ln(PNC) = {} & a_1 \times \{\Delta \ln(PSTAR)\} + \{1 - a_1 - a_2 - a_3 - a_4\} \times \{\Delta \ln(PSTAR(-1))\} \\ & + a_2 \times \{\Delta \ln(PSTAR(-2))\} \\ & + a_3 \times \{\Delta \ln(PSTAR(-3))\} \\ & + a_4 \times \{\Delta \ln(PSTAR(-4))\} \\ & - a_5 \times \{\Delta \ln(PMGS)\} \\ & + a_5 \times \{\Delta \ln(PMGS(-1))\} \\ & + a_0 \times \{\ln(PSTAR(-5)) - \ln(PNC(-5))\}\end{aligned}$$

where PSTAR is defined as above.

Results (from joint estimation of business employment, investment and price of non-commodities equations)

Sample: 1970(4) to 1999(2)

Parameter	**Interpretation**	**Estimate**	**t-Statistic**
a_1	equilibrium prices	0.486	7.87
a_2	lagged equilibrium prices	0.041	0.67*
a_3	lagged equilibrium prices	0.297	5.01
a_4	lagged equilibrium prices	0.009	0.15*
a_5	change in import prices	0.071	1.67*
a_0	error correction	0.040	1.96
β	CES parameter on K	0.392	7.83

Diagnostic Statistics

$R^2 = 0.36$	
SE = 1.8%	
DW = 2.46	
Box-Pierce Q (1-8th order auto correlation)	16.45*
Jarque-Bera Test for Normality	46.28*
Chow Test for Parameter Stability	1.66
Ramsey's Reset Test	0.005
Breusch-Pagan Heteroscedasticity Tests:	
Trend	2.95
Y-Hat	0.67
Joint	5.41

* Indicates the test has failed at the 5% confidence level.

Economic Interpretation

The lag distribution reflecting the effect of changes in PSTAR on the growth of PNC is well determined, except for the coefficient on the second and fourth lags (a_2 and a_4), which are insignificant but have been included to maintain continuity in the dynamics of PNC. Any disequilibrium between actual and desired PNC is eliminated very slowly, by around 4 per cent each quarter.

Imports are not included as a factor of production in TRYM. However, it seems likely that fluctuations in import prices will have some effect on short term movements in non-commodity output prices. Hence, the equation contains changes in import prices in the short term dynamics, but with the restriction that there is no effect after two quarters. The results indicate that import prices have a positive effect on non-commodity output prices after one quarter. This could reflect:

- changes in the price of imported inputs affecting the timing of non-commodity output price changes even though non-commodity output is net of imports;

- changes in the exchange rate leading to fluctuations in exporters' margins and, hence, in the relationship between the domestic price and the Australian dollar non-commodity export price (non-commodity export prices are assumed to be supply determined in TRYM with the Australian dollar price assumed to be a simple ratio of the domestic price); or

- the ABS practice of constructing some expenditure deflators (such as the one used for plant and equipment) with lagged import prices resulting in contamination of the data.

The main avenue by which import prices affect domestic prices in the model is via the price of total supply (both domestically produced and imported) to the domestic market (PT) and, in turn, via the block of equations for relative expenditure prices. The above equation for PNC deals with the price of domestically produced non-commodities only.

3.3 Wage Equation — Wage Setting and the NAIRU [20]

It is reasonably clear from observing the history of wage setting in Australia that institutional factors have played a large role. This makes modelling wage behaviour a difficult exercise. It is also clear from the brief discussion in Section 2 above that it is difficult to distinguish between alternative theories of wage behaviour from the aggregate data. As Nickell (1988) and Bean (1994) point out, aggregate wage behaviour is likely to reflect a mix of factors, some of which may be more important in some sectors than others. Given the aim of parsimony in modelling the labour market in TRYM, it is not possible to introduce the detailed disaggregated data required to distinguish between the different theories (although the inclusion of the change in unemployment term, discussed later, is suggestive of insider/outsider effects being present in the data to a significant extent).

However, it does appear to be possible to directly distinguish between search effectiveness and wage setting / price setting explanations of the increase in unemployment at a very broad level by the use of unfilled vacancy data. Any decrease in the search effectiveness of the unemployed (for whatever reason) should lead to an increase in unfilled vacancies for a given level of unemployment. The unemployment/vacancy relationship thus represents a powerful summary indicator of the state of the labour market, and there has been something of a resurgence in interest in this relationship over recent years. Some have attempted to examine the Beveridge curve in combination with the Phillip's curve to identify the sources of unemployment shocks. Blanchard (1989) for example, does this for the US, UK and Germany and concludes that labour market efficiency and mismatch problems (i.e. a reduction in search effectiveness) explain most

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20 Much of the material in this section is drawn from Downes and Stacey (1996)

of the rise in unemployment in the US and the UK but not in Germany. Attempts within Treasury to replicate the Blanchard approach for Australia appear to indicate that only a part of the increase in unemployment can be explained by search effectiveness factors.[21] This is consistent with earlier work by Trivedi and Baker (1985) and Matthews (1991).

Given the interest in search effectiveness factors (such as the increase in long-term unemployment), a Beveridge curve is estimated to introduce a simple summary measure of search effectiveness into the TRYM wage equation. However, no attempt is made to comprehensively model in TRYM the unemployment/vacancy relationship. For example, it has become popular following the work of Jackman, Layard and Pissarides (1983) and Blanchard and Diamond (1989) to use labour market flows data to estimate an equilibrium unemployment/vacancy relationship. The lack of gross flows data in TRYM and other relevant factors (such as immigration occupational or industry mismatch data, unemployment duration or other factors that researchers have found to be relevant to the relationship) means that it is not possible to identify the cause of shifts within the context of the variables used in TRYM. A fairly simple formulation is therefore adopted for modelling purposes and the results of this should be interpreted with caution.

The choice of a Beveridge curve for estimating the level of search effectiveness and shifts in structural unemployment was partly based on the desire for parsimony in the overall model design. The vacancies data, for example, helps to identify the labour demand equation and also enters into the hours worked equation. A recent trend in macroeconomic modelling has been to use unemployment duration data to separate out the short-term unemployed and enter this into the wage equation, on the basis that the long-term unemployed have effectively separated from the labour market (e.g. Beaumont, Dennis and Ng (1995)). This approach was considered for TRYM but a factor that weighed against it was that most models of long-term unemployment in Australia find that the lagged aggregate unemployment rate itself is the best predictor of long-term unemployment (e.g. Chapman, Junanker and Kapukinski (1993) show that 93% of the variation in male long-term unemployment is accounted for by the third lag of the unemployment rate).[22] As unemployment rises the proportion who are long-term unemployed also rises, but with a lag. (It takes twelve months for the newly unemployed to become long-term unemployed.) The relatively stable relationship between the lagged unemployment rate and the level of long-term unemployment in Australia is exemplified by the Figure 4 below which shows the relationship between the proportion of the unemployed who are long-term unemployed (expressed as a percentage of the unemployed from a year earlier) and the unemployment rate.

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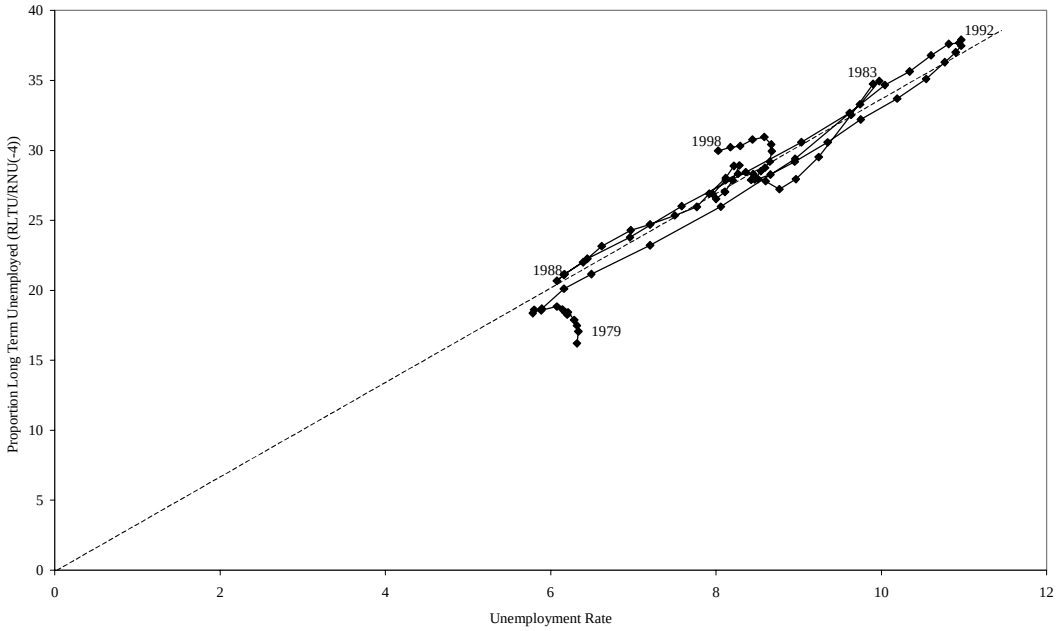
21 Heeney M, (1994) The application of the technique is limited by the quality of the Australian labour market flows data.

22 See also Committee on Employment Opportunities (1993), Background Paper 2A "Long-Term Unemployment Projections".

Figure 4: Proportion Long-Term Unemployed against UE Rate

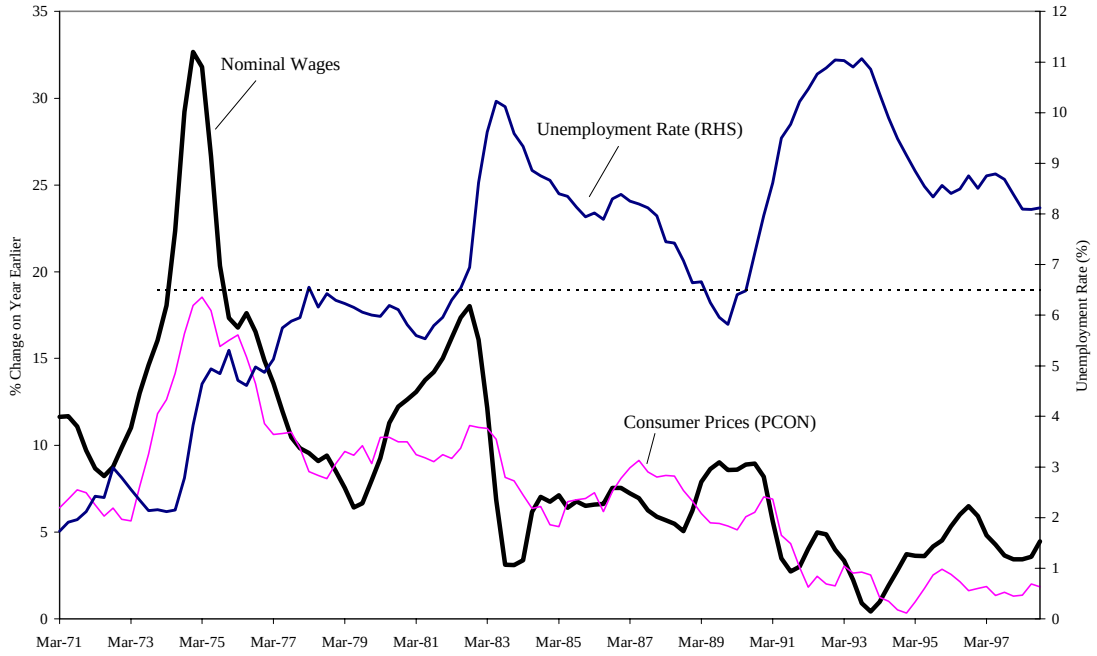


It was not clear, therefore, that introducing unemployment duration data into the model would add very much in terms of explanatory power in the wage equation. Moreover, while changes in long-term unemployment clearly contribute to changes in search effectiveness (see for example Fahrer and Pease (1993) and Hughes (1987)) there is a large range of other factors that impinge on search effectiveness. Therefore, as mentioned above, to capture search effectiveness in a comprehensive way an unemployment vacancy relationship is estimated. The effects of changes in long-term unemployment on search effectiveness should be captured by movements in this relationship. Estimates of search effectiveness are then introduced into the wage equation. While the reasons for shifts in search effectiveness are not explained (endogenised), where a shift in the relationship is established by more detailed study it can be imposed on the model. The use of vacancy data thus limits the number of additional variables that need to be endogenised, as well as being very useful in properly identifying employment demand and in explaining movements in average hours worked.

3.3.1 Wage Data and Institutional Context

Figure 5 below depicts the evolution of the unemployment rate, and wage and price inflation in Australia over the past twenty five years. One of the characteristics of the period has been the development of persistently high levels of unemployment following the apparent increase in the NAIRU in the 1970s. Broadly speaking the period can be divided into two. The first is the period of accelerating wages (relative to prices and underlying productivity) in the 1970s and early 1980s when the unemployment rate was lower than 6 ½ per cent, and the second period of disinflation in the mid to late 1980s and early 1990s when unemployment has generally been higher than 6 ½ per cent.

Figure 5: Wage and Price Inflation and Unemployment



Unfortunately, (from the point of view of estimating the effect of unemployment on wage inflation) these two periods have also been characterised by changed wage-setting arrangements. The two rounds of rapid wage inflation in 1974-75 and 1981-82 were both characterised by movements to collective bargaining but within the context of a centralised system where the Conciliation and Arbitration Commission (now the Industrial Relations Commission) registered collective agreements from leading sectors and passed them on to other workers on the basis of "comparative wage justice". The period between these two inflationary episodes was one of centralised wage indexation which tended to maintain the increases in the real wage which occurred in 1974-75. Following the second round of wage inflation in 1981-82, there was a move back to centralised wage fixing, first with the "wage freeze" in 1982-83 and then with the Price and Incomes Accord (Marks 1 to 8) from late 1983 to early 1996. However, within the centralised framework there was increasing scope for decentralised bargains first under the "two-tier" wage structure of the late eighties which encouraged bargaining over productivity and award conditions, and then in the early nineties with the increasing encouragement of and moves towards enterprise bargaining, particularly with the introduction of the Industrial Relations Reform Act in 1994. The more recent Workplace Relations Act 1996 introduced further sweeping reforms including: further expanding the role of enterprise bargains which now cover around a third of the workforce; the introduction of Australian Workplace Agreements as an alternative to collective agreements; the abolition of paid rate awards and the simplification of awards conditions to allowable matters.

The fact that major changes in institutional wage arrangements[23] have coincided with the movement between periods of wage inflation and wage deflation makes it difficult to interpret the exact role of changes in unemployment in determining wage behaviour. It seems likely that changing institutional arrangements in combination with other factors such as the slow down in productivity growth, the reduction in the immigration intake, and insider/outsider dynamics played a major role in generating high levels of wage inflation in the 1970s. It could also be

23 See Downes and Stacey (1996) for a fuller discussion.

argued that in the 1980s the Accord played some role in generating wage restraint in the face of factors which may have reduced the influence of high rates of unemployment on wage outcomes. (These factors include: the craft-based cross-industry union structure; high level of award coverage (around 90 per cent of the work force covered by awards); and high levels of union membership (around 56 per cent of the workforce in the early eighties) which could be argued to have contributed to a high level of insider power in the 1980s, reducing the role of the unemployed in the wage bargaining process.) A counter view is that while the centralised wage fixing system could enforce wage minimums, it had little power to restrict over-award payments and hence to enforce wage restraint. The system could contribute to wage inflation as in the 1970s, and alter wage relativities as with the equal pay decision of 1973, but do little to generate lower wage outcomes in the 1980s. Against this view, it could be argued that the National Wage Decisions during the Accord period played a *coordinating* role in generating wage outcomes broadly in line with the Accord agreements.

It is obviously difficult to quantify the exact role of various institutional factors either in terms of the role of the centralised system in generating wage inflation in the 1970s, the role of the Accord in generating wage restraint in the 1980s, or in terms of the effects of the more recent shifts towards enterprise bargaining, increases in product market competition and declines in union membership and the role of the award system. This is particularly the case in the context of an aggregative model such as TRYM. The increases in wage inflation in the 1970s are largely attributed to an increase in the NAIRU to around 6 ½ per cent in 1974. Likewise, the wage deflation following from the high levels of unemployment in the 1980s seems broadly consistent within the framework of the model with what would have been expected if the NAIRU were around 6 ½ per cent. The estimated NAIRU from the wage equation below is essentially an average NAIRU for the period. There is a wide range of uncertainty around the estimate and a variety of factors can impinge upon the NAIRU at any one time.

3.3.2 TRYM Wage Equation

The TRYM approach to modelling Australian wage behaviour, in common with other Australian models, takes the form of an expectations augmented Phillip's curve (wage inflation is the dependant variable and the unemployment level is introduced in a non-linear fashion).[24] Wage inflation in the equation is adjusted for productivity growth and conditioned on expected consumer price inflation (proxied by lags of past inflation) and the degree of excess demand in the labour market (measured by the deviation in the level of the unemployment rate from some NAIRU level).[25] At the heart of the equation is the assumption that those people outside

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24 There is some debate about whether the wage equation should be specified in change or levels term. Blanchflower and Oswald (1994) for example argue strongly for a levels specification and conclude that the Phillip's curve is dead although their testing equation is controversial. Also in a model like TRYM it could be argued that the appropriate form for the wage equation is a levels form and that Phillip's curve behaviour will result from the interaction of the price equation and the wage equation. We have experimented with estimating wage level equations in TRYM in the past but with little success, partly because of measurement problems related to productivity growth and estimating after tax wage levels for the private sector. Arguably a wage change specification is an appropriate structural specification in Australia given the nature of the wage bargaining which is usually to bargain over the size of wage increases. In the steady state in the model the real wage is determined by the employment demand equation (in combination with labour supply) while the wage equation gives the equilibrium unemployment rate.

25 This unemployment/NAIRU level term enters the wage equation in a non-linear fashion as in the Phillip's curve analysis.

employment (the unemployed or outsiders) will place downward pressure on wages in periods of excess supply, and this will restore equilibrium in the labour market.

The TRYM wage equation augments the basic Phillips curve specification with modifications to allow for the wage behaviour of those inside employment or insiders. Outsiders may be viewed as imperfect substitutes for insiders for a variety of reasons, including labour market rigidities or regulations, imperfect information, on-the-job training or significant transaction costs involved in hiring/firing decisions. In this world, insiders may find their jobs relatively more secure and, therefore, be less sensitive to the level of the unemployment rate in determining wage claims. Simes and Horn (1988) used detrended overtime per worker to capture this internal labour market pressure.[26] In TRYM, this effect is modelled by a change in the unemployment rate term (ΔRNU), where the changing risk of unemployment influences insiders' wage claims. When the economy is in equilibrium and the unemployment rate is stable, wage inflation will be equal to price inflation plus increases in efficiency. In the long run, real wages are assumed to be primarily determined by labour productivity. In the short term, wage adjustments to labour market imbalances play a critical role in determining how the model responds to various shocks.

The difference between the actual rate of unemployment (RNU) and the NAIRU is used as the main explanator of wage pressure. The NAIRU has been estimated from the wage equation using historical data commencing in the early 1970s. A dummy variable (Q741) has been included to account for an apparent shift up in the level of the NAIRU in 1974. Q741 takes a value of one prior to 1974 and zero thereafter.

As mentioned above, there are number of competing theories about why the NAIRU appears to have increased over time. Working at a highly aggregative level, TRYM does not contain the detail to be able to precisely distinguish between the different theories, although the framework employed in TRYM suggests a range of overlapping factors are involved (c.f. Sections 2.1, 3.3.3 and 4.1). As discussed above, it does appear to be possible, however, to broadly distinguish between search effectiveness and wage setting explanations of the increase in NAIRU by the use of unfilled vacancy data.[27] This is done by introducing into the wage equation a variable (RNUST) which can be viewed as a summary measure of the search effectiveness of the unemployed.[28] This attempts to capture the impact on equilibrium unemployment (where the unemployment rate equals the unfilled vacancy rate) of changes in search effectiveness as evidenced by shifts in the Beveridge curve. This, in combination with two wage setting parameters (WS and WSo), determine the level of the NAIRU in the model.

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26 In different versions, Simes and Horn (1988) used both a detrended as well as a truncated asymmetric measure where only *increases* in overtime per worker feed into wage pressure.

27 The specification of the labour market (in particular the incorporation of unfilled vacancies data) enables TRYM to be used to explore a wide range of issues relating to the link between labour market imbalances and other areas of the economy. For example, if the user establishes or judges that the NAIRU may move in a given set of circumstances (changes in search effectiveness of the unemployed or wage setting factors) the model can be used to examine the macroeconomic implications of these movements. For an example of the use of the model in this way see Stacey and Downes (1995).

28 The Hansen equilibrium unemployment variable (RNUST) is calculated from the long run part of the Beveridge curve equation by setting the vacancy rate (NVA/NLF) equal to the unemployment rate (RNU) - and solving for RNU (whose value over time then depends on the logistical growth function). If search effectiveness falls, the level of the vacancy rate for any given unemployment rate will rise and the equilibrium unemployment rate (where RNU equals NVA/NLF) will increase. The residuals from the Beveridge curve equation are included in the equilibrium measure so that any unexplained movements in search effectiveness have an immediate effect on the NAIRU.

The wage setting parameters capture the effect on the NAIRU of factors other than search effectiveness, associated with the wage bargaining process. For example, they may reflect insider/outsider factors in combination with institutional features of the wage bargaining system and/or changes in the reservation wage due to changes in the unemployment benefit system (c.f. Section 2.1).

This approach gives the following NAIRU term:

$$NAIRU = (RNUST + WS) \times \left(1 - Q741\right) + (RNUST + WSo) \times Q741$$

In the short run, changes in average wages per hour worked, Δln(RWT/NH), are a function of:

- changes in the price of total consumption (PCON) — a homogeneity constraint is imposed so that changes in prices will eventually be fully reflected in wages; and

- changes in the unemployment rate (RNU), weighted for the proportion of employees who are union members (RUM) to reflect the influence of insiders on wages behaviour.

    - To allow for the possibility of an asymmetric response to unemployment changes, the coefficient on the change in unemployment term is allowed to vary between positive and negative changes in unemployment — ΔRNUP and ΔRNUN respectively.[29] As a result, a sharp increase in unemployment due to an unanticipated negative shock will have less effect on wages than an equivalent fall so that the unemployment rate will tend to ratchet up in a recession — consistent with the observation that unemployment rises sharply during a downturn but takes a long time to fall in a recovery.

A through-the-year change in an institutional variable (QCC) has also been included to capture the effects of the varying degrees of centralisation of the wage determination system since 1970. Accordingly, changes in the institutional arrangements for wage setting directly influence wages. QCC is assumed to be exogenous. Allowance has also been made for the metal trades wage decision in the third quarter of 1974 by introducing a dummy variable (Q743).

These features result in the following estimated equation:

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29 A simple justification for this is that changes in wages tend to be limited on the downside. When unemployment was rising sharply in 1982-83 and 1990-91 the implied distribution of wage increases would have contained a negative tail — some firms and industries should have had falling wages. As no change presents an obvious psychological threshold the distribution of wage changes would tend to contain a hump around zero rather than a negative tail [see [] 1988] leading to an asymmetry in the wage response. An implication of this line of reasoning would be that the asymmetry might become larger at low rates of inflation — a corollary to Akerlof's goal lines idea in the US — i.e. that inflation becomes harder to reduce at lower rates of inflation. A cluster around zero may have been especially the case under the protection that the award system provided insiders in the 1980s. Simes and Horn used only positive changes in overtime in the NIF88 wage equation for similar reasons.

$$\Delta \ln\left(\frac{RWT}{NH}\right) = \frac{\lambda}{4} + \frac{1}{(1+a_1+a_1^2+a_1^3)} \times \Delta \ln\left(PCON(-1)\right)$$
$$+ \frac{a_1}{(1+a_1+a_1^2+a_1^3)} \times \Delta \ln\left(PCON(-2)\right)$$
$$+ \frac{a_1^2}{(1+a_1+a_1^2+a_1^3)} \times \Delta \ln\left(PCON(-3)\right)$$
$$+ \frac{a_1^3}{(1+a_1+a_1^2+a_1^3)} \times \Delta \ln\left(PCON(-4)\right)$$
$$- a_2 \times RUM \times [c_1 \times \Delta RNUP(-1) + (1-c_1) \times \Delta RNUN(-1)]$$
$$- a_3 \times \left(QCC - QCC(-4)\right)$$
$$+ a_4 \times \frac{[(RNUST(-1)+WS) \times (1-Q741) + (RNUST(-1)+WSo) \times Q741 - RNU(-1)]}{RNU(-1)}$$
$$+ a_5 \times Q743$$

Results

Sample: 1971(1) to 1999(2)

Parameter	Interpretation	Estimate	t-Statistic
a1	change in prices	0.798	2.99
a_2	change in RNU	0.0004	2.70
c_1	asymmetry on ΔRNU	0.367	1.51*
a_3	change in centralisation	0.018	2.95
a_4	unemployment level	0.011	2.85
NAIRU	after 1974	6.45 (WS 3.70)	3.46#
	1971 to 1973	4.05 (WSo 1.83)	1.94*#
a_5	metal decision 74(3)	0.075	5.42

t-statistics refer to the estimates of WS and WSo.

Diagnostic Statistics

R^2 = 0.61	
SE = 1.2%	
DW = 2.14	
Box-Pierce Q (1-8th order auto correlation)	15.57*
Jarque-Bera Test for Normality	1.79
Chow Test for Parameter Stability	0.79
Ramsey's Reset Test	0.001
Breusch-Pagan Heteroscedasticity Tests:	
Trend	1.41
Y-Hat	0.05
Joint	2.16

* Indicates the test has failed at the 5% confidence level.

Economic Interpretation

The estimated equation implies that:

- A permanent reduction in the level of the NAIRU of 1 percentage point would lead to a *temporary* reduction in nominal wage growth of about 0.17 of a percentage point *per quarter*, other things being equal. Put another way, if the unemployment rate was 1 percentage point higher than the level of the NAIRU, this would result in wage deflation of between ½ and ¾ of a percentage point per year. However, this is a temporary effect as nominal wage growth would return to prior levels once the unemployment rate had fallen to the new NAIRU. As the change in wage levels fed into prices (see the PNC equation above) the real wage would return to around its initial level.

    - Similar logic applies to a 1 percentage point increase in labour supply due to say an increase in female participation or an increase in immigration. In this case unemployment would rise initially by 1 percentage point generating a *temporary* reduction in nominal wage growth of around the same magnitude.

- A fall in the unemployment rate of 1 percentage point in one year would imply an increase in wage growth of around 0.8 percentage points via the change in unemployment term (again other things being equal).

    - Therefore, given a one per cent fall in the NAIRU, the speed of adjustment of the unemployment rate (to the new NAIRU) must be at least one year in order to leave wage growth unchanged and therefore be non-inflationary. (That is the non increasing inflation adjustment path for unemployment would stretch over several years.) This follows from the comparison of the effect from the level term (noted in the first dot point) with the effect from the change term. [30]

- An increase in prices of 1 per cent will increase wages by 1 per cent after five quarters with a 0.3 per cent increase in the second quarter. (Note the coefficient on the contemporaneous price term is restricted to zero.) An inflation expectations term (FIE) was tested in the equation but found to be insignificant.[31]

- Wages respond to changes in the institutional environment in the wage determination system.

The equation implies that the NAIRU has increased from around 2 per cent in the 1960s (the above equation does not extend back into the sixties but 2 per cent can be inferred from the data and is the level the Kalman filter estimates arrive at) to around 4 per cent in the early to mid 1970s to around 6.4 per cent in the 1980s and 1990s. The estimate derived from the equation is shown in Figure 7 below. As discussed above, the change in the NAIRU can be decomposed, at least from a conceptual point of view, into a change in the search effectiveness of the unemployed (captured by changes in RNUST) and a change in other factors associated with the wage setting process (captured by WS and WS_o). The estimated value of RNUST (implied by the estimates of WS and WS_o) has risen from levels of around

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30 Debelle and Vickery (1987) also test for a change in unemployment term in their wage equation but find it insignificant although the form is ΔRNU/RNU (i.e. decreasing effect with higher unemployment) rather than ΔRNU above. Gruen, Pagan, and Thompson (1999) with slightly different assumptions do find a significant effect on the speed limit term.

31 A simple modification to the coding in TSP allows the user to specify simulations where wage bargainers are forward looking if a particular shock or policy change is thought likely to be anticipated.— see Downes and Louis (1996)

2.1 per cent prior to 1974 to around 2.6 per cent more recently. That is, reductions in the search effectiveness of the unemployed appear to have increased the unemployment rate by around half of a percentage point since the 1960s. This compares with the estimated increase in the NAIRU of around 4 ½ percentage points since the 1960s and 2 ½ percentage points since the mid 1970s. However, given the measurement and estimation difficulties involved and the general uncertainty surrounding the NAIRU estimate itself (see below) this decomposition of the change in the NAIRU should be treated with caution.

3.3.3 Non-Linearity and Movements in the NAIRU

One focus of recent research (e.g. Debelle and Vickery (1997)) has been the degree of non-linearity in the wage relationship. One reason for this is that the degree of non-linearity will determine how much higher the average rate of unemployment is than the NAIRU for a given amount of cyclical volatility. In the TRYM case non-linearities occur on both the unemployment level term and the unemployment change term. As a result the estimated NAIRU is much lower at 6.4 per cent than the overall rate of unemployment which has averaged 8.3 per cent since 1980 or 7.7 per cent since the mid seventies. The much higher level of the average rate of unemployment vis a vis the NAIRU has been due to: (a) the increased volatility of unemployment in the 1980s and 1990s (see Table 2 below) in combination with these non linearities, and (b) and the sequence of shocks the economy has had to adjust to. For example, the high levels of unemployment in the 1980s and 1990s have led to a reduction in inflation — a process made more difficult by the trend decline in the terms of trade over the period and, in particular, the collapse in the exchange rate in 1986. The 1980s were also marked by low productivity growth and a strong pick up in participation due to demographic and trend factors on top of strong population growth (e.g. in terms of the framework — a shift to the right in the LS curve).

A number of studies have questioned the degree of non-linearity of the Phillip's curve in the US with one study (CEA 1996) even suggesting that the Phillip's curve is concave towards the origin (or at least locally concave).[32] Debelle and Laxton (1997) show that the finding is due to the assumption of a constant NAIRU and that allowing for a time varying NAIRU estimated using a Kalman filter restores the convexity of the relationship. Debelle and Vickery (1997) confirm the Debelle and Laxton result for Australia. Some feeling for this might be gained from Figure 6 below. The estimated relationship would be much more linear if the NAIRU was not allowed to change between the two periods, i.e. if one line was to explain both periods. Douglas (1996) performs extensive testing on the functional form of the TRYM equation, following the methodology in an earlier IMF paper, confirming that the non-linear specification above provided the best fit. Estimating the wage equation using short-term unemployed as the explanator rather than total unemployed would lead to a more linear relationship. That is the degree of curvature is possibly accounted for by systematic changes in long term unemployment, which is one reason originally advanced by Phelps for the non-linearity of the relationship (see Figure 6). Alternatively, Lipsey advanced an aggregation argument to explain the non-linearity (translating Keynes' kinked backward L into a smooth relationship). As usual, the interpretation of the result should depend on the structure that is thought to underlie it. For example, on the Phelps explanation, labour market programs or

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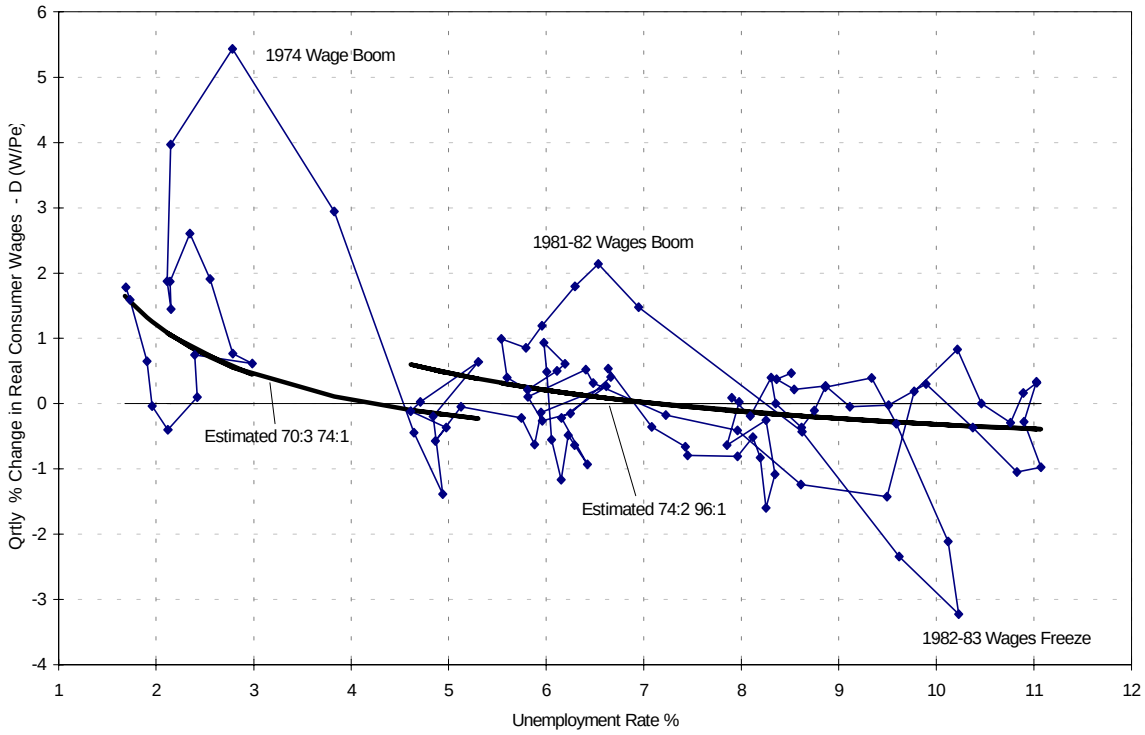
[32] Leading the authors to argue that the Fed should push the bounds on unemployment as any inflation generated could be easily removed.

other reforms which made the long-term unemployed more search effective might tend to flatten the curve.

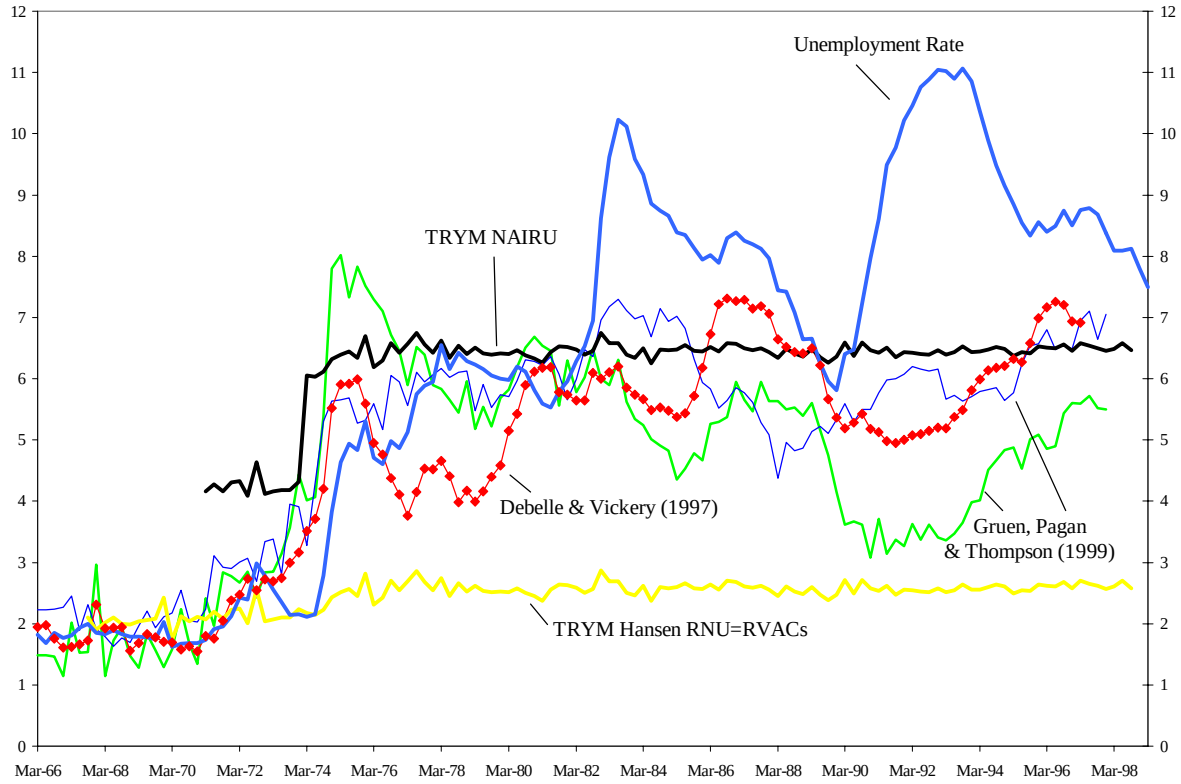
Figure 6: Estimated Expectations-Augmented Phillip's Curves in TRYM



The flatness of the curve at high levels of unemployment also helps to explain why it is difficult to tie down the NAIRU and highlights the uncertainty surrounding the estimates. The 95 per cent confidence interval around the estimate ranges from a NAIRU of 4 per cent to 8.8 per cent.[33] Moreover, this is an average for the period as a whole — rolling regressions of the equation indicate that the band has widened during the nineties perhaps not surprising given the institutional changes mentioned above. Debelle and Vickery (1997) and Gruen, Pagan and Thompson (1998) apply Kalman filter techniques to the wage equation and find considerable variation in the NAIRU over time with a marked upward shift in the mid seventies consistent with the shift in the TRYM equation (see Figure 7). Debelle and Vickery also demonstrate that the NAIRU estimate is sensitive to the degree of non-linearity. When a dummy is introduced for the 1973-74 period (oil shock and wages explosion) the estimated curve becomes much flatter leading to an estimated NAIRU that hovers between 4 and 6 per cent in the 1980s and 1990s. In effect the coefficient on the unemployment level term must also be lower so that the wage deflation of the 1980s is consistent with a lower NAIRU.

33 Moreover the probability distribution will not be normal even with direct estimation of the NAIRU using non-linear least squares as strictly speaking two coefficients are involved - a4 and WS. The problem is similar to that outlined by Ericsson (1998) in his critique of monetary condition indexes.

Figure 7: TRYM NAIRU and Kalman Filter Estimates



#* One sided Kalman Filter estimates (i.e. evolving estimates). The Debelle and Vickery measure is from a price Phillip's curve with no speed limit term. The Gruen, Pagan and Thompson estimates are based on a price and unit labour cost Phillip's curves respectively (the lower line is the price NAIRU) with speed limit terms and in the case of the price Phillip's curve an allowance for import price inflation. The Gruen et al ULC based measure is the closest in specification to the TRYM wage equation.

One final thing to note about the equation is the productivity constant ($\lambda/4$ — underlying labour productivity growth derived from the employment equation). This is introduced to avoid steady state bias. From the form of the equation a 1 per cent increase in trend labour productivity growth would imply a 1.4 percentage point reduction in the NAIRU. This leads to two qualifications to the NAIRU estimate.

- The first is that trend productivity growth tends to be underestimated from the production function equations.[34] Adjusting the $\lambda/4$ term for the likely underestimation would reduce the estimated NAIRU by around ½ to ¾ of a percentage point.

- The second is that trend productivity growth varies over time which on the logic of the equation implies variation in the NAIRU over time.[35] The slow down in productivity growth in the 1970s from the high rates of the 1960s is likely to have contributed to the rise in the estimated NAIRU. Similarly, the accumulating evidence of a pick up in

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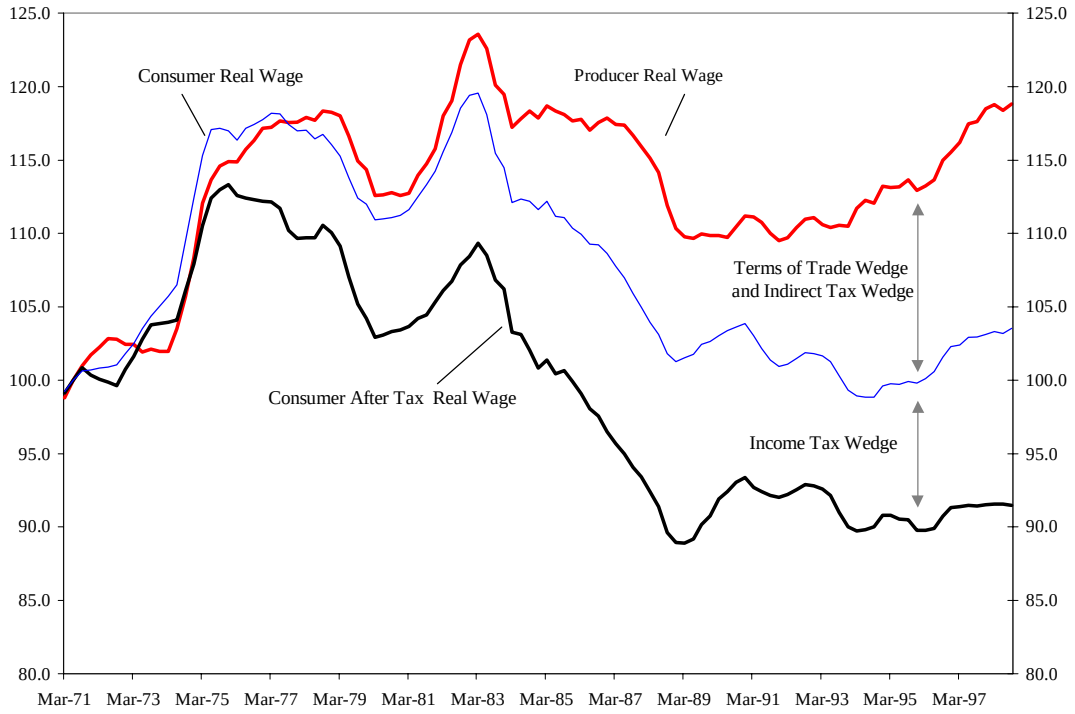
34 This follows from problems with the measurement of output in the finance property and business services and community services sectors leading to a trend decline in the output to capital ratio in history rather than a constant output to capital ratio implied by the Harrod neutral assumption.

35 In some models such as the Fed's MPRS the NAIRU is estimated indirectly as a function of productivity growth and the unemployment benefit replacement rate – see also Turner and Rauffet (1994) who estimate the NAIRU as a funtion of trend productivity growth and the wedge for the five major OECD countries for the OECD Interlink model.

productivity growth in the 1990s, would suggest that the NAIRU should be falling relative to the 6.4 estimate for 1975 to 1998 period as a whole.

Perhaps the most important qualification to the estimate is that the equation is estimated in change rather than level terms. In the case of levels estimation the NAIRU would be determined by the interaction of the price setting and wage equations. The problem with levels estimation is that it involves a number of difficult measurement issues which mean that implementation would be hazardous. The drawback of change estimation is that is difficult to identify the structural reasons for the change in WS. For example Layard, Nickell and Jackman provide convincing evidence from their cross country regressions that tax and terms of trade wedges in common with institutional wage bargaining arrangements play a role in addition to factors which determine search effectiveness captured by RNUST above. The wedge that has developed between consumer and producer wages is shown in the Figure 8 below. Part of this is due to the trend decline in the terms of trade and the consequent fall in the real exchange rate. The other part is due to the increased incidence of taxation both direct and indirect. Part of this has been due to increased public spending on things like health and education (which is where one of the measurement difficulties in estimating is levels — i.e. measuring the social real wage — is found). But part has been due to perverse feedback from the increase in unemployment itself (increased benefit payouts and reduced revenue base). (See also Section 7.3 and the real after tax consumer wage results in Appendix C).

Figure 8: The Wedge between Producer and Consumer Wages



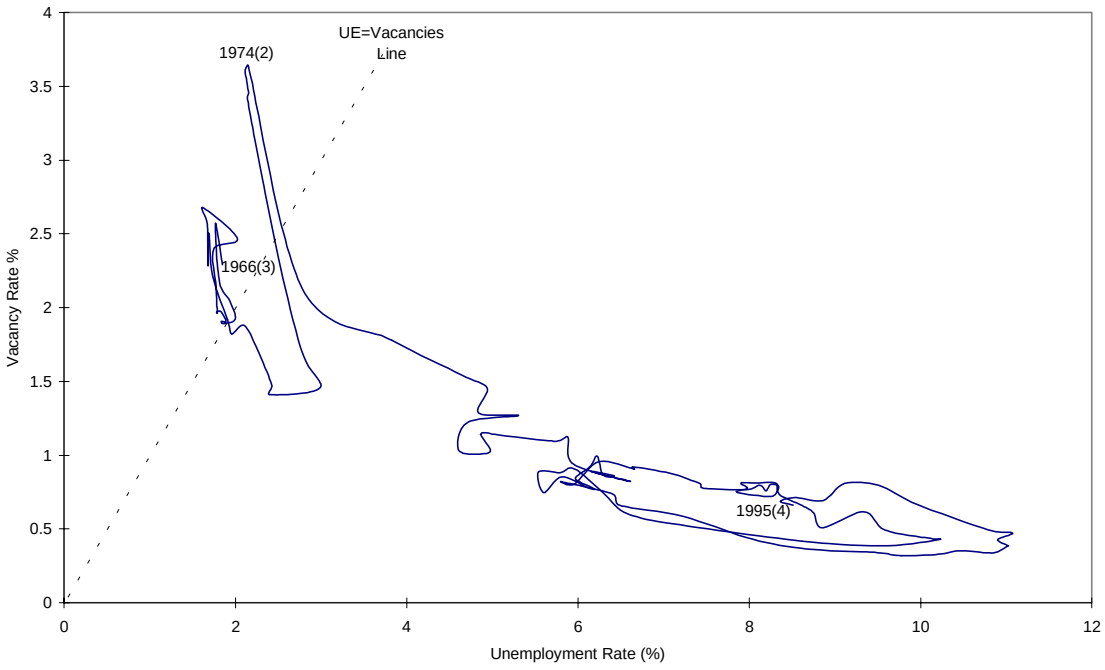
Producer real wage = RWH*RTPRB/(PGB*exp(.015*QTIME))
Consumer real wage = RWH/(PCON*exp(.015*QTIME))
Consumer after tax real wage = RWH*(1-RTN)/(PCON*exp(.015*QTIME))
Measures are indexed — 1971-72 =100, Trend productivity growth of 1.5 per cent per annum is assumed for the purpose of the Figure.

3.4 Unfilled Vacancies and Unemployment — Beveridge Curve

Traditionally, unemployment has been decomposed into frictional, structural and cyclical components. As outlined in Section 2, the cyclical fluctuations in unemployment can be mainly attributed to cyclical fluctuations in employment demand and labour supply. The frictional and structural elements can be attributed to either wage setting/price setting (insider) factors or search effectiveness (outsider) factors. Search effectiveness can be effected by a range of factors including changes in the benefits system, structural changes in industry and occupational demand relative to supply, the responsiveness of occupational and industry wage relativities to changes in the pattern of demand, the responsiveness of the education and training system, the skill composition and level of immigration, the degree of turnover in the labour market and the duration structure of unemployment. Any reduction in search effectiveness of the unemployed for whatever reason should be reflected in a rise in unfilled vacancies for a given number of unemployed and hence an outward movement in the unemployment/vacancy (U/V) relationship or Beveridge curve.

Hansen (1970) provided the most widely used justification for the existence of the inverse relationship between the unemployment rate and the vacancy rate. According to Hansen, the convex shape of the Beveridge curve (see Figure 9 below) is caused by the effect that excess supply or excess demand for labour has on the matching of the unemployed to vacancies. He assumes that there are always, in a given short period, some employers who do not succeed in finding sufficient labour to satisfy their demands completely, even though total supply exceeds total demand. Furthermore, there will always be some members of the labour force who do not succeed in getting a job even though there is more than a sufficient number of jobs to employ the total supply. In terms of ordinary demand and supply theory, this means that observed employment is less than employment demand (see BC in Figure 1 above). The full employment point in Figure 1 is the point where unemployment equals vacancies — the dashed line in Figure 9 below.

Figure 9: Australian Beveridge Curve 1966(3) to 1995(4)



The TRYM approach to estimating the Beveridge curve is based around a dynamic error correction specification, including a logistical function to capture the structural shift in the Beveridge curve thought to have occurred in the early 1970s. The logistical function is an S-shaped curve which acts as a structural break 'dummy' variable where the data determines the size and timing of any shift in the relationship. The inflection point of the function, or timing of the break, is captured by the c_3 parameter, which is estimated rather than imposed. Similarly, c_2 reflects the size of the shift while c_4 determines the slope of the function (whether the shift is sudden or gradual). The function indicates a significant outward movement in 1974 in the unemployment/vacancy relationship (i.e. reduction in search effectiveness). Tests for a structural break in the 1980s and early 1990s were unsuccessful.

The estimated Beveridge curve equation is:

$$\begin{aligned}\Delta \ln(RNU) = {} & a_1 \times \Delta \ln\left(\frac{NVA}{NLF}\right) \\ & + a_2 \times \Delta LGF \\ & + a_0 \times \left\{ \ln\left(RNU(-1)\right) - \left[c_0 + LGF(-1) - c_1 \times \ln\left(\frac{NVA(-1)}{NLF(-1)}\right)\right]\right\}\end{aligned}$$

Logistical Function: $LGF = c_2 / \left[1 + \exp\left(-\left(QTIME - c_3\right)/ c_4\right)\right]$

Results

Sample: 1967(3) to 1999(2)

Parameter	Interpretation	Estimate	t-Statistic
a_0	error correction	0.157	4.59
a_1	change in vacancy rate	-0.206	-4.96
a_2	change in LGF	2.271	2.56
c_0	Constant	1.304	12.31
c_1	vacancy rate	-0.773	-7.17
c_2	LGF parameter	0.419	2.86
c_3	LGF parameter	-23.276	-415.49
c_4	LGF parameter	0.198	4.83

Diagnostic Statistics

$R^2 = 0.55$	
SE = 4.78%	
DW = 2.20	
Box-Pierce Q (1-8th order auto correlation)	12.06
Jarque-Bera Test for Normality	93.07* #
Chow Test for Parameter Stability	1.51
Ramsey's Reset Test	0.00
Breusch-Pagan Heteroscedasticity Tests:	
Trend	8.48* ##
Y-Hat	0.016
Joint	8.80* ##

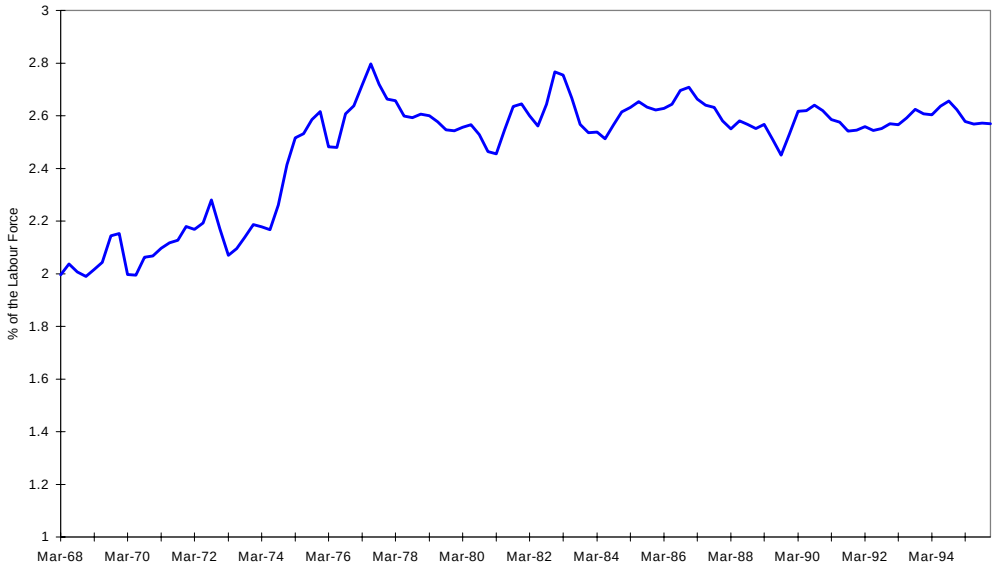
* Indicates the test has failed at the 5% confidence level.

\# The failure of the test at the 5% confidence level was thought to be attributable to a number of outliers in the residuals in the first half of the sample period.

Inspection of the vacancy data revealed greater volatility in the period prior to 1980. The failure of the test at the 5% confidence level may therefore be data related. The vacancy data used were from the ABS spliced vacancy series (see data base documentation for the TRYM model).

Figure 10 shows the Hansen equilibrium unemployment rate (RNUST) derived from the equation (including unexplained movements). The relationship indicates a significant increase in this measure in the mid seventies (reduction in search effectiveness). The figure indicates that reductions in search effectiveness have increased the unemployment rate by around half of a percentage point over the past twenty five years (although this estimate should be interpreted with caution). This compares with estimates of the NAIRU for Australia (discussed earlier) which have risen by around 41/2 percentage points since the 1960s and 3 percentage points since the early seventies. Hence, it seems likely that other factors associated with the wage setting process are also at work. This view is consistent with the findings of Trivedi and Baker (1985) who argue that the NAIRU has risen in Australia because of wage bargaining factors rather than search effectiveness factors.

Figure 10: Hansen Equilibrium Unemployment Rate (RNUST)



The result above in terms of the shift in the relationship are similar to those found in other Australian studies. The most recent and comprehensive empirical study is that by Fahrer and

Pease (1993) of the Reserve Bank of Australia.[36] Fahrer and Pease ran two models. The first was a simple model similar to the equation above. The second attempted to distinguish between cyclical changes and equilibrium movements in the unemployment vacancy relationship using the matching methodology set out in Layard, Nickell and Jackman (1991) and employing ABS gross flows data to identify flows to and from unemployment. In neither case did they find any large outward movement in the relationship in the 1980s and early 1990s. With the simple model (which they ran with both linked ABS vacancy series and an alternative series based on Commonwealth Employment Service vacancies data) they found no outward shift in the 1980s, but a significant outward shift in the mid seventies. In the second model, they found an outward shift in the equilibrium relationship around 1983-84 of about half a percentage point, but this was unwound in the late 1980s/early 1990s (as long-term unemployment fell).

The outward shift in the relationship in the mid seventies coincided with a number of changes in the Australian labour market. These included:

- changes to the unemployment benefit system (i.e. increases in the unemployment benefit replacement ratio, changes to eligibility requirements and relaxation of the work test);
- reductions in the overall level of immigration following the high levels of the sixties and early seventies (previously migrants had been directed towards areas of labour shortage);
- the equal pay decision in 1973 which led to a marked increase in female wage relativities;
- increases in youth wage relativities at around the same time; and
- changes in the duration structure of unemployment (due to factors other than the changes to the unemployment benefits system mentioned above).

Of the above factors, the only variable tested in the estimation of the TRYM equation was the unemployment benefit replacement rate. This was not found to be significant.

- However, it seems likely that the combined effect of changes to the benefit rate and the other changes to the unemployment benefit system (changes in eligibility requirements and relaxation of the work test) would have made the unemployed more selective in their job search and reduced motivation and search effectiveness. Unfortunately, the model does not contain the detail to quantify the effect of these other factors. Nor does it have the detail to test the role of changes in immigration levels and the relative wage structure on mismatch unemployment.
- Changes in unemployment benefits will also have effects on the reservation wage separate to those on search effectiveness, and in a full model context any rise in unemployment and increase in benefits will necessarily be funded by an increase in tax rates increasing the tax wedge and lowering the price setting curve. That is in a full model context the effects of unemployment benefits on unemployment may be much greater than they appear to be from studying individual relationships. However, the

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[36] Other empirical studies of the Australian relationship such as in Trivedi and Baker (1985), Hughes (1987) and Matthews (1991) have been virtually unanimous in finding a significant structural break in the mid seventies but no significant outward movement in the 1980s. The empirical studies all use the linked vacancy series.

unemployment benefit replacement ratio did not appear to be significant when tested in the wage equation and consequently is not included in that relationship.

On the effect of the change in the duration structure on search effectiveness, the relatively stable relationship between unemployment and long-term unemployment (see Figure 4) tends to suggest that the movements in long-term unemployment since the late seventies have been endogenous rather than exogenous. The effect of any such systematic variation in long-term unemployment should already be largely captured in the dynamic structure of the equations parameters (e.g. the parameters that determine the degree of non-linearity in the relationship). As noted above, while there appears to be a significant structural break in the unemployment/vacancies relationship in the mid 1970s, we could not find evidence of a further structural break in the 1980s.

3.5 Labour Supply Equation

The participation rate is measured as the ratio of the labour force (NLF) to the population aged 15 to 64 years (NPADA). Total labour supply also depends on hours supplied per person. Hence, to test for wage effects on labour supply, the measure is adjusted by a proxy for the desired level of hours worked (NHLR). In the long run, the participation rate is also a function of:

- The encouraged worker effect — the employment (NET) to population (NPADA) ratio adjusted for NHLR to capture this effect in the long run; and

- A variable time trend — this is included to capture the upward movement in the labour participation rate over time due to social factors and changing preference(s). Over the period (1966 to 1998) this has largely been due to the rise in female participation, which has more than offset the effect of a decline in male participation, and increases in education retention rates. The time trend allows for variations in the rate of increase over time and in particular for the fact that the upward trend must have an upper limit. Obviously the trend cannot lift the participation rate above 100 per cent. While the functional form of the trend is assumed, the timing and extent of any changes in trend are driven by the data.

- Demographic effects — there are two parts to the demographic effects. One is the effect of the baby boom working through the age cohorts over time leading to variations in the participation rate. The second is the effect of increased longevity, particularly since the mid 1970s.

    - The baby boomer effect is captured by QDEML which is an index generated by taking participation rates by age cohort in 1996-97 and applying them to population proportions over time. Population projections from the Retirement Income Modelling (RIM) group's POPMOD are used to project QDEML into the future.

    - To abstract from longevity effects the participation rate is estimated on a 15-64 year old basis. Increased longevity has raised the proportion of the population in the over 70 age cohort of the population over time. As this cohort has almost no participation, the increase in longevity has tended to bias down the upward trend in the participation rate as measured as a proportion of the adult population 15 and

over. The ABS defines the participation rate as the labour force over the population 15 and over (NPAD). The OECD defines labour force participation as a ratio of the working age adult population 15 to 64 (NPADA). The latter is the definition used below.

This gives the following equilibrium relationship for the participation rate.

$$\ln\left(\frac{NLF \times NHLR}{NPADA}\right) = c_0 + c_1 \times \ln\left(\frac{NET \times NHLR}{NPADA}\right) + TREND + \ln(QDEML)$$

Where:

$$TREND = c_0 + c_1/(1+\exp(c_2 \times (QTIME + c_3))) + c_4 \times \{QTIME - [abs(QTIME + c_5) + QTIME + c_5]/2 + c_6 \times [4/(1+\exp(-abs(QTIME + c_5) + QTIME + c_5]/(2 + c_6))) - 2\}$$

In the short run, changes in the participation rate are also assumed to depend on changes in private business sector and government employment.

- The measure for private business sector employment includes unfilled vacancies (i.e. labour demand NEBD) rather than employment. This reflects the point made by Debelle and Vickery (1998) that encouraged workers should be responding to available jobs rather than employment per se. A further problem is that the employment and labour force measures are drawn from the same survey. Hence the survey error on the employment measure (in this case private employment demand) will be correlated with the survey error on the labour force measure leading to overestimation of the encouraged worker effect. To compensate for this and avoid overestimation of the encouraged worker effect, a proportion of the residual from the NEBD equation is subtracted from the employment measure.[37]

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37 The residuals of the employment equations and the vacancy equations should both contain information on the survey error in the labour force measures. For example, say the labour force sample for a particular month by chance has a larger percentage of households in the labour force than a count of the complete population would reveal. Both the labour force and the employment and unemployment estimates will be too high. If so the residual from the employment demand equation would tend to be positive as would the residual from the unfilled vacancies equation. This suggests SUR estimation of the employment, labour force and vacancies equations but with the complication that the information from the residuals only flows one way, the residuals from the vacancy and employment equations contain information about the residuals of the labour force equation but not vice versa. SUR estimation made little difference to the estimated parameters perhaps reflecting the one way nature of the relationship of the residuals. Entering the residuals into the labour force equation directly indicated that they contained explanatory power, and reduced the size of the encouraged worker effect. One complication here is that the residuals need to be entered into both the change and the level parts of the equation (the latter requiring the integral of the residuals from the change equations). Another indication of a potential overestimation of the encouraged worker if an adjustment is not made, was that when the system of labour market equations was estimated using FIML the coefficient on the change in employment term in the labour supply equation fell (to a level consistent with the estimate from the equation with the adjustment above). However there are a number of problems with using FIML in this context, including the practical one that the employment equation is already estimated jointly with the investment and price equations. Clearly the residuals from the other equations contain information that can help define the labour supply relationship. Moreover the system of labour market equations (NEBD, NH, NLF and NVA) with a number of identities (NEB, NET and RNU) forms a sub system within the model that should be amenable to systems estimation. Both of these are the subject of current work.

A further complication is that the encouraged worker effect is likely to have increased over time as a greater proportion of females have entered the workforce. To allow for this a dummy variable QNLF based on the proportion of female to total employment and the difference between the female and male responsiveness is introduced into the equation.

- The response to changes in public employment (NEG=NEGE+NEGG) is allowed to vary from that of private business employment reflecting possible effects of different recruitment practices between the public and private sectors. The public sector employment estimates are drawn from the Survey of Employment and Earnings (SEE Survey) and hence do not suffer from the survey error problem referred to above.

An error correction specification is used to bring together the dynamic and long-run responses. The estimated equation is as follows:

$$\ln\left(\frac{NLF\times NHLR}{NPADA}\right) = a_0 \times \left[\begin{array}{l} \ln\left(\frac{NLF(-1)\times NHLR(-1)}{NPADA(-1)}\right) \\ + a_1 \times QNLF \times \left(\Delta\ln\left(\frac{NEBD}{NPADA}\right) - a6ld \times QPRIV - \text{u\_nebd}/4\right) \\ + a_2 \times QNLF \times \left(\Delta\ln\left(\frac{NEGG+NEGE}{NPADA}\right) + a6ld \times QPRIV\right) \\ + \Delta TREND + \Delta\ln(QDEML) + \Delta\ln(NHLR) \end{array}\right] + (1-a_0)\times\left\{\begin{array}{l} TREND + \ln(QDEML) + \ln(NHLR) \\ + c_7 \times \ln\left(\frac{NET}{NPADA}\right) - u\_nebd/5 \end{array}\right\}$$

Where:

$$\begin{aligned} TREND = {} & c_0 + c_1/(1+\exp(c_2\times(QTIME+c_3))) \\ & + c_4 \times \{QTIME - [abs(QTIME+c_5) + QTIME + c_5]/2 \\ & + c_6 \times [4/(1+\exp(-abs(QTIME+c_5)+QTIME+c_5]/(2+c_6))) - 2\} \end{aligned}$$

Results

Sample: 1971(2) to 1999(2)

Parameter	Interpretation	Estimate	t-Statistic
a_0	partial adjustment	0.611	7.03
a_1	private employment demand (NEBD)	0.341	4.93
a_2	public employment	0.145	1.99
c_7	employment to population	0.400	8.27
c_0	constant	1.01	4.49
c_1	LGF lower bound	-0.99	-4.95
c_2	LGF transitional slope	-0.15	-10.13
c_3	LGF inflexion	18.42	37.06
c_4	secondary trend	0.04	5.36
c_5	decay inflexion	14.47	12.27
c_6	pace of decay	5.0	Imposed

Diagnostic Statistics

$R^2 = 0.985$	
SE = 0.32%	
DW = 1.75	
Box-Pierce Q (1-8th order auto correlation)	10.14
Jarque-Bera Test for Normality	7.14*
Chow Test for Parameter Stability	0.89
Ramsey's Reset Test	0.00
Breusch-Pagan Heteroscedasticity Tests:	
Trend	3.11
Y-Hat	0.006
Joint	3.19

* Indicates the test has failed at the 5% confidence level.

Economic Interpretation

The adjustment towards equilibrium is fairly quick, with any difference between the actual and desired participation rates being closed by about 39 per cent per quarter. The dynamics of the equation also imply that:

- A 1 per cent increase in employment growth relative to population growth will lead to an increase an increase in labour supply of around a half of a percent in the first quarter falling to 0.4 in the long run.

- Labour supply is roughly twice as responsive to private sector employment growth than to public sector employment growth in the short run.

Real wage and additional worker effects were tested for in a variety of forms in both the short run and long run — but on the current specification were found to be insignificant. The measure used for the real wage effect was the change in the after-tax consumer real wage,

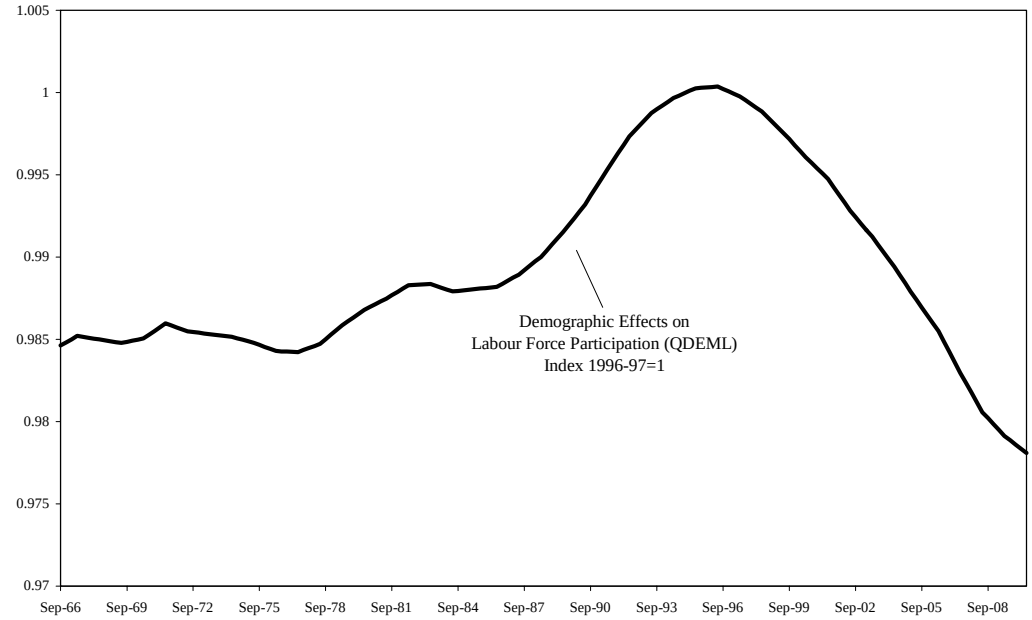
while that for the additional worker effect was an affordability index based on the established house price times the interest rate over after tax average labour income.[38]

A recent paper by Dixon (1996) suggests that the encouraged worker effect is asymmetric for females — a pick up in employment growth may lead to an increase in female participation, but a fall will not lead to an equivalent reduction. We have not tested for an asymmetry in the equation above, which is for total participation, but would note that the data for female participation seems to be consistent with the argument — with female participation rising strongly during boom years but failing to respond significantly to the sharp fall in employment growth during the 1982-83 recession. However, if such an asymmetric response does exist it must vary over time otherwise the female participation rate would continue to ratchet up indefinitely. This in turn suggests that we should expect the size of the encouraged worker effect to fall once the long run trend female participation rate becomes stable.

3.5.1 Demographics and Trends in Labour Supply

Just as important as the cyclical effects are the demographic and trend effects on labour supply in the equation above. Figure 11 shows the demographic effects on participation from the baby boomer bulge moving through the population cohorts.

Figure 11: Demographic Influences on the Participation Rate

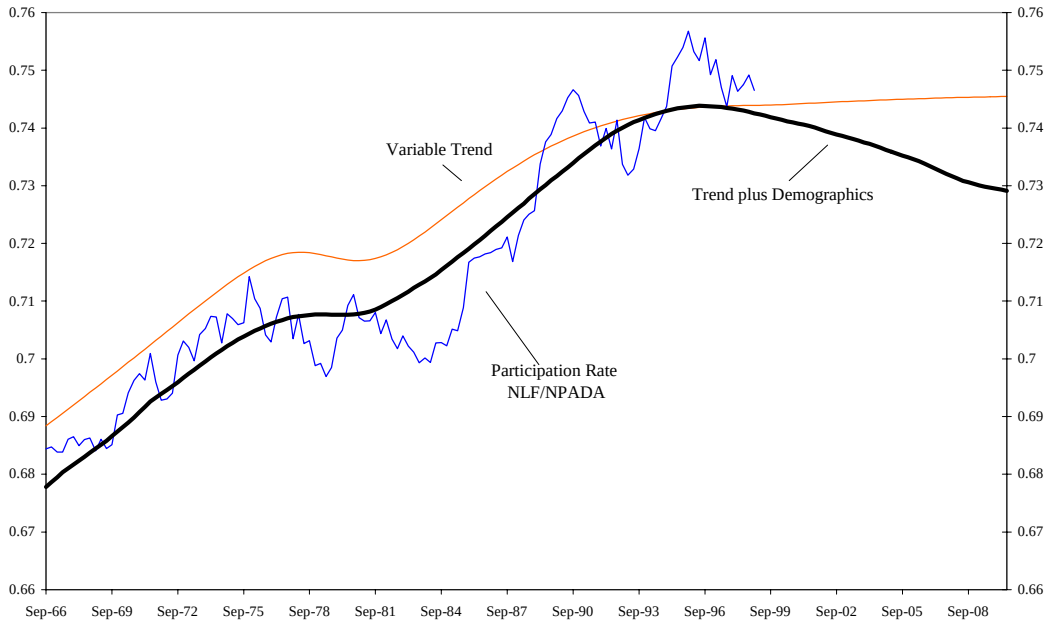


By themselves the demographic effects are currently subtracting about 0.15 of a per cent per year from underlying labour supply growth. The demographic effects above are combined

38 It may be the case that the encouraged worker effect is inversely correlated with the inter-temporal real wage effect (higher real wages leading to an interest rate reaction and slower employment growth) making the positive wage effect difficult to identify. This would not be the case if movements in real wages were productivity driven. However in that case interest rates would be low and affordability would be high leading to an offsetting additional worker effect. This could be the case, for example, in the late 1990s with rising real wages associated with high productivity growth and low interest rates — i.e. the positive inter-temporal real wage effect and the negative additional worker effect might be offsetting. Hence the results above should not be taken as definitive evidence against either the real business cycle hypothesis or the additional worker effect. The results only indicate that support for either proposition is difficult to detect at the aggregate level.

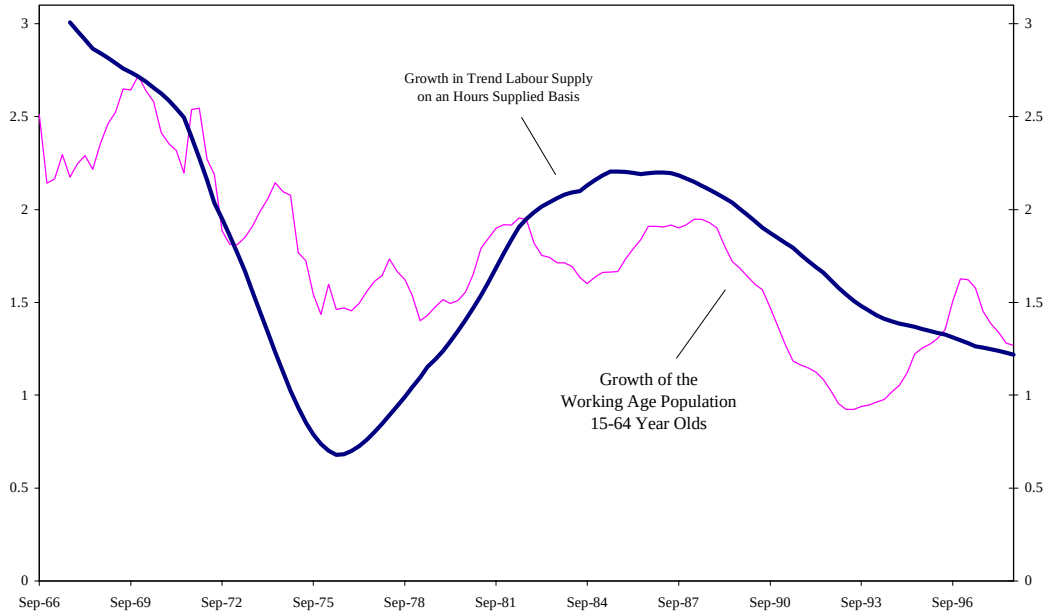
with the estimated variable time trend to form the total underlying trend in labour force participation. This is shown in Figure 12.

Figure 12: Variable Time Trend and Demographic Effects



The labour force trends when combined with trend average hours supplied (NHLR) and growth in the working age population (NPADA) provide a picture of underlying labour supply. Note that most of the variation in population growth has come from variations in immigration levels. Natural increase in the working age population has fallen over time following the sharp fall in fertility rates in the mid 1970s.

Figure 13: Growth in Underlying Labour Supply



One thing that is noticeable from Figure 13 is the large increase in supply in the 1980s largely due to the combination of demographic and trend participation rate effects. This represented a considerable shift out in labour supply (or rightward shift in LS in Figure 1).

3.6 Hours Worked

Hours worked is modelled as a function of output growth, the dwelling cycle (reflecting the high level of overtime per worker in the construction industry) and the vacancy rate. In the long run, hours worked move to a supply equilibrium estimated by a logistical growth function. This gives the long-run equilibrium level of hours worked (NHLR) and reflects trends over time due to increased part-time work and the sharp movement down in the mid-1970s due to the move to 35 hours as the standard work week.

The estimated hours worked equation is:

$$\Delta \ln(NH) = a_0 \times \left\{ \begin{array}{l} a_1 \times (\Delta GBA - GR) + a_2 \times [\Delta GBA(-1) - GR(-1)] \\ + a_3 \times \left[\dfrac{\ln(IDW / IDW(-10))}{10} - \dfrac{(GR + GR(-10))}{2} \right] \\ + a_4 \times \left[(\ln(NVA / NLF) \times 100) - \left(\dfrac{(\ln(RNU - U\_NVA) - LRNUB)}{c_1(bc)} \right) \right] \\ + \Delta LGF \end{array} \right\} + (1 - a_0) \times [c_0 + LGF]$$

Logistical Growth Function: $LGF = c_1 / [1 + \exp(QTIME(-1) + c_2) / c_3]$

Results

Sample: 1971(2) to 1999(2)

Parameter	Interpretation	Estimate	t-Statistic
a_0	Partial adjustment	0.474	5.73
a_1	Change in output	0.076	1.03*
a_2	Change in output lagged 1 qtr	0.163	2.07
a_3	Dwelling Cycle	0.112	1.49*
a_4	Vacancy rate	0.010	1.38*
c_0	LGF parameter	0.134	3.15
c_1	LGF constant	-0.133	-3.09
c_2	LGF parameter	-0.387	-4.31
c_3	LGF parameter	24.51	13.72

* Indicates the test has failed at the 5% confidence level.

Diagnostic Statistics

R^2 =0.96	[Equation estimated in levels]	
SE =0.52%		
DW =2.03		
Box-Pierce Q (1-8th order auto correlation)		17.61*
Jarque-Bera Test for Normality		0.61
Chow Test for Parameter Stability		0.76
Ramsey's Reset Test		0.00
Breusch-Pagan Heteroscedasticity Tests:		
	Trend	1.37
	Y-Hat	0.41
	Joint	1.53

* Indicates the test has failed at the 5% confidence level.

Economic Interpretation

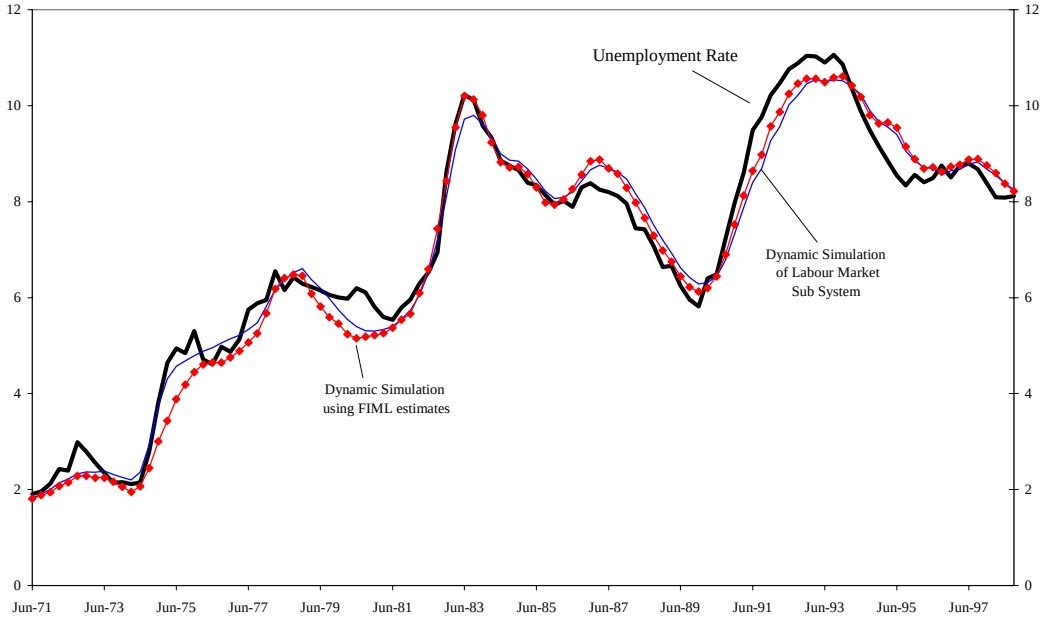
The dynamics of the equation also imply that a 1 per cent rise in output growth will increase hours worked by 0.23 per cent in the short run although a cyclical pick up in dwelling construction and vacancies will add to this effect. The adjustment towards equilibrium is fast, with any difference between the actual and desired long-run level being closed by around 53 per cent per quarter.

3.7 Labour Market System — Dynamic Properties

The labour market equations for employment, hours worked, vacancies and labour supply in combination with three identities (for NEB, NET, and RNU) form a simple sub-system that is amenable to system estimation and simulation. FIML estimation of the system indicated little variation in the parameters. One parameter of interest was that for the encouraged worker effect which was virtually unchanged — suggesting that simultaneity is not a problem.

The results for unemployment of a dynamic simulation of the system are shown below. This involves setting all of the residuals to zero and jointly simulating the labour market equations mentioned above.

Figure 14: Dynamic Simulation Results for Unemployment



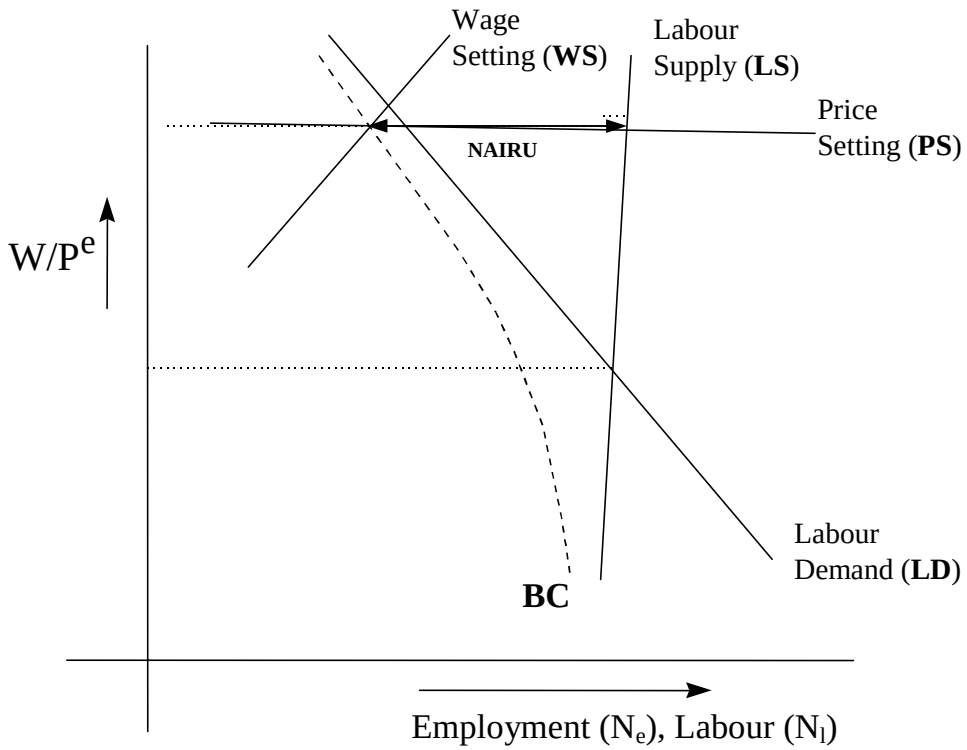
4 Validation of the Labour Market

4.1 Cyclicality of Employment

The decomposition of unemployment above suggests that search effectiveness or outsider explanations only account for a small part of the rise in unemployment. The results of the Beveridge Curve analysis are subject to potential measurement and estimation problems. On the measurement side there are potential linking problems with the ABS series which may mean it understates the level of vacancies in the 1980s and 1990s relative to the 1960s and 1970s — although cross checking with two other series (the ANZ and the CES series) indicates broadly consistent movements. Nevertheless it is a critical conclusion with significant policy implications so it is worth checking from other angles. The framework outlined in Section 2.1 would yield two other conclusions if unemployment had risen for wage setting / price setting reasons rather than search effectiveness.

The first is that unemployment would become much more cyclical. If we recall the framework set out in Section 2.1:

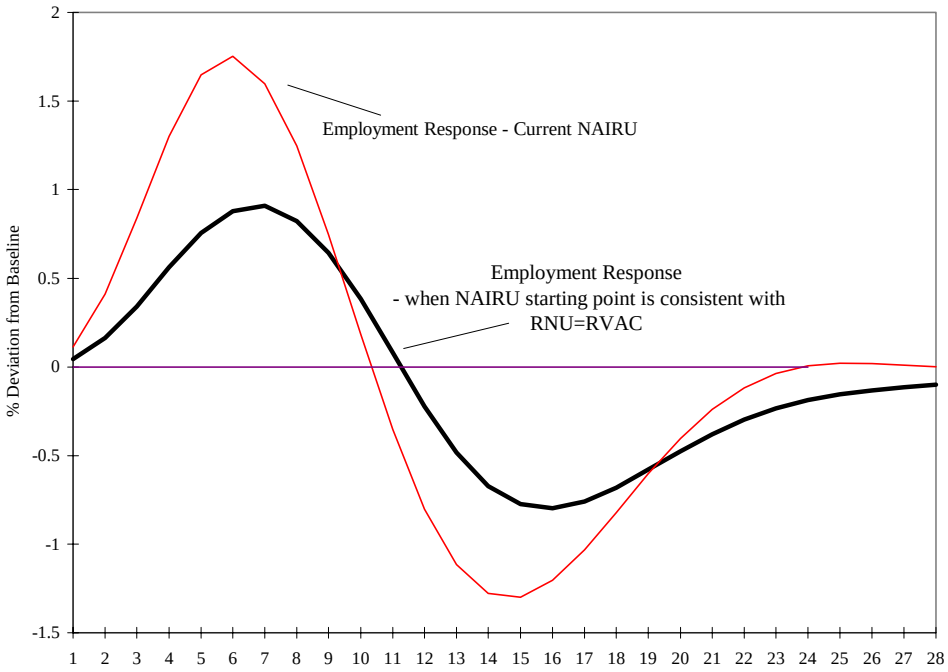
Figure 15: Labour Market Framework



One prediction of this framework would be that volatility of unemployment should increase as unemployment increases. To see this shift the labour demand curve to the left. A fall in unfilled vacancies should soak up some of the fall in employment demand. When the

unemployment rate is high and vacancies are low as in the 1980s and 1990s — this buffering role is reduced.[39] A simple way to derive this is to do it numerically – take TRYM, reset the NAIRU at a lower unemployment equilibrium, generate a new steady state baseline, and then impose a standard demand shock on the two versions (low and high equilibrium unemployment versions) of the model and compare the results. The results in terms of employment volatility are shown in Figure 15 below. The current model with a NAIRU of 6.4 is roughly twice as volatile in terms of employment for a given demand shock that produces approximately the same GDP volatility (actually slightly more volatile in the high NAIRU case than the equivalent model with a full employment (U=V) equilibrium.

Figure 16: Employment Response to Given Shock to GDP — High and Low NAIRU



The same pattern can be observed in the historical data, and it is difficult to think of an explanation for this other than the one above. It may be that a range of other responses have changed. But it would seem a large coincidence for these changes to have coincided with the movement of unemployment away from the equilibrium represented by the Beveridge Curve.

39 A simple mathematical model could be used to demonstrate this utilising Var(A+B)=VarA+VarB+2Cov(AB) with employment demand (A+B) equalling actual employment (A) plus vacancies (B) and remembering that vacancies move inversely with unemployment positive Cov(AB) If Var(A+B) is a function of Var(GDP), then Var(A) by itself will be considerably lower when the average vacancy rate is high.

Table 3: Australia 1960s, 70s and 80s — Volatility of GDP Employment and Vacancies

% Standard Errors on Detrended Log Levels*

	1960s 59(3)-69(2)	1970s 69(3)-79(2)	1980s 79(3)-89(2)	1990s 89(3)-98(3)
GDPA	1.72	1.28	1.98	1.78
Non Farm GDPA	**1.72**	**1.42**	**1.96**	**1.87**
Employment (NET)	0.76	0.98	1.76	2.24
Demand (NET+Vacs)	1.11	1.46	1.87	2.32
Labour Force	0.61	0.60	0.68	1.05
Unemployment Rate	**0.52**	**0.60**	**1.10**	**1.25**
Vacancy Rate	0.57	0.63	0.15	0.14
Average UE Rate	1.96	3.71	7.55	8.95

- Detrended using a Hodrick Prescott Filter (lamda =10000). GDP pre filtered with lamda=0.5 [40]

The standard errors in the table are not additive and the method of detrending using an HP filter can potentially effect the comparison between variables. (The value of lambda is set deliberately high to allow only decade long changes in trend.)

The table indicates a monotonic increase in unemployment volatility as unemployment has risen. The volatility of employment and unemployment has roughly doubled as unemployment has increased.

The increased volatility of unemployment is itself a cause of persistence if one recalls the non-linearity of the Phillips curve and further accept the asymmetry on the change in unemployment term so that a sharp deterioration in unemployment has little effect on wages. This adds to the perverse feedbacks discussed in Section 2.1 that might help to account for persistence in the unemployment data in the 1980s early 1990s, e.g. the feedback from unemployment to taxes and wages, especially when account is taken of the decline in the terms of trade, the slow down in productivity growth and the demographic effects on participation.

4.1.1 Employment Responsiveness to Wage Movements

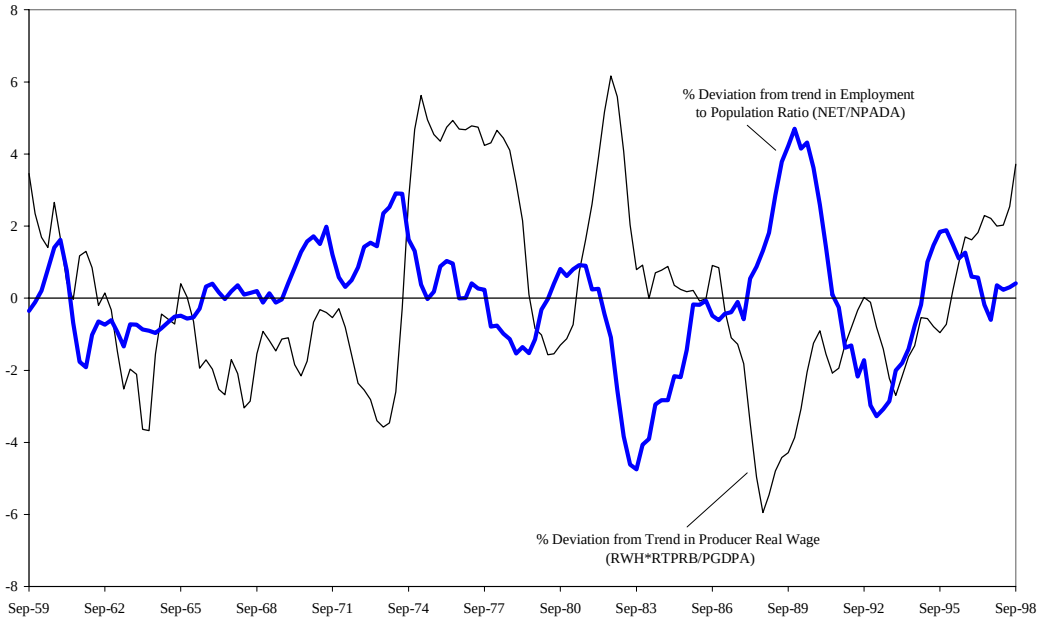
Another prediction of the framework is that the responsiveness of employment to real wage movements should rise as the average level of unemployment moves away from the full employment equilibrium. In terms of Figure 15, the implied elasticity of employment with respect to the real wage falls as we move down the locus of observed employment wage outcomes. Indeed if mismatch and frictional unemployment was low and BC was close up against the labour demand and supply curves, employment and wage points below the

[40] The pre filtering is to remove noise from the pre 1974 data which is GDP(I) based, and has greater survey error than the post 1974 GDP(A) data. The filter at 0.5 has almost no effect on the smoother GDPA data but greatly reduces the spikiness of the earlier GDP(I) based data (in turn suggesting negative auto-correlation in the errors in the earlier data possibly due to timing difficulties in measuring income flows, i.e. income not counted in this quarter falling into the next quarter.)

unemployment equals vacancies equilibrium would essentially trace out the labour supply curve (in which case the estimated elasticity with respect to the real wage would be positive rather than negative). Hence, the framework would predict that the more data points we had from the 1960s early seventies full employment period the lower and less significant would be the estimated elasticity. Again this appears to be a feature of the data at the aggregate level. If we push the employment and output data back to 1959(3) and attempt to estimate the TRYM wage equation for the period 1961(3) to 1974(2) without the adjustment on vacancies the estimated elasticity becomes small and loses all statistical significance.

Figure 17 below broadly compares fluctuations in real wages and employment in the two periods. While a strong negative relationship seems clearly apparent in the period from the early to mid seventies onwards, the negative correlation is much less apparent for the 1960s.

Figure 17: Employment to Population Ratio and Real Producer Wages



Detrended using a HP Filter (lamda=8,000)

There are some difficulties in pushing the equation estimates back into the 1960s given the large slowdown in productivity growth that occurred in the 1970s and 1980s. The impression from simple OLS techniques of employment changes against lagged changes in wages and the Figure 17 both suggest less of a relationship between wages and employment in the 1960s compared to the latter period.

5 Reconciliation with Debelle and Vickery

5.1 Introduction

Debelle and Vickery's (1998) paper on the macroeconomics of the Australian labour market has proven to be quite influential. The results of their research have been widely cited, including in the Joint Governments' Submission to the recent junior rates inquiry. This section aims to reconcile the differences between the results found in Debelle and Vickery and TRYM — in particular the employment demand equation; the labour supply equation, and differences in the macro system.

5.2 The Labour Market Model in Debelle and Vickery

Debelle and Vickery outline a model of the labour market that represents a departure from the standard neoclassical framework in order to address the issue of unemployment. Rather, the model presented is similar to the imperfect competition model of the labour market developed by Layard and Nickell (1986) or the insider-outsider model of Lindbeck and Snower (1988). Similar to the representation in Figure 1 the model incorporates the standard neoclassical downward sloping labour demand curve and upward sloping labour supply curve (although it is relatively invariant to the real wage). As in the TRYM model, an upward sloping wage setting curve is also incorporated to capture wage setting behaviour, such as efficiency wage and insider-outsider models. The main difference is that while vacancies are endogenised so that the model can track the labour force there is no distinction between employment demand and observed employment as in the Hansen set up. One would expect that excluding vacancies would tend to reduce the estimated employment elasticity with respect to the real wage especially if the sample period is extended back into the 1960s.

When this and a number of other data differences are addressed, it appears that the results reported in the Debelle and Vickery paper can be reconciled with those in TRYM.

5.3 Labour Demand

The preferred specification of Debelle and Vickery is presented in Table 4 as column 1. This specification has an elasticity of substitution of labour for capital of –0.4. This result is at the lower end of the range for Australian aggregate wage studies. Also, the sign of the coefficient on the lagged dependent variable is negative, which is contrary to *a priori* expectations and the results of the TRYM model. Both data and theoretical considerations assist in reconciling these differences.

Table 4: Labour Demand Results

		(1)	(2)	(3)	(4)	(5)
Sample period		**1978:Q1-97:4**	**1969:Q1–97:Q4**	**1969:Q1–97:Q4**	**1969:Q1–97:Q4**	**1969:Q1–97:Q4**
Long-run elasticities						
Real wage	β_2	-0.40	-0.67	-0.54	-0.60	-1.04
		(0.05)	(0.08)	(0.03)	(0.04)	(0.13)
Output	β_3	1.09	1.14	1.12	1.21	1.63
		(0.09)	(0.21)	(0.10)	(0.12)	(0.36)
Trend	β_5	-0.33	-0.35	-0.35	-0.42	0.53
		(0.08)	(0.16)	(0.08)	(0.09)	(0.27)
Short-run coefficients						
ΔHours$_{t-1}$	γ_1	-0.19	-0.30	0.00	0.04	0.14
		(0.08)	(0.07)	(0.08)	(0.08)	(0.09)
ΔReal wage$_t$	γ_2	-0.21	-0.51	-0.16	-0.18	-0.18
		(0.05)	(0.10)	(0.04)	(0.04)	(0.06)
ΔOutput$_t$	γ_3	0.45	0.10	0.30	0.33	0.37
		(0.11)	(0.17)	(0.07)	(0.08)	(0.10)
Speed of adjustment	β_1	-0.54	-0.40	-0.34	-0.31	-0.14
Cointegration test						
$\bar{R}^2$			0.46	0.45	0.43	0.32

Notes: The dependent variable is the change in aggregate hours worked. All variables are in logs. Estimation by ordinary least squares Columns 1 and 2 show the Debelle and Vickery preferred equations over the two sample periods. Column 3 reports results when the hours worked measure is adjusted and Column 4 when vacancies are added to the dependant variable and Column 5 when the data is defined for the private sector using TRYM variables i.e. NEBD*NH, RWH and GBA.

The first data consideration that helps to reconcile the results of Debelle and Vickery with those of TRYM is the choice of sample period over which the labour demand equation is estimated in Debelle and Vickery. Debelle and Vickery estimate their labour demand specification over the period 1978:Q1 1997Q4, whereas TRYM extends to the pre-1978 period. The Debelle and Vickery results for the longer period, which are more comparable with the TRYM results, are shown in column 2. The second difference is in the hours worked series used in constructing the employment demand measure. While Debelle and Vickery use 'raw' ABS data for average hours worked, TRYM adjusts this measure to account for outliers that appear to be due to show day holidays affecting the hours worked data in particular months (identified via a detailed check of the Labour Force Survey disaggregated hours worked data). The effect of this adjustment is to remove a number of large spikes in the data which might otherwise lead to negative auto-correlation in the dynamics.

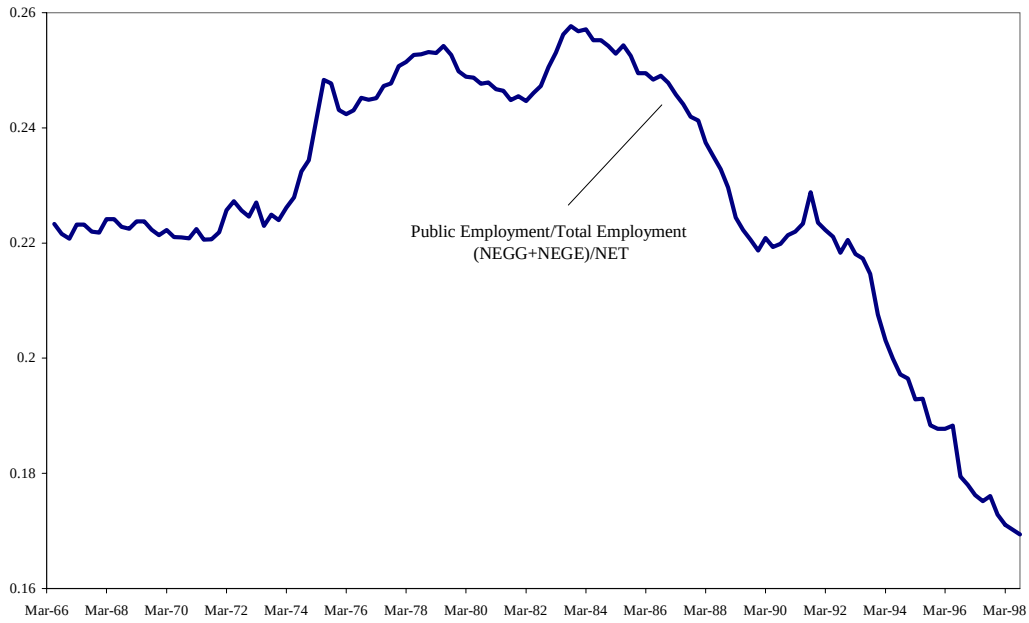
As shown in column 3 of Table 4, using the adjusted level of average hours leads to significant changes in a number of the coefficients. In particular, the negative coefficient on the lagged dependent variable comes more into line with expectations. The elasticity of substitution decreases slightly, while the short-run elasticity becomes insignificantly different from zero.

Thirdly, the distinction between employment and labour demand also accounts for part of the difference between Debelle and Vickery's and TRYM's elasticity of substitution. As discussed previously, excluding vacancies is likely to bias the elasticity downwards slightly.

This is reflected in column 4, which shows that when vacancies are included in the labour demand specification that the elasticity of substitution increases.

Fourthly, the inclusion of the public sector is likely to be a significant source of the difference between the results in Debelle and Vickery and TRYM. As noted earlier, the inclusion of the public sector is likely to be problematic given the movements in public sector employment since the 1970s (see Figure 18). This also contains significant implications for the calculation of productivity growth, given that the ABS measure of the level of labour productivity is lower in the general government sector. While Debelle and Vickery estimate the labour demand equation using the non-farm sector, TRYM is estimated only for the private business sector. Column 5 of Table 4 shows that when the public sector is excluded, the elasticity of substitution of Debelle and Vickery's specification is similar to TRYM's.

Figure 18: Public Sector Employment as a Proportion of Total Employment



Another way of putting this is that real wage impacts will be mainly felt in the private business sector — that is where the capital for labour substitution will mainly occur. By measuring the effects against total employment, (i.e. taking the consequent change in employment over a larger denominator) the estimated elasticity will naturally be smaller. Taken together with the vacancy adjustment, this probably explains most of the difference between the two estimates. It is worth remembering that when the TRYM employment equation is simulated, it is done jointly with general government and public enterprise employment which are not responding to real wages, and an identity which adjusts private employment demand back to private employment by removing vacancies. The response of total employment to real wages coming out of the sub system of employment equations and identities in TRYM is unlikely to be greatly different to that from the single equation for total employment in Debelle and Vickery. In other words, while the elasticity in TRYM might appear much higher the employment response for the employment equations and identities taken together is probably the same. The elasticity in TRYM has the strict interpretation of a factor elasticity of substitution for the private business sector, while the Debelle and Vickery elasticity is a broad measure and has more of an econometric interpretation (see Section 2.2

above and Table 1). There would be something wrong if it wasn't significantly smaller than the TRYM elasticity.

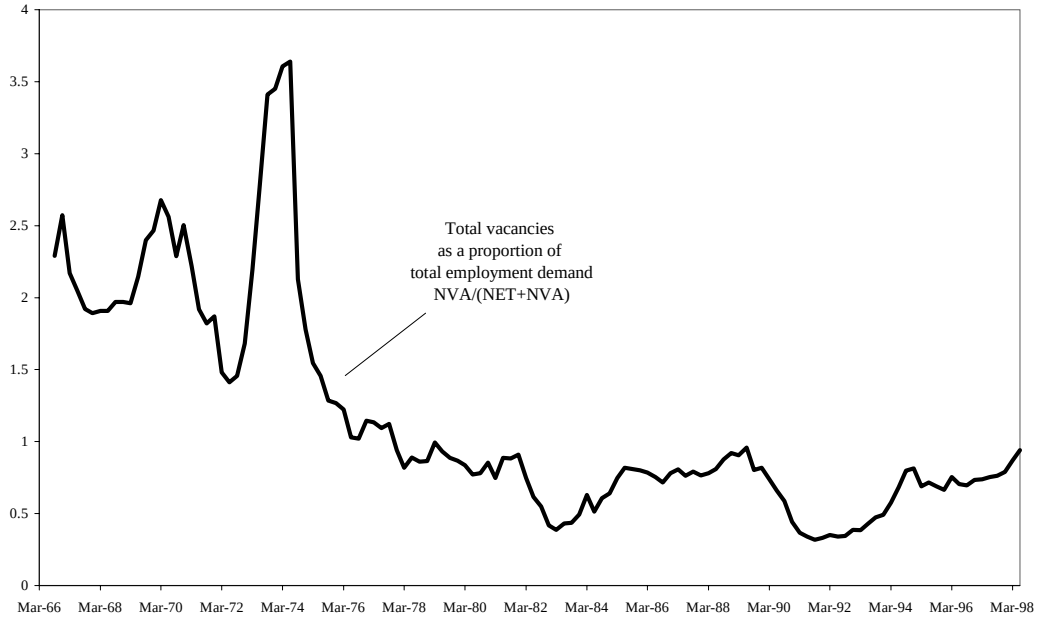
5.4 Labour Supply

There are two main differences in the treatment of labour supply between Debelle and Vickery and TRYM. These are: the method of capturing the encouraged worker effect; and the separate estimation of male and female labour supply equations in Debelle and Vickery.

The encouraged (or discouraged) worker effect refers to those people who decide to move in (or out) of the labour force in response to favourable (unfavourable) labour market conditions. The method chosen in Debelle and Vickery (1998) to capture the encouraged worker effect was to use the vacancy rate as a measure of the probability of finding employment. In TRYM, the employment-to-population ratio is used. One advantage of using vacancies is that the vacancy data is drawn from a different survey and hence avoids the problem of correlation between survey error on the employment and labour force estimates. However, an adjustment is made in the TRYM equation to offset this problem (Section 3.5) and the analysis of the TRYM equations as a system indicate reasonable simulation properties as shown in Figure 14, Section 3.7. In other words, there doesn't appear to be a significant problem with the estimate of the encouraged worker effect in TRYM.

Figure 19 shows the level of vacancies as a proportion of total labour demand since September 1966. It shows that while the vacancy rate has remained relatively constant over the sample period of the Debelle and Vickery labour supply equation, the vacancy rate was much higher in the pre-1978 period. The change in level between the two periods appears to cause problems with the estimation of the equation. When the male and female labour supply equations of Debelle and Vickery were extended back to 1966:Q1, the explanatory power of the specification decreased substantially and a number of the coefficients changed. This was also the case when vacancies were tried individually in the TRYM labour supply equation which is estimated back to 1967(4). The vacancies data clearly contains information on labour demand which could be used for estimating an encouraged worker effect, but the change in the level of the vacancy rate between the two periods presents a thorny issue. However, it is possibly only a significant problem when the equilibrium unemployment rate is changing. Insofar as the vacancy rates do contain information on employment demand or the chance of finding the job, and so long as the equation is estimated over a period of reasonably stable equilibrium unemployment, they will probably provide efficient estimates of the encouraged worker effect. It would be surprising therefore if the dynamic responses to an employment change were greatly different between the TRYM and Debelle and Vickery specifications.

Figure 19: Vacancy Rate



As noted above, Debelle and Vickery also separate the labour supply equations into male and female rather than using a combined labour supply representation. When a total labour supply equation was estimated using the Debelle and Vickery representation of the labour supply curve, it was found that the explanatory power was not significantly different from the male and female labour supply equations. The authors themselves aggregate the two equations (male and female) in generating their unemployment results. Therefore, the separation into male and female components would not seem to be a significant source of difference between the two systems.

5.5 Macro Results

The conclusion that might be drawn from the discussion above is that while there are some definitional differences between the equations for employment and labour supply between Debelle and Vickery and those used in TRYM, the two sets of labour market equations as a system have many similarities. Where there are differences they appear to be reconcilable.

While Debelle and Vickery set out a small theoretical model of the macroeconomics of unemployment their estimated unemployment responses to a change in real wages are based on the simulation of their three labour market equations (similar to the sub system simulated for Figure 14 above). The results in their paper show different unemployment outcomes assuming different wage elasticities and different scale effects.[41] They conclude that a 2 per reduction in the growth of real wages for a year, would lead to a 1 percentage point reduction in unemployment. The results are an extension on simple partial analysis and in that they focus on more than the employment demand by itself. Yet they fall short of full model analysis where feedback is allowed to the capital stock, prices and a range of other variables. As the authors acknowledge:

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41 Table 3 of Debelle and Vickery (1998) in G. Debelle and Borland, J. (eds), *Unemployment and the Australian Labour Market*, Reserve Bank of Australia, p. 239.

> "However, the scale effect [wage effect on output] will induce more investment and an expansion in the capital stock. This process is difficult to quantify in the framework used here, however the Murphy and TRYM models explicitly address the issue."

The results below allow this feedback, and the output effects are therefore determined by a full set of relationships. One further crucial difference is in the feedback from wages to prices. Debelle and Vickery impose a 2 per cent real wage change on their labour market equations, but there is no feedback from wages to prices. As outlined above, the Price Setting curve in TRYM is virtually horizontal in the long-run (no long-run factor constraints — capital adjusts without leading to a medium-term increase in investment prices) and hence the feedback from wages to prices erodes any initial increase or decrease in real wages stemming from a change in WS and the NAIRU. Nominal wage restraint involving a temporary reduction in real wages leads to lower unemployment. The linkages are described in more detail in Section 7 below.

6 Macro Linkages —Interest Rate Reaction

As mentioned earlier the monetary policy reaction to the inflation generated by a shift in wage setting behaviour is one of the central reactions that link wage behaviour with activity and employment at the aggregate level. The monetary response is in two parts. One is the assumed response of the authorities to the inflation. The other is the impact of the interest rate change on the economy itself. The first part of this section deals with the effect of interest rates on the economy in TRYM. The second deals with the interest rate response to inflation used in the Submission to the Wages Safety Net Review.

6.1 Monetary Policy Effects

The effect of interest rates in TRYM is discussed in detail in Downes and Louis (1996). The models response is very close to those in other Australian macroeconomic models. The response of activity and inflation have similar profiles to those from the Access Economics Macro (AEM) Model and Chris Murphy's Murphy Model (MM2). The Monash group has validated the monetary response by coding a version of the model in their own software and changing the expectational assumptions (Malakellis and Transom (1995)) demonstrating that the results from a monetary policy simulation in TRYM are not greatly sensitive to the expectational specification in the financial market. Downes and Louis (1996) contains material comparing different expectational specifications in the financial sector and show that the financial market response can alter the timing of a given shock stemming from the product or labour markets but cannot alter the overall magnitude of the response. Comparison of the TRYM response with results from the RBA six equation model (de Brouwer, G. and Regan, J. (1997)) and the Pagan Dungey VAR model indicate that the timing of the activity and inflation effects is reasonably similar (Stoney 1997). This is also a conclusion that can be drawn from a RBA study (Gruen et al 1997) from which the table below is drawn.

Table 5: Model Comparison of the Effect on Output Growth of a One Percentage Point Rise in Short-term Interest Rates

Model	First Year	Second Year	Third Year
RBA Single Equation Model:	-0.35	-0.33.	-0.18
Murphy [MM2]	-0.51	-0.31	+0.08
TRYM	-0.37	-0.37	-0.07

Source: Gruen et al (1997) P22.

6.2 Interest Rate Response

The monetary policy response in the model results for the Wages Safety Net Review is based on a control algorithm which adjusts interest rates in a forward looking manner and is intended to broadly mimic the way interest rates have moved in the past. The algorithm searches for a solution for the path for interest rates that minimises the following loss function:

$$Loss = \sum_{t=001}^{47} \frac{\left(\alpha \times (\pi_t - \pi^*)^2 + \beta \times (RNU_t - RNU^*)^2 + \delta \times (\Delta RI90_t)^2\right)}{(1+r)^t}$$

where π_t is inflation, RNU_t is the unemployment rate, and $\Delta RI90_t$ is the change in the 90 day bill rate. Starred variables denote target values. The form has some similarity to Taylor's rule but with unemployment rather than an output gap measure, and the addition of an interest smoothing parameter reflecting the observation of Goodhart and others that monetary authorities (for whatever reason) tend to have a preference for interest stability. The discount rate is set at 5 per cent per annum and the loss is minimised over 47 quarters with an end point constraint where the interest rate is held unchanged for the last 30 quarters (to prevent the model sweeping problems under the carpet). Only one instrument (the 90 day bill rate) is used and discretionary fiscal policy is left unchanged (i.e. no change in tax rates or discretionary expenditure — the normal fiscal stabilisers are allowed to work).[42]

Perhaps the best way to gauge whether the size of the response is reasonable, given the change in monetary policy arrangements that have occurred over time,[43] is to compare it with the scale of monetary policy responses in recent history. This is done below where we examine the interest rate increases in 1994-95. One difficulty in doing this, and making a comparison with the interest rate response in the sensitivity analysis presented in the Joint Governments' Submission to the Wages Safety Net Review, is that we also need to know what would have happened if interest rates had not been raised in 1994-95. That is we need to know what the outlook was that the authorities were responding to. To obtain some feel for this we use TRYM to provide an indication of what the outcomes may have been if interest rates had not been raised.

Figure 20 indicates the movements in the 90 day bill rate during the period and the counterfactual assumption. Between July 1994 and January 1995 the cash rate was raised three times from 4 ¾ per cent to 7 ½ per cent. The interest rate increases were pre-emptive. At the time growth in the underlying rate was running at around 2 per cent at the bottom of the target range, and the headline CPI was lower. The interest rate increase was primarily in reaction to the inflation pressures that were developing with rapid growth in the economy, rapid employment growth and increasing wage growth, and the anticipated effect these were likely to have on inflation.[44] Through the year growth in private sector AWOTE rose from 2 ¾ per cent in March 1994 to be 4 ¾ per cent by December 1994 (see Figure 21).

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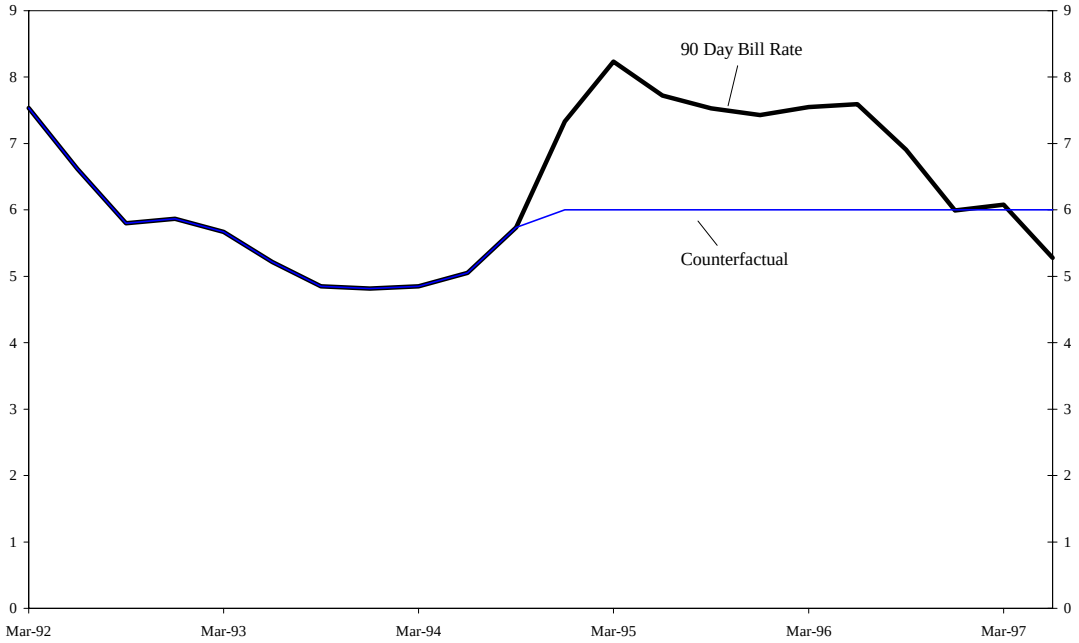
42 The algorithm uses the Newton Raphson procedure to interatively minimise the loss. The Jacobian is derived numerically by first shocking each instrument and lagging the response of each target variable by one quarter for each new quarter. In this case only one instrument is used. The set up here is a specific form of a more general form set out in Louis (1995).

43 Macfarlane (1998) "Australian Monetary Policy in the Last Quarter of the Twentieth Century", Shann Memorial Lecture, provides a comprehensive guide to the changing institutional arrangements.

44 Reserve Bank of Australia (1995) Annual Report, P15.

Figure 20: 90 Day Bill Rates — Actual and Counterfactual



Figures 21 and 22 show the likely outcomes for wage and price inflation and unemployment if interest rates had been raised to a relatively neutral 6 per cent and maintained at that level as shown above.

Figure 21: Growth in AWOTE and the Treasury Underlying CPI

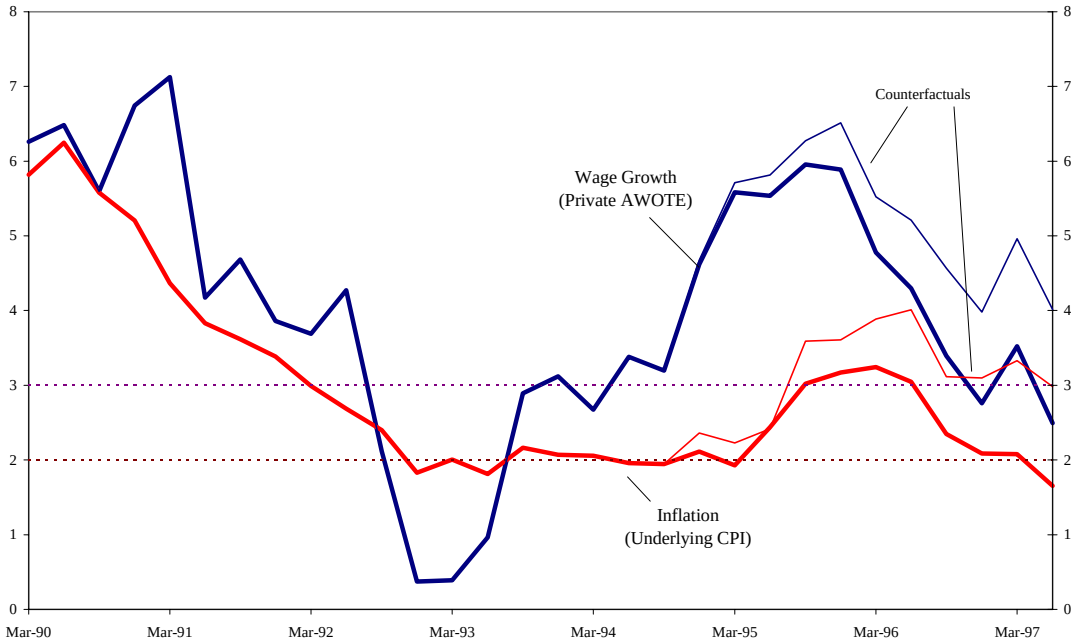
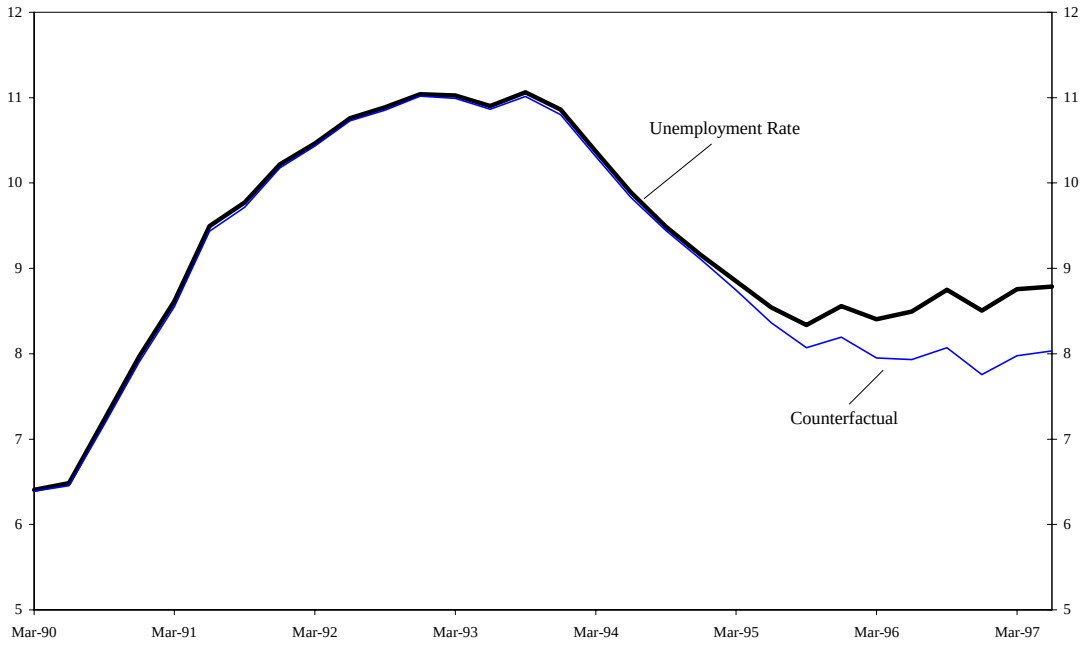


Figure 22: Unemployment — Actual and Counterfactual



As can be seen in Figure 21, in the absence of an increase in interest rates, inflation would have risen by around 1 ½ percentage points according to the model. The increase in interest rates in comparison (Figure 20) was 2 ¾ points. The interest rate increase in the TRYM analysis of the ACTU's claim in this year's Joint Governments' Submission to the Wages Safety Net Review using the procedure above is ½ a percentage point in reaction to a change in wages which adds ½ of a percentage point to inflation (see Chapter 7 of the Submission). In last year's Submission, an increase in wage growth leading to an increase in inflation of 1 ¼ per cent above the baseline led to a modelled interest reaction of 1 ¼ percentage points. In that sensitivity run unemployment was ¾ of a percentage point higher after two years, which is similar to the magnitude of effect shown in Figure 22. It is instructive to note that if the Reserve Bank had not raised interest rates in 1994 real interest rates would have fallen rapidly in 1995. The minimum required to leave the real interest rate unchanged is that nominal interest rates rise by the amount of inflation.

7 Wage Shock — Implications of Reducing the NAIRU

7.1 Wages and Unemployment

As argued above, wage bargaining factors and aggregate wage outcomes appear to have played a major role in the increase in Australian unemployment over the last twenty five years. This in turn suggests that policies that successfully reduce the labour market's tendency to produce wage inflation at high levels of unemployment can have a major impact on macroeconomic outcomes.

One of the surprising outcomes is that reducing unemployment via reducing the NAIRU in TRYM does not require large or lasting reductions to real wages. This is in contrast to the "real wage overhang" debate which was the focus of much discussion in Australia in the 1970s and 1980s in relation to the rise in unemployment and whether it was Keynesian (demand driven) or Classical (wage related). By definition, the real wage in TRYM is usually reasonably close to equilibrium unless there is a large NAIRU shock, as occurred in the early 1970s. A NAIRU shock may have an influence on real wages for a number of years, but eventually prices will adjust and the real wage will return to near its former equilibrium level. The equilibrium real wage level in turn is largely determined by labour productivity levels. This follows from the assumption that there is no constraint (other than normal lags and adjustment costs) on firm's price setting. The logic of the TRYM result is very close to that described by Layard, Nickell and Jackman (1991) and therefore cuts through the real wage overhang debate and the arguments about whether unemployment is Classical or Keynesian. To quote Layard, Nickell and Jackman:

> "The reason for this is that, while wage determination reveals the demands of wage bargainers at given unemployment, the price setting behaviour of firms governs the real wage that is actually available. The sharpest expression of this point arises with mark-up pricing when the real wage available in the long run is independent of the level of activity. Workers may then press for higher wages as much as they wish. Their quest is wholly unsuccessful, and all that is achieved is higher unemployment".
> (Ch 8, p.384)

In common with the Layard, Nickell and Jackman framework, TRYM assumes that workers bargain over consumer wages (Section 3.3) while firms set prices in accordance with input costs, productivity and the state of demand (Section 3.2). Workers thus have little control over prices and hence, the real wage in the medium to long term. In the medium to long run, the real wage is almost entirely determined by technology/productivity. In the initial stages an increase in wage pressure due to an increase in the NAIRU will lead to an increase in real wages. Unemployment will appear to be classical. However, as prices and the capital stock adjust the real wage will fall to its original level. The higher unemployment will then appear to be Keynesian even though it has resulted from higher wage pressure. Unemployment is higher consistent with the higher NAIRU, but with no significant improvement in the real wage. Moreover, as the government has to increase taxes on a reduced tax base to finance an increase in unemployment benefit pay outs, the after-tax real wage can actually fall.

Figures 23 and 24 present the unemployment and real wage outcomes of two different sets of model projections, one with the NAIRU set at 8.3 per cent from 1997-98 onwards, and one with the NAIRU set at 5.0 per cent from the same point in the simulation. The projections

were prepared for an earlier paper on the NAIRU for the OECD.[45] They were purely for the purpose of illustration and should in no way be interpreted as forecasts.

Figure 23: Unemployment Projections with Different NAIRU Assumptions

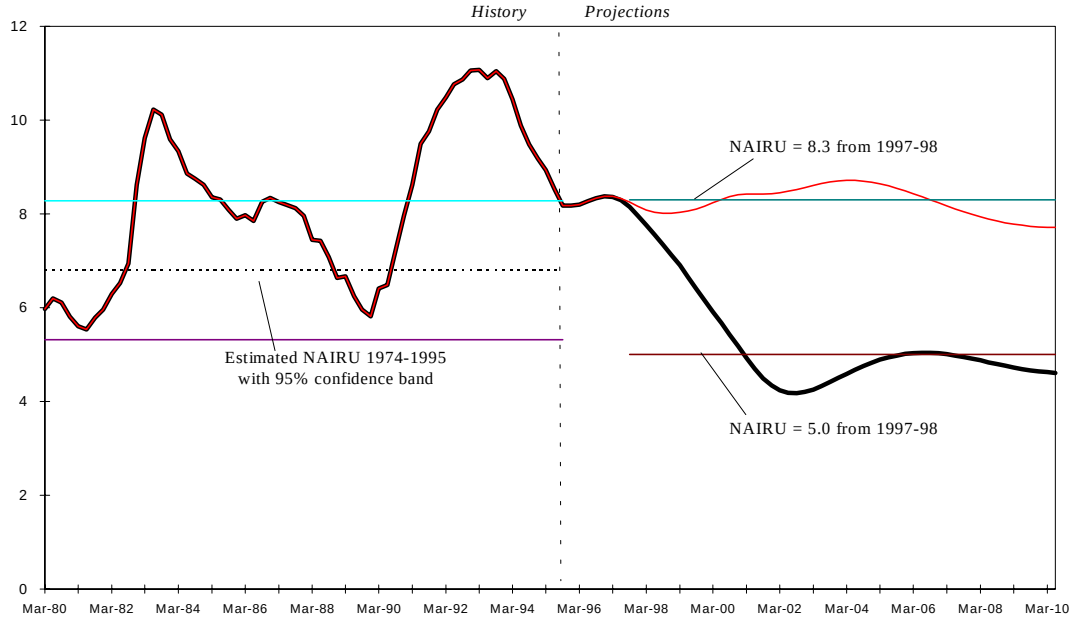
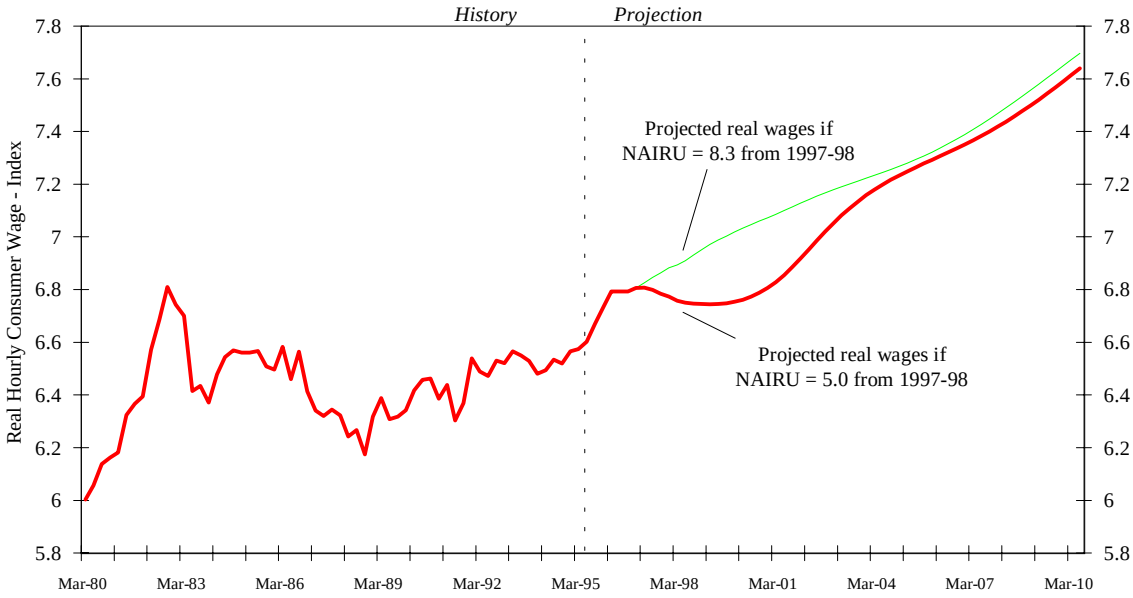


Figure 24: Real Hourly Consumer Wages Under Different NAIRU Assumptions



A 1 per cent reduction in the NAIRU (or the equilibrium rate of unemployment) leads to a roughly proportional increase in labour supply in equilibrium (around 0.8 per cent).[46] The

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45 See Downes and Stacey (1996).

46 As discussed in Section 2, in TRYM, the combination of an unemployment variable adjusted for search effectiveness (RNUST) and two wage setting parameters (WS and WSo) determine the level of the NAIRU. Therefore, it is possible to examine the macroeconomic implications of changes in search effectiveness of the unemployed and wage

availability of more employment encourages previously discouraged workers to enter the labour market, which increases equilibrium labour supply. As a result, employment rises by around two per cent in the long run. The higher level of employment is associated with a similarly higher level of output.[47]

While the long-term effects are driven by the supply side, the short-term effects are driven by the demand response to the reduction in inflationary pressures. The initial effect is to lower the inflation rate (for any given level of unemployment). This leads to lower interest rates and a lower exchange rate. It is this interest rate and exchange rate response which initially stimulates investment (and, therefore, GNE) and output growth.[48]

In response to the initial fall in real wages, employers also substitute labour for capital for a given level of output. However, this is a relatively small effect compared to the interest rate and exchange rate effects. Thus, the short-term response of employment is much greater than would be thought from simply looking at the short-term elasticity of the labour demand curve.

A similar result occurs in the long run. In the long run, the price setting curve is relatively flat for an open economy like Australia. As a small economy, Australia imports most of its business capital and buys it at the world price. Supply of investment goods is elastic. Apart from adjustment costs there is little reason for the long-run price setting curve not to be completely flat. Small wedges are driven between consumer and business wages by the need to sell more exports and hence a fall in export prices and an associated small depreciation in the real exchange rate. The elasticity of employment for the economy as a whole in the long run is again much greater than would be apparent from the labour demand equation.

The greater response in the long run is sometimes referred to as the scale effect. The elasticity of employment with respect to wages is the partial derivative in the employment equation i.e. it ignores the reaction of the firm in terms of investment, prices and output. The scale of the response when these other factors are allowed to adjust is very large. There are various ways of representing the partial adjustment depending on which factor is held constant. For example the TRYM labour demand equation derived above is of the general form in logs:

Equation 1 $N^* = Y - \sigma . W$ where: N^* is equilibrium employment,
Y is output and
W the real wage

In this case σ is the factor elasticity of substitution. According to Hamermesh (1993), the own wage, constant output elasticity of substitution is $(1-s)\,\sigma$ where s is the factor share of labour. This is the increase in employment stemming from the movement around the isoquant. As capital has to fall as labour is substituted for it, measured labour productivity falls limiting the increase in employment for a given change in wages. However, in this case, there are no scale

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setting factors separately. In the projections in Figure 10 the reduction in the NAIRU is achieved by lowering the wage setting parameter, WS.

47 The equilibrium price level depends on the monetary policy assumption. In this simulation, monetary policy is assumed to be non-accommodating of the increase in real activity. Hence, the long run price level is lower. A monetary policy setting that accommodated the increase in real activity would lead to an unchanged price level. Inflation would then be the same on average over the period. The initial deflation would be offset by a future inflation.

48 There is little external "crowding out" of the GNE stimulus and, in fact, there is a slightly positive contribution from net exports.

(income) effects. There is little practical point to dwelling on the constant output own price elasticity as the capital stock does not fall at any point in the simulations attached. A different perspective is provided if we derive the employment demand equation in terms of capital and wages rather than output and wages (see Appendix A). In which case Equation 1 becomes:

Equation 2 $N^* = K - (\sigma /(1-s)).W$ where: K is the business capital stock

In this case, the equilibrium response with an elasticity of around 0.84 and a profit share of about 0.3 would be 2.5. Equilibrium output given capital and wages (YSTWK) which is a similar concept is derived in Appendix A and is closely associated with the variable PSTAR which feeds into the price equation. N* in equation 2 would be the level of employment consistent with YSTWK. However YSTWK is an artificial concept — it neither gives the long-run effect on output or the short-run path to the long run. Capital and prices also adjust. For example, given a 10 per cent wage shock YSTWK might fall by 26 per cent but in the short-run output is fixed — determined by demand. Before the firm can adjust output it will be adjusting prices to the wage shock. Without a constraint on prices in the long run real wages and YSTWK merely return to their original level with real wages being determined by productivity (technology). Unless there is a fixed factor of production the price setting curve should be virtually horizontal.

The following table shows the response of employment in TRYM to real wage changes in comparison to results from the AEM model reported in Brooker (1993). Note that by the end of the simulation real wages are close to their starting point. In the case of the TRYM simulation after-tax real consumer wages are considerably higher in Appendix C.

Table 6 : Full Model Response of Private Employment Relative to the Real Wage

% Deviation in Private Employment / % Deviation in the Producer Real Wage.

Year	1	2	3	4	5	6	Long Run
AEM	-0.56	-1.18	-2.03	-3.14	-4.34	-5.51	-20.25
TRYM*	-1.03	-2.27	-2.52	-2.88	-3.28	-3.78	-8.87

* Derived from simulation shown in Appendix C

The intuition behind the result of the NAIRU shock is similar to that of an increase in labour supply. In the case of an increase in labour supply due to, say, increased immigration or an increase in the female participation rate, we would expect some short-term adjustment costs but no permanent effect on unemployment or the real wage. The real wage would only have to fall if there were some constraint to the supply of some other factor of production leading to a fall in aggregate labour productivity. TRYM's production function contain only two factors of production (homogenous labour and capital) and assumes constant returns to scale. As a result, labour supply and output can be increased proportionally given existing technology without any significant reduction in the real wage. This is partly because, as a small open economy, Australia imports a significant proportion of its investment goods and the supply of capital is highly elastic at a given price in the medium term. The result is complicated slightly by the fact that as a small open economy we also need to sell some proportion of the additional output on the world market. A small fall in the real exchange rate is thus required in the medium to long-term to achieve the increase in exports necessary to counterbalance the

increased demand for imports. This leads to a small wedge between producer and consumer prices and a small fall in the consumer real wage relative to the producer real wage.

Thus, the NAIRU shock might be considered to be a special case of a labour supply shock. The initial effect of a labour supply shock in TRYM is for an increase in unemployment which leads to downward pressure on wages (and, hence, also inflation, interest rates and the exchange rate) as the additional workers are accommodated into the employed labour force. There is no significant impact on real wages in the medium term once the additional workers have been accommodated. Similar short-term downward adjustments to the real wage occur in a NAIRU shock. The difference with the NAIRU shock is that in the medium term government benefit payments are reduced, while the tax base is increasing leading to a significant improvement in the net PSBR. The improved fiscal position provides room for reductions in tax rates or increased public provision of services and, hence, increased living standards for the population as a whole. (Per capita living standards are unchanged in a population shock.) Similar logic underlies the discussion of the benefits of reducing the NAIRU in the modelling work in the Appendix to Committee on Employment Opportunities (1993) and in the definition of the NAIRU in Box 2.1, p50, of that document where the point is made that the NAIRU is not about real wage levels *per se*, but about the point where nominal wage inflation begins to accelerate.

While there are a large number of caveats to the model's results, the results serve to illustrate how an analysis done in the context of a fully articulated model can provide a very different view from that of a partial analysis that focuses only on the employment relationship.

7.2 Implications for the net PSBR, Saving, Investment and the CAD

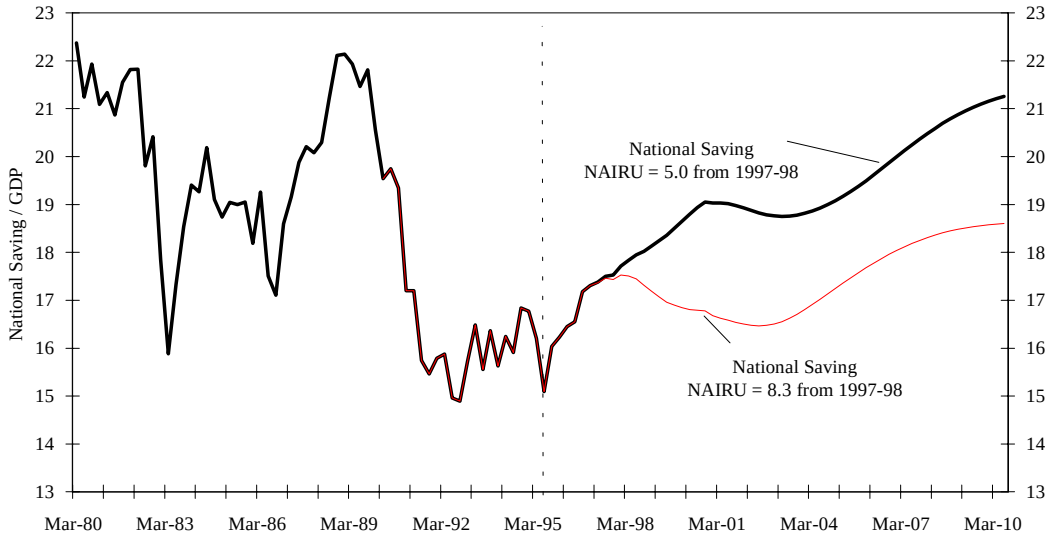
This section briefly discusses the outcomes for the net PSBR, national saving and investment in the two projections discussed in Section 4.3.

A key question in assessing the impact of a NAIRU shock is how fiscal policy will react. The appropriate assumption to make in assessing the long-run welfare effects is to assume no change in the government debt to GDP ratio (i.e. that average tax rates would rise with unemployment and the debt to GDP ratio would be unchanged). This assumption is made for the results presented in Appendix B. However, in practice government may struggle to make the necessary expenditure cuts, especially in a period when welfare, education and health costs are rising. The alternative is to run the simulations with no discretionary change in taxes or expenditure.

This is done in the first projection prepared for an earlier (1996) paper. The projection assumes that despite the poor initial outlook for wages the NAIRU falls to 5 per cent in 1997-98. The second projection assumes that unemployment has already hit the NAIRU of 8.3 per cent and that the NAIRU will remain at this level for the rest of the decade. As mentioned above the projections were purely for the purpose of illustration and in no way should be interpreted as forecasts. As can be seen below, the contrast between the two sets of numbers is quite stark. The low NAIRU case is characterised by high growth, low interest rates, rising living standards, higher public and national saving and, once unemployment has fallen, a lower CAD. In contrast, the high NAIRU outcome is characterised by low growth, high interest rates, lower saving, higher public deficits and a stagnant CAD.

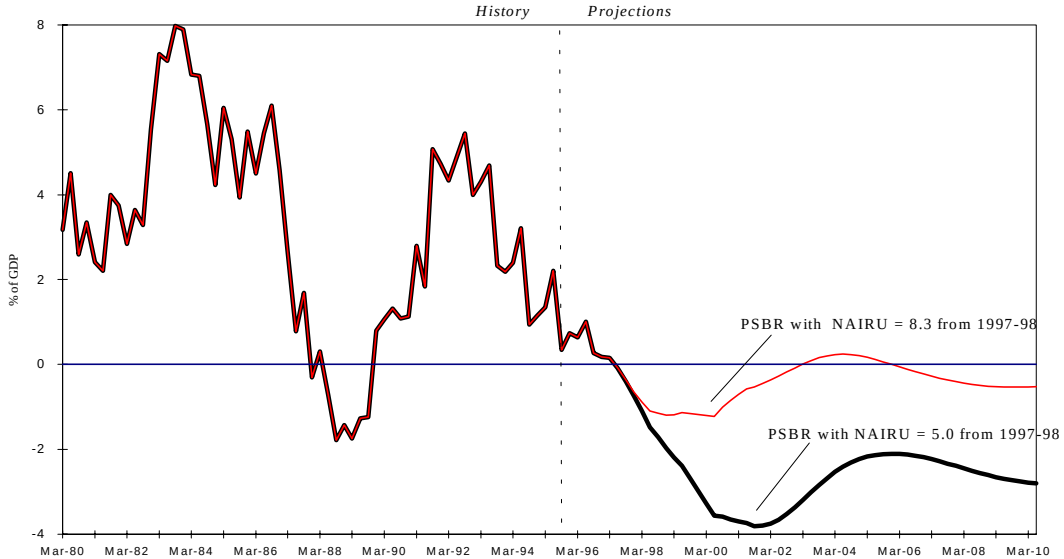
The quickest way to present the two sets of results is by contrast. Perhaps the most surprising difference is between national saving in the two simulations. This is shown in figure 25.

Figure 25: National Saving Projections with Different NAIRU Assumptions



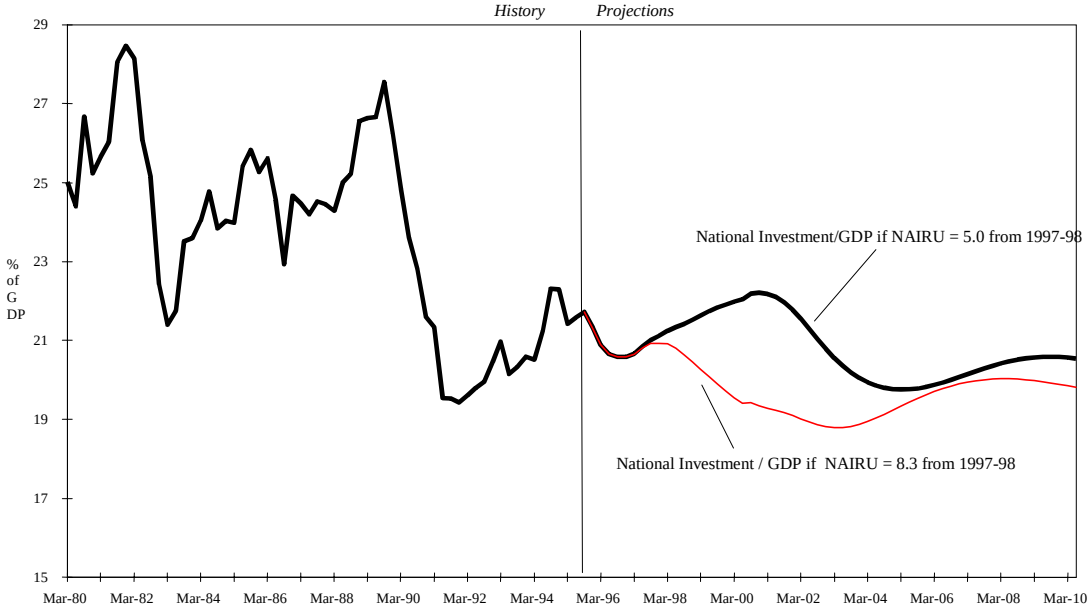
The change in national saving is partly due to the fiscal policy assumption underlying the shock. The fiscal policy assumption is that public final demand (expenditure on goods and services) and tax rates are unchanged as a result of the shock. This means that the net PSBR moves into substantial surplus in the lower NAIRU case due to the activity offsets on the tax base, and the effect of lower unemployment benefit payments on government expenditure.

Figure 26: Net PSBR Projections under Different NAIRU Assumptions



The improvement in the net PSBR leads to a substantial improvement in national saving (there is a small offsetting effect on private saving as the increase in private sector incomes more than outweighs a decline in the savings rate[49]). However, there is a large increase in national investment following from the requirement of the capital stock to adjust to a level compatible with the higher level of output. This necessitates an increase in the level of investment which is unwound once the capital/output ratio has been restored to normal levels (after around seven years).

Figure 27: National Investment Projections under Different NAIRU Assumptions



That current account deficits are therefore higher initially in the lower NAIRU case as the increase in national investment required for the capital stock adjustment more than offsets the increase in national saving. However, once capital stock adjustment has taken place investment levels fall and the current account improves. In the medium term, there is a substantial improvement in the CAD as a percentage of GDP. The scale of the improvement is almost one-for-one with the reduction in the NAIRU. However, as always the particular size of the effect in the model should be interpreted with caution as it is dependent on the assumptions used in running the simulation, particularly the fiscal policy assumptions mentioned above.

7.3 Implications for Living Standards

The TRYM simulations above illustrate what may happen if discretionary fiscal settings (i.e. government expenditures on goods and services, tax rates and benefit rates. In these circumstances, per capita living standards rise by around 2 per cent for every 1 per cent

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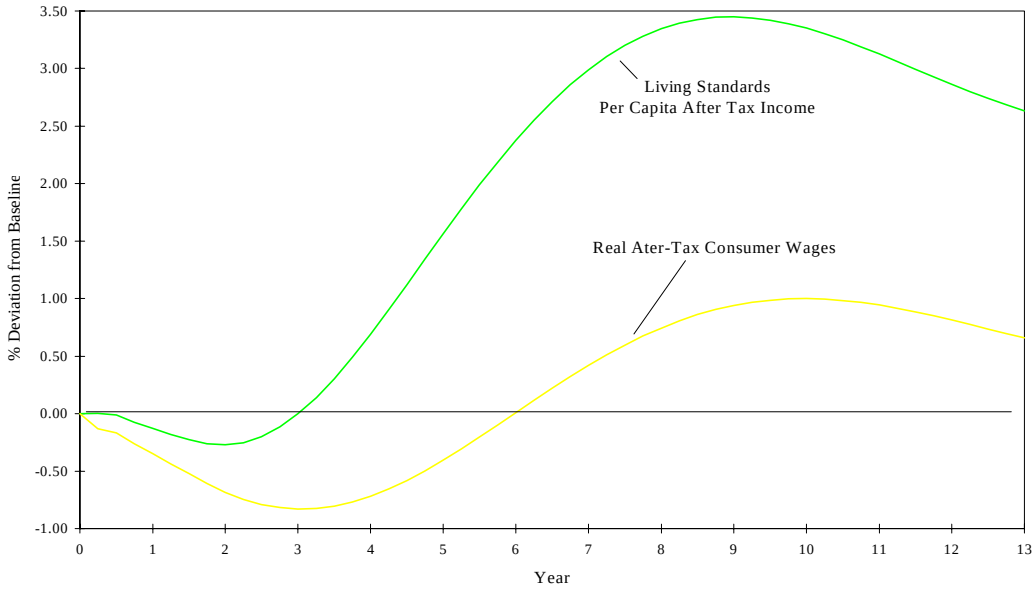
49 The improvement in national saving is different to the Ricardian equivalence case where a fall in the deficit (improvement in public saving) due to a reduction in public consumption say is offset by a fall in private saving due to expected future reductions in the tax rate and hence higher expected lifetime income. This can be most clearly seen if the population is split into two groups: employed households who react in the Ricardian way; and unemployed households who do no saving. Even if the employed householders were fully Ricardian they would only partly offset the effects on the PSBR of an increase in structural unemployment. Perhaps this helps to explain the failure of private saving to offset the structural deterioration in public saving over the seventies and eighties in many industrialised countries, (i.e. the failure of Ricardian equivalence to work even in the medium to long term.).

reduction in the NAIRU) remain unchanged. However, it seems reasonable to assume that elected governments would give back some of the fiscal dividend. In that case, the income tax rate would fall and after tax incomes as a measure of living standards would rise by more than 2 per cent for every 1 per cent reduction in the NAIRU. Figure 28 shows the results for living standards of a "shock" where the NAIRU is reduced by 1 percentage point and where government's target debt-to-GDP ratio is assumed to be unchanged. In this case, after-tax consumer real wages actually increase, as do living standards for the population as a whole which increase by around 3 per cent.

Figure 28: Effect on Living Standards of a Reduction in the NAIRU

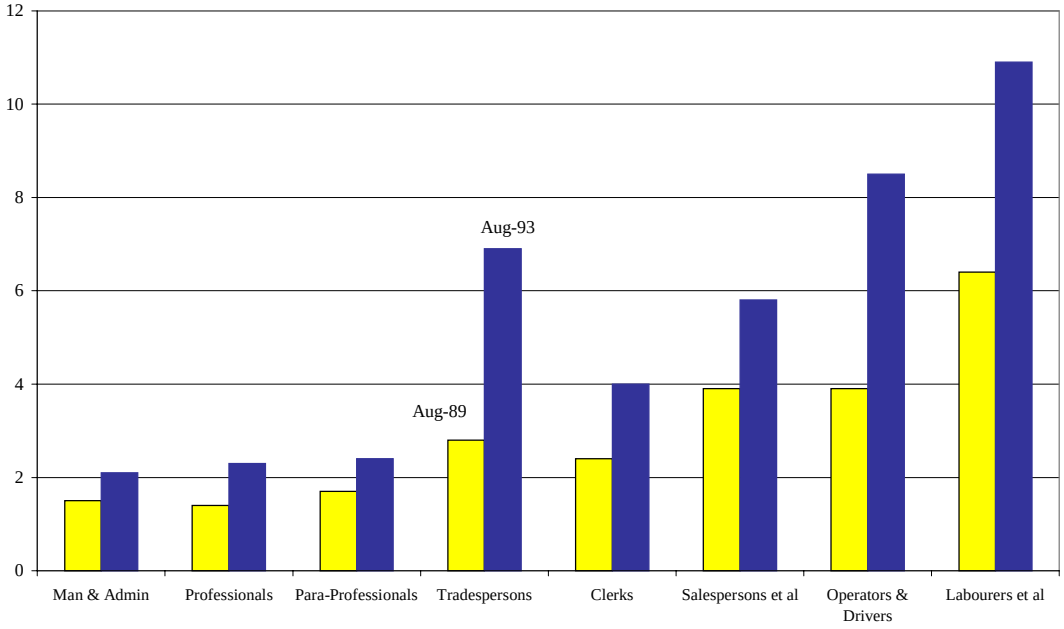


The results above are generated with backward-looking behaviour on the part of the fiscal and monetary authorities and a sudden fall in the NAIRU. An alternative scenario is presented at Appendix C. The shock imposed here is a gradual 2 per cent fall in the NAIRU, with an unchanged target public debt-to-GDP ratio as above, but this time with forward-looking fiscal and monetary policy settings. Monetary policy is slightly more stimulatory in reaction to the lower outlook for inflation, and tax rates are gradually reduced in reaction to an improving PSBR. One noticeable feature of this simulation is that the reduction in wage inflation is very modest with real producer wages falling by about a ¼ of a per cent per year initially to allow a reduction in unemployment of 2 per cent. A small decrease in wage pressures accumulates into a large reduction in unemployment other things being equal. The most appropriate measure of the welfare effect is the long-run increase in consumption which is 4.1 per cent.

7.4 Distribution of the Employment Effects

While TRYM does not contain industry or occupational detail but rather deals with employment and unemployment at the aggregate level, it is not difficult to infer from the data that any increase in unemployment due to an aggregate shock or a generalised wage increase will be concentrated at the less skilled level. Figure 29 below shows unemployment rates by occupation immediately prior to and immediately after the 1990-91 recession. There were no significant changes in occupational wage relativities prior to the recession, yet the resulting unemployment was almost entirely concentrated on the least skilled occupations.

Figure 29: Unemployment Rate by Occupation



This is likely to largely reflect the turnover characteristics of the labour markets with the least skilled having the highest levels of turnover. A similar pattern is observable for teenage unemployment for similar reasons. Also:

- the low skilled are likely to have less firm-specific capital and hence are less likely to be subject to labour hoarding.

- elasticities are higher at lower skill levels.

- screening — when unemployment rises employers will screen applications by setting higher qualification hurdles for unskilled jobs so that the unskilled are forced to the back of the queue, and if they become unemployed may face a further screening barrier (unemployment duration).

Although TRYM does not contain detailed occupational data, TRYM does suggest that when unemployment is high, modest wage restraint will lead to reductions in unemployment. It is not difficult to draw the implication that any aggregate reduction in unemployment will be at the unskilled level. Low safety net adjustments should therefore lead to both increases in welfare (efficiency) and improvements in equity by reducing unemployment at the least skilled end of the occupation spectrum. The degree of wage restraint required in the simulations attached is comparable to the difference between high and low outcomes in the Safety Net decisions.

8 Conclusion

In conclusion, it would seem the framework and system of estimated equations incorporated in TRYM can explain the rise in unemployment. In common with the conclusion drawn by most people who have looked at the Australian case, the data seems to indicate that search effectiveness has played some role in the rise in unemployment but that wage setting / price setting factors dominate. The main support for this is:

- direct evidence of the Beveridge curve shifting (and movements in vacancies can be checked against three historical series).

- the prediction of the framework that unemployment would become more volatile as we moved away from the full employment equilibrium.

This suggests that wage setting/price setting behaviour has had a large impact and that there are considerable gains to be had from slower wage growth when unemployment is high. The benefits of wage restraint are clearly shown in the model simulations. At the aggregate level, it is a temporary reduction in nominal wage growth which is required for the economy to adjust and accommodate the additional workers. As the adjustment takes place, real wages adjust back to near their original levels. Employment is higher and real wages are only marginally lower. With the feedback through fiscal policy after-tax real wages can be higher.

The required moderation in wage growth is surprisingly small in the model results. As Debelle and Vickery have also shown, the speed of the adjustment path depends critically on the monetary policy reaction and more specifically, the degree to which the monetary authorities can anticipate the effects of wage moderation. With forward looking policy, the adjustment costs can be very small. The benefits for both welfare (efficiency) and equity seem potentially large.

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Appendix A: Derivation of Joint Long-Run Forms for the Employment, Investment and Output Price Equations

Production Function in TRYM

Based on CES Technology

$$Y = \left[\alpha L^{\rho} + \beta K^{\rho}\right]^{\frac{1}{\rho}}$$

First Order Conditions give Real Wage and ERR

$$Y = a^{\frac{1}{\rho}} \quad \text{where} \quad a = \alpha L^{\rho} + \beta K^{\rho}$$

$$\frac{\partial Y}{\alpha L} = a^{\frac{1}{\rho-1}} * \alpha L^{\rho-1}$$

$$= \left[\alpha L^{\rho} + \beta K^{\rho}\right]^{\frac{1}{\rho-1}} \alpha L^{\rho-1} = \frac{W}{P}$$

sub in for Y

$$= \left[Y^{\rho}\right]^{\frac{1}{\rho-1}} \alpha L^{\rho-1} = \frac{W}{P}$$

$$= Y^{-(\rho-1)} \alpha L^{\rho-1} = \frac{W}{P}$$

$$\frac{W}{P} = \alpha\left(\frac{L}{Y}\right)^{\rho-1} = \frac{W}{P} \Rightarrow \frac{L}{Y} = \left[\frac{1}{\alpha}\frac{W}{P}\right]^{\frac{1}{\rho-1}}$$

Similarly

$$\frac{\partial Y}{\partial K} = \beta\left(\frac{K}{Y}\right)^{\rho-1} = ERR$$

In Documentation

$$\text{ERR} = \beta^{\frac{1}{\rho}}\left[1 - \alpha^{\frac{1}{1-\rho}}\left(\frac{W}{P}\right)^{\frac{-\rho}{1-\rho}}\right]^{\frac{\rho-1}{\rho}} \Rightarrow Investment$$

$$\ln L = \ln Y + c\ln\alpha - c\ln\left(\frac{W}{P}\right) \Rightarrow LabourDemand$$

$$PSTAR = \frac{W}{\alpha}\left[\frac{1}{\alpha} - \frac{\beta}{\alpha}\left(\frac{K}{Y}\right)^{\frac{c-1}{c}}\right]^{\frac{1}{c-1}} \Rightarrow \text{Pr}\,ices$$

$$YSTWK = \left[\left(1 - \alpha^{C}\left(\frac{W}{P}\right)^{1-c}\right)^{\frac{1}{\beta}}\right]^{\frac{c}{1-c}} K..... \Rightarrow \text{ Desired Output given } \frac{W}{P}, K$$

Derivation of ERR in terms of $\frac{w}{p}$

$$y^p = \alpha L^p + \beta K^p$$

$$\frac{w}{p} = \alpha\left(\frac{L}{Y}\right)^{p-1} \rightarrow L = \left[\frac{1}{\alpha}\left(\frac{W}{P}\right)\right]^{\frac{1}{P-1}} Y$$

Substitutes into 1.

$$Y^p = \alpha\left(\frac{1}{\alpha}\right)^{\frac{p}{p-1}} \frac{W}{P}^{\frac{p}{p-1}} Y^p + \beta K^p$$

$$Y^p\left[1-\alpha^{\left(1-\frac{p}{p-1}\right)} \frac{W}{P}^{\frac{p}{p-1}}\right] = \beta K^p$$

$$\frac{Y^p}{K^p} = \beta\left[1-\alpha^{\left(1-\frac{p}{p-1}\right)} \frac{W}{P}^{\frac{p}{p-1}}\right]^{-1`}$$

$$\left(\frac{K}{Y}\right)^p = \beta^{-1}\left[1-\alpha^{\left(1-\frac{p}{p-1}\right)} \frac{W}{P}^{\frac{p}{p-1}}\right]$$

$$\frac{K}{Y} = \beta^{-\frac{1}{P}}\left[1-\alpha^{\left(1-\frac{P}{P-1}\right)} \frac{W}{P}^{\frac{P}{P-1}}\right]^{\frac{1}{P}}$$

$$ERR = \beta\left(\frac{K}{Y}\right)^{p-1}$$

$$= \beta^{1-\frac{p-1}{p}}\left[1-\alpha^{\frac{1}{1-p}} \frac{W}{P}^{\frac{p}{p-1}}\right]^{\frac{p-1}{p}}$$

$$ERR = \beta^{\frac{1}{p}}\left[1-\alpha^{\frac{1}{1-p}} \frac{W}{P}^{\frac{p}{p-1}}\right]^{\frac{p-1}{p}}$$

Derivation of Labour Demand

From First Order Conditions

$$\frac{W}{P} = \alpha\left(\frac{L}{Y}\right)^{\rho-1}$$

$$\alpha\left(\frac{L}{Y}\right)^{\rho-1} = \frac{W}{P} \Rightarrow \frac{L}{Y} = \left[\frac{1}{\alpha}\left(\frac{W}{P}\right)\right]^{\frac{1}{\rho-1}}$$

$$L = \frac{1}{\alpha}^{\frac{1}{\rho-1}}\left(\frac{W}{P}\right)^{\frac{1}{\rho-1}} Y$$

$$\ln L = \ln Y + c\ln\alpha - c\ln\left(\frac{W}{P}\right)$$

Derivation of PSTAR

From First Order Conditions

$$\frac{W}{P} = \alpha\left(\frac{L}{Y}\right)^{\rho-1} \Rightarrow L = \left[\frac{1}{\alpha}\left(\frac{W}{P}\right)\right]^{\frac{1}{\rho-1}} Y$$

Substitute into Production Function

$$Y^{\rho} = \alpha\left[\frac{1}{\alpha}\left(\frac{W}{P}\right)\right]^{\frac{\rho}{\rho-1}} Y^{\rho} + \beta K^{\rho}$$

$$1 = \alpha\left[\frac{1}{\alpha}\left(\frac{W}{P}\right)\right]^{\frac{\rho}{\rho-1}} Y^{\rho} + \beta\left(\frac{K}{Y}\right)^{\rho}$$

$$\alpha\left[\frac{1}{\alpha}\left(\frac{W}{P}\right)\right]^{\frac{\rho}{\rho-1}} = 1 - \beta\left(\frac{K}{Y}\right)^{\rho}$$

$$\frac{1}{\alpha}\left(\frac{W}{P}\right) = \left[\frac{1}{\alpha} + \frac{\beta}{\alpha}\left(\frac{K}{Y}\right)^{\rho}\right]^{\frac{\rho-1}{\rho}}$$

$$P = \frac{W}{\alpha}\left[\frac{1}{\alpha} + \frac{\beta}{\alpha}\left(\frac{K}{Y}\right)^{\rho}\right]^{\frac{1-\rho}{\rho}}$$

$$P^{*} = \frac{W}{\alpha}\left[\frac{1}{\alpha} + \frac{\beta}{\alpha}\left(\frac{K}{Y}\right)^{\frac{c-1}{c}}\right]^{\frac{1}{c-1}}$$

Derivation of YSTWK

From First Order Conditions

$$\frac{W}{P} = \beta\left(\frac{K}{Y}\right)^{\rho-1} \Rightarrow L = \left[\frac{1}{\alpha}\left(\frac{W}{P}\right)\right]^{\frac{1}{\rho-1}} Y$$

Substituting into Production Function

$$Y^{\rho} = \alpha\left[\frac{1}{\alpha}\left(\frac{W}{P}\right)\right]^{\frac{\rho}{\rho-1}} Y^{\rho} + \beta K^{\rho}$$

$$Y^{\rho}\left[1 - \alpha\left(\frac{1}{\alpha}\frac{W}{P}\right)^{\frac{\rho}{\rho-1}}\right] = \beta K^{\rho}$$

$$Y^{\rho} = \left[1 - \alpha\left(\frac{1}{\alpha}\frac{W}{P}\right)^{\frac{\rho}{\rho-1}}\right]^{-1} \beta K^{\rho}$$

$$Y = \left[1 - \alpha\left(\frac{1}{\alpha}\frac{W}{P}\right)^{\frac{\rho}{\rho-1}}\right]^{-\frac{1}{\rho}} \beta^{\frac{1}{\rho}} K$$

$$= \left[1 - \alpha\left(\frac{1}{\alpha}\frac{W}{P}\right)^{1-c}\right]^{-\frac{1}{\rho}} \frac{1}{\beta}^{-\frac{1}{\rho}} K$$

$$YSTWK = \left\{\left[1 - \alpha^{c}\left(\frac{W}{P}\right)^{1-c}\right]\frac{1}{\beta}\right\}^{\frac{c}{1-c}} K$$

Appendix B: Full Information Maximum Likelihood Estimates

The results, below, were obtained through FIML estimation of the following equations as a system: labour demand (NEBD); labour supply (NLF); hours worked (NH); vacancies (NVA) and wages (RWT). Identities for business employment (NEB), total employment (NET) and the rate of unemployment (RNU) were also included.

Labour Demand

The estimated labour demand equation is:

9.1.1

$$
\begin{aligned}
\Delta \ln(NEBD) = {} & \frac{\Delta_8 \ln(NPAD)}{8} - a_1 \times \sigma \times \left[\Delta \ln\left(\frac{RWH \times RTPRB}{PGB} \right) - \frac{\lambda}{4} \right] \\
& - (1 - a_2) \times \Delta \ln(NH) \\
& + a_3 \times \left[\Delta \ln(GBA) - \frac{\Delta_4 \ln(NPAD)}{4} - \frac{\lambda}{4} \right] \\
& + a_4 \times \left[\Delta \ln(GBA(-1)) - \frac{\Delta_4 \ln(NPAD(-1))}{4} - \frac{\lambda}{4} \right] \\
& + a_5 \times \left[\Delta \ln(GBA(-2)) - \frac{\Delta_4 \ln(NPAD(-2))}{4} - \frac{\lambda}{4} \right] \\
& - a_0 \times \left[\begin{array}{l} \ln\left(\frac{NEBD(-1)}{GBA(-1)} \right) + \ln(NH) - \sigma \ln(\alpha) + \\ \sigma \times \left[\ln\left(\frac{RWH(-1) \times RTPRB(-1)}{PGB(-1)} \right) - \lambda \times QTIME(-1) \right] + \lambda \times QTIME(-1) \end{array} \right]
\end{aligned}
$$

Results

Sample: 1971(1) to 1998(3)

Parameter	Interpretation	Estimate	t-Statistic
a_0	error correction	0.162	3.56
a_1	real wages	0.113	1.96
a_2	hours worked	0.769	2.86
a_3	output	0.242	2.78
a_4	output lagged 1 qtr	0.110	1.44*
a_5	output lagged 2 qtrs	0.101	1.27*
σ	elasticity of substitution	0.839	8.21
λ	trend labour productivity	0.009	imposed

* Indicates the test has failed at the 5% confidence level.

9.1.2

Appendix C: Simulation Results

Table A4: NAIRU Shock

- Permanent two per cent decrease in the non-accelerating inflation rate of unemployment (NAIRU)
- Fiscal reaction function ON (unchanged long run debt to GDP target - income tax rates adjust, net PSBR to GDP unchanged)
- Monetary reaction function Modified (higher nominal GNE accommodated - partial adjustment to higher level)

Deviation from a steady-state baseline (per cent unless otherwise indicated)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 8	Year 10	Year 12	Year 15	Long Run
Product Market											
Demand											
Consumption	0.1	0.3	0.7	1.1	1.6	2.0	2.9	3.5	3.7	3.5	4.1
Dwelling Investment	0.2	1.1	2.4	3.5	4.5	5.4	6.2	5.2	3.0	0.7	4.5
Business Investment	0.3	1.2	2.0	2.7	3.3	3.9	4.6	4.3	2.7	0.3	2.7
Government Final Demand	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stock-building (a)	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Gross National Expenditure	0.1	0.5	0.9	1.3	1.7	2.1	2.8	2.9	2.7	2.0	3.0
Net Exports (a)	0.1	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.4	0.4	0.0
Gross Domestic Product	0.2	0.6	1.1	1.5	2.0	2.4	3.1	3.3	3.0	2.4	3.4
Supply											
Business Output	0.3	0.8	1.4	2.0	2.6	3.1	4.0	4.2	3.8	3.1	3.9
Desired Output (given K,L)	0.2	0.6	1.1	1.7	2.2	2.7	3.5	3.9	3.9	3.4	3.9
Balance of Payments											
Commodity Exports	0.1	0.6	1.1	1.6	2.2	2.8	3.8	4.5	4.6	4.2	4.8
Non-commodity Exports	0.4	0.9	1.4	1.8	2.3	2.7	3.3	3.4	3.1	2.4	2.9
Exports of Goods and Services	0.2	0.7	1.2	1.7	2.3	2.8	3.6	4.0	3.9	3.4	3.9
Imports of Goods and Services	-0.3	0.0	0.4	0.8	1.1	1.5	2.2	2.6	2.4	1.7	2.2
Terms of Trade	-0.2	-0.5	-0.7	-0.9	-1.0	-1.0	-1.0	-0.6	-0.3	-0.2	-0.6
Trade Deficit (b)	-0.1	-0.1	0.0	0.0	-0.1	-0.1	-0.1	-0.2	-0.3	-0.3	
Net Income Deficit (b)	0.0	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.2	0.2	
Current Account Deficit (b)	-0.1	0.0	0.1	0.2	0.2	0.2	0.2	0.1	-0.1	-0.1	
Labour Market											
Employment	0.2	0.6	1.1	1.6	2.2	2.7	3.5	3.8	3.7	3.2	3.6
Labour Force	0.1	0.2	0.5	0.7	0.9	1.1	1.5	1.6	1.5	1.3	1.5
Unemployment Rate (c)	-0.1	-0.3	-0.6	-0.9	-1.2	-1.5	-1.9	-2.1	-2.0	-1.8	-2.0
Nominal Wages	0.0	-0.1	-0.4	-0.7	-1.0	-1.3	-1.2	-0.5	0.5	1.3	0.1
Consumer Prices	0.1	0.1	0.1	0.0	-0.1	-0.2	-0.2	0.4	1.3	2.2	0.5
Business Output Prices	0.1	0.1	0.1	-0.1	-0.2	-0.4	-0.3	0.2	1.1	2.0	0.8
Real Consumer Wages (after-tax)	0.3	0.7	0.9	0.9	0.9	0.9	1.1	1.3	1.5	1.4	1.3
Real Producer Wages	-0.2	-0.3	-0.5	-0.7	-0.8	-0.9	-0.9	-0.8	-0.6	-0.7	-0.3
Wage Inflation (c)	0.0	-0.1	-0.3	-0.3	-0.3	-0.2	0.1	0.4	0.5	0.1	0.0
Consumer Price Inflation (c)	0.1	0.0	0.0	-0.1	-0.1	-0.1	0.1	0.3	0.5	0.2	0.0
Financial Markets											
Money and Bond Markets											
90 Day Bank Bills (c)	-0.1	-0.2	-0.3	-0.3	-0.3	-0.3	-0.1	0.1	0.3	0.4	0.0
10 Year Bonds (c)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Inflationary Expectations (10 year) (c)	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	-0.1	-0.1	0.0
Foreign Exchange Market											
Export Weighted Exchange Rate											
- Nominal	-1.7	-2.0	-2.1	-2.1	-2.1	-2.0	-1.8	-1.8	-2.1	-2.6	-2.2
- Real	-1.6	-1.8	-2.0	-2.2	-2.3	-2.3	-2.1	-1.5	-0.9	-0.6	-1.4
Net Lending											
- Net PSBR (b)	0.2	0.3	0.3	0.3	0.2	0.1	-0.1	-0.2	-0.1	0.2	0.0
- Net Private Lending (b)	-0.3	-0.3	-0.2	-0.1	0.0	0.1	0.3	0.2	0.0	-0.3	
- Gross Private Investment (b)	0.0	0.2	0.3	0.4	0.5	0.6	0.6	0.5	0.1	-0.3	
- Gross Private Saving (b)	0.3	0.4	0.5	0.5	0.5	0.5	0.3	0.2	0.1	0.1	
- CAD (b)	-0.1	0.0	0.1	0.2	0.2	0.2	0.2	0.1	-0.1	-0.1	
Stock Accumulation											
Dwelling Capital Stock	0.0	0.0	0.1	0.2	0.4	0.6	1.0	1.3	1.5	1.5	4.5
Business Capital Stock	0.0	0.1	0.2	0.4	0.7	0.9	1.5	2.0	2.2	1.9	2.7
Net Public Sector Debt (d)	0.0	0.1	0.3	0.5	0.6	0.6	0.3	-0.2	-0.5	-0.3	0.0
Net Foreign Debt (d)	0.1	0.0	0.2	0.4	0.4	0.3	-0.1	-0.7	-1.2	-1.1	0.0
Net External Liabilities (d)	0.1	0.0	0.2	0.3	0.3	0.2	-0.3	-1.1	-1.7	-1.7	0.0