Macroeconomic Policy and Labour Market Structure

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Abstract

This thesis comprises three chapters. Each considers a particular manner in which policy choice and labour market structure interact to determine macroeconomic performance.

The first chapter argues that employment protection legislation can significantly reduce equilibrium employment. It considers the impact of firing costs on the pricing behaviour of intermediate-good firms facing idiosyncratic productivity shocks. It is shown that, since they might work against existing market distortions, such costs can lead to either more or less efficient labour allocations. Simulations indicate that the magnitude of their effects is potentially much greater than is found in standard, representative-firm models, particularly when they act to reduce employment.

The second chapter links the decentralisation of wage-bargaining in industrialised countries over the last twenty years to the more anti-inflationary macroeconomic regimes also in evidence. It presents a monetary policy game in which, prior to the central bank choosing inflation, wages are set by coalitions of unions. Unions are assumed to anticipate central bank behaviour when forming these coalitions. Using both cooperative and non-cooperative theories of coalition stability and formation, it is shown that highly conservative central banks are associated with decentralised patterns of wage-setting.

The third chapter considers the effect of spatial unemployment dispersion on inflationary pressure in the aggregate. It reviews the theoretical rationales for any such effect, and argues that some previous studies have been overly restrictive in their assumption of homogeneous disaggregate Phillips curves. A theoretical rationale for disaggregate heterogeneity is provided and aggregate and regional Phillips curves estimated. Statistics on the spatial unemployment distribution are found to explain a significant part of the variation of the GB NAIRU over time.

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1 Introduction

Macroeconomics may be thought of as the investigation of relationships between economic variables at a fairly aggregated level. While there has been, in the last thirty years or so, increasing emphasis on the provision of adequate microfoundations for macroeconomic models, the assumptions typically made to render a model tractable often rule out the sort of heterogeneity that is empirically observed. For example, restrictive homogeneity conditions may be imposed whereby aggregate behaviour is equivalent to that of a representative individual. This 'representative agent' paradigm has been at the core of modern macroeconomics; it has proved invaluable in the construction of explicitly dynamic economic models such as those associated with Real Business Cycle theorists. If one thinks of macroeconomic models as low-dimensional reductions of an extremely high-dimensional system, this simplification is intuitive and may be seen as the sacrifice of one dimension (heterogeneity) in order to understand more fully the implications of another (time, for example). However, given that such modelling choices must be made, the choice of the dimension upon which to focus should be dictated by the problem at hand[1]. The dominance of the representative agent in macroeconomics has been the cause of some disquiet[2], and the rehabilitation of heterogeneity has been at the heart of much recent research[3]. The models contained in the three main chapters of this thesis may be seen as complementary to such efforts. Each incorporates into a macroeconomic model a particular institutional feature of the 'real world' - namely, the existence of firing costs in a world with heterogeneous firms, of coalition formation amongst wage-setters and of heterogeneous regional Phillips curves.

That the labour market is the source of heterogeneity in each case is not accidental. While employment and unemployment are obviously among the economic variables with which macroeconomics is concerned, labour economics as a subdiscipline has arguably become increasingly microeconomic[4].

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[1] And perhaps by the talent of the modeller.

[2] See for example Gallegati and Kirman (1999).

[3] An example is the literature on interacting agents, in which individuals and firms are assumed to interact in ways other than through the mediation of the price system. See Aoki (1996) and Brock and Durlauf (1995).

[4] See the comments of Steven Nickell in Ibanez (1999), p.198. An obvious exception to this trend is the incorporation of search theory into the standard neoclassical growth model - see Pissarides (1990).

However, insights developed by labour economists may be profitably used in macroeconomic models. Moreover, the beauty of macroeconomics as a study of systems is that phenomena which remain unexplained at a microeconomic level may (sometimes) be shown to be intuitive at the system level. The first model in this thesis provides an example. While many economic commentators believe it is a prime cause of Europe's sclerotic labour market, the impact of costly dismissal on employment remains controversial, both theoretically and empirically. Most research has examined the impact of employment protection on a single firm in isolation, and concluded that its effects are likely to be insignificant. Chapter 2, in contrast, introduces such protection into a fully-articulated macroeconomic model and shows how it can reduce employment significantly. More specifically, it introduces firing costs into an economy where firms produce heterogeneous intermediate goods and productivity shocks are firm-specific, and examines the consequences for the price of the composite input portfolio used in the final-good sector. It is shown that, since they might work against existing market distortions, firing costs can lead to either more or less efficient labour allocations. Simulations show that the magnitude of their effects is potentially much greater than is found in standard, representative-firm models, particularly when they act to reduce employment. The model is then extended to endogenise firm entry, which exacerbates the negative effects of costly dismissal by reducing the variety of intermediate goods available. Further extensions consider the impact of international trade in intermediates on (i) the incentives for national governments to reform their labour markets, and (ii) the interpretation of extant empirical work on the effect of employment protection. Finally, it is shown how the model is easily reconciled with the cross-country labour turnover pattern.

Most models that do incorporate heterogeneity of some sort simply assume it. This is consistent with almost all macroeconomics, in that institutional features of an economy are supposed invariant in the face of changes in policy[5]. Chapter 3 shows how policy can in fact engender heterogeneity; it examines the interaction between monetary policy stance and institutional structure in the labour market, and argues that the observed decentralisation of wage-bargaining in industrialised countries over the last

[5] While the Lucas Critique is inevitably invoked should a modeller assume unvarying agent behaviour when there are shifts in the policy regime, attention is rarely paid to any possible evolution of the basic structure of the economy.

twenty years is a result of the concurrent shift towards more anti-inflationary macroeconomic regimes. It presents a monetary policy game in which, prior to the central bank choosing inflation, wages are set by (non-atomistic) coalitions of unions. Unions are assumed to anticipate central bank behaviour when forming these coalitions, a process modelled using the coalition formation game proposed by Bloch (1996). It is shown that highly conservative central banks, i.e. those that attach little weight to real variables as opposed to inflation, are associated with highly decentralised patterns of wage-setting. This is also found to be true under the cooperative concept of coalitional stability. Appreciation of the endogeneity of labour market structure proves crucial for the relationship between employment and central bank conservatism. Given the structure of the labour market, employment is strictly increasing in the degree of conservatism. However, once the effect on labour market structure is taken into account, a central bank that attaches some weight to real variables will in fact maximise employment. The model is used to analyse the likely impact of the single currency on Europe's labour markets; it is argued, in contrast to recent predictions that the advent of the euro will lead to consolidation among labour unions, that the effect is *a priori* ambiguous, and that monetary union may even accelerate the fragmentation of European wage-bargaining.

The final chapter considers the implications of labour market heterogeneity for the appropriate conduct of macroeconomic policy; specifically, the effect of unemployment dispersion at regional and subregional levels on the aggregate NAIRU, or Non-Accelerating-Inflation-Rate-of-Unemployment. The idea that the distribution of unemployment rates across space (or across industries, for that matter) should affect inflationary pressure in the aggregate dates back at least to Lipsey (1960). However, most empirical investigations of the hypothesis are, it is argued here, overly restrictive in their assumption of homogeneous, nonlinear disaggregate Phillips curves. It is shown how such nonlinearity is not a necessary condition for the existence of a dispersion effect; in contrast, disaggregate heterogeneity is a sufficient condition for the presence of such an effect, and a simple model is developed to provide a theoretical rationale for such heterogeneity. The Shapiro-Stiglitz shirking framework is generalised to allow for endogenous monitoring intensity, and it is shown how variations in monitoring technology are likely to affect the slope of the unemployment-inflation locus in each region. These predictions are taken to the data, and are borne out by the experience of the GB labour market from 1966-1996. The slopes of regional wage curves are investigated, and considerable heterogeneity is found. Aggregate Phillips curves are also estimated, and statistics on the spatial unemployment distribution are found to explain a significant part of the variation of the GB NAIRU over time.

The three chapters, therefore, investigate in a macroeconomic framework three different ways in which policy and labour market structure interact. Different patterns of disaggregate heterogeneity may alter the optimal policy choice at an aggregate level; the theoretical implications of a particular labour market policy may differ, depending on whether or not the macroeconomic implications of that policy are taken into account; and, since any labour market structure is presumably the result of the actions of (possibly self-interested) individual agents, variations in policy stance may in turn lead the institutional structure itself to evolve. As with any macroeconomic modelling strategy, the elaboration of the institutional features of the labour market no doubt entailed some costs. However, it is hoped that the models contained in this thesis are not only instructive as exercises in methodology, but useful in understanding the problems at hand.

2 Employment Protection, Pricing and Cross-Sectional Efficiency

2.1 Introduction

It has long been maintained, by assorted policymakers and economic commentators, that onerous regulation is at the heart of Europe's 'sclerotic' labour market performance, with employment protection legislation (EPL) a chief culprit[6]. In this view the comparative dynamism of the US economy, with its admirable record on job creation, is due to the absence there of such nannyish interference[7]. A solid case for the prosecution has proved hard to build, however. In 1999 the OECD released a report on the labour market implications of employment protection regulations[8]. To the organisation's evident discomfort, conclusions contained therein - that EPL had 'little or no effect' on overall unemployment, and that there was only 'very weak' evidence for any deleterious effects on employment levels - sparked a heated debate, and drew 'protests from governments, congratulations from trade unions, and uproar from the OECD's economics department'[9].

The furore surrounding the OECD publication neatly illustrates both the level of feeling surrounding the topic of employment protection and the lack of a consensus as to its effects. A substantial body of empirical work, surveyed below, has failed conclusively to establish EPL as a root cause of Europe's dismal employment record. This is, in fact, consistent with the standard theoretical treatment, which concludes that the relationship between firing costs and employment is ambiguous in sign and likely to be insignificant in magnitude; employment protection induces a representative firm to fire less in bad times and hire less in good times, with the net impact on average employment small. Furthermore, even if employment protection were associated with inferior labour market outcomes, one would then have to explain why governments do not repeal the offending legislation.

The current chapter argues that the effects of firing costs on employment can in fact be substantial. It

[6]See Siebert (1997) and Brittan (1999) for examples.

[7]In 1996 the employment-population ratio in the US was nearly 75%; in Europe it was a full fifth lower, at 60%.

[8]OECD (1999). See this for an international comparison of employment protection regimes.

[9]The report had been drawn up by the OECD's education, employment, labour and social affairs directorate, not by its economics department. The OECD subsequently retreated a little from its findings, saying the report was only 'a first step in an ongoing study that requires further evidence'. See Taylor (1999a,1999b).

provides a theoretical model which emphasises not their 'direct' effect on an individual firm's employment, but the aggregate labour market consequences of the disaggregate pricing distortions they imply. Now, while this has not been the focus of theoretical work in this area[10], the issue of cross-sectional labour reallocation is one which many economists would raise when asked about the possible drawbacks of firing costs. A quote from the OECD report is illustrative:

> "...EPL may result in a more sclerotic labour market, unable to achieve quickly the volume of workforce adjustment that is required in response to rapid changes in technologies...Any such diminished ability to reallocate labour in a flexible manner would tend to lower aggregate productivity levels and growth prospects."[11]

In the model here, firing costs are introduced into an economy where monopolistic firms use labour to produce intermediate goods, and where these firms face idiosyncratic shocks to their productivity. The result is that the rate at which labour is dynamically reallocated across firms, from unproductive to productive, is reduced. This has implications for firms' pricing policies, and thus for the productivity of the final-good sector, as measured by the cost of the portfolio of intermediate inputs. The effect on output and employment of the relative price distortions introduced is shown to be of indeterminate sign; depending on the size of productivity shocks and the substitutability of intermediates, the price of the composite intermediate good may rise or fall. This raises the possibility that firing costs can actually 'improve' the labour allocation and increase final-sector productivity and output, as well as intermediate-sector employment. This rather surprising result is explained by the theory of the second-best - firing costs actually work against an existing market failure in the intermediate goods sector. However, simulations are used to show that, in practice, employment protection is more likely to reduce aggregate productivity. The associated falls in intermediate employment are potentially an order of magnitude greater than any in standard, representative-firm models. Indeed, they can be arbitrarily large, depending on the elasticity of final good output to the price of the composite intermediate good.

[10]Hopenhayn and Rogerson (1993), Bertola (1994) and Bertola and Caballero (1994) are exceptions, and will be discussed below.

[11]OECD (1999), p.69.

The entry decision of a firm is also considered, and it is shown that employment protection restricts the variety of intermediate goods on offer. Further extensions show how the model can account for the empirical failure to identify any significant labour market effects of employment protection. It is shown, for example, how the introduction of labour into the final good sector as a complementary input can reconcile the model with cross-country labour turnover patterns. Some implications of international trade in intermediate goods are also drawn. It is argued that the presence of such trade can explain why cross-country regressions of employment against the level of employment protection may fail to identify any robust relation. Moreover, simulations show how trade in intermediates can reduce the incentives for national policymakers to reduce the level of employment protection, suggesting that fundamental reform of Europe's labour markets may have to be the result of coordinated action on the part of national governments, or else be initiated by a supra-national authority.

Section 2.2 reviews existing research into the effects of EPL, both empirical and theoretical. Section 2.3 introduces the baseline model, while Section 2.4 presents the extensions. Section 2.5 concludes.

2.2 Survey of existing research

2.2.1 Empirical

While much effort has been expended in the attempt to identify the effects of firing costs empirically, the results are mixed. Lazear (1990) remains the classic study. He examines a panel of 22 developed countries across 29 years, and finds that EPL significantly increases unemployment rates and reduces employment. His work has been criticised, however, for its reliance on severance pay alone as a proxy for EPL in any given country[12], as well as for the absence of controls for various other factors that would affect structural rates of employment and unemployment[13].

Subsequent studies have addressed these shortcomings, and employed both more comprehensive measures of employment protection and a broader selection of controls. Unfortunately, these studies have

[12] One could additionally include (at least) provisions regarding unfair dismissals, and regulations governing the amount of notice an employee must receive.

[13] See Addison, Teixeira and Grosso (2000) for a fuller discussion of the limitations of Lazear's paper.

varied markedly in their conclusions. Scarpetta (1996) considers a mix of time-averaged and time-varying data on 17 countries, from 1983 to 1993, and concludes that employment protection increases unemployment, in particular among youths. Nickell (1997) examines averaged data for two sub-periods, 1983-1988 and 1989-1994, and finds the effects of EPL on employment and unemployment to be statistically insignificant, by and large. He argues that there is a spurious correlation between low female participation in the labour force and EPL, both of which are common in southern European countries; this could bias any studies which link firing costs to low employment. In support of this thesis, Nickell points out that firing costs seem to have no effect on the employment of prime-age men. A slew of further studies has failed to settle the matter conclusively. For example, Di Tella and MacCulloch (1999) find that EPL reduces employment, as do Garibaldi and Mauro (1999); this is in contrast to the controversial OECD (1999) report which largely exculpates EPL from responsibility for low employment rates.

Other empirical work has considered the effects of employment protection, not on structural rates of employment and unemployment, but on their respective dynamics. While some authors have found EPL to be associated with longer durations of unemployment (see for example Nickell (1997), Table 6), there seems to be little correlation between rates of job creation and destruction and the strictness of EPL across countries. Bertola and Rogerson (1997) note the similarity of job turnover rates across the Atlantic. Given that the US labour market is considerably less regulated than those in Europe, this is inconsistent with the standard theory[14]. The authors argue, though, that it is due to the more compressed wage distributions in European countries. Indeed, they suggest that Europe's high-EPL, low-wage inequality combination may be ascribed to political economy considerations; workers unable to perfectly insure against idiosyncratic labour income shocks may lobby for a package of stricter EPL and wage-compression legislation[15]. The Bertola and Rogerson paper is instructive; the endogeneity of policy choices is ignored by most empirical work. This is one reason why it is difficult to obtain robust

[14] Even if the net effect of firing costs on the level of employment is minuscule, theory suggests that rates of job creation and destruction should be affected. For opposing evidence on employment protection and job turnover, see Blanchard and Portugal (1998).

[15] EPL without wage-compression would lead to variability in labour income via low wages in bad times; wage-compression without EPL would lead to the same thing, this time via no employment in bad times.

correlations between EPL and labour market performance, given that, ceteris paribus, the economies most likely to have strict employment protection regulations imposed are those with least to lose.

Overall, the empirical case against employment protection is not proven. The inadequacy of measures of EPL used, the need to control for other labour market factors, the interaction between employment protection and other institutional features and the endogeneity of policy choices all militate against the identification of EPL's effects on labour market performance. In particular, the effect on employment rates remains ambiguous, and even any impact on job turnover has yet to be established.

2.2.2 Theoretical

Optimal hiring and firing: the firm's problem The modern treatment of a firm's hiring and firing decisions in the presence of firing costs stems from Bentolila and Bertola (1990), who consider the dynamic optimisation problem of a firm facing demand shocks and linear labour adjustment costs. The following, somewhat simplified analysis follows Bertola (1990) and will serve also as an introduction to the theoretical model in Section 2.3. Ignoring any costs associated with hiring workers, consider a firm choosing employment at time t in order to maximise the present value of its expected cash flows when the discount rate is r:

$$Max_{\{l_\tau\}} E_t \left(\sum_{i=0}^{\infty} \left(\frac{1}{1+r} \right)^i \left(R\left[a_{t+i}, l_{t+i}\right] - w_{t+i} l_{t+i} - C\left[l_{t+i} - l_{t+i-1}\right] \right) \right). \tag{1}$$

The stochastic process $\{a_\tau\}$ indexes the firm's business conditions, while $R\left[a, l\right]$ is the revenue generated by l homogeneous workers in a period where business conditions are described by a. All other firm decisions, such as pricing and use of other factors of production, are assumed to be taken optimally. $R\left[a, .\right]$ is assumed to be increasing and concave in l, with $R\left[a, 0\right] = 0$. The process for the nominal wage, $\{w_\tau\}$, is assumed exogenous. The firm must pay firing costs according to the piecewise function $C[.]$:

$$C\left[l_\tau - l_{\tau-1}\right] = f\left[l_\tau - l_{\tau-1}\right] \quad \text{if } l_\tau > l_{\tau-1}, \tag{2}$$

$$0 \quad \text{otherwise}. \tag{3}$$

The dismissal cost per worker, f, is constant and exogenous, and it is assumed for simplicity that there is no source of job separation save dismissals.

The stochastic environment that will be assumed in this paper will be the most simple available, a symmetric two-state Markov chain where a_g denotes good times and a_b bad times, and where the current value of a is observed before the level of employment is chosen. Let $a_g > a_b$, $\partial R/\partial a > 0$, $\partial^2 R/\partial l \partial a > 0$, and $w_g = w_b = w$ for simplicity. It is implicit that desired employment is higher in good times than bad. The probability of a transition from the good state to the bad state, or *vice versa*, is 0.5.

Define $M[a,l] \equiv \partial R[a,l]/\partial l$, *i.e.* the marginal revenue product of labour (MRPL) function. The dynamic shadow value of labour at time t is then:

$$SVL(t) = E_t \left\{ \sum_{i=0}^{\infty} \left(\frac{1}{1+r} \right)^i M\left[a_{t+i}, l_{t+i}\right] - w \right\}, \tag{4}$$

and the following first order conditions are necessary and sufficient for the firm's hiring policy to be optimal:

$$\begin{aligned} -f &\leq SVL(t) \leq 0 && \text{always;} && (5) \\ SVL(t) &= 0 && \text{if } L_t > L_{t-1}; && (6) \\ SVL(t) &= -F && \text{if } L_t < L_{t-1}. && (7) \end{aligned}$$

Intuitively, should the firing cost f be prohibitively large, then the firm may choose not to respond to changes in the state; employment is then historically determined and will remain at the initial level, assumed to satisfy (5). If on the other hand f is small (or the variance in a large) enough, then optimal labour demand also follows a two-state Markov process; the firm hires when conditions improve, and fires when they deteriorate.

Focusing on the case where the firm follows an active hiring and firing policy, one may use (6), (7) and the law of iterated expectations to obtain the following indirect conditions on l_g and l_b:

$$\begin{aligned} M\left[a_g, l_g\right] &= w + \frac{f}{2(1+r)} && (8) \\ M\left[a_b, l_b\right] &= w - \frac{f(1+2r)}{2(1+r)}. && (9) \end{aligned}$$

Given the concavity of $R[a,l]$, we thus have the well-known result that the introduction of dismissal costs reduces not only firing in bad times, but also hiring in good times. In the latter case forward-looking firms behave as if the wage is higher by $f/2(1+r)$, the discounted expected loss on the marginal worker, who may have to be dismissed next period. It is worth noting that the effect on the MRPL is greater in magnitude when $a = a_b$; this is because, when business conditions deteriorate and workers are laid off, firing costs are incurred with probability one rather than in some uncertain future. While this implies that the average long-run MRPL of an individual such firm is lowered by firing costs, the net effect on average employment is less clear-cut. For this, the precise functional form of $M[a, l]$ is crucial. As shown in Bertola (1990), if the marginal revenue function is steeper (more shallow) in bad times than good, then there is likely to be a net reduction (increase) in employment. Either way, one would expect the magnitude of any such effect to be rather small, unless rather tortuous assumptions regarding revenue functions and interest rates were made, as shown by the calibrations in Bentolila and Bertola.

Employment protection and wage-setting Given the failure of the above analysis to generate significant consequences for employment of dismissal costs, theorists have relaxed the assumption of an exogenous wage structure. Groenewold (1999) introduces employment protection into a model of efficiency wages, and finds the effect on unemployment to be ambiguous. Risager and Sorensen (1999) consider how firing costs affect employment and investment in an open economy, and find the result depends on the wage-setting behaviour of trade unions. Lindbeck and Snower (2001), in their survey of insider-outsider theory, argue that labour turnover costs are likely to afford employed workers greater bargaining power than their potential replacements, the unemployed; as a result, wages are likely to be bid up and employment to fall. This indirect effect on employment, the authors argue, is unambiguous in sign and 'could well be large'. However, it is not necessarily clear why EPL should render the unemployed less able to compete for jobs. In a dynamic model, one could argue that outsiders could bid down not just a single-period wage, but the entire present value of the wage process. For example, they could post a bond and 'buy' themselves a job. Of course, in realistic dynamic settings, the imperfect nature of contracts could make such schemes infeasible[16].

[16] On a related note, Pissarides (2001) examines the role played by employment protection in the absence of perfect insurance markets.

The model to be set out below retains an exogenous wage structure. This is not to say that firing costs have no effects on the process of wage formation, nor that any such relationship is likely to be quantitatively unimportant. Rather, insider-outsider theories could be seen as complementary to the pricing mechanism outlined here.

2.2.3 Idiosyncratic shocks and aggregate productivity

Hopenhayn and Rogerson (1993), Bertola and Caballero (1994) and Bertola (1994) have a somewhat different perspective. They introduce dismissal costs into a environment with many firms, where uncertainty is firm-specific, and analyse the aggregate efficiency consequences. Bertola and Caballero consider the distortionary effects of dismissal costs in a matching model. They show that such costs unambiguously reduce what they call the 'cross-sectional efficiency' of the labour market, since they lead to the employment of a greater proportion of workers in relatively unproductive jobs. However, they also reduce unemployment, for reasons similar to the standard analysis of Section 2.2.2, and the net effect on output may be positive. The authors show that, once resources allocated to costly search and firing are taken into account, employment protection reduces welfare. Bertola considers the effect of employment protection on capital accumulation in a full-employment model of growth, where monopoly firms supply imperfectly substitutable varieties of good, and each unit of capital is used to enlarge the measure of existing firms. Again, firing costs are found to reduce both cross-sectional efficiency[17] and the rate at which new firms appear, reducing the welfare of the representative individual. Hopenhayn and Rogerson also focus on the creation of new firms. They extend the analysis of Bentolila and Bertola (1990) to endogenise the entry decision of a firm, and find that EPL reduces both average productivity and firm entry, which in their model leads to a fall in employment.

It should be emphasised that these three papers all conclude that employment protection worsens the allocation of labour across firms. Also, the consideration of the firm entry decision apart, they have little to add with regard to the employment implications of firing costs, beyond the insights already implicit in the model of Bentolila and Bertola. The baseline model to be described next is perhaps closest to

[17] In the same sense as in the paper by Bertola and Caballero.

the full employment model of Bertola (1994), in that it assumes firms are monopolistic producers of individual varieties of good. However, the model here focuses on the employment effects of firing costs. Moreover, the implications of costly dismissal for the pricing of intermediate goods are drawn, and it is shown that the result is not necessarily an inferior labour allocation. Productivity in fact increases for certain parameter values. Finally, it is shown how the indirect employment implications of any changes in productivity can be an order of magnitude larger than the direct effect usually considered.

2.3 The model

The baseline model of the chapter will now be introduced. The following section lays out the basic structure and solves the model; subsequent sections examine more closely the effect of costly dismissal on pricing and employment respectively.

2.3.1 Firing costs and intermediate goods

Consider an economy with a measure n of firms, with each firm i the monopoly producer of a single variety of intermediate good x_i, with labour l_i the sole input:

$$x_i = a_i l_i. \tag{10}$$

Each firm is subject to labour productivity shocks, indexed by $a_i \in \{a_g, a_b\}$ where $a_g > a_b$. As in Section 2.2.2, the stochastic process for a is the most simple possible, with symmetric transition probabilities from each state of 0.5. The final-good sector uses these intermediate goods as inputs, and produces the final good Y with technology

$$Y = X^{\alpha}, \tag{11}$$

where $\alpha < 1$ and

$$X = \left(\int_0^n x_i^{(\sigma-1)/\sigma} di \right)^{\sigma/(\sigma-1)}. \tag{12}$$

The parameter σ indexes the substitutability of the intermediate varieties; the higher is σ, the more readily substitutable they are. The final-good sector is assumed perfectly competitive, and the representative firm there takes both the input prices p_i and the final good price p_Y as given. It is straightforward to obtain the relative input demand functions:

$$\left(\frac{x_i}{X}\right) = \left(\frac{p_i}{P_X}\right)^{-\sigma} \tag{13}$$

where

$$P_X = \left(\int_0^n p_i^{1-\sigma} di\right)^{1/(1-\sigma)} \tag{14}$$

is the price of the composite intermediate good X. Finally, it is assumed that a monetary authority sets p_Y as a nominal anchor, and for simplicity the normalisation $p_Y = 1$ is made. Total final good output may then be written as a decreasing function of the price of the portfolio of intermediate inputs:

$$X = \widetilde{\alpha} P_X^{-1/(1-\alpha)}, \tag{15}$$

where $\widetilde{\alpha} = \alpha^{1/(1-\alpha)}$.

Each firm in the intermediate sector is infinitesimally small, and ignores the impact of its own price-setting behaviour on P_X. The revenue function of each is simply

$$\begin{aligned} R[a_i, l_i] &= (a_i l_i)^{(\sigma-1)/\sigma} X^{1/\sigma} P_X && (16) \\ &= \widetilde{\alpha}^{1/\sigma} (a_i l_i)^{(\sigma-1)/\sigma} P_X^{1-1/\sigma(1-\alpha)}. && (17) \end{aligned}$$

with resulting marginal revenue function

$$M[a_i, l_i] = \widetilde{\sigma}^{-1} \widetilde{\alpha}^{1/\sigma} a_i^{(\sigma-1)/\sigma} l_i^{-1/\sigma} P_X^{1-1/\sigma(1-\alpha)}, \tag{18}$$

where $\widetilde{\sigma} = (\sigma/(\sigma-1))$. Each firm pays a wage w, exogenous to the model, and must incur a cost f per unit of labour dismissed. This may take the form of direct payments to the worker, but could also represent administrative costs associated with firing[18]. Using (17), (8) and (9), the pricing decisions of firms in good and bad states are obtained:

$$\begin{aligned} p_g &= \widetilde{\sigma} a_g^{-1} \left(w + \frac{f}{2(1+r)}\right) && (19) \\ p_b &= \widetilde{\sigma} a_b^{-1} \left(w - \frac{f(1+2r)}{2(1+r)}\right), && (20) \end{aligned}$$

[18] Whether or not f represents payments to the worker is of little import in this model, since the wage profile is assumed exogenous.

Firing costs increase the price of input varieties produced at high-productivity firms and reduce the price of those at low-productivity firms. Again, the firms are infinitesimally small; all idiosyncratic uncertainty thus washes out in the aggregate, and the price of the composite intermediate good is

$$P_X = \widetilde{\sigma}\left(\frac{n}{2}\right)^{1/(1-\sigma)}\widetilde{P}, \tag{21}$$

where

$$\widetilde{P} = \left(a_g^{\sigma-1}\left(w + \frac{f}{2(1+r)}\right)^{1-\sigma} + a_b^{\sigma-1}\left(w - \frac{(1+2r)f}{2(1+r)}\right)^{1-\sigma}\right)^{1/(1-\sigma)}. \tag{22}$$

Disaggregate employment levels are

$$\begin{aligned} l_g &= \widetilde{\alpha} a_g^{-1} p_g^{-\sigma} P_X^{\sigma-1/(1-\alpha)} && (23)\\ l_b &= \widetilde{\alpha} a_b^{-1} p_b^{-\sigma} P_X^{\sigma-1/(1-\alpha)}, && (24) \end{aligned}$$

allowing us to express total employment as a function of the dismissal cost f:

$$\begin{aligned} L &= (l_g + l_b)\frac{n}{2} && (25)\\ &= \widetilde{\alpha}\widetilde{\sigma}^{-1/(1-\alpha)}\left(\frac{n}{2}\right)^{\alpha/(1-\alpha)(\sigma-1)} L_1 \widetilde{P}^{\sigma-1/(1-\alpha)}, && (26) \end{aligned}$$

where

$$L_1 = a_g^{\sigma-1}\left(w + \frac{f}{2(1+r)}\right)^{-\sigma} + a_b^{\sigma-1}\left(w - \frac{(1+2r)f}{2(1+r)}\right)^{-\sigma}. \tag{27}$$

Figure 1 shows how firing costs affect disaggregate prices and employment levels, for some arbitrary parameter values. Note that when firing costs are so large as to eliminate labour reallocation completely, so that $l_g = l_b$, the price charged by highly productive firms is still lower than that charged by relatively unproductive firms.

2.3.2 Firing costs and P_X

Before considering directly the effect of dismissal costs on employment, it is instructive to examine their effect on P_X. This is of interest in itself, given that final output is a decreasing function of the price of the composite intermediate good.

Productivity shocks, σ and the input portfolio Since in the baseline model the measure of firms is fixed at n, attention may be restricted to the sign of $\delta\widetilde{P}/\delta f$.

Proposition 1 *The relationship between $\widetilde{P}$ and firing costs depends,* inter alia, *on the size of productivity shocks (a_g/a_b) and the substitutability of intermediate inputs σ. In particular, it is straightforward to show*[19] *that*

$$\frac{\delta\widetilde{P}}{\delta f} \gtrless 0 \Longleftrightarrow \frac{a_g}{a_b} \gtrless (1+2r)^{1/(\sigma-1)} \left(\frac{2(1+r)w+f}{2(1+r)w-(1+2r)f}\right)^{\sigma/(\sigma-1)}. \tag{28}$$

So, if productivity shocks, as measured by a_g/a_b, are small, the introduction of firing costs can actually *reduce* the price of the composite intermediate good. The reason is simply that costly dismissal reduces the prices charged by 'bad' firms by more than it raises those charged by 'good' ones, as can be seen from (19) and (20). Again, this is because in bad times firing costs are incurred with certainty rather than in some hypothetical future.

However, should productivity shocks be large this result is reversed. This is because, if 'good' firms are very much more productive than 'bad', then in the absence of firing costs the price of their varieties will be correspondingly lower. As a result, the portfolio of inputs used by the final-good sector will be heavily weighted towards such goods, and the impact of any increase in their price will be exacerbated. Note also that the right-hand-side of (28) is decreasing in σ, the substitutability of the intermediate varieties; the higher is σ, the more likely are firing costs to increase P_X. The reasoning behind this is analagous. Should the varieties be highly substitutable, then the original portfolio of inputs will be more heavily biased towards those from the high-productivity firms, and increases in their price will be felt more keenly[20].

[19] All propositions are proven in the chapter appendix.

[20] One might have thought that, if intermediate inputs are close substitutes, the final sector would be more able to take advantage of the falls in price of those from low-productivity firms, by reweighting the input portfolio appropriately. However, as long as $p_g < p_b$, inputs from high-productivity firms will make up more than half of the input portfolio X. The higher is σ, the greater the bias towards these inputs, and the more significant any rise in their price. This 'composition' effect outweighs the 'reweighting' effect.

Finally, the right-hand-side is also increasing in f, for similar reasons. As firing costs increase, so does the price charged by high-productivity firms, resulting in a diminution of their role in the input portfolio. Subsequent increases in f thus have a smaller effect. The chapter appendix confirms that $\delta^2\widetilde{P}/\delta f^2 < 0$ globally, and shows that if $a_g/a_b < (1+2r)^{1/(\sigma-1)}$, then $\delta\widetilde{P}/\delta f < 0$ for all positive f. If $a_g/a_b > (1+2r)^{1/(\sigma-1)}$, then $\widetilde{P}$ is increasing in f, at least initially.

Anatomy of coordination failure That firing costs can theoretically reduce the price of the portfolio of inputs used by the final-good sector is perhaps surprising. There is no direct welfare metric in this model, so some caution is appropriate when making general efficiency claims. However, should their introduction in fact reduce P_X, then it should be clear that firing costs can increase profits in the intermediate sector as well as final-good output[21]. To understand this we must turn to the theory of the second-best. The distortionary effect of costly dismissal can in fact work against existing distortions in the model, the most obvious of which is the monopolistic status of the intermediate-good firms. Both market failure and the potential countervailing effect of firing costs persist, though, even absent the monopoly price mark-up $\widetilde{\sigma}$. The source of the remaining market failure is the lack of coordination on the part of firms in the intermediate sector, manifest in two distinct aspects of their behaviour.

For one, being infinitesimally small, each ignores the direct effect of changes in its price on P_X, holding constant the prices of other varieties. It fails to internalise the implications for final-good output, and thus for demand for intermediate goods as a whole. In the aggregate, this leads to intermediate-good prices being set too high. Since firing costs act to reduce the average price of intermediate varieties, $\overline{p} = 1/n \int_0^n p_i di$, they work against this particular distortion.

There is a second consequence of its price-setting behaviour that an individual intermediate firm fails to consider, though, and that is the effect on the behaviour of other firms. Since any firm j ignores the effect of p_j on P_X, it ignores the effect on the demand for other varieties, *via* (13). Changes in p_j lead to changes in the pricing policy of other firms, which affect the optimal pricing policy of firm j in

[21] This must be true, given that the elasticity of X with respect to P_X, namely $\eta_X = -1/(1-\alpha)$, can be of arbitrary magnitude.

return. Again, the resulting implications for P_X and X are ignored. Put another way, were a central planner to choose all input prices, she would have as her choice variable not only the average price across varieties, but also the price distribution. In a decentralised setting, the ignorance on the part of individual firms of cross-elasticities of demand may result in a price distribution that fails to minimise P_X, even conditional on a particular average input price $\overline{p}$. To see this, ignore firing costs for a moment and consider a mean-preserving spread in the price distribution, and its effect on P_X:

$$\begin{aligned} P_X &= \left(\int_0^n p_i^{1-\sigma} di\right)^{1/(1-\sigma)} && (29)\\ &= \left(\frac{n}{2}\right)^{1/(1-\sigma)} \left(\left(p_g^o - c\right)^{1-\sigma} + \left(p_b^o + c\right)^{1-\sigma}\right)^{1/(1-\sigma)}, && (30)\end{aligned}$$

where c is a positive constant and $p_g^o < p_b^o$ are intermediate-good prices as before (with f set equal to 0). It is easy to confirm that the result of the spread is to reduce P_X. In other words, atomistic intermediate firms may tend to set prices too close together; cross-sectional efficiency would be increased were productive firms to lower their prices even further, and unproductive firms to raise theirs by the same amount[22]. It is similarly straightforward to show that a mean-preserving contraction increases P_X[23]. In this instance firing costs therefore work in the same direction as an existing distortion, in that they increase the prices charged by high-productivity firms and decrease those charged by low-productivity firms, compressing the price distribution and increasing P_X.

The above suggests a ready measure of the cross-sectional efficiency of the intermediate sector, the ratio of the average input price $\overline{p}$ to P_X; this captures the effect of the shape of the distribution of input prices p_i, holding constant the average such price. It is perhaps a slightly more nuanced idea of cross-sectional efficiency than that usually considered.

Proposition 2 *Define cross-sectional efficiency as* $Xeff = \overline{p}/\widetilde{P}$. $Xeff$ *is decreasing in* f.

Firing costs therefore have two opposing effects on the price of the input portfolio. On the one hand they reduce the average input price $\overline{p}$; on the other they lead to a contraction in the price distribution,

[22] Again, for high enough η_X this would increase profits at *all* firms, in addition to increasing final output X^α.

[23] This is true as long as p_b remains above p_g; this is always true in the model here, thanks to the implied restriction that $l_t \geq l_b$.

a deleterious result from the point of view of the final-good sector. Which of these effects dominates depends, as shown in the previous section, on (a_g/a_b) and σ. In the terms of the current analysis, increased substitutability of intermediates means that P_X will be relatively more sensitive to shifts in the price distribution than to changes in the average input price. Consider for example a situation where the intermediate goods were not substitutes at all, and had to be used in equal, unvarying proportions no matter their price[24]. In that case, all that would matter for P_X would be $\overline{p}$. If they were perfectly substitutable, then the average price would be irrelevant, and only the lowest price would matter.

The implications of a more volatile stochastic process for P_X are more subtle. It would increase the size of the average price effect relative to the distributional effect, since

$$\frac{\frac{\delta \overline{p}}{\delta f}}{\frac{\delta(p_b - p_g)}{\delta f}} = \frac{(a_g/a_b)(1+2r)-1}{(a_g/a_b)(1+2r)+1} \tag{31}$$

is increasing in (a_g/a_b). However, it would also increase the sensitivity of P_X to distributional shifts. Again, the greater the initial productivity (and therefore price) differences between the two sets of intermediate varieties, the more increases in p_g matter relative to falls in p_b. This latter effect turns out to dominate in the model, as was shown by (28) above.

It is worth emphasising that the potential for dismissal costs to improve the allocation of resources in this model stems from a lack of coordination on the part of the intermediate-good firms. A market for corporate control is thus assumed missing, for if one existed a single firm would produce all varieties, fully internalising the effects of individual price changes on P_X and X. A possible justification for this missing market could be based on informational imperfections. The model here is highly stylised, and does not fully capture the complexity inherent in the real-world production process of any final consumption good.

Simulations The foregoing analysis showed that increases in firing costs could either increase or reduce the price of the input portfolio. The respective magnitudes of these potential effects are now explored using simulations. In each simulation the nominal wage w is normalised to one, as is the labour productivity of a low-productivity firm a_b. In addition, the discount rate r is set at 0.08. Assuming productivity shocks arrive every couple of years, this corresponds to an annual real interest rate of around 0.04. The

[24]Not possible in this model, strictly speaking.

elasticity of substitution of intermediate varieties, σ, is allowed to vary between 2.1 and 6, while a_g ranges from 1.25 to 1.75[25].

First, Figure 2 graphs the relationship between the elasticity of substitution of intermediates, the size of productivity shocks and $fmax$. Recall the implicit restriction that $l_g \geq l_b$; $fmax$ is merely the highest level of firing costs for which this is the case. Any further increases would have no effect on labour allocation or input prices. We see that, for $\sigma = 6$ and $(a_g/a_b) = 1.75$, $fmax$ can reach about 0.45. Assuming again that each period in the model lasts roughly two years, this corresponds to nearly one year's wages. The magnitudes seem to be about right. Hopenhayn and Rogerson (1990) argue that a year's wages are 'a reasonable description of the magnitude of legislated severance payments in several countries'. However, one has to bear in mind that the impact of such severance payments is diluted by natural attrition of the labour force - voluntary quits and the like - and that the effective severance payment, per unit reduction in workforce, is likely to be lower than that which is legislated[26].

Figures 3.1 and 3.2 show how the effect of firing costs on P_X varies with productivity shocks and substitutability of inputs, holding constant the other parameter; Figure 3.3 displays slices through the respective hills, graphing P_X against f for fixed σ and a_g. In each case P_X has been normalised with respect to P_X^0, its level when $f = 0$. First, for the range of parameters chosen, we can see that P_X is hump-shaped, initially increasing in f[27]. The higher are σ and a_g, the more likely firing costs are to increase the price of the input portfolio, in accordance with the analysis above. For $\sigma = 2.1$ and $a_g = 1.25$, firing costs eventually reduce P_X below P_X^0. However, in percentage terms any such reduction is minuscule, below 0.1%. In contrast, the increase in P_X when $a_g = 1.75$ is potentially large, exceeding 10% with $\sigma = 6$. The asymmetry in the potential effects stems partly from in the fact that, when substitutability and productivity shocks are small, the same is true of $fmax$; labour reallocation across

[25]An implied maximal (a_g/a_b) ratio of 1.75 is not an outlandish figure by the standards of the literature. Bertola (1994) chooses an equivalent ratio of 5. He cites as justification the importance of idiosyncratic uncertainty noted by Davis and Haltiwanger (1990).

[26]Risager and Sorensen (1999) consider firing costs ranging from 0% to 26.3% of a year's wages.

[27]Obviously a lower starting point for a_g could have been chosen. However, simulations with a_g below 1.25 showed a corresponding fall in $fmax$. This was both unrealistic, given the level of dismissal costs observed empirically, and uninteresting, since low firing costs had little effect on P_X.

firms ceases at relatively low levels of f, and as a result the aggregate impact is muted.

Figure 3.4 shows how the interaction of productivity shocks and substitutability is crucial for there to be large effects on the composite input price. It graphs P_X against σ and a_g, at $f = fmax$ and $f = fmax/2$ respectively. It can be seen that neither volatility of productivity nor highly substitutable intermediates is alone sufficient.

Finally, Figures 4.1 to 4.4 proceed similarly for cross-sectional efficiency $Xeff$, again normalised with respect to its value when $f = 0$. Once more, significant reductions in efficiency are found when a_g and σ are high, with the interaction between the two crucial.

2.3.3 Firing costs and employment

Using the insights of the previous section, the implications of dismissal costs for employment are now considered.

L_1, L_2 and L. It is pedagogically useful to break down the effect of firing costs on employment, described in (26) above, into three parts:

1. $\frac{\delta L_1}{\delta f} = \frac{\delta}{\delta f}\left\{a_g^\sigma p_g^{-\sigma} + a_b^\sigma p_b^{-\sigma}\right\}$. This can be thought of as measuring the impact of firing costs if they were incurred by a single firm only, with no effect on the aggregate price and output levels; L_1 would proxy the average employment of this firm over time, and $\delta L_1/\delta f$ thus corresponds to the 'direct' employment effect considered in the standard, single-firm analysis of Bentolila and Bertola (1990). It is shown in the chapter Appendix that

$$\frac{\delta L_1}{\delta f} \gtrless 0 \Longleftrightarrow \frac{a_g}{a_b} \lesseqgtr (1+2r)^{1/(\sigma-1)}\left(\frac{2(1+r)w+f}{2(1+r)w-(1+2r)f}\right)^{(\sigma+1)/(\sigma-1)}. \tag{32}$$

It is also confirmed that $\delta^2 L_1/\delta f^2 > 0$. The intuition behind the shape of L_1 is as outlined in Section 2.2.2: should $a_g/a_b > (1+2r)^{1/(\sigma-1)}$, then the marginal revenue function (18) is steeper in bad times than good and low levels of firing costs reduce employment[28]. Figure 5.1 shows how L_1 varies with (a_g/a_b) and σ. The interaction of productivity shocks and input substitutability is once

[28] Again, holding constant P_X and X.

again crucial in obtaining substantial reductions in L_1[29]. Indeed, reductions of up to 40% were implied by certain parameter values, much larger than those obtained elsewhere in the literature. However, such a comparison is perhaps unhelpful. The marginal revenue function (18) is not directly comparable to those considered in other work, ignoring as it does any aggregate effects of individual price-setting behaviour.

2. $\frac{\delta L_2}{\delta f}$, where $L_2 = L_1 \widetilde{P}^{\sigma}$. This takes into account the implications of dismissal costs for the aggregate price level, but ignores the effect on final output. It can be thought of as representing a situation where output is perfectly inelastic with respect to P_X. It is shown in the chapter appendix that $\frac{\delta L_2}{\delta f} > 0$; for a given output, firing costs unambiguously raise employment. The intuition is straightforward. Since firing costs tend to redistribute labour from productive to unproductive firms, more labour is needed to produce the same amount of the composite intermediate good X. This effect dominates the one above. The effects of increased σ and (a_g/a_b) on the size of $\delta L_2/\delta f$ are *a priori* unclear. For a given reweighting of X towards goods from low productivity firms, a higher productivity differential implies a larger increase in employment. However, higher (a_g/a_b) also means that the shift towards low productivity varieties is smaller, while an increase in σ has an ambiguous effect on the size of this shift[30]. It can be seen from Figure 5.2 that, in practice, the rise in L_2 tends to be greater, the higher are σ and (a_g/a_b). Quite significant increases in employment, of up to 12%, are obtained.

3. $\frac{\delta L}{\delta f}$. Finally, the output implications of input price changes may be taken into account. The chapter appendix shows that a necessary, but not sufficient, condition for $\frac{\delta L}{\delta f} < 0$ is that $\frac{\delta \widetilde{P}}{\delta f} > 0$. If this

[29] As before, simulations were performed assuming $a_g/a_b < (1+2r)^{1/(\sigma-1)}$; the increases in L_1 and the implied $fmax$ were so small that the results are not reported. Even if $a_g/a_b > (1+2r)^{1/(\sigma-1)}$, it is possible, thanks to the curvature of the marginal revenue function, that at high levels of firing costs L_1 begins to increase. Any such increases were tiny in the simulations reported.

[30] Note that

$$\frac{\delta\left(\frac{x_b}{x_g}\right)}{\delta\left(\frac{p_g}{p_b}\right)} = \sigma\left(\frac{p_g}{p_b}\right)^{\sigma-1},$$

where the price ratio $\left(\frac{p_g}{p_b}\right) < 1$ is decreasing in the productivity differential.

is the case, firing costs have two opposing effects. On the one hand they reduce final output, and thus demand for the composite intermediate good X. On the other they mean that more labour is required to produce any given amount of X, as seen just above. The implications for employment are thus ambiguous, and depend in particular on $\eta_X = -1/(1-\alpha)$, the elasticity of final output to the input portfolio price. Should for example $\sigma = -\eta_X$, then we can see from (26) that any aggregate price effects disappear, and we are left with only the 'direct' effect of $\delta L_1/\delta f$.

The elasticity of substitution of intermediates, σ, and the volatility of productivity, (a_g/a_b), thus play an interesting role in determining the sign of $\delta L/\delta f$. It was shown in the previous section that increased σ or (a_g/a_b) meant that firing costs were more likely to increase P_X, reducing final output and, *ceteris paribus*, employment. However, it was just shown that, given the demand for the composite intermediate good X, higher σ and (a_g/a_b) are likely to lead to firing costs increasing employment. The next section explores the relative sizes of these effects.

L and η_X: simulations Figures 5.3 and 5.4 show how the effect of firing costs on total employment varies with σ and (a_g/a_b), for an arbitrary value of $\alpha = 0.01$; this implies an elasticity of final output with respect to P_X of $\eta_X \approx 1$, the lowest possible given the model structure. Figure 5.5 again provides slices through the respective hills. We see that L is typically U-shaped in f. Employment initially decreases, but may even report a net gain at $f = fmax$. A couple of features of the simulation results are of particular note. First, high levels of σ and (a_g/a_b) tend to exacerbate the effects of f, effectively deepening the 'U'. Second, the potential falls in employment at intermediate levels of firing costs are potentially significant, up to 5% , while subsequent (net) increases are at most of the order of about 1%. Figure 5.6 highlights the interaction of σ and (a_g/a_b).

Figures 5.7 to 5.10 repeat the procedure for $\alpha = 0.5$, implying $\eta_X = 2$. The potential falls in employment are considerably larger, now up to about 13%, and any subsequent increases smaller. This is consistent with the theoretical analysis, and the results of the previous simulations suggesting that firing costs tend, in practice, to increase the price of the composite intermediate good. Again, the interaction of σ and $(a_g a_b)$ is crucial, in this instance in obtaining large falls in employment. It seems then that the price effects of high substitutability and a large productivity differential (*i.e.*. to increase $\frac{\delta P_X}{\delta f}$) outweigh the labour reallocation effects (*i.e.*. to increase $\frac{\delta L_2}{\delta f}$), at least for $\eta_X > 1$.

Finally, Figures 5.11 and 5.12 show how the employment implications of firing costs vary with α. With $\{\alpha = 0.75, \sigma = 6, a_g = 1.75\}$, employment can be reduced by at least 25% by firing costs. Obviously, one could allow α to approach unity, and thus η_X to become arbitrarily large, and obtain even greater reductions in employment.

2.4 Extensions

2.4.1 Firm entry

In all the foregoing analysis the number of intermediate varieties was taken as exogenously given. The entry of firms into the intermediate sector is now endogenised, and the effect of firing costs on such entry examined.

Some assumptions are necessary. First, potential entrants are unable to produce an intermediate variety that is already on the market. Second, each entrant must sink one unit of capital into the new business. This capital is then no longer fungible, and has no subsequent alternative use. This assumption could be justified on grounds of asset-specificity. Third, it is assumed in this section that $\sigma > 1/(1-\alpha)$; this ensures that the entry of a new firm reduces rather than increases profits at existing firms[31].

The non-fungibility assumption implies that, once a firm has entered the intermediate-good sector, exit is not an option, as it will always be dominated by continuing to produce the intermediate good. Now, consider the value of a firm at the end of a period, V_τ, where τ once more indexes the state of nature. Denote by π_τ the per-period profit in state τ, gross of any firing costs incurred; i.e. $\pi_\tau = (a_\tau p_\tau - w)\, l_\tau$. The value of the firm is merely the expected discounted value of tomorrows's profits plus tomorrow's

[31] Recall that P_X is, *ceteris paribus*, decreasing in the number of varieties. Should $\sigma < 1/(1-\alpha)$, then an increase in n would increase profits thanks to the increase in final output.

end-of-period value, less any firing costs that will have to be paid:

$$V_g = \left(\frac{1}{1+r}\right)\left(\frac{1}{2}(\pi_g + V_g) + \frac{1}{2}(\pi_b - (l_g - l_b) f + V_b)\right) \tag{33}$$

$$V_b = \left(\frac{1}{1+r}\right)\left(\frac{1}{2}(\pi_g + V_g) + \frac{1}{2}(\pi_b + V_b)\right). \tag{34}$$

Note that $V_g < V_b$; a firm that has just experienced a low-productivity period has a higher value than one emerging from a period of high productivity, since it will under no circumstances have to incur firing costs in the immediate future. Solving, one has:

$$V_g = \frac{1}{2r}(\pi_g + \pi_b) - \frac{(1+2r)}{4r(1+r)}(l_g - l_b) f \tag{35}$$

$$V_b = \frac{1}{2r}(\pi_g + \pi_b) - \frac{1}{4r(1+r)}(l_g - l_b) f. \tag{36}$$

Let V_E be the value of a new entrant at the start of a period. The no-entry condition is then

$$V_E = \frac{1}{2}(\pi_g + V_g) + \frac{1}{2}(\pi_b + V_b) = \frac{1}{r}, \tag{37}$$

since the discounted present value of the firm must equal the (exogenous) discounted stream of returns from investing the unit of capital in alternative projects. Now, since profits are affected by the price of the input portfolio P_X, which in turn depends on the number of intermediate varieties available, (37) allows one to solve for the number of firms:

$$n = \overline{k}\left\{(\sigma-1)^{-1}\widetilde{P}^{1-\sigma} - \frac{rf}{1+r}a_b^{\sigma-1}\left(w - \frac{(1+2r)f}{2(1+r)}\right)^{-\sigma}\right\}^{\frac{(\sigma-1)}{(\sigma-1/(1-\alpha))}}\widetilde{P}^{\sigma-1}, \tag{38}$$

where $\overline{k}$ is a constant and $\widetilde{P}$ is as defined in (22) above. Now, it is straightforward to show that the burden imposed by costly labour adjustment deters potential entrants.

Proposition 3 $\frac{\delta n}{\delta f} < 0$; *firing costs reduce the number of varieties of intermediate good supplied in the market.*

Figure 6.1 shows how $\frac{\delta n}{\delta f}$ depends on σ, α and (a_g/a_b). The number of varieties on the market can be reduced by nearly 20% for certain parameter combinations. With n now endogenous, the implications of costly dismissal for final output and employment may be re-examined. First, consider the price of the composite intermediate good. It follows from (21) that, *ceteris paribus*, a fall in the number of varieties increases P_X. Indeed, the sensitivity of n to f removes the previous ambiguity regarding the sign of $\frac{\delta P_X}{\delta f}$:

Proposition 4 *With firm entry endogenous, $\frac{\delta P_X}{\delta f} > 0$; firing costs unambiguously increase the price of the input portfolio.*

Figure 6.2 displays the effects on P_X of dismissal costs, allowing for the endogeneity of n. The potential increase in the price of the input portfolio now ranges up to 25%, over double the maximum obtained when the number of varieties was held constant. Note that, in another contrast, $\frac{\delta P_X}{\delta f}$ now depends on α. Figure 6.3 depicts final output Y as a function of firing costs; Figure 6.4 does the same for the case where n is exogenous, to allow comparison. Figure 6.5, finally, shows the effect of firing costs on employment. As one would expect, their impact on firm creation leads to larger potential reductions in L; for example, for the parameter combination $\{\sigma = 2.1, a_g = 1.25, \alpha = 0.5\}$ there is a 3% fall in employment, compared to a negligible effect when n is taken as given.

2.4.2 Trade in intermediates

This section briefly examines the impact of international trade in intermediate inputs, and the associated implications for empirical work and the incentives for labour market reform. Consider a simple extension of the baseline model to a 'continent' of N countries, indexed by j. Each country contains a measure n of monopolistic firms producing varieties of intermediate good, where n is once again fixed and exogenous. The intermediate varieties are distinct; no single variety is produced in more than one country. Each country also has a perfectly competitive final-good sector, with production function:

$$Y(j) = X(j)^{\alpha}, \tag{39}$$

where

$$X(j)^{\alpha} = \left(\int_0^{n \times N} x_i^{(\sigma-1)/\sigma} di \right)^{\sigma/(\sigma-1)} \tag{40}$$

is the composite intermediate good, consisting of inputs from all N intermediate sectors. Transport costs are assumed nonexistent[32]. The familiar relative input demand function is obtained:

$$\left(\frac{x_i(j)}{X(j)} \right) = \left(\frac{p_i}{P_X} \right)^{-\sigma}, \tag{41}$$

[32] There is also no price discrimination. All final-good firms pay the same for any input i, no matter their location.

where $x_i(j)$ is the amount of input i demanded by the final sector in country j, and

$$P_X = \left(\int_0^{n \times N} p_i^{1-\sigma} di \right)^{1/(1-\sigma)} \tag{42}$$

is the price of the intermediate input portfolio, common to all countries. Once again, a monetary authority sets the price of the final good Y in each economy to unity[33]. However, labour market policies may differ; each final-good sector j faces a unit firing cost $f(j)$. As before, perfect competition in the final sector renders final output determinate, and we have:

$$X(j) = \alpha^{1/(1-\alpha)} P_X^{-1/(1-\alpha)} = \overline{X}. \tag{43}$$

The technology and stochastic environment facing each individual intermediate firm are as in the baseline model. It is simple to show that the pricing schedule of an optimising such firm in the face of firing costs is also unchanged[34]. The continent-wide price of the input portfolio is then:

$$P_X = \widetilde{\sigma} \left(\frac{n}{2} \right)^{1/(1-\sigma)} \widehat{P}, \tag{44}$$

where

$$\widehat{P} = \left(\begin{array}{c} a_g^{\sigma-1} \left(\sum_{j=1}^N \left(w + \frac{f(j)}{2(1+r)} \right)^{1-\sigma} \right) \cdots \\ .. + a_b^{\sigma-1} \left(\sum_{j=1}^N \left(w - \frac{(1+2r)f(j)}{2(1+r)} \right)^{1-\sigma} \right) \end{array} \right)^{1/(1-\sigma)}. \tag{45}$$

Note that wages are, for convenience, assumed identical across economies. Employment in country j is then:

$$L(j) = \widetilde{\alpha} \widetilde{\sigma}^{-1/(1-\alpha)} \left(\frac{nN}{2} \right)^{\alpha/(1-\alpha)(\sigma-1)} L_1(j) \widehat{P}^{\sigma-1/(1-\alpha)}, \tag{46}$$

where

$$L_1(j) = \left(a_g^{\sigma-1} \left(w + \frac{f(j)}{2(1+r)} \right)^{-\sigma} + a_b^{\sigma-1} \left(w - \frac{(1+2r)f(j)}{2(1+r)} \right)^{-\sigma} \right). \tag{47}$$

[33]This could be the work of separate, national banks with a common inflation target, or of a single, supranational authority such as the European Central Bank.

[34]The only difference is that the revenue function $R[a_\tau, l_\tau]$ is multiplied by N; this washes out, leaving (19) and (20) as the optimal pricing policy.

Consider now the effect of varying $f(j)$, from the point of view of a single national policymaker. Obviously the impact on the price $\widehat{P}$ of the input portfolio, and thus on final-sector output $Y(j) = \overline{X}^{\alpha}$, will be somewhat muted, given that $\widehat{P}$ reflects the labour market policies of all N countries. This is confirmed in the chapter appendix. What, though, of the impact on domestic employment $L(j)$?

Proposition 5 *The effect of any national labour market policy on employment, $\frac{\delta L(j)}{\delta f(j)}$, is altered by the presence of trade in intermediates. In particular, as the number of countries N becomes large, it approaches $\frac{\delta L_1(j)}{\delta f(j)}$.*

It should be intuitive that, since the presence of trade in intermediates dilutes the effect of any single, national employment protection policy on the price of the input portfolio, the impact of firing costs on employment will approach $\frac{\delta L_1(j)}{\delta f(j)}$[35]. Of particular interest here is the potential for such trade to alter incentives for labour market reform. Consider for example Figure 7. This compares the employment effects of the national labour market policy of country j when intermediates are internationally traded to those under autarky. The size of the continent is chosen as $N = 15$. Employment protection policies of other countries are assumed invariant, and are fixed as follows: three countries each set $f = 0.1$, four set $f = 0.2$, four set $f = 0.3$ and finally three set $f = 0.4$. The (normalised) employment level of country j under autarky is represented by $L(j)\,norm$, that when there is trade in intermediates by $L(j)\,Tnorm$. It is assumed that the elasticity of output to P_X is high - α is set to equal 0.95. Note the potential differential impact of firing costs. For example, for the parameter combinations ($\sigma = 2.1$, $a_g = 1.75$) and ($\sigma = 6$, $a_g = 1.25$) employment under autarky falls substantially with employment protection, while when there is trade in intermediates the labour market policy of country j has relatively little effect on its own employment. When inputs are traded across many economies, it is the relative insensitivity of this portfolio price to changes in the price of inputs from any single country that muffles the effect of national labour market policies.

There are obvious implications for the incentive to reform labour markets. If labour market policy is chosen in isolation, at the national level, then there may be little employment or output cost associated

[35]Recall from Section 2.3.3 that this is merely the 'direct' impact of firing costs, holding constant aggregate price and output levels; it is the subject of Figure 5.

with employment protection. Firing costs may influence employment and output chiefly through the price of the input portfolio, which is composed chiefly of goods traded abroad and thus largely exogenous to the domestic policymaker. Taken together, though, the continent-wide impact of national labour market policies may be significant. This suggests, perhaps, that employment protection policies ought not to be chosen nationally, since inefficiently high levels of firing cost may result.

A second implication of trade in intermediates is with regard to empirical work. Suppose firing costs were indeed responsible for Europe's low employment rates, via their effects on input prices. Figure 7 suggests that, were a simple cross-country regression on the 15 countries performed, a researcher would be hard pressed to identify a robust link between EPL and employment. This is especially true given the problems associated with definition and measurement of employment protection, as well as the difficulty in controlling for other national labour market institutions. Of course, the level of economic interdependence assumed here may be unrealistic, as therefore would be the size of policy spillovers between countries. However, the analysis is at the very least suggestive.

2.4.3 Job turnover with labour in the final sector

The previous section argued that the theoretical results of the baseline model, which suggest firing costs may give rise to low employment, could be reconciled with the empirical failure to identify any such causation. The simple extension presented now aims to do the same for another apparent empirical anomaly, the cross-country job turnover pattern. Recall that Nickell (1997) and Bertola and Rogerson (1997), amongst others, have emphasised the similarity in rates of job turnover across countries with very different employment protection regimes. This is problematic for any model that emphasises the dynamic, optimising behaviour of rational firms,as do both the standard model reviewed in Section 2.2.2 and the baseline model of this paper. Firing costs imply lower hiring in good times and lower firing in bad times, unambiguously depressing turnover. In the model of this paper, the job turnover rate ρ is

$$\rho = \frac{n}{2}\frac{(l_g - l_b)}{L} = \frac{(l_g - l_b)}{(l_g + l_b)} \tag{48}$$

$$= \frac{\left(a_g^{-1} p_g^{-\sigma} - a_b^{-1} p_b^{-\sigma}\right)}{\left(a_g^{-1} p_g^{-\sigma} + a_b^{-1} p_b^{-\sigma}\right)}. \tag{49}$$

As Figure 8 illustrates, ρ is highly sensitive to firing costs; turnover is reduced by at least 30% when $f = fmax/2$.

Consider a straightforward extension to the model of Section 2.3.1. Suppose final-sector technology is in fact Leontief, with labour as a complementary input in the production process. Each final-sector firm must combine q units of labour with each unit of the composite intermediate good X to produce a second-stage input $\widetilde{X}$. The consumption good is then produced according to:

$$Y = \widetilde{X}^{\alpha}. \tag{50}$$

Labour is homogeneous: wages in the final sector are exogenous, and identical to those paid at intermediate-good firms. The remainder of the model structure is unchanged. The unit cost of $\widetilde{X}$ is $qw + P_X$, rendering $\widetilde{X}$ (and thus X) determinate once more:

$$\widetilde{X} = \widetilde{\alpha}\left(P_X + qw\right)^{-1/(1-\alpha)}. \tag{51}$$

It should be clear that the effect of costly dismissal on the pricing behaviour of intermediate-sector firms will be analogous to that found in the baseline model. They will have no bearing on that of final-sector firms, though, as their environment is deterministic; as a result, they neither hire nor fire. The relationship between firing costs and total employment differs from the basic model, though. Suppose q, the unit labour requirement in the final sector, is large. Aggregate employment will therefore depend chiefly on the output of final-good firms, and thus on the price of the original composite intermediate good X, w being exogenous. Employment in the intermediate sector could be arbitrarily small as a fraction of total employment, yet firing costs could continue to exert a large negative effect on total employment via their influence on P_X. At the same time, while firing costs would reduce job turnover at intermediate-good firms, this could be dwarfed by turnover at final-good firms (due to voluntary quits, say). Again, cross-country regressions of turnover on dismissal costs would find it hard to identify any robust relationship. The fact that, in this model, firing costs work chiefly through their effect on P_X allows the link between the turnover implications of such costs and their employment implications to be weakened.

2.5 Concluding remarks

The principal channel through which employment protection might make itself felt is via the pricing behaviour of firms producing intermediate inputs. It is possible for firing costs to lead to a more efficient labour allocation in the intermediate sector, by working against existing market distortions. This is more likely to be the case when labour productivity differences across firms are small, and when the inputs these firms produce are not readily substitutable. This is intuitive; under such circumstances the costs associated with loss of flexibility are low. However, the other side of that coin is that, even in the absence of firing costs, the amount of labour reallocation is anyway small. The degree of freedom to increase efficiency afforded such costs is thus in practice rather limited.

The downside, in contrast, is potentially significant. When productivity differences are large and inputs close substitutes, the flexibility costs of employment protection, in terms of lowered employment and output, are substantial. This would suggest that one source of Europe's low employment rates may indeed be the degree to which the jobs of incumbent workers are safeguarded, and that the repeal of the offending legislation could be in order. It was shown, though, that the presence of trade in intermediates dilutes national incentives to carry out such reforms, and that coordinated efforts on the part of individual governments would be needed.

The model presented is obviously a very highly abstracted version of a real economy. First, the process by which wages are formed is ignored. Given that some of the paper's results rely on the uncoordinated behaviour of infinitesimally small firms, it would be interesting to introduce centralised wage-bargaining into the model. Second, the two-sector structure is a considerable simplification. This does not necessarily render the general conclusions reached here invalid. Matsuyama (1995), for example, shows that allowing for multi-stage production can amplify spillover effects found in a basic model such as this. Whether or not the pricing distortions focused upon here would be similarly exacerbated would be an interesting avenue to explore in future work.

2.6 Appendix

2.6.1 Proofs

1. Proposition 1: $\frac{\delta \widetilde{P}}{\delta f}$;

$$\widetilde{P} = \left(a_g^{\sigma-1}(w+cf)^{1-\sigma} + a_b^{\sigma-1}(w-df)^{1-\sigma}\right)^{1/(1-\sigma)} \tag{52}$$

where $c = 1/(2(1+r))$ and $d = (1+2r)/(2(1+r))$. We then have

$$\frac{\delta \widetilde{P}}{\delta f} = \widetilde{P}^{\sigma}\left(ca_g^{\sigma-1}(w+af)^{-\sigma} - da_b^{\sigma-1}(w-bf)^{-\sigma}\right) \tag{53}$$

from which Remark 1 is readily derived. It is straightforward to show that $\frac{\delta^2 \widetilde{P}}{\delta f^2} < 0$:

$$\frac{\delta^2 \widetilde{P}}{\delta f^2} = -\sigma a_g^{\sigma-1} a_b^{\sigma-1} \widetilde{P}^{2\sigma-1}\left(\frac{w-df}{w+cf}\right)^{\sigma}\left(2cd + c^2\left(\frac{w-df}{w+cf}\right) + d^2\left(\frac{w+cf}{w-df}\right)\right). \tag{54}$$

Hence, setting $f = 0$ in (53), we have $da_b^{\sigma-1} > ca_g^{\sigma-1}$ as a sufficient condition for $\frac{\delta \widetilde{P}}{\delta f} < 0$ for all positive f.

2. Proposition 2: $\frac{\delta Xeff}{\delta f} < 0$;

$$Xeff = (1/2) \times \frac{a_g^{-1}(w+cf) + a_b^{-1}(w-df)}{\widetilde{P}} \tag{55}$$

and so

$$\frac{\delta Xeff}{\delta f} = \frac{\widetilde{P}^{\sigma-2}}{2a_g a_b}\left(c(w-df) + d(w+cf)\right)A(f), \tag{56}$$

where

$$A(f) = a_b^{\sigma}(w-df)^{\sigma} - a_g^{\sigma}(w+cf)^{\sigma}. \tag{57}$$

Now, recall the implicit restriction in the model that $l_g \geq l_b$. Effectively this implies

$$a_b^{\sigma-1}(w-df)^{\sigma} < a_g^{\sigma-1}(w+cf)^{\sigma}. \tag{58}$$

Since $a_g > a_b$, it is immediate that $A(f) < 0$ and thus that $\frac{\delta Xeff}{\delta f} < 0$.

3. $\frac{\delta L_1}{\delta f}$;

$$L_1 = a_g^{\sigma-1}(w+cf)^{-\sigma} + a_b^{\sigma-1}(w-df)^{-\sigma} \tag{59}$$

and so

$$\frac{\delta L_1}{\delta f} = \sigma\left(\frac{a_b^{\sigma-1}d}{(w-df)^{(1+\sigma)}} - \frac{a_g^{\sigma-1}c}{(w+cf)^{(1+\sigma)}}\right), \tag{60}$$

$$\frac{\delta^2 L_1}{\delta f^2} = \sigma(1+\sigma)\left(\frac{a_b^{\sigma-1}d^2}{(w-df)^{(2+\sigma)}} + \frac{a_g^{\sigma-1}c^2}{(w+cf)^{(2+\sigma)}}\right). \tag{61}$$

(32) follows directly from (60).

4. $\frac{\delta L_2}{\delta f} > 0$;

Recall that $L_2 = L_1\widetilde{P}^{\sigma}$; a little algebra shows that

$$\frac{\delta L_2}{\delta f} = \sigma\widetilde{P}^{2\sigma-1}\left(\frac{a_b^{\sigma-1}a_g^{\sigma-1}}{(w+cf)^{-\sigma}(w-df)^{-\sigma}}\right)\left(\frac{d(c+d)f}{w-df} + \frac{c(c+d)f}{w+cf}\right). \tag{62}$$

5. $\frac{\delta L}{\delta f}$;

Focus on $\widehat{L} = L_1\widetilde{P}^{\sigma-1/(1-\alpha)}$:

$$\frac{\delta\widehat{L}}{\delta f} = \widetilde{P}^{2\sigma-\frac{(2-\alpha)}{(1-\alpha)}}B(f), \tag{63}$$

where

$$\begin{aligned} B(f) &= \sigma\left(\frac{a_b^{\sigma-1}d}{(w-df)^{-(1+\sigma)}} - \frac{a_g^{\sigma-1}c}{(w+cf)^{-(1+\sigma)}}\right)\widetilde{P}^{1-\sigma} \\ &\quad + (\sigma - 1/(1-\alpha))L_1\left(\frac{a_g^{\sigma-1}c}{(w+cf)^{\sigma}} - \frac{a_b^{\sigma-1}d}{(w-df)^{\sigma}}\right). \end{aligned} \tag{64}$$

Collecting terms,

$$\begin{aligned} B(f) &= \sigma\left(\frac{d(c+d)f}{(w-df)} + \frac{c(c+d)f}{(w+cf)}\right) \\ &\quad + \frac{d}{(1-\alpha)}\left(\left(\frac{a_b}{a_g}\right)^{\sigma-1}\left(\frac{w+cf}{w-df}\right)^{\sigma} + 1\right) \\ &\quad - \frac{c}{(1-\alpha)}\left(\left(\frac{a_g}{a_b}\right)^{\sigma-1}\left(\frac{w-df}{w+cf}\right)^{\sigma} + 1\right). \end{aligned} \tag{65}$$

The first term in $B(f)$ is unambiguously positive. For $\frac{\delta \widehat{L}}{\delta f} < 0$, it must be the case that the terms in $1/(1-\alpha)$ sum to a negative number, *i.e.*.

$$\frac{d}{c} < \left(\frac{a_g}{a_b}\right)^{\sigma-1} \left(\frac{w - df}{w + cf}\right)^{\sigma} \tag{66}$$

However, (66) is merely the condition for $\frac{\delta \widetilde{P}}{\delta f} > 0$. So, a necessary (but not sufficient) condition for $\frac{\delta L}{\delta f} < 0$ is that firing costs increase the price of the input portfolio. Note from (65) that the higher is α, the more weight placed on the price effect of firing costs.

6. Proposition 3: $\frac{\delta n}{\delta f} < 0$;

   From (38):

$$n = \overline{k}\left\{(\sigma-1)^{-1}\widetilde{P}^{1-\sigma} - (d-c)fa_b^{\sigma-1}(w-df)^{-\sigma}\right\}^{\frac{(\sigma-1)}{(\sigma-1/(1-\alpha))}}\widetilde{P}^{\sigma-1}. \tag{67}$$

   A little algebra confirms that the sign of $\frac{\delta n}{\delta f}$ is that of the following expression

$$\phi = \left(d - c\left(\frac{a_g}{a_b}\right)^{\sigma-1}\left(\frac{w+cf}{w-df}\right)^{\sigma}\right)C(f) - (d-c)D(f) \tag{68}$$

   where

$$C(f) = \left(\frac{\alpha}{\sigma(1-\alpha)-1}\right)\left(\left(\frac{a_g}{w+cf}\right)^{\sigma-1} + \left(\frac{a_b}{w-df}\right)^{\sigma-1}\right) + \frac{(\sigma-1)a_b^{\sigma-1}(d-c)f}{(w-df)^{\sigma}}, \tag{69}$$

$$D(f) = \left(\frac{\sigma-1}{\sigma-\frac{1}{1-\alpha}}\right)\left(\left(\frac{a_g}{w+cf}\right)^{\sigma-1} + \left(\frac{a_b}{w-df}\right)^{\sigma-1}\right) \times\left(1 + \frac{\sigma df}{w-df}\right). \tag{70}$$

   Now, recall again the implicit restriction that $l_g > l_b$. It follows from (58) and (68) that

$$\begin{aligned}
\phi &< (d-c)(C(f) - D(f)) && (71)\\
&= -(d-c)\left(\left(\frac{a_g}{w+cf}\right)^{\sigma-1} + \left(\frac{a_b}{w-df}\right)^{\sigma-1}\right) \\
&\quad -d(d-c)\frac{\sigma(\sigma-1)}{\left(\sigma-\frac{1}{1-\alpha}\right)}\frac{f}{(w-df)}\left(\left(\frac{a_g}{w+cf}\right)^{\sigma-1} + \left(\frac{a_b}{w-df}\right)^{\sigma-1}\right) \\
&\quad + (d-c)^2(\sigma-1)\frac{f}{(w-df)}\left(\frac{a_b}{w-df}\right)^{\sigma-1} && (72)\\
&< 0. && (73)
\end{aligned}$$

So, n is decreasing in f over the whole range for which labour reallocation occurs.

7. Proposition 4: $\frac{\delta P_X(n)}{\delta f} > 0$;

   From (21) we have

$$P_X = \widetilde{\sigma}\left(\frac{n}{2}\right)^{1/(1-\sigma)}\widetilde{P} \tag{74}$$

$$= \widehat{k}\left((\sigma-1)^{-1}\left(\left(\frac{a_g}{w+cf}\right)^{\sigma-1}+\left(\frac{a_b}{w-df}\right)^{\sigma-1}\right)-\frac{a_b^{\sigma-1}(d-c)f}{(w-df)^{\sigma}}\right)^{\frac{-1}{\sigma-\frac{1}{1-\alpha}}}. \tag{75}$$

   where $\widehat{k}$ is a constant. Bearing in mind the restriction that $\sigma > \frac{1}{1-\alpha}$, the sign of $\frac{\delta P_X(n)}{\delta f}$ can be shown to equal that of

$$c\left(\frac{a_g^{\sigma-1}}{(w+cf)^{\sigma}}-\frac{a_b^{\sigma-1}}{(w-df)^{\sigma}}\right)+\frac{\sigma a_b^{\sigma-1}d(d-c)f}{(w-df)^{-(\sigma+1)}}. \tag{76}$$

   Again, (58) ensures that the first term is positive over the relevant range.

8. Proposition 5: $\frac{\delta L(j)}{\delta f(j)}$;

   A calculation shows that the sign of $\frac{\delta L(j)}{\delta f(j)}$ is that of

$$\sigma E(f,N)\left[\frac{a_b^{\sigma-1}d}{(w-df)^{(\sigma+1)}}-\frac{a_g^{\sigma-1}c}{(w+cf)^{(\sigma+1)}}\right]-\left(\sigma-\frac{1}{1-\alpha}\right)F(f) \tag{77}$$

   where

$$E(f,N) = \widehat{P}^{1-\sigma} \tag{78}$$

$$= a_g^{\sigma-1}\left(\sum_{j=1}^{N}\left(w+\frac{f(j)}{2(1+r)}\right)^{1-\sigma}\right) + a_b^{\sigma-1}\left(\sum_{j=1}^{N}\left(w-\frac{(1+2r)f(j)}{2(1+r)}\right)^{1-\sigma}\right) \tag{79}$$

$$F(f) = \left(\frac{a_g^{\sigma-1}}{(w-df)^{-\sigma}}+\frac{a_b^{\sigma-1}}{(w+cf)^{-\sigma}}\right) \times\left(\frac{a_b^{\sigma-1}d}{(w-df)^{-\sigma}}-\frac{a_g^{\sigma-1}c}{(w+cf)^{-\sigma}}\right). \tag{80}$$

   As N grows large, so does $E(f,N)$, and more weight is placed on the term in square brackets in (77). This is simply $\frac{\delta L_1(j)}{\delta f(j)}$.

2.6.2 Figures

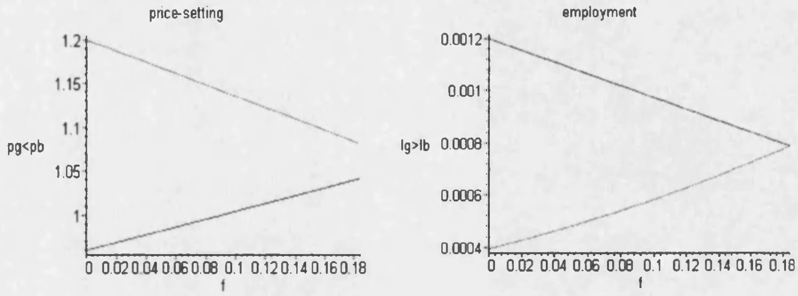

Figure 1 - firing costs and disaggregate employment, price-setting

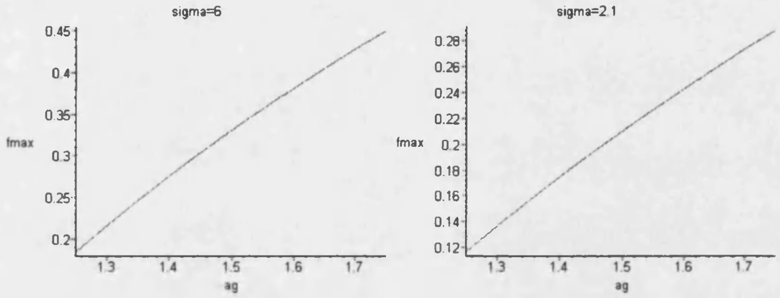

Figure 2 - productivity shocks and fmax

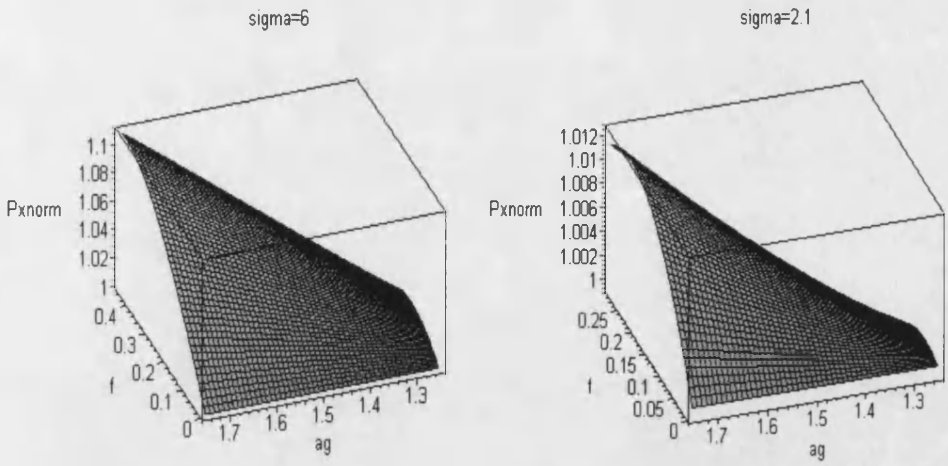

Figure 3.1 - firing costs, productivity shocks and the aggregate price level

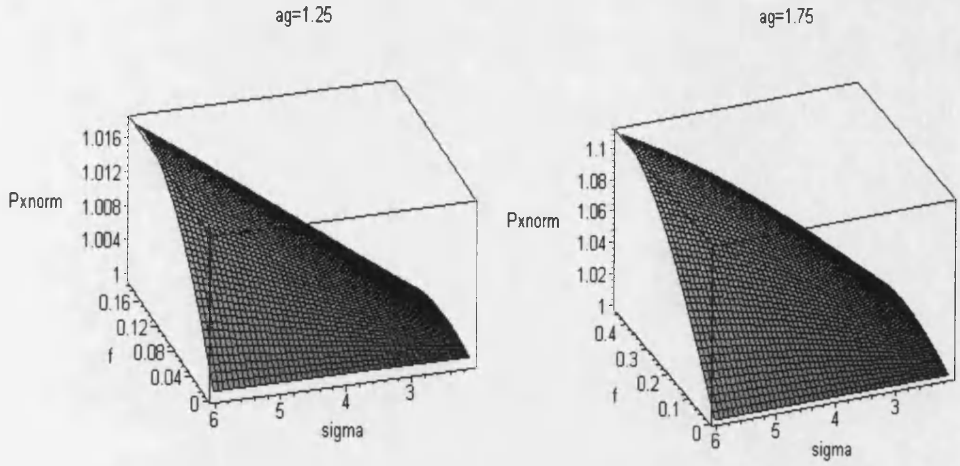

Figure 3.2 - firing costs, σ and the aggregate price level

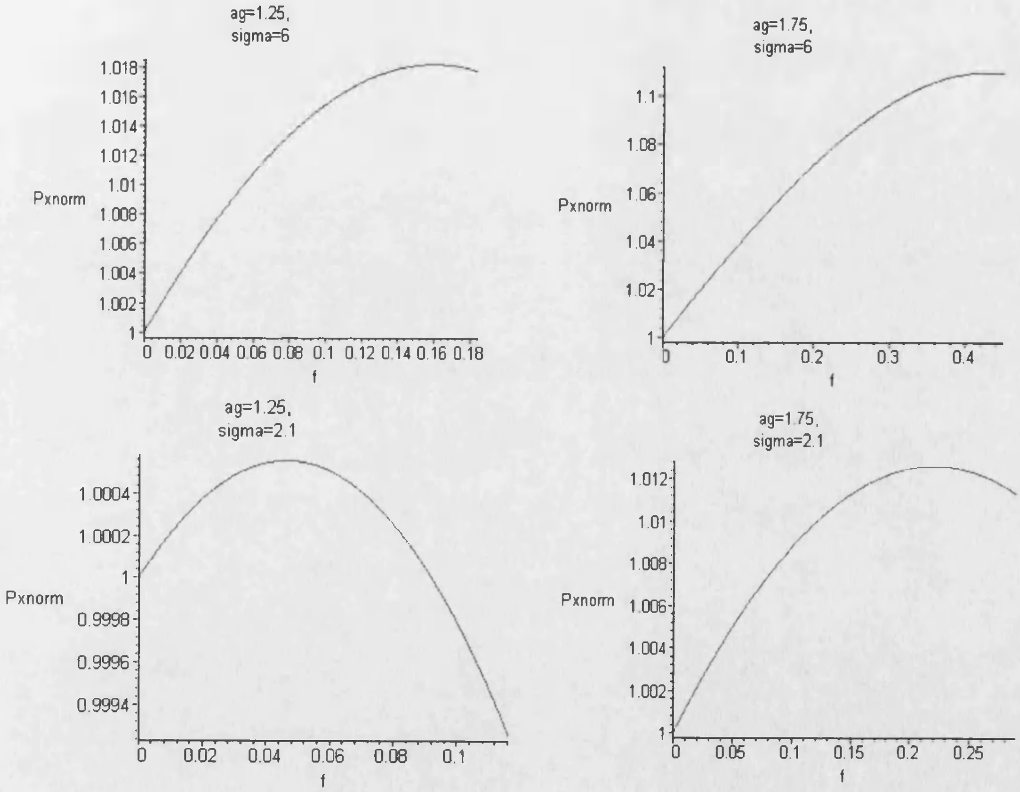

Figure 3.3 - firing costs and the aggregate price level

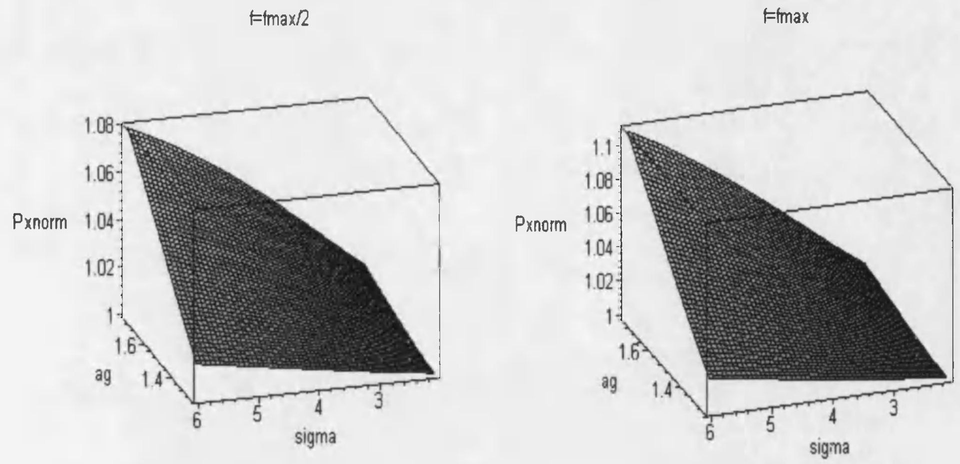

Figure 3.4 - productivity shocks, σ and the aggregate price level

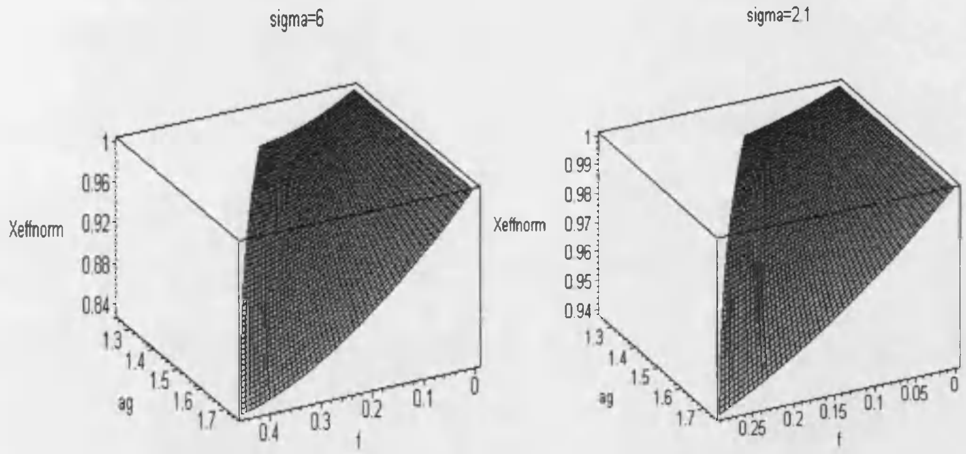

Figure 4.1 - firing costs, productivity shocks and cross-sectional efficiency

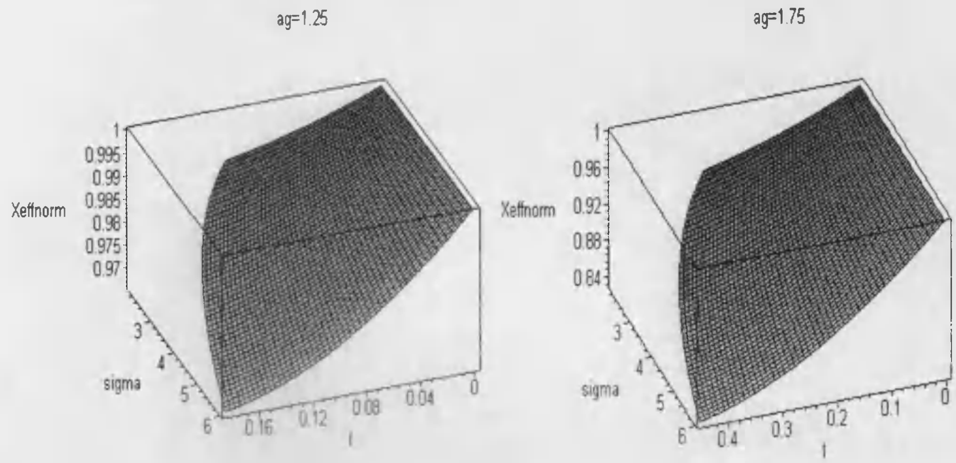

Figure 4.2 - firing costs, σ and cross-sectional efficiency

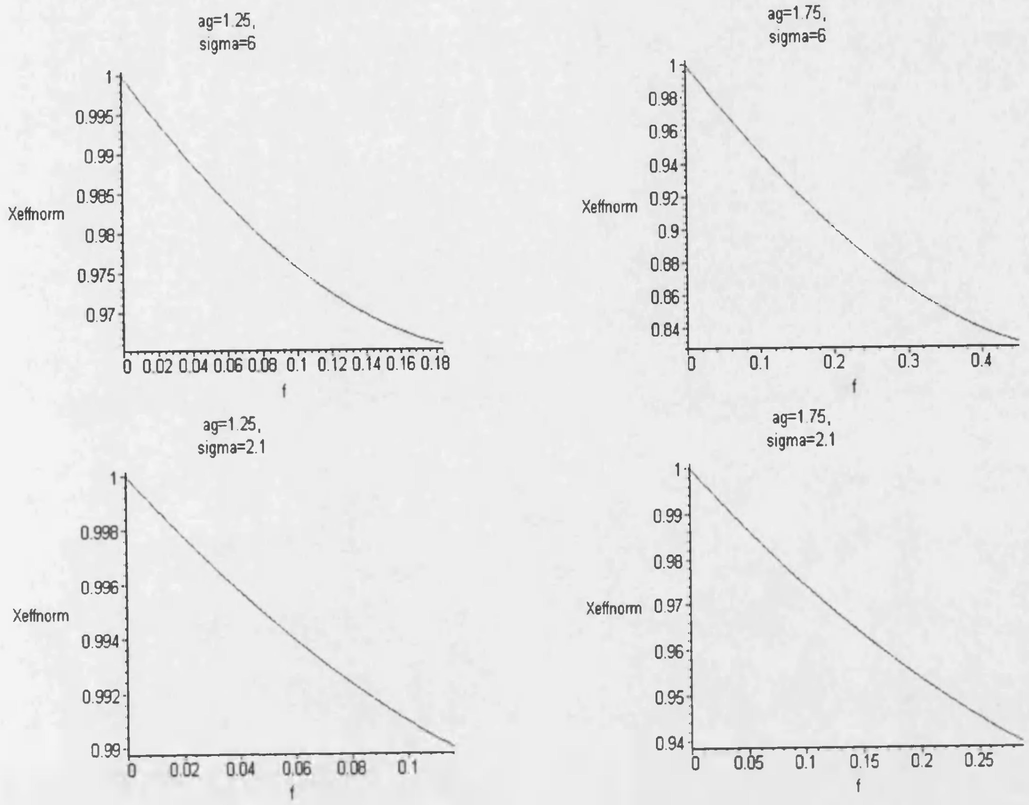

Figure 4.3 - firing costs and cross-sectional efficiency

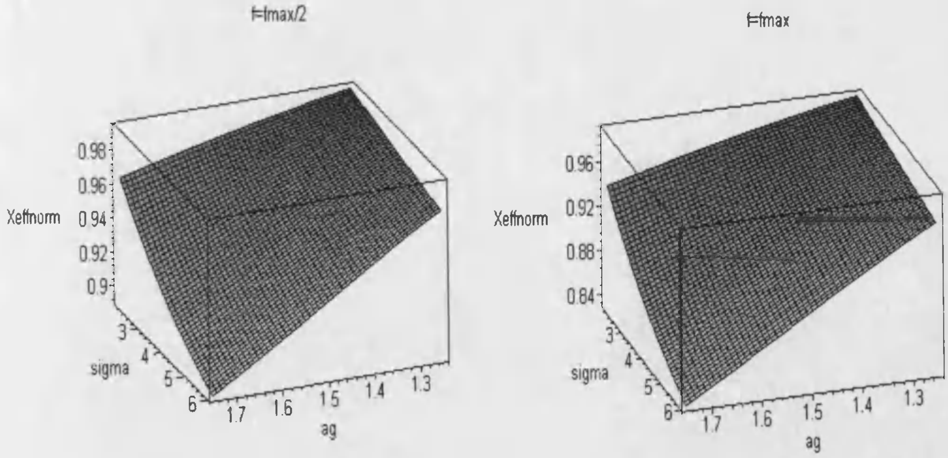

Figure 4.4 - productivity shocks, σ and cross-sectional efficiency

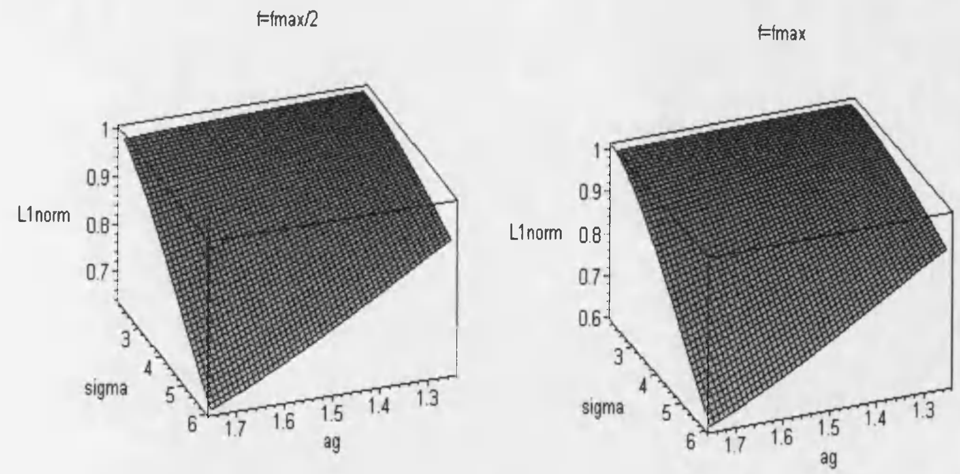

Figure 5.1 - productivity shocks, σ and L_1, $\alpha = 0.5$

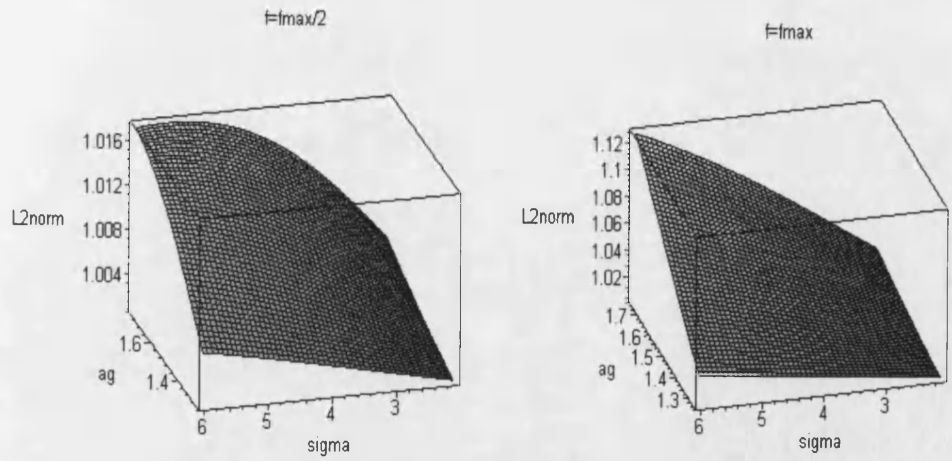

Figure 5.2 - productivity shocks, σ and L_2

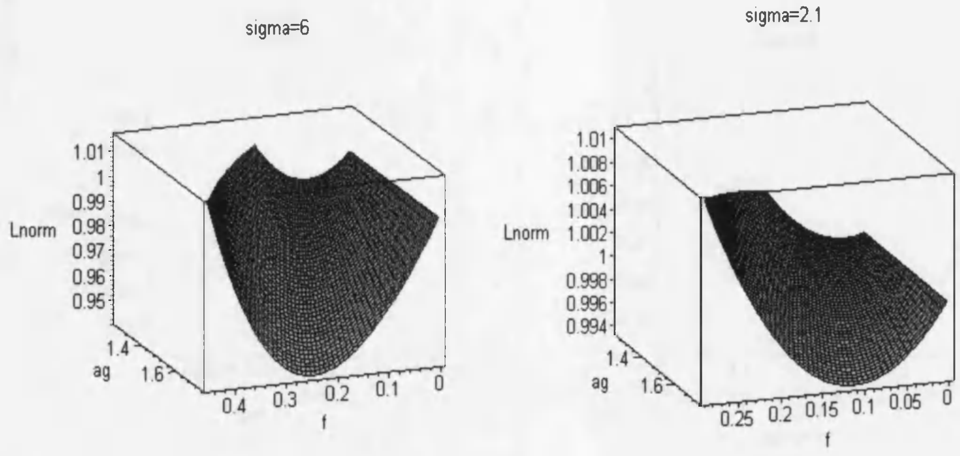

Figure 5.3 - firing costs, productivity shocks and aggregate employment, $\alpha = 0.01$

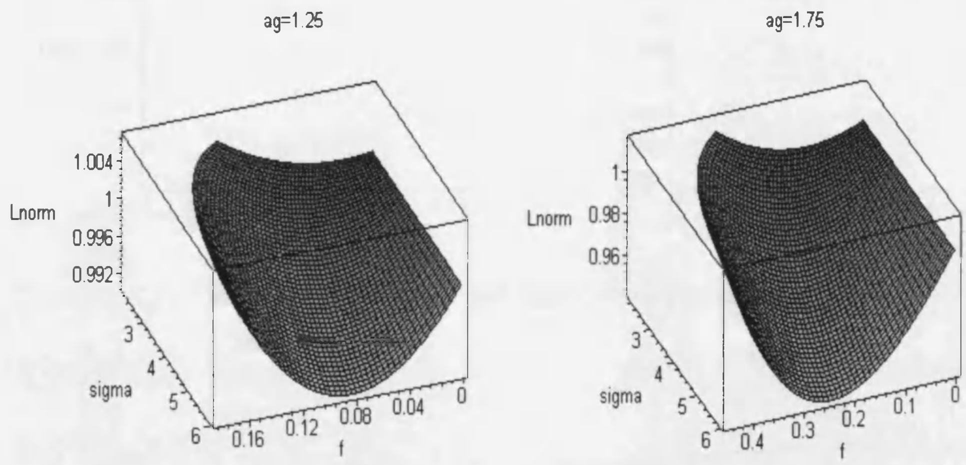

Figure 5.4 - firing costs, σ and aggregate employment, $\alpha = 0.01$

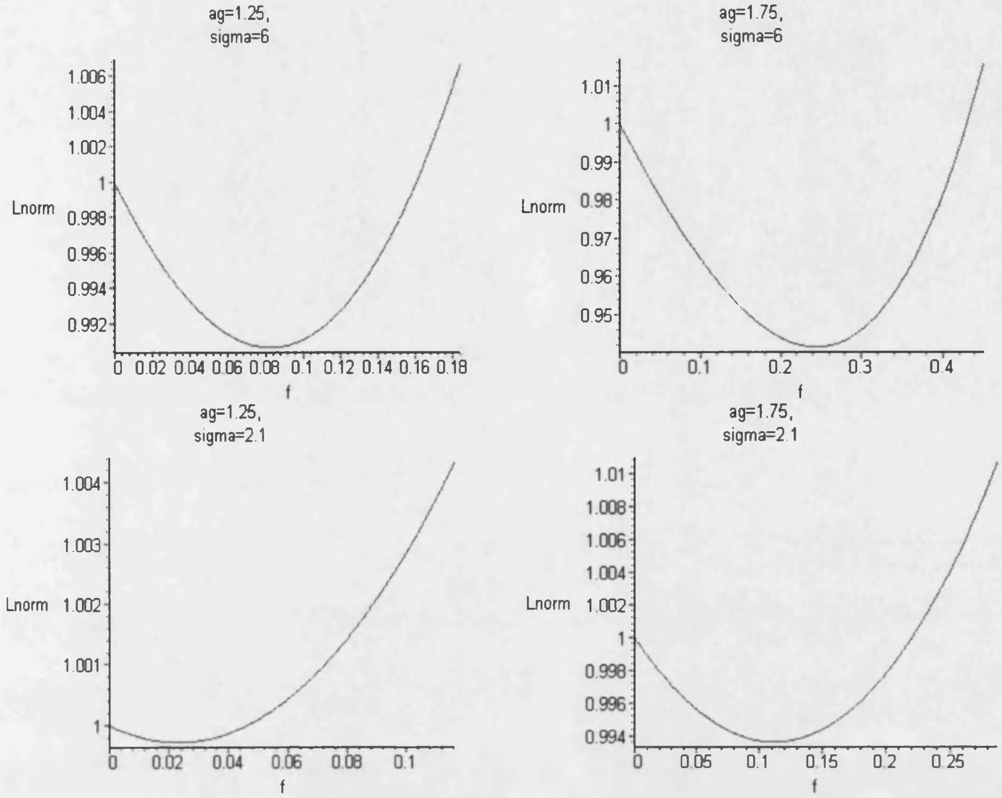

Figure 5.5 - firing costs and aggregate employment, $\alpha = 0.01$

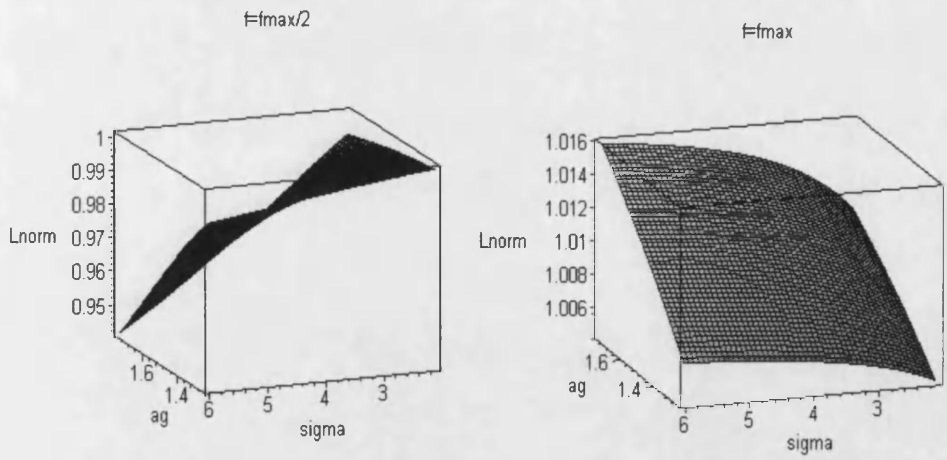

Figure 5.6 - productivity shocks, σ and aggregate employment, $\alpha = 0.01$

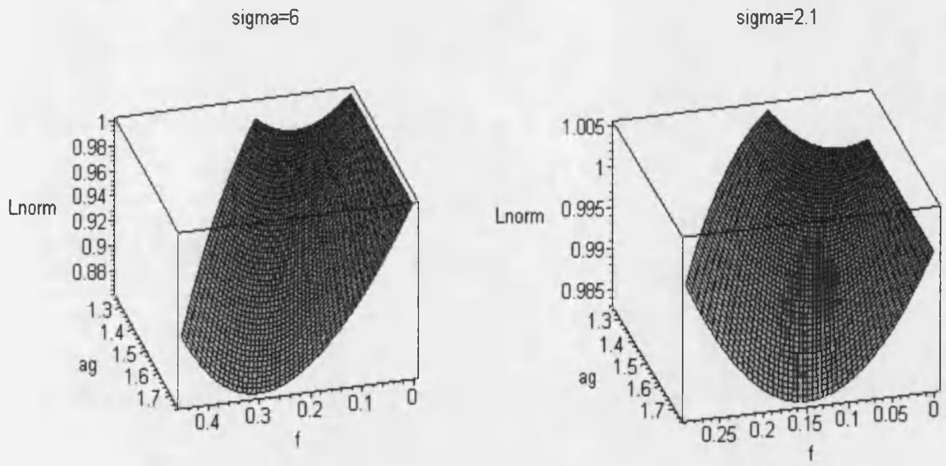

Figure 5.7 - firing costs, productivity shocks and aggregate employment, $\alpha = 0.5$

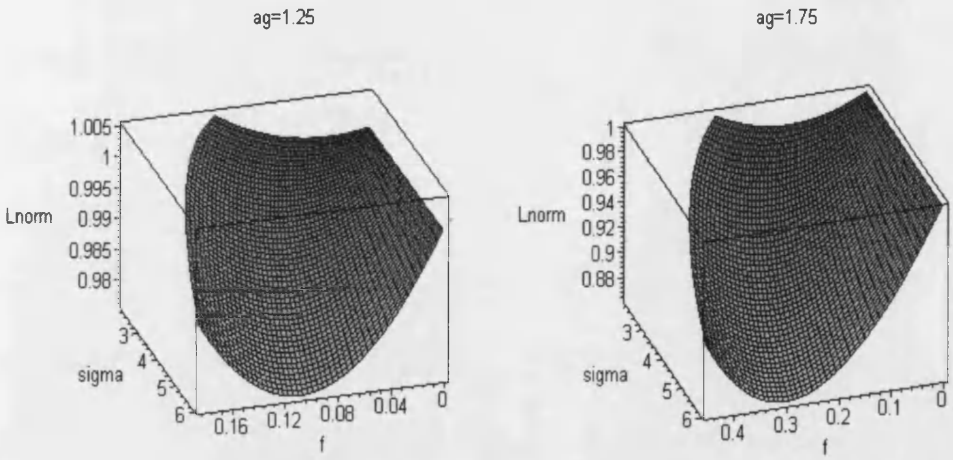

Figure 5.8 - firing costs, σ and aggregate employment, $\alpha = 0.5$

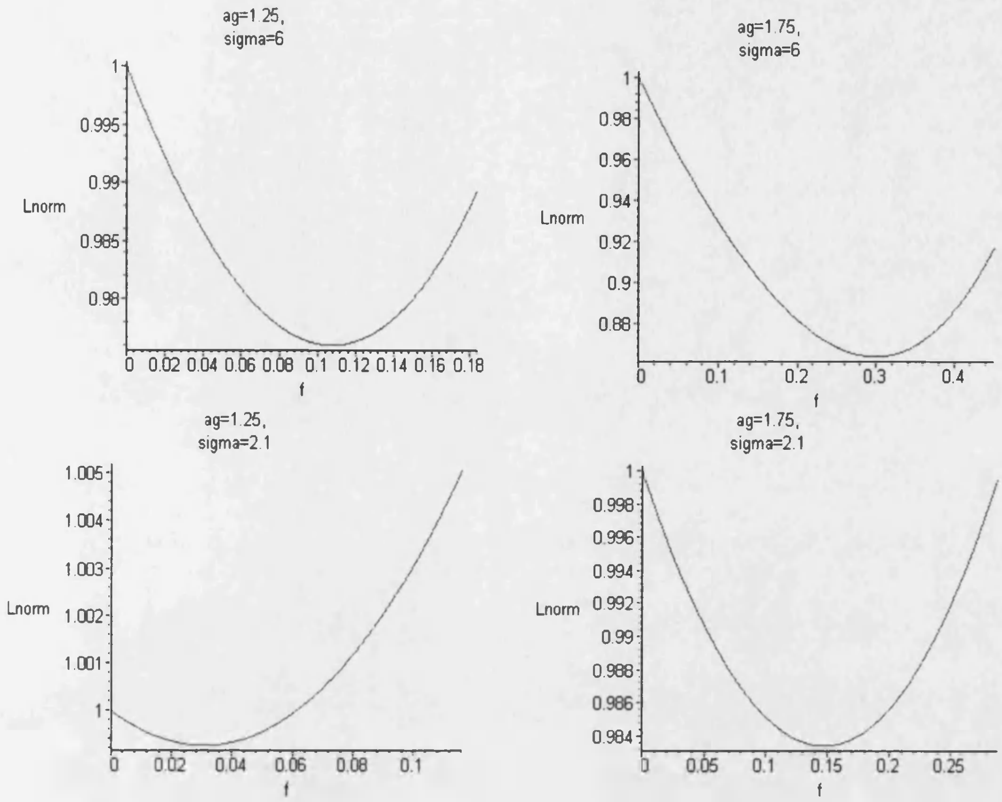

Figure 5.9 - firing costs and aggregate employment, $\alpha = 0.5$

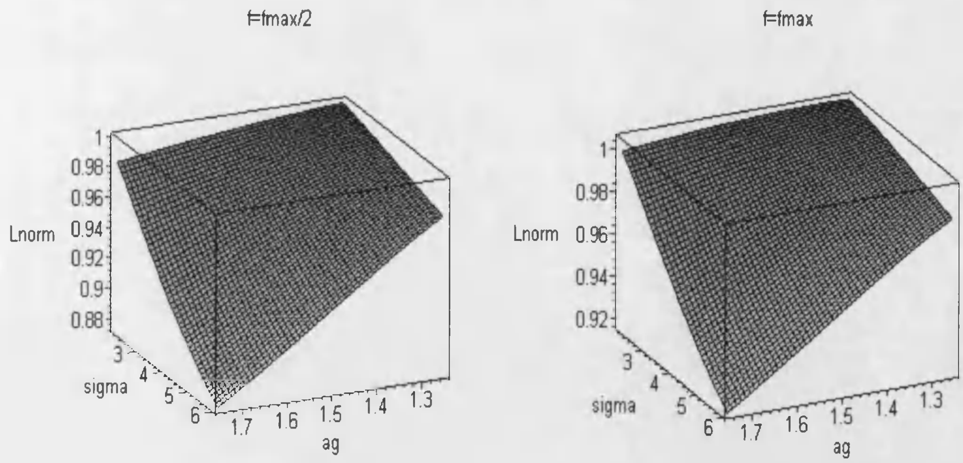

Figure 5.10 - productivity shocks, σ and aggregate employment, $\alpha = 0.5$

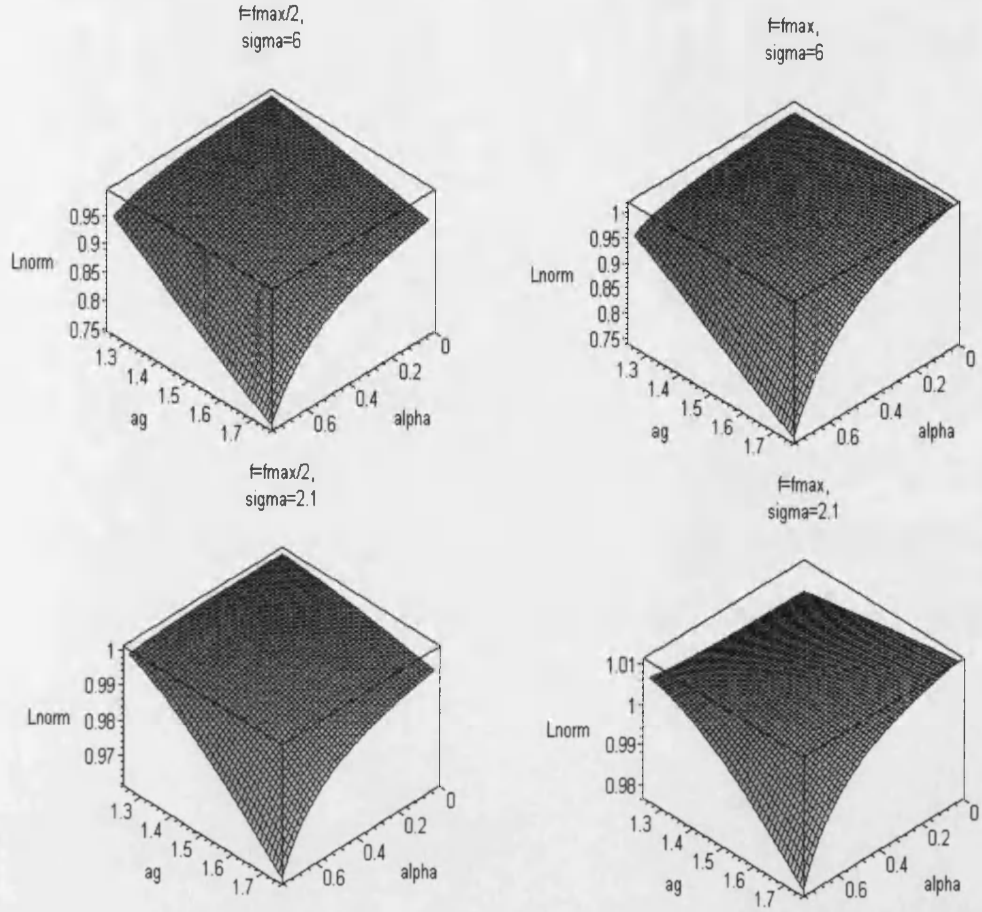

Figure 5.11 - α, productivity shocks and aggregate employment

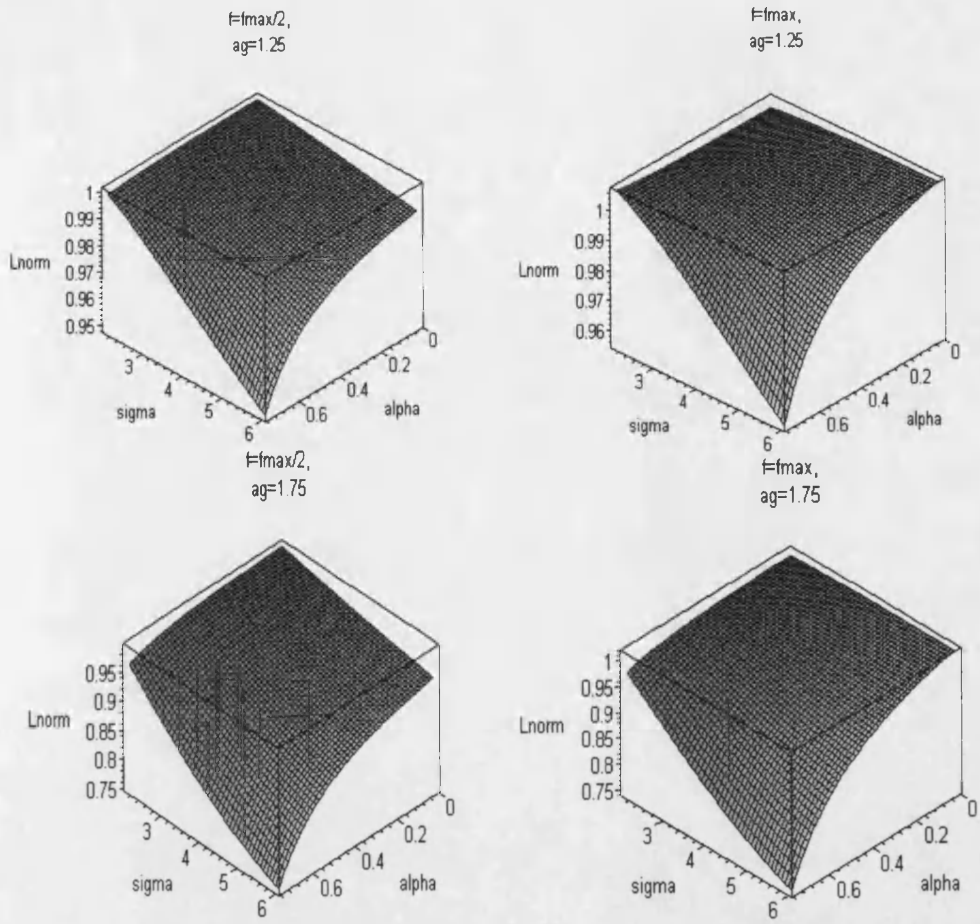

Figure 5.12 - α, σ and aggregate employment

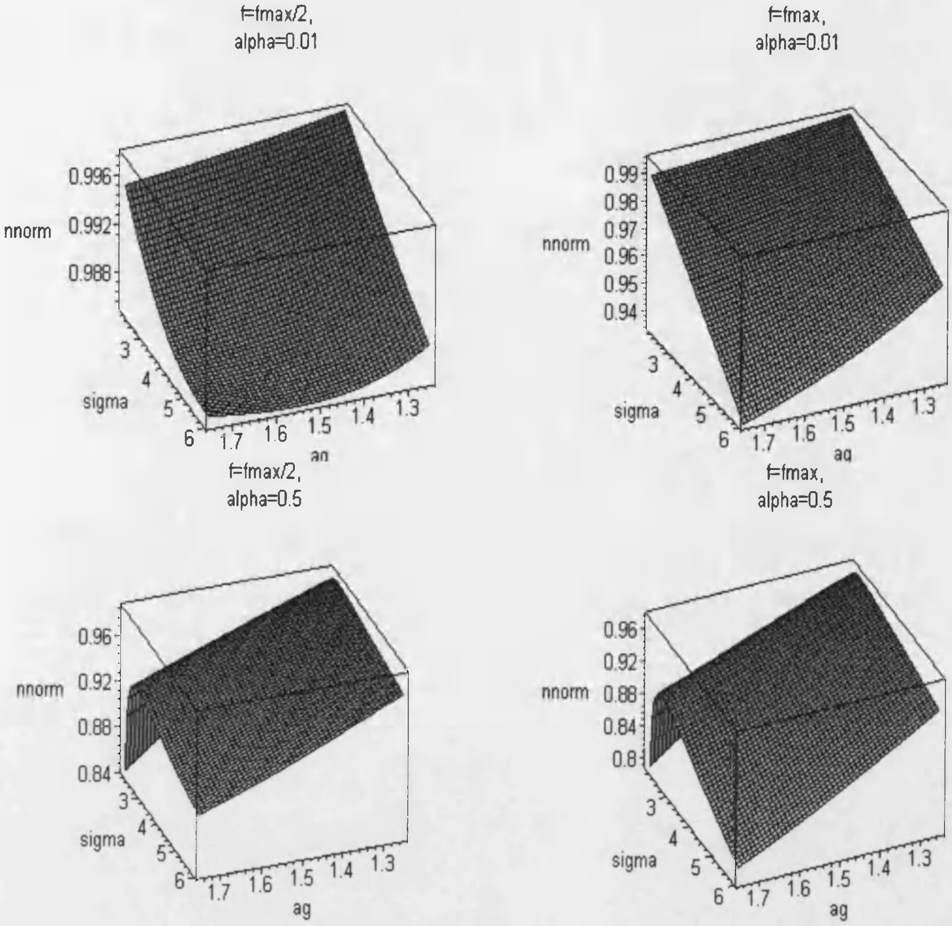

Figure 6.1 - productivity shocks, σ and the number of firms

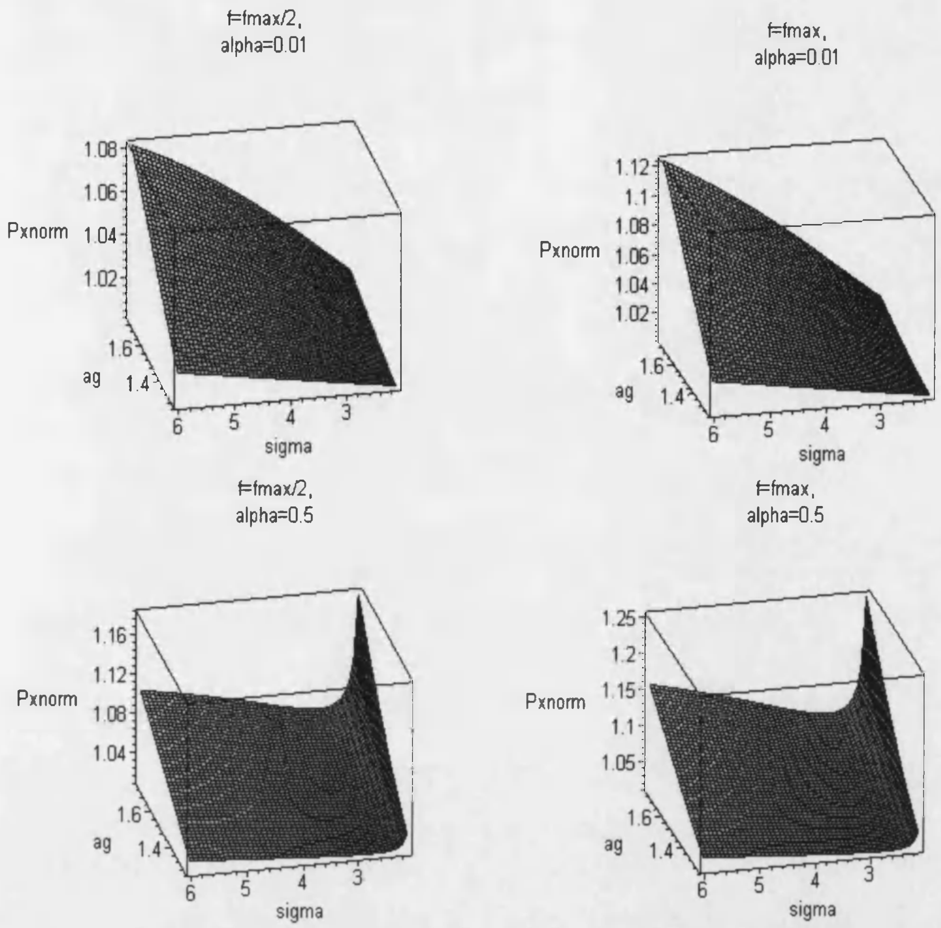

Figure 6.2 - productivity shocks, σ and the aggregate price level with endogenous firm entry

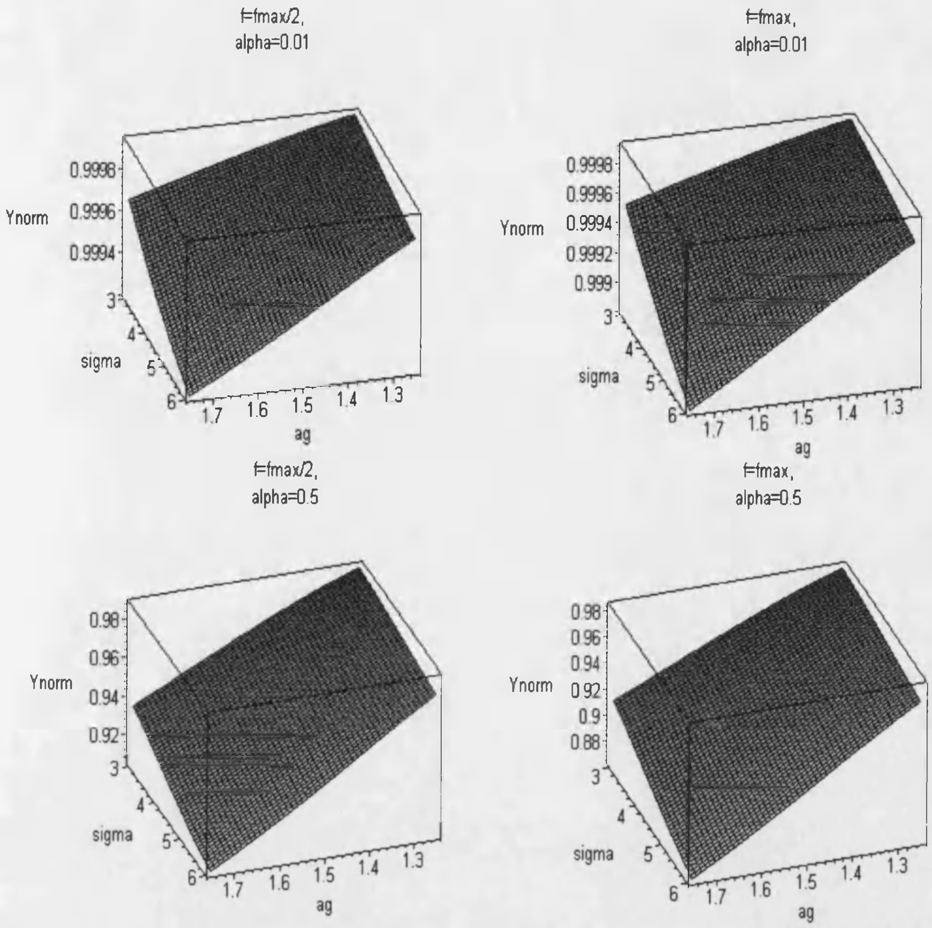

Figure 6.3 - productivity shocks, σ and final output with endogenous firm entry

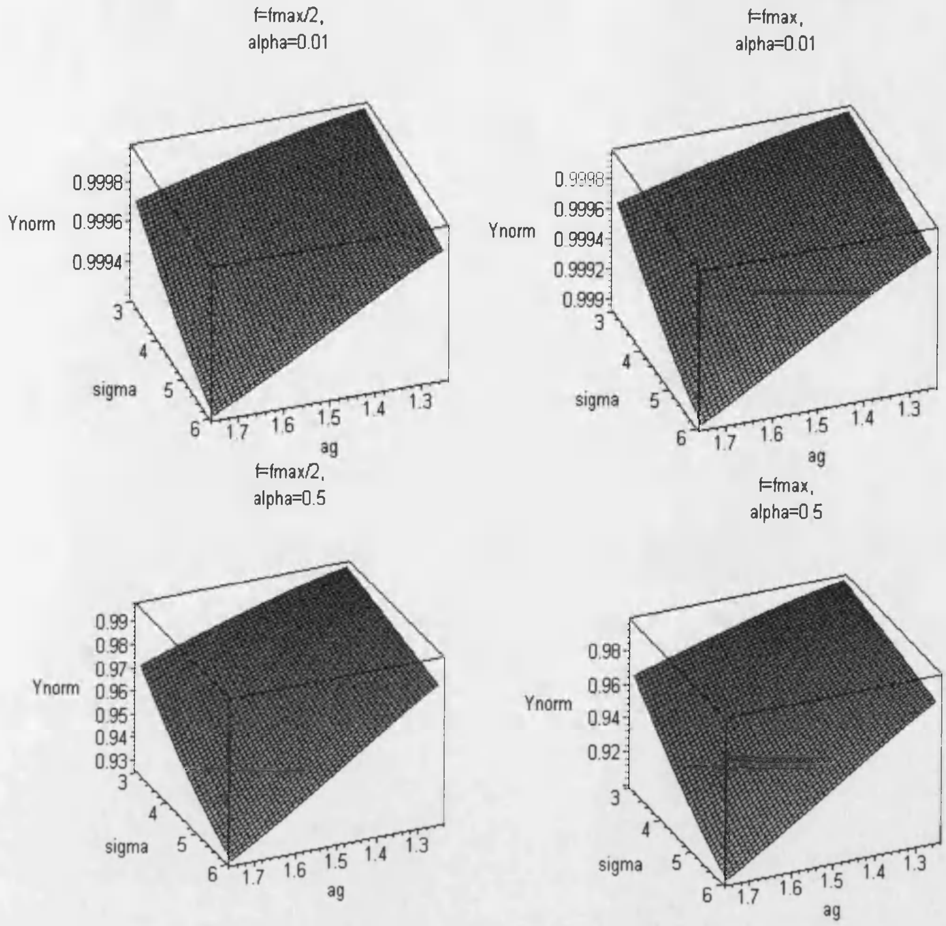

Figure 6.4 - productivity shocks, σ and final output with n exogenous

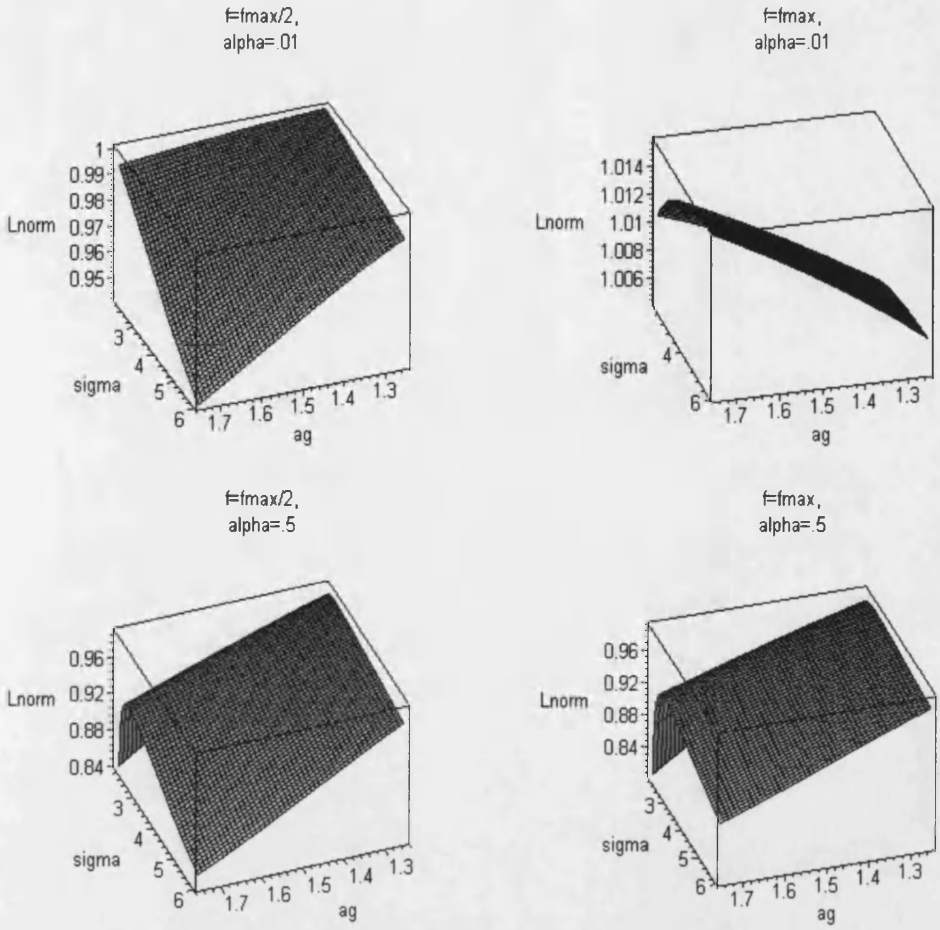

Figure 6.5 - productivity shocks, σ and aggregate employment with endogenous firm entry

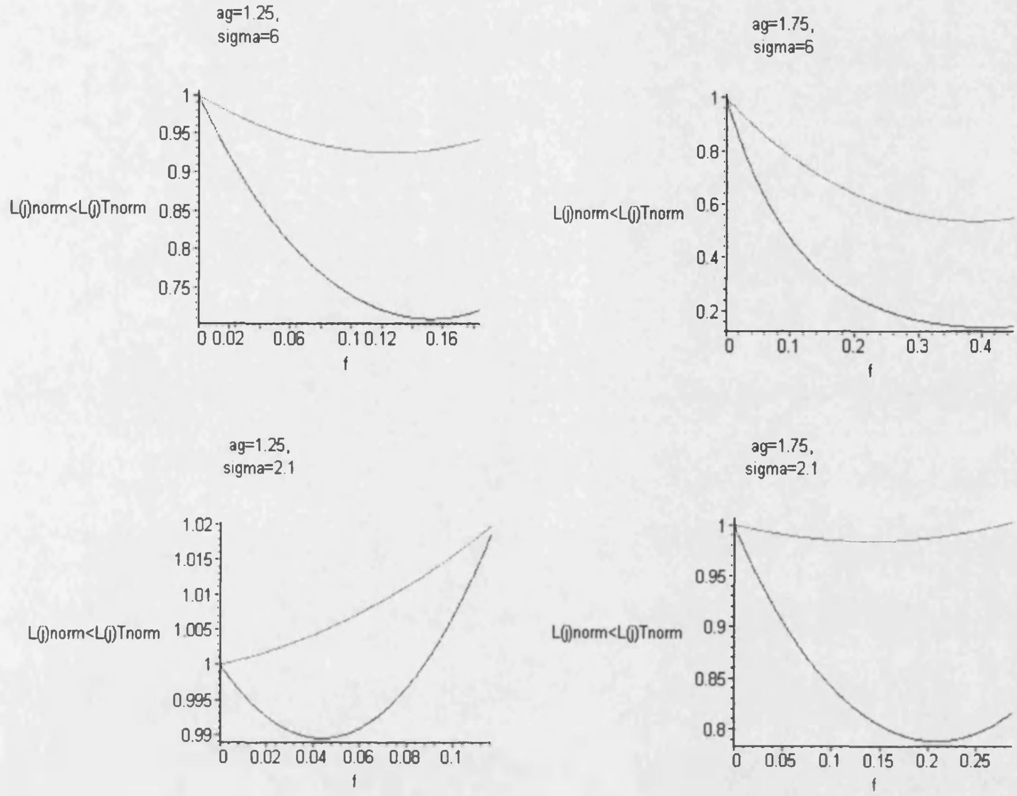

Figure 7 - firing costs and employment with traded intermediates, $\alpha = 0.95$

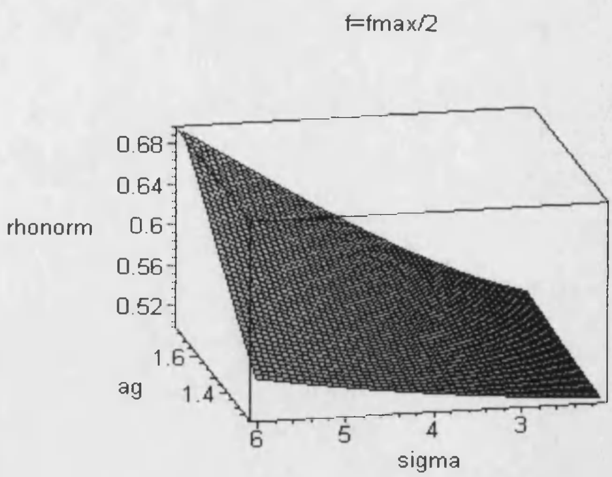

Figure 8 - productivity shocks, σ and labour turnover

3 Central Bank Conservatism and the Fragmentation of Wage-Bargaining

3.1 Introduction

Much economic policy evaluation is informed by the institutional environment in which the policy-maker must work. The salient characteristics of this environment, be they the ways in which information is distributed across private agents or the relative bargaining powers of groups of such agents, are usually taken as given. Relatively little formal attention is paid to the role of economic policy, in particular macroeconomic policy, in determining such arrangements, except of course where the very object is to explicitly remould the institutional structure[36].

That such indirect effects of policy are commonly ignored is perhaps surprising. While the nature of economic institutions may conceivably be affected by non-economic, 'historical' processes, as well as by explicit policy prescription, one would expect it to be in part the result of self-interested actions by individual agents; private information may be shared and restricted, private coalitions may arise and dissolve. Since, from the point of view of the individual agent, the optimal institutional structure will be sensitive to the policy regime, changes in policy will lead to changes in this structure[37]. Accordingly, any attempt to explain evolution in institutional structure should consider the potential influence of the policy regime. Any comprehensive evaluation of economic policy will do well to take such influence into account.

This paper applies such logic to the interaction between macroeconomic policy stance - specifically, central bank conservatism - and corporatism in the labour market - specifically, the extent to which labour unions coordinate when setting wages. The past twenty years have seen two broad trends in developed economies: a shift towards greater decentralisation of wage-bargaining, and increasing policy emphasis on price stability. It is argued here that these phenomena are linked, and that the fragmentation of bargaining structures in the labour market has its roots in the more anti-inflationary monetary regimes

[36] As is the case with much competition policy, for example.

[37] This is not a new insight, merely a particular statement of the Lucas Critique.

in evidence.

Each of these topics has a substantial literature devoted to it in isolation. That on the effects of central bank preferences lies squarely within the neoclassical mainstream[38], while the literature dealing with institutional arrangements in the labour market owes a little more to political scientists and scholars of industrial relations[39]. It is only recently that the two have been integrated; several papers[40] augment the standard strategic monetary policy game with multiple, non-atomistic wage-setters, and find that doing so provides richer insights than afforded by the earlier, separate literatures. However, while these papers may focus on the interplay between policy stance and the structure of wage bargaining, they allow for no causal link between the two; the degree of coordination on the part of wage-setters is immutable in the face of varying degrees of central bank conservatism. This paper extends this analysis.

First, it presents a monetary policy game where, given the preferences of the central bank, an increase in the number of wage-setting coalitions will lead to lower levels of employment. Also, *given the structure of the labour market*, a more conservative central bank will lead to higher aggregate employment. The monetary policy game has two stages. In the first, the (multiple) wage-setters simultaneously post wages. In the second, the central bank determines the level of inflation at its discretion.

The second, and more novel, aspect of the model is that it allows the basic structure of wage-setting to change with policy stance. The model adds an anterior stage to the standard, two-stage monetary policy game. Before wages are set, unions are allowed to form alliances with one another, with each alliance to set a single wage on behalf of all constituent workers. The labour unions are assumed to anticipate the behaviour of the monetary authority when forming these alliances. The overall model structure is thus as follows:

- Stage 1: labour unions organise themselves into coalitions;
- Stage 2: each coalition sets a single wage on behalf of its constituents;

[38]For example Barro & Gordon (1983).

[39]See for instance Schmitter (1974) and Crouch (1985).

[40]Notably in papers by Guzzo and Velasco (1999) and Cukierman and Lippi (1999a). See also Iversen (1999), Gruner and Hefeker (1999) and Bleaney (1996).

- Stage 3: the central bank chooses the rate of inflation.

Using the non-cooperative coalition-formation game proposed by Bloch (1996), the relationship between central bank preferences and equilibrium labour market structure is derived. It is found that, given the nature of the proposed game between the wage-setters and the central bank (Stages 2 and 3), increased conservatism leads to a more diffuse pattern of wage-setting, consistent with the observed institutional changes. A highly accommodating central bank results in fully centralised wage-bargaining, while one that is strongly averse to inflation leads to wage-setting being completely decentralised. Between these two extremes, the relationship is nonlinear; there is an upper bound to the number of independent wage-setting units, said upper bound increasing in the degree of conservatism. The robustness of this conclusion, that conservatism is associated with a diffuse labour market structure, is ascertained with reference to the cooperative concept of coalition stability. It is shown that decentralised structures are more likely to be stable under conservative monetary regimes, while centralised ones are likely to be stable when the central bank cares about real variables.

The reason for such a relationship is as follows. A feature of the labour market in the model will be that demand for the labour of an individual union is decreasing in the economy-wide real wage - it is implicit that, at the level of aggregation considered, the labour inputs of different unions are complements in the production function of the representative firm. Now, small wage-setting coalitions have the advantage that they can demand high real wages without too deleterious an effect on the aggregate economy. There is thus an incentive for an individual labour union to join a relatively small coalition, or even to remain isolated. However, should all other labour unions do likewise, the aggregate real wage will be high, aggregate labour demand low, and all unions will suffer. This provides an incentive for groups of unions to form alliances, so that wage demands may be coordinated. Unions, therefore, face a trade-off between the ability of large coalitions to solve this coordination problem and the flexibility afforded small coalitions - that is, the ability to free-ride on the coordination efforts of others and obtain high wages to boot. The degree of central bank conservatism will determine the nature of this trade-off, and thus the number and sizes of coalitions formed in equilibrium.

Having solved the coalition formation game, the implications of the monetary policy regime for employment are then re-examined, taking into account the endogeneity of the labour market structure. It is shown that the direct effect of greater conservatism, which is to increase employment, is eventually outweighed by the indirect effect, which is to lower employment via a decentralisation in wage-setting. A central bank with intermediate preferences may in fact maximise employment.

The likely effect of monetary union on the structure of European wage-bargaining is then addressed. It has been argued elsewhere[41] that the introduction of a supranational European monetary authority will encourage consolidation among wage-setters, as they come to appreciate the increased costs of uncoordinated behaviour. It is pointed out here that this argument ignores the incentives facing the individual wage-setter. While monetary union does imply higher costs from coordination failure, it may also increase the payoff from acting alone while other wage-setters coordinate. It is shown that, in equilibrium, this may imply an unchanged or even a more diffuse coalition structure, post-EMU. Rather than ushering in an era of cross-border alliances of labour unions, the single currency may in fact accelerate the fragmentation of European wage-bargaining.

Section 3.2 reviews the literature on the macroeconomic consequences of corporatism and of central bank conservatism. Section 3.3 outlines the strategic monetary policy game, for a given labour market structure, and analyses the effect on welfare when the degrees of corporatism and conservatism are varied in isolation. Section 3.4 endogenises the labour market structure and solves the coalition-formation game. Section 3.5 considers the overall impact on the economy of different monetary policy stances. Section 3.6 examines the implications of EMU within this framework. Section 3.7 concludes.

3.2 Corporatism and central bank conservatism

The roles of both the structure of wage-setting and of central bank conservatism in determining national economic performance have been extensively studied. The literature on the former will be surveyed first.

[41] See for example Holden (2001).

3.2.1 The coordination of wage-setting

Bruno and Sachs (1985) and Calmfors and Driffill (1988) argue that the aggregate wage (employment) level is hump-shaped (U-shaped) in the degree of decentralisation of wage-setting. The logic is as follows. In highly decentralised labour markets, any single union has little monopoly power, and faces being undercut should it set wages too high; in highly centralised labour markets each union is large enough to internalise the effects of its actions, again restraining wage claims; with an intermediate degree of centralisation, neither of these forces is at hand to moderate wage demands, and wages are high. This 'hump-shaped' hypothesis received much attention.

What of the actual pattern of wage-setting? For much of the post-war period, many developed economies, particularly those in Western Europe, have been characterised by coordinated wage-bargaining[42]. The extent of such coordination, and the precise form it has taken, have varied. From the 1950s to the early 1980s wage increases in Sweden were largely dictated by agreements made at national level, between the employers' confederation (SAF) and the blue-collar union federation (LO). Germany, meanwhile, traditionally relied on 'master labour agreements', negotiated regionally and covering industrial sectors; union participation in this process was coordinated by central unions, principally the 16 national unions covering industrial sectors affiliated with the Deutscher Gewerkschaftsbund (DGB). In the UK, in contrast, what coordination there was tended to take the form of multi-employer, firm-wide and plant-level bargaining.

Whatever the historical, cross-country differences in wage-bargaining structure, the 1980s and 1990s saw a gradual decentralisation of wage-setting in developed economies. In Sweden, for example, the importance of the SAF-LO agreement gradually declined, and in 1988 was replaced by industry-level negotiations. While the formal bargaining structure in Germany has remained largely intact, observers have detected a significant move towards decentralisation, with informal bargaining by works councils at

[42]Eichengreen and Iversen (1999) argue that this helped the economies of Western Europe overcome three pressing economic difficulties faced after WWII, namely short-termism, collective-action problems and distributive conflict.

plant and company level growing in importance[43]. Even the UK has seen a degree of decentralisation, starting though it was from a relatively decentralised base; there has been a decline in the number of multi-employer agreements, and the replacement of firm-wide agreements by those made at plant level. This fragmentation of bargaining systems is not confined to European countries. Both New Zealand and Australia have seen a bargaining structure based on industrial agreements eroded by growth in single-employer bargaining. The experience in the US has been similar to that in the UK, with a movement from multi-employer to plant level bargaining, while Canada has also seen bargaining fragmentation. See Katz (1993) and Walsh (1995) for a general review.

Several suggestions have been made as to the causes of this apparent move towards less coordinated wage-setting structures. Katz (1993) identifies three in particular as worthy of consideration. The first is that there was a shift in bargaining power away from the workforce towards management, due to intensified international competition and declines in both unions' membership and their political strength; employers have used this increased bargaining power to push for decentralisation, which they see as conducive to improved bargaining outcomes. Circumstantial evidence in favour of this 'bargaining power shift' hypothesis is that management have indeed tended to push for such decentralisation, while the central unions have opposed it. However, Katz points out that the constituent local unions were generally in favour of more devolved wage-setting, and argues that any decentralisation in Germany cannot have been due to weakness on the part of the unions, who retained significant bargaining power throughout[44]. A second possible cause is the diversification of corporate structure, with bargaining decentralisation a natural consequence of more independent business units. Katz favours a third suggested explanation, whereby workplace restructuring was necessitated by new technology; local bargaining was necessary for the implementation of new, more flexible forms of workplace organisation[45].

[43]Note that the dimension of interest for this paper will be the degree of coordination of wage-bargaining, rather than the extent to which it is formally centralised.

[44]Union membership in Germany remained strong throughout the 1980s, and improvements in wages and working hours were consistently obtained.

[45]Iversen (2000) also argues that new technology, in conjunction with competition from newly industrialised countries, has led to growing pressure for wage flexibility.

Walsh (1995) also emphasises reorganisation in the workplace. However, she argues it was a response to the productivity slowdown in the 1970s, after which firms were willing to experiment with new techniques and workplace structures, again with local bargaining a natural consequence. Walsh stresses in turn the importance of increased workforce heterogeneity, and of increased international economic integration, with the rise of multinational corporations undermining domestic corporatist arrangements.

In each of the explanations considered hereto, there is little or no role for the labour unions themselves - the forces behind decentralisation are external, in the form of new technology, international competition or corporate restructuring. This is unsatisfactory. To quote Katz (1993, p.17),

> "...the evidence from the six countries suggests that unions can influence the nature of bargaining structure and are not just passive recipients of a 'decentralisation effect'."

It is argued in this paper that the move to more diffuse wage-setting systems may be in part a result of changes in the perceived benefits, to labour unions, of coordinated wage bargaining. In response to such changes, which result in turn from changes in the macroeconomic environment, the unions have themselves prompted a decentralisation in wage-setting. It is suggested in Iversen (2000), though not formally modelled, that

> "...capital market integration has constrained the capacity of governments to run deficits and pursue inflationary monetary policies, thus limiting the incentives for employers and better-paid workers to agree to centralised controls on wage increases."

This argument, that the advent (for whatever reason) of more anti-inflationary monetary policies made wage coordination less appealing to workers, is close to that presented later.

3.2.2 Central bank conservatism

It was long the received wisdom, at least in academic circles, that greater conservatism brought lower inflation with no cost in terms of higher unemployment. The work of Kydland and Prescott (1977) and Barro and Gordon (1983) suggested that atomistic, forward-looking wage-setters will anticipate the disinflationary actions of a more conservative central bank, and moderate their wage demands accordingly; in the absence of shocks there will be no 'real' effects.

Perhaps partly as a result of this view, the status of which approached that of a folk-theorem in macroeconomics, many governments began to follow more anti-inflationary policies. In Western Europe a gradual movement towards 'hard-currency' regimes was observed in the 1980s, one manifest in the targeting of exchange rates within the European Monetary System (EMS). Bleaney (1996), along with many others, argues that the operation of the EMS, in which high-inflation countries allowed their currencies to steadily appreciate against the Deutschemark, allowed these countries to acquire some of the anti-inflationary credibility of the Bundesbank. There has also been a movement towards increased independence of central banks. Tavelli, Tullio and Spinelli (1998) found that, between 1990 and 1997, the 'functional' and 'political' independence[46] of a number of European central banks increased, in some cases markedly; meanwhile, the UK, one of the notable absentees from monetary union, has had a functionally independent, inflation-targetting central bank since 1997[47]. This process reached what some would call its natural conclusion with the establishment, in advance of the adoption of the euro in 1999, of the European Central Bank (ECB), by most measures highly independent. Again, this move towards anti-inflationary macroeconomic policies was not confined to European countries. In, the US the 1980s began with the Volcker disinflation; The Reserve Bank of New Zealand was made functionally independent in 1989; other banks to adopt explicit inflation targeting are the Bank of Canada and the Reserve Bank of Australia.

[46] Defined respectively as the power to deploy the instruments and to set the targets of monetary policy.

[47] It is of course worth emphasising that the concepts of central bank conservatism and independence are completely distinct; one can have conservatism without independence, and *vice versa*. However, it is perhaps arguable that independence is a reasonable *empirical* indicator of conservatism, although Forder (1996) argues forcefully against this approach. It is also arguable that increased independence is, if anything, a lagging indicator of increased conservatism, since presumably constitutional amendments take longer to implement than short-term monetary policy decisions. This increase in independence through the 1990s could be viewed in light of the tensions apparent in the EMS by the early part of that decade, brought on by differing economic policies across participating countries and by German reunification. Governments may have decided to swap one set of anti-inflationary institutions for another, or at least decided that complementary arrangements were required.

There seems to have been, then, an increased willingness on the part of governments to pursue anti-inflationary macroeconomic policies. This may be due to increased international capital mobility, as suggested in Iversen (2000). As alluded to above, it may also be a result of the (then) economic orthodoxy, that increased conservatism reduces inflation at no real cost. The empirical debate regarding the potential 'neutrality' of central bank preferences is, though, far from settled. Most early work found that economies with relatively independent central banks had relatively low inflation rates, and that there were indeed no associated costs in terms of growth and unemployment - see for example De Haan and Sturm (1992) or Alesina and Summers (1993). Again, interpretation of such results hinges on the confidence one places in the measures of central bank independence used, and whether or not 'independence' is indeed a useful concept at all in the debate. While it would seem more legitimate to infer increases over time in conservatism from increased independence *within* countries, controlling as this does for any idiosyncratic constitutional and political features of an economy, interpretation of static cross-country regressions is more difficult. What is more, the empirical work largely omits other variables of interest, for example any relating to labour market structure. Even if independence is a perfect proxy for conservatism, one must control for any other institutional variables which vary with it.

Neither is the 'neutrality' view, that central bank behaviour has no real effects, easily reconciled with casual observation. As Solow and Taylor (1998) point out:

> "...contrary to what many modern macroeconomic models suggest, central bank actions often affect both inflation and measures of real economic activity...but the nature and magnitude of these effects are not yet understood."

Recent work, to be reviewed next, provides one possible theoretical basis for such effects, based on the interaction between central bank behaviour and the structure of the labour market.

3.2.3 Institutional interaction

The two strands of literature, on central bank preferences and on labour market structure, remained largely distinct until recently, with several papers augmenting the standard strategic monetary policy game with non-atomistic wage-setters. Soskice and Iversen (2000) provide a model where non-accommodatory monetary policy deters such wage-setters from demanding large nominal wage increases. The intuition is as follows: if the central bank refuses to accommodate any wage increases and instead sets a nominal anchor, the aggregate demand implications of said wage increases are more severe; large wage-setters, interacting strategically with one another, will as a result moderate their wage demands. Highly conservative central banks will thus be associated with high levels of employment.

This is the opposite conclusion to those reached by two other recent papers. Both Cukierman and Lippi (1999a) and Guzzo and Velasco (1999) assume unions dislike inflation *per se*; if unions also like higher real wages, then increased conservatism will result in higher wage demands (and thus lower employment), since the inflationary cost of a given nominal wage increase is smaller[48]. More interestingly, at least for the purposes of this paper, Cukierman and Lippi provide a second channel through which conservatism reduces employment. They assume that, in addition to being increasing in its real wage, the objective function of a single union j is decreasing in (w_j/w), where w is the economy-wide nominal wage level. This is justified on grounds of inter-union labour market competition, and leads to what they call a 'competition-induced strategic non-neutrality'; a more conservative central bank means that, for a given increase in its real wage, a union incurs a smaller 'relative wage cost', and so in equilibrium real wages will be higher, employment lower. In models such as this, therefore, the results are highly sensitive to the specification of labour demand. Crucial is whether the labour demand facing a single union is increasing in the average wage across unions (as in Soskice and Iversen (2000)), or is decreasing therein (as in Cukierman and Lippi (1999a)). In the latter case the competition effect of an aggregate wage increase dominates; in the former, it is the aggregate demand effect which prevails.

The model presented below will follow Soskice and Iversen (2000) (and Guzzo and Velasco (1999)) in its implicit assumption that the labour varieties offered by different unions are complements in the representative production function. Any competitive advantage conferred upon union j by an increase in the wages of 'rival' unions will be outweighed by the impact of the rise in the aggregate wage level on

[48] Gruner and Hefeker (1999) present a model, similar in spirit, which analyses the effect of a monetary union between many countries, each with a single labour union that dislikes inflation.

aggregate output and labour demand[49]. Such an assumption may be justified as follows. The paper is concerned with the formation of coalitions between unions, not with the initial formation of the unions themselves.The empirical motivation is the fragmentation of bargaining systems, starting in many cases from high levels of centralisation, particularly in western Europe. It should be emphasised that the model here *will not* encompass the case of an atomistic labour market, where the number of wage-setters is allowed to go to infinity. Given that the basic building block is the labour union, not the individual worker, an assumption of low substitutability is not so strong.

3.2.4 Institutional evolution - a causal link?

While the papers considered above explicitly model the interaction between monetary policy and labour market structure, the latter is taken as given. This may be appropriate over a short enough time horizon, for example over the course of a single-period monetary policy game; labour market institutions are presumably characterised by greater inertia than are monetary policy instruments. Such games are, though, repeated indefinitely, and one would expect the the wage-setting structure to gradually evolve in response to policy stance.

The model presented here necessarily abstracts from any inertia in the labour market structure and considers a single monetary policy game in isolation. Unions set wages and the central bank subsequently chooses inflation; prior to this, the forward-looking unions may form coalitions with one another. The preferences of the central bank will determine the equilibrium coalition structure.

The possibility that the pattern of wage-bargaining and the conduct of monetary policy are causally linked has been raised before. Eichengreen and Iversen (1999, p.133) suggest that the observed increase in conservatism was a *response* to the more diffuse wage-setting structure:

> "Instead, where centralised bargaining and continuous consultation between the peak associations and government could no longer be relied on for wage restraint, there was a pressing need to anchor inflationary expectations...by adopting an exchange-rate commitment and

[49] In this view, for example, an increase in the real wages of the engineers' union will reduce demand for the labour of postal workers.

giving the central bank the independence to pursue it."

However, as they point out in the preceding paragraph:

"...decentralisation came first in those countries most committed to price and exchange-rate stability and integrated into international capital markets. Belgium and the Netherlands shifted to industry-based bargaining systems in the 1970s, followed by Denmark in the 1980s, and Sweden in the 1990s."

Discerning which came first, decentralisation or increased conservatism, is not straightforward, since discerning changes in the *effective* degree of wage coordination or of central bank conservatism is itself not easy. Overt institutional changes are likely to lag changes in behaviour, especially with regard to monetary policy. However, the thesis of this paper is that the fragmentation of wage bargaining was, at least in part, a result of more anti-inflationary macroeconomic regimes. This is consistent with recent work by Steinar Holden[50], examining the incentives for wage-coordination under various monetary regimes in the presence of trigger strategies[51]. Holden's model will be discussed in more detail below, when the implications of monetary union are examined. He also surveys the cross-country empirical evidence on monetary regime and the coordination of wage-setting. He argues that, if one omits countries with highly decentralised labour markets such as the UK and the US, there is evidence that countries with more accommodating monetary policies also have more centralised wage-bargaining systems. This is consistent with the current paper; it was argued above that the model here does not apply to countries with atomistic labour markets. However, the sample of countries in such work is always rather small, and any evidence they provide should be treated as no more than suggestive.

The next section introduces the monetary policy game between the central bank and the unions.

3.3 Many wage-setters and one central bank: a simple monetary policy game

The monetary policy game will now be presented and solved, assuming a given coalition structure.

[50] Holden (2001).

[51] This author came across Holden's model while preparing the final draft of this chapter for this thesis.

3.3.1 The labour unions

There are n labour groups, referred to hereon as unions. Let w_j denote the normalised, nominal wage set on behalf of union j:

$$w_j = \widetilde{w}_j - \delta \tag{81}$$

where $\widetilde{w}_j$ is the simple nominal wage and δ is a parameter. The normalisation is for technical purposes only. Now, the demand for the labour of union j is assumed to be decreasing in the average wage across all unions; recall the discussion in Section 2.3[52]. Purely for simplicity, this is the only argument in the labour demand function:

$$l_j = \beta_0 \left(\frac{w}{p}\right)^{-1}, \tag{82}$$

where $w = \frac{1}{n}\sum_{k=1}^{n} w_k$, p is the price level and β_0 is a parameter. As noted before, the implication is that labour is not highly substitutable across different unions - a higher aggregate wage leads to a fall in demand for the labour of union j via a fall in aggregate demand.

The objective function of each union, V_j, is increasing in both its income and employment levels:

$$\begin{aligned} V_j &= \left(\frac{w_j}{p}\right) l_j - l_j^{-1} && (83) \\ &= \beta_0 \left(\frac{w_j}{w}\right) - \beta_0^{-1}\left(\frac{w}{p}\right). && (84) \end{aligned}$$

Each union's utility is thus increasing in its relative wage $\left(\frac{w_j}{w}\right)$, and decreasing in the aggregate real wage[53]. Unions may be thought of as wanting high wages, but not to the extent that this feeds into the aggregate real wage and chokes off aggregate demand. We thus have that aggregate union welfare, as

[52] The use of the normalised nominal wage in the labour demand function could be justified as follows. Think of the parameter δ as the cost of leisure activity, fixed for the duration of the game. The labour demand function may then be thought of as resulting from a simple shirking model; the higher the cost of leisure, the greater the cost of shirking, and the harder each employee will work.

[53] A more 'realistic' labour demand function than (82) could have been used, for example by including the union's own wage $\frac{w_j}{p}$. Then, to obtain (84), which is convenient for the coalition formation game to come, one would merely have to tinker with the basic specification for the objective function, (83), a little.

measured by averaging over their objective functions, is linearly decreasing in the aggregate real wage:

$$\overline{V} = \frac{1}{n}\sum_{j=1}^{n} V_j \quad (85)$$

$$= \beta_0 - \beta_0^{-1}\left(\frac{w}{p}\right). \quad (86)$$

The unions are organised into N wage-bargaining groups or coalitions, where $N \geq 2$. These coalitions may be of heterogeneous size. Each coalition i sets a single wage $w_i$on behalf of all constituent unions, with its aim to maximise the average of the constituents' objective functions:

$$\Omega_i = \frac{1}{s_i}\sum_{j=1}^{s_i} V_j \quad (87)$$

$$= \beta_0\left(\frac{w_i}{w}\right) - \beta_0^{-1}\left(\frac{w}{p}\right) \quad (88)$$

where $s_i \in [1, n-1]$ is the number of labour unions in coalition i.

3.3.2 The central bank

The central bank has a loss function that is increasing in inflation and decreasing in the average utility across unions:

$$L = [\log(\beta_0\left(\beta_0 - \overline{V}\right))]^2 + \theta[\log \pi]^2, \quad (89)$$

where $\pi = \log p - \log p_{-1}$ is the rate of inflation and $\theta \in (0, \infty)$ measures the degree of conservatism of the central bank. Setting the previous period's price level, p_{-1}, equal to unity without loss of generality, the loss function may be rewritten:

$$L = [\log w - \log p]^2 + \theta[\log p]^2. \quad (90)$$

3.3.3 Solving the game

The game is in two stages - first, the labour coalitions set wages, then the central bank chooses inflation. To obtain a subgame-perfect equilibrium, the game is solved backwards.

The central bank's problem The central bank chooses inflation to minimise (90), taking wages as given. Analysis of the first-order condition leads to the following expression for inflation:

$$\log p = \frac{1}{1+\theta}\log w, \tag{91}$$

If $\theta = \infty$, then any increase in nominal wages will show up as an increase in real wages; should $\theta = 0$, then the real wage is fixed - all nominal wage increases are matched by increases in the price level. Note that (91) implies:

$$\frac{\partial p}{\partial w} = \frac{1}{1+\theta}\frac{p}{w}. \tag{92}$$

The wage-setters' problem Each coalition i sets a wage w_i to maximise Ω_i in (88). Consider the following first-order condition:

$$\begin{aligned}\frac{\partial \Omega_i}{\partial w_i} &= \beta_0\left(\frac{1}{w} - \frac{\alpha_i w_i}{w^2}\right) - \beta_0^{-1}\alpha_i\left(\frac{1}{p} - \frac{w}{p^2}\frac{\partial p}{\partial w}\right) && (93)\\ &= \beta_0\left(\frac{1}{w} - \frac{\alpha_i w_i}{w^2}\right) - \beta_0^{-1}\alpha_i\frac{\theta}{(1+\theta)p}, && (94)\end{aligned}$$

where $\alpha_i = \frac{s_i}{n}$ denotes the proportion of all labour unions that are members of coalition i; thus, $\frac{\partial w}{\partial w_i} = \alpha_i$. Rearranging, we have an expression involving the aggregate wage:

$$\beta_0^2\left(1 - \frac{\alpha_i w_i}{w}\right) = \left(\frac{\theta}{1+\theta}\right)\alpha_i\frac{w}{p}, \tag{95}$$

which may be summed over all coalitions to obtain an explicit solution for $\frac{w}{p}$:

$$\left(\frac{w}{p}\right)^* = \beta_0^2\,(N-1)\left(\frac{1+\theta}{\theta}\right). \tag{96}$$

Substituting this into the first-order condition (95), we can solve for the relative wage of each coalition[54]:

$$\left(\frac{w_i}{w}\right)^* = 1 + \left(\frac{1}{\alpha_i} - N\right). \tag{97}$$

[54] And with this expression in hand the second-order condition to the wage-setting problem is easily obtained:

$$\frac{\partial^2 \Omega_i}{\partial w_i^2} = \beta_0\left[\frac{\alpha_i^2\,(N-1)}{w^2}\right]\cdot\left(\frac{1}{(1+\theta)} - 2\right) < 0.$$

We see that if all coalitions are of the same size, i.e. $\alpha_i = \frac{1}{N}, \forall i$, then they all set the same wage $w_i = w$. With coalitions of heterogeneous size, the larger coalitions set lower wages; in effect, they are restrained in their wage demands by their disproportionate effect on aggregate labour demand.

3.3.4 Inflation and unemployment

We see from (96) that the aggregate wage level is increasing in N, but, given the number of wage-setters, is decreasing in θ[55]. The former result is due to a straightforward internalisation effect - the more wage-setters there are, the less each takes into account its effect on the average wage, and the higher each sets its own wage.

That wages are decreasing in conservatism is due to the particular reduced-form taken by the coalition objective function (88). It is increasing in the nominal wage ratio (w_i/w) and decreasing in the aggregate wage (w/p). For a given increase in its own wage w_i, coalition i gains from an increase in its relative wage (w_i/w), but incurs an aggregate wage cost via the associated increase in (w/p). The more conservative the central bank, the higher will be this aggregate wage cost, as increases in the aggregate nominal wage w will be met by less accommodating increases in p; wage-setters will moderate their actions accordingly[56]. Figure 9 shows how the aggregate real wage varies with conservatism and with decentralisation of wage-setting.

Average union welfare, as measured by (86), and employment are both therefore increasing in central bank conservatism and decreasing in the decentralisation of wage bargaining. The inflation rate is obtained as:

$$\begin{aligned} \pi^* &= \frac{1}{\theta}\left[\log w - \log p\right] && (98) \\ &= \frac{1}{\theta}\log\left[\beta_0^2 (N-1)\left(\frac{1+\theta}{\theta}\right)\right] && (99) \\ &\approx \frac{1}{\theta}\left[2\log\beta_0 + \log(N-1) + \frac{1}{(1+\theta)}\right]. && (100) \end{aligned}$$

[55] Specifically, $\frac{\partial\left(\frac{w}{p}\right)^*}{\partial N} = \beta_0^2\left(\frac{1+\theta}{\theta}\right) > 0$ and $\frac{\partial\left(\frac{w}{p}\right)^*}{\partial\theta} = -\beta_0^2\left(\frac{N-1}{\theta^2}\right) < 0$.

[56] This is similar to the 'competition-induced strategic non-neutrality' in Cukierman and Lippi (1999a), but one that works in the opposite direction.

Inflation is therefore decreasing in conservatism and increasing in decentralisation[57]; see Figure 10.

It seems, then, that central bank conservatism is unambiguously beneficial, *given the structure of the labour market* - greater conservatism results in lower inflation, lower aggregate wages and higher employment. A more decentralised wage-setting structure, on the other hand, leads to higher inflation, higher aggregate wages and lower employment[58].

What about disaggregate union welfare? Using (97) and (96) to solve for the equilibrium value of the objective function for each coalition, we see that the welfare of each coalition is decreasing in its size:

$$\Omega_i^* = \beta_0 \left[\frac{1}{\alpha_i} - \left(2 + \frac{1}{\theta} \right) (N-1) \right]. \tag{101}$$

A relatively small coalition is able to increase its own wage without too much effect on aggregate labour demand. However, each coalition's welfare is also decreasing in the total number of coalitions. This is due to the internalisation effect: many coalitions means high aggregate wages, which means low aggregate demand. This tension between wanting to be as small a coalition as possible, but not wanting the number of coalitions to be too high, will be crucial in the next section, where the coalitional structure of wage-bargaining is endogenised.

3.4 Endogenous labour market structure

3.4.1 Stable coalition structures

Game theorists have thought about the endogenous formation of coalitions since the field's inception. Much work, however, focuses not on the actual process of formation. Instead, it seeks to identify the classes of 'stable' coalition structures - those that, once formed, are immune to defection and will not disintegrate. This of course requires an operative concept of stability. In a game like the one here, the formation or disintegration of a coalition imposes externalities on members of other coalitions; agents' payoffs are affected not just by the nature of the coalitions of which they are members, but by the

[57] Precisely, $\frac{\partial \pi^*}{\partial N} = [\theta(N-1)]^{-1} > 0$, while

$\frac{\partial \pi^*}{\partial \theta} = -\theta^{-2} \left[log(\beta_0^2(N-1)\left(\frac{1+\theta}{\theta}\right)) + \frac{1}{1+\theta} \right] < 0.$

[58] Again, it should be emphasised that the model here does not capture any competitive effects associated with extreme decentralisation.

entire coalition structure[59]. Consideration of stability thus necessitates a specification of the reaction of external players to any defections. Kurz (1988) delineates five concepts of stability applicable in games with externalities; these range from core stability, where external players act as if to maximise the payoffs of deviating players, to α stability, where external players minimise the payoffs of any defectors. That used here is that δ-stability, in which coalitions untouched by defections remain intact, and members of coalitions from which others have defected remain together, forming smaller coalitions[60,61].

Formally, a coalition structure C is a partition of the player set P. Each player P_j will here correspond to a labour union. Each coalition C_i is a non-empty subset of players, with $C_i \cap C_h = \emptyset$ for $i \neq h$, and $\bigcup_{i=1}^{N} C_i = P$. The set of all coalition structures is Ψ. For any subset K of P, the set of partitions on K is denoted Ψ_K, with typical member C_K. Denote by $u_j(C)$ the payoff obtained by player P_j if the coalition structure C is formed.

Definition 6 *A coalition structure C' is δ-stable if there does not exist a group of players K and a partition C''_K on K such that, $\forall i \in K$, $u_j\left(C''_K \cup C'_{P\backslash K}\right) > u_j(C')$.*

The classes of coalition structures that are stable under this stability concept, with payoffs according to the monetary policy game above, will be presented below, after non-cooperative games of coalition

[59] Recall that each union's payoff depends not only on the size of its coalition but also on the total number of coalitions.

[60] As such, δ-stability assumes either that non-deviators will not react to any deviations, or that they will and deviators are myopic. This is obviously unattractive. However, the expected reactions of non-deviators implied by the other cooperative stability concepts are at least equally unsatisfactory. Myopia or inertia may be more acceptable than, say, assuming non-deviators act to punish deviators, no matter the cost to themselves.

[61] The other two stability criteria suggested by Hart and Kurz are as follows. Under γ stability, coalitions which are left by some members dissolve. Under β stability, a group K of players deviates if, for any possible reaction of the external players, there exists a partition of K such that all members of K are better off in the new coalition structure. Note that this is different to α-stability, under which players deviate if there exists a partition of K such that, for any possible reaction of the external players, all members of K are better off. Denote, for any mapping u from coalition structures to payoffs, the sets of core stable, γ stable, δ stable, β stable and α stable structures by $\Delta c(u)$, $\Delta\gamma(u)$, $\Delta\delta(u)$, $\Delta\beta(u)$ and $\Delta\alpha(u)$ respectively. Bloch (1996) provides the following result:

$$\forall u,\ \Delta c(u) \subset (\Delta\gamma(u) \cup \Delta\delta(u)) \subset \Delta\beta(u) \subset \Delta\alpha(u).$$

formation are reviewed.

3.4.2 Non-cooperative coalition formation with externalities

Non-cooperative theories of coalition formation focus on the actual process by which coalitions are formed, rather than their subsequent stability. There has been considerable attention paid to such models in recent years, with particular focus on games where the formation of a coalition imposes externalities on non-members. Models presented by Bloch (1996), Ray and Vohra (1998) and Yi and Shin (1995) deal with such games, and share a common, two-stage structure[62]. In the first stage, agents form coalitions with one another, while in the second they play a non-cooperative game, with payoffs dependent on the coalition structure determined initially. The models differ in the rules they propose for the first-stage coalition formation process. Bloch requires that a coalition forms if and only if all potential members agree to form the coalition; Ray and Vohra consider an 'equilibrium binding agreements' rule, under the condition that coalitions may break up into smaller subcoalitions only; and Yi and Shin allow non-members to join a coalition without the permission of members. The model used here is that used in Bloch (1996), as the unanimity rule seems most intuitive and appropriate.

The formal structure of the coalition formation game is laid out below.

Coalitional unanimity with infinite horizons The coalition formation process in Bloch's game is as follows. Formally, let there be q identical players. In the first stage of the game, these players form coalitions. In the second, they engage in a non-cooperative game of the type set out in this paper, given the coalition structure determined initially. The payoffs from this second-stage game are assumed to be shared equally among the members of each coalition - there are no side payments. The players are labelled $P_1, P_2, ..., P_q$, according to an exogenous *rule of order* R; this rule of order determines the sequence in which players will move in the coalition formation game. Finally, it is assumed that players do not discount the future.

The coalition formation game proceeds as follows. Player P_q starts the game by proposing the

[62] See Yi (1997) for a comparison of these three games.

formation of a coalition to which she belongs, e.g $\{P_q, P_{24}, P_{18,}P_{13}\}$. Then, the player in the proposed coalition with the highest index, apart from P_q (here, P_{24}), accepts or rejects the proposal. If P_{24} accepts, it is then P_{18}'s turn to accept or reject, and the process goes on until either all potential members have accepted, or the first person rejects it. If a player rejects the proposed coalition, the proposal is immediately thrown out, and the player who rejects it starts the process again by proposing a coalition. If all potential members accept the coalition, then the coalition is formed and the process is repeated with the remaining players in P, again starting with the player with the highest index. Once a coalition is formed, it cannot dissolve, admit new members or merge with any other coalition.

Bloch (1996) focuses on stationary subgame perfect equilibrium strategies. He shows that, where players are *ex ante* identical, the infinite-horizon Coalition Unanimity game results in the same equilibrium coalition structure as the following "Size Announcement" game[63].

Definition 7 *The Size Announcement game. Again, the players move according to the exogenous rule of order R. P_q simply chooses the size of her coalition, $s(q)$, and players $\{P_q, P_{q-1}, ..., P_{q-s+1}\}$ form such a coalition. Then, player $P_{q-s(q)}$ announces a coalition size $s(q - s(q))$, and the next $s(q - s(q))$ players form such a coalition. This continues until player P_1 is reached. The equilibrium coalition structure of such a game is generically unique.*

This Size Announcement game provides a relatively straightforward method for obtaining the subgame-perfect equilibrium coalition structure in the formal coalition unanimity game. Player P_q has first-mover advantage, and will choose her coalition size to maximise her payoff, given the strategies of the other players in the game. This technique will be used to solve for the equilibrium pattern of alliances between labour unions, prior to the monetary policy game.

3.4.3 Equilibrium coalition structure and central bank conservatism

Before solving for the equilibrium coalition structure, the appropriate payoff function $u_j(C)$ must be agreed upon. We saw in (101) that the equilibrium payoff for the members of a coalition C_i from the

[63]Strictly speaking, equivalence between the two games requires that, in the Size Announcement game, players' payoffs are decreasing in the order that coalitions are formed. This will be true here.

monetary policy game is decreasing in both the size of the coalition, $\alpha_i = \frac{s_i}{n}$, and in the number of coalitions. All that is necessary for the coalition formation game is the relative weight placed upon these two arguments. Using (101), and in a slight abuse of notation, we may therefore write the payoff as follows:

$$\begin{aligned} u_j(C) &= u_j\left(n^{j,C}, N^C\right) = \beta_0^{-1}\Omega_i^* && (102) \\ &= \frac{n}{n^{j,C}} - \left(2 + \frac{1}{\theta}\right) N^C, && (103) \end{aligned}$$

where $n^{j,C}$ is the number of members in union j's coalition under coalition structure C, while N^C is the total number of coalitions under C.

Finally, since the monetary policy game is well-defined only if the number of coalitions $N \geq 2$, the n unions are split into v groups of equal size, and coalition formation will be restricted to within each group[64]. Within each group, the unions are labelled $\{P_1, P_2, ..., P_{\frac{n}{v}}\}$, and play the Size Announcement game as detailed above. Note that the fact that the payoff function (103) is linear in N means each group may ignore the result of the Size Announcement game in its counterpart.

First, the equilibrium coalition structure using Bloch's non-cooperative game.

Proposition 8 *In the equilibrium of each Size Announcement game, the coalition structure depends on both the number of unions n and the degree of central bank conservatism. Denote by m^0 the highest integer such that $m^0 < \frac{n}{n-\left(2+\frac{1}{\theta}\right)}$, and define $m^y = m^{y-1} + \frac{n}{\left(2+\frac{1}{\theta}\right)}$.*

- *If $2 + \frac{1}{\theta} > \frac{1}{n-v-2}$, a single 'grand coalition' consisting of all $\frac{n}{v}$ unions will form.*
- *If $2 + \frac{1}{\theta} \leq \frac{1}{n-v-2}$, then multiple coalitions may emerge. The relationship between the number of coalitions and conservatism is nonlinear, with the precise equilibrium structure characterised as follows. Consider m^z, where $\frac{n}{v} - \frac{n}{\left(2+\frac{1}{\theta}\right)} < m^z \leq \frac{n}{v}$. All players P_m where $m > m^z$ will choose to remain isolated, starting with $P_{\frac{n}{v}}$; then, P_{m^z} will announce a single unifying coalition, consisting*

[64] This division is admittedly arbitrary, but allows for the formation of 'grand coalitions' consisting of all players in the respective Size Announcement games. Also, it could be thought of as accommodating a degree of institutional realism - there may indeed be unions that are unable to form coalitions with one another, for reasons external to the model. Examples could be the services and manufacturing industries, or the public and private sectors.

of the remaining m^z players. If $m^z = \frac{n}{2}$, then $P_{\frac{n}{2}}$ will announce the grand coalition. The number of coalitions formed (including those players remaining isolated) will be equal to $\frac{n}{2} - m^z + 1$. The maximum possible number of coalitions will be equal to $\frac{n}{\left(2+\frac{1}{\theta}\right)}$.

Proof: see chapter appendix.

Corollary 9 *If the central bank is sufficiently conservative, then wage-bargaining is completely decentralised.*

Proof: if $\left(2+\frac{1}{\theta}\right) < \frac{n}{2}$, then by the above proposition multiple coalitions will emerge, and $m^0 = 1$. All that remains is to ensure that $\frac{n}{\left(2+\frac{1}{1+\theta}\right)} > \frac{n}{v} - 1$; this is true if $\theta > \frac{n-v}{nv-2(n-v)}$.

To see why conservatism tends to lead to decentralisation of wage-setting, examine (103). The weight attached to number of coalitions as opposed to coalition size in determining the payoff of each coalition member is increasing in $\frac{1}{1+\theta}$, the degree to which the central bank accommodates nominal wage increases. To see in turn why this is the case, we must again go back to the objective function Ω_i. The first argument in (88) is the relative wage $\left(\frac{w_i}{w}\right)$. We can see from (97) that, in equilibrium, the associated payoff to 'smallness' is unaffected by the central bank's preferences. However, the disutility caused by there being many wage-setting groups is decreasing in conservatism.

Intuitively, the existence of multiple wage-setters leads to a collective action problem, whereby individual wage-setters fail to internalise the aggregate effects of their actions, and are only partially restrained in their wage demands by the threat of a higher aggregate real wage. The less conservative the central bank, the less effective is even this restraint, as increasing the individual wage will have an even lower impact in the aggregate, and the higher will wages be set. Essentially, a more accommodating central bank exacerbates the internalisation problem[65]. When forming coalitions, the labour unions must trade off the gains from being small against the harm caused by there being many coalitions; the more accommodating the central bank, the greater such harm, and the fewer coalitions formed in equilibrium. In contrast, a more conservative central bank means that each union places more weight on being small, and the number of coalitions formed will increase.

[65] Note that the internalisation problem remains even when the central bank is infinitely conservative.

The strategies are summarised in Figure 11, for the case where many coalitions emerge. Figure 12 shows the results of simulations of the coalition-formation game, for $n = 60$ and $v = 3, \frac{1}{1+\theta} \in (0, 1)$. We see that, while the relationship is not strictly monotonic, high levels of conservatism will tend to result in more wage-setters. Figure 13 shows how the aggregate real wage varies with conservatism, allowing for the endogeneity of the labour market structure; for comparison, also graphed is the wage when no coalition formation is allowed.

The non-monotonicity of the relationship between conservatism and the equilibrium number of coalitions stems from a particularity of the coalition formation game, namely the existence of an *(ad hoc)* order rule forcing players to move sequentially. Each player looks forward to the strategies of subsequent players, with the crucial statistic being the number of such players that will remain isolated before some future player chooses to unify with those remaining. From the point of view of the first player to move, greater conservatism has two effects. It will mean that she will tolerate a larger number of immediately subsequent players remaining isolated before she decides to announce the grand coalition - this will tend to lead to more coalitions (of isolated players) in equilibrium. However, increased conservatism also affects the number of subsequent players that choose to remain isolated; for exactly the same reason as above, increased conservatism may mean the first subsequent player to announce a unifying coalition comes earlier in the sequence. This would tend to lead to fewer coalitions in equilibrium.

That the order rule is ad hoc may be unappealing. Any non-cooperative coalition formation game must have rules of some sort, however, and given the symmetry of the players this is perhaps the least offensive; changing the order the players moved would not alter the basic equilibrium structure, nor the general conclusion that increased conservatism is associated with a more diffuse wage-setting structure. The following proposition confirms that a cooperative stability concept affords similar results[66].

Proposition 10 *Given the payoffs described by the monetary policy game above, the only possible δ-stable coalition structures are the grand coalition, consisting of all $\frac{n}{v}$ unions, the completely diffuse structure where all unions are isolated, and the coalition structure consisting of one isolated player and a*

[66] Once more it is assumed that the unions are divided into v separate groups, with coalitions formed within these groups. Potential deviations are similarly restricted.

single coalition comprising the remaining $\frac{n}{v} - 1$ players. In particular:

- *the grand coalition is δ-stable if and only if $\theta < \frac{1}{n-v-2}$.*
- *the coalition structure consisting of one isolated player and a single coalition of $\frac{n}{v} - 1$ players is δ-stable if and only if $\frac{1}{n-v-2} \leq \theta < \frac{n-v}{(n-v)(n-2)-vn}$.*
- *the diffuse structure is δ-stable if and only if $\theta \geq \frac{1}{v-2}$.*

Proof: see Appendix.

This pattern of coalition structures is summarised in Figure 14. Note that for some values of θ there is no δ-stable structure. This is a shortcoming of the cooperative concept, when compared with the non-cooperative game of Bloch.

3.5 The effects of monetary union

The analysis above has some bearing on the likely effects of European monetary union on labour market structure and unemployment in the eurozone. Cukierman and Lippi (1999b) consider explicitly the effect of a single European monetary authority, using their model examined above. They argue that transition to monetary union will tend to make labour unions more aggressive in their wage demands, increasing unemployment; in terms of the model of this paper, they see the introduction of the European Central Bank as analagous to an increase in N in (96). Crucially in their analysis, the total number of labour unions across constituent countries remains fixed. Given that monetary union constitutes a major shift in the macroeconomic policy regime, one might think this a strong assumption. One may expect the architecture of wage coordination across these countries to evolve as a result, either via the re-organisation of unions within countries or via the development of alliances across national borders.

Holden (2001) develops this argument, using his model of wage-coordination enforced by trigger strategies. His model focuses on two wage-setting regimes: a non-cooperative one where each of his k industries (corresponding to the n labour unions here) sets wages in isolation, and one where the industries cooperate and each sets the wage that jointly maximises their payoff function. All industries are better off in the latter, cooperative regime. However, there is an incentive for an individual union to deviate and raise its wages while others are restrained. Should a single industry thus increase its wage demands, it will enjoy a one-period increase in its payoff; in subsequent periods the other $(k-1)$ industries will do likewise, reverting to the non-cooperative equilibrium; this will continue until an exogenous shock shifts the economy back to the cooperative regime. Again, while the effect of central bank conservatism is ambiguous over certain parameter ranges, his simulations show that the discount rate needed to sustain cooperation tends to be lower when monetary policy is accommodating. This conclusion is in the spirit of this paper's results. Holden goes on to argue informally that monetary union, since it increases the costs associated with the non-cooperative regime (*cf.* Cukierman and Lippi), will increase the incentive to cooperate[67], and therefore that the coming years should see either the formation of cross-border wage-bargaining coalitions in the eurozone, or an increase in the degree of coordination within constituent countries.

This might seem intuitive. There is perhaps more to be said, though. While monetary union will undoubtedly, in Holden's model, reduce the payoff associated with the non-cooperative equilibrium, it will also affect the one-period payoff from deviation; this is ignored in his argument[68]. His general conclusion may be robust to this consideration. However, it is does not necessarily carry over to alternative theories of wage coordination. In terms of the model of this paper, consider an increase in n, the number of labour unions, as a crude way to proxy the effect of a single currency area; say the number of unions rises to Qn, where Q is the number of eurozone countries, assumed of equal 'size'. Suppose there is no change in θ. As for v, the number of arbitrarily distinct wage-setting groups, suppose it neither falls nor rises more than proportionately with n; denote by v^b its value prior to monetary union (*i.e.* within each country) and $v^a \geq v^b$ the number following the introduction of the single currency (*i.e.* across the whole eurozone)[69]. What will be the consequences for the equilibrium coalition structure?

[67] More precisely, it will reduce the discount rate necessary to sustain cooperation.

[68] Holden does not derive the optimal deviation strategy, but assumes that a defecting industry union raises wages by an arbitrary amount, compared to the cooperative equilibrium.

[69] That v will not rise more than proportionately with n seems plausible, since two extremes may be reasonably considered. Should idiosyncracies in local bargaining conditions rule out cross-border alliances, n and v should rise proportionately,

First consider Bloch's non-cooperative model, with $(2+\frac{1}{\theta}) > n - v^b$. Prior to monetary union, in each Size Announcement game the grand coalition will be formed, and the total number of wage-setting coalitions across the Q countries will be equal to $N^{EUb} = Qv^b$. Under a single currency, should $(2+\frac{1}{\theta}) > Qn - v^a$ then the grand coalition will once again be announced in each of the v^a Size Announcement games, and the number of wage-setting coalitions across countries will be equal to $N^{EUa} = v^a$, potentially less than the Qv^b such coalitions before the single currency. Should $(2+\frac{1}{\theta}) \leq Qn - v^a$, however, then there may be multiple coalitions announced in each of the v^a games. Suppose that in each of these games the maximum possible number of coalitions results: the total number of coalitions across the eurozone will then be equal to $N^{EUa} = \frac{Qnv^a}{(2+\frac{1}{\theta})}$. The condition for monetary union to have actually increased the total number of wage-setters, i.e. for $N^{EUa} > N^{EUb}$, is then that $\frac{n}{(2+\frac{1}{\theta})} > \frac{v^b}{v^a}$; this condition is consistent with all the previous assumptions. Figure 15 shows the results of simulations of N^{EUa} and N^{EUb}, with $n = 60$, $v^b = 3$, $Q = 10$ and $v^a \in \{3, 6, 15\}$. Even when it is assumed that $v^a = v^b = 3$, we see that the coalition structure under a single currency is almost identical to that with many monetary authorities; where the number of exogenous divisions is allowed to increase by reasonable amounts (bearing in mind that the number of countries has risen ten-fold), the structure is considerably more diffuse under a single currency, at least at lower levels of conservatism[70].

That monetary union does not necessarily lead to an increase in coordination, and may even accelerate fragmentation of the wage-bargaining structure, is thanks to the increased payoff from being small. This is perhaps analagous to the incentive to deviate in Holden's model. Examining (101), one sees that a coalition of a given size (that is, consisting of a given number of labour unions) receives a higher payoff, the more unions there are in the game overall, since this reduces $\alpha_i = \frac{s_i}{n}$. Under the cooperative stability concept, this will lead to a greater incentive for a given labour union to defect, holding constant the number of coalitions in the structure. The intuition for the non-cooperative result is similar. From the perspective of a single labour group, while monetary union may increase the loss associated with *nobody*

and one would expect $v^a = Qv^b$. If instead unions are divided along industry lines, and unions from the same industry but different countries *are* able to bargain jointly, then one would expect $v^a = v^b$.

[70] Similar results obtain if the cooperative concept of δ-stability is used.

forming alliances, it increases the payoff associated with retaining wage-setting autonomy while other labour groups coordinate.

Of course, the models of coalition structure here are highly stylised, and to suggest their predictions for labour market structure following monetary union are robust would be egregious. It seems reasonable to conclude that there are forces working in each direction, towards either fragmentation or consolidation of wage-setting structures post-EMU. However, it is not enough to directly compare a regime with complete coordination to one where there is none at all. One must examine the incentives of *individual* unions to engage in such coordination, the effects of monetary union upon which are not *a priori* obvious.

3.6 Concluding remarks

In the model presented, for a given labour market structure, increasing central bank conservatism is unambiguously good for the economy, resulting as it does in lower inflation and higher employment. However, increasing conservatism tends to result in decentralisation of wage-setting, associated with lower employment. It was argued that the gradual decentralisation of wage bargaining in developed economies was a result of the concurrent shift towards more anti-inflationary macroeconomic policy regimes. It was also shown that, once the effect of monetary regime on labour market structure is taken into account, an employment-maximising central banker is one that indeed attaches some weight to real variables.

The work here is relevant for the debate on the macroeconomic implications of monetary union. One might expect the architecture of wage coordination across eurozone countries to evolve as a result. However, it was argued that the nature of any such evolution is not *a priori* clear, and that EMU could even accelerate the observed fragmentation of bargaining systems.

There are obvious extensions. The model is restrictive in its treatment of labour demand, in that the workforces of different unions are assumed not to be close substitutes. It would be interesting to see how the equilibrium coalition structure in the labour market varied with the substitutability of labour.

There was no direct role played here by the union federations, the umbrella organisations which are responsible for bargaining in highly centralised systems; in the model, they are chimeric entities, assumed to maximise the welfare of their constituent unions. In reality these federations are distinct bodies, with separate administrations, personnel and perhaps separate goals. It was noted that in Germany the federations were against decentralisation of wage-setting, despite their constituent unions being in favour. There are at least two competing explanations for this. The first is that the federations were simply trying to retain a degree of influence that would be diminished, were wage-setting responsibilities devolved to individual unions - they were not maximising the welfare of their constituents, but their own. While this is plausible, there is a second argument more in keeping with the spirit of this paper. In the language of the model laid out above, the incentive for the individual union to break away from the parent federation is that it will be able to free-ride on the wage restraint shown by the remaining unions. However, if a sufficient number do this, then little wage restraint will be shown and most will be worse off. Institutionalised coordination of wage-bargaining, for example via the establishment of a union federation, may be seen as an attempt to solve this collective action problem. The federation not only sets wages on behalf of its constituents, but actively tries to prevent individual 'defections' and keep the coalition intact. It monitors the behaviour of the member unions for wage increases over and above those agreed centrally, and punishes such deviations. This is in contrast to the procedure in this paper, whereby the individual unions are free to form what coalitions they choose, subject to the rule of order. The fact that Germany has managed to retain a relatively high degree of wage coordination *and* pursue anti-inflationary monetary policies is, in this light, testament to the success of the centralised institutions in maintaining consensus in the face of pressures for decentralisation from constituents (although, as noted, there has been some informal decentralisation of wage-bargaining). A richer model than that presented here would consider the interaction between the unions and their parent federations, in particular the ability of the latter to monitor the former for potential defection and subsequently enforce punishment, as in Holden (2001). The credibility of any threat of punishment is key here. The individual incentives to free-ride on the wage restraint of other unions were shown to be crucial in this paper; presumably similar incentives, namely to free-ride on any credible punishment commitments by others, would exist in this putative model.

The results here have a bearing on existing empirical work. The literature purporting to show the 'neutrality' of increased conservatism, that lower inflation can be achieved at no real economic cost, tends not to include additional institutional variables. It may be that the neutrality result is in some sense spurious - greater central bank conservatism may indeed affect real output and unemployment, but this result may be offset by the indirect impact on labour market structure.

Finally, more empirical work needs to be done on the links between increased conservatism and the observed decentralisation in wage bargaining over the last twenty years. Did the former induce the latter, or *vice versa*? Alternatively, of course, they may share a common cause. In truth, the relationship between macroeconomic policy and labour market structure is likely to be characterised by considerable feedback, with causality running in both directions. Separating these effects from notionally 'external' influences will not be easy. This paper constitutes a first attempt at formally modelling this causal relationship. This seems a topic that merits further attention, theoretical as well as empirical.

3.7 Appendix

3.7.1 Proofs

Proposition 8 The proof will be concerned with one of the v Size Announcement games, taking the result of the others as given. Denote by T the total number of coalitions formed in the other games, and let $\gamma = 2 + \frac{1}{\theta}$. Also, assume that, if a player is indifferent between choices of coalition size, she will choose the smaller.

The proof consists of three stages:

(1) Consider the optimal strategy of player P_m, where $m \geq 2$, given that it is her turn to announce a coalition size $s(m)$. Bear in mind that there are m players remaining in the game when it is P_m's turn to move. Assume that the strategy of the next player according to the order rule R is to form a single coalition with all the remaining players, i.e. $s(m-1) = m-1$. It is immediately clear that P_m will not announce any $s(m)$ such that $1 < s(m) < m$; the best that could be hoped for then would be for the remaining players to coalesce into a single coalition, but even this is strictly dominated by remaining isolated and allowing P_{m-1} to move. Player P_m will therefore choose either to remain isolated or to form a single coalition consisting of all m remaining players. The possible payoffs to player P_m are thus:

$$\Gamma(.,.) = n - \gamma(T + K + 2) \qquad \text{if } s(m) = m \tag{104}$$

$$\Gamma(.,.) = \frac{n}{m} - \gamma(T + K + 1) \qquad \text{if } s(m) = m, \tag{105}$$

where K is the number of coalitions formed so far in this game. It is straightforward to obtain the following condition, under which remaining isolated dominates uniting with the remaining players:

$$\Gamma(1, T + K + 2) \geq \Gamma(m, T + K + 1) \tag{106}$$

$$\Longleftrightarrow m \geq \frac{\overline{n}}{\overline{n} - \gamma}. \tag{107}$$

Note that both the number of coalitions formed in the other size announcement game and the number formed hereto in the current game are irrelevant for P_m's decision. Assume $(n-\gamma) \geq v$, and denote by m^0 the highest integer such that $m^0 < \frac{n}{n-\gamma}$. By induction on $m = 2$, where by definition $s(m-1) = m-1$, we may use (107) to see that all players P_m such that $m \leq m^0$ will choose to unite with the remaining players; the optimal strategy of P_{m^0+1} is to remain isolated. If $(n-\gamma) < v$, all $\frac{n}{v}$ players will choose to unite with the remaining players, and the result will be a single grand coalition.

(2) Assume $(n-\gamma) \geq v$. Consider players $P_{m'}$ and P_m, where $\frac{n}{n-\gamma} \leq m'+1 < m$. Assume the following:

- $P_{m'}$'s strategy is always to unite with all remaining players, i.e. $s(m') = m'$; as a result, player $P_{m'+1}$ will remain isolated, by the previous step, since $\frac{n}{n-\gamma} < m'+1$;
- if player P_m announces $s(m) \leq (m-m')$, then the next $(m-m'-s(m))$ players choose to remain isolated (i.e. $s(.)=1$), and then player $P_{m'}$ announces $s(m') = m'$.

What is player P_m's optimal strategy? It cannot be optimal to announce $s(m)$ such that $m > s(m) > (m-m')$, by the same logic as in the first part of the proof. So, the optimal strategy must involve either $s(m) = m$ or $s(m) \leq (m-m')$. Consider the payoff from the latter, given the strategies of the remaining players as outlined above:

$$\Gamma(.,.) = \frac{n}{s(m)} - \gamma\left(T+K+2+[m-m'-s(m)]\right) \quad \text{if } s(m) \leq (m-m'). \tag{108}$$

What is the optimal coalition size over this range? Differentiating (108) by the choice of coalition size, we have:

$$\frac{\partial\Gamma(.,.)}{\partial s(m)} = \gamma - \frac{n}{s(m)^2} \tag{109}$$

$$\frac{\partial^2\Gamma(.,.)}{\partial s(m)^2} = \frac{2n}{s(m)^3} > 0, \tag{110}$$

and so we see an internal choice cannot be optimal - player P_m will announce either $s(m) = 1$ or $s(m) = m'$. There are thus three options overall:

$$\Gamma(.,.) = n - \gamma\left[T+K+(m-m')+1\right] \qquad \text{if } s(m) = 1 \tag{111}$$

$$\Gamma(.,.) = \frac{n}{(m-m')} - \gamma\left[T+K+2\right] \qquad \text{if } s(m) = (m-m') \tag{112}$$

$$\Gamma(.,.) = \frac{n}{m} - \gamma\left[T+K+1\right] \qquad \text{if } s(m) = m. \tag{113}$$

It will now be shown that $s(m) = (m-m')$ cannot be optimal. First, observe that, for choosing a coalition of size 1 to be better than choosing one of size $(m - m')$, it must be the case that:

$$\Gamma(1, T + K + (m - m') + 1) \geq \Gamma((m - m'), T + K + 2) \tag{114}$$

$$\iff n - \gamma(m - m') \geq \frac{n}{(m - m')} - \gamma \tag{115}$$

$$\iff ((m - m') - 1)(n - \gamma(m - m')) \geq 0 \tag{116}$$

$$\iff \frac{n}{(m - m')} \geq \gamma. \tag{117}$$

Similarly, for $s(m) = (m - m')$ to be a better choice than $s(m) = m$, we must have:

$$\Gamma((m - m'), T + K + 2) \geq \Gamma(m, T + K + 1) \tag{118}$$

$$\iff \frac{n}{(m - m')} \geq \gamma + \frac{n}{m}. \tag{119}$$

Comparing (117) and (119), we see that whenever the choice of $(m - m')$ as coalition size dominates that of m, it must be the case that remaining isolated is still better. The optimal coalition strategy is therefore either to remain isolated or to form a coalition with all the remaining players. Now, for $s(m) = 1$ to be optimal we must have that:

$$\Gamma(1, T + K + (m - m') + 1) \geq \Gamma(m, T + K + 1) \tag{120}$$

$$\iff n - \frac{n}{m} - \gamma(m - m') \geq 0 \tag{121}$$

$$\iff -m^2 + \left(m' + \frac{n}{\gamma}\right) m - \frac{n}{\gamma} = Q(m) \geq 0. \tag{122}$$

This quadratic $Q(.)$ has a negative second derivative: $\frac{\partial Q(m)}{\partial m} = -2m + (m' + \frac{n}{\gamma})$, $\frac{\partial^2 Q(m)}{\partial m^2} = -2$. The lowest root of $Q(.)$, immediately above which the function is positive, is lower than m'. We may thus confine our attention to the higher root, for all m below which it will be optimal for P_m to remain isolated. For simplicity, and to avoid integer problems, assume that $\frac{n}{\gamma}$ is an integer. Then, given that:

$$Q\left(m' + \frac{n}{\gamma} - 1\right) = m' - 1 \geq 0 \tag{123}$$

and

$$Q\left(m' + \frac{n}{\gamma}\right) = -\frac{n}{\gamma} < 0, \tag{124}$$

it must be the case that P_m will remain isolated as long as $m < m' + \frac{n}{\gamma}$. If $m \geq m' + \frac{n}{\gamma}$, then P_m will announce $s(m) = m$ and form a single coalition with the remaining players. So, by induction on $m = m' + 2$, we have the following: all players P_m such that $m' + 1 < m \leq m' + \frac{n}{\gamma} - 1$ will choose to remain isolated; player $P_{m'+\frac{n}{\gamma}}$ will announce $s(m' + \frac{n}{\gamma}) = m' + \frac{n}{\gamma}$. If $\frac{n}{\gamma} \leq 2$, then player $P_{m'+2}$ will announce $s(m' + 2) = m' + 2$.

(3) From the preceding steps we may construct the equilibrium coalition structure.

- From step 1 we have that, if $(n - \gamma) < v$, it will entail a single grand coalition.
- Assume $(n - \gamma) \geq v$. Define $m^y = m^{y-1} + \frac{n}{\gamma}$. Consider player P_{m^0}, whose strategy is to announce a single unifying coalition. From step 2, the preceding $(\frac{n}{\gamma} - 1)$ players will choose to remain isolated, and player P_{m^1} will choose to unite with all those remaining. Again, the preceding $(\frac{n}{\gamma} - 1)$ players will choose to remain isolated, and P_{m^2} will announce a unifying coalition. This cycling will continue until player P_{m^z}, where $\frac{n}{2} - \frac{n}{\gamma} < m^z \leq \frac{n}{v}$. She will announce $s(m^z) = m^z$, while the preceding $\frac{n}{v} - m^z$ players will choose to remain isolated. The total number of coalitions formed will be equal to $\frac{n}{v} - m^z + 1$. The maximum possible number of coalitions will be equal to $\frac{n}{\gamma}$.

(4) In terms of θ, these strategies result in the coalition structures outlined in Proposition 8.

QED.

Proposition 10 The proof will be concerned with the class of coalition structures that are δ-stable. Recall that attention is confined, as above, to v distinct groups of players, with coalitions only possible within these groups[71]. Again, assume that, if a player is indifferent between choices of coalition size, she will choose the smaller.

(1) Consider a coalition structure C, comprising $k \geq 2$ coalitions. Consider further a defection by all the members of two of these coalitions, of size s_i and s_j, whereby a new coalition of size $(s_i + s_j)$ is formed. For none of the defectors to be better off, given the preference structure, it is necessary and

[71] Also, it is assumed that defections within any particular group do not cause defections in other groups; this is consistent with the δ-stability concept.

sufficient that defectors from the smaller of the two coalitions are no better off. Assuming $s_i \geq s_j$, this requires:

$$\frac{n}{s_j} - \gamma(T+k) \geq \frac{n}{s_i + s_j} - \gamma(T+k-1) \tag{125}$$

$$\Longleftrightarrow (s_i + s_j)\, n - \gamma(s_i + s_j)\, s_j \geq s_j n \tag{126}$$

$$\Longleftrightarrow \frac{n}{\gamma} \geq s_j + \frac{s_j^2}{s_i} \tag{127}$$

where T is the number of coalitions formed in the other $(v-1)$ groups. From (127) it follows that there is only room for one coalition of size greater than n/γ in any δ-stable structure.

(2) Consider a coalition of size s_i in a coalition structure C. A possible defection is for the members of this coalition to form q smaller coalitions of equal size[72]. For such a defection to be unprofitable, one needs:

$$\frac{n}{s_i} - \gamma(T+k) > \frac{qn}{s_i} - \gamma(T+k+q-1) \tag{128}$$

$$\Longleftrightarrow (q-1)\,\gamma > (q-1)\,\frac{n}{s_i} \tag{129}$$

$$\Longleftrightarrow s_i > \frac{n}{\gamma}. \tag{130}$$

In other words, any coalition (consisting of more than one player) of size $s_i \leq n/\gamma$ cannot be part of a δ-stable structure.

(3) Combining steps (1) and (2), it is clear that there are only three possible types of core stable structure:

- the grand coalition comprising all n/v players;
- structures with one coalition of size greater than n/γ, and the rest of the players isolated;
- the completely diffuse structure, with all players isolated.

These will be examined in turn.

[72] Integer problems are once again ignored.

(i) The grand coalition is δ-stable if and only if it is immune to defection by a single player, since this is the most profitable deviation possible. This entails:

$$\frac{n}{n/v} - \gamma (T+1) > n - \gamma (T+2) \tag{131}$$

$$\iff \gamma > n - v. \tag{132}$$

(ii) Consider now a coalition structure comprising one coalition of size $s_b > \frac{n}{\gamma}$, with the remaining $(k-1)$ players isolated. Consider a defection by a single player from the large coalition. For this not to be worthwhile:

$$\frac{n}{s_b} - \gamma (T+k) > n - \gamma (T+k+1) \tag{133}$$

$$\iff \frac{n}{s_b} > n - \gamma \tag{134}$$

$$\iff \frac{n}{\gamma} < 1 + \frac{1}{s_b - 1} \leq 2. \tag{135}$$

But, from (127) above, if $\frac{n}{\gamma} < 2$ the maximum number of isolated in any δ-stable coalition structure is one. So, the only possible δ-stable structure (of this type) is now that consisting of only one isolated player, with the remaining players forming a single coalition. This is stable if (135) is satisfied (since if defection by a single player from the large coalition is unprofitable, so will be defection by multiple players) and if the single isolated player is no better joining the larger coalition (if she were better off, so would be the original coalition members). This latter condition requires that:

$$n - \gamma (T+2) \geq \frac{vn}{n} - \gamma (T+1) \tag{136}$$

$$\iff \gamma \leq n - v. \tag{137}$$

So, combining (135) and (137), the coalition structure with one isolated and the rest in a single coalition is δ-stable if and only if:

$$n\left(1 - \frac{v}{n-v}\right) < \gamma \leq n - v. \tag{138}$$

(iii) Consider the completely diffuse coalition structure, with all players isolated. The 'best' defection is that by all players at once (thus eliminating as many coalitions as possible), where q larger coalitions of equal size are formed (since it is the size of the largest coalition formed that provides the incentive compatibility constraint). The diffuse structure is therefore δ-stable if and only if:

$$n - \gamma\left(T + \frac{n}{v}\right) > \frac{qvn}{n} - \gamma\left(T + q\right) \tag{139}$$

$$\iff \quad n - \gamma\frac{n}{v} \geq q\left(v - \gamma\right) \tag{140}$$

$$\iff \quad \left(\frac{n}{v} - q\right)\left(1 - \frac{\gamma}{v}\right) \geq 0 \tag{141}$$

$$\iff \quad v \geq \gamma, \tag{142}$$

since necessarily $\frac{n}{v} > q$.

(4) Cast in terms of θ, the conditions in (3) above provide Proposition 10.

QED.

3.7.2 Figures

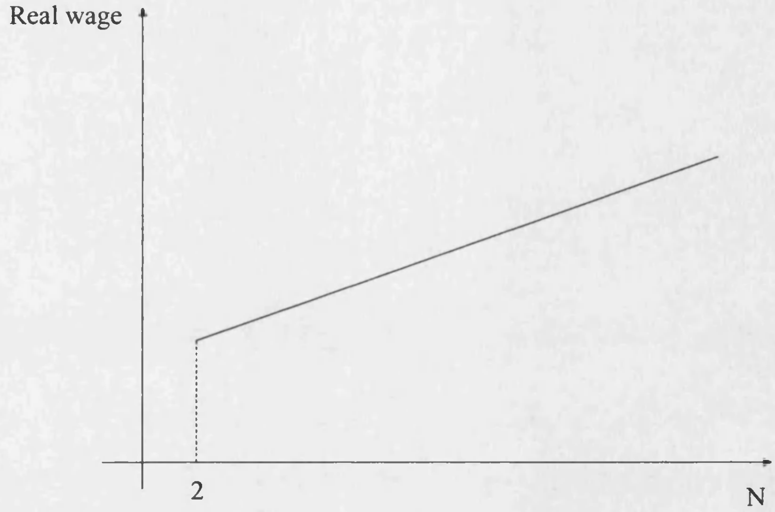

Figure 9.1 - number of wage-setting coalitions, N, and the average real wage

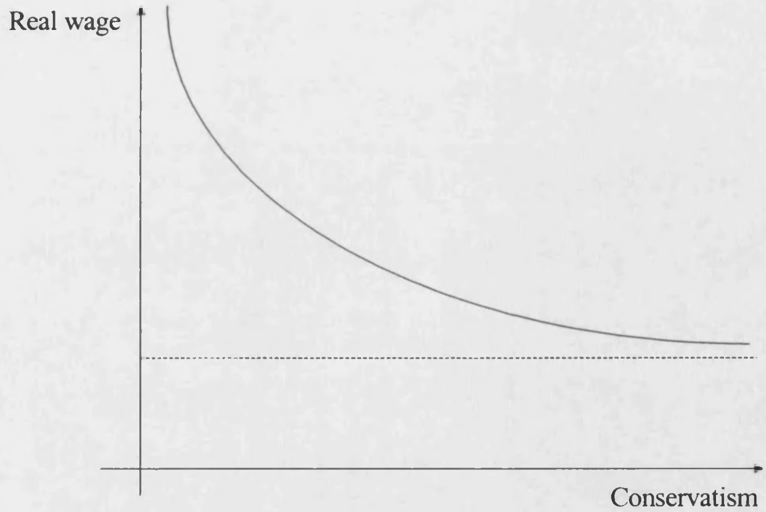

Figure 9.2 - central bank conservatism and the average real wage, *given the labour market structure*

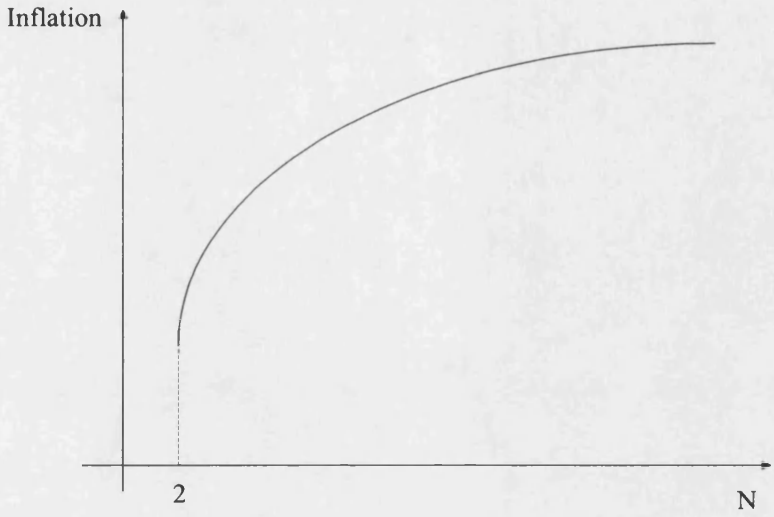

Figure 10.1 - number of wage-setting coalitions, N, and inflation

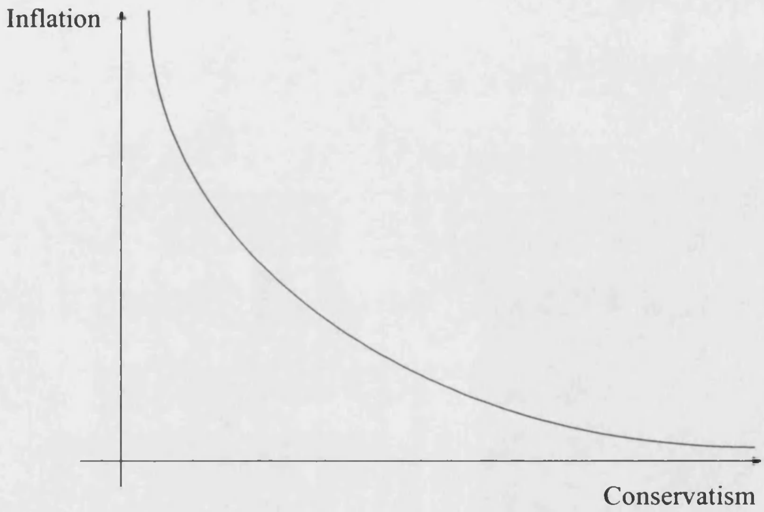

Figure 10.2 - central bank conservatism and inflation, *given the labour market structure*

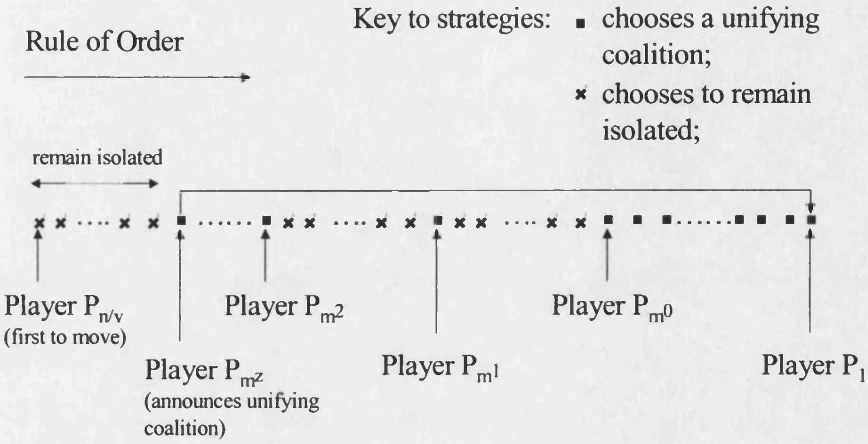

Figure 11 - strategies in the Size Announcement Game

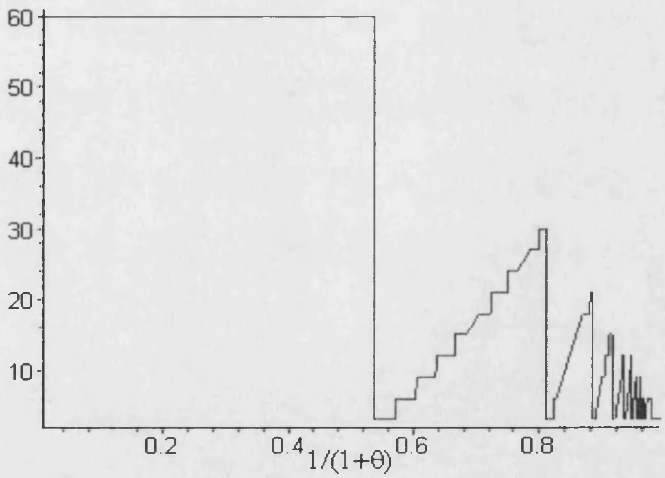

Figure 12 - number of wage-setting coalitions: results of simulations of Size Announcement game; $n = 60$, $v = 3$.

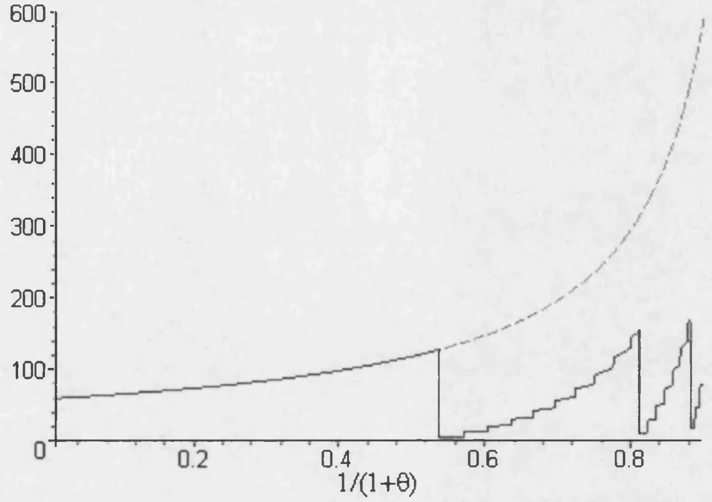

Figure 13 - aggregate real wage, with and without coalition formation; $n = 60$, $v = 3$. The upper contour formed by the dashed line is the aggregate real wage in absence of any coalition formation, *i.e.* with $N = n = 60$. The solid line shows the wage with endogenous labour market structure.

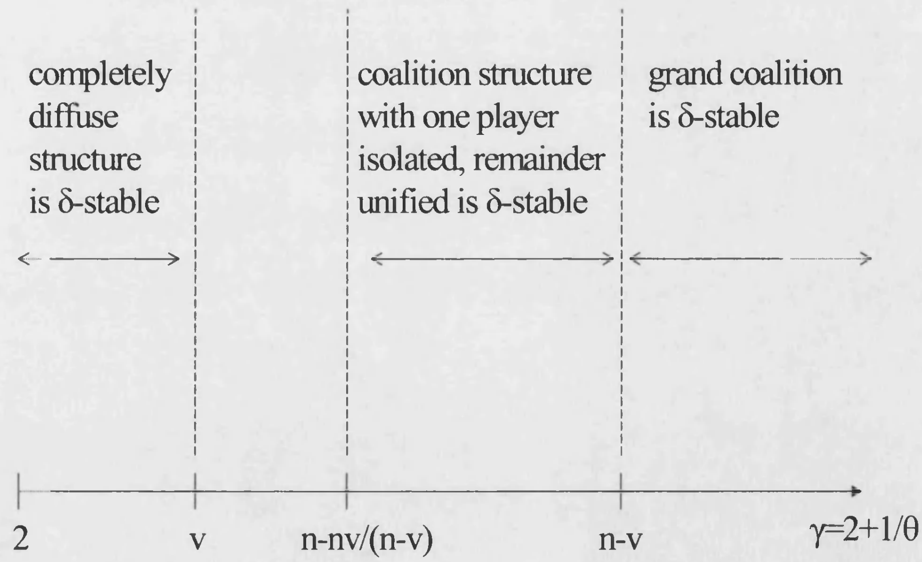

Figure 14 - δ-stable coalition structures

4 The NAIRU and the Spatial Unemployment Distribution

4.1 Introduction

A noted feature of the GB economy over the last few decades has been the apparent 'North-South divide', with much popular debate centred on the apparent imbalance between a low-unemployment, service-based economy in the South and a high-unemployment, manufacturing-based North. Despite such regional unemployment differentials, much macroeconomic policy must be formulated at a more aggregate level. Witness the statement in October 1998 by the Governor of the Bank of England, on the topic of unemployment in the North-East of England:

> "In response to a journalist's suggestion that regional unemployment was 'an acceptable price to pay', I made it clear - as I have very often before - that monetary policy can only target the situation in the economy as a whole, not particular regions or sectors, however uncomfortable that reality might be."[73]

While it is true that the Bank of England can set only one interest rate for the aggregate economy, it does not necessarily follow that only aggregate information, such as the national level of unemployment, need be considered when choosing this rate. There are sound theoretical (and, it is argued below, perhaps empirical) grounds for believing that information on the spatial distribution of unemployment is pertinent when assessing the degree of inflationary pressure in the economy. Specifically, this paper investigates the effect of geographical unemployment dispersion on the aggregate NAIRU. As emphasised recently by James Tobin, the NAIRU should be distinguished from the *natural rate* of unemployment:

> "NAIRU and NATURAL RATE are not synonymous. NAIRU is a macro outcome of an economy with many labour markets in diverse states of excess demand and excess supply. NAIRU represents an overall balance between the inflation-increasing pressures from excess-demand markets and the inflation-decreasing pressures from excess-supply markets. The natural rate, as described by Friedman, is a feature of Walrasian market-clearing general equilibrium....The

[73] Taken from the Daily Telegraph, Thursday 22 October 1998.

determinants of the two are theoretically different, and so are their implications for policy." (Tobin (1997)).

So, the NAIRU, properly considered in a multiregional framework, is that aggregate level of unemployment consistent with the absence of inflationary or deflationary pressure, given individual local labour markets in varying states of excess demand and supply[74]. As made more precise below, different distributions of unemployment across these regions may lead to different aggregate NAIRU; one is aggregating over probably heterogeneous, possibly nonlinear regional Phillips curves. It may be that these are idiosyncratic across regions, with those in low-unemployment regions being relatively steep; any given increases in unemployment in these regions may be accompanied by greater unemployment reductions in regions with relatively shallow Phillips curves, with no increase in aggregate inflationary pressure. A situation where regions have identical, convex Phillips curves is also consistent with this 'Aggregation Hypothesis'. In both cases, a reduction in unemployment dispersion across regions would lessen inflationary pressure for a given aggregate unemployment rate; in other words, it would reduce the NAIRU.

This paper provides a simple model, based on a generalisation of the Shapiro-Stiglitz (1984) shirking model, which generates a convex Phillips curve for each region, the shape of which is dependent on the monitoring technology available to individual firms. Aggregate Phillips curve equations are then estimated, with statistics on the spatial unemployment distribution included.

Section 4.2 below reviews the basic facts concerning the evolution of the regional and subregional unemployment distributions since 1965, and briefly considers other work on the time path of the GB NAIRU. Section 4.3 considers the appropriate distributional statistics to include in aggregate Phillips-curve equations. Section 4.4 outlines the theoretical model. Section 4.5 reviews the empirical literature on the relation between the unemployment distribution and aggregate inflationary pressure. Section 4.6 presents estimation results. Section 4.7 concludes.

[74] In this paper an excess-demand (-supply) region will simply be one where the rate of unemployment is below (above) that region's natural rate.

4.2 GB unemployment, 1966-1996

4.2.1 (Sub)Regional unemployment differentials

As detailed in Figure 15, using annualised data, significant disparities in regional unemployment rates have been present since at least the middle of the 1960s[75]. Scotland, Wales and the Northern region have experienced especially high unemployment all through the sample period, in particular at the start; the North-West, Yorkshire and Humberside and the South-West have also tended to have relatively high unemployment rates; East Anglia began the period with unemployment rates of nearly 150% of the national average, but has seen its fortunes improve since then; the two Midlands regions have remained close to the national average, with some evidence of a gradual increase in relative unemployment; and finally, the South-East[76] consistently outperformed the rest of the country until the recession of the early 1990s. Figure 16 shows the path of the GB unemployment rate.

Within this context of substantial, reasonably persistent *relative* regional unemployment differentials, the *absolute* level of unemployment dispersion across space has varied considerably over time. Figure 17 graphs the evolution of the standard deviations of the regional and subregional unemployment distributions; it can be seen that these rose dramatically in the 1980s. In the 1990s, the standard deviation of the regional unemployment distribution settled down to a level around that attained in the 1960s and 1970s, while that of the subregional distribution remained somewhat higher. Finally, even within individual regions there is considerable variation in the unemployment rates of the constituent subregions, as shown in Figure 18.

4.2.2 The UK NAIRU

Coulton and Cromb (1994) review eleven empirical studies of the UK NAIRU[77]. The range and average NAIRU estimate for these studies are detailed in Table 1. We see that, while there is considerable uncertainty as to its exact level, the NAIRU seems to have risen over the 1970s and much of the 1980s,

[75] See the chapter appendix for details of all data sources.

[76] Note that this includes London.

[77] Note that Coulton and Cromb's study refers to the UK NAIRU. Since no subregional unemployment data were available for Northern Ireland, this chapter focuses solely on Great Britain.

with evidence of a decline towards the end of the decade. Coulton and Cromb conclude, from their review of the available evidence, that the reasons for this rise are not fully understood. They are likely, they say, to include increased union power, a more generous unemployment benefit system, real wage resistance arising from higher taxes and a deceleration in the productivity trend. The subsequent fall in the NAIRU is likely to be related to supply-side changes such as a reduction in union power, lower taxes and benefit system reforms, Coulton and Cromb argue. Hysteresis in the form of increased long-term unemployment also seems to be have played a role in the 1980s, they add.

4.3 The NAIRU and the spatial distribution of unemployment

The notion that unemployment dispersion may affect the degree of inflationary pressure in the aggregate was implicit in the earliest work on the Phillips curve. Following Lipsey (1960), several authors[78] considered the impact of the unemployment distribution on the NAIRU, with particular attention paid to the appropriate distributional statistics to include in Phillips-curve-type regressions. One line of research focused on the implications of aggregating over many labour and/or product markets, each with its own (possibly idiosyncratic and nonlinear) Phillips curve. This strand of the literature is directly antecedent to the model of this paper; the theoretical rationale behind this 'aggregation hypothesis' is outlined immediately below, with a review of earlier empirical work deferred until Section 4.5.

An alternative hypothesis was also developed by these earlier authors. This concerns the existence of a 'wage transfer mechanism', whereby workers in high-unemployment regions demand wages equivalent to those paid to workers in low-unemployment areas. A reduction in unemployment dispersion would therefore reduce the NAIRU, assuming it is associated with an increase in unemployment in the 'leading' region. The basic analytics of this argument are relegated to an appendix; suffice to say they provide no dispersion measure that is obviously appropriate for use in estimated equations. Moreover, the plausibility of this hypothesis is perhaps questionable. Local wage demands may conceivably be (directly) affected by those in other regions if labour markets are not, geographically, entirely distinct. However, the UK is noted more for its immobility of labour than the converse, and for the purposes of this paper its

[78] See for example Thirlwall (1969, 1970), Archibald (1970) and Thomas and Stoney (1971).

labour market is treated as perfectly segmented[79]. As such, any wage-transfer mechanism is ignored; the possible existence of such a mechanism may be seen as a complementary justification for the empirical work later in the paper.

4.3.1 The aggregation hypothesis

In this section a simple model of the Phillips curve is outlined, using the framework set down in Layard, Nickell and Jackman (1991)[80]. Consider a system of n subregions, indexed by i; in each, a large number of identical firms face downward-sloping demand curves for their respective outputs and set prices as a mark-up on expected marginal costs:

$$p_i = w_i^e + \phi_i(u_i) \qquad \phi_i'(.) \prec 0; \quad i = 1, ..., n \tag{143}$$

where p_i is the (log of the) price level set by each firm, w_i^e is the (log of the) expected wage paid, $\phi_i(.)$ is a decreasing function and u_i is the subregional unemployment rate. The presence of the unemployment rate in the price-setting equation is typically justified by either a cyclically-varying mark-up[81] or simply diminishing returns to labour. In the latter case, unemployment is proxying for aggregate demand; as demand and firms' output rise, the marginal product of labour falls[82].

The price-setting equation is accompanied by a wage equation of the form:

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[79] Low levels of observed migration are of course compatible with labour mobility. One could envision an efficiency-wage model of the type developed in Section 4.4, extended to allow for the interregional movement of workers, that contained a 'no-migration' equilibrium with the sort of wage spillovers predicated under the wage-transfer hypothesis. However, the absence of significant labour migration in the UK is more likely to be due to market failures associated with its housing market (Evans and McCormick (1994)). Moreover, Pissarides and Wadsworth (1989) find that migration decisions are not driven by regional unemployment differentials.

[80] For a general review of the type of model outlined here, see Blanchard and Katz (1997).

[81] Here procyclical.

[82] Capital stock is held constant in this short-run analysis. In the model developed in Section 4.4 an alternative justification is given for the presence of the unemployment term in the price-setting equation, one that does not rely on diminishing returns to labour in the conventional sense.

$$w_i^e = p_i^e + \mu_i(u_i) \qquad \mu_i'(.) \prec 0; \quad i = 1, ..., n \tag{144}$$

where p_i^e is the (log of the) expected aggregate price level in subregion i and $\mu_i(.)$ is a decreasing function. Wage equations such as this may be derived from models of bargaining or shirking (see Layard et al. for an overview). In the latter case, each firm expects to have to pay its employees enough to prevent them from shirking; as unemployment increases, the penalty associated with being detected and subsequently fired also increases, as any fired worker faces more competition for jobs. The employer need not therefore pay the workers so much. The (expected) price level included is that prevailing in the subregion as a whole, as it is the workers' real consumption wage that matters.

Combining (143) and (144) and aggregating over firms gives us a Phillips curve relationship for each subregion:

$$\begin{aligned} p_i - p_i^e &= \phi_i(u_i) + \mu_i(u_i) && (145) \\ &= \theta_i(u_i) \qquad \theta_i'(.) \prec 0; \quad i = 1, ..., n. && (146) \end{aligned}$$

The *natural rate* of unemployment in each subregion, u_i^*, is given implicitly by $\theta_i(u_i^*) = 0$. Assuming identical labour forces across subregions, the natural rate for the aggregate economy is then simply $\frac{1}{n}\sum_i u_i^*$. As emphasised above, however, the concept of the natural rate is rather different from that of the NAIRU. To see this, aggregate over subregions to obtain a Phillips curve for the whole economy:

$$p - p^e = \frac{1}{n}\sum_{i=1}^{n} \theta_i(u_i) \tag{147}$$

where p is the aggregate price level[83]. Absence of inflationary or deflationary pressure obtains when $\sum_{i=1}^{n} \theta_i(u_i) = 0$. It should already be clear that the distribution of disaggregate unemployment rates may

[83] Note that it is being implicitly assumed that subregions have equal weighting when aggregating over prices, and indeed expected prices. With regard to the latter, it may be sensible to set $p_i^e = p^e, \forall i$; this is more appropriate if the real consumption wage in (144) is based on a bundle of goods drawn from all subregions.

affect the NAIRU. To see this, take a Taylor Expansion of each $\theta_i(u_i)$ around the aggregate unemployment rate $\overline{u}$:

$$p - p^e \approx \frac{1}{n}\sum_{i=1}^{n}[\theta_i(\overline{u}) + \theta_i{}'(\overline{u})(u_i - \overline{u}) + \frac{1}{2}\theta_i''(\overline{u})(u_{it} - \overline{u})^2]. \tag{148}$$

The precise effect of unemployment dispersion is sensitive to the form of the $\theta_i(.)$ It is instructive to consider two particular cases.

CASE 1: Identical, convex Phillips curves Assume that $\theta_i(.) = \theta(.)$, $\forall i$, where $\theta''(.) > 0$. In that case, (6) reduces to:

$$\begin{aligned} p - p^e &\approx \theta(\overline{u}) + \frac{1}{2}\theta''(\overline{u})\frac{1}{n}\sum_{i=1}^{n}(u_i - \overline{u})^2 && (149) \\ &= \theta(\overline{u}) + \frac{1}{2}\theta''(\overline{u}).s^2 && (150) \end{aligned}$$

where s^2 is the variance of the subregional unemployment rates. We see that the aggregate NAIRU is minimised when unemployment dispersion is zero. Alternatively, for a given level of aggregate unemployment, a rise in dispersion increases inflationary pressure (Figure 19). It is important to note that the appropriate unemployment dispersion measure to include in any aggregate equation depends on the exact form of nonlinearity assumed. Taking a general specification $\theta(\overline{u}) = \alpha - \gamma\frac{\overline{u}^\delta}{\delta}$, where $\delta \prec 1$, (8) becomes:

$$p - p^e = \alpha - \gamma\frac{\overline{u}^\delta}{\delta} + \frac{\gamma(1-\delta)}{2\overline{u}^{(2-\delta)}}.s^2 \tag{151}$$

Under the hypothesis of identical, convex Phillips curves, appropriate dispersion measures will therefore consist of the simple variance of subregional unemployment rates, deflated by the aggregate level of unemployment raised to some power. Note also that there are joint restrictions implied for the coefficients on unemployment and the variance measure.

However, nonlinearity of the disaggregate wage curves is not necessary for the presence of a dispersion effect, as will be seen in Case 2.

CASE 2: Heterogeneous Phillips lines Assume $\theta_i(u_i) = \beta_i^0 - \beta_i^1 u_i$, with $\beta_i^1 < 0, \forall i$. (6) then reduces to:

$$p - p^e \approx \widetilde{\beta}^0 + \widetilde{\beta}^1 \overline{u} + \frac{1}{n} \sum_{i=1}^{n} \beta_i^1 (u_i - \overline{u}) \tag{152}$$

where $\widetilde{\beta}^0 = \widetilde{\beta}^0 = \sum_{i=1}^{n} \beta_i^0$ and $\widetilde{\beta}^1 = \sum_{i=1}^{n} \beta_i^1$.

So, the appropriate specification is then linear in the aggregate unemployment rate. The effect of the summation term on the right-hand-side, though, is ambiguous. Suppose, though, that subregions with relatively high unemployment (ie $u_i \succ \overline{u}$) have relatively flat Phillips curves (ie β_i^1 is relatively small). The summation term is then positive and we have the familiar dispersion effect - the presence of unemployment dispersion increases wage pressure for a given aggregate unemployment rate[84]. This is seen graphically for the 2-region case in Figure 20. However, the precise form of the appropriate dispersion measure in such a case is not clear, in the absence of detailed knowledge of the underlying Phillips lines (ie the β_{1i}'s). If one were to assume, though, that regions retain the same ordering (with those with steepest Phillips curves having the lowest unemployment rates) over the economic cycle, then simple measures of dispersion such as the standard deviation may prove most useful. Note that, with idiosyncratic Phillips lines, a given pattern of unemployment dispersion has identical effects at low and high levels of aggregate unemployment. This is in contrast to Case 1 above, where a given degree of dispersion has smaller effects at higher aggregate unemployment levels. It is not necessarily true that Case 2 can be approximated by using (151) with some arbitrary nonlinear functional form.

In short, while there are theoretical reasons to believe that, given the aggregate unemployment rate, unemployment dispersion increases inflationary pressure, there is no clear candidate for the appropriate distributional statistic to include in empirical equations. If one believed in the 'pure' nonlinear aggregation hypothesis, where subregions have identical, convex Phillips curves (ie Case 1 above), then it is possible to obtain such a statistic. However, this seems unlikely in light of the way industrial structures vary across regions in the UK. Section 4.4 below presents a model where Phillips curves are not only

[84] Note that the situation is reversed should the high-unemployment region be that with the steeper wage curve - then, wage pressure is lower than would be the case with zero unemployment dispersion.

nonlinear but are likely to be heterogeneous. It is then an empirical matter - are there distributional statistics, perhaps ad-hoc, which have predictive content in aggregate Phillips curve equations?

4.4 Shirking with endogenous monitoring intensity

It was shown above how convexity of disaggregate Phillips curves may lead spatial unemployment variation to affect the NAIRU. It was also argued that possible heterogeneity of these Phillips curves means the precise form of dispersion measure to be used in empirical work is unclear, quite apart from the additional complications arising from any wage transfer mechanism. This section presents a simple model which generates nonlinear wage and price-setting equations, and which also locates a possible source of heterogeneity in the ability of firms in different industries to monitor their workers. It should of course be emphasised that there are many possible sources of variation in economic structure across regions. The aim here is partly to show how heterogeneity is likely to be the rule rather than the exception, partly to provide a plausible source for it.

The model is a variant of that of Shapiro and Stiglitz (1984), where workers decide whether or not to shirk in the face of imperfect monitoring by their employers. Firms then have an incentive to provide a real wage above the workers' reservation levels, thereby reducing the workers' incentive to shirk, given the increased cost of possible subsequent detection. High levels of unemployment also increase the cost of detection, and reduce the wages that firms need offer workers in a no-shirking equilibrium; this then generates a wage curve of the form of (144) above.

In the original Shapiro-Stiglitz model a minimum acceptable effort level is set by firms, and is exogenously given. While this is true of much of the shirking literature, many variants of the model endogenise the effort choice of firms, so that firms trade off increased effort (and hence productivity) against higher wages (increased effort is costly to workers, who therefore require higher wages in order not to be tempted to shirk)[85]. The model outlined here treats the minimum acceptable effort level as exogenous, as in the

[85] See for example Simmons (1991) and Carter (1998). A criticism of this type of model is that an efficient outcome can be attained if workers are forced to post a bond, to be forfeit if they are caught shirking. Incomplete capital markets are one reason this may not be possible.

original paper, and instead endogenises the monitoring intensity of firms. A firm can increase its detection rate by switching some of its workforce from the task of producing goods to that of monitoring fellow workers; however, this comes at the cost of reduced output per worker employed[86]. A simple and intuitive functional form is chosen to relate the probability of shirking workers being detected and fired to the proportion of the workforce engaged in monitoring. The firm's choice of monitoring intensity is then shown to be related to the outside unemployment rate in such a way that nonlinearities emerge in both the pricing and wage equations.

4.4.1 The model

All workers are identical. No longer working in logs, and with subregional subscripts dropped, utility is a function of the real wage and effort expended:

$$U = \frac{W}{P} - e \tag{153}$$

Let the (exogenous) minimum acceptable effort level of a worker, set by the firm, be denoted by $\overline{e}$. If the effort level of a worker is below $\overline{e}$, that worker is detected and fired with probability $q(\tau)$, where $q'(.) \succ 0$. Probability of detection is thus a function of τ, the proportion of the workforce engaged in monitoring[87]. Workers will always choose an effort level equal either to zero or to the minimum acceptable level, ie $e \in (0, \overline{e})$. Risk neutral workers maximise their expected lifetime utility, and make their shirking decision accordingly. For simplicity, income when unemployed is here normalised to zero. It is straightforward to obtain a no-shirking condition, under which the expected lifetime utility from not shirking exceeds that

[86] Carter (1992) provides a model with endogenous monitoring costs with a quite different flavour. In his model, probability of shirking workers being detected is invariant and exogenous, but effort levels are endogenous. The proportion of total effort used in monitoring rather than production is then assumed to vary with effort levels in an unspecified manner.

[87] It is assumed that those workers engaged in monitoring report fellow workers they find to be shirking, and that they do not shirk themselves. A possible justification for this is as follows: each monitor is responsible for a team of workers whose aggregate (although not individual) performance is readily ascertained from the final production statistics; employers are thus able to costlessly gauge the performance of the monitors. Another way to avoid this problem is to follow Carter (1998) and assume each member of a team monitors each other member; τ is then the proportion of each worker's time spent monitoring.

from shirking (see, for example, Simmons (1991)):

$$\frac{W}{P} = \bar{e}\left(1 + \frac{k(u)}{q(\tau)}\right) \tag{154}$$

where $k(u) = r + c/u$, r being the discount rate, u the rate of unemployment in the surrounding labour market and c the probability of an employee being separated from employment for reasons not associated with shirking. Again, note that a high level of unemployment reduces the real wage necessary to induce workers not to shirk.

There are many firms, each facing elasticity of demand for their product of σ. Each firm's output is a linear function of the effective labour input into production:

$$y = a\bar{e}(1-\tau)l \tag{155}$$

where a is a productivity parameter and l is the total amount of labour employed. Capital is suppressed in this model. Firms maximise profit subject to the above technology, the wage bill and the no shirking condition. The ordering of events is as follows: at the beginning of the period, firms set prices, total employment and the proportion of monitors[88]; during the period, firms produce output and pay wages paid in accordance with the no-shirking condition, given the realised aggregate price level. The unemployment rate to which firms refer when paying wages is that prevailing at the start of the period; it is assumed that the state of the labour market arising from the interaction of firm's pricing decisions and aggregate demand is not revealed to workers until the end of the period. The firm's problem is then:

$$Max_{w^e,l,\tau}: \quad P_i a\bar{e}(1-\tau)l - W^e l \qquad s.t. \qquad \frac{W^e}{P^e} = \bar{e}\left(1 + \frac{k(u)}{q(\tau)}\right). \tag{156}$$

From the resulting Lagrangean the following first-order conditions arise:

$$\frac{\partial L}{\partial l} = P_i a\bar{e}(1-\tau)\left(\frac{\sigma-1}{\sigma}\right) - W^e = 0 \tag{157}$$

$$\frac{\partial L}{\partial W^e} = -l + \frac{\lambda}{P^e} = 0 \tag{158}$$

$$\frac{\partial L}{\partial \tau} = -P_i a\bar{e}l\left(\frac{\sigma-1}{\sigma}\right) + \lambda\bar{e}\frac{k(u)}{q(\tau)^2}q'(\tau) = 0 \tag{159}$$

[88] Assumed irrevocable. Again, this is consistent with a situation where production is organised into teams, each having a single monitor associated with it; reorganisation during the period could then be too costly. This assumption is not central to the analysis.

where λ is the associated Lagrange multiplier. From (157) we get the usual result that firms set prices as a mark-up on (expected) marginal costs. Combining (158) and (159) we have:

$$P_i a\left(\frac{\sigma-1}{\sigma}\right)=P^e\frac{k(u)}{q(\tau)^2}q'(\tau). \tag{160}$$

The LHS represents the increase in revenue (per worker) from a rise in the proportion of workers employed in production rather than monitoring, the RHS the associated increase in the expected wage bill. Profit maximisation requires that the two be equal. Combining (157) and (160), and using the no-shirking condition, we have:

$$\frac{k(u)}{q(\tau)}\left(\frac{\tau}{q(\tau)}q'(\tau)-1\right)=\frac{\partial(1-\tau)}{\partial W^e}.\frac{W^e}{(1-\tau)}=1. \tag{161}$$

This is the counterpart to the well-known Solow condition from the literature on endogenous effort choice, which stipulates that the wage elasticity of effort must equal unity in equilibrium; here it is the wage elasticity of $(1-\tau)$, the proportion of the workforce that is engaged in production, that must be equal to one.

To solve for τ explicitly it is necessary to be more specific with regard to its relation to the probability of detection. A simple functional form is chosen:

$$q(\tau)=b\left(\frac{\tau}{1-\tau}\right) \tag{162}$$

where b is a parameter governing the effectiveness of a firm's monitoring technology. This could vary randomly, according to industrial type or size of workforce, or indeed with the productivity parameter a. The above formulation is intuitive: the probability of detection is simply proportional to the ratio of monitors to production workers. Using (161) to solve for optimal values of $q(\tau)$ and therefore τ, we have:

$$q(\tau^*) = \sqrt{bk(u)} \tag{163}$$

$$\tau^* = \frac{q(\tau)}{b+q(\tau)}=\frac{\sqrt{k(u)}}{\sqrt{b}+\sqrt{k(u)}}. \tag{164}$$

Recalling that $k'(u)\prec 0$, we see that the optimal proportion of workers engaged in monitoring is negatively related to the unemployment rate, as therefore is the probability of detection. Since unemployment acts as a disincentive for workers to shirk, as it rises firms are able to reallocate resources away from monitoring and towards more productive activity. Substituting the solution for τ^* into the pricing decision of the firm, (157) above, we have a price equation with unemployment on the RHS as in Section 4.3.1:

$$p_i = w^e - \log\left[a\bar{e}\left(\frac{\sigma-1}{\sigma}\right)\right] + \log\left[1+\frac{\sqrt{k(u)}}{\sqrt{b}}\right]. \tag{165}$$

Using the solution for $q(\tau^*)$ in the no-shirking condition, we also have a nonlinear wage curve:

$$w^e = p^e + \log\bar{e} + \log\left[1+\frac{\sqrt{k(u)}}{\sqrt{b}}\right]. \tag{166}$$

Combining (165) and (166), and aggregating across firms, gives a convex Phillips curve:

$$\begin{aligned} p - p^e &= -\log\left[a\left(\frac{\sigma-1}{\sigma}\right)\right] + 2\log\left[1+\sqrt{\frac{k(u)}{b}}\right] && (167) \\ &\approx -\log\left[a\left(\frac{\sigma-1}{\sigma}\right)\right] + 2\sqrt{\frac{k(u)}{b}}, && (168) \end{aligned}$$

with the Taylor Approximation holding for b large enough[89]. As for the slope of the Phillips curve, that $\sqrt{k(u)}$ is convex is proven in an appendix. The price and wage curves are graphed in Figure 21. The intuition for the shape of the price curve is as follows - as unemployment rises, firms switch resources from monitoring to production (thereby increasing the marginal labour product), but at a decreasing rate. As for the wage curve, the dampening influence of increased outside unemployment upon wages remains; this dominates the effect of the substitution away from monitoring, which *ceteris paribus* means that workers require a higher wage in order to be induced not to shirk.

So, it is relatively simple to generate a nonlinear Phillips curve. Should all subregions have identical monitoring technologies, as measured by b, and should the productivity parameter a also be common across labour markets, the 'pure' Aggregation Hypothesis of Section 4.3.1 would apply. However, differences in economic structure across regions are likely to imply heterogeneous Phillips curves.

First, it seems reasonable that a firm's monitoring technology be viewed as an integral part of the rest of the firm's activities; b could then be expected to be correlated with a, the productivity parameter, although *a priori* it is not clear what sign such correlation should take. A positive correlation could arise

[89] It seems reasonable to assume, given the form of $q(.)$, that b is considerably greater than 1.

from common management practices; a negative correlation could be a result of limited management resources being divided between overseeing the production and the monitoring processes.

Second, since it is probable that the monitoring process in capital-intensive manufacturing is qualitatively different from that in services, a stylised fact that merits consideration is the concentration of (relatively highly productive) service sector industries in the South of the UK. It is plausible that the contribution of an individual worker to a firm's final output is less tangible in services than manufacturing; more precisely, that it is less easy in services to infer each worker's input from the final firm output, assuming that this is all that is directly observed, and so monitoring in services is likely to be less 'efficient'. Note that this conjecture has nothing to do with workers in service sector firms working more in teams, say. There is no reason for this to be the case; think of a production or assembly line in a manufacturing firm. The argument is more about the differing nature of team-work across sectors. It might be easier to examine final output at the end of the proverbial production line and discern where any shirking has occurred[90].

The UK economy could thus be caricatured as consisting of a high-value-added (high-a) service sector, with poor (low-b) monitoring technology, in the South, with its mirror image the manufacturing sector concentrated in the North[91]. This is all the more true if one accepts the notion that, *ceteris paribus*, a and b are anyway likely to be negatively correlated. Southern regions would therefore have steeper, more convex Phillips curves[92], as will be confirmed by the data. Note that the pure version of the aggregation hypothesis will no longer be appropriate in such a situation. Figure 22 details two subregional Phillips curves for the case where productivity and monitoring technology are negatively related.

[90] In fact, on a production or assembly line the individual worker inputs might be observable directly, making monitoring even more efficient.

[91] Another stylised fact is the concentration of small or medium-sized enterprises (SMEs) in the South (see, for example, Keeble (1996)). It is possible that there are economies or diseconomies of scale in the monitoring process. For example, Ringuede (1998) has a model with endogenous effort where monitoring technology depends explicitly on firm size. More importantly, perhaps, workers in SMEs will probably feel their future is more bound up with that of the enterprise. Peer pressure may then be more likely to act as a disciplinary device, and the efficacy of monitoring in fact increased. I thank Charles Bean for this last point.

[92] Again, this is confirmed in the chapter appendix.

4.5 Previous empirical work

This section briefly reviews the empirical literatures on the effect of unemployment dispersion on aggregate inflationary pressure and on the shape of the aggregate unemployment-inflation trade-off.

4.5.1 The dispersion effect

Most early work uses regional data to estimate naive wage-inflation Phillips curves, with little or no role for expectations. Cowling and Metcalf (1967) examine the wage transfer hypothesis, and find earnings increases in six high unemployment regions to be correlated with those in London & the SE. They conclude that some sort of 'earnings spread' is indeed at work. Thirlwall (1969) suggests that their findings were a result of not considering earnings spread independently of aggregate demand, for which London & the SE may be a proxy. Thirlwall tests the effect of regional unemployment dispersion directly, using post-war data to estimate aggregate equations of the form:

$$w - w_{-1} = c_0 + c_1(p - p_{-1}) + c_2\overline{u} + c_3 s \tag{169}$$

where s is the standard deviation of regional unemployment rates and $\overline{u}$ the aggregate unemployment rate. He found no role for regional dispersion, although a similar measure based on industrial disaggregates was significant.

Archibald (1969) carries out similar analysis, using the inverse of the unemployment rate instead of a simple linear function. In contrast to Thirlwall, he finds that the second moment of the regional unemployment distribution *does* have a positive effect on the rate of change of wages, again using post-war data. However, he notes that there was a problem of multicollinearity, as the first and second moments were highly correlated.

Thirlwall (1970) examines regional (wage-inflation) Phillips curves directly, rather than working with aggregate data. He finds evidence that high-unemployment regions had Phillips curves that lay to the right of those for low-unemployment regions, and that they were flatter. He concludes there is indeed some support for the aggregation hypothesis, but doubts its quantitative significance.

Thomas and Stoney (1971) criticise the dispersion measures of Thirlwall and Archibald as *ad hoc.*

Starting with disaggregate wage-inflation Phillips curves, they take Taylor expansions as in Section 4.3.1 above, and test the aggregation hypothesis jointly with that of the wage transfer mechanism by estimating aggregate equations of the form:

$$w - w_{-1} \approx k(p - p_{-1}) + (1-h)[f(\overline{u}) + \frac{1}{2}s^2.f''(\overline{u})] + hf(\widehat{u}). \tag{170}$$

where $\widehat{u}$ is unemployment in the leading sector[93]. Using post-war regional data, they find that, for various choices of $f(.)$, all variables are significant and enter with the correct sign, and moreover that the implied restrictions on the coefficients cannot be rejected. They interpret their results as support for both the aggregation and wage transfer hypotheses. Indeed, they argue that regional unemployment dispersion is of quantitative importance in its effect on aggregate wage inflation - they estimate that, in the absence of such dispersion, the annual rate of wage inflation in the UK would have been over two percentage points lower (3.33% as opposed to 5.46% p.a.). However, there is a significant problem with their results - they retrieve estimates of h of around 2.5, whereas *a priori* one might expect h to be bounded between zero and one. They suggest data inadequacies may be responsible.

Brechling (1973) is the first to incorporate the neoclassical approach into a model of regional submarkets. His model is a variant of that of Phelps (1970) where firms are assumed to adjust wages in relation to expected wage changes elsewhere, in an attempt to achieve and maintain their desired labour recruitment levels. Brechling also extends the earlier empirical work, and tests the nonlinear aggregation hypothesis while incorporating the concept of a natural rate of unemployment. He estimates a wage-inflation Phillips curve similar in form to that of Thomas and Stoney above, but includes terms for wage and price expectations on the RHS. Using state-level US data, quarterly 1950-1969, he fails to find a form of nonlinearity that substantially outperforms a simple linear specification. He concludes that there is little empirical support for the nonlinear aggregation hypothesis. Neither does he find any support for the proposition that low-unemployment regions were 'expectational leaders' in any sense[94].

[93] They define the leading sector that region with the lowest unemployment rate at any particular time; they also consider an alternative specification where the leading sector is a group of three regions with low levels of unemployment historically.

[94] However, he does find some empirical support for the proposition that regions with relatively high average earnings (these were not those with low unemployment) influenced wage changes in other regions.

More recently, Jackman, Layard and Savouri (1990) consider whether increased subregional unemployment dispersion could be responsible for the increase in the UK NAIRU, 1963-1987[95]. They do not include a dispersion measure in any estimated equation. Rather, they derive the appropriate measure for the case of identical, logarithmic regional wage curves (ie s^2/u^2), and note that this had in fact fallen over the sample period. They conclude that subregional unemployment dispersion played no role in the NAIRU increase.

Finally, Tootell (1994) includes the variance of unemployment rates in US states, quarterly 1960-1993, in an aggregate Phillips-type equation:

$$p - p_{-1} = a(L)(p_{-1} - p_{-2}) + b(L)(\overline{u} - \overline{u}_n) + c(L)z_t + s^2 \tag{171}$$

where $\overline{u} - \overline{u}_n$ is the deviation of unemployment from the NAIRU, z_t is a vector of supply shock variables and $a(L)$, $b(L)$ and $c(L)$ are (linear) functions in the lag operator. Note that expected inflation is proxied by lagged values of actual inflation, typically with the coefficients on the lagged values are restricted to sum to one. As it is, Tootell finds the variance to be insignificant, and concludes that unemployment dispersion was not responsible for any variation in the US NAIRU.

In short, empirical work on the effect of unemployment dispersion on inflationary pressure in the aggregate has had mixed results. Note that the most recent Brechling (1973) and Tootell (1994) studies, neither of which found any role for unemployment dispersion, both used US data.

4.5.2 Phillips curves or Phillips lines?

In much recent empirical work on aggregate Phillips-type equations, the unemployment-inflation trade-off is assumed to be linear. This assumption has been questioned by work at the IMF; see for example Clark and Laxton (1997), Clark, Laxton and Rose (1996), Debelle and Laxton (1996) and Laxton, Meredith and Rose (1995). While the potential nonlinearity of the Phillips curve was explicit in the work of Phillips (1958) and Lipsey (1960), it tended to become implicit in later work. To quote Clark and Laxton (1997), p.8:

[95] They call it the regional mismatch hypothesis.

"The question of whether the Phillips relationship was a straight line or a curve was eclipsed in part because in the 1960s and 1970s the dominant issue was the extent to which the relationship was stable. First, the natural rate hypothesis propounded by Friedman (1968) and Phelps (1970) called into question the usefulness of the Phillips curve as an analytical construct. Moreover, attention shifted to the expectations-augmented Phillips curve and the determinants of the NAIRU, as well as the factors generating the apparent rise in the NAIRU during the 1970s and 1980s in many industrial countries. Second, the two oil price shocks and unstable monetary policies in the 1970s led to large shifts in inflation relative to the level of the unemployment rate, so that...the connection between these two variables was considerably obscured. Partly as a result of these developments, the important policy implications of the nonlinearity of the Phillips curve were never explored."

With regard to the UK, Debelle and Laxton (1996) use the Kalman Filter to estimate a Phillips curve while allowing for a time-varying NAIRU[96]. After imposing restrictions on the variability of the NAIRU, they find that a convex Phillips curve provides a better fit than a linear alternative, with similar results for the US and Canada. In contrast, Stiglitz (1997) suggests that the curve for the US is mildly concave.

The issue is thus far from settled, and is complicated by the tendency of certain variables, thought to have an impact on the NAIRU, to move with the aggregate unemployment rate. These include the amount of long-term unemployment, and indeed for the purposes of this paper the spatial dispersion of unemployment. The studies above do not allow for the effects of such variables, or for more general hysteresis effects. Next, results from linear and nonlinear Phillips curve estimations are reported, with variables thought to influence inflationary pressure included.

[96] They use an explicit measure of inflationary expectations incorporating information from bond markets. Of course, whether or not financial markets' expectations regarding inflation are the same as those used by firms and workers to set wages and prices is unclear.

4.6 Empirical results

In this section the possible implications of unemployment dispersion for the GB NAIRU are tested. First, aggregate (price-inflation) Phillips curves are estimated, with various dispersion measures included on the right-hand-side. Then wage curves are estimated for the individual regions; this is done both to check for possible regional heterogeneity and to see if wage inflation in any region is affected by the dispersion in unemployment of the constituent subregions.

4.6.1 Aggregate Phillips curves

Phillips curves of the form:

$$p - p_{-1} = (p - p_{-1})^e + f(u) + dispersion + Z \tag{172}$$

were estimated using quarterly data, 1966:1-1996:4. As well as measures of unemployment dispersion, other variables (Z) were included that are commonly thought to have influenced the inflation-unemployment trade-off, such as import-price inflation, long-term unemployment, union membership, the replacement ratio and productivity growth. Changes in the tax wedge were also allowed a short-run effect. Inflationary expectations were proxied by a distributed lag of prior inflation, with the coefficients restricted to sum to one.

Table 2 shows the estimation results for Phillips curves without unemployment dispersion measures. Columns I-III report results for a simple linear specification, and are quite representative of the search process across various specifications. Column I includes all variables (save an unemployment dispersion measure); the replacement ratio (rr) and the change in employment taxes ($cht1$) both enter with the wrong sign, while the unemployment-change term (chu) and the change in indirect taxes ($cht3$) are insignificant. These results obtained across all specifications (both loglinear and with added dispersion measures), and these variable were dropped from the regressions. Note that this leads to the union membership variable ($union$) being insignificant (column II); column III reports results with the union variable excluded. Both the percentage of the unemployed that have been without work for over a year (ltu) and the change in income taxes ($cht2$) are highly significant. The variable for import inflation (*importinf*) is the correct sign but insignificant; however, it is included as it proved significant in some specifications with dispersion measures included. The term for productivity growth was consistently significant and of the right sign. Columns IV-VI report the identical procedure using a loglinear unemployment term. The conclusions regarding the variables to be included are the same, but the fit is slightly worse. Other nonlinear specifications were tried, including one using the inverse of the aggregate unemployment rate, but these showed deteriorations in fit and are not reported.

Columns I-IV of Table 3 show the results when simple unemployment dispersion measures were added to the estimated equations. Various distributional statistics were tried, including the variance, various percentile ranges and the coefficient of variation. However, the best results were achieved using the simple standard deviation. Columns I and II report results for the linear and loglinear specifications with the standard deviation of regional unemployment rates (*stdevreg*) added; columns III and IV use the standard deviation of the subregional distribution (*stdevsub*). The 10 Standard Statistical Regions were used to obtain *stdevreg*, while the subregional distributional statistic was based on a variety of datasets, typically with more than 300 constituent subregions; details are in the data appendix. Again, the linear specification provides the best fit, while *stdevsub* outperforms *stdevreg*. Indeed, the linear specification, with the standard deviation of subregional unemployment rates included, proved to have the highest explanatory power of all specifications attempted. The timepath that this specification implies for the NAIRU is detailed in Figure 23, along with the GB unemployment rate. The rise in the NAIRU from the 1960s onwards is reproduced, as is the subsequent fall at the end of the 1980s. This is followed by a further cycle in the NAIRU at the start of the 1990s. Table 4 breaks down the increase in the NAIRU between 1977:1 and 1987:1, a rise of over 8%, by variables responsible. The results indicate that over half of the increase was due to the rise in subregional unemployment dispersion.

The pure version of the aggregation hypothesis was also tested. Table 3 reports estimation results for equations of the form (150), with and without the implied parameter restrictions imposed. The appropriate dispersion measure with a logarithmic unemployment term is $\frac{var}{u^2}$, i.e. the variance of the regional or subregional unemployment distribution, deflated by the square of the aggregate unemployment rate[97]; the implied restriction is that the coefficient on this statistic is equal to (minus) half the coefficient on the log of the unemployment rate. Other forms of nonlinearity were tried, but none outperformed the simple loglinear specification. The results from the unrestricted regressions are reported in columns VII and VIII of Table 3. The coefficients on the deflated dispersion terms are insignificant and incorrectly signed, no matter whether the regional or subregional unemployment distributions were used. With restrictions imposed (columns V and VI), the coefficient on the unemployment and dispersion terms is in each case correctly signed and highly significant. This is perhaps unsurprising, given the significance of the unemployment term in all specifications. However, Wald tests indicate that both restrictions are rejected at the 5% level. Moreover, in both cases the fit is inferior to the simple linear specification with standard deviation included, and even to the logarithmic specification with no dispersion measure.

So, while it seems that spatial unemployment dispersion may help explain movements in the GB Phillips curve, this seems unlikely to arise from aggregation over identical, nonlinear disaggregate Phillips curves. Possible heterogeneity is investigated next.

4.6.2 Regional wage curves

In the absence of regional price data, any investigation of regional heterogeneity must focus on wage curves of the form (144) above. There are, however, associated difficulties. The timing of the wage- and price-setting described in Section 4.4.1 was *ad hoc*, and in practice it is not clear whether one is estimating a wage-setting equation or uncovering a firm's pricing decision. Moreover, Manning (1992) and Bean (1992) point out that problems of identification arise when estimating wage curves. Manning also argues that such difficulties can be overcome, and that the correct form of the wage equation is similar to an old-fashioned Phillips curve, with variables in the form of rates of change rather than levels. The approach taken here is to estimate such equations in error-correction form:

$$(w - w_{-1}) = \alpha_0 + \alpha_1(p - p_{-1}) - \alpha_2(w - p)_{-1} + f(u) + dispersion + Z \tag{173}$$

where $\alpha_2 = 1$ would imply an equation in levels. This was done for the 10 Standard Statistical

[97] This is of course also the variance of the relative unemployment rates, and is the measure examined by Jackman, Layard and Savouri (1990).

Regions using annual data[98], 1970-1996. Wage data were based on average gross weekly earnings of all full-time adults. The lack of regional price data meant that the national RPI index was again used, while the unemployment variable used was the mean unemployment rate across a region's constituent subregions. Again, variables such as the replacement ratio, union membership and the tax wedge were included; none of these was significant, not even that for long-term unemployment (*ltu*) or the change in indirect taxes (*cht*2). This may be an artefact of the rather smaller sample. These results are not reported for the sake of brevity. A term for the change in unemployment was found to be significant, however, for all regions, as was a variable in the *level* of productivity[99]. Also striking was the fact that simple dispersion measures reflecting the variation in unemployment across a region's constituent subregions, for example the standard deviation, were invariably wrongly signed and insignificant; again, these omitted for reasons of brevity.

Reported in Table 5 are the results for the 10 regions using a linear specification. The coefficient on the lagged real wage is invariably highly significant but with a value below one, suggesting consistent but less than complete error-correction. Tables 6 and 7 present results for logarithmic and inverse specifications of the regional wage curves, with and without allowing for dispersion effects. Again, the pure version of the aggregation hypothesis is tested, with associated restrictions imposed[100]. χ^2 tests of the restrictions show they largely fail to be rejected.

Also reported, in Table 8a, are the results obtained by estimating the linear system as a Seemingly Unrelated Regressions (SUR) model; this is intended to account for omitted common variables across the regional equations[101]. The fitted residuals do indicate significant cross-regional error correlation, as shown in Table 8b. Table 9a reports results from a SUR model where each regional equation used the

[98] No quarterly historical wage data were available at regional level.

[99] Again, regional productivity data were unavailable, and national data were used. These proved a better fit than a simple time trend.

[100] The implied dispersion measure and associated restrictions for the logarithmic specification are as for the aggregate Phillips curve estimation. For the inverse specification, the appropriate dispersion measure is s^2/u^3, i.e. the variance of unemployment across the constituent subregions deflated by the cube of the region's unemployment rate; the associated restriction is that the coefficient on this measure is equal to that on the inverse of unemployment.

[101] Again, I thank Charles Bean for this suggestion.

specification that provided the best fit in Tables 5-7. A Wald test of the three linear restrictions in the system (on the parameters of the dispersion terms included in the *sel*, *em*, and *wm* equations) returned a χ^2 statistic of 6.41, with a p-value of 0.093. Again, Table 9b provides the contemporaneous correlation matrix for the residuals.

Importantly for the purposes of this paper, there is considerable variation in the responsiveness of wages to unemployment. Moreover, regions where wages are more sensitive to unemployment also tend to have more convex wage curves; these results are broadly consistent with the shirking model outlined above. We see that for five out of the ten regions, predominantly southern, the best fit is provided by one of these nonlinear specifications, while for three of these it is that which incorporates a dispersion measure. This is summarised in Table 10, which also ranks regions according to the size of the coefficients on unemployment, using the SUR estimates for the linear model. Figure 24 is a scatter-plot of these regional wage curve slopes against the respective average unemployment rates over the sample. A situation where aggregate wage inflation is minimised would have relatively high levels of unemployment in regions with steeper wage curves. The opposite is true; unemployment seems to have been higher in regions where wages were less responsive to unemployment[102]. It is instructive to carry out a similar exercise, focusing this time on the relative unemployment rates in different sub-periods. Figures 25.1-25.5 do this for the periods 1970-1975, 76-80, 81-85, 86-90 and 90-96. While the pattern is again of relatively high unemployment in regions with flatter wage curves, this disappears in the 1990s, suggesting that the advent of a more benign inflationary environment was in part due to a more favourable regional distribution of unemployment.

4.7 Concluding remarks

Most studies of the effect of unemployment dispersion on the aggregate NAIRU consider aggregation over identical, convex disaggregate Phillips curves, here called the pure aggregation hypothesis. It was argued above that such an homogeneity assumption is overly restrictive, and that the likely heterogeneity across spatial units has implications both for the possible existence of a dispersion effect and for the correct

[102]This echoes the results of Thirlwall (1970).

statistics to include in aggregate Phillips curve equations. Using GB data, 1966-1996, the pure version of the aggregation hypothesis was rejected by the data. However, *ad hoc* measures of dispersion were found to explain a significant proportion of the inflationary pressure; this is consistent with a situation where regional Phillips curves are heterogeneous, with those in low-unemployment regions being steeper. This conjecture was supported by the results from estimating wage curves at regional level. Moreover, for some regions the pure aggregation hypothesis was not rejected when considering the impact on wage inflation of unemployment dispersion across constituent subregions; this is intuitive, since it is more likely to hold when aggregating over labour markets of similar economic structure, and perhaps explains why the subregional unemployment distribution was more successful in explaining aggregate inflationary pressure than the regional.

A simple shirking model was developed which generated nonlinear Phillips curves and located any possible heterogeneity in differences in monitoring technology across regions. Regions with less efficient monitoring processes were shown to have steeper, more convex wage and Phillips curves, consistent with the data. Of course, the model is highly specific, but the aim is in part didactic. A general conclusion is that differences in economic structure across regions are likely to lead to differences not only in disaggregate natural rates but also in the slopes of the inflation-unemployment trade-off.

As for further research, the wage-transfer mechanism is one candidate. This paper mentioned it as a possible justification for the use of *ad hoc* dispersion measures, but further investigation may be warranted. Embedding the wage-transfer mechanism in a fully-specified migration model would perhaps be instructive. This brings one to another shortcoming of the analysis here, and of almost all previous work, namely that it is essentially spaceless and equally applicable to the analysis of a general multi-sector economy. Clark (1980) argued that wage changes in tight labour markets could spill over to contiguous labour markets, and future work could incorporate explicitly spatial measures of unemployment dispersion, such as Moran's I-statistic[103].

Finally, much attention has been paid in recent years to the role of increasing returns, path dependence and agglomeration in regional economics. While models of this type focus more on long-term

[103] See Moran (1948).

location decisions than short- and medium-run fluctuations, a reasonable hypothesis is that the severe recession experienced by some regions during the 1980s had a lasting effect. A fuller investigation of the link between regional path dependence and aggregate hysteresis, perhaps involving consideration of the differential regional effects of monetary policy, seems in order.

4.8 Appendix

4.8.1 Nonlinear Phillips curves

The convexity of the Phillips curve in obtained in Section 4.4.1 is confirmed here. We have:

$$p - p^e = const. + 2\sqrt{\frac{k(u)}{b}} \tag{174}$$

$$= const. + 2\sqrt{\frac{r + \frac{c}{u}}{b}}. \tag{175}$$

It is straightforward to derive:

$$\frac{\partial(p-p^e)}{\partial u} = -\frac{c}{\sqrt{b}} \cdot (ru^4 + cu^3)^{-\frac{1}{2}} < 0 \tag{176}$$

and hence:

$$\frac{\partial^2(p-p^e)}{\partial u^2} = \frac{c}{2\sqrt{b}} \cdot \frac{4ru^3 + 3cu^2}{(ru^4 + cu^3)^{\frac{3}{2}}} > 0. \tag{177}$$

Inspection of (42) and (43) also confirms that regions with less efficient monitoring technologies (i.e. those with low values of b) will have steeper, more convex Phillips curves.

4.8.2 The wage transfer hypothesis

To see the aggregate effect of a wage-transfer mechanism, divide subregions into two distinct groups: *leading* subregions, indexed by l, and *lagging* subregions indexed by m. In the former, unemployment is relatively low, and wages and prices are set as before, resulting in the familiar Phillips curves:

$$p_l - p_l^e = \phi_l(u_l) + \mu_l(u_l) \tag{178}$$

$$= \theta_l(u_l) \qquad l = 1, ..., L. \tag{179}$$

In the latter, prices are set as before:

$$p_m = w_m^e + \phi_m(u_m) \qquad m = 1, ..., M. \tag{180}$$

Wages, though, are driven partly by those wages available to workers elsewhere. For each lagging subregion m, denote by $(w_{lm}^e - p_{lm}^e)$ the expected real wage available in the leading labour market l used as a reference, and by $\mu_{lm}(u_{lm})$ the usual wage curve in that market. It is assumed that wages are partly driven by local conditions, partly by wages in the low-unemployment reference labour market:

$$w_m^e = p_m^e + (1 - h_m)\mu_m(u_m) + h_m(w_{lm}^e - p_{lm}^e) \tag{181}$$

$$= p_m^e + (1 - h_m)\mu_m(u_m) + h_m\mu_{lm}(u_{lm}) \qquad 0 \prec h_n \prec 1; \tag{182}$$

The extent to which wages in any lagging subregion are influenced by those elsewhere depend on the parameter h_m. From (180) and (182) Phillips curves for these subregions are obtained:

$$p_m - p_m^e = \phi_m(u_m) + (1 - h_m)\mu_m(u_m) + h_m\mu_{lm}(u_{lm}) \tag{183}$$

$$= \theta_m(u_m) + h_m[\mu_{lm}(u_{lm}) - \mu_m(u_m)]. \tag{184}$$

Aggregating over both sets of subregions, we have an aggregate Phillips curve:

$$p - p^e = \frac{1}{n}\sum_{i=1}^{n}\theta_i(u_i) + \frac{1}{M}\sum_{m=1}^{M} h_m[\mu_{lm}(u_{lm}) - \mu_m(u_m)]. \tag{185}$$

The second summation term is positive, since $u_{lm} \prec u_m$ and the $\mu_.(.)$ are decreasing functions. Once again, a reduction in the dispersion of unemployment rates reduces inflationary pressure for a given level of aggregate unemployment, as long as it is associated with an increase in unemployment in the leading labour markets. Note that, while we may have in addition the familiar aggregation hypothesis from the first term on the RHS in (185), this result obtains even with identical, linear $\phi_{.}(.)$ and $\mu_{.}(.)$. Once again, absent knowledge of the disaggregate functional forms, the dispersion measure appropriate for empirical work is unclear. The matter is complicated further by the notion of leading and lagging labour markets. It seems implausible that nationwide wage demands are based on wages received in the South-East. It is at least as likely that any transfer mechanism operates at more local levels, given the extent of unemployment dispersion present even with the Standard Statistical Regions. It may be that the labour market which workers use as a basis for wage comparisons is the contiguous subregion with the lowest unemployment rate; or perhaps the subregion with the lowest unemployment within a 100 mile radius.

4.8.3 Data

Note that regional data refer to the 10 Standard Statistical Regions (abbreviations used in the paper in brackets): East Anglia (EA), East Midlands (EM), North (N), North-West (NW), Scotland (SCOT), South-East including London (SEL), South-West (SW), Wales (WAL), West Midlands (WM) and Yorkshire and Humberside (YH).

Unemployment The subregional unemployment data were drawn from three sources:

(a) a dataset collated by Martin Frost and Nigel Spence, covering unemployment rates in 428 subregions, 1963:2 - 1976:1 [the frequency of the dataset was every two months; these were converted into quarterly data as follows:Q1=Feb, Q2=Average(Apr,Jun), Q3=Aug, Q4=Average(Oct,Dec). The dataset is available at the ESRC Data Archive].

(b) 1976:2 - 1978:2: data were taken from issues of the Employment Gazette, based on 171 subregions.

(c) four separate NOMIS files, using the *narrow base*[104] denominator for calculating unemployment rates; all data were monthly, and were converted into quarterly data by simple averaging:

(i) 1978:3 - 1982:3: file URPUB. The series is based on the information collected from individual Jobcentres, and was aggregated to the 380 '1978 travel-to-work areas [Jobcentre base]' (*ttwa78jc*). The data are unrevised and match those published in the *Employment Gazette*; they are based on registrant counts[105];

(ii) 1982:4 - 1983:2: file USJ. Again, these data are based on individual Jobcentres and were aggregated to *ttwa78jc;* they are derived using claimant counts;

(iii) 1983:3 - 1996:1: file USW81. These data are based on 1981 Wards base rather than Jobcentres, and were aggregated to the 322 '1984 travel-to-work areas' (*ttwa84*); again, they are derived from claimant counts;

(iv) 1996:2 - 1998:2: file USW91. These data are based on 1991 Wards, and were aggregated to the 322 '1984 travel-to-work areas: 1991 Ward best fit' (*ttwa8491*); as before, they are derived from claimant

[104] ie estimated employees in employment + unemployed.

[105] Missing data for March and April, 1981.

counts.

The national and regional unemployment data used in estimation were drawn from the above files.

The long-term unemployment share was drawn from historical issues of the Employment Gazette, and refer to the proportion of unemployed who had been unemployed for 12 months or more.

Inflation The RPI inflation series was supplied by the ONS, series $FRAG$. The import inflation series was from the same source, series $BQKS$.

Wages Regional wage data were available annually from the New Earnings Survey, and were based on average gross weekly earnings of all full-time adults.

Taxes - $cht1$ is the annual change in employment taxes. Quarterly index numbers for unit wage costs (series $DJDO$) and unit labour costs (series $DJDP$) were obtained from the ONS. Then, $\log(DJDP/DJDO)$ was used as a proxy for employment taxes.

- $cht2$ is the annual change in income taxes. The income tax series was computed as follows:

$$t2 = (DT + HSS)/(HCR - ESS)$$

where DT is direct taxes on household income, SS is households' contributions to social security schemes, HCR is household's current receipts and ESS is employer contributions to social security schemes. All series were taken from OECD National Accounts, and were available only annually.

- $cht3$ is the annual change in the indirect tax rate. The series for indirect taxes was computed as $t3 = \log(DJDT/DJCM)$, where $DJDT$ is the GDP deflator at market prices and $DJCM$ is the GDP deflator at factor cost. Data were obtained from the ONS, and were available quarterly.

Productivity The productivity inflation term was based on a ratio of two index numbers, $(CGCE/DYDCI)$, where $CGCE$ is gross value added at basic prices (1995:2=100) and $DYDCI$ is an index for the workforce in employment (1995:2=100). The latter was constructed from $DYDC$, a raw series for the workforce in employment. Both $CGCE$ and $DYDC$ were available quarterly from the ONS.

Replacement ratio *rr* was based on a married worker with 2 children claiming income support, with the denominator being average gross weekly earnings of full-time adults. Data were available annually.

Unions The *union* variable was an annual time series of trade union membership, taken from issues of Labour Market Trends.

4.8.4 Tables

Periods within which estimates fall	1969-73	1974-80	1981-87	1988-90
NAIRU range	1.6% - 5.6%	4.5% - 7.3%	5.2% - 9.9%	3.5% - 8.1%
Average NAIRU	2.9%	5.7%	7.0%	6.1%

Table 1 - NAIRU estimates for the UK (claimant count definition); taken from Coulton and Cromb (1994)

Dependent variable is aggregate RPI inflation

	I	II	III	IV	V	VI
8 lags(rpiinf)	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	-	-	-	-	-	-
u	-0.3477	-0.2803	-0.2586	-	-	-
	-(4.96)	-(5.32)	-(5.30)	-	-	-
log(u)	-	-	-	-1.5231	-1.3827	-1.3441
	-	-	-	-(3.76)	-(4.67)	-(4.77)
importinf	0.0091	-0.0010	0.0072	0.0118	0.0087	0.0118
	(0.57)	-(0.07)	(0.57)	(0.70)	(0.59)	(0.93)
constant	-0.4161	-1.8815	-0.6004	3.4665	-0.3092	0.1841
	-(0.15)	-(1.51)	-(1.49)	(1.20)	-(0.26)	(0.44)
oil1	1.6516	1.3993	1.5579	1.6033	1.8148	1.8738
	(2.19)	(2.01)	(2.29)	(2.03)	(2.48)	(2.62)
oil2	2.9821	3.8318	3.9121	2.9182	3.7549	3.7946
	(3.05)	(4.17)	(4.27)	(2.86)	(3.99)	(4.07)
prodinf	-0.0919	-0.0998	-0.1058	-0.1149	-0.1148	-0.1167
	-(1.59)	-(1.75)	-(1.86)	-(1.92)	-(1.97)	-(2.02)
union	4.8372	2.5714	-	2.9358	1.0384	-
	(1.91)	(1.09)	-	(1.14)	(0.44)	-
cht1	-15.3373	-	-	-0.5168	-	-
	-(0.32)	-	-	-(0.01)	-	-
cht2	48.4401	61.3429	53.4939	30.6674	35.6812	33.1546
	(2.39)	(3.46)	(3.30)	(1.48)	(2.04)	(2.01)
cht3	26.5440	-	-	21.0718	-	-
	(1.09)	-	-	(0.83)	-	-
rr	-3.8426	-	-	-7.0459	-	-
	-(0.94)	-	-	-(1.53)	-	-
ltu	0.1003	0.1029	0.0866	0.0534	0.0855	0.0795
	(2.81)	(4.44)	(4.89)	(1.59)	(3.80)	(4.45)
u-u(-1)	0.1797	-	-	-0.1378	-	-
	(0.60)	-	-	-(0.47)	-	-
R-sq	0.9727	0.9682	0.9678	0.9700	0.9666	0.9665
Adjusted R-sq	0.9671	0.9638	0.9637	0.963972	0.9619	0.9622
DW statistic	1.9278	1.9958	1.9814	1.9236	1.9806	1.9786

t-statistics are in brackets
Sample(adjusted): 1966:1 1996:4
Included observations: 124 after adjusting endpoints

Table 2 - aggregate Phillips curves, linear and logarithmic specifications

Dependent variable is aggregate RPI inflation

	I	II	III	IV	V	VI	VII	VIII
8 lags(rpiinf)	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	-	-	-	-	-	-	-	-
u	-0.2660	-	-0.3995	-	-	-	-	-
	-(5.32)	-	-(5.22)	-	-	-	-	-
log(u)	-	-1.3536	-	-1.6373	-	-	-2.0600	-1.7744
	-	-4.7400	-	-(4.10)	-	-	-(4.57)	-(3.84)
log(u) -	-	-	-	-	-1.2011	-	-	-
(varreg/u*u)/2	-	-	-	-	-(4.61)	-	-	-
log(u) -	-	-	-	-	-	-0.9699	-	-
(varsub/u*u)/2	-	-	-	-	-	-(4.45)	-	-
(varreg/u*u)/2	-	-	-	-	-	-	-8.3242	-
	-	-	-	-	-	-	-(2.01)	-
(varsub/u*u)/2	-	-	-	-	-	-	-	-0.7443
	-	-	-	-	-	-	-	-(1.17)
importinf	0.0084	0.0123	0.0237	0.0195	0.0137	0.0178	-0.0015	0.0024
	(0.66)	(0.95)	(1.68)	(1.32)	(1.07)	(1.37)	-(0.10)	(0.16)
constant	-0.7708	0.1302	-1.7515	-0.1108	-0.0602	-0.5233	1.7774	1.2178
	-(1.64)	(0.28)	-(2.79)	-(0.22)	-(0.15)	-(1.26)	(1.99)	(1.25)
oil1	1.5656	1.8765	1.8475	2.0580	1.8863	1.9469	1.5655	1.6457
	(2.29)	(2.61)	(2.72)	(2.79)	(2.61)	(2.65)	(2.17)	(2.22)
oil2	3.9373	3.8005	3.9661	3.7888	3.7586	3.6978	3.9134	3.8747
	(4.29)	(4.06)	(4.42)	(4.07)	(4.01)	(3.93)	(4.25)	(4.15)
prodinf	-0.1011	-0.1152	-0.0954	-0.1150	-0.1148	-0.1134	-0.1327	-0.1233
	-(1.76)	-(1.97)	-(1.71)	-(1.99)	-(1.97)	-(1.94)	-(2.30)	-(2.12)
stdevreg	0.1782	0.0632	-	-	-	-	-	-
	(0.72)	(0.25)	-	-	-	-	-	-
stdevsub	-	-	0.7416	0.3008	-	-	-	-
	-	-	(2.35)	(1.04)	-	-	-	-
cht2	54.8780	33.4662	49.5169	27.0721	31.6221	27.6658	45.6348	42.5523
	(3.36)	(2.02)	(3.10)	(1.55)	(1.90)	(1.64)	(2.62)	(2.32)
ltu	0.0847	0.0785	0.0724	0.0720	0.0766	0.0728	0.0863	0.0827
	(4.72)	(4.29)	(3.94)	(3.74)	(4.31)	(4.15)	(4.81)	(4.59)
R-sq	0.9680	0.9665	0.9694	0.9669	0.9661	0.9658	0.9677	0.9669
Adjusted R-sq	0.963532	0.961901	0.965147	0.962255	0.961798	0.961369	0.96326	0.962359
DW statistic	1.9794	1.9765	1.9927	1.9708	1.9696	1.9605	2.0237	2.0019
Chi-sq statistic					5.3361	3.8680		
on restriction*					*0.0209*	*0.0492*		

* p-values in italics
t-statistics are in brackets
Sample(adjusted): 1966:1 1996:4
Included observations: 124 after adjusting endpoints

Table 3 - aggregate Phillips curves with dispersion measures

variable	change in variable	effect on NAIRU
stdevsub	+2.75	+5.11
ltu	+20	+3.62
prodinf	-.46	+0.13
cht2	+0.0065	+0.81
importinf	-17.41	-1.03
total change in NAIRU		+8.64

Table 4 - relative effects of explanatory variables on the NAIRU, 1977:1 - 1987:1

Dependent variable is nominal wage inflation in each region

region	rpiinf	constant	u	u-u(-1)	log(prod)	log(w-p)(-1)	R-sq	Adjusted R-sq	DW statistic
ea	0.9397	3.2783	-0.0037	0.0103	0.6617	-0.6134	0.882	0.852	1.999
	(6.15)	(3.73)	-(1.81)	(3.36)	(3.37)	-(3.66)			
em	0.9843	3.5997	-0.0062	0.0123	0.7293	-0.6729	0.894	0.867	2.063
	(7.65)	(4.46)	-(3.19)	(3.57)	(4.38)	-(4.38)			
n*	1.1306	3.8127	-0.0044	0.0115	0.7158	-0.7174	0.868	0.835	1.899
	(6.94)	(4.40)	-(2.18)	(2.94)	(4.08)	-(4.34)			
nw*	0.9629	4.1927	-0.0050	0.0105	0.8438	-0.7822	0.898	0.873	2.032
	(8.15)	(4.91)	-(3.37)	(3.64)	(4.81)	-(4.85)			
scot*	1.1549	4.3173	-0.0026	0.0102	0.8646	-0.8128	0.882	0.852	2.181
	(7.53)	(4.61)	-(1.41)	(2.64)	(4.37)	-(4.56)			
sel	0.8517	2.7926	-0.0061	0.0097	0.7088	-0.4949	0.830	0.788	2.091
	(6.70)	(3.61)	-(2.55)	(2.77)	(3.58)	-(3.54)			
sw	0.8988	2.9858	-0.0044	0.0066	0.6122	-0.5551	0.823	0.779	2.083
	(5.75)	(3.05)	-(1.67)	(1.71)	(2.86)	-(3.01)			
wal*	0.9515	3.4979	-0.0038	0.0061	0.5439	-0.6607	0.869	0.836	2.043
	(7.00)	(3.68)	-(2.43)	(2.07)	(3.39)	-(3.63)			
wm	0.7131	2.7507	-0.0060	0.0075	0.4632	-0.5096	0.862	0.828	2.012
	(6.11)	(3.43)	-(3.00)	(2.67)	(3.21)	-(3.36)			
yh*	1.0758	4.0282	-0.0037	0.0090	0.7688	-0.7600	0.888	0.860	2.054
	(7.43)	(4.51)	-(1.98)	(2.73)	(4.24)	-(4.45)			

* particular specification provided the best fit for the region.
t-statistics are in brackets
Sample(adjusted): 1971 1996
Included observations: 26 after adjusting endpoints

Table 5 - regional wage curves, linear specification

Dependent variable is nominal wage inflation in each region

region	rpiinf	constant	log(u)	log(u) - (var/u*u)/2	u-u(-1)	log(prod)	log(w-p)(-1)	R-sq	Adjusted R-sq	DW statistic	Chi-sq statistic on restriction**
ea	0.9502	3.3600	-0.0296	-	0.0109	0.6913	-0.6228	0.888	0.860	2.051	
	(6.56)	(3.92)	-(2.14)	-	(3.59)	(3.60)	-(3.81)				
ea	0.9472	3.3313	-	-0.0298	0.0111	0.6889	-0.6174	0.890	0.863	2.077	2.870
	(6.60)	(3.92)	-	-(2.24)	(3.67)	(3.62)	-(3.82)				*0.0902*
em	1.0141	3.5646	-0.0455	-	0.0126	0.7477	-0.6578	0.894	0.868	2.182	
	(8.00)	(4.45)	-(3.21)	-	(3.63)	(4.44)	-(4.35)				
em*	1.0126	3.5461	-	-0.0441	0.0129	0.7471	-0.6553	0.895	0.869	2.222	0.014
	(8.00)	(4.45)	-	-(3.23)	(3.67)	(4.45)	-(4.35)				*0.9056*
n	1.1347	3.7433	-0.0427	-	0.0118	0.7113	-0.6936	0.867	0.834	1.946	
	(6.96)	(4.34)	-(2.15)	-	(2.96)	(4.05)	-(4.23)				
n	1.1352	3.6538	-	-0.0398	0.0119	0.6924	-0.6786	0.865	0.831	1.943	2.320
	(6.89)	(4.23)	-	-(2.04)	(2.91)	(3.95)	-(4.12)				*0.1442*
nw	1.0063	4.1518	-0.0410	-	0.0108	0.8650	-0.7660	0.896	0.869	2.151	
	(8.48)	(4.80)	-(3.24)	-	(3.62)	(4.73)	-(4.72)				
nw	0.9988	4.1140	-	-0.0393	0.0109	0.8557	-0.7599	0.895	0.869	2.162	0.255
	(8.39)	(4.77)	-	-(3.22)	(3.62)	(4.71)	-(4.69)				*0.6133*
scot	1.1488	4.2934	-0.0266	-	0.0105	0.8612	-0.8015	0.882	0.852	2.208	
	(7.41)	(4.59)	-(1.40)	-	(2.66)	(4.36)	-(4.49)				
scot	1.1537	4.2424	-	-0.0242	0.0105	0.8546	-0.7932	0.881	0.852	2.237	0.198
	(7.47)	(4.53)	-	-(1.37)	(2.65)	(4.32)	-(4.43)				*0.6564*
sel	0.8866	3.1598	-0.0437	-	0.0107	0.8215	-0.5546	0.845	0.806	2.168	
	(6.48)	(3.57)	-(2.48)	-	(2.71)	(3.53)	-(3.49)				
sel*	0.9040	3.1514	-	-0.0401	0.0109	0.8238	-0.5551	0.847	0.808	2.215	0.375
	(6.70)	(3.61)	-	-(2.55)	(2.77)	(3.58)	-(3.54)				*0.5405*
sw	0.9280	3.1219	-0.0380	-	0.0070	0.6517	-0.5729	0.828	0.786	2.125	
	(6.16)	(3.19)	-(1.87)	-	(1.84)	(3.01)	-(3.14)				
sw	0.9300	3.0693	-	-0.0355	0.0071	0.6456	-0.5644	0.828	0.785	2.181	0.053
	(6.17)	(3.17)	-	-(1.85)	(1.84)	(2.99)	-(3.11)				*0.8181*
wal	0.9802	3.4538	-0.0376	-	0.0062	0.5513	-0.6429	0.866	0.833	2.088	
	(7.18)	(3.60)	-(2.32)	-	(2.06)	(3.35)	-(3.53)				
wal	0.9815	3.4497	-	-0.0363	0.0062	0.5518	-0.6430	0.867	0.833	2.094	0.206
	(7.20)	(3.61)	-	-(2.35)	(2.06)	(3.37)	-(3.54)				*0.6498*
wm*	0.7588	2.9813	-0.0463	-	0.0082	0.5354	-0.5445	0.868	0.835	2.084	
	(0.00)	(0.82)	(0.01)	-	(0.00)	(0.15)	(0.15)				
wm	0.7561	2.9226	-	-0.0449	0.0082	0.5237	-0.5342	0.866	0.833	2.078	2.699
	(6.70)	(3.58)	-	-(3.15)	(2.86)	(3.42)	-(3.50)				*0.1004*
yh	1.0787	3.9516	-0.0297	-	0.0092	0.7637	-0.7392	0.887	0.859	2.105	
	(7.42)	(4.43)	-(1.93)	-	(2.73)	(4.20)	-(4.34)				
yh	1.0846	3.9064	-	-0.0277	0.0093	0.7586	-0.7318	0.888	0.859	2.129	0.007
	(7.52)	(4.40)	-	-(1.94)	(2.75)	(4.19)	-(4.31)				*0.9342*

* particular specification provided the best fit for the region.
** p-values in italics
t-statistics are in brackets
Sample(adjusted): 1971 1996
Included observations: 26 after adjusting endpoints

Table 6 - regional wage curves, logarithmic specification (with and without dispersion effects)

Dependent variable is nominal wage inflation in each region

region	rpiinf	constant	inv(u)	1/u + (var/u*u*u)	u-u(-1)	log(prod)	log(w-p)(-1)	R-sq	Adjusted R-sq	DW statistic	Chi-sq statistic on restriction**
ea	0.9884	3.3654	0.1703	-	0.0109	0.7230	-0.6400	0.891	0.864	2.119	
	(7.14)	(3.98)	(2.31)	-	(3.69)	(3.78)	-(3.97)				
ea*	0.9915	3.3241	-	0.1476	0.0111	0.7202	-0.6318	0.895	0.869	2.176	2.485
	(7.32)	(4.01)	-	(2.51)	(3.84)	(3.85)	-(4.00)				*0.1149*
em	1.0610	3.2280	0.2241	-	0.0117	0.7139	-0.6180	0.885	0.856	2.221	
	(8.10)	(4.01)	(2.80)	-	(3.29)	(4.10)	-(3.98)				
em	1.0679	3.1762	-	0.1724	0.0118	0.7016	-0.6076	0.883	0.854	2.273	0.357
	(8.09)	(3.93)	-	(2.73)	(3.25)	(4.03)	-(3.91)				*0.5500*
n	1.1495	3.4766	0.3434	-	0.0118	0.6986	-0.6683	0.865	0.831	1.985	
	(7.04)	(4.07)	(2.04)	-	(2.90)	(3.97)	-(4.07)				
n	1.1545	3.3662	-	0.2588	0.0118	0.6702	-0.6467	0.861	0.826	1.971	1.902
	(6.97)	(3.89)	-	(1.87)	(2.82)	(3.81)	-(3.89)				*0.1679*
nw	1.0548	3.7584	0.2209	-	0.0101	0.8235	-0.7138	0.882	0.853	2.211	
	(8.32)	(4.26)	(2.66)	-	(3.19)	(4.24)	-(4.23)				
nw	1.0415	3.6712	-	0.1741	0.0100	0.7973	-0.6968	0.880	0.850	2.212	1.195
	(8.16)	(4.16)	-	(2.55)	(3.13)	(4.14)	-(4.13)				*0.2743*
scot	1.1482	4.1602	0.2300	-	0.0106	0.8567	-0.7923	0.881	0.851	2.240	
	(7.35)	(4.43)	(1.36)	-	(2.65)	(4.33)	-(4.42)				
scot	1.1623	4.0950	-	0.1549	0.0105	0.8451	-0.7790	0.880	0.850	2.292	0.364
	(7.52)	(4.31)	-	(1.27)	(2.61)	(4.25)	-(4.30)				*0.5461*
sel	0.9552	2.9799	0.1700	-	0.0094	0.8038	-0.5432	0.839	0.799	2.242	
	(6.96)	(3.39)	(2.29)	-	(2.48)	(3.38)	-(3.36)				
sel	0.9894	2.9166	-	0.1054	0.0092	0.7840	-0.5309	0.838	0.798	2.298	0.088
	(7.13)	(3.36)	-	(2.27)	(2.44)	(3.35)	-(3.32)				*0.7662*
sw*	0.9699	3.0195	0.2462	-	0.0068	0.6654	-0.5751	0.830	0.788	0.830	
	(6.52)	(3.19)	(1.93)	-	(1.83)	(3.05)	-(3.17)				
sw	0.9807	2.9533	-	0.1713	0.0066	0.6519	-0.5615	0.829	0.786	2.270	0.123
	(6.56)	(3.14)	-	(1.89)	(1.79)	(3.02)	-(3.12)				*0.7263*
wal	1.0161	3.2214	0.3099	-	0.0061	0.5498	-0.6213	0.862	0.827	2.123	
	(7.29)	(3.41)	(2.14)	-	(1.97)	(3.25)	-(3.39)				
wal	1.0206	3.2012	-	0.2573	0.0060	0.5476	-0.6169	0.863	0.828	2.136	0.053
	(7.33)	(3.41)	-	(2.17)	(1.96)	(3.26)	-(3.39)				*0.8182*
wm	0.8222	2.5633	0.2049	-	0.0072	0.4969	-0.4889	0.852	0.815	2.172	
	(6.92)	(3.13)	(2.66)	-	(2.47)	(3.03)	-(3.10)				
wm	0.8157	2.4644	-	0.1743	0.0071	0.4725	-0.4697	0.848	0.810	2.162	4.319
	(6.79)	(3.02)	-	(2.52)	(2.39)	(2.90)	-(2.98)				*0.0377*
yh	1.0949	3.7564	0.1830	-	0.0090	0.7500	-0.7186	0.884	0.855	2.150	
	(7.49)	(4.19)	(1.74)	-	(2.62)	(4.08)	-(4.17)				
yh	1.1150	3.6948	-	0.1224	0.0089	0.7377	-0.7061	0.883	0.853	2.172	0.214
	(7.71)	(4.10)	-	(1.67)	(2.58)	(4.02)	-(4.08)				*0.6433*

* particular specification provided the best fit for the region.
** p-values in italics
t-statistics are in brackets
Sample(adjusted): 1971 1996
Included observations: 26 after adjusting endpoints

Table 7 - regional wage curves, inverse specification (with and without dispersion effects)

Dependent variable is nominal wage inflation in each region

region	rpiinf	constant	u	u-u(-1)	log(prod)	log(w-p)(-1)	R-sq	Adjusted R-sq	DW statistic
ea	0.9039	3.0951	-0.0045	0.0099	0.6249	-0.5769	0.880	0.850	2.013
	(8.19)	(8.42)	-(4.32)	(7.57)	(6.96)	-(8.20)			
em	0.9798	3.6278	-0.0065	0.0129	0.7376	-0.6777	0.894	0.867	2.059
	(10.07)	(12.64)	-(7.68)	(9.98)	(10.65)	-(12.39)			
nw	1.1191	3.6211	-0.0040	0.0107	0.6767	-0.6815	0.868	0.834	1.943
	(9.43)	(12.37)	-(3.90)	(7.47)	(9.21)	-(12.15)			
nw	0.9397	3.5579	-0.0043	0.0089	0.7133	-0.6631	0.895	0.869	2.218
	(10.28)	(13.38)	-(6.97)	(9.55)	(10.99)	-(13.16)			
scot	1.1029	3.7362	-0.0026	0.0101	0.7484	-0.7018	0.879	0.849	2.326
	(9.83)	(9.68)	-(2.87)	(6.50)	(8.28)	-(9.54)			
sel	0.8209	2.5405	-0.0067	0.0097	0.6544	-0.4475	0.829	0.786	2.190
	(6.99)	(7.86)	-(5.38)	(6.14)	(6.98)	-(7.63)			
sw	0.8293	2.1285	-0.0046	0.0066	0.4407	-0.3908	0.814	0.768	2.349
	(6.67)	(4.86)	-(3.49)	(3.77)	(4.20)	-(4.73)			
wal	0.9303	3.1316	-0.0034	0.0062	0.4850	-0.5909	0.868	0.835	2.136
	(8.98)	(9.18)	-(4.69)	(5.70)	(7.00)	-(9.03)			
wm	0.7144	2.7632	-0.0060	0.0071	0.4644	-0.5120	0.862	0.828	2.002
	(7.56)	(9.93)	-(7.58)	(6.75)	(7.60)	-(9.69)			
yh	1.0257	3.5210	-0.0037	0.0084	0.6700	-0.6627	0.886	0.858	2.174
	(9.92)	(11.14)	-(3.96)	(7.14)	(9.04)	-(10.95)			

t-statistics are in brackets
Sample(adjusted): 1971 1996
Included observations: 26 after adjusting endpoints
Total system observations: 260

Table 8a - SUR results (using linear specifications)

	ea	em	n	nw	scot	sel	sw	wal	wm	yh
ea	1.000	0.830	0.866	0.909	0.899	0.851	0.883	0.861	0.874	0.875
em	0.830	1.000	0.893	0.922	0.886	0.922	0.774	0.891	0.883	0.911
n	0.866	0.893	1.000	0.924	0.873	0.787	0.741	0.907	0.888	0.966
nw	0.909	0.922	0.924	1.000	0.919	0.923	0.896	0.954	0.962	0.936
scot	0.899	0.886	0.873	0.919	1.000	0.868	0.821	0.859	0.846	0.921
sel	0.851	0.922	0.787	0.923	0.868	1.000	0.901	0.880	0.899	0.823
sw	0.883	0.774	0.741	0.896	0.821	0.901	1.000	0.855	0.876	0.759
wal	0.861	0.891	0.907	0.954	0.859	0.880	0.855	1.000	0.938	0.918
wm	0.874	0.883	0.888	0.962	0.846	0.899	0.876	0.938	1.000	0.868
yh	0.875	0.911	0.966	0.936	0.921	0.823	0.759	0.918	0.868	1.000

Table 8b - contemporaneous correlation matrix for residuals

Dependent variable is nominal wage inflation in each region

region (specification)	rpiinf	constant	f(u)	u-u(-1)	log(prod)	log(w-p)(-1)	R-sq	Adjusted R-sq	DW statistic
ea (inverse plus	1.0008	3.3240	0.1327	0.0100	0.7127	-0.6317	0.894	0.868	2.140
dispersion measure)	(10.07)	(9.98)	(5.06)	(8.59)	(8.55)	-(9.94)			
em (logarithmic plus	1.0262	3.6601	-0.0428	0.0136	0.7681	-0.6778	0.894	0.868	2.173
dispersion measure)	(10.73)	(12.87)	-(7.95)	(10.28)	(10.97)	-(12.59)			
n (linear)	1.1661	3.8186	-0.0032	0.0104	0.7090	-0.7217	0.866	0.832	1.875
	(9.93)	(12.86)	-(3.59)	(7.25)	(9.55)	-(12.71)			
nw (linear)	0.9655	3.7417	-0.0039	0.0088	0.7462	-0.6991	0.895	0.869	2.141
	(10.62)	(13.89)	-(7.24)	(9.42)	(11.39)	-(13.71)			
scot (linear)	1.1173	3.7238	-0.0207	0.0100	0.7445	-0.6958	0.879	0.849	2.348
	(9.95)	(9.54)	-(2.43)	(6.21)	(8.17)	-(9.34)			
sel (logarithmic plus	0.8992	2.8224	-0.0338	0.0102	0.7337	-0.4975	0.845	0.806	2.294
dispersion measure)	(8.23)	(9.42)	-(5.72)	(7.14)	(8.16)	-(9.25)			
sw (inverse)	0.9143	2.2244	0.2043	0.0066	0.4921	-0.4226	0.824	0.780	2.423
	(7.65)	(5.30)	(3.40)	(3.88)	(4.65)	-(5.25)			
wal (linear)	0.9563	3.2642	-0.0028	0.0062	0.5027	-0.6181	0.866	0.833	2.064
	(9.29)	(9.81)	-(4.55)	(5.77)	(7.37)	-(9.69)			
wm (logarithmic)	0.7818	3.2045	-0.0446	0.0078	0.5682	-0.5883	0.867	0.833	1.953
	(8.59)	(11.34)	-(8.35)	(7.58)	(8.96)	-(11.12)			
yh (linear)	1.0523	3.4839	-0.0238	0.0081	0.6661	-0.6525	0.885	0.856	2.207
	(10.25)	(11.03)	-(3.61)	(6.78)	(8.97)	-(10.78)			

Chi-square statistic on 3 linear restrictions: 6.41 (p=*0.093*)
t-statistics are in brackets
Sample(adjusted): 1971 1996
Included observations: 26 after adjusting endpoints
Total system observations: 260

Table 9a - SUR results (using best fits)

	ea	em	n	nw	scot	sel	sw	wal	wm	yh
ea	1.000	0.837	0.861	0.901	0.893	0.855	0.882	0.869	0.850	0.889
em	0.837	1.000	0.865	0.898	0.868	0.925	0.777	0.876	0.878	0.906
n	0.861	0.865	1.000	0.923	0.866	0.756	0.719	0.908	0.897	0.960
nw	0.901	0.898	0.923	1.000	0.909	0.901	0.876	0.957	0.963	0.931
scot	0.893	0.868	0.866	0.909	1.000	0.854	0.810	0.853	0.835	0.920
sel	0.855	0.925	0.756	0.901	0.854	1.000	0.905	0.866	0.876	0.824
sw	0.882	0.777	0.719	0.876	0.810	0.905	1.000	0.848	0.857	0.766
wal	0.869	0.876	0.908	0.957	0.853	0.866	0.848	1.000	0.956	0.917
wm	0.850	0.878	0.897	0.963	0.835	0.876	0.857	0.956	1.000	0.878
yh	0.889	0.906	0.960	0.931	0.920	0.824	0.766	0.917	0.878	1.000

Table 9b - contemporaneous correlation matrix of residuals

region	I - coefficient on unemployment (linear SUR estimates)	II - Specification with best fit
sel	-0.0067	logarithmic, with dispersion measure
em	-0.0065	logarithmic, with dispersion measure
wm	-0.0060	logarithmic
sw	-0.0046	inverse
ea	-0.0045	inverse
nw	-0.0043	linear
n	-0.0040	linear
yh	-0.0037	linear
wal	-0.0034	linear
scot	-0.0026	linear

Table 10 - wage curve slopes and best fits

4.8.5 Figures

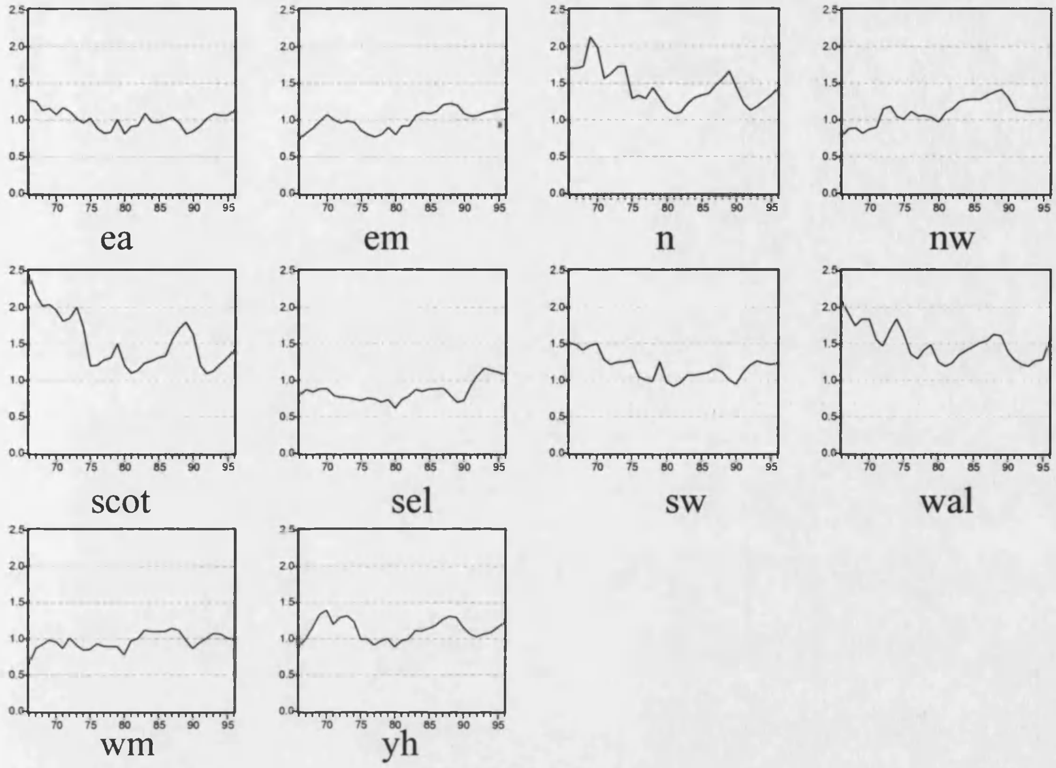

Figure 15 - regional unemployment rates, relative to GB average, 1966-1996

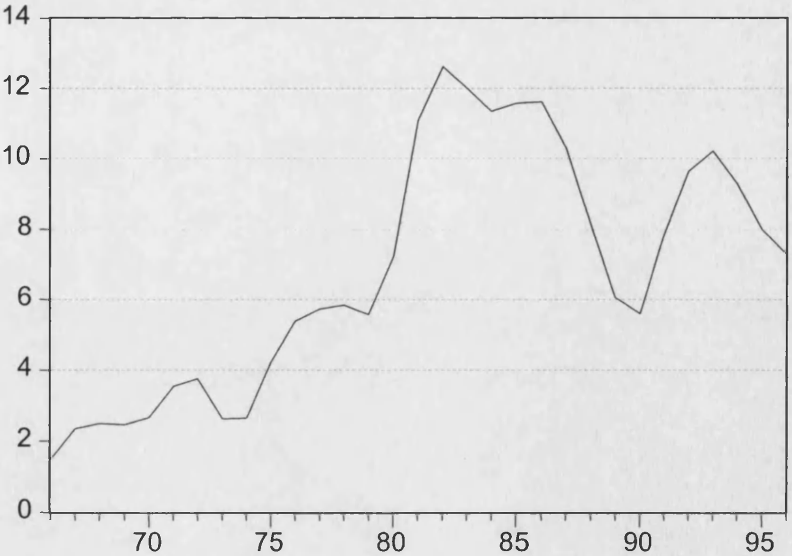

Figure 16 - GB unemployment rate, 1966-1996

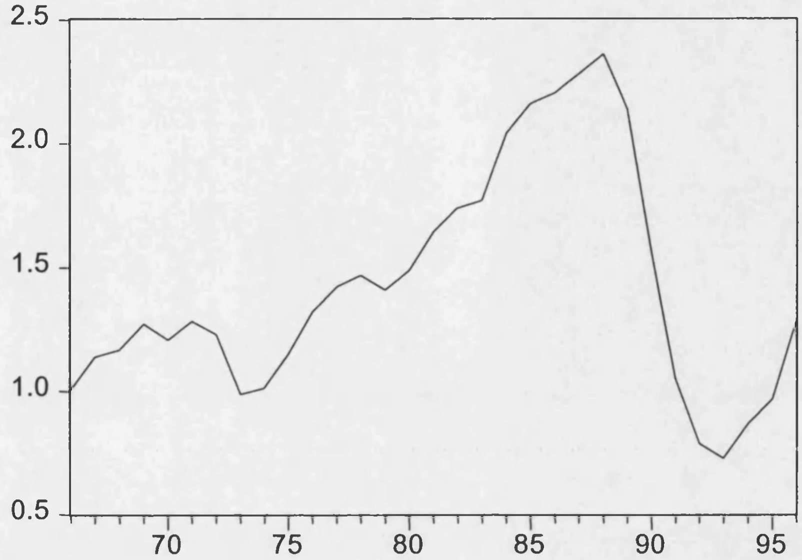

Figure 17.1 - standard deviation, regional unemployment, 1966-1996

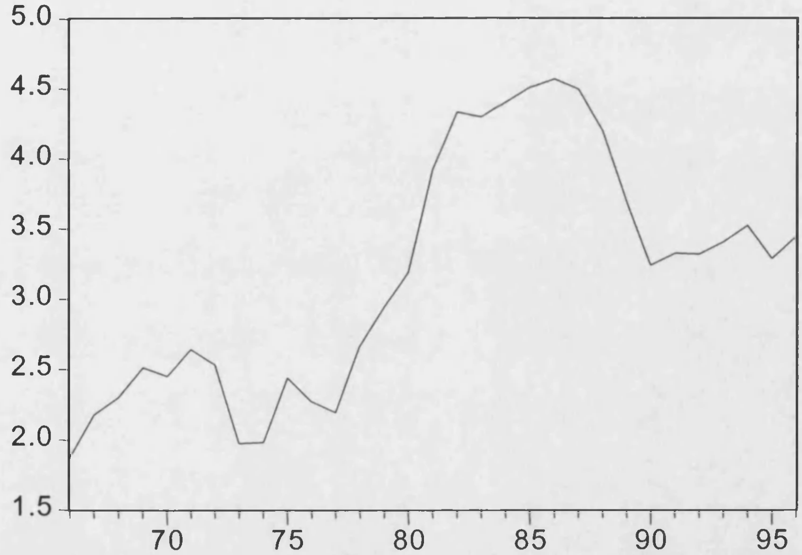

Figure 17.2 - standard deviation, subregional unemployment, 1966-1996

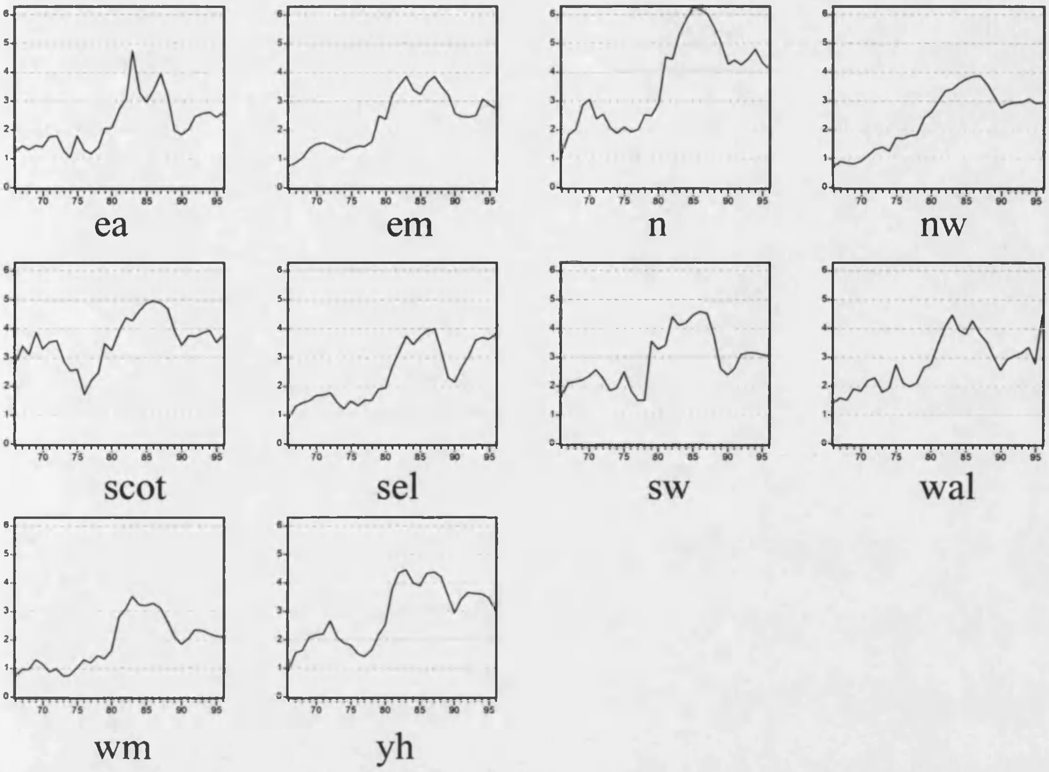

Figure 18 - standard deviations of subreional unemployment rates, by region, 1966-1996

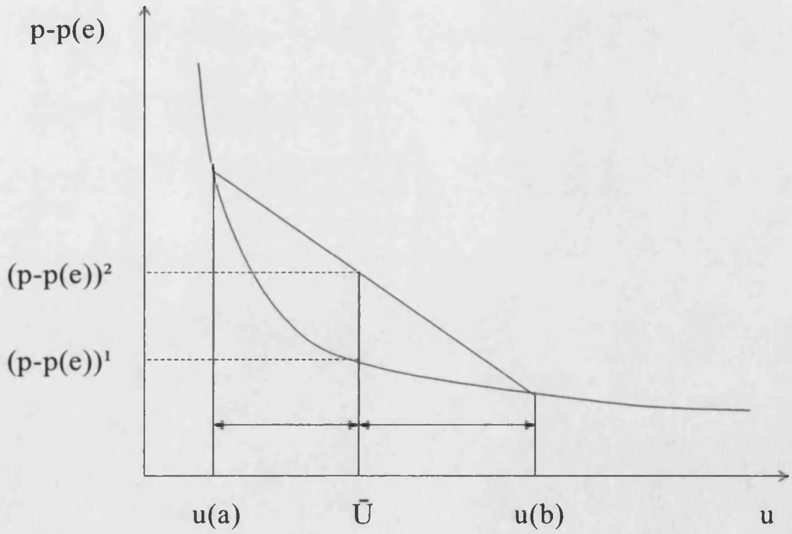

Figure 19 - dispersion effect: 2 regions (a and b) with identical, nonlinear Phillips curves

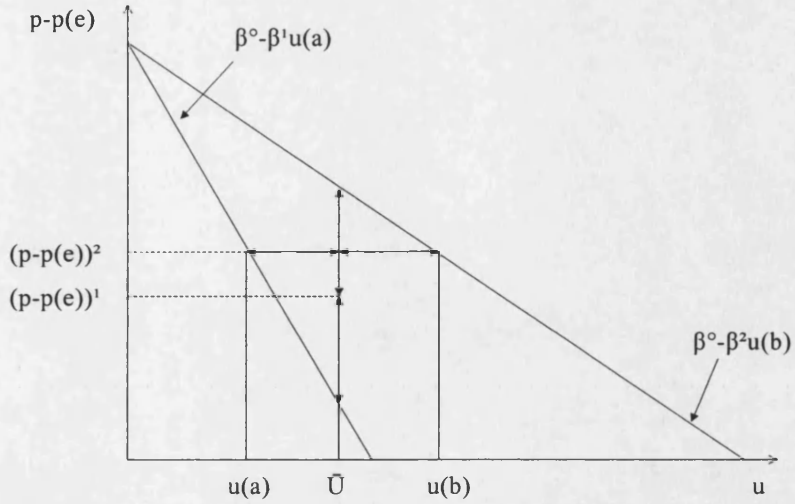

Figure 20 - dispersion effect: 2 regions (a and b) with linear, heterogeneous Phillips curves

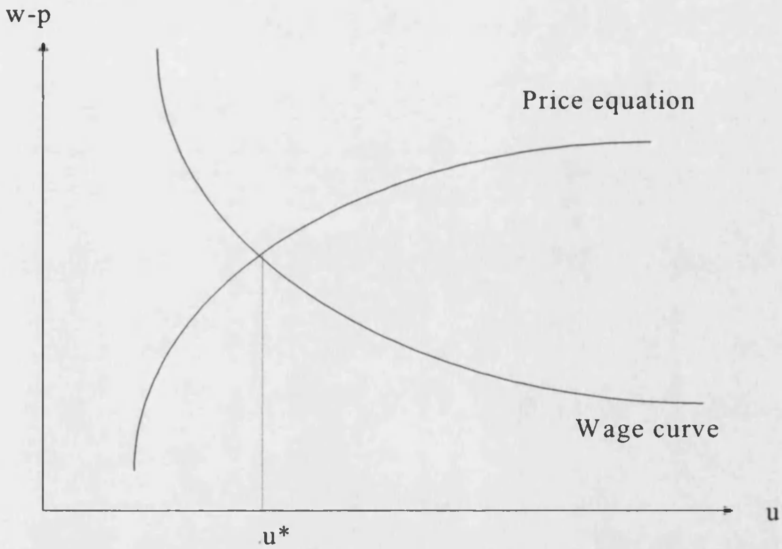

Figure 21 - nonlinear wage and price equations

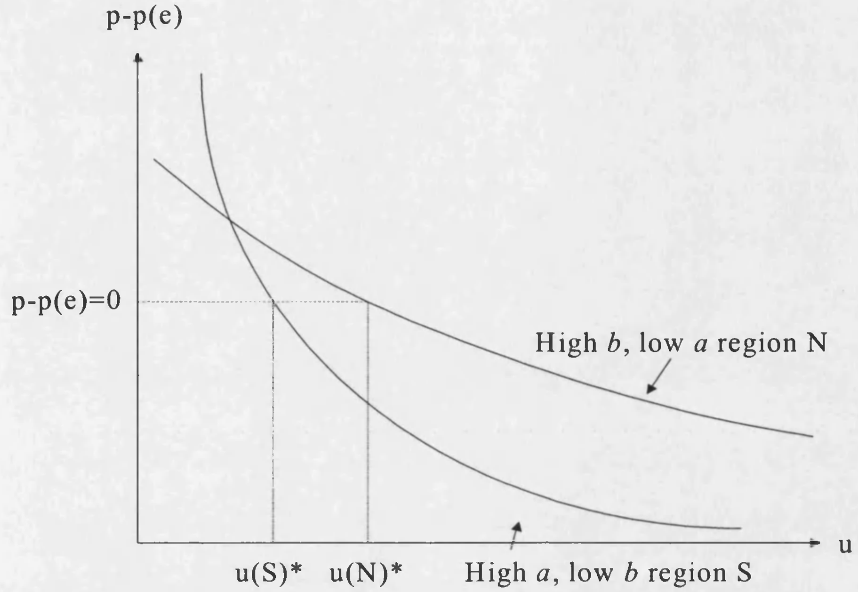

Figure 22 - differences in productivity and monitoring technology across regions

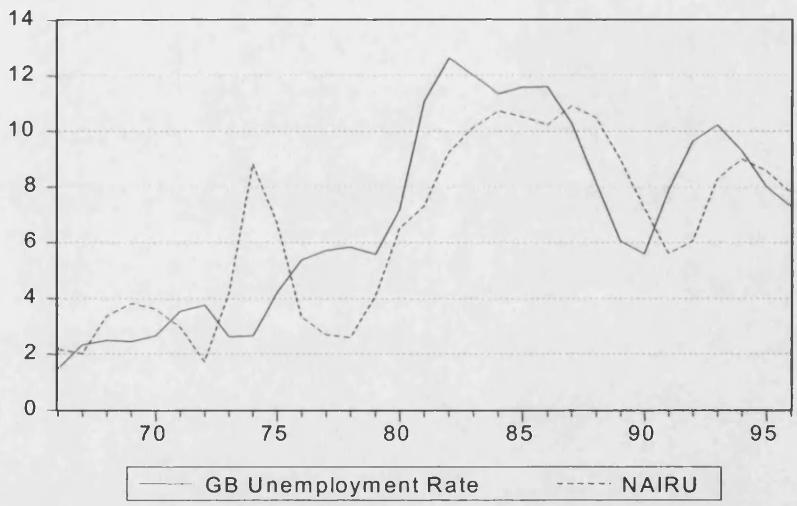

Figure 23 - the implied GB NAIRU, 1966-1996

Figure 24 - wage curve slope versus relative unemployment, 1970-1996

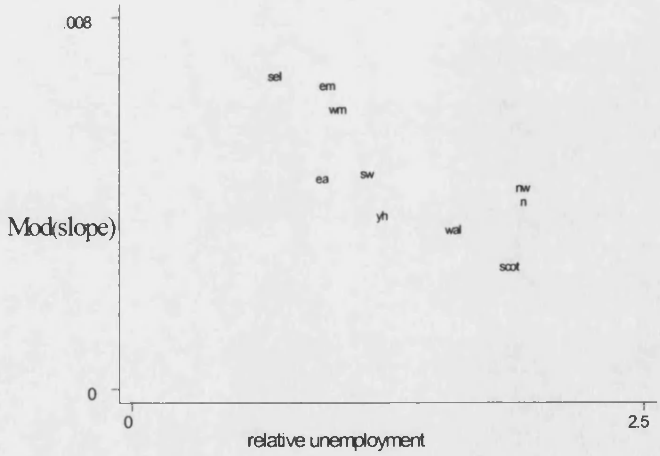

Figure 25.1 - wage curve slope versus relative unemployment, 1970-1975

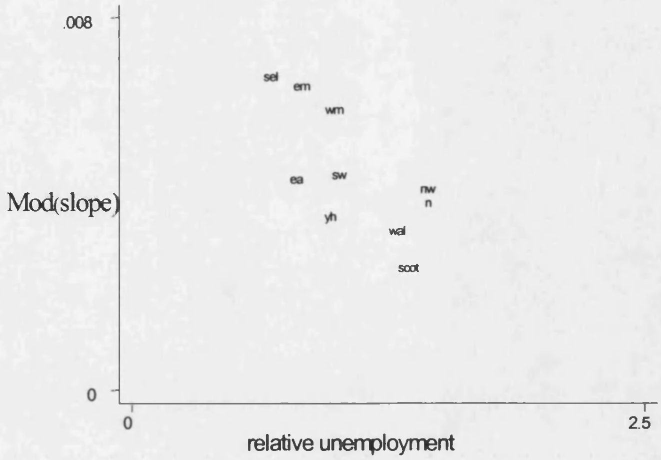

Figure 25.2 - wage curve slope versus relative unemployment, 1976-1980

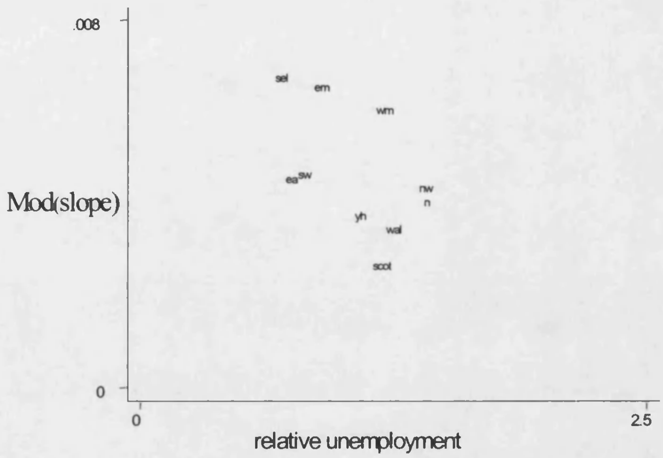

Figure 25.3 - wage curve slope versus relative unemployment, 1981-1985

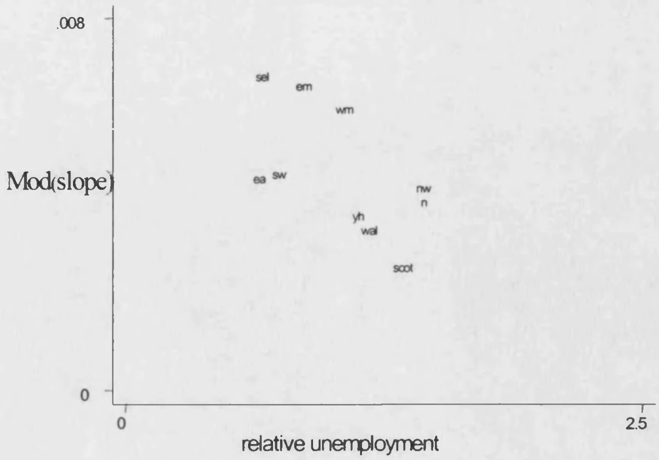

Figure 25.4 - wage curve slope versus relative unemployment, 1986-1990

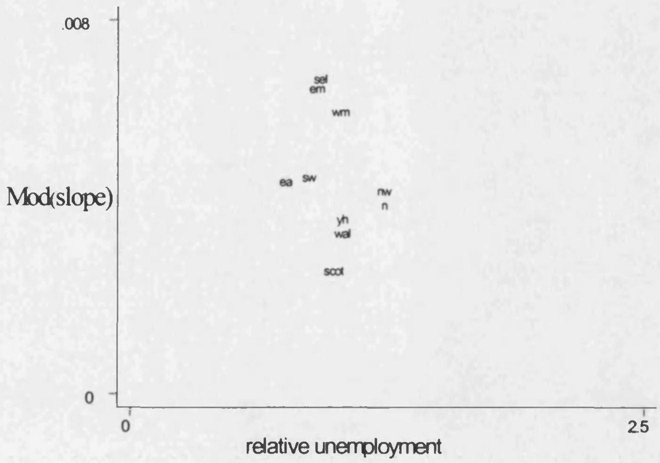

Figure 25.5 - wage curve slope versus relative unemployment, 1991-1996

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