The Effect of Collective Bargaining and Central Bank Independence on Inflation and Unemployment: *Evidence from the OECD*

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Abstract

In this paper, panel data from 15 OECD countries (1971-1990) are used to test the hypothesis that differences in monetary and labour market institutions explain a significant portion of the surprisingly diverse inflation and unemployment experiences among similarly developed economies. As an alternative to the measures of centralization of wage bargaining and corporatism used in previous studies, a Hefindahl index of union concentration is used as a proxy for the degree of coordination failure extant in wage setting. Additional explanatory variables used include union density, union coverage and the level of wage bargaining. We observe that inflation has a hump-shaped relationship with central bank independence and union density, as well as a negative relationship with union concentration, while unemployment has a U-shaped relationship with union density, and a hump-shaped relationship with union concentration and central bank independence. These findings are largely robust to the use of alternative estimators and assumptions on the structure of the error term. Further results are obtained from stratifying the sample by central bank independence and union concentration. These are then compared with the contrasting predictions of two recent theoretical models. Finally, we show that high union concentration is associated with smaller deviations of actual inflation rates from predicted rates in the aftermath of the 1973-74 OPEC price shock.

JEL Classification: E24, E31, E58, J51

1. Introduction

This paper contributes to the growing body of empirical evidence suggesting that the interaction of labour market institutions and the preferences of central bankers have a significant impact on macroeconomic outcomes such as inflation and unemployment. Inflation results from coordination failures in wage contracting when rational, optimizing unions participating in unsynchronized and decentralized wage bargaining with firms engage in nominal wage push or leapfrogging to prevent erosion of their relative and real wages. If this push is accommodated by the monetary authority, then wage and price inflation results. If it is not, the increase in real wages raises unemployment. Previous papers have shown that differences in the organization of worker and employer unions (such as the degree of centralization or "corporatism") explain a considerable part of the diverse inflationary experiences among otherwise similar economies, even after accounting for differences in the independence of their central banks. In this paper, we use data on 15 OECD countries (1955-1990) drawn from the Golden-Wallerstein-Lange (1997) dataset to determine the effect of various labour market variables on inflation and unemployment. Theoretical models consistent with our hypothesis that labour market variables are important determinants of inflation and unemployment are found in Calmfors and Driffill (1988), Bleaney (1996), Cukierman and Lippi (1999), and Velasco and Guzzo (1999), and will be discussed later.

Our results suggest that inflation has a hump-shaped relationship with central bank independence and union density, as well as a negative relationship with union concentration, while unemployment has a U-shaped relationship with union density, and a hump-shaped relationship with union concentration and central bank independence. These findings are largely robust to the use of alternative estimators and assumptions on the structure of the error term. Further results are obtained from stratifying the sample by central bank independence and union concentration. These are then compared with the conflicting predictions of two recent theoretical models to verify their empirical validity. Finally, we estimate the impact of central bank independence, union density and union concentration on the unexpected jump in inflation arising from the 1973-4 OPEC oil shock. The counterfactual is generated from the multi-country version of the FAIRMODEL. In the immediate aftermath of the oil price shock, greater central bank independence is strongly correlated with smaller deviations of actual inflation from their predicted values. Two years after the shock, the effects of central bank independence fade away and are replaced by that of union concentration. These findings are consistent with our hypothesis that greater union concentration inhibits the wage-price spiral set off by negative aggregate supply shocks.

The paper is organized as follows: Section 2 reviews previous literature related to our study while section 3 looks at two competing theoretical models and their contrasting predictions. Section 4 discusses our data sources and methodology. Section 5 describes our empirical specifications, and is followed by a presentation of our results in section 6. In Section 7, we show the corresponding results when unemployment is the dependent variable. Section 8 investigates how differently union variables impact on inflation and unemployment in countries with low central bank independence vis-à-vis those with high central bank independence. Section 9 examines the relationship between union concentration and supply shocks, while Section 10 concludes.

2. Related Literature

2.1 Collective Bargaining and Macroeconomic Performance

In a seminal paper, Calmfors and Driffill (1988) found the existence of a hump-shaped relationship between the degree of centralization in wage bargaining and real wages, inflation and unemployment. The idea is that competitive forces restrain wages, while potential gains from internalization of the external effects of wage increases are greater within large encompassing organizations. Intermediate degrees of centralization are harmful in the way that Olson (1982) suggested: organized interests may be most detrimental to social welfare when they are strong enough to cause significant disruptions but insufficiently encompassing to bear sufficiently the costs inflicted upon society by their self-interested actions.

More specifically, when wage bargaining is centralized, the parties involved tend to internalize the impact of their wage push on price inflation and recognize its futility in raising the real wage. On the other hand, decentralized wage bargaining makes individual firms more resistant to rising wage demands, as each firm faces an elastic demand curve and competitors who may not be under the same cost pressure. Intermediate levels of wage bargaining result in the worst inflation and unemployment performance because neither of these "externality" and "competition" effects is present to induce wage restraint.

Defining centralization as the extent of inter-union and inter-employer cooperation in wage bargaining with the other side, Calmfors and Driffill ranked countries based on an index which takes into account the extent of coordination both within and between various central organizations. They find that both highly centralized and highly decentralized economies are likely to perform better (in terms of unemployment, employment, and inflation) than intermediately centralized ones.[1] To complement their empirical findings, they simulate a model where intermediate levels of centralization produce the highest real wage and lowest employment levels. Further support for the hump-shaped hypothesis may be found in Dowrick (1993), Freeman (1988), Heitger (1987), and Rowthorn (1992). In addition, other collective bargaining rankings may be found in Blyth (1979), Schmitter (1981), Lehmbruch (1984), Lijphart and Crepaz (1991) and Layard et al. (1991).

Papers prior to Calmfors and Driffill tested for the presence of a *linear* relationship between a country's economic performance and its degree of "corporatism". [Bruno and Sachs (1985), Cameron (1984), Couch (1985), and Tarantelli (1986)][2]. For example, Bruno and Sachs (1985) examine the relationship between corporatism (defined as the 'institutionalized negotiation, bargaining, collabouration, and accord about wages and 'income policies' between representatives of the major economic groupings, most typically labour confederations and employers' associations') and macroeconomic outcomes such as the misery index. Using an index of labour market corporatism (taking in consideration union movement centralization, shop-floor autonomy, and employer coordination), the authors find

[1] Subsequent studies have found mixed evidence for this hump-shape hypothesis. For example, Bean (1994), Grier (1997), Soskice (1990) and OECD (1997) find no evidence for the hypothesis, in contrast to Bleaney (1996) [discussed later in the text] and Scarpetta (1996).

[2] More recent proponents of a linear relationship have based their preference on their belief that the afore-mentioned "externality" effect (which is larger with more centralized wage bargaining arrangements) dominates the "competition" effect present in decentralized wage bargaining systems. See Layard et al. (1991), Soskice (1990) and Traxler et al. (1996), for example.

that each unit rise in the index is associated, for given GDP performance, with a reduction in inflation of 1.5 percentage points. The weakness of their approach is that it does not focus sufficiently strongly on the issue of the proportion of the labour force covered by the typical wage bargain. It fails to distinguish highly decentralized systems with weak unions (such as the US) from less decentralized systems with union power diffused to shop floor level (such as the UK): both earn a score of zero on the corporatism index. Moreover, a maximum score is consistent both with separate negotiations for each industry (Germany) or for economy-wide negotiations (Austria). As Bleany (1996) points out, the ability to push up relative wages in the former case but not the latter makes it crucial to distinguish them.

Appendix B [drawn from OECD (1997)] summarizes the results of recent research on the impact of collective bargaining structures on macroeconomic performance. For an authoritative and comprehensive survey on recent attempts to study the link between a country's labour market structures and its economic performance, Flanagan (1999) is an invaluable resource. In explaining the apparent fragility of many of the results reported in these studies, Flanagan point to their serious shortcomings such as:

(1) Failing to distinguish between union density/membership and union coverage, the percentage of the labour force that is actually covered by collective bargaining agreements.
(2) Omitting the role of international trade in muting the institutional impact of union structures on macroeconomic performance. Clearly, the increased competitive pressures from greater openness to imports will undermine unions' influence on the price setting behavior of firms.
(3) Ranking countries by their degree of bargaining centralization and then including the rank of a country as the independent variable representing institutional structure. Apart from the disputes about the correctness of various ranking criteria, this procedure also imposes the undesirable assumption that equal differences in ranking denote equal differences in structure. The focus on a single aggregative measure may also obscure the exact effect of common institutional features producing the correlation and suggest an influence on economic outcomes for some elements of the index that actually have no influence.

Our study may thus be seen as a concerted attempt to address many of these important issues and concerns.

2.2 Central Bank Independence and Macroeconomic Performance

The framework that has guided the other strand of related literature on monetary institutions and inflation consists of time consistency models of inflation, especially Kydland and Prescott (1977) and Barro and Gordon (1983). In these models, the lack of credible commitment devices leads central banks to choose higher than optimal rates of inflation, even though they share the private sector's preferences for inflation relative to output. These models suggest that institutional features of a central bank (such as the length of it's governor's term of appointment) may significantly affect inflation outcomes. In addition, Rogoff (1985) has argued that governments have an incentive to appoint 'conservative' central banks (that is, those who have an anti-inflation reputation) so as to raise their anti-inflation credibility. The degree of influence of the central bank on monetary policy (its 'independence') should therefore be reflected in the country's inflation figures.

Several authors have examined the relationship between average inflation and proxies for central bank independence (CBI for short, and sometimes also referred to as 'central bank conservatism'[3]). Grilli, Masciandaro, and Tabellini (1991), for example, construct one indicator of political independence and another of economic independence of central banks for a sample of high-income countries. They regress cross-country differences in inflation rates on both indicators and a dummy variable for participation in the European Monetary System (EMS). The indicators of CBI have what is seen to be the expected negative sign, while the estimated coefficient on the EMS dummy is not significantly different from zero. Alesina and Summers (1993) generate a comparable result using similar indices and samples. Cukierman, Webb, and Neyapti (1992), also document a negative relationship between inflation and CBI for high-income countries, but they show that the relation exhibits the wrong sign for low- and middle-income countries. When Posen (1993, 1995) inserts a variable called 'financial opposition to inflation' that is designed to measure the financial sector's distaste for inflation and its ability to express that distaste, the commonly presumed ability of CBI to lower inflation, independent of the central bank's political context, is refuted. Other factors which some researchers believe are important to the inflation story include the openness of economies (see, for example, Romer (1993)) and optimal tax considerations (Mankiw (1997); Poterba and Rotemberg (1990), among others). A summary of the results from these works may be found in Campillo and Miron (1997). These authors proceed to show that when the openness, size, political stability, exchange rate regime, per-capita debt, and per-capita incomes of countries are taken into account, central bank independence has no significant independent effect on inflation. For these reasons, we restrict our study to 15 advanced economies that differ primarily in the conservatism of their central banks and their labour market structures.

One of the first attempts to synthesize the two strands of research is Bleaney (1996). He presents a simple model which encompasses both hypotheses and tests the model on data for 17 OECD countries. In this model, the inflationary bias is imparted by the fact that the unemployment rate necessary to curb upward pressure on real wages is higher than that represented by the government's 'bliss point'. The authorities' willingness to accommodate this inflationary pressure depends on the independence of the central bank. The institutional structure of the labour market influences the outcome by affecting the trade-off between real wages and employment faced by the unions. One significant feature of the model is that countries with less favorable wage bargaining structures have more to gain from greater independence of their central bank. Bleaney finds that central bank independence has a significant effect on CPI inflation while the labour market variables (the Bruno-Sachs corporatism index, the Calmfors-Driffill centralization ranking, and a composite index of the two) are mostly insignificant. With regard to unemployment, Bleaney finds that greater centralization and stronger corporatism exert a salubrious influence.

3. Two Theoretical Models and Their Predictions

[3] Strictly speaking, central bank independence and central bank conservatism are only interchangeable if we believe that a more independent central bank has a stronger distaste for inflation. Of course, we can find instances where a central bank is legally and politically highly independent but chooses to view unemployment as being a greater evil than inflation.

Two recent papers attempt far more sophisticated modelling of the interaction between labour unions and a monetary authority in the framework of a non-cooperative game. Interestingly, they produce contrasting predictions for the role of centralization and central bank independence in explaining inflation and unemployment. Our results can therefore be used to discriminate between the efficacy of the two models.

3.1 Cukierman and Lippi (1999)

In Cukierman and Lippi (1999), the labour market is characterized by the degree of centralization of bargaining and by the degree of trade unions' inflation aversion. The latter leads each union to moderate its wage demands in order to induce the central bank to inflate at a lower rate. As in the Calmfors and Driffill paper, increasing centralization produces two opposing effects on real wages and inflation: the decrease in the number of unions reduces the substitutability between the labours of different unions and the degree of effective competition between them (the "competition effect") while strengthening the moderating effect of inflationary fears on the real wage demands of each union (the "strategic effect"). The interaction between these two effects determines the shape and position of the relation between centralization, real wages, inflation and unemployment.

In their model, each union sets its nominal wage taking the nominal wages of other unions and the reaction function of the central bank as given. The central bank then chooses monetary policy and inflation. This game between unions and the central bank is solved by backward induction: the authors first derive the choice of inflation by the central bank, and then the choice of wage rates by unions.

The typical union seeks high wages and low unemployment for its members, and also dislikes inflation. Its loss function is given by

$$\Omega_j \equiv -2w_{rj} + Au_j^2 + Bp^2 \tag{1}$$

where u_j is the rate of unemployment among members of union j, $p = p - p_{-1}$ is the rate of inflation (equal to the difference in the log of the price level) and A and B are positive parameters.

The demand for the labour of workers in union j is given by

$$L_j^d = \left[\frac{a}{n}\left(d - w_{rj}\right) - g\left(w_{rj} - \overline{w}_r\right)\right]L \tag{2}$$

where L_j^d is demand for the labour of that union, w_{rj} is the log of the real wage obtained by its members, $\overline{w}_r$ is the average real wage over all unions, while a, ?, d and n are positive parameters. Summing over unions, the aggregate demand for labour in the economy is therefore

$$L^d \equiv \sum_{j=1}^{n} L_j^d = a\left(d - \overline{w}_r\right)L \tag{3}$$

which is independent of the number of unions.

The central bank is concerned with aggregate unemployment u and price stability, choosing inflation to minimize the loss function

$$\Gamma \equiv u^2 + Ip^2 \tag{4}$$

(where I is a measure of the relative inflation aversion of the central bank), subject to the labour demand equation reformulated in terms of nominal wages and inflation:

$$u \equiv \frac{L - L^d}{L} = a\left(\bar{w} - p - p_{-1} - w_r^c\right), \tag{5}$$

where $\bar{w}$ is the average nominal wage, p_{-1} is the log of the previous period price level and $w_r^c \equiv d - 1/a$ is the market clearing real wage, at which $u = 0$. This yields the monetary reaction function:

$$p = \frac{a^2}{a^2 + 1}\left(\bar{f} + Ep\right),\ \bar{f} \equiv \bar{w}_r - w_r^c \tag{6}$$

Since $\bar{f}$ represents the excess of the average equilibrium real wage over the competitive real wage, it is referred to as the real wage premium. Imposing the rational expectations condition $p = Ep$ in the absence of uncertainty, the equilibrium expression for inflation is

$$p = \frac{a}{I}\bar{f}\,. \tag{7}$$

Each union thus chooses the nominal wage w_j so as to minimize its loss function, taking the nominal wages of other unions and the central bank's reaction function of monetary policy to nominal wages as given. The solution to the union's optimization problem yields the real wage premium

$$\bar{f} = \frac{I\left[(n-1)a^2 + nI\right]}{a\left\{Ba^3 + AI\left[a\left((n-1)a^2 + nI\right) + g\,(n-1)n\left(a^2 + I\right)\right]\right\}} = f_j\,. \tag{8}$$

The equilibrium unemployment rate is equal to $u = a\bar{f}$.

Predictions:

1. For a finite number of unions, the more unions care about price stability (the higher is B) and/or the higher is substitutability between different types of labour (the higher is g), the lower is the equilibrium real wage premium and the lower are inflation and unemployment.
2. Both unemployment and inflation are lower in a fully decentralized labour market than in a fully centralized one, as long as the weight attached to inflation by the central bank is non-zero.
3. Unemployment and inflation are positively related to the degree of centralization of unions ($1/n$) when unions do not care much about price stability (low values of B), while the relationship is a hump-shaped one for sufficiently high degrees of inflation aversion.
4. An increase in the degree of central bank independence raises the rate of unemployment if unions are averse to inflation ($B > 0$) and/or there are at least two unions and some degree of substitutability in the demands for their labour ($g > 0$ and $n > 1$).
5. The sign of the partial derivative with respect to inflation with respect to the inflation aversion of the central bank (B) is negative for sufficiently large number of unions n, but may be positive for given values of n if B is sufficiently large.

Broadly stated, (i) a rise in CBI is associated with lower inflation and higher unemployment[4]; (ii) there is a hump-shaped relationship between centralization and inflation

[4] Hall and Franzese (1996) also find that in economies with highly centralized labor markets, greater central bank independence increases unemployment.

for countries with low CBI and a positive monotonic relationship for countries with high CBI; and (iii) the effect of CBI on unemployment is stronger at high levels than low levels of centralization, while the (absolute) effect of CBI on inflation is hump-shaped with respect to centralization.

Cukierman and Lippi then use pooled cross-section and time-series data (for the years 1980, 1990 and 1994) from 19 developed economies to undertake a preliminary evaluation of their model's theoretical implications. Their empirical results provide support for some of the implications. For example, at low levels of CBI, they identify a clear hump-shaped relationship between inflation (as well as unemployment) and centralization[5]; this relation vanishes at high levels of CBI. In addition, they show that the inflation-reducing impact of CBI is largest when centralization of wage bargaining is at intermediate levels, and that there is a significant and positive effect of CBI on unemployment at low levels of centralization. Their findings are summarized in Tables C1 and C2 in Appendix C.

3.2 Velasco and Guzzo (1999)

Velasco and Guzzo (1999) present a general equilibrium, optimizing model to study the joint effects of centralization in wage setting and central bank independence. Their model dispenses with the somewhat ad-hoc assumption made in Cukierman and Lippi (1999) that the elasticity of substitution of labour supplied by different unions is always increasing in the number of unions and goes to infinity as the number of unions goes to infinity. Rather, the model is built completely on microeconomic foundations, using the firm's production function as the starting point. They obtain very different implications for the number of unions on the elasticity of substitution between various types of labour.

In this model, the economy consists of a single representative firm that produces a single consumption good, and a continuum of symmetric workers (indexed by i and arranged in the unit interval) who supply labour, receive dividends from the firm, and consume. Workers are organized in $n \geq 2$ unions (indexed by j), each of which has a set of members of measure n^{-1} on whose behalf it sets wages. There exists a government, which sets the rate of inflation and thus affects real wages. The timing of moves is as follows: Unions move first, setting the rate of nominal wage growth w_i for each worker i in each union j. The government moves next, setting the rate of price increase p. Finally, the firm sets employment and output by moving along its labour demand curve.

The representative firm maximizes profits

$$D = Y - \int_0^1 W_i L_i di \tag{9}$$

taking wages as given, using the production process:

$$Y = \left(\int_0^1 L_i^{(s-1)/s} \, di \right)^{as/(s-1)}, \; o \leq a \leq 1, \; s > 1, \tag{10}$$

[5] Centralization is defined as the predominant level at which wage negotiations occur. Cukierman and Lippi assume that as wage bargaining becomes more centralized, the number of negotiating units which bargain in an uncoordinated manner increases. This, they argue, correspond to an increase in n in the theoretical model, and hence, centralization can be interpreted as a proxy for $1/n$.

where Y is the representative firm's output and L_i is labour input from worker i. The parameter s is the elasticity of substitution among the different types of labour supplied by workers, and a is a returns to scale parameter.

Each worker has the utility function

$$U_i = \log C_i - \frac{g}{2}(\log L_i)^2 - \frac{b_p}{2}p^2,\ g > 0,\ b_p \geq 0, \tag{11}$$

where C_i is consumption by worker i, and g and b_p are preference parameters, and each worker faces the budget constraint

$$C_i = W_i L_i + D_i. \tag{12}$$

Each union j represents the workers that lie contiguously in the interval $(j-n^{-1}, j)$, maximizing the utility of its members:

$$V_j = n\int_{j-n^{-1}}^{j} U_i di. \tag{13}$$

In the symmetric equilibrium, the elasticity of demand for the labour of each worker i is

$$\frac{\partial L_i}{\partial W_i}\frac{W_i}{L_i} = -y\ ,\ y \equiv s + \left[\frac{1-s(1-a)}{(1-a)n}\right] \tag{14}$$

Finally, the objective of the government, which moves last, is

$$J = \int_0^1 \left[\log C_i - \frac{g}{2}(\log L_i)^2\right] di - \frac{b_g}{2}p^2, \tag{15}$$

which it maximizes by setting the rate of price inflation every period.[6] In doing so, it affects the level of the aggregate real wage, whose time path is given by

$$W = (1+w)/(1+p) \tag{16}$$

where p and w are again the percent increases in the price level and the nominal wage.

Solving the stage game backwards, the government's policy rule may be derived as

$$p = \frac{a - g\log L_i}{(1-a)b_g}. \tag{17}$$

Taking this into account, the representative union solves its maximization problem and obtains in symmetric equilibrium the policy rule

$$p = \left[a\left(\frac{1-y}{yg}\right) + \log L\right]\left[\frac{n(1-a)b_g}{b_p}\right]. \tag{18}$$

Combining the rules of government and union yields the equilibrium level of employment for the representative union and for the economy as a whole:

$$\log L = \left(\frac{a}{g}\right) f \tag{19}$$

where

$$0 < f \equiv \frac{(y-1)n(1-a)^2 b_g^2 + y b_p g}{y n(1-a)^2 b_g^2 + y b_g g} \leq 1.$$

[6] The worker's and government's objective functions differ by the degree of aversion to inflation, b_p and b_g.

In turn, optimal output is

$$\log Y = \left(\frac{a^2}{g} \right) f \ , \tag{20}$$

and the equilibrium rate of inflation is given by

$$p = \left(\frac{a}{1-a} \right) \left(\frac{1-f}{b_g} \right). \tag{21}$$

Predictions:

1. For a fixed number *n* of unions, a radical-populist central banker, who cares not at all about the costs of inflation, maximizes the welfare of the population by delivering zero inflation and optimal employment and output levels.
2. For a fixed number *n* of unions, employment and output fall as the central bank becomes more conservative (independent).
3. For a fixed number *n* of unions, inflation is hump-shaped in the degree of central bank independence, and a moderate central banker (one that is neither strongly conservative nor strongly populist) maximizes the rate of inflation.
4. For a given level of central bank independence,
   (a) If the elasticity of substitution among different types of labour is sufficiently small, then economic performance (inflation and unemployment) and welfare are uniformly decreasing in the number of unions.
   (b) Otherwise, economic performance and welfare are hump-shaped in the number of unions (and thus U-shaped with respect to centralization), and there is an intermediate degree of centralization that maximizes economic performance and welfare.

The two models therefore make very different predictions with regard to the impact of centralization of wage bargaining on inflation and unemployment. Cukierman and Lippi's model predicts a positive or *hump-shaped* relationship between inflation/unemployment and centralization depending on the central bank's aversion to inflation, while Velasco and Guzzo's model predicts that economic performance is either increasing or *U-shaped* in the degree of centralization.

In this paper, we re-examine the empirical relationships between the structure of the labour market, monetary institutions, inflation and unemployment in light of these recent theoretical developments. The conflicting predictions and therefore the validity of the theoretical models will be tested by the careful examination of available data. A summary of these comparisons is given in Appendix C. Compared to previous empirical studies on the joint effect of labour market and monetary institutions on macroeconomic performance, our primary innovations are: the replacement of corporatism or centralization ratings/rankings with an index of union concentration, the use of panel data that this time-varying index makes possible, the deployment of more sophisticated econometric techniques, stratification of the panel by central bank independence and union concentration, and the inclusion of important controls such as trade openness and the generosity of unemployment benefits. Panel data from 15 OECD countries is used to test our hypothesis that labour market variables are important in explaining price inflation and unemployment, even after controlling for differences in the degree of central bank independence. In contrast to previous studies where the *average* rate of inflation over some time period (for example, a decade) is regressed on CBI and wage setting

variables, we regress *annual* inflation rates on these variables. Doing so enables us to take into account country-specific observable characteristics, as well as unobservable ones such as tastes and preferences for inflation and unemployment. To deal with the econometric complications that arise from using time series in addition to cross section data, we employ additional estimators (with different assumptions on the structure of the error term) to test the robustness of our results.

4. Data Sources and Methodology

4.1 Data sources

4.1.1 Central Bank Independence

The measure of central bank independence used in our regressions is the overall decade-average measure by Cukierman, Webb and Neyapti (1992). This is an index of legal independence based on 16 different criteria covering the following areas: the terms of office, appointment and dismissal of the central bank governor; determination of monetary policy; the objectives of the central bank; and the limitations on the ability of the central bank to lend to the government. An alternative index using eight criteria for political independence and seven for economic independence of central banks constructed by Grilli, Masciandaro, and Tabellini (1991) is available but was not used. The chief drawback of these indices is that CBI is assumed to be time-invariant, when in fact regime shifts are plausible and indeed do occur, albeit infrequently.

4.1.2 Union Variables

The figures for union density, union coverage and union concentration are drawn from the comprehensive data set on union structures compiled by political scientists Golden, Wallerstein and Lange (1998) [henceforth called the GWL dataset]. Additional data on other labour market variables such as unemployment benefits are taken from Layard, Nickell and Jackman (1991), and Nickell and Layard (1999). Inflation and unemployment figures are provided by the OECD.

Although the GWL data set covers the years 1950 to 1992 for 16 OECD countries[7], there are many missing union concentration data values for Belgium throughout this period and for the years 1950-1954, 1991 and 1992 for most countries. Several other countries also have substantial missing data points between 1955 and 1970. Consequently, we have restricted our data set to 15 countries spanning the years 1971 to 1990. Union coverage data is only available for the years 1980 and 1990 in 12 countries, only the year 1990 in 3 countries, and unavailable in Italy for either of those two years. In addition, many of the other institutional variables pertaining to unemployment benefits and the tax wedge are only available for a single year, almost always in the mid-1980s. In summary, time-series data are only available for union density and union concentration, while all other explanatory variables

[7] The countries are: Australia, Austria, Belgium, Canada, Denmark, France, Finland, Germany, Italy, Japan, Netherlands, Norway, Sweden, Switzerland, UK, and USA.

(including mean union coverage, obtained by averaging the two time observations per country, when available) are time invariant.

4.2 Methodology

We regress the annual inflation and unemployment rates on central bank independence, union density, union coverage, union concentration and the wage bargaining level. In the inflation regressions we also control for the degree of trade openness, as the union span of control in product markets decreases in more open economies as imports exert competitive pressures on domestic producers. In the unemployment regressions, we include other institutional features that have been shown to be important determinants of unemployment in earlier studies. These include the total tax wedge, employment protection (as proxy for the extent to which unions take into account wage effects on employment), active labour market program expenditure (as proxy for worker search effectiveness), and replacement rate and benefit duration variables (as proxies for the effects of unemployment benefits). Although one may argue that variables controlling for the macroeconomic effects such as the output gap or changes in inflation and unemployment should also be included, we believe that these variables tend to be highly endogenous and may potentially bias the estimates on *all* the explanatory variables. The inclusion of controls for year effects in one of our regression specifications takes care of demand and supply shocks common to all the OECD countries in our sample. Moreover, the degree of independence of a country's central bank should also act as a proxy for the macroeconomic policies pursued in that country (with their resultant impact on aggregate demand).

In our regressions, we include both union density and union coverage as each variable captures a different aspect of union bargaining strength and scope of influence. Union density by itself is an inadequate measure of union scope, as even in countries where legal extension of collective bargaining coverage does not exist, some non-union employers may adopt wages, benefits and other features of union contracts in an effort to thwart unionization of their workforce.

Our measure of union concentration in each country is a Herfindahl index of the membership shares of each union confederation in that country. Specifically,

$$H_{it} = \sum_j \left(\frac{m_{ijt}}{m_{it}} \right)^2 \qquad (22)$$

where *i* denotes a country and *t* denotes a year. m_{ijt} is the membership figure for the *j*th union confederation in country *i* in year *t*, while m_{it} is the total union membership for country *i* in year *t*. The index attains its maximum value when there is one union confederation accounting for the entire union membership in a country. For a given number of union confederations, the index is smallest when these confederations are of identical size.[8]

[8] Alternatively, we can combine the measures of union density and union concentration into a single index: $H_{it} = \sum_j \left(\frac{m_{ijt}}{L_{it}} \right)^2$ where L_{it} is the total labor force for country *i* in year *t* and every non-unionized worker is treated as an independent union with a membership of one. However, we believe that union density and union concentration exert independent effects on our nominal and real variables of interest, and that it is important to distinguish between these effects.

The theoretical motivation for using this Herfindahl index of union concentration is our belief that nominal wage push is generated by unions who do not internalize the costs that their demands for higher nominal wages impose on the economy. The lack of coordination and the resulting wage inflation (which feeds into price inflation if firms practice mark-up pricing) are expected to be more severe in countries where union confederations are numerous, weak and fragmented. Although wage bargaining in some countries may take place at the industry or firm level rather than at the national level, industry-level and firm-level unions operate largely under the direction of their national union confederations, which set wage norms and determine the affiliated unions' posture at the bargaining table.

Conceptually, our measure of union concentration is similar to the Calmfors and Driffill's centralization rankings and Bruno-Sachs' corporatism index. Bruno and Sachs use an index of 'corporatism' which arranges countries on a scale of 0 to 4. The corporatism index is made up of a subjective one/zero categorization along four dimensions: national rather than plant-level wage negotiations, power of trade unions *vis-à-vis* their members; degree of employer organization; and weakness of shopfloor union representatives.

Calmfors and Driffill (1988) argue that both highly centralized and highly decentralized wage-bargaining systems are better than moderately centralized systems, which tend to create an incentive for leapfrogging behavior between well-organized bargaining groups. Translating the concept of centralization into a number for each country is complicated, however. The authors offer only a ranking of countries by degree of centralization based on subjective judgement on the levels of coordination within national union confederations and national employer organizations, as well as the number of existing central union confederations (and employer federations) and the extent of their cooperation.

The primary advantage of using union concentration as a proxy for the degree of union coordination in wage setting has over alternatives like the Calmfors-Driffill and Bruno-Sachs measures is that it is objective, being mathematically computed from raw data on union confederation membership. Moreover, union confederation membership figures fluctuate from one year to another, and new union confederations are occasionally created while some others are dissolved, thereby making the use of panel data possible. A comparison between the three measures from an earlier study of 10 OECD countries (1971-85) by Chou (1999) is shown in Table 1[9]. The drawback to the union concentration measure, however, is that it does not take into consideration the actual level (plant, industry, or national) where wage bargaining takes place, and may be missing qualitative information captured by the other indices. For example, our measure has particular difficulties with the UK. The UK appears to have high union concentration since there is only one national union confederation (the Trade Union Congress), although in reality the wage negotiations take place at the plant level, and are largely informal, fragmented, and autonomous. Wage push is thus a significant problem in the UK, although it would not appear to be so just by looking at its degree of union concentration. This problem is addressed by including an index of the level at which wage bargaining takes place in each country. This index takes an account the fact that bargaining may take place at multiple levels in a single country. For example, lower levels of bargaining may emerge not only to implement the wage provisions of an agreement reached at a higher level, but also address industry or firm-level issues on which the central agreement is silent.

[9] The correlation coefficient between our Herfindahl index of union concentration and the Bruno-Sachs corporatism index is 0.227 (or 0.462 with the UK excluded); the correlation coefficient between the union concentration measure and the Calmfors-Driffill centralization ranking is 0.463 (0.634, UK excluded).

5. Model Specifications

5.1 Predicted Results

In accordance with the theoretical discussions above, our basic empirical specification for the inflation regression takes the following form:

$$\begin{aligned} INFLATION_{it} = a &+ b_1 * CBI + b_2 * UDENS_{it} + b_3 * UDEN2_{it} + b_4 * UCOV_i \\ &+ b_5 * UCONC_{it} + b_6 * UCONC2_{it} + b_7 * BARGLEV_i \\ &+ b_8 * BARGLEV2_i + b_9 * OPENNESS_i + u_{it} \end{aligned} \quad (23)$$

where *CBI* stands for central bank independence, *UDENS* for union density, *UDEN2* for union density squared, UCOV for union coverage, *UCONC* for the Herfindahl index of union concentration, *UCONC2* for union concentration squared, *BARGLEV* for the level of wage bargaining and *OPENNESS* for the imports-GDP ratio.

The specification for the unemployment regression is almost identical to that of the inflation equation:

$$\begin{aligned} UNEMPLOY_{it} = a &+ g_1 * CBI + g_2 * UDENS_{it} + g_3 * UDEN2_{it} + g_4 * UCOV_i \\ &g_5 * UCONC_{it} + g_6 * UCONC2_{it} + g_7 * BARGLEV_i + \\ &g_8 * BARGLEV2_i + \Psi_9 * LABMKTVAR_i + v_{it} \end{aligned} \quad (24)$$

where *LABMKTVAR* is a vector of institutional variables including the total tax wedge (*TOTAXWED*), employment protection (*EMPROTCT*), unemployment benefits replacement rate (*BENRR*), benefit duration (*BENDUR*), and active labour market program expenditure (*ALMP*).

Conventional wisdom holds that greater central bank independence will result in lower inflation and higher unemployment. The assumption is that central bankers are relatively more averse to inflation than are governments, who greatly dislike unemployment because it reduces their prospects of re-election. However, the theoretical model of Velasco and Guzzo (1999) predicts that, for a fixed number of unions (that is, controlling for the extent of centralization in wage bargaining), inflation is hump-shaped with respect to the degree of central bank independence. The relationship between inflation and CBI only becomes monotonic in the special case where the number of unions approaches infinity. More conventionally, Velasco and Guzzo's model also predicts that employment and output fall as the central bank becomes more conservative/independent.

Holding the number of unions constant, union density should also exhibit a hump-shaped relationship with inflation. When union density/membership is high, the demand for unionized labour becomes less elastic, inducing greater wage pressures from unions. On the other hand, the effect of an increase of nominal union wages on the general price level (and therefore real union wages) is also stronger when union density is high, which will counteract the first effect. Similarly, when union density is low, demand for unionized labour becomes highly elastic while the effect of rising nominal union wages on the general price level is low. Like the Calmfors-Driffill argument for centralization of wage bargaining, it is the intermediate case (where union density is neither very high nor very low) where the counterbalancing of the two opposing effects are absent and therefore the macroeconomic outcomes worst. Inflation and unemployment are thus predicted to be highest in countries with intermediate union densities.

Theoretically, the impact of union coverage (the percentage of the labour force that is covered by collective wage bargaining agreements) on inflation and unemployment is unclear. If a country has relatively high union density, then greater union coverage has a similar effect to an increase in union density, which will reduce inflation and unemployment. However, if union density is relatively low, greater union coverage will cause the unions to behave like those in a country with an intermediate degree of unionization, worsening macroeconomic performance.

As explained previously, the recent theoretical models of Cukierman and Lippi (1999) and Velasco and Guzzo (1999) make very different predictions for the impact of the number of unions (proxied empirically by "centralization", the predominant level at which wage negotiations take place[10]) on inflation and unemployment. Our Herfindahl index of union concentration is related to the number of unions in the following way: holding the relative size of union confederations constant, an increase in their number lowers the value of the index. The estimated coefficients for union concentration and union concentration squared can therefore be used to discriminate between the empirical validity of the two competing theoretical models.

We can also study the interaction between union concentration and union density in determining the inflation rate. If unions are heavily concentrated (the extreme case being the existence of only one union confederation), there arises a hump-shaped relationship between union density and inflation. When union density is high so that the size of each identical union confederation is large, all union confederations realize the futility of nominal wage push in raising real wages: their wage push will simply result in higher production costs and product prices. When union density is low, the elasticity of demand for unionized labour is high, so nominal wage push by a union will likely result in layoffs of unionized workers. When union density is in the intermediate range, neither of these salutary effects is present, leading to higher inflation in such an economy.

On the other hand, when union concentration is low, we should see a positive relationship between union density and inflation. The reason is as follows: suppose now that there are many union confederations of equally small size. When union density is low, each union confederation knows that demand for its labour is highly elastic and so refrains from wage push. When union density is high, it fails to internalize fully the cost of its wage push since its members contribute to only a fraction of total labour costs in the economy. The incidence of wage push in countries with low union concentration thus becomes more likely when union density falls. In the parlance of Cukierman and Lippi (1999), the "strategic effect" is weak when union concentration is low.

We can test whether this line of reasoning fits the observed data by dividing our sample of 15 countries into three equal-sized groups according to the average union concentration measure for each country. We then jointly estimate the relationship between the inflation, central bank independence and union density for the three groups. In addition, we can test the restriction that central bank independence has an identical effect on all groups of countries.

The relationship between the level of wage bargaining and inflation is expected to be a hump-shaped one. Holding all other conditions constant, countries in which bargaining takes

[10] Cukierman and Lippi argue that as wage bargaining becomes more decentralized, the number of negotiating units which bargain in an uncoordinated manner increases. This corresponds to an increase on n in the theoretical model and hence, centralization can be interpreted as a proxy for $1/n$.

place primarily at the intermediate (industry) level will suffer higher inflation than those with decentralized or highly centralized wage bargaining systems. When wage bargaining is completely decentralized unions have comparatively little monopoly power, while unions involved in highly centralized wage bargains are concerned about the impact of their nominal wage push on the general price level and real wages. Just as in the argument made previously regarding union density, unions are up to the most mischief when neither the "monopoly" nor "real-wage" effects are present to restrain their wage push. This undesirable situation arises in countries with intermediate levels of wage bargaining.

The openness of a country is predicted to reduce inflation by making product markets more competitive and reducing the ability of firms to pass on wage increases to consumers. The total tax wedge (the gap between the real cost of labour per worker and the consumption wage) is expected to be positively correlated with the unemployment rate. The impact of employment protection legislation on inflation is, however, ambiguous. On the one hand, they may reduce arbitrary dismissals, lower contracting costs by setting general rules and standards, as well as encouraging on-the-job training and human capital formation. On the other hand, firms may become more cautious in hiring workers if they feel that these regulations oblige them to retain workers who are no longer needed. [Scarpetta (1996)]. By reducing incentives for the unemployed to engage in serious job search, unemployment benefit duration and the replacement rate (the ratio of benefits to the last earned wage) should both be positively correlated with the unemployment rate. A more generous benefit duration also increases the size of the long-term unemployed pool. Expenditure on active labour market programs (a proxy for worker search effectiveness) is predicted to be negatively correlated with the unemployment rate.

5.2 Econometric Issues

In using panel data, we are able to explore how cross-country differences and time series variations in central bank independence and union variables affect inflation and unemployment. To investigate how pure cross-country differences impact inflation, we can regress the average inflation (and unemployment) rate for each country on their CBI index, their average union density, union coverage and concentration values, as well as their wage bargaining level. This is the "between regression":

$$\begin{aligned}\overline{INFLATION}_i = a + b_1 * CBI_i + b_2 * \overline{UDENS}_i + b_3 * \overline{UDEN2}_i + b_4 * UCOV_i \\ b_5 * \overline{UCONC}_i + b_6 * \overline{UCONC2}_i + b_7 * BARGLEV_i + \\ b_8 * BARGLEV2_i + u_i\end{aligned} \qquad (25)$$

where $\overline{INFLATION}_i$ is the average inflation rate for country i, $\overline{UDENS}_i$ is the average union density for country i, and $\overline{UCONC}_i$ is the average union concentration for that country.

In addition, panel data allows us to remove time-invariant country-specific effects by using a fixed effects estimator. These idiosyncratic, country-specific effects encompass both observed variables such as central bank independence and unobservables such as tastes and preferences for low inflation. This "within regression" may be written as:

$$\begin{aligned}INFLATION_{it} = \sum_i^N d_i + b_2 * UDENS_{it} + b_3 * UDEN2_{it} \\ + b_5 * UCONC_{it} + b_6 * UCONC2_{it} + u_{it}\end{aligned} \qquad (26)$$

where the d_i's are country dummies. The estimated parameters indicate how much time variations in union density and concentration explains the evolution of inflation in each country. Since our measure of CBI is fixed for each country, it is subsumed in the country fixed effect.

The loss of degrees of freedom arising from using fixed effects estimation can be avoided if we assume that the country-specific effects are random. The random effects model (implemented by using generalized least squares) is an appropriate specification if we are drawing the countries in our sample randomly from a larger population (such as *all* the OECD countries). In the two-way error component regression model, we also allow for a time (year) effect to absorb shocks that impact all countries in the sample in a given year. This in some sense accounts for part of the autocorrelation we observe in the inflation data as well as the impact of demand and supply shocks on inflation (and unemployment), since in our sample period all the countries were concurrently affected by the two OPEC shocks. The random effects or variance components model is given by:

$$\begin{aligned} INFLATION_{it} = a + m_i + l_t + b_2 * UDENS_{it} + b_3 * UDEN2_{it} + b_4 * UCOV_i \\ b_5 * UCONC_{it} + b_6 * UCONC2_{it} + b_7 BARGLEV_i + \\ b_8 BARGLEV2_i + u_{it} \end{aligned} \tag{27}$$

The validity of the random effects model hinges on the independence of the individual invariant effects from the other dependent variables and the *i.i.d.* disturbance term. When the independence criteria is satisfied, the GLS estimator is BLUE, consistent and asymptotically efficient, but is otherwise biased and inconsistent. On the other hand, the "within" (fixed effects) estimator is consistent whether or not the independence criteria is satisfied. Based on these differences, the Hausman test may be used to discriminate between these two specifications.

Finally, we consider a first-order autoregressive model in which the random errors are allowed to be contemporaneously correlated, heteroscedastic, and first-order autoregressive ($u_{it} = r u_{it} + e_{it}$ where e is the pure white-noise component). This model is particularly appropriate since the inflation time-series often exhibits a high degree of autocorrelation. Details on the various estimators used are provided in Appendix D.

6. Empirical Results

6.1 Sample Statistics

The sample statistics for the 15 OECD countries is shown in Tables 2 and 3. Table 2 shows the mean, standard deviation, minimum and maximum values for the dependent and explanatory variables used in our regressions. Table 3 table shows the average union density, union coverage and union concentration values for each country. A summary of wage bargaining systems in OECD countries by Layard, Nickell and Jackman (1991) is reproduced in Appendix A. Plots of union density and union concentration versus inflation and unemployment are shown in Fig. 1.

From Table 2, we see that the mean inflation and unemployment rates for the 15 OECD countries in our sample from 1971 to 1990 were 7.26% and 4.99% respectively. The standard deviations for both variables were large at 4.33 and 3.18 respectively. Pronounced cross-country differences in their inflation and unemployment experiences are also apparent.

For example, inflation and unemployment in Switzerland averaged 4.6% and 0.4% respectively between 1971 and 1990. In the same period, Italy's mean inflation and unemployment rates were 12.6% and 8.4%. As is well known, the plots in Fig. 1 show that inflation in most countries rose sharply (spiked) during the two oil price shocks in the 1970s but declined throughout the 1980s, while unemployment rose steadily after the shocks and decreased somewhat only from the mid- to late-eighties. Tables 2 and 3 also show that labour market institutions and policies differed sharply across the 15 countries. Union density ranged (across time and between countries) from 0.085 to 0.846 with a mean of 0.419, union coverage from 0.22 to 0.95 (mean = 0.655), union concentration from 0.25 to 1 (mean = 0.653), the unemployment benefit replacement ratio from 20% to 90%, and benefit duration from 0.5 to 4 years. Even the total tax wedge varied between countries from 28.7% to 70.7%, while the openness to imports measure varied between 0.07 (USA) to 0.48 (Netherlands)[11]. Finally, the degree of central bank independence ranged from 0.17 (Norway) to Germany (0.69).

6.1 Aggregate Data (OLS Estimation)

Table 4 presents the results of the inflation regressions using Ordinary Least Squares. The first column shows the estimates from a regression with CBI, union coverage, union concentration, level of wage bargaining and openness to trade as the explanatory variables. Only union coverage has a significant positive correlation with the rate of inflation, while trade openness has a significant negative correlation. When union coverage is replaced by union density (columns 2 and 3), union concentration is shown to exhibit a U-shaped relationship with inflation, while union density exhibits a hump-shaped relationship with inflation. Allowing for a non-linear relationship between inflation and the bargaining level index improves the fit of the regression, raising the adjusted R^2 from 0.2307 to 0.2385 (compare column 2 against column 3). The fit improves considerably when both union density and union coverage are included in the regression (column 4), and improves further when we allow for a non-linear relationship between central bank independence and inflation. The following relationships are robust to the various changes in specification: (1) Union density has a hump-shaped relationship with inflation; (2) greater union coverage raises inflation; (3) union concentration exhibits an mild U-shaped (almost purely negative) relationship with inflation; and (4) greater openness to trade reduces inflation. (Fig. 2 shows the plots of these relationships, using the mean values of all other variables.) On the other hand, the convex relationship between inflation and wage bargaining level index (which violates the prediction made in Section 5.1) vacillates between statistical significance at the 5% level (column 4) and significance at the 10% level or worse (columns 3 and 5). Allowing for a non-linear relationship between CBI and inflation raises the adjusted R^2 from 0.2648 to 0.3071, making column 5 the most preferred specification. The relationship between CBI and inflation should therefore be characterized as a hump-shaped one rather than the downward-sloping one which emerges when the relationship is constrained to be linear.

6.2 Robustness Checks with Alternative Estimators

[11] Recall that data for the total tax wedge and openness measure were taken in the mid-1980s.

With the preferred OLS specification from column 5 of Table 4, we now test the robustness of those results to the use of alternative estimators. Column 1 in Table 5 shows the results of the "between regression" where the intertemporal dimension has been eliminated to produce a pure cross-country regression. Each data point comprises the mean values of all explanatory variables for each country in the sample. The results are surprisingly strong, considering the fact that there are only 15 observations in the regression. Central bank independence still exhibits a hump-shaped relationship with inflation (with the *t*-values at 1.98 and –2.47 for the squared term), union coverage again has a positive correlation with inflation (*t*-statistic = 2.47), while trade openness shows a negative correlation with inflation (*t*-statistic = -1.29). Perhaps not surprisingly, the time-varying variables, union density and union concentration, now become statistically insignificant. When we examine the results from the fixed effects estimation (the "within" regression) shown in column 3 of the same table, the robustness of the results for the union density and union concentration variables from the OLS regression are confirmed. The *t*-statistics for these variables and their squared counterparts range in absolute value from 4.30 to 7.65.

Columns 4 and 5 in Table 5 show the results from the 2-way random effects (or variance components) model implemented using the Fuller-Battase (1974) method, and from an autoregressive model implemented using the Parks method. The random effects model allowing for unobservable country and time effects is preferable to the fixed effects model if the sample countries is believed to be drawn from a large population. The fixed effects model it valid only when the differences between units can be viewed as parametric shifts of the regression function. Since our sample of 15 countries forms a majority of all OECD countries, we may suspect that the fixed effects approach is superior to the random effects approach. As explained previously, a major consideration is that the error component (random effects) regression model requires the unobserved individual invariant effects contained in the error term be uncorrelated with the explanatory variables so that $E(u_{it} / X_{it}) = 0$. When this condition is satisfied, the random effects estimator is BLUE, consistent and asymptotically efficient. When it is not, this estimator is inconsistent. By contrast, the fixed effects estimator is consistent regardless whether the condition is met nor not, since the within transformation wipes out the unobserved individual effects. The Hausman (1978) test allows us to discriminate between the two specifications. In our case, the Hausman test statistic of 67.76 (with a *p*-value of less than 0.0001) clearly rejects the validity of the random effects model. It is thus unsurprising to note that the model performs poorly with an adjusted R^2 of only 0.0947. A glance at column 4 reveals that only the bargaining level variables are strongly correlated with inflation in this regression.

The results from the autoregressive model (shown in column 5) are much more reassuring. Even when the autoregressive nature of inflation is accounted for, CBI and union density continue to exhibit a hump-shaped relationship with inflation, while union concentration again shows a mild convex relationship with inflation. Only the union coverage and bargaining level variables lose some statistical significance when compared with the corresponding OLS regression.

We can now compare our findings against the predictions of the Cukierman-Lippi and Velasco-Guzzo theoretical models. The hump-shaped relationship observed between inflation and central bank independence agrees with the prediction of the Velasco-Guzzo model. The Cukierman-Lippi model predicts that CBI has two opposing effects on the rate of inflation. For a given wage premium, an increase in CBI reduces equilibrium inflation as in Rogoff

(1985), but an increase in CBI also raises the wage premium, which tends to increase the rate of inflation. The net effect of an increase in CBI on inflation is therefore ambiguous in their model.

The downward-sloping and mildly convex relationship we observed between inflation and the union concentration is clearly inconsistent with the Cukierman-Lippi model which predicts an *upward*-sloping or hump-shaped relationship[12] depending on the degree of inflation aversion among unions. Our results in this respect are, however, consistent with the Velasco-Guzzo model, which predicts that inflation is monotonically increasing in the number of unions (n) if the substitutability among different types of labour is limited (see the left-hand panels in Fig.2 and upper panel in Fig.3).

Moreover, even if Cukierman and Lippi argue in their empirical work that the wage bargaining level (or "centralization" in their parlance) is a better proxy for $1/n$, our results here also reject their theoretical model in favor of Velasco and Guzzo's. We find a negative relationship between inflation and the wage bargaining level rather than a hump-shaped one.

6.3 High-Union Concentration versus Low-Union Concentration Countries

In this section, we investigate whether the relationships between inflation, central bank independence and labour market institutions are similar in countries where union confederations are concentrated when compared with those with fragmented union confederations.

We divide the sample of 15 countries into three groups of five according to their index of union concentration. The first group comprises Australia, Austria, the UK, USA and Canada with an average Herfindahl index of 0.947. The second group consists of most of the Scandinavian countries (Denmark, Norway, and Sweden) as well as Germany and the Netherlands, with an average union concentration index of 0.606. The last group, made up of Finland, France, Italy, Japan and Switzerland, have an average concentration index of 0.411. (See Table 7.) It is interesting to note that the countries in the middle group have, on average, relatively high union density (0.519 against 0.380 and 0.357 for the other two groups) and bargaining level (3.1 against 1.9 and 2.4), and relatively low inflation (6.65% against 7.46% and 7.55%) and unemployment (4.59% against 5.98% and 7.75%).

Table 8 reports the results from a joint estimation of the effects of CBI and union variables on inflation in all three groups. This is implemented in both OLS and GLS (using the Parks autoregressive model) by interacting dummies for the three groups with all explanatory variables except union concentration. The results may be summarized as follows:

(1) Central bank independence exhibits a hump-shaped relationship with inflation for countries with high and low degrees of union concentration but a primarily downward-sloping relationship for countries with intermediate degrees of union concentration.
(2) Union density and unemployment have a positive and convex relationship for countries with high union concentration; the relationship is a hump-shaped one for countries in the other two groups. This result is the *exact reverse* of our earlier prediction that the relationship between union density and unemployment is hump-shaped when union concentration is high and positive when union concentration is low.

[12] More precisely, the Cukierman-Lippi model predicts an upward-sloping or hump-shaped relationship between inflation and the inverse of the number of unions (i.e. $1/n$). We showed earlier that an increase in n, *ceteris paribus*, also reduces the Herfindahl index of union concentration.

(3) The level of bargaining and inflation have a hump-shaped relationship for countries with high union concentration (*a là* Calmfors and Driffill, and in accord with the prediction made in Section 5.1), but a positive convex relationship for countries with low union concentration. The relationship is statistically insignificant for countries with intermediate degrees of union concentration.
(4) Union coverage and inflation are negatively related for countries with high and intermediate degrees of union concentration, but positively related for countries with low union concentration. (Recall our prediction of an ambiguous relationship in Section 5.1).
(5) Openness to trade reduces inflation in countries with medium and low union concentration, but has no impact on inflation in countries with high union concentration.

7. Union Variables and Unemployment

7.1 Results for Full Panel of Countries

Table 6 presents the results of the unemployment regressions. The explanatory variables included in these regressions can be divided broadly into three groups: (1) central bank independence (which partially controls for the state of the macroeconomy); (2) variables characterizing the wage bargaining institutions in an economy such as union density, union coverage, union concentration and wage bargaining level; and (3) variables intended to capture other aspects of a country's labour market, such as the total tax wedge, employment protection, unemployment benefit duration and replacement ratio, and the extent of active labour market programs.

Column 1 presents the results from the "between" regression which uses only cross-country variations in each of the independent variables. Just as in the corresponding inflation regression, CBI exhibits a hump-shaped relationship with unemployment. However, contrary to expectations, union density and unemployment have a U-shaped relationship while union coverage is negatively correlated with the unemployment rate. In addition, unlike the "between" inflation regression, even pure cross-country differences in union concentration can explain a significant portion of differences in the mean unemployment rate between countries. The relationship between union concentration and unemployment is a hump-shaped one. Among the other labour market variables, employment protection and unemployment benefit duration have a positive correlation with the unemployment rate, while more active labour market programs and a higher benefit replacement ratio tend to reduce unemployment, the last of which is a counter-intuitive result. One would expect that a higher benefit replacement ratio to reduce the intensity of job search by the unemployed.

Almost all the above results are replicated in the full panel data estimation using ordinary least squares (reported in column 2). The only exception is that union coverage now loses its explanatory power. In addition, the level of bargaining exhibits a slightly convex but clearly negative relationship with unemployment. That is, highly centralized bargaining systems appear to reduce unemployment, which is the result that gave rise to the corporatist hypothesis and its associated literature.

The Hausman test statistic reported at the bottom of column 4 in the same table indicates that the random effects (variance components) model should be rejected in favor of the fixed effects model. The estimated coefficients from the fixed effects estimation are

reported in column 3; again, union density and unemployment exhibit a U-shaped relationship while the relationship between unemployment and union concentration is a hump-shaped one.

Finally, the results from the autoregressive model (reported in the last column) are almost qualitatively identical to those of the standard OLS model. The only important difference is that the estimated coefficients for employment protection and benefit duration now become statistically insignificant.

We note that the hump-shaped relationship observed between unemployment and central bank independence are inconsistent with the Cukierman-Lippi and Velasco-Guzzo models, which both predict an upward-sloping relationship. Similarly, the hump-shaped relationship between unemployment and union concentration is inconsistent with the prediction of the Velasco-Guzzo model, which posits either a negative relationship between unemployment and the inverse of the number of unions[13] ("centralization" in their parlance) when the elasticity of substitution among different types is sufficiently small, or an *U*-shaped relationship otherwise. Our results are, however, consistent with the prediction of the Cukierman-Lippi model that unemployment and the inverse of the number of unions (1/*n*) have a hump-shaped relationship when unions are sufficiently averse to inflation. (Their model predicts a positive relationship when unions do not care much about price stability.) A joint plot of unemployment, CBI and union concentration is shown in Fig.3 - compare these with Fig. 4 and Fig. 5 in Velasco and Guzzo (1999), p.1336-37.

7.2 High-Union Concentration versus Low-Union Concentration Countries

As in the case with inflation, we divide our sample of 15 countries into three equal-sized groups according to their index of union concentration, and proceed to jointly estimate the effects of CBI and union variables on unemployment for all three groups. This is implemented in OLS and GLS (using both the Fuller-Battase variance components model[14] and the Parks autoregressive model) by interacting dummies for the three groups with all explanatory variables except union concentration. The results are reported in Table 9, and may be summarized as follows:

(1) Central bank independence and unemployment exhibit a hump-shaped correlation for countries in the intermediate union concentration group (see columns 2 and 3). Inflation and CBI are uncorrelated for countries in the other two groups.

(2) Unemployment is hump-shaped with respect to union density in countries with high union concentration, and U-shaped in countries with medium and low union concentration. In the last case, however, the relationship is of statistical significance only when using the random effects (variance components) estimator (column 3).

(3) There is a negative relationship between unemployment and the level of wage bargaining in countries with high union concentration. The relationship is always statistically insignificant in countries with low union concentration and significant in countries with medium union concentration only when the random effects estimator is used.

(4) The effect of union coverage on unemployment in each of the three groups is not robust to the use of alternative estimators.

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[13] As explained in footnote 9, an increase in the number of unions, *ceteris paribus*, lowers our Herfindahl index of union concentration.

[14] This specification cannot be rejected at the 10% level. The Hausman statistic is 10.67 with a *p*-value of 0.0992.

8. CBI and the Impact of Union Variables on Macroeconomic Outcomes.

We now turn to the results obtained when the sample is divided into two groups according to the degree of central bank independence in each country. Countries classified in the high-CBI group are Germany, Austria, Switzerland, Denmark, USA, Canada and the Netherlands (in descending order of independence). Countries classified in the low-CBI group are Sweden, Finland, UK, Italy, France, Japan and Norway (again in descending order of independence). The CBI index ranged from 0.42 to 0.69 for the former group, and from 0.17 to 0.29 for the latter.

Table 10 reports the results from the inflation regression. The left half of the table (columns 1 and 2) show the estimated coefficients for the autoregressive (Parks) model, while the right half (columns 3 and 4) show their counterparts for the variance components (Fuller-Battase) model. The results for the two models are qualitatively similar. The relationship between inflation and CBI is humped-shaped in low-CBI countries but statistically insignificant in high-CBI countries. Union density and inflation are hump-shaped in high-CBI countries and monotonically positive in low-CBI countries. Union concentration and inflation are U-shaped in high-CBI countries but statistically insignificant in low CBI countries. The wage bargaining level is negatively correlated with inflation in high-CBI countries and positively correlated with inflation in low-CBI countries. The trade openness variable has a negative correlation with inflation in high-CBI countries only in the autoregressive model.

The next table (Table 11) shows the corresponding results from the unemployment regression. CBI and unemployment are uncorrelated in high-CBI countries but positively-correlated in low-CBI countries. Union density has a convex downward-sloping relationship with unemployment in the low-CBI countries; the relationship is statistically insignificant in the high-CBI countries. Union coverage is negatively correlated with unemployment in high-CBI countries but positively correlated with unemployment in low-CBI countries. Union concentration and unemployment are hump-shaped in high-CBI countries and monotonically downward-sloping in low-CBI countries. The level at which wage bargaining takes place is positively correlated with unemployment in high-CBI countries but uncorrelated with unemployment in low-CBI countries. In both groups of countries, the total tax wedge and employment protection index are negatively and positively correlated with unemployment respectively. However, the benefit replacement rate and unemployment are negatively correlated in high-CBI countries but positively correlated in low-CBI countries. Conversely, benefit duration and unemployment are positively correlated in high-CBI countries but negatively correlated in low-CBI countries.

The Cukierman-Lippi model predicts that the higher CBI the larger the range of "centralization" (or $1/n$) levels (equivalent to our union concentration levels, as explained earlier) for which further *de*centralization is beneficial in the sense that it is likely to reduce both inflation and unemployment. Conversely, the lower CBI, the larger the range of levels of centralization (concentration) for which further centralization (concentration) is beneficial since it reduces inflation and unemployment. Graphically, the upward-sloping portion of the unemployment-centralization curve is more dominant when CBI is high, while the downward-sloping portion is predominant when CBI is low. An increase in CBI is also expected to shift the entire curve up.[15]

[15] See Fig.3 in Cukierman and Lippi (1999), p.1409.

A glance at Table 10 reveals that this prediction is clearly not borne out by our inflation results. However, as can been seen from Table 11, the estimated coefficients for union concentration in the unemployment regressions for high-CBI and low-CBI countries are somewhat more consistent with the prediction of the Cukierman-Lippi model, in that the relationship is largely upward-sloping for high-CBI countries and largely-downward sloping for low-CBI countries.[16] The corresponding plots are shown in Fig. 4.

9. Union Concentration and Aggregate Supply Shocks

In this penultimate section, we examine whether variation in union concentration explains the widely differing inflationary responses of OECD countries to the 1973-74 OPEC oil price shock. To test this hypothesis, we create a counterfactual in which there were no unanticipated supply shocks to raise average import prices between 1974 and 1976. For generating the predicted values of inflation for this period, we used the Multi-Country (MC) version of the FAIRMODEL. This model by Ray Fair consists of estimated structural equations for 33 countries and estimated trade share equations for 44 countries. There are 328 stochastic equations and 1440 estimated coefficients in the MC model; the number of endogenous and exogenous variables, not counting the trade shares, is about 4000. The estimation technique used for all the countries is two stage least squares except when there are too few observations to make the technique practical, whereupon ordinary least squares is used. To generate predicted rates of inflation, we replaced actual average import price indices for all countries in the model with values fitted to trends generated from 1971-73 historical data. One caveat that should be noted about this simulation is that the parameters of the model are estimated from data beyond the 1970s, and is thus vulnerable to the Lucas critique. Unfortunately, the model cannot be easily altered to address this problem and we have thus far been unable to find a suitable alternative forecasting model.

In order to focus our attention on countries which are as similar as possible in all other respects except for differences in their labour market structures and monetary institutions, we restrict our sample to only 9 continental European countries (Austria, Denmark, France, Germany, Italy, Netherlands, Norway, Sweden and Switzerland). We also chose as parsimonious an empirical specification as possible, bearing in mind that we are working with only 9 observations. From our results in Section 6.1, we decided to exclude the square of union concentration.

The results are suggestive: Our estimates (shown in Table 12) indicate that central bank independence is significantly correlated with the difference between actual and predicted inflation rates for the year 1974; however, its effects on inflation fades away in 1975. Union density and density squared have the correct signs in both 1974 and 1975, but become statistically significant only in the latter year. The most intriguing finding is that union concentration is at first insignificant in explaining unexpected inflation, but becomes significant even at the 5% level by 1975. This observation is consistent with our hypothesis that wage institutions affect the transmission of aggregate supply shocks to hikes in the inflation rate. In the immediate aftermath of the shock, central banks with greater independence were more successful in resisting the urge to accommodate the shock. However, by the second year (when a significant fraction of wages would have been

[16] This result is however the exact *reverse* of that found by Cukierman and Lippi (1999) in their empirical work (see column 5, Table C2).

renegotiated), more concentrated unions in certain countries were better able to convince their members to accept the reality of lower real wages, thereby allowing firms to institute smaller price increases and bringing down actual inflation. Note that we used 1973 values for all other explanatory variables to prevent the sharp, unexpected rise in inflation from feeding back into central bank independence, union density and union concentration.

10. Conclusion

In this paper, we have investigated the impact of central bank independence, union density and union concentration and other labour market variables on inflation and unemployment. We also reviewed the existing empirical literature and theoretical models supporting our belief that coordination failures in wage setting and bargaining are responsible for a significant fraction of price inflation observed in developed economies. The extent of these coordination failures, we argued, is in turn dependent on the union structures extant in these countries.

While previous studies in this field have used subjective measures of centralization and corporatism to capture the degree to which a country's wage setting institutions ameliorate the effects of coordination failures, we have used a Herfindahl index of union concentration which is objective and captures much of the subtleties inherent in the phenomena under study. In addition to union density, union coverage and wage bargaining level, other variables used to characterize the labour market institutions in a country are the total tax wedge, employment protection, unemployment benefit duration and replacement ratio, as well as spending on active labour market programs. A trade openness variable was also included as a proxy for the intensity of external competition faced by firms in product markets.

Our results using panel data for 15 OECD countries from 1971 to 1990 show that inflation exhibits a hump-shaped relationship with central bank independence and union density, but a negative relationship with union concentration. Unemployment has a U-shaped relationship with union density, but a hump-shaped relationship with union concentration and central bank independence. These findings are robust to the use of alternative estimators and assumptions on the structure of the error term. In addition to ordinary least squares, the model was estimated using the "between", fixed effects ("within"), two-way random effects and autoregressive estimators. Interestingly, our full-panel inflation results fully support the predictions of the Velasco-Guzzo (1999) model, while our full-panel unemployment results partially support the predictions of the Cukierman-Lippi (1999) model and reject those of the Velasco-Guzzo model.

Stratifying the sample into three groups by the degree of union concentration in each country, we find that central bank independence, union density, union concentration and wage bargaining level had very different impacts on inflation and unemployment for each of the three groups. For example, the relationship between CBI and inflation is hump-shaped for countries with high and low union concentration, but monotonic and negative for countries with intermediate union concentration. On the other hand, union density and inflation exhibit a hump-shaped relationship for countries with low and intermediate union concentration, but an upward-sloping relationship for countries with high union concentration. When we divide our sample by the degree of central bank independence, we again find considerable divergence in the impact of labour market variables on inflation and unemployment in

countries with highly independent central banks and in those that do not. As in the full sample, the results from the unemployment regressions are more supportive of the Cukierman-Lippi model than those from the inflation regressions.

Finally, we estimated the impact of central bank independence, union density and union concentration on the unexpected rise in inflation arising from the 1973-74 OPEC shock. Our regressions show that in the immediate aftermath of the oil price shock, greater central bank independence is strongly correlated with smaller deviations of actual inflation from their predicted values. Two years after the shock, the effects of central bank independence fade away and are replaced by that of union concentration. These findings are consistent with our hypothesis that greater union concentration inhibits the wage-price spiral set off by negative aggregate supply shocks.

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TABLE 1

Centralization, Corporatism and Union Concentration Rankings for 10 OECD countries, 1971-85.

Index *Ranking*	Union Concentration	Centralization (Calmfors-Driffill)	Corporatism (Bruno-Sachs)
1	Austria	Austria	Austria
2	(UK)	Norway	Germany
3	Germany	Sweden	Netherlands
4	Denmark	Denmark	Norway
5	Norway	Germany	Sweden
6	Sweden	Netherlands	Denmark
7	Italy	France	Switzerland
8	Netherlands	UK	Italy
9	Switzerland	Italy	UK
10	France	Switzerland	France

TABLE 2

Sample statistics for 15 OECD countries, 1971-90.

Statistic **Variable**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
Inflation (%)	7.26	4.33	-1.40	27.20
Unemployment (%)	4.99	3.18	0.00	11.90
Central bank independence	0.39	0.156	0.17	0.69
Union density	0.419	0.173	0.085	0.846
Union coverage	0.655	0.232	0.22	0.95
Union concentration	0.653	0.247	0.25	1.00
Bargaining Level	2.47	0.99	1.0	4.0
Total tax wedge (%)	50.15	11.76	28.70	70.70
Employment protection	9.47	5.20	1	20
Benefit replacement rate (%)	58.07	17.07	20	90
Benefit duration (yrs)	1.98	1.24	0.5	4.0
Active labour market programs	12.78	13.68	3.0	59.3
Openness	0.254	0.106	0.07	0.48

TABLE 3
Key statistics for individual countries.

Country	Average Inflation (%)	Average Unem-ployment (%)	Average Union Density	Average Union Concen-tration	Central Bank Indepen-dence	Openness	Bar-gaining Level
Australia	9.5	5.9	0.450	1.	0.36	0.17	3
Austria	5.1	2.5	0.495	1	0.61	0.32	2
Canada	7.0	8.1	0.323	0.737	0.45	0.22	1.45
Switzerland	4.6	0.4	0.296	0.445	0.58	0.33	2
Germany	4.0	4.9	0.333	0.703	0.69	0.21	2
Denmark	7.9	6.4	0.666	0.627	0.50	0.32	3.2
Finland	9.3	4.3	0.638	0.457	0.28	0.26	2.75
France	8.0	6.7	0.160	0.322	0.24	0.18	2
UK	10.1	6.7	0.432	1	0.27	0.24	1.75
Italy	12.6	8.4	0.393	0.401	0.25	0.21	3.4
Japan	4.3	2.1	0.297	0.432	0.18	0.11	2
Netherlands	5.0	7.0	0.296	0.517	0.42	0.48	2.95
Norway	7.0.	2.4	0.529	0.696	0.17	0.43	3.65
Sweden	8.8	2.3	0.773	0.488	0.29	0.26	3.5
US	5.8	6.7	0.198	1	0.48	0.07	1.3

TABLE 4

Inflation, CBI and wage bargaining structure in 15 OECD countries, 1971-90.

Dependent variable: annual inflation (%)
Estimation method: **OLS**

Explanatory variables	1	2	3	4	5
Intercept	8.119 (2.58)	9.346 (3.99)	13.762 (4.29)	11.721 (3.65)	0.628 (0.16)
Central bank independence	-5.796 ** (-3.35)	-4.052 ** (-2.40)	-2.966 * (-1.68)	-3.201 * (-1.85)	33.621 ** (3.87)
CBI squared	------	------	------	------	-44.618 ** (-4.32)
Union density	------	35.895 ** (4.78)	41.142 ** (5.20)	39.884 ** (7.78)	45.140 ** (5.90)
Union density squared	------	-30.204 ** (-4.00)	-34.848 (-4.44)	-35.926 ** (-4.65)	-42.862 ** (-5.59)
Union coverage	5.461 ** (4.42)	------	------	4.357 ** (3.38)	4.593 ** (3.66)
Union concentration	-2.095 (-0.25)	-28.110 ** (-3.22)	-35.849 ** (-3.77)	-27.226 ** (-2.81)	-19.870 ** (-2.08)
Union concentration squared	2.872 (0.48)	19.607 ** (3.21)	24.277 ** (3.73)	18.232 ** (2.75)	12.546 * (1.91)
Bargaining level	-1.401 (-0.92)	19.607 ** (3.21)	-2.257 ** (-1.53)	-4.058 ** (-2.63)	-2.228 (-1.43)
Bargaining level squared	0.408 (1.45)	------	0.547 ** (2.00)	0.841 ** (2.98)	0.487 * (1.70)
Openness	-6.540 ** (-2.62)	-8.393 ** (-3.35)	-8.469 ** (-3.40)	-9.616 ** (-3.89)	-10.889 ** (-4.50)
n	300	300	300	300	300
Adjusted R^2	0.1977	0.2307	0.2385	0.2648	0.3071

Notes: Figures in parentheses are *t* statistics. ** indicates statistical significance at the 5% level. * indicates statistical significance at the 10% level.

TABLE 5

Inflation, CBI and wage bargaining structure in 15 OECD countries, 1971-90.

Dependent variable: annual inflation

Estimation method: **OLS, Fixed Effects, Random Effects**

Explanatory variables	"Between" Regression	OLS	Fixed Effects	Variance Components Model (Fuller-Battase)	Auto-regressive Model (Parks)
Intercept	-2.323 (-0.41)	0.628 (0.16)	------	2.974 (0.67)	2.902 (1.13)
Central bank independence	27.184 * (1.98)	33.621 ** (3.87)	------	-3.253 (-0.86)	19.362 ** (3.23)
CBI squared	-40.185 ** (-2.47)	-44.618 ** (-4.32)	------	------	-24.050 ** (-3.17)
Union density	7.496 (0.50)	45.140 ** (5.90)	94.109 ** (7.65)	21.806 ** (1.99)	31.029 ** (5.66)
Union density squared	-5.715 (-0.37)	-42.862 ** (-5.59)	-65.85 ** (-4.83)	-12.440 (-1.10)	-23.599 ** (-4.10)
Union coverage	4.676 ** (2.47)	4.593 ** (3.66)	------	1.215 (0.41)	1.116 (1.31)
Union concentration	4.733 (0.30)	-19.870 ** (-2.08)	-46.29 ** (-4.83)	-14.172 (-1.33)	-19.933 ** (-3.77)
Union concentration squared	-2.048 (-0.19)	12.546 * (1.91)	36.436 ** (4.30)	10.456 (1.35)	13.571 ** (3.67)
Bargaining level	------	-2.228 (-1.43)	------	3.954 ** (2.59)	-0.389 (-0.72)
Bargaining level squared	------	0.487 * (1.70)	------	-0.716 ** (-2.60)	0.017 (0.17)
Openness	-5.312 (-1.29)	-10.889 ** (-4.50)	------	-9.323 (1.49)	-5.04 * (-1.67)
n	15	300	300	300	300
Adjusted R^2	0.6640	0.3071	0.8541	------	0.2899
Hausman Test Statistic	------	------	------	69.76 (*p*-value: <0.0001)	------

Notes: Figures in parentheses are *t* statistics. ** indicates statistical significance at the 5% level. * indicates statistical significance at the 10% level.

TABLE 6

Unemployment, CBI and wage bargaining structure in 15 OECD countries, 1971-90.

Dependent variable: annual unemployment rate
Estimation method: **OLS, Fixed Effects, Random Effects**

Explanatory variables	"Between" Regression	OLS	Fixed Effects	Variance Components Model (Fuller-Battase)	Auto-regressive Model (Parks)
Intercept	-9.978 (-13.89)	0.170 (0.06)	------	0.719 (0.12)	1.933 (1.11)
Central bank independence	59.971 ** (24.36)	42.922 ** (5.71)	------	48.237 ** (2.84)	29.920 ** (7.12)
CBI squared	-72.768 ** (-24.80)	-52.624 ** (-5.59)	------	-59.608 ** (-3.36)	-36.344 ** (-7.29)
Union density	-102.902 ** (-27.05)	-52.859 ** (-8.70)	-50.562 ** (-6.72)	-14.628 ** (-2.08)	-20.670 ** (-8.17)
Union density squared	119.344 ** (25.23)	56.990 ** (8.00)	41.397 ** (4.97)	0.786 (0.11)	14.273 ** (6.32)
Union coverage	-6.823 ** (-17.84)	0.1383 (0.09)	------	6.626 (1.31)	1.730 (0.85)
Union concentration	114.631 ** (31.81)	59.671 ** (9.61)	52.636 ** (8.98)	-2.184 (-0.34)	17.798 ** (6.87)
Concentration squared	-83.745 ** (-30.34)	-44.524 ** (-10.19)	-38.016 ** (-7.34)	2.337 (0.49)	-14.136 ** (-7.11)
Bargaining level	------	-5.257 ** (-5.34)	------	-1.718 * (-1.93)	-0.743 ** (-2.98)
Bargaining level squared	------	0.973 ** (5.43)	------	0.296 * (1.83)	0.138 ** (2.96)
Total tax wedge	0.011 (1.27)	0.003 (0.11)	------	-0.002 (-0.02)	0.024 (0.81)
Employment protection	0.412 ** (13.84)	0.221 ** (3.03)	------	-0.008 (-0.04)	-0.081 (-1.16)
Benefit replacement rate	-0.203 ** (-18.35)	-0.102 ** (-6.45)	------	-0.002 (-0.05)	-0.048 ** (-3.03)
Benefit duration	1.705 ** (34.13)	0.986 ** (5.11)	------	0.018 (0.02)	0.318 (1.18)
Active labour market programs	-0.221 ** (-27.54)	-0.133 ** (-7.18)	------	0.031 (0.48)	-0.020 * (-1.85)
n	15	300	300	300	300
Adjusted R^2	0.9980	0.5796	0.8889	0.2093	0.5885
Hausman Test Statistic	------	------	------	106.95 (*p*-value: <0.0001)	------

Notes: Figures in parentheses are *t* statistics. ** indicates statistical significance at the 5% level. * indicates statistical significance at the 10% level.

TABLE 7
Characteristics of high, medium and low concentration groups

Variables Group	Average Union Concen-tration	Average Union Density	Average Bar-gaining Level	Average CBI	Average Inflation (%)	Average Unem-ployment (%)
High concentration (Australia, Austria, Canada, UK, USA)	0.947	0.380	1.9	0.43	7.47	5.98
Medium concentration (Denmark, Germany, Netherlands, Norway, Sweden)	0.606	0.519	3.1	0.41	6.55	4.59
Low concentration (Finland, France, Italy, Japan, Switzerland)	0.411	0.357	2.4	0.31	7.75	7.75

TABLE 8

Inflation, CBI and wage bargaining structure in 15 OECD countries (1971-90), grouped by union concentration.

Dependent variable: Annual inflation rate
Estimation methods: **OLS**, **GLS**

Variable	**Ordinary Least Squares**	**Autoregressive Model (Parks)**
Hi (dummy for high concentration group)	-17.405 (-2.12)	-12.67 (-0.95)
Hi x CBI	113.152 (2.70) **	87.396 (1.47)
Hi x CBI squared	-163.29 (-3.25) **	-128.424 (-1.87) *
Hi x union density	-1.104 (-0.03)	6.083 (0.50)
Hi x union density squared	98.205 (2.11) **	71.736 (4.31) **
Hi x union coverage	-29.34 (-6.25) **	-22.342 (-7.26) **
Hi x bargaining level	12.586 (3.01) **	9.975 (5.64) **
Hi x bargaining level squared	-2.587 (-3.07) **	-2.098 (-5.91) **
Hi x openness	-10.292 (-0.87)	-12.130 (-1.18) **
Med (dummy for high concentration group)	229.073 (2.61)	212.384 (3.10)
Med x CBI	-80.443 (-1.83) *	-68.280 (-2.71) **
Med x CBI squared	29.394 (0.81)	18.259 (1.12)
Med x union density	85.725 (3.76) **	84.171 (8.08) **
Med x union density squared	-63.916 (-3.12) **	-64.105 (-6.72) **
Med x union coverage	-225.190 (-2.72) **	-211.645 (-3.44) **
Med x bargaining level	-0.422 (-0.07)	1.810 (1.28)
Med x bargaining level squared	0.254 (0.27)	-0.220 (-0.92)
Med x openness	-161.986 (-2.89) **	-154.300 (-3.18) **
Lo (dummy for high concentration group)	-89.257 (-4.33)	-75.053 (-5.64) **
Lo x CBI	535.599 (2.82) **	529.525 (4.52) **
Lo x CBI squared	-461.45 (-2.82) **	-435.614 (-4.26) **
Lo x union density	115.574 (7.14) **	98.278 (7.91) **
Lo x union density squared	-102.955 (-4.85) **	-74.678 (-5.39) **
Lo x union coverage	24.597 (6.26) **	23.974 (6.98) **
Lo x bargaining level	15.540 (2.43) **	9.099 (3.45) **
Lo x bargaining level squared	-2.797 (-2.65) **	-1.597 (-3.28) **
Lo x openness	-350.702 (-2.89) **	-372.853 (-5.31) **
n	300	300
Adjusted R^2	0.8730	0.8430

Notes: Figures in parentheses are *t* statistics. * denotes statistical significance at the 10% level. ** denotes statistical significance at the 5% level.

TABLE 9

Unemployment, CBI and wage bargaining structure in 15 OECD countries (1971-90), grouped by union concentration.

Dependent variable: Annual unemployment rate
Estimation methods: **OLS**, **GLS**

Variable	**Ordinary Least Squares**	**Autoregressive Model (Parks)**	**Variance Components Model (Fuller-Battase)**
Hi (dummy for high concentration group)	0.747 (0.14)	4.195 (0.68)	-7.760 (-0.34)
Hi x CBI	20.337 (0.84)	15.115 (0.61)	48.729 (0.50)
Hi x CBI squared	-27.449 (-0.99)	-24.754 (-0.92)	-61.577 (-0.57)
Hi x union density	45.126 (2.86) **	17.895 (1.97) *	57.969 (4.12) **
Hi x union density squared	-83.029 (-3.31) **	-40.949 (-3.41) **	-81.865 (-4.40) **
Hi x union coverage	5.693 (1.88) *	2.406 (1.44)	-0.703 (-0.11)
Hi x bargaining level	-5.107 (-1.96) *	-1.956 (-3.37) **	-3.680 (-2.13) **
Hi x bargaining level squared	0.942 (1.79) *	0.393 (3.46) **	0.681 (1.96) *
Med (dummy for high concentration group)	28.956 (2.34)	-13.433 (-1.65)	-9.358 (-0.46)
Med x CBI	12.463 (0.79)	63.942 (3.23) **	73.863 (1.84) *
Med x CBI squared	-10.410 (-0.53)	-67.940 (-3.27) **	-89.521 (-1.95) *
Med x union density	-11.838 (-1.22)	-10.722 (-1.29)	-41.528 (-4.22) **
Med x union density squared	14.390 (1.32)	0.545 (0.09)	19.787 (2.21) **
Med x union coverage	-23.877 (-2.24) **	13.001 (1.64)	32.539 (1.58)
Med x bargaining level	-4.833 (-1.33)	0.263 (0.56)	-4.701 (-2.00) **
Med x bargaining level squared	0.666 (1.12)	-0.068 (-0.83)	0.728 (1.90)*
Lo (dummy for high concentration group)	9.705 (1.77)	16.715 (5.75)	7.700 (1.00)
Lo x CBI	-17.152 (-0.97)	-37.031 (-8.01) **	21.675 (0.75)
Lo x CBI squared	14.151 (0.65)	31.441 (7.02) **	-35.726 (-1.34)
Lo x union density	-35.564 (-3.43) **	4.645 (0.77)	-35.877 (-3.83) **
Lo x union density squared	32.740 (2.72) **	-13.805)-1.86)	25.990 (2.15) **
Lo x union coverage	3.801 (2.52) **	6.918 (5.86) **	5.831 (1.34)
Lo x bargaining level	-0.522 (-0.13)	-7.072 (-4.32) **	-1.436 (-0.53)
Lo x bargaining level squared	0.740 (1.09)	1.387 (4.79) **	0.398 (0.90)
N	300	300	300
Adjusted R^2	0.8920	0.8076	0.4106
Hausman test statistic	------	------	10.67 (*p*-value = 0.0992)

Notes: Figures in parentheses are *t* statistics. * denotes statistical significance at the 10% level. ** denotes statistical significance at the 5% level.

TABLE 10

Inflation, CBI and wage bargaining structure in 15 OECD countries, 1971-90. Countries grouped according to their CBI index.

Dependent variable: annual inflation (%)
Estimation method: **GLS**

Explanatory variables	**Autogregressive Model (Parks)**		**Variance Components Model (Fuller-Battase)**	
	High CBI Countries	**Low CBI Countries**	**High CBI Countries**	**Low CBI Countries**
Intercept	33.220 (1.38)	-162.201 (-2.86)	53.516 (1.06)	-211.503 (-5.42)
Central bank independence	-44.902 (-0.51)	1444.164 ** (2.85)	-150.684 (-0.84)	18456.686 ** (5.34)
CBI squared	31.756 (0.39)	-3259.24 ** (-2.97)	131.129 (0.85)	-4044.99 ** (-5.33)
Union density	49.826 ** (4.42)	45.586 ** (2.28)	27.264 * (1.81)	19.039 * (1.76)
Union density squared	-44.259 ** (-3.47)	-16.754 (-0.87)	-22.244 (-1.37)	2.495 (0.22)
Union coverage	2.745 (0.67)	4.095 (0.54)	0.222 (0.03)	-5.938 (-0.95)
Union concentration	-40.025 ** (-4.08)	-14.730 (-1.02)	-38.961 ** (-2.62)	-2.474 (-0.13)
Union concentration squared	24.360 ** (3.68)	15.146 (1.42)	34.294 ** (2.98)	3.777 (0.29)
Bargaining level	-6.431 ** (-4.43)	4.374 ** (2.43)	-5.558 ** (-2.50)	5.245 ** (2.18)
Bargaining level squared	1.152 ** (4.33)	-0.785 ** (-2.29)	1.025 ** (2.53)	-0.883 ** (-2.08)
Openness	-11.917 ** (-2.57)	-17.837 (-0.80)	8.454 (0.65)	14.154 (0.82)
n	140	140	140	140
Adjusted R^2	0.4167	0.3510	0.1473	0.4879
Hausman Test Statistic	------	------	49.97 (*p*-value <0.0001)	11.12 (*p*-value = 0.3479)

Notes: Figures in parentheses are *t* statistics. ** indicates statistical significance at the 5% level. * indicates statistical significance at the 10% level.

TABLE 11

Unemployment, CBI and wage bargaining structure in 15 OECD countries, 1971-90. Countries grouped according to their CBI index.

Dependent variable: annual unemployment rate
Estimation method: **GLS**

Explanatory variables	**Autogregressive Model (Parks)**	
	High CBI Countries	**Low CBI Countries**
Intercept	197.773 (5.31)	-1.659 (-0.57)
Central bank independence	-1.172 (-0.64)	262.296 ** (6.80)
Union density	-13.983 (-1.28)	-39.117 ** (-7.82)
Union density squared	3.670 (0.27)	21.286 ** (5.35)
Union coverage	-168.56 ** (-3.06)	65.405 ** (7.01)
Union concentration	51.144 ** (7.01)	-8.209 ** (-2.01)
Union concentration squared	-49.833 ** (-8.43)	2.638 (0.87)
Bargaining level	2.113 ** (2.71)	-0.763 (-1.67)
Bargaining level squared	-0.420 ** (-2.87)	0.128 (1.50)
Total tax wedge	-3.429 ** (-4.45)	-2.034 ** (-6.65)
Employment protection	2.910 ** (2.44)	1.426 ** (5.55)
Benefit replacement rate	-0.395 ** (-3.24)	0.343 ** (4.97)
Benefit duration	78.889 ** (4.40)	-5.665 ** (-5.44)
Active labour market programs	-8.810 ** (-4.47)	------
n	140	140
Adjusted R^2	0.7510	0.6743

Notes: Figures in parentheses are *t* statistics. ** indicates statistical significance at the 5% level. * indicates statistical significance at the 10% level.

TABLE 12

Deviation of Actual Inflation from Predicted Inflation, central bank independence, and wage-bargaining structure in 9 OECD countries, 1974-1976.

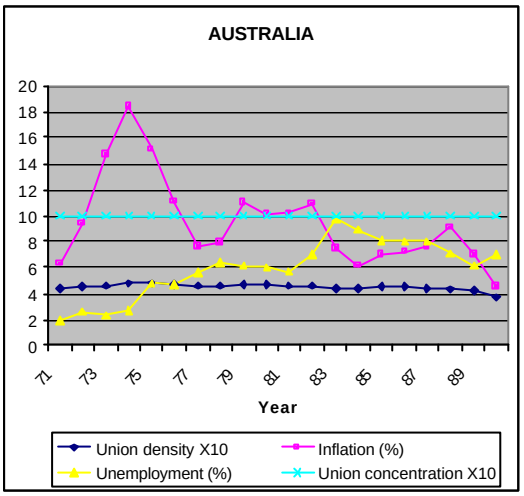
Dependent variable: deviation of actual inflation from value predicted by FAIRMODEL (%)
Estimation method: **OLS**

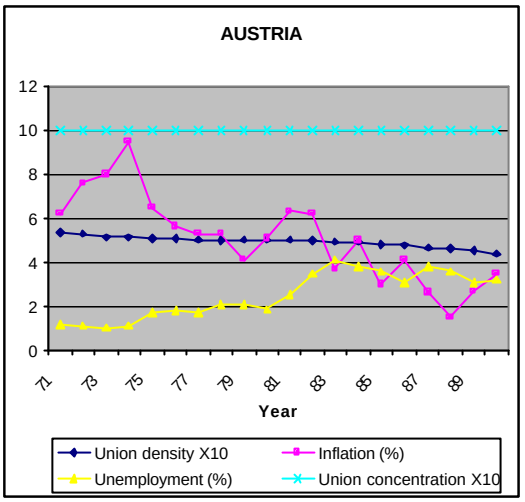
Year *Independent variables*	**1974**	**1975**	**1976**
Intercept	1.06 (0.26)	-6.03 (-1.27)	1.98 (0.78)
Central bank independence (1973)	-7.87 ** (-4.28)	-0.42 (-0.20)	-0.82 (-0.42)
Union density (1973)	22.18 (1.40)	39.62 ** (2.15)	0.21 (0.02)
Union density squared	-21.55 (-1.58)	-28.90 * (-1.83)	3.41 (0.28)
Union concentration (1973)	-0.79 (-0.41)	-5.77 ** (-2.58)	-2.30 (-0.98)

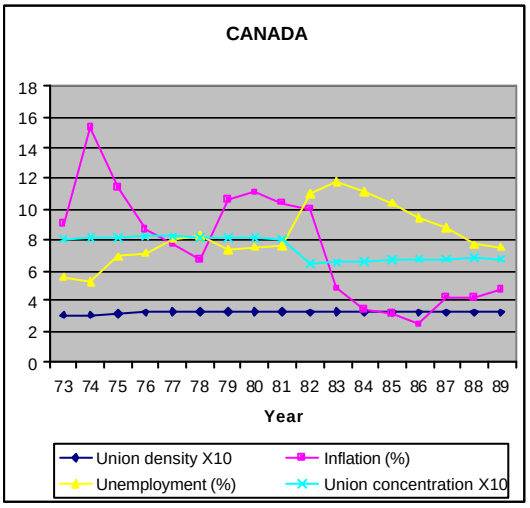
Notes: Figures in parentheses are *t*-statistics. * indicates statistical significance at the 10% level. ** indicates statistical significance at the 5% level.

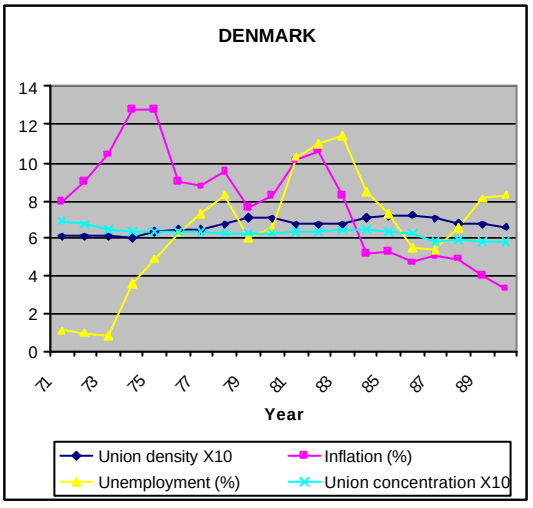
FIG. 1

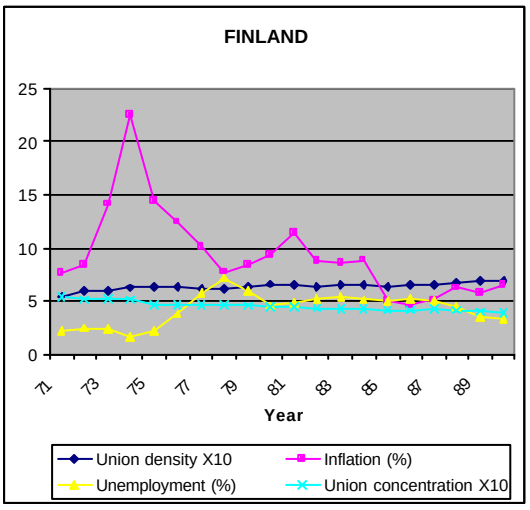
Inflation, unemployment, union density and union concentration plots, 15 OECD countries (1971-90)

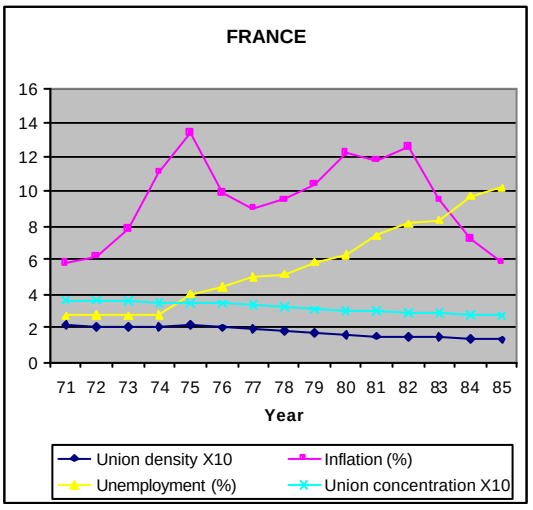


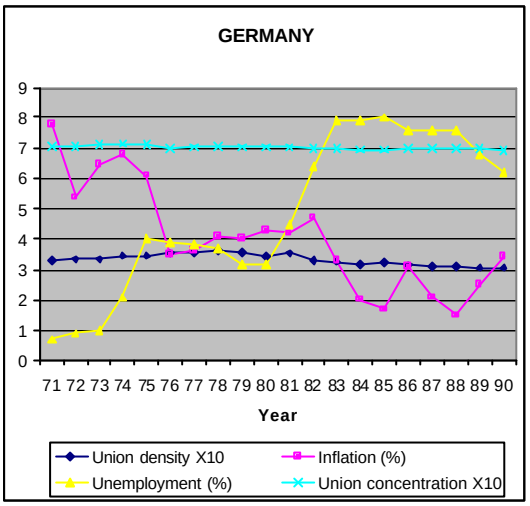


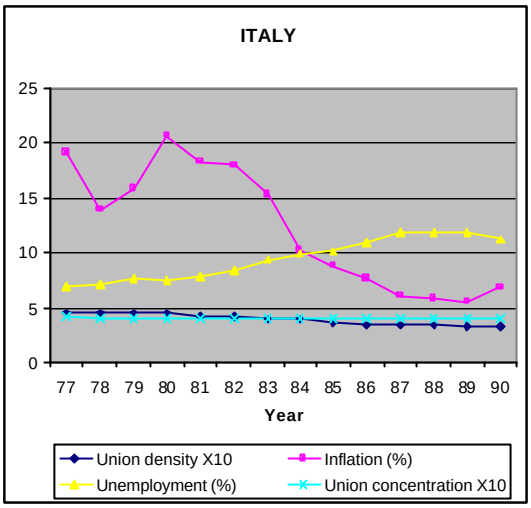


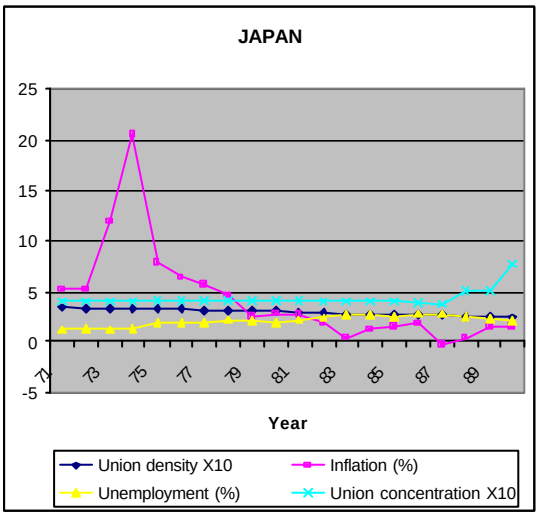


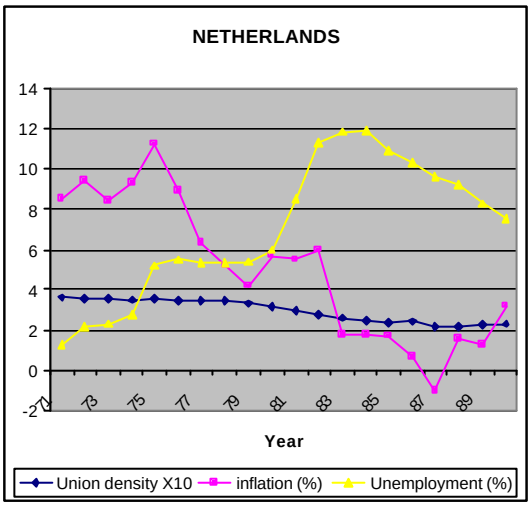


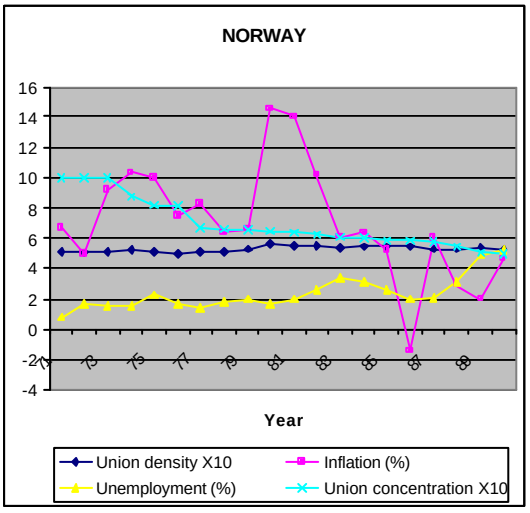


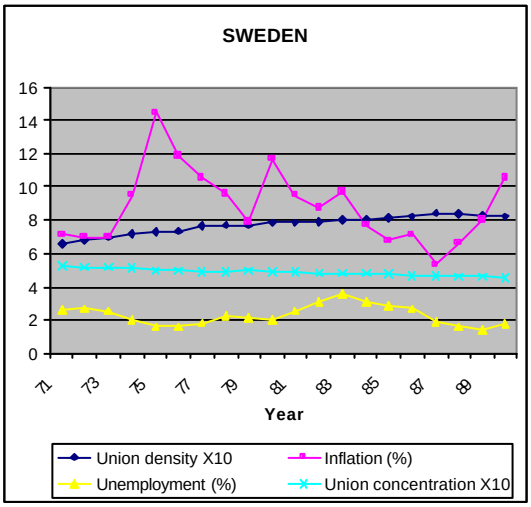

GERMANY
9
8
7
6
5
4
3
2
1
0
71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90
Year
Union density X10
Inflation (%)
Unemployment (%)
Union concentration X10

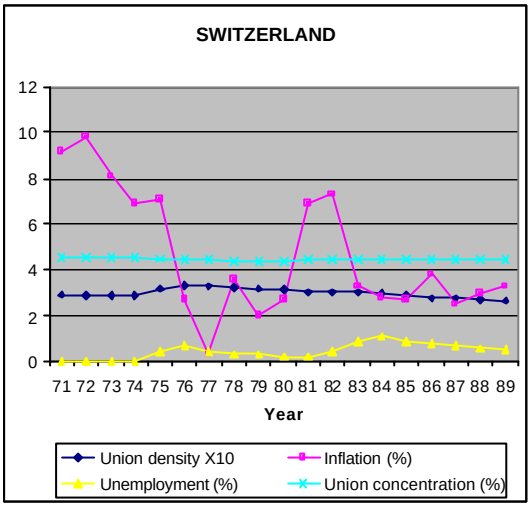

ITALY
25
20
15
10
5
0
77 78 79 80 81 82 83 84 85 86 87 88 89 90
Year
Union density X10
Inflation (%)
Unemployment (%)
Union concentration X10

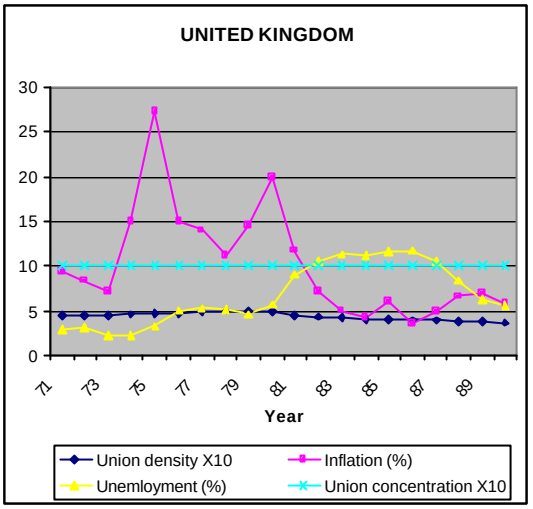

JAPAN
25
20
15
10
5
0
-5
Year
Union density X10
Inflation (%)
Unemployment (%)
Union concentration X10


NETHERLANDS
14
12
10
8
6
4
2
0
-2
Year
Union density X10
inflation (%)
Unemployment (%)


NORWAY
16
14
12
10
8
6
4
2
0
-2
-4
Year
Union density X10
Inflation (%)
Unemployment (%)
Union concentration X10


SWEDEN
16
14
12
10
8
6
4
2
0
Year
Union density X10
Inflation (%)
Unemployment (%)
Union concentration X10


SWITZERLAND
12
10
8
6
4
2
0
71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89
Year
Union density X10
Inflation (%)
Unemployment (%)
Union concentration (%)


UNITED KINGDOM
30
25
20
15
10
5
0
71 73 75 77 79 81 83 85 87 89
Year
Union density X10
Inflation (%)
Unemloyment (%)
Union concentration X10

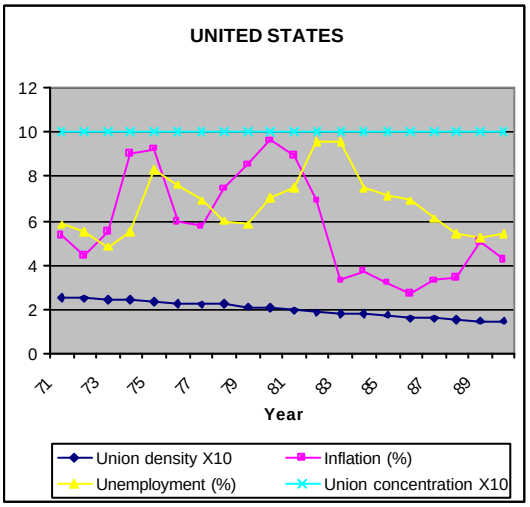
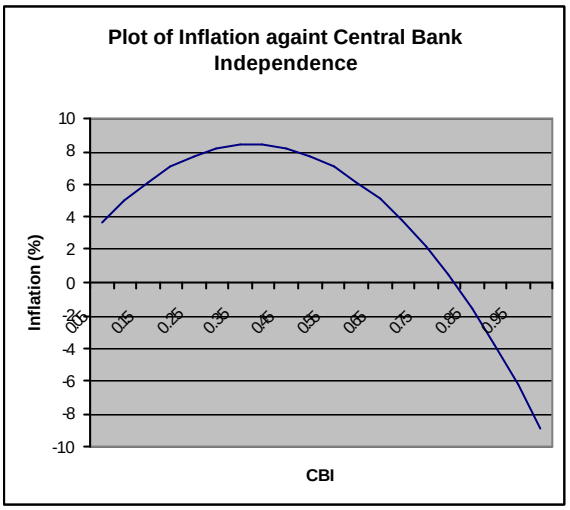
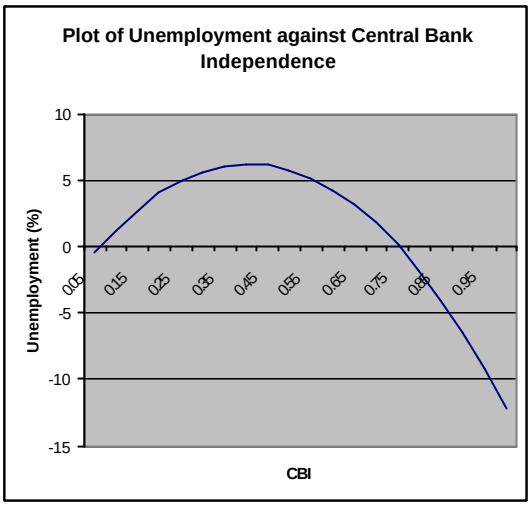
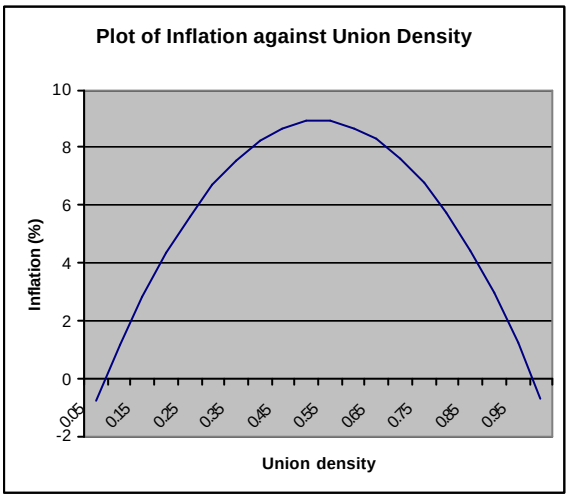

UNITED STATES
12
10
8
6
4
2
0
71 73 75 77 79 81 83 85 87 89
Year
Union density X10
Inflation (%)
Unemployment (%)
Union concentration X10

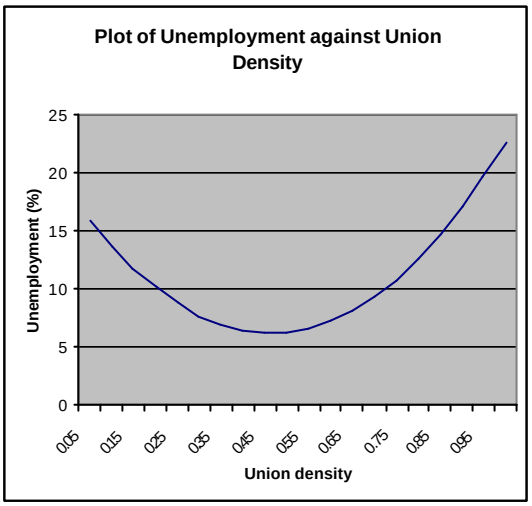
FIG. 2

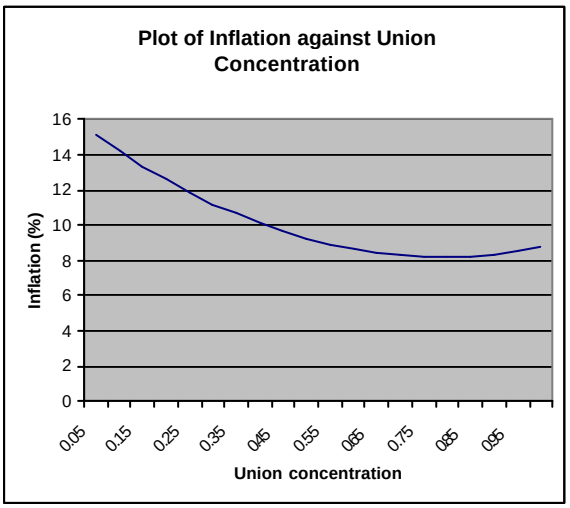
Plot of Inflation and Unemployment against CBI, Union Density and Union Concentration











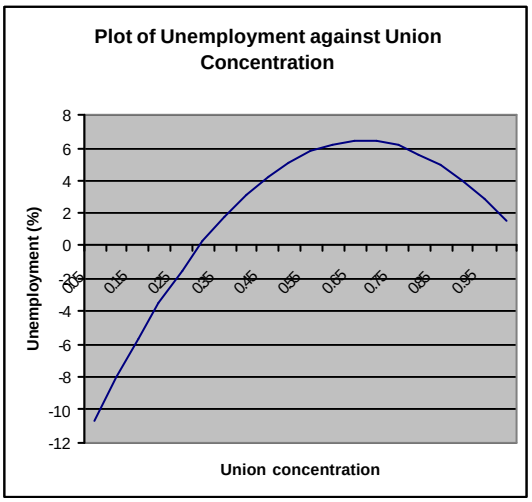
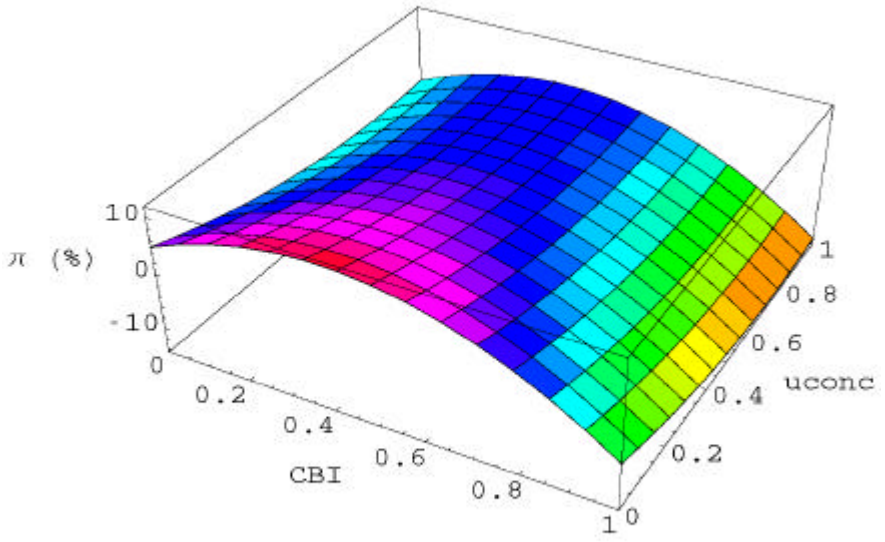


FIG. 3

3-D Plots of Inflation and Unemployment against CBI and Union Concentration.



Above: Inflation 3-D Plot (Full Sample) || **Below**: Unemployment 3-D Plot (Full-Sample)

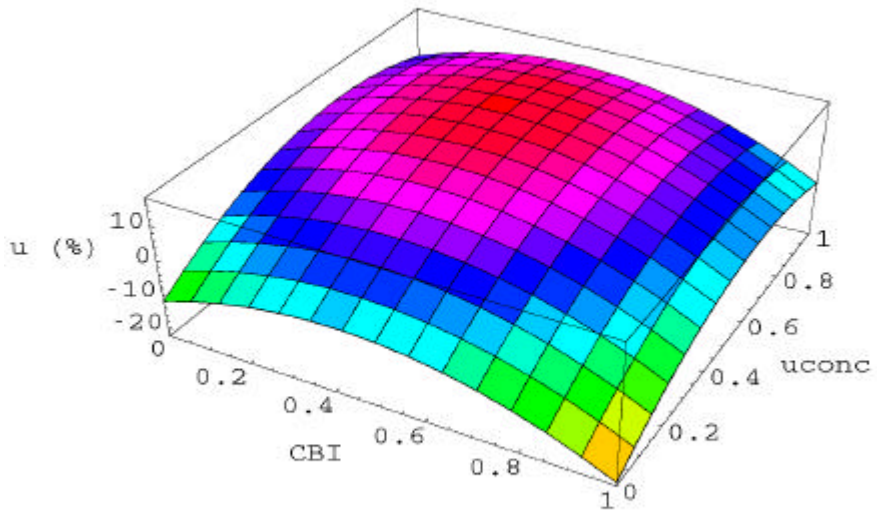
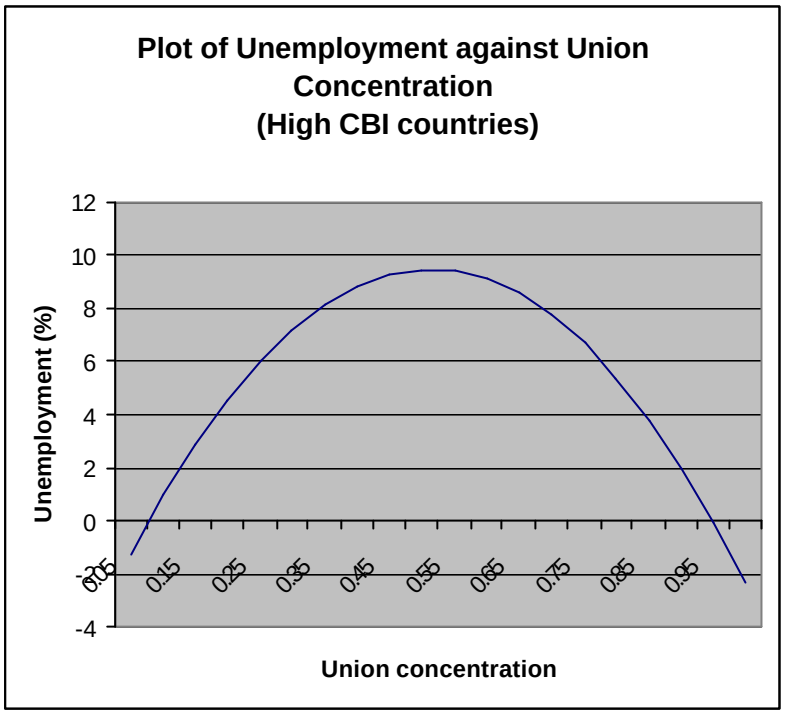
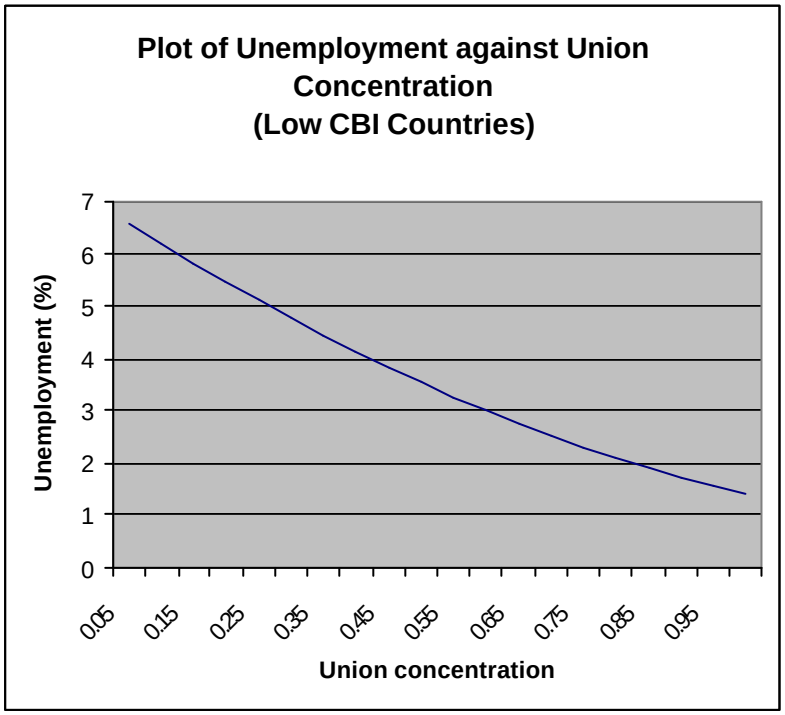


FIG. 4

Plot of Unemployment against Union Concentration for High-CBI and Low-CBI Countries.





Appendix A

Wage Bargaining Systems in Selected OECD Countries (up to 1990)[17]

Australia
Union Confederations: Australian Council of Trade Unions (ACTU), Australian Council of Salaried and Professional Associations (ACSPA), Council of Australian Government Employee Associations (CAGEO), Australian Federation of Police Associations and Unions (AFPU), Australian Public Service Federation (APSF), Australian Teachers' Federation (ATF), Council of Professional Associations (CPA)
Coverage: High.
Bargaining System: National Industrial Relations Commission set general principles for pay increases. Industry-level bargains either followed these principles or had to be endorsed by the Commission. All such bargains related to minimum rates. However, firm-level bargains could agree on 'over-award' pay increases.
Coordination: Employers' federation generally weaker than union federation.

Austria
Union Confederations: Austrian Confederation of Trade Unions, 1945- .
Coverage[18]: High.
Bargaining System: Industry-level agreements, which depended on approval by the union confederation.
Coordination: Strong guidance from tripartite Party Commission and its bipartite Subcommittee on Wages and Prices.
Incomes Policy: None.

Canada
Union Conferderations: Canadian Labour Congress (CLC), American Federation of Labour-Congress of Industrial Unions (AFL-CIO), Confederation of National Trade Unions (CNTU), Centre of Democratic Trade Unions (CSD), Canadian Federation of Labour (CFL), Confederation of Canadian Unions.
Coverage: Medium.
Bargaining System: More public sector bargaining than in the USA.
Co-ordination: Nil.
Incomes policy: Wage controls (1975-77).

Denmark
See Scandinavian countries.

France
Union Confederations: Reformist Federation of Labour (FO), 1948- ; French Federation of Christian Workers (CFTC), 1919- ; Democratic Federation of French Labour (CFDT), 1964- , General Federation of Staff Employee Unions (CGC), 1944- ; National Federation of Unions in Education (FEN), 1948- .
Coverage: High.

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[17] This section is taken from Layard et al. (1991), pp.517-524. List of union confederations from Visser (1989).
[18] This refers to the fraction of the labor force covered by collective wage bargains.

Bargaining System: Industry-level bargains applying by law to all workers in the sector. Most pay above this determined at employer's discretion.
Coordination: Employers' confederation had some influence. Unions divided between four federations..
Incomes Policy: (Implemented in June 1982.) Wage and price freeze for three months followed by strict public-sector pay limits, generally followed by private sector at least as regards minimum rates in each grade (as a result of informal agreements with employers' organization).

Finland
See Scandinavian Countries.

Germany
Union Confederations: German Confederation of Trade Unions (DGB), 1949- ; German Union of White-Collar Employees (DAG), 1945- ; Christian Union Confederation (CGB), 1959- ; German Civil Servants Federation (DBB), 1949- .
Coverage: High.
Bargaining System: Industry-level bargains in each region, frequently extended by law to all workers in the sector. Firm-level bargains supplemented these but strikes at this level illegal.
Coordination: Informal talks within and between national employers' organization and trade unions federation. This led to a pattern settlement generally in the metal industry in one region, broadly followed elsewhere. National industry-level union had to authorize any strike. Council of Economic Experts and the five research institutes helped to create climate of opinion in favor of wage moderation.
Incomes Policy: (1966-77) "Concerted Action'. Tripartite guidance on wage limits. Unions withdrew over 'co-determination'. Indexation illegal.

Italy
Union Confederations: General Confederation of Italian Labour (CGIL), 1944- ; Italian Confederation of Labour Unions (CISL), 1950- ; Italian Confederation of Labour (UIL), 1950- .
Coverage: High.
Bargaining System: Industry-level bargains applying by law to all workers in the sector. Firm-level bargains supplemented these.
Coordination: Some employer coordination, especially regionally. Strike insurance by employers. Union confederations had variable control over their members (more in 1980s).
Incomes Policy:
1976-78: 'Historic compromise' establishing full indexation in return for presumption of low settlements and reasonable strike behavior.
1983: Agreement to alter calculation of *COL*.
1984: Government proposal for reduction of permitted degree of indexation in the 'scala mobile'. Rejected by CGIL, union federation. Confirmed by plebiscite on 9 June 1985.

Japan
Union Confederations: General Council of Trade Unions of Japan, National Federation of Industrial Organization, Federation of Independent Unions of Japan, Japanese Confederation of Labour, Japanese Trade Union Confederation, Japanese Confederation of Trade Unions, National Trade Union Council, Japan Trade Union Confederation.
Coverage: Medium (high in large firms, low in small firms).
Bargaining System: Firm-level bargains, synchronized in *Shunto* (Spring offensive).
Coordination: Strong employer coordination, especially after the great inflation of 1974. Weaker union coordination.
Incomes Policy: Nil.

Netherlands
Union Confederations: Dutch Confederation of Trade Unions (NVV), 1905-81 (merger with NKV to form FNV); Dutch Catholic Trade Union Confederation (NKV), 1909-81 (merger with NVV to form FNV); Confederation of Dutch Trade Unions (FNV), 1981- ; Center for Higher Civil Servants (CHMA), 1917- ; Dutch Federation of Staff Associations (NCHP), 1966- ; Federation of White-Collar Employee Organizations (MHP), 1974- ; Employee Organization (CRP), 1916- , Civil Servant's Center (AC), 1946- .
Coverage: High.
Bargaining System: Industry-level bargains applying by law to all workers in the sector. Firm-level bargains supplemented these, but at this stage strikes are outlawed.
Coordination: Three federations of employers and three of unions. Since 1982, the Foundation of Labour, a joint employer-union organization, proposes a general framework for pay.
Incomes Policy: Tripartite incomes policy broke down in 1963. Frequent short wage freezes between 1971-82.

Scandinavia

Union Confederations:
Denmark: Danish Confederation of Trade Unions (LO), 1898- ; Joint Council of Public Servants and Salaried Employees Associations (FTF), 1952- ; Federation of Supervisory and Technical Staff Associations (FR), 1953- ; Association of Unions of Lower Grade Public Servants (CO-1), 1953- ; Central Organization of Professional Employees (AC), 1972- .
Finland: Central Organization of Finnish Trade Unions (SAK), Confederation off Salaried Employees (TVK), Confederation of Technical Employees (STTK), Central Organization of Professional Workers (AKAVA), Finnish Trade Union Federation (SAJ), 1960-69
Norway: Confederation of Trade Unions (LO), 1899- ; Federation of Civil Servants (EL), 1918-74 (joined AF per 1-1-1975); Federation of Professional Associations (AF), 1974- ; Federation of State Employees (ST), 1923-76 (joined YS per 1-1-1977); Federation of Public Employee Unions (YH), 1965-76 (joined YH per 1-1-1977); Confederation of Occupational Unions (YS), 1976- .
Sweden: Swedish Confederation of Trade Unions (LO), 1898- ; Central Organization of Swedish Workers (SAC), 1909- ; Central Organization of Salaried and Government Employees (TCO), 1944- ; National Federation of Civil Servants (SR), 1917-73 (merged with TCO to form SACO-SR); The Swedish Confederation of Professional Associations (SACO), 1947-74 (merged with SR to form SACO-SR), The Swedish Confederation of Professional Associations (SACO-SR), 1974- .
Coverage: High.
Bargaining System: National bargain between trade union federation and employers' federation: one bargain in Denmark, three in Finland, Norway, and Sweden. Industry-level and firm-level bargains supplemented these, but strikes were not allowed at firm level (because of peace agreements at higher level). National unions had to agree to local claims. LO, national union federation, controls strike fund nationally in Sweden.
Coordination: Strong employers' and union federations, e.g. powerful coordination after 1982 Swedish devaluation.
Mediation: In Denmark and Norway this was compulsory, and there was sometimes binding arbitration.
Incomes Policies:
Denmark: Frequent legislative intervention setting ceiling on wage growth: 1982: wage freeze; 1983: indexation suspended; 1985-87: legal wage norms.
Finland: Comprehensive tripartite incomes policy from 1968. Wage indexation opposed.
Norway: Frequent social contracts mainly in the 1970s. Firm-level wage bargaining prohibited in 1978-79 and 1988.

Sweden: Minimal direct intervention, though occasional guidelines.

Switzerland
Union Confederations: Confederation of Swiss Trade Unions (SGB), 1880- ; Christian-National Confederation of Swiss Trade Union (CNG), 1907- ; Swiss Federation of Protestant Workers (SVEA), 1920-82 (affiliated to CNG in 1982); Liberal Federation of Swiss Workers (LFSA), 1919- ; Central Organization of Swiss White-Collar Employee Unions (VSA), 1918- .
Coverage: Medium.
Bargaining System: Mainly firm-level. Mainly subject to industry-wide five- to six-year peace agreements ruling out use of strikes. Multi-year settlements. Cost-of-living agreements negotiated at the industry level.
Coordination: Strong employer coordination. Unions weak.
Arbitration: Important.

UK
Union Confederations: Trade Union Congress (TUC), 1868- .
Coverage: High (after including workers covered by statutory Wages Councils).
Bargaining System: Some industry-level bargains. Majority of private-sector workers covered by firm-level bargains (sometimes building on industry-level bargains).
Coordination: Virtually none among employers. Ditto among unions.
Incomes Policy:
1972-74: Wage freeze (for six months); 4 per cent (for six months); 5 per cent plus extra if inflation exceeded 7 per cent (which it did). Statutory.
1975-79: 6 pounds a week (1st year); 5 per cent (2nd year); 10 per cent (3rd year); 5 per cent (4th year). Supported by TUC in first two years.

USA
Union Confederations: American Federation of Labour-Congress of Industrial Unions (AFL-CIO), American Federation of Labour (AFL), Congress of Industrial Unions (CIO), Assembly of Government Employees (AGE), National Federation of Independent Unions (NFIU), American Associationof Classified School Employees (AACSE).
Coverage: Low.
Bargaining System: Firm level.
Coordination: Nil, though some pattern within industries.
Incomes Policy:
1971: 90-day wage freeze, and controls lasting to 1974.
1978-9: Commission on Wage and Price Stability promotes pay and price standards (essentially voluntary).

Appendix B

Economic performance and the structure of collective bargaining (some recent findings)

Reproduced from OECD (1997).

Study	Performance measure	Number of countries	Years	Findings	Support for U/hump-shape hypothesis
Bean (1994)	Unemployment	20	1956-1992	Linear relationship with coordination.	No
Bleaney (1996)	Unemployment and inflation	17	1973-1989	Negative linear relationship between corporatism and unemployment; some evidence of a hump-shaped relation with centralisation in later years.	Mixed
Dowrick (1993)	Productivity growth	18	1960s-1980s	U-shaped conclusion that intermediate economies grow more slowly.	Yes
Freeman (1988)	Employment, unemployment and wage growth	19	1984, 1979-1984/85	U-shaped relationship between dispersion of wages, as a proxy measure of corporatism, and employment; hump-shaped relationship with unemployment and wage growth.	Yes
Golden (1993)	Unemployment, employment, Okun index and API[a]	17	1974-1984	Mixed results.	Mixed
Grier (1997)	Real GNP growth	24	1951-1988	Negative relationship with decentralised economies growing the fastest.	No
Heitger (1987)	Productivity growth	18	1960s-1970s	U-shaped view that intermediate economies grow more slowly.	Yes
Jackman (1993)	Unemployment	20	1983-1988	Linear relationship.	No
Jackman *et al.* (1996)	Unemployment	20	1983-1994	Linear relationship.	No
McCallum (1986)	Okun index[a] and real wage rigidity	18	1974-1984	Linear relationship between corporatism and performance.	No
OECD (1988)	Unemployment and inflation	17	1971-1986	Hump-shaped relationship for unemployment.	Yes
Rowthorn (1992*b*)	Employment and unemployment	17	1973-1985	U-shaped and hump-shaped relationships, respectively, but only in the 1980s.	Yes
Scarpetta (1996)	Unemployment	15 to 17	1970-1993	Negative relationship between unemployment and co-ordination; Some evidence of U-shaped relationship between unemployment and centralisation.	Mixed
Soskice (1990)	Unemployment and API[a]	11	1985-1989	Positive relationship between co-ordination and performance.	No
Traxler *et al.* (1996)	Unemployment, employment, Okun index and API[a]	16	1974-1985	Negative relationship between co-ordination and unemployment; U-shaped relationship between co-ordination and employment; mixed results for the Okun index and API.	Mixed

a) The Okun index is the sum of the unemployment and inflation rates; the Alternative Performance Index (API) is the sum of the unemployment rate and the current account deficit as a percentage of GDP.

Appendix C

Table C1: Effect of CBI and union variables on inflation (*p*) in various models

Sample	**Theoretical Models**		**Empirical Work**		
	Cukierman And Lippi (1999)	**Velasco and Guzzo (1999)**	**Chou (2000)**	**Cukierman and Lippi (1999)**	**Bleaney (1996)**
Full	Negative correlation between CBI and π. Hump-shaped or positive relation between π and centralization depending on unions' inflation aversion.	Hump-shaped relation between CBI and π. Negative relation between π and centralization (low elasticity of substitution of labour); U-shaped relation (high substitution elasticity).	Hump-shaped relation between CBI and π. Slightly U-shaped or negative relationship between π and union concentration. Similarly for wage bargainng level. Hump-shaped relationship between π and union density.	Negative correlation between CBI and π in 2 of 3 cases (but only statistically significant in 1 case). Hump-shaped relation between π and centralization.	Negative correlation between CBI and π. No significant relationship between centralization / corporatism and π.
High CBI	Possibly positive relation between π and centralization.		Negative relation between π and union concentration.	No relationship between π and centralization.	
Low CBI	Hump-shaped relation between π and centralization.		U-shaped relation between π and union concentration.	Hump-shaped relation between π and centralization.	
High centralization/ union concentration	Effect of centralization on inflation is strongest at intermediate levels of centralization.		Slightly-humped (mostly) negative relation between π and CBI.	Positive relationship between π and CBI.	
Medium centralization/ union concentration			Negative relationship between π and CBI.	Strong negative relationship between π and CBI.	
Low centralization/ union concentration			Pronounced hump-shaped relationship between π and CBI.	Milder negative relationship between π and CBI.	

Table C2: Effect of CBI and union variables on unemployment (*u*) in various models

Sample	**Theoretical Models**		**Empirical Work**		
	Cukierman and Lippi (1998)	**Velasco and Guzzo (1998)**	**Chou (1999)**	**Cukierman and Lippi (1998)**	**Bleaney (1996)**
Full	Negative relationship between CBI and *u*. Hump-shaped or positive relation between *u* and centralization depending on unions' inflation aversion.	Negative relationship between CBI and *u*. Negative relation between *u* and centralization (low elasticity of substitution of labour); U-shaped relation (high substitution elasticity).	Hump-shaped relationship between CBI and *u*. Hump-shaped relation between *u* and union concentration. U-shaped relation between *u* and union density. Negative relation between *u* and bargaining level.	Positive relation between CBI and *u* (in 1 out of 3 cases), negative but statistically insignificant in other cases. Hump-shaped relation between *u* and centralization.	No significant relationship between CBI and *u*. Negative relationship between corporatism and *u*.
High CBI	Hump-shaped relation between *u* and centralization (peaking to the right).		Hump-shaped relation between *u* and centralization.	Negative relation between *u* and centralization.	
Low CBI	Hump-shaped relation between *u* and centralization (peaking to the left)..		Negative relation between *u* and centralization.	Hump-shaped relation between *u* and centralization.	
High centralization/ union concentration	Effect of centralization on *u* is stronger at high levels of centralization.		Relationship between *u* and CBI is statistically insignificant.	Positive relationship between *u* and CBI.	
Medium centralization/ union concentration			Hump-shaped relation between *u* and CBI.	Negative relationship between *u* and CBI.	
Low centralization/ union concentration			U-shaped relationship between *u* and CBI.	Negative relationship between *u* and CBI.	

Appendix D

Feasible GLS Procedures

Fuller-Battese Method (Variance Components Model)

In the Fuller-Battese implementation, we assume that the error term has the decomposition

$$u_{it} = n_i + e_t + e_{it}$$
$$i = 1, 2, \ldots, \mathrm{N}; \quad t = 1, 2, \ldots, \mathrm{T}$$

The errors, ν_i, e_t, and e_{it} are independently distributed with zero means and positive variances s_n^2, s_e^2, and s_e^2. The linear model with this error structure is written in matrix notation as

$$\mathbf{y} = \mathbf{X}b + \mathbf{u}$$

where

$$\mathrm{y} = (y_{11}, y_{12}, \ldots, y_{1T}, \ldots, y_{N1}, \ldots, y_{NT})'$$
$$\mathrm{X} = (\mathrm{x}_{11}, \mathrm{x}_{12}, \ldots, \mathrm{x}_{1T}, \ldots, \mathrm{x}_{N1}, \ldots, \mathrm{x}_{NT})'$$

$\mathbf{x}_{it}$ are p x 1 vectors of independent variables

b is a p x 1 parameter vector

$$\mathrm{u} = (u_{11}, u_{12}, \ldots, u_{1T}, \ldots, u_{N1}, \ldots, u_{NT})'$$

The covariance matrix for the vector of random errors **u** can be expressed

$$\mathrm{V} = \mathrm{E}(\mathrm{uu}') = s_e^2 \mathrm{I}_{NT} + s_n^2 \mathrm{A} + s_e^2 \mathrm{B}$$
$$\mathrm{A} = \mathrm{I}_N \otimes \mathrm{J}_T$$
$$\mathrm{B} = \mathrm{J}_N \otimes \mathrm{I}_T$$

where I_{NT}, I_N, and I_T are identity matrices of order NT, N, and T; and J_N and J_T are N x N and T x T matrices with all elements equal to one. The following square matrices are defined:

$$\mathrm{M}.. = \mathrm{J}_{NT} / NT$$
$$\mathrm{M}_{1.} = \mathrm{A} / T - \mathrm{M}..$$
$$\mathrm{M}_{.2} = \mathrm{B} / N - \mathrm{M}..$$
$$\mathrm{M}_{12} = \mathrm{I}_{NT} - \mathrm{A} / T - \mathrm{B} / N + \mathrm{M}..$$

where J_{NT} is a NT x NT matrix with all elements equal to 1.

The estimators for variance components are obtained by the fitting-of-constants method (Searle 1971) with the provision that any negative variance components is set to 0 for parameter estimation purposes.

First, the least-squares residual vectors are defined as

$$\hat{e} = C_1(I_{NT} - X[X'C_1X]^{-}X'C_1)y$$
$$\hat{v} = C_2(I_{NT} - X[X'C_2X]^{-}X'C_2)y$$
$$\hat{e} = C_3(I_{NT} - X[X'C_3X]^{-}X'C_3)y$$

where A^{-} denotes the generalized inverse of A, $C_1 = M_{12}$, $C_2 = M_{12} + M_{1.}$, and $C_2 = M_{12} + M_{.2}$.
Then unbiased estimators for variance components are computed using the following formula:

$$\hat{s}_e^2 = \frac{\hat{e}'\hat{e}}{(N-1)(T-1) - \text{rank}(X'M_{12}X)}$$
$$\hat{s}_n^2 = \frac{\hat{v}'\hat{v} - [T(N-1) - \text{rank}(X'M_{.2}X)]\hat{s}_e^2}{T(N-1) - T \cdot \text{trace}([X'C_2X]^{-}X'M_{1.}X)}$$
$$\hat{s}_e^2 = \frac{\hat{e}'\hat{e} - [N(T-1) - \text{rank}(X'M_{1.}X)]\hat{s}_e^2}{N(T-1) - N \cdot \text{trace}([X'C_3X]^{-}X'M_{.2}X)}$$

The generalized leasts-squares estimation takes the following steps:

1. Obtain the constants using the following estimators for variance components.

$$\hat{a}_1 = 1 - \left[\hat{s}_e^2 / (\hat{s}_e^2 + T\hat{s}_n^2)\right]^{\frac{1}{2}}$$
$$\hat{a}_2 = 1 - \left[\hat{s}_e^2 / (\hat{s}_e^2 + N\hat{s}_e^2)\right]^{\frac{1}{2}}$$
$$\hat{a}_3 = \hat{a}_1 + \hat{a}_2 - 1 + \left[\hat{s}_e^2 / (\hat{s}_e^2 + T\hat{s}_n^2 + N\hat{s}_e^2)\right]^{\frac{1}{2}}$$

2. Transform the variables using constants $\hat{a}_1, \hat{a}_2,$ and $\hat{a}_3,$ as follows:

$$y_{it}^{*} = y_{it} - \hat{a}_1 y_{i.} - \hat{a}_2 y_{.t} + \hat{a}_3 y_{..}$$
$$x_{it}^{*} = x_{it} - \hat{a}_1 x_{i.} - \hat{a}_2 x_{.t} + \hat{a}_3 x_{..}$$

where $y_{..}, y_{i.},$ and $y_{.t}$ are defined the same way as $x_{..}, x_{i.},$ and $x_{.t}$.

3. Regress y_{it}^{*} on x_{it}^{*} using OLS.

The estimated generalized least-squares (EGLS) estimator $\hat{b}_F$ and its standard error can be obtained from the OLS estimator in step 3. The EGLS estimator can be represented in matrix notation as

$$b_F = (X'\hat{V}^{-1}X)^{-1}X'\hat{V}^{-1}y$$

where

$$\hat{V}^{-1} = \frac{M_{12}}{\hat{s}_e^2} + \frac{M_{1.}}{(s_e^2 + Ts_n^2)} + \frac{M_{2.}}{(s_e^2 + Ns_e^2)} + \frac{M_{..}}{(s_e^2 + Ts_n^2 + Ns_e^2)}$$

Parks Method (Autoregressive Model)

In the Parks method, we consider a first-order autoregressive model in which the random errors $u_{it,}$ $i = 1, 2, \ldots, N,$ $t = 1, 2, \ldots, T,$ have the structure

$$\begin{aligned} &\mathrm{E}(u_{it}^2) = s_{ii} && \text{(heteroscedasticity)} \\ &\mathrm{E}(u_{it}u_{jt}) = s_{ij} && \text{(contemporaneously correlated)} \\ &u_{it} = r_i u_{i,t-1} + e_{it} && \text{(autoregression)} \end{aligned}$$

where

$$\begin{aligned} &\mathrm{E}(e_{it}) = 0 \\ &\mathrm{E}(u_{i,t-1}, e_{jt}) = 0 \\ &\mathrm{E}(e_{it}e_{jt}) = f_{ij} \\ &\mathrm{E}(e_{it}e_{js}) = 0 \qquad (s \neq t) \\ &\mathrm{E}(u_{i0}) = 0 \\ &\mathrm{E}(u_{i0}u_{j0}) = s_{ij} = f_{ij} / (1 - r_i r_j) \end{aligned}$$

The model assumed is first-order autoregressive with contemporaneous correlation between cross sections. We allow for contemporaneous correlation in the error term across countries since it is conceivable that each central bank reacts to the policies and actions of the other central banks.
In this model, the covariance matrix for the vector of random errors **u** can be expressed

$$\mathrm{E}(uu') = \mathrm{V} = \begin{bmatrix} s_{11}\mathrm{P}_{11} & s_{12}\mathrm{P}_{12} & \cdots & s_{1N}\mathrm{P}_{1N} \\ s_{21}\mathrm{P}_{21} & s_{22}\mathrm{P}_{22} & \cdots & s_{2N}\mathrm{P}_{2N} \\ \vdots & \vdots & \vdots & \vdots \\ s_{N1}\mathrm{P}_{N1} & s_{N2}\mathrm{P}_{N2} & \cdots & s_{NN}\mathrm{P}_{NN} \end{bmatrix}$$

where

$$\mathrm{P}_{ij} = \begin{bmatrix} 1 & r_j & r_j^2 & \cdots & r_j^{T-1} \\ r_j & 1 & r_j & \cdots & r_j^{T-2} \\ r_i & 1 & 1 & \cdots & r_j^{T-3} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ r_i^{T-1} & r_i^{T-2} & r_i^{T-3} & \cdots & 1 \end{bmatrix}$$

The matrix **V** is estimated by a two-stage procedure, and b is then estimated by generalized least squares. The first step in estimating **V** involves the use of ordinary least squares to estimate b and obtain the fitted residuals, as follows:

$$\hat{u} = \hat{y} - X\hat{b}_{OLS}$$

A consistent estimator of the first-order autoregressive parameter is then obtained in the usual manner, as follows:

$$\hat{r}_i = \left[\sum_{t=2}^{T} \hat{u}_{it}\hat{u}_{i,t-1}\right] \Big/ \left[\sum_{t=2}^{T} \hat{u}_{i,t-1}^2\right] \qquad i = 1,2,\ldots,N$$

Finally, the autoregressive characteristic of the data can be removed (asymptotically) by the usual transformation of taking weighted differences. That is, for i= 1, …, N and t = 2, …, T

$$y_{it} - \hat{r}_i y_{i,t-1} = \sum_{k=1}^{p} \left(X_{itk} - \hat{r}_i X_{i,t-1,k}\right) b_k + u_{it} - \hat{r}_i u_{i,t-1}$$

while for i = 1, 2, …, N and t = 1

$$y_{i1}\sqrt{1-\hat{r}_i^2} = \sum_{k=1}^{p} X_{i1k} b_k \sqrt{1-\hat{r}_i^2} + u_{i1}\sqrt{1-\hat{r}_i^2}$$

This system is written as

$$y_{it}^* = \sum_{k=1}^{p} X_{itk}^* b_k + u_{it}^* \qquad i = 1,2,\ldots,N; \qquad t = 1,2,\ldots,T$$

The second step in estimating the covariance matrix **V** is to apply ordinary least squares to the preceding transformed model, obtaining

$$\hat{u}^* = y^* - X^* b_{OLS}^*$$

from which the consistent estimator s_{ij} is calculated:

$$s_{ij} = \frac{\hat{f}_{ij}}{(1-\hat{r}_i\hat{r}_j)} \qquad \text{where} \quad \hat{f}_{ij} = \frac{1}{(T-p)}\sum_{t=1}^{T} \hat{u}_{it}^*\hat{u}_{jt}^*$$

EGLS then proceeds in the usual manner,

$$\hat{b}_P = (X'\hat{V}^{-1}X)^{-1}X'\hat{V}^{-1}y$$

where $\hat{V}$ is the derived consistent estimator of **V**. For computational purposes, $\hat{b}_p$ is obtained directly from the transformed model,

$$\hat{b}_p = \left[X^{*\prime}(\hat{\Phi}^{-1} \otimes I_T)X^*\right]^{-1} X^{*\prime}(\hat{\Phi}^{-1} \otimes I_T)y^*$$

where $\hat{\Phi} = \left[\hat{f}_{ij}\right]_{i,\, j=1,..,N}$.

Parks demonstrates that his estimator is consistent and asymptotically, normally distributed with

$$\mathrm{Var}(\hat{b}_p) = (\mathrm{X}'\mathrm{V}^{-1}\mathrm{X})^{-1}$$