



The determination of R&D: Empirical evidence on the role of unions

Naercio Menezes-Filho^{a,*}, David Ulph^a, John Van Reenen^{a,b}

^a *University College London, Gower Street, London WC1E 6BT, UK*

^b *Institute for Fiscal Studies, London, UK*

Abstract

This paper examines the empirical evidence of the role of union bargaining on innovation. We review the existing empirical evidence and emphasize some of the problems with the theoretical assumptions. We outline a simple model of strategic R&D with union bargaining and compare its predictions with econometric results from U.K. enterprise data. Union power (as proxied by density) has at first a positive effect on a firm's relative R&D performance. The effects of union power are only negative when the (a) union density is very high; (b) the union bargains only over wages. © 1998 Published by Elsevier Science B.V. All rights reserved.

JEL classification: O3; J5

Keywords: R&D; Union bargaining

1. Introduction

Many authors have argued that the main problem with the rent-seeking activities of trade unions is their effect on innovation and therefore on the growth of firms, industries and nations (Grout, 1984; Addison and Hirsch, 1989).

* Corresponding author.

Static losses of efficiency may be relatively minor compared to these dynamic losses. The argument is based on the view that the union wage mark-up is financed from appropriating the quasi-rents earned on capital. This acts as a tax which will raise the costs of sunk investment and therefore reduce the amounts that firms are willing to invest. This is particularly a problem for intangible investments such as R&D because it is highly risky, has long gestation lags and is largely irreversible. There are various ways to overcome this 'hold-up' problem, but one of the flaws in the analysis is that the strategic element of R&D is largely ignored. Recent models (e.g. Ulph and Ulph, 1994) seek to address this problem.

An empirical literature has started to emerge that is rooted in the first generation of theories. This paper seeks to evaluate these econometric studies in the light of new data and theory. It is important to note that empirical economists were also stimulated by an older question relating to the effects of unions on the diffusion of new technologies. The adoption of new technologies may be discouraged either directly (like the Luddites) or indirectly by forcing management to use new machines in an inefficient manner (through high manning ratios, poor industrial relations, etc.). On the other hand, Freeman and Medoff (1984) emphasize that by encouraging greater training, reducing turnover and increasing morale unions may increase the speed of diffusion. The effect of unions on diffusion will be relevant for a firm's incentive to invest in R&D if (a) there are complementarities between the production of innovations and their first use within the firm or (b) part of the purpose of R&D is to enhance the company's ability to absorb the knowledge created by other firms.

In Table 1 summarises recent micro-econometric evidence on the effects of unions on R&D.¹ Most U.S. studies uncover a negative association between union power and R&D, although the evidence from the few European studies is less compelling. In Britain, Ulph and Ulph (1989) find a negative association for high-tech industries, Addison and Wagner (1994) find a positive (but insignificant) correlation. Both these studies are essentially on aggregated industry level data and for only one or two cross-sections (1989 data in Addison and Wagner and 1972 and 1978 in Ulph and Ulph). None of the authors have thoroughly investigated the nonlinearity of the union effect or how the union effect differs with different bargaining regimes.

The layout of this paper is as follows. Section 2 provides a simple model of union bargaining and R&D. Section 3 sketches the data and econometric techniques. Section 4 details the results and uses them to calibrate the model. Finally, Section 5 offers some conclusions.

¹ For recent surveys on the effects of unions on diffusion see Keefe (1992).

2. A model of union bargaining and R&D

Consider the following stylised set-up. There is a homogeneous product Cournot duopoly in the product market with linear demand. Each firm faces a single but independent union. The focus here is on the case where both firms bargain over only wages and possibly employment conditional on the R&D decision (ex post bargaining).² Formally this is modelled as a two-stage game (R&D is set in the first stage and wages/employment in the second stage are conditioned on this). We will seek a sub-game perfect equilibrium relating R&D in period 1 to union power. To do this it is necessary first to consider the second stage and then solve backwards. It is assumed that the scope of the bargain is the same in each firm.

To fix ideas assume that demand is linear and defined as

$$P = M - q_1 - q_2, \tag{2.1}$$

where the output of firm 1 is q_1 and firm 2 is q_2 , P is industry price. Assume that q_1 units of output need q_1^2/a units of labour (N) where a is a parameter representing technical efficiency. Firm 2 has a technical efficiency parameter b .

The union of each firm maximises the utility of the median union member. This median member’s utility is parameterised as

$$U = N \frac{1}{1 - m} (W - \tilde{W})^{1 - m}, \tag{2.2}$$

where \tilde{W} is the alternative wage, W the own wage, N is employment and m a parameter representing the weight the union gives to employment vis-à-vis wages in the utility function. The closer m is to unity, the more the union values wages rather than jobs.

If there is ex post bargaining over wages and employment, then the game is solved by using the generalised Nash bargaining solution where firm 1 determines wages and employment by maximising the Nash product, Ω , with respect to wages (W) and employment (N). It takes the wage and employment decision of the other firm as fixed (the Cournot assumption):

$$\Omega = (U - \bar{U})^s (\Pi - \bar{\Pi})^{1 - s}. \tag{2.3}$$

Firm 2 does the same but instead of a relative bargaining power parameter s , it faces a union with power t . In the case where there is only bargaining over the wage then 2.3 is maximised with respect to wages and the constraint that the

² See Ulph and Ulph (1993) for the case where there is bargaining over wages, employment and R&D (ex ante bargaining).

Table 1
Studies of the effects of unions on R&D and innovation

Authors	Methodology	Data	Indicators of technical change and unionisation	Controls	Results
<i>Research and development</i>					
Hirsch (1991)	Regressions of R&D on union coverage	452 U.S. firms; 4327 observations; 1968-1980	Firm specific R&D, lagged stock of R&D as a control; R&D/sales	Labour, capital, firm growth, industry growth, industry wages, concentration, imports, profits	Consistently negative in all specifications, especially in drugs and medicines. Fixed effects of 2SLS models severely reduce union effect
Hirsch (1992)	R&D regressions	706 firms; 5841 observations 1972-1980;	Proportion of a firm's North American workforce covered by a collective bargaining agreement in 1972 and 1978 (retrospective questioning in 1987)	As above plus age of firm	Always a negative effect
Bronars and Deere (1993)	$\log(R\&D)/K$ regressions	600 firms (firm specific averages over sample period)	Percentage of industry who are members of trade union weighted by firm's sales across these three digit industries	Sales, industry dummies, sales growth, concentration, median firm size in industry	One standard deviation in unionisation rate associated with a 51.1% fall in R&D/K
Bronars, Deere and Tracey (1994)	R&D/Sales-time averages 1975-1978 and 1979-1982	120-130 firms 1979-1982; 130-150 1975-1978	Various: Bureau of Labor Statistics contact data matched to Compustat firms; Hirsch's survey; CPS industry averages	Sales growth, concentration, ind dummies, capital-labour ratios, investment/sales ratios	Unionisation has generally a negative effect, although this is not significant when industry effects included or estimates in first differences

Allen (1988)	OLS regressions of industry R&D/output by industry of origin and industry of use	74 U.S. industries 1973–1975	1972 concentration ratio	1973–1975 average union density	Negative and significant. R&D intensity 17% lower in unioised industries
Ulph and Ulph (1989)	R&D/sales regressions	33 British industries in 1972 and 1978	Percentage of workforce covered by a union agreement; percentage of workforce covered by a local agreement	Concentration, high tech sector dummy	Union measures have a positive effect in low tech industries, but a negative effect in high tech industries
Addison and Wagner (1994)	Least Median Squares regression of British R&D/value added against union density in Britain, use German information on density to control for endogeneity	38 British industries 1989; 18 matched U.K.–German industries	Percentage of workers in a union from Labour Force Survey.	German R&D/value added	Positive association between unions and R&D in 'low tech' industries; argued that this is due to enogeneity of unionisation. When German R&D entered in a UK R&D equation no significant effect of unions
Schnabel and Wagner (1992a)	Robust regression techniques as well as OLS regressions	29 German industries 1983–1984	Predicted union density based on previous study. R&D/Sales and % of R&D workers in total employment	Wages, concentration, firm size, capital intensity, rate of profit, capital vintage, sales growth	No significant association
Connolly et al. (1986)	R&D/Sales regressions and market value including R&D as explanatory variable. Is rate of return to intangible capital lower in union firms?	367 firms from Fortune 500 in 1977	Industry level union density R&D/Sales	Concentration, market share, advertising/sales, growth, diversification	Unions have consistently negative effects on R&D/Sales; they reduce the rate of return to R&D as measured on the stock market.

outcome is on the labour demand curve. The profit functions of each firm are expressed as functions of technology and union power:

$$\Pi_1(a, s; b, t) \quad \text{and} \quad \Pi_2(b, t; a, s).$$

R&D is assumed to be determined by a stochastic patent race where firms are in tournament to discover a new technology with productivity parameter c which is greater than the existing technologies of the firms (a and b). We can solve for the value functions of each firm and use these to determine the R&D reaction functions of each firm. These will then determine the equilibrium relative R&D expenditures of each firm. One can then calculate the comparative static predictions of changes in own and rival union power on the relative R&D efforts of each firm.

As stated in the text, two interesting implications of this model are:

1. When there is bargaining over wages and employment, if the union is weak and places a high weight on employment averse then increases in union power can increase the probability of a firm winning a patent race, but after a certain level of union power the effect always becomes negative.
2. When both unions bargain only over wages then increases in own union power will always reduce the probability of the firm winning a patent race. For details see Ulph and Ulph (1994).

3. Data and econometrics

We use two datasets, one drawn from a panel of companies the other from a cross-section of plants in 1990. The company dataset is taken from the accounts of U.K. firms between 1982–1990 taken from the EXSTAT database. This comprises essentially all the firms on the U.K. stock exchange and the (few) large non-stock exchange firms. We used a survey carried out amongst managers of the entire population of EXSTAT firms to provide information on the occupational proportions and many indices of union activity. These firms tend to be large (median size was 895 workers). Unlike many of the other studies both manufacturing and non-manufacturing firms are included in the sample.

The model we estimated had the form³

$$\ln(R\&D_{it}) = \alpha UNION_i + X'_{1it}\beta + X'_{2it-1}\gamma + v_{it}. \quad (3.1)$$

³ A selectivity term for non-random disclosure of R&D was also included using the Heckman (1979) procedure. The natural experiment of shifts in accounting regimes in 1987 and 1989 were used to identify the disclosure equation.

$R\&D$ is the ratio of the firm's R&D expenditure over its sale. $UNION$ is the proportion of the firms's workforce who were members of a trade union (we also used a dummy variable equal to unity if there was at least one union recognised for the purpose of wage bargaining as an alternative). In Eq. (3.1) X_{1i} is a vector of other time-invariant characteristics drawn from the survey (such as skill composition variables), and X_{2it} is a vector of time varying control variables. These include the firm size (number of employees), capital intensity (physical capital over sales ratio), industry wage, market share, and cohort dummies. Technology opportunity and appropriability conditions are captured by the two-digit R&D/sales ratio and industry patents to employment ratio. Many of our firms operate over many different industries so the industry measures were weighted by the distribution of sales across these industries. The variables were transformed to be natural logarithms.⁴ Further details are contained in a Data Appendix (available on request).

The establishment level data is from the workplace industrial relations survey (WIRS). The source of R&D information comes from a follow-up survey, employer manpower and skills practices survey (EMSPS). Unlike the original WIRS all respondents were asked how many R&D workers were based at the establishment.⁵ This should be a good proxy for R&D effort as about half of the costs associated with R&D are staff costs. Since the plant surveys are anonymous, it is assumed that those firms claiming to do no R&D were being truthful and the zeros in the data are genuine rather than a refusal to disclose. Consequently, tobit analysis was used as there is a censoring problem at zero (see below for experiments with alternative econometric methods). The model is of the form

$$R\&D_i^* = \alpha UNION_i + X'_{1i}\beta + v_i, \quad (3.2)$$

where $R\&D_i^*$ is a latent variable. Observed $R\&D = R\&D^*$ if $R\&D^* > 0$; otherwise $R\&D = 0$. The v_i are assumed to be normally distributed with variance σ^2 .

4. Results

Table 2 contains the main results. Columns (1) and (2) report the results for companies and columns (3) and (4) for firms. The basic finding in column (1) is

⁴ For those variables where there are zeros or negative values we use the method of Pakes and Griliches (1984) and set the logarithm to zero but add an extra dummy variable equal to one if there was a zero.

⁵ There is a special section of the WIRS questionnaire administered to the organisation's financial manager where the plant was an individual cost or profit centre. Financial managers were asked what proportion of total current expenditure was spent on R&D. The results are robust to this alternative definition which is available for a smaller sample.

Table 2
R&D intensity equations

	Firms		Plants	
	(1)	(2)	(3)	(4)
Union density	0.139 <i>0.237</i>	– 0.463 0.203	– 0.012 <i>0.013</i>	– 0.029 <i>0.013</i>
ln (industry R&D sales ratio)	0.422 <i>0.085</i>		0.013 <i>0.005</i>	
ln (industry patents per employee)	0.109 <i>0.078</i>		0.057 <i>0.004</i>	
ln (industry wage)	1.627 <i>0.712</i>		– 0.060 <i>0.045</i>	
New cohort	0.892 <i>0.230</i>		0.001 <i>0.013</i>	
Old cohort	0.283 <i>0.172</i>		0.026 <i>0.012</i>	
Employees * 10 ⁻³	0.005 <i>0.013</i>	0.002 0.013	0.055 <i>0.012</i>	0.069 <i>0.018</i>
Employees ² * 10 ⁻⁷	0.001 <i>0.008</i>	– 0.001 0.008	– 0.109 <i>0.031</i>	– 0.141 <i>0.040</i>
Proportion non-manual	0.339 <i>0.314</i>		– 0.013 <i>0.021</i>	
Proportion skilled manual	– 0.211 <i>0.398</i>		– 0.056 <i>0.045</i>	
Proportion managers			0.227 <i>0.073</i>	
Single site establishment			0.030 <i>0.011</i>	
Ln (market share)	– 0.002 <i>0.056</i>		—	
Ln (capital/sales)	0.551 <i>0.122</i>		—	
Inverse Mill's Ratio	0.745 <i>0.406</i>	0.387 0.419	—	
Sample size	339	339	826	826
Industry dummies (9)	Yes	Yes	Yes	Yes
Log-likelihood	—	—	74.18	51.55
R ² adjusted	0.36	0.26	—	—

Note: The dependent variable for the firm level data is ln(R&D/Sales). The dependent variable for the plant level data is ln(R&D employees/total employees). For the company level data estimation is by Heckman two-step selection equation (based on 2940 observations). For plant level data estimation by Tobit ML. All variables are dated $t - 1$. New cohort is unity if enterprise born after 1979. Old cohort is unit if company born before 1940 (columns 1–3) or 1970 (columns 4 and 5). Source: Menezes-Filho et al. (1997).

that there is a positive, but insignificant association of union power on R&D. In column (2) we drop all the main variables to illustrate the importance of our controls. There is a negative and significant correlation. The reason for the

difference is mainly linked to the fact that unions are more prevalent in low tech industries (low industry R&D intensity) and less prevalent in younger firms (which tend to be more R&D intensive). Column (3) repeats the specification for the plant survey and again shows that there is an insignificant effects of union density on R&D. A strong and significant negative effect would only occur if the econometrician omitted the important covariates as column (4) illustrates.

This pattern of results is quite robust to alternative measures of union power (recognition instead of density), alternative definitions of R&D (R&D employees instead of expenditure) and other econometric techniques and control⁶ (see Menezes-Filho et al., 1997, for a more detailed analysis). The simple negative correlation of unions and R&D is driven by the failure to control for industry conditions and age of enterprise.

The theoretical model in Section 2 indicates, however, that the models on Table 1 are still misspecified as the union effect may be non-linear. There are, indeed, significant non-linearities in the union density variable when higher-order terms are included. For example, in a model of relative R&D (own R&D relative to industry R&D) the coefficient on the quadratic term is -5.49 with a standard error of 1.2. To illustrate these we plot the marginal effect of union density on R&D using company level data and plant level data in Figs. 1 and 2. Across these simulations⁷ it is clear that there is a quadratic relationship which is consistent with the ex post efficient bargaining model of Section 2.

To push this finding further we also drew on some separate information in the WIRS dataset. According to the theory for plants where there is only bargaining over wages the relationship between union power and R&D should be simply negative. In WIRS managers were asked about they bargain over a variety of different pay and non-pay issues with unions. We used this information to separate unionised plants into two types: those which bargained solely over wages and those which also bargained over non-pay issues (such as staffing levels, manning ratios, hiring and firing, etc). The models were re-estimated separately for the two types of plants. In the establishments where there was non-pay bargaining the quadratic relationship re-emerged (coefficient on squared term -0.168 with a standard error of 0.071). By contrast when there

⁶ For example: we included cash flow and diversification; we dropped the potentially endogenous occupational variables; we dropped capital intensity as unions may reduce this; we estimated in first differences; we instrumented the union variable with industry unionisation at firm set up. This results are all robust to these experiments.

⁷ We have experimented with various other functional forms of the union density variables such as cubics and splines. There pattern of a rising and then falling union effect is common to all these experiments.

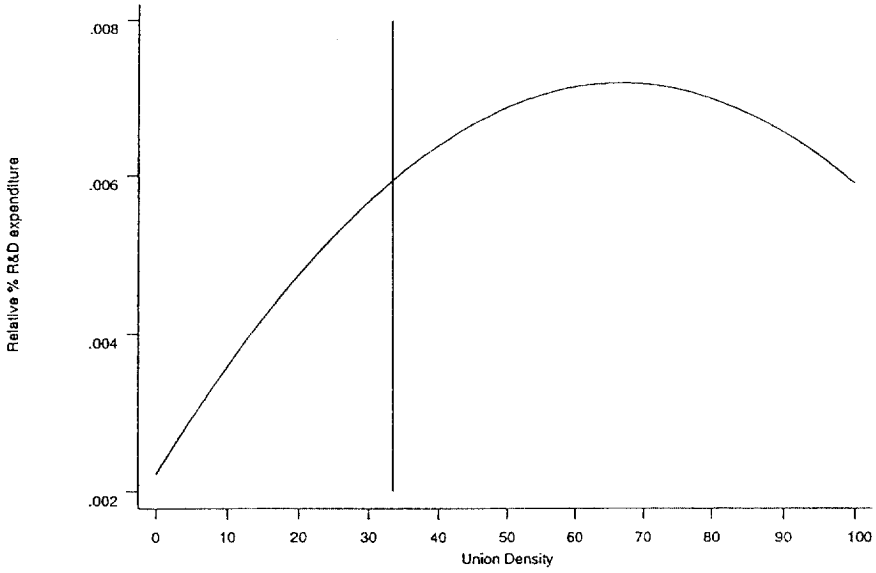


Fig. 1. Relative R&D expenditure. Vertical line is the sample median union density.

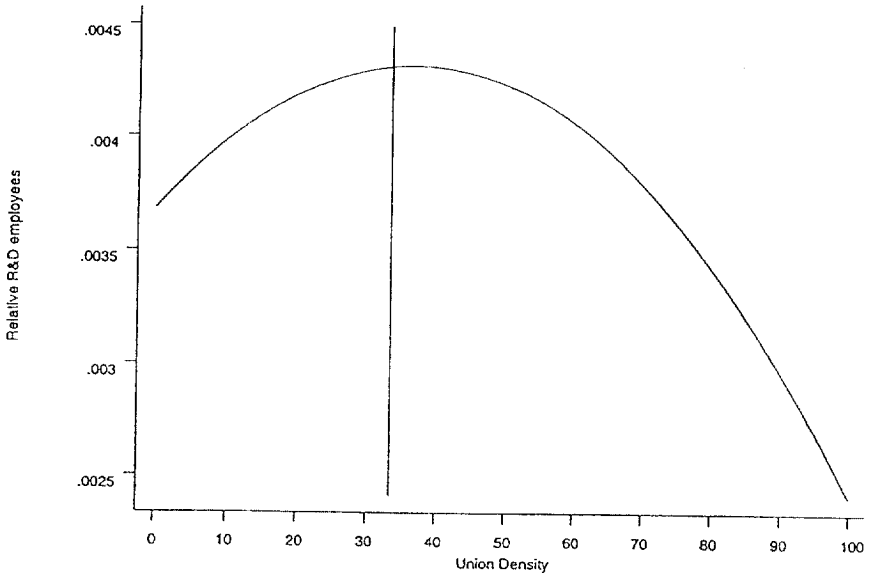


Fig. 2. Relative % R&D employees. Vertical line is the sample median union density.

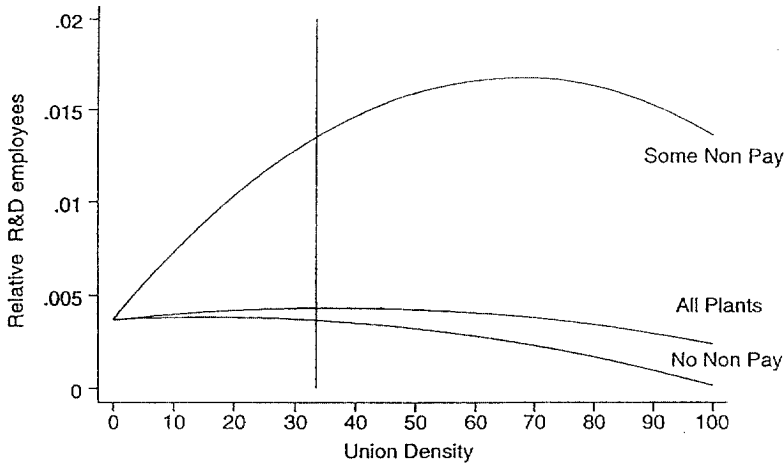


Fig. 3. Relative R&D employees. Vertical line is the sample median union density. Predictions are based on Table: column (2) all; column (4) Some nonpay bargaining; column (6) No nonpay bargaining.

was bargaining solely over pay the squared term was insignificant. This is illustrated in Fig. 3. This is exactly what the theory would predict for risk-averse unions.

5. Conclusions

There is still relatively little empirical work on the important issue of the effect of labour market institutions on growth and R&D. This paper has sought to shed a little more light on the issue. Using micro-econometric evidence in the U.K. from firms and plants we find that there is no significant association of union density on R&D when one controls for other factors correlated with union status that may effect enterprise R&D (such as the technological opportunities in the industry and cohort effects). More interestingly, perhaps, we also find that the relationship between union density and relative R&D is non-linear as the theory of *ex post* efficient bargaining suggests. Our simulations show that R&D rises with union density up to a threshold and then falls again. This is true in both plant and firms datasets. This patterns does not hold, however, when unions bargain only over wages. In these plants there is a simple negative relationship between union power and R&D. These results are broadly consistent with the model of *ex post* efficient bargaining in Section 2.

These findings are subject to many caveats. The measure of union power is very crude; we do not have any panel element to the establishment data and the split into bargaining regimes only poorly reflects the difference between the theoretical models examined in Section 2. It would be very interesting to extend

this work into other countries with different bargaining patterns; to use patents or innovations data instead of R&D and to expand the time period covered. Nevertheless, we think the results presented here are stimulating and suggest that a closer attempt to match some of the theoretical advances in this area with micro-economic data could be a fruitful avenue for future research.

Acknowledgements

We would like to thank the CNPq, ESRC and Department of Employment for help with funding the research. Jonathan Haskel, Stephen Machin, Stephen Nickell, Andrew Oswald, Mark Stewart and participants in seminars in Birkbeck College, the 1997 EEA Conference, the LSE, the 1996 Royal Economic Society Conference, University of College London and Warwick University. The views expressed here are the authors' own.

References

- Addison, J.J., Hirsch, B.T., 1989. Unions effects on productivity, profits and growth: Has the long run arrived? *Journal of Labour Economics* 7, 72–105.
- Addison, J.T., Wagner, J., 1994. U.K. unionism and innovative activity: Some cautionary remarks on the basis of a simple cross-country test. *British Journal of Industrial Relations* 32, 85–98.
- Allen, S., 1988. Productivity levels and productivity change under unionism. *Industrial Relations* 27, 94–113.
- Bronars, S., Deere, D., 1993. Unionisation, incomplete contracts and capital investment. *Journal of Business* 66, 117–132.
- Connolly, R., Hirsch, B., Hirschey, M., 1986. Union rent seeking, intangible capital and the market value of the firm. *Review of Economics and Statistics* 68, 567–577.
- Freeman, R., Medoff, J., 1984. *What do Unions Do?* Basic Books, New York.
- Grout, P.A., 1984. Investment and wages in the absence of binding contracts: A Nash bargaining approach. *Econometrica* 52, 449–460.
- Heckman, J., 1979. Sample selection bias as a specification error. *Econometrica* 47, 153–161.
- Keefe, J.H., 1992. Do unions hinder technological progress? In: Mishel, L., Voos, P. (Eds.), *Unions and Economic Competitiveness*. Economic Policy Institute.
- Menezes-Filho, N.A., Ulph, D., Van Reenen, J., 1997. R&D and union bargaining: evidence from British companies and establishments. Mimeo., University College, London.
- Schnabel, C., Wagner, J., 1992a. Unions and innovative activity in Germany. *Journal of Labour Research* 13, 393–406.
- Ulph, A., Ulph, D., 1994. Labour markets and innovation: Ex post bargaining. *European Economic Review* 38, 195–202.
- Ulph, A., Ulph, D., 1993. Labour markets institutions and innovative success. Mimeo., University College, London.