MARKET STRUCTURE, INNOVATION AND UNION BARGAINING:
AN EMPIRICAL INVESTIGATION INTO THE THE CREATION AND CAPTURE OF ECONOMIC RENTS

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DECLARATION

1. No part of this thesis has been presented to any University for any degree.

2. Chapter 3 was undertaken as joint work with my supervisor S.J. Machin. As such I contributed 50% to the venture. Chapter 4 was undertaken as joint work with S.J. Machin and P. A. Geroski and I contributed 33% to the work. I would like to thank my co-authors for permission to use this joint work here. A statement from them confirming this is given below.

3. A considerably different version of Chapter 3 is forthcoming in the Journal of Industrial Economics entitled 'Profit Margins and the Business Cycle'.

I confirm the above declaration referring to joint work I have carried out with J. Van Reenen

S.J. Machin

P. A. Geroski

SUMMARY

A panel of firms in the 1970s and 1980s and a cross section of establishments in 1984 is used to investigate the impact of market structure and technological innovation on profit margins, employment and wages. The primary findings are as follows:

- Profit margins are pro-cyclical across all product groups, they increase with the firm's market share and degree of industrial concentration in the firm's principal operating industry.
- Innovations are associated with greater profitability for up to six years. This is only partly due to the innovation itself; it is mainly because innovative firms have permanent differences from non-innovators and are better at protecting their profit margins during recessions.
- Technological change creates jobs at the micro-level and particularly in companies with strong unions. The hypothesis that unions bargain over employment is rejected.
- Wages tend to increase with innovations in the union sector. The firm panel shows that this 'technological differential' persists into the medium run and is stronger in the late 1970s than the early 1980s. The establishment cross section shows that the result is robust to controls for skill and workplace characteristics and does not seem to be a compensating differential. For all these reasons it is concluded that the wage differential is more likely to arise from bargaining than from purely competitive reasons.
- The wage mark-up from innovation appears to be greater for skilled workers and declines at higher levels of union power.

CHAPTER 1
INTRODUCTION

Economic power and technological change are two pervasive characteristics of modern societies that economists are frequently, and often with justification, accused of dutifully ignoring. Whatever else, the work presented here is not vulnerable to this criticism. It consists of five empirical investigations of the process of the creation and capture of economic rents in British industry during the 1970s and 1980s. The first two studies deal with the relationship between profit margins and market power, the business cycle and technical innovation. The later three chapters examine whether these economic rents are shared with workers through higher wages and employment. As a prelude, this introduction details the motivations behind the studies, the basic argument (as expressed in a simple model) and the principal findings.

1. Motivation

An academic treatise, like any other crime of passion, arises from mixed motives. Each individual chapter has its own raison d'être but there are three underlying motives: a vision of the economic system, a preoccupation with the economic outcomes of major innovations and a frustration with inadequate data. The vision, or theoretical perspective of this study is that industrial capitalism is dominated by oligopolistic firms engaged in bargaining (at least to some degree) with their workers. This is especially true of the manufacturing sector where a supra-competitive surplus (or 'rent') is generally battled over between unions and firms. Unions have been in decline in recent years but it is still the case that the majority of workers in Britain have their pay set by a collective bargain either directly or indirectly through institutions such as the Wages Councils. Furthermore, even when there is not a formal union present, workers often have 'insider power' due to job specific skills, for example. Their individualistic bargains may be mimicked as special cases of a union model.

Besides the motive to put more empirical flesh on the theoretic bones of union-oligopoly models, there is also the problem of *where* the rents originate. Some portion doubtlessly arises from collusion, entry deterrence and other forms of non-competitive practices which are predicated on technologies that militate against market fragmentation. But part is also due to firms having successfully innovated which has enabled them to capture larger chunks of the market or even expand it into new areas of product space. These technological shifts seem to be a vitally important, but empirically neglected, aspect of the union-oligopoly paradigm.

One of the reason for this benign neglect is due to the need for a particularly rich dataset capable of observing technical changes. Such a dataset has been compiled by matching a panel of companies to the Science Policy Research Unit's database of major UK innovations. Rather than be forced to rely on dubious indirect measures of technical change such as total factor productivity, we can isolate innovation directly and track its impact on profitability, employment and wages. Moreover, the emphasis on firms themselves (where decisions are actually made) avoids the aggregation problems which beset studies at the level of the industry or macroeconomy. Finally, the panel element of the data has huge advantages for addressing the issues of interest - the micro dynamics of technical change can be treated explicitly; controls for attributes of companies that are unobserved but relatively stable over time are possible; and some correction can be made for the simultaneous determination of many variables through the use of lags as instruments. There are of course drawbacks (loss of information in first differencing, potential selectivity biases from attrition) and the seventh chapter uses a different dataset to triangulate some of the results. This final dataset uses a measure of whether or not an establishment adopted microelectronic technology, rather than whether it was first in the field. Thus the economic effects of innovation at a later stage in its life cycle can be analysed.

2. The Basic Model and Methodology

Figure 1.1 The Innovation Game

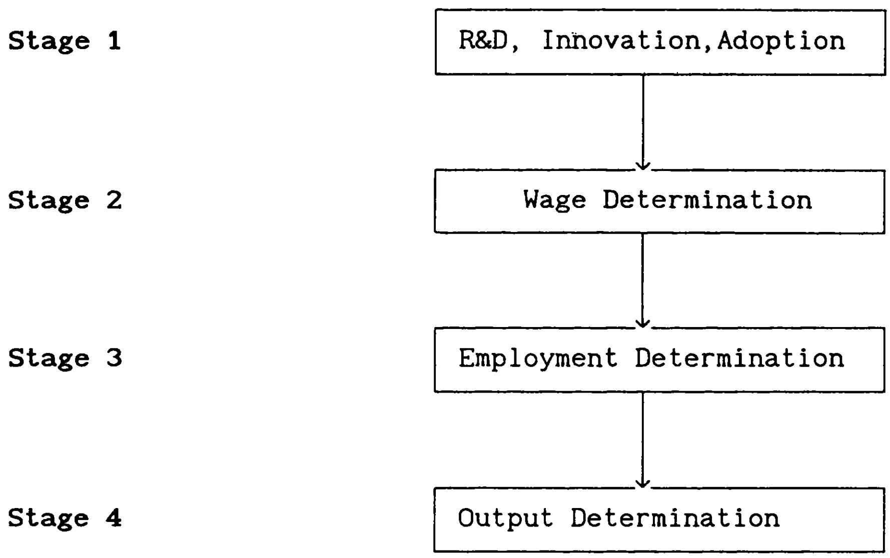

Figure 1.1 illustrates the simplified model of a firm's decision-making process. At stage one there various tangible and intangible capital investments are made which will stochastically determine the state of technology at Stage Two. Next comes the process of wage bargaining followed by employment and profit determination. It is assumed that the final stage is an oligopoly game between a finite number of quantity setting firms and this is tackled in the first two empirical studies. Many different bargaining scenarios are considered as variations around the basic model.

Chapter 5 looks at the implications of union bargaining over employment and Chapter 7 of bargains over Research and Development.

The whole model is not set up immediately to derive the wage, employment and profit equations through backwards induction. This is done gradually, chapter by chapter. The *modus operandi* of the study is to sequentially investigate the data, beginning with an examination of the profits-market structure relationship and then expanding the details of the model as the thesis develops. If there was no evidence for the rent-creating effects of innovation and market power then further investigation would have been unlikely to be fruitful. Having found some support for our basic model in Chapters 3 and 4, wage and employment determination (Stages 2 and 3 of Figure 1.1) are the subject of attention in the later chapters.

Some disclaimers must be immediately made. Analysing the *consequences* of innovation is not the same as investigating it's *causes* (although a thorough understanding of the latter is predicated on knowledge of the former). Solving an 'innovation equation' in Stage 1 of Figure 1 would seem a natural progression that will be followed in future work (see also Chapters 4 and 7), but it is not the focus here. This is because the measure of innovation used is extremely difficult to predict being far closer to inventions than to the measures of diffusion normally used in applied work. This makes them ideal for looking at technological shocks as the danger of backwards causality is very low, but much less suitable for looking at the reasons why firms introduce new products and processes. This is not to say the issue is unimportant, but that one should be wary of setting goals which cannot be solved with the available tools.

3. The Argument and the Layout of the Thesis

The main findings have already been summarised. To recapitulate the argument at its simplest: economic rents appear to be created by innovative activity but also by other forms of market power (which rises in booms and with firm market share and industrial concentration). These gains are shared with unionised workers in the form of higher wages, and these wage gains are not simply due to skill upgrading, compensating differentials or temporary labour supply frictions. Finally, although innovative firms have a superior employment performance this does not seem to be due to unions bargaining over jobs.

Chapter 2 sets the theoretical backdrop, surveying and synthesising the literature on the creation and capture of rents. It looks at formal models of the union, different forms of rent creation (organisational, oligopolistic and technological) and the methods unions use to appropriate these rents. The empirical literatures testing between union models and the effects of unions on innovation are also summarised.

Chapter 3 finds the solution of the oligopoly game in Figure 1. It investigates the cyclicality of profit margins and the influence of market structure using our firm panel. More complex parameterisations of the conjectural variations term than are usually considered are utilised and alternative models of the dynamic evolution of profits based on entry and adjustment costs are presented.

Having established the importance of market structure for profitability, Chapter 4 introduces innovations into the profits equation and examines its short and long-run impacts. The question of whether the superior profits performance of innovative firms is merely due to technology shifts or whether it rests on some deep-seated differences between innovators and non-innovators is also adressed.

Chapter 5 looks at the employment effects of innovation, beginning with a theoretical discussion of the likely impacts. The standard result (that positive employment effects arise when labour demand is elastic) is supported in more complex models of union bargaining, and it is shown that positive effects are more probable if bargaining covers employment. An econometric testing procedure is specified to discriminate between different union models and a shirking model. The test is then implemented on the firm level panel.

Chapters 6 and 7 are both concerned with the association between wages and new technology. Chapter 6 solves the wage bargain (Stage 2 of Figure 1.1) and derives some comparative statics illustrating that although the innovations are likely to covary in the same direction as the wage, other forms of market power will not do so in a linear manner. The empirical section uses the firm panel to test these predictions. Compared to innovative firms with weak unions, innovative firms with high union density are found to have experienced slower wage growth but faster employment growth in the late 1970s and early 1980s.

Chapter 7 uses a different dataset to the rest of the study, the 1984 Workplace Industrial Relations Survey, to cross check some of our findings. A measure of diffusion of micro-electronics is used across four skill groups to see if the higher remuneration attached to an innovation merely represents an upgrading of the workforce or a compensating differential. Two subsidiary issues addressed are how the size of the technological mark-up varies with union power and whether technology has been a cause of the increases in wage inequality experienced in the 1980s.

Finally, Chapter 8 draws together the threads of the study, offers some conclusions and delineates some areas for future research.

Chapter 2

The Creation and Capture of Rents: A Critical Survey

The joint literatures on innovation, market structure and union bargaining defy a comprehensive survey so the approach taken here is necessarily selective. The theoretical building blocks for the studies which follow and essential background empirical work not covered in subsequent chapters are laid out. The guiding principle of this survey is to explain the creation of economic rents and how they may be captured by workers through union bargaining. It is divided into three parts. First the micro-economic theory of the trade union is presented paying particular attention to basic concepts from game and bargaining theory, union preferences and the sequence of bargaining. It is demonstrated that an encompassing framework has evolved based upon recursive contracts and that the existing models can be nested within this. The second part of the literature review looks at how a supra-competitive 'surplus' is actually created through organisational, collusive, and above all, innovative rents. The final section looks at the ability of unions to capture these rents and what implications this has for the effect of innovations on profits, employment and wages (the empirical focus of chapters Four through Seven).

I. The Formal Theory of the Trade Union

Why should one even attempt a formal economic model of the trade union? Arthur Ross, one of the most skillful economists to study unions declared: "Among the participants in economic life, the trade union is probably least suited to purely economic analysis." (Ross, 1948, p.297). Although many social scientists would share Ross' skepticism over the utility of utility theory (e.g. Freeman and Medoff, 1984) even the most atheoretical applied worker has some model of the way unions operate. It is merely a question of whether the model is implicit or fully exposed to the light of critical appraisal. Furthermore, developments in the theory of games have enabled economists to enter domains they previously believed impervious to rational analysis.

1. The Theory of Games and Bargaining

Game theory really has revolutionised the way social scientists analyse the complexity of economic life. Neoclassical economics was traditionally rooted in the idea that rational agents act as if they maximise an objective function against an environment wholly external to their choices (captured in a vector of prices and assets). The fundamental contribution of game theory is to relax this parametric decision making and allow it to be strategic. I recognise that what I do affects what you do and what you do constitutes the shifting environment constraining and conditioning my actions.

The crucial equilibrium concept of game theory comes from John Nash (1951). A Nash Equilibrium is a strategy profile defining an array of strategies for all players such that each is an optimal reply given the strategies of all other players at that equilibrium. In terms of Figure 1.1 one looks for Nash Equilibria at the final stage of oligopolistic competition in the product market. The set of Nash Equilibria for the entire game comprising all sub-games is also a matter of interest. The problem is that this set holds many profiles that would never occur as they are based on threats which are actually only bluffs ('cheap talk' in the jargon). To solve the game of Figure 1.1 the Perfect Equilibrium concept developed by Selten (1975) is appropriate using the logic of backwards induction. First the stage 4 sub-game is solved to get the firms reaction functions, then the employment game (if there is bargaining) at stage three is solved taking into account firms' reactions in the product market. And so on back to the determination of innovation at stage 1.

This still leaves the bargaining process. Formally the bargaining problem looks like Figure 2.1 : we have a 'pie' defined in utility space that must be divided between two parties. The size of the pie depends on what would be lost if the two sides separated permanently. We call this their 'outside options', U^0 and Π^0. In the case of wage bargaining this would be what would happen if all the workers were sacked or the firm closed down. All points on the Bargaining Frontier are Pareto Optimal and any efficient solution would be somewhere along the curve. Many economists, more wedded to efficiency than determinancy would be content to leave it at that. Braver individuals have proposed particular points on the frontier. This study frequently uses the most popular one, the Generalised Nash Bargaining Solution[1] (Nash, 1951). It is defined to be the point which maximises the product $\Omega = (U-\bar{U})(\Pi-\bar{\Pi})^{\beta}$ subject to $U \geq U^0$ and $\Pi \geq \Pi^0$ where $\bar{U}$ and $\bar{\Pi}$ are the utility values of the 'inside options' at d, the disagreement point and β is the relative bargaining strength of the firm viz a viz the union. The inside options are the discounted utility streams obtained during a breakdown in the bargaining process (strike or lockout, for example)[2].

Nash himself derived his solution axiomatically from a co-operative game. More recently it has been shown to be the perfect equilibrium of a Rubinstein bargaining game as the period between alternating offers shrinks to zero (Binmore, Rubinstein and Wolinsky, 1986). This gives the solution

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[1]This has *nothing* in common with the Nash Equilibrium concept except for the fact that it was also invented by John Nash.

[2]There is still considerable confusion over over the difference between the inside and outside options (e.g. Svenjar(1986)). On the union side, the inside options will be determined by strike pay rather than unemployment benefits or outside wages. These are part of the outside options which *have no effect* on the solution unless they are binding.

great appeal, especially since the experimental bargaining literature seems to put it ahead of its main competitors[3]. Direct tests of the solution have not been econometrically attempted which is somewhat surprising as the Nash Solution has different predictions from others. For example, Kalai and Smorodinsky (1975) argued that outside options should affect the wage at an interior solution.

2. Union Preferences

What are the objectives of trade unions? Dunlop (1944) popularised the notion of a 'rent maximising' utility function: the union counts all its M members equally. So, $U = WN + (M-N)\tilde{W}$ where $\tilde{W}$ is the 'alternative wage' earned outside the firm and W and N are wages and employment respectively. Many later writers have then claimed that the inside option is $\tilde{W}M$ and so the union's contribution to the Nash product $(W - \tilde{W})N$. To allow for risk aversion the wage is changed to utility u(W) and the union sometimes compared to a perfect democracy acting as if it maximised the utility of the median member. If lay-off is by random draw this can be written $(u(W) - u(\tilde{W}))N$ or parameterized conveniently as

$$(2.1)\quad U(W,\tilde{W},N) = (W - \tilde{W})N^{\psi}$$

where $\psi=1$ corresponds to risk neutrality[4] and $\psi>1$ is the usual case of risk aversion.

The stories justifying these forms are a little far fetched. In the

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[3]See e.g. Binmore, Proulx and Swiezbinski (1992).

[4]Even if members were risk averse, by redistributing wages between employed and unemployed members through an insurance scheme, $\psi=1$. There may be some justification for this in the U.S. where lay-offs and union unemployment benefits are more common than in the U.K. Few of the unemployed stay in unions and severance pay is rarely enough to make those who leave as happy as those who stay.

first place the relevant disagreement point is not $\tilde{W}$, which is the outside option. Furthermore, as Ross (1948) said in his classical rejoinder to Dunlop "the central objective of the union must be defined as institutional survival and growth" and not "the mechanical application of the maximisation principle". Ross' position is bolstered by the difficulties of aggregating individuals preferences (non-transitivities are the rule rather than the exception) and the principal-agent problem which allows leaders to have great leeway in pursuing their own interests. One would be on safer ground as interpreting (2.1) as the expression of the leaders' utility rather than a mythical median member.

3. The Sequence of Bargaining

A key to understanding the plethora of union models is through viewing them as special cases of a sequential bargaining game, or 'recursive contract' as Pencavel (1991) puts it. For expositional purposes it is easier to present these models historically. Two of the most important and well-studied classes of models are those on the demand curve ('Labour Demand' models) and those on the Contract Curve (the locus of the points of tangency between the union's indifference curves and the firm's iso-profit curves). Labour Demand models have the structure of a bargain over wages in the first stage and then allow the firm to unilaterally set the level of employment in the second stage (the 'Right to Manage' model of Andrews and Nickell, 1983). A special case of this is the Monopoly Union model where the union has total power to set the wage. Leontief (1942) and others have pointed out that Labour Demand models are inefficient: rents are destroyed as the union attempts to share in them. An efficient solution to the bargaining problem would lie on the contract curve (McDonald and Solow,1980). These different solutions are illustrated on Figure 2.2. Although the contract curve can slope forwards or backwards, the vertical case is of particular interest (known also as 'strong efficiency' this will occur if the union behaves as if it was maximising wage rents). In this case employment is set at the level of the alternative wage and the contract wage merely distributes the surplus.

Both Contract Curve and Labour Demand models are special cases of a more general Sequential Bargaining model as demonstrated by Manning (1987). In this model the parties are allowed to have different relative bargaining powers in bargains over different variables. This seems quite reasonable as wages are usually negotiated formally, annually and at a higher level than job regulation which is informal and more frequent. Efficient bargains are struck when the bargaining power is equal in both bargains and the Labour Demand model holds when the union's power over employment is zero. Let X_1 be exogenous shifters of profits, X_2 exogenous shifters of union utility (e.g. the alternative wage) and β^N and β^W be the *firm's*[5] relative bargaining strength over employment and wages respectively. The wage-employment bargain can be written formally as:

Stage 2: $\max_{\{N\}} \log U(W,N,X_2) + \beta^N \log \Pi(W,N,X_1)$

Giving an employment function of the form $N(W;\beta^N,X_1,X_2)$.

Stage 1: $\max_{\{W\}} \log U(W,N,X_2) + \beta^W \log \Pi(W,N,X_1)$ subject to $N=N(W;\beta^N,X_1,X_2)$. Giving us a wage equation of the form $W=W(\beta^W,\beta^N,X_1,X_2)$.

The Labour Demand Model assumes $\beta^N \longrightarrow \infty$ so the wage and employment equations can be written $W(\beta^W,X_1,X_2)$ and $N(W;X_1)$. The wage contains all the relevant information on the union's powers and preferences, so these do not enter independently into the employment rule. If we impose $\beta = \beta^W = \beta^N$ the

[5]Note that Layard, Nickell and Jackman define β as *union* relative bargaining power.

objective functions are identical at stage one and two and the envelope theorem can be used to write the bargaining problem as

$$\max_{\{W,N\}} \log U(W,N,X_2) + \beta \log \Pi(W,N,X_1)$$

This is identical to the Contract Curve model which gives wage and employment equations of the form $W=W(\beta,X_1,X_2)$ and $N=N(W,X_1,X_2)$. Unlike the general model all information on union power is incorporated into the wage, so it will not enter independently into the employment function[6].

Manning's model has taken a while to become very popular because it imposes the Nash Solution a priori and also because it makes wage-employment determination dependent on more unobservable terms in 'power'. On the positive side, the framework is very flexible and could of course be extended to allow more issues to be bargained over at different stages (e.g. capital -see Section III.3 below).

A major preoccupation of union micro-econometrics has been to try to test between different union models. Table 2.1 summarises this literature as exhaustively as possible and Chapter 5 presents our own stab at the problem. The conundrum faced by economists is that there seems no legal impediment to prevent efficient contracts evolving yet actual existing collective bargains do not explicitly cover jobs. For example Oswald's (1987) survey showed that only three of the eighteen largest British Unions said they directly bargained over employment[7]. McDonald and Solow (1981) conjectured that the

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[6]These identification restrictions distinguish the employment equation from the wage equation by the exclusion of X_2 and β (Labour Demand), just β (Contract Curve), or just β^W (General Bargaining Model). The wage equation is not identified unless more structure is placed on the models and this is done in Chapter 6.

[7]See also Oswald and Turnbull (1985) and Clark and Oswald (1989).

efficient bargain could be approximated by featherbedding, fixing crew sizes, manning levels and so on: aspects of the workplace that are often the subject of negotiations. However, fixing the capital-labour ratio still allows the employer to alter the numbers of machines and shifts. Theoretical work on the issue suggests that a 'crew size' efficient bargain will lie between the labour demand and employment contract curves, but how far from the latter is very unclear[8].

The usual reason given for the conspicuous lack of efficient contracts is that the median member of the union is unconcerned with employment. These 'insiders' have horizontal indifference curves and so efficient bargains are on the labour demand curve. This seems highly unlikely for number of reasons - a job loss at the bottom of the ladder reduces promotion chances for all workers; unions both in their rhetoric and actions strike to protect jobs even when their own are not directly threatened; and since demand shocks are correlated one wave of job losses may soon be followed by another. In light of this it is unsurprising that econometric analyses (see Table 3.4 in Pencavel (1991) have universally found that unions give weight to jobs.

When one moves into a stochastic world there are many reasons why efficient contracts may not evolve. During demand shocks the firm may often have to adjust optimal employment and constant renegotiation may involve such large transaction costs that the union loses more rents than it would gain by exercising any of its potential power. In this case, efficient contracts are not efficient. Can this be the whole picture? This argument would seem to

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[8] Johnson (1990) and Clark (1990) are skeptical that the efficiency gains from are very large. Their sequential structure is first over the labour-capital ratio *then* the wage. If this sequence is reversed then one can be more optimistic about the prospects of getting close to the contract curve (Manning, 1992)

be more applicable to wage bargaining given the large adjustment costs associated with employment changes (e.g. Nickell, 1986) and yet wages certainly are negotiated.

A more plausible explanation for the absence of efficient contracts highlights the asymmetrical information over demand conditions between the bargainers. The firm is likely to exaggerate the bad times and hide the good ones and the costs of monitoring may be too high for the union to overcome the moral hazard problem. Presuming that the union discovers the true situation ex post (e.g. through the company accounts) then we are in a classical Prisioner's Dilemma. This formal similarity has been noted by many writers (e.g. De La Rica and Espinosa, 1990) who have then used the Folk Theorem of repeated games to suggest that efficient bargains can be supported as the perfect equilibrium of a repeated Labour Demand Game if the future is discounted heavily enough. An important general idea is contained here which will be replayed often: long term contracts depend on the time-horizon of the union. Long tenured union members and leaders concerned with growth should aid the development of efficient bargaining[9].

Finally, a more radical explanation for the lack of employment bargains is due to Dowrick (1987). Consider Figure 2.2 again, it is clear that all points inside the lens shaped area between U' and Π' (union and firm welfare at the right-to manage solution) are Pareto superior. In order to reach such a point within this lens U' and Π' must be considered the inside options during the Nash Bargain over wages and jobs. By contrast, if the fall back levels are exogeneous to the type of bargaining regime it might well be the case that the firm ends up with lower absolute profits in the employment and

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[9]Note that one cannot rely of allowing the bargaining interval to shrink asymptotically to zero as wage bargains are negotiated infrequently.

wages bargaining model. This is because the threat of job loss may sufficiently reduce wage claims to overcome the benefits to the firm of higher employment. (this is more likely the greater the elasticity of labour demand and the more risk-averse is the union). This argument has the advantage that it corresponds to two empirical facts. First, unions are generally in favour of extending the bargaining agenda whereas management are usually opposed to such interference with their right to manage. Second, unions reduce profitability (see Section III below).

How have applied workers tried to discriminate between these models? There are essentially three styles of modeling, only one of which looks explicitly at the general sequential bargaining model. The most popular testing procedure was pioneered by Ashenfelter and Brown (1986) and McCurdy and Pencavel (1986) who looked at the American Typesetters union. Let $R(N,K,X_1)$ be the firm's revenue function and profit be $\Pi = R - WN - rK$, where K is the capital stock and r its rental cost. Then the first order condition for employment is simply $R_N = W$ under labour demand models. If there is efficient contracting then the condition is $\Pi_N/\Pi_W = U_N/U_W$ or

(2.2) $$R_N - W = -N(U_N/U_W)$$

An intuitively appealing test is therefore whether the right-hand side of (2.2) is zero or not. If it is not then the Right-to-Manage model can be rejected. Since $R_N(N,X_1)$ and U_N/U_W depends on X_1 the employment equation on the contract curve can be written as before $N(W;X_1,X_2)$. Since the prime candidate for X_2, the exogenous influence on union utility is the alternative wage the test boils down to testing the significance of $\tilde{W}$ in an employment equation - which is exactly what Ashenfelter and Brown do. McCurdy and Pencavel take a slightly more sophisticated approach first estimating a translog production function to get an estimate of R_N[10] and then using these estimates in (2.2). The union's marginal rate of substitution is parameterized by a much more general functional form than in Ashenfelter and Brown. Both authors find that the alternative *and* own wage are important so they reject both extremes of a vertical contract curve ('strong efficiency') and labour demand curve models.

Most of the studies following this tradition have also found a significant role for outside wages and so concluded in favour of efficient bargains[11]. Table 2.1 gives a reasonably exhaustive listing of these studies. The results have not proven to be overwhelmingly strong and criticism of this modeling strategy abound. I focus on four here.

First, if X_2 is weakly separable from the other arguments in (2.1) then as Andrews and Harrison (1991) show, the absence of an effect of the alternative wage is consistent with efficient bargaining. For example if $U = (W/\tilde{W})N^{\psi}$ then the marginal rate of substitution will be $\psi W/N$. Furthermore, finding a role for $\tilde{W}$ may imply that the outside option is binding rather than be evidence for efficiency. These considerations highlight the large amount of work being performed by one variable - it enters into the preference set, the outside and (mistakenly) the inside option in many approaches.

Secondly, the alternative wage may be influencing employment because of efficiency wages. In these theories employers may wish to set higher wages than their competitors because this has a positive effect on the productivity

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[10] The marginal revenue product of labour is the ratio of the marginal products of labour and capital multiplied by the rental cost of capital under their assumptions.

[11] Bean and Turnbull (1988), Bean (1991), Card (1986), Eberts and Stone (1986), Doiron (1986), Martinello(1989), Oswald and Christofides (1991). Card (1990) finds no role for the outside wage. Wessels (1991) using a union dummy directly rather than union preferences also accepts the labour demand model.

of the workforce (for example, by reducing shirking in the model of Shapiro and Stiglitz, 1984 - see Chapter 5.III). In other words increases in the alternative wage will reduce employment because productivity is lower. Nickell and Wadwhani (1991) interpret the significance of alternative wages in their employment equations as evidence of efficiency wages as they find it is the rate of change between own and outside pay which matters. Yet the change in relative wages could easily enter the union utility function so one could argue their result reflects efficient bargaining by a union which values relativities. A different route would be to see if the presence of a union increases employment after controlling for own and outside wages. This route is followed by by Hendricks and Kahn (1991) who find support for the Contract Curve model[12].

Thirdly, in a dynamic context the alternative wage may enter into the employment rule because of the strategic effect of employment today on wage bargaining tomorrow (Lockwood and Manning,1989). It could also be that $\tilde{W}$ helps to forecast the future path of contract wages[13].

Finally, and most importantly, the two models are not nested. Consider (2.2) again. We are testing the hypothesis that $U_N/U_W = 0$, i.e. that the union has flat indifference curves. But it is the labour demand model not the Seniority Model, which is supposed to be the relevant null hypothesis.

To overcome this difficulty, Andrews and Harrison (1989) have argued for a different methodology to test efficiency by nesting both theories

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[12] Of course there are problems with this approach too, as unions could be affecting productivity directly. It is possible that in trying to test too many hypotheses at the same time we shed light on none of them and a better way forward would be to find competing predictions of all bargaining models against all efficiency wage models. This is the basic tactic of Machin and Manning (1992b).

[13] Appendix 5.2 deals with these dynamic problems by following Machin, Manning and Meghir (1992) in specifying an Euler equation for employment.

explicitly in Manning's general sequential bargaining model. As shown above the employment equation under the general model contains terms in union power absent from the other two models. In principle this is the sound approach, but in practice there are huge difficulties in finding adequate proxies for union job power vs. wage power. Since dynamics are known to be vitally important in employment equations there is the additional problem of measuring changes in two vaguely defined, empirically unobservable and theoretically problematic variables *over time*. Consequently all empirical attempts to implement this methodology until now have been disappointing and shown opposing conclusions[14].

In the light of these huge data demands, Abowd (1989) has recently proposed an elegant test for strong efficiency. An implication of vertical contract curves is that unexpected gains in union wealth are exactly offset by losses in shareholder wealth. If we assume that the stock market price of the firm reflects all relevant information over the current and expected future value of the firm, then changes in this reflect changes in shareholders' wealth. Abowd looks at the share price reaction over three months to news of collective bargaining agreements. He finds that the hypothesis that gains in the present value of union rents are offset exactly by losses in the present value of shares cannot be rejected.

Despite the fact that his results are as equally consistent with a coefficient of -0.5 as -1 on the change in union versus change in

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[14] Andrews and Harrison (1991) themselves use the 1980-1984 Workplace Industrial Relations Survey Panel which has very rich information on bargaining structures but quite poor economic variables, and a low number of observations. Alogoskoufis and Manning (1991) try a similar approach, but aggregate data forces them to proxy power in a very arbitrary and unconvincing way. Paci, Wagstaff and Holl (1992) try to recover the structural parameters of union power from the same dataset as Andrews and Harrison, but this time use the 1984 cross-section. They seem blissfully unaware of the formidable identification and data problems this presents.

shareholders' wealth equations, Abowd's work is the most persuasive to date on strongly efficient contracts. One major problem is that he is assuming that the contract curve has not shifted and that he has captured all information in his union and shareholder expected wealth equation. Yet there are likely to be firm-specific product market[15] effects known to the parties but not the econometrician which vitiate this assumption. It is hard to effectively control for this but it needs to be explicitly recognised.

Chapter 5 takes up some of these problems by examining the impact of innovation on jobs under different union bargaining scenarios. The elasticity of labour demand is the crucial determinant of whether technology will lead to increases or decreases in employment. The condition becomes progressively weaker (and so employment increases more likely) when one turns to the Contract Curve model and then to the General Bargaining Model.

II. The Creation of Rents

Unions increase the remuneration of their members both through higher wages and better fringe benefits. As seen in the last section they may also increase employment. In any case, the firm is facing higher costs than it would be in the absence of unions. In a world of perfect competition where firms face demand curves of infinite elasticity these costs cannot be passed on and the union firm would have to exit the market. If the union could set the same wage for the entire industry so that costs are the same in all firms this problem would be mitigated. But there would still be the threat of entry by domestic firms or from foreign competition. Organizations protected by regulation or in the public sector may fit this bill, but it seems almost

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[15] For example, there are no firm specific effects in the union's expected wealth equation.

impossible in a competitive private sector. So one is left with a fundamental question: how can unions survive in the long-run?[16]

There are three candidate sources of persistent rents that may explain the fact that unions have not been in long-term decline in most European countries (see Blanchflower and Freeman, 1991). There may be organizational rents created by union presence, there may be firm product market power or there may be rents from innovation[17]. Or there may be combinations of all three. An alternative perspective might seek the sources of rents in the labour market power possessed by small firms in the non-union sector. Modern monopsonsy which suggests that unions survive by reducing neo-classical exploitation will not be examined here (see Green et al ,1992).

1. Organisational Rents

The resurgence in interest in unions stems in part from the growth of an empirical literature associated with the 'Harvard School' claiming to show positive effects of unions on productivity. In a classic article Brown and Medoff (1978) conclude:

"Union and nonunion establishments in U.S. manufacturing can compete in the same product market despite the fact the former pays their workers more because unionised workers establishments are more productive by a roughly offsetting amount" (p.377).

Positive union productivity effects are compatible with orthodox neoclassical analysis. If the effects of unions is to raise wage costs the

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[16]The line of argument pursued by Addison and Hirsch in their 1989 article ("..Has the Long-Run Arrived") is that unions cannot survive. The decline of union density in the United States, and presumably in Britain, is interpreted in this light.

[17]We will also consider quasi-rents from capital. Innovation could be seen as a quasi-rent from intangible 'knowledge capital' created through Research and Development expenditures.

firm will respond by substituting labour for capital or higher quality workers. Although this will raise labour productivity the allocation of resources is sub-optimal and will still place the firm at a competitive disadvantage. When the damaging effects of restrictive practices, lower investment and industrial action are also taken into account union power seems to offer few social benefits. The Harvard School does not deny that these effects exist, but they claim they are quantitatively small in relation to the benefits of 'Collective Voice'. The Voice of the union reduces the propensity of workers to exit the firm, increases morale, monitors effort and helps provide public workplace goods. Turnover costs are very high in the presence of nontransferable skills which constitute the 'organizational rents' (Aoki,1984) of the firm, and lower quits seem to be an important transmission mechanism for collective voice (Freeman, 1980).

Two theoretical objections immediately arise. For one, if these benefits are available why can management not implement them without unions and so get the collective voice without the collective boot? Essentially, management have a credibility problem as they will always have the temptation to use private information supplied by workers to increase effort or root out 'troublemakers'. This makes workers reluctant to reveal private information. A second objection is to ask why management generally oppose unions if they can improve efficiency? The obvious rejoinder is that firms are interested in profits not efficiency. The increased wages of workers may overwhelm the productivity effects as illustrated in Figure 2.3. In this case the original problem of how it is that unions survive in competitive markets remains.

Apart from Voice there is an older industrial relations tradition that suggests that unions can 'shock' lethargic management into profit maximising behaviour through the reduction of X-inefficiency (Clarke, 1980). Note that this is a one-off boost in productivity levels rather than an ongoing increase in productivity growth: a trick that can only be played once.

The U.S evidence over unions and productivity is summarised in Addison and Hirsch (1989) and the British evidence in Metcalf (1991). The methodology of most studies follows Brown and Medoff(1978) by estimating production functions with extra terms included to represent union power. There are great difficulties in interpreting most of these studies, there is a danger of confounding price with quantity effects; the response of managers is crucial but rarely controlled for; there may be differing production technologies (especially between industries); backward causality problems are particularly acute (unions may be located in declining industries) and there is sample selection bias because we only observe surviving firms.

The overall impression one gets is that there do not appear to be any strong productivity variations associated with unions on average, but in the U.S. there is a tendency to find positive effects on the *level* of productivity[18] and in Britain, neutral or negative ones. The most careful studies find considerable heterogeneity in the influence of unions. For example, Machin (1991) finds that in a panel of 52 engineering firms his index of union presence is only significantly associated with lower value added per head in the *largest* firms. All in all the British evidence does not suggest that organisational rents could be the main source of union wage gains.

2. Oligopolistic Rents

As a discipline, industrial organisation has been through a paradigm shift over the last decade. Founded in the 'Structure-Conduct-Performance'

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[18] For the story on productivity growth see sub-section III.2.

work beginning with Bain (1951) the empirical agenda was to search for collusion by relating industrial concentration to price cost margins in an inter-industry cross-section. The generally accepted conclusion was that there was a positive relationship indicating that market power was widespread, particularly in manufacturing. These oligopolistic rents could be a prime source of union gains as many economists have argued (e.g. Kalecki, 1971). The application of game theory in the 1980s tended to show that successful collusion depended very sensitively on the details of a market and so attempts to quantitatively detect them were fraught with peril. Consequently, there has been a shift towards 'ultra-micro' studies of particular markets to measure market power at the firm level[19]. Our own attempt to look at the implications of some recent supergame models of price wars for rent creation is in Chapter Three and this section serves as a backdrop to the work presented there.

A good way to understand the literature of the 'New Empirical Industrial Organisation' as Bresnahan (1989) calls it is to consider the supply relation under imperfect competition. Write the profits of firm i in homogenous goods industry j as

$$\Pi_i = P(Q_j)q_i - c_i(q_i), \quad Q_j = \Sigma q_i, \ P'(Q)<0, \ c_i'(q_{ij})>0$$

The the first order condition for the firm's choice of output is

$$(2.3) \quad P(Q_j) + q_i P'(Q_j)(1 + \lambda_i) = c_i'(q_i)$$

Where $\lambda_i = \partial\Sigma q_{-i}/\partial q_i$, the 'conjectural variations' parameter which indexes any outcome from perfect competition to the monopoly/joint profit maximising solution. The left hand side terms sum to be the 'perceived marginal revenue

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[19] Although there is perhaps a recent counter-trend to look for stable comparative static results which will hold across a wide range of industries in order to avoid the accusation that game theory explains everything and nothing. Sutton (1991) is an excellent example of this.

product' which is equal to the firm's marginal cost. There are two paths to travel based on (2.3). One way is to estimate it directly, which is what the 'ultra-micro' studies do. I discuss these below. The second path is to follow Cowling and Waterson (1976) and rewrite it as

$$(2.4)\ (P - c_i'(q_i))/P = MS_i(1 + \lambda_i)/\eta_j$$

η_j being the industry elasticity of demand and MS_i the firm's market share. We can then aggregate over all firms in the industry:

$$(2.5)\ \Sigma[(P - c_i'(q_i))/P] = H(1 + \lambda_j)/\eta_j$$

This relates the Lerner Index (price-cost margin) to $H = \Sigma q_i^2/Q_j^2$, the Herfindahl index and $\lambda_j = \Sigma\lambda_i q_i^2/Q^2$ the weighted average conjectural variation. If the left hand side of (2.5) is replaced by the profit-sales ratio and if we assume that the five firm concentration ratio is a good proxy for H this gives a theoretical justification for the traditional profitability -concentration regressions.

In his recent review of these inter-industry studies Salinger (1990) argues that although there seems to be some pro-cyclical variation in the concentration coefficient over time (see also Machin and Van Reenen, 1992) it remains positive and significant. The effect proves to be even stronger when one controls for the fact that the existence of rents encourages union organisation to bid them away and foreign firms to enter the market.[20] So why does Salinger say that ".. it is hard to imagine a literature for which graduate students in economics are taught to have more contempt"? (p.287). There have been two major theoretical attacks[21].

The first offensive came from Chicago with Demsetz's (1973) critique

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[20]It may also promote monopsony power by purchasers of the firm's products, severe non-price competition and leisure preference by mangers.

[21]Some other criticism, such as the definition of the dependent variable are tackled in the following chapter.

that the observed relationship had nothing to do with concentration but merely reflected the fact that there was differential efficiency[22] between firms within an industry. Since the most efficient firms gain more market share a concentrated market structure may be due to a relatively larger number of efficient firms rather than a small numbers oligopoly. A narrower version of this critique had long been recognised; industries where there existed large scale economies had fewer firms because the market could not support large numbers. Most evidence, however, suggested that levels of concentration were above those demanded by minimum efficient scale.

Empirical support for the Demsetz proposition seemed to come from Line of Business Studies (Ravenscraft, 1983, Kwoka and Ravenscraft, 1986) which showed that once one controlled for market share, concentration was often negatively related to profitability. Despite the rhetoric it is unclear why the Chicago view is not complementary to the market power hypothesis: if firms have cost advantages why will they not use them to alter the price level strategically? As Simons (1944) said "Monopoly power must be abused. It has no purpose save abuse" (p.6). The debate does alert one to the fact that equation (2.4) suggests that it is market share which is the best measure of rents at the level of the firm.

The second line of attack, formally articulated by the the game theorists, but acknowledged for a long time by empirical workers[23], was more fundamental. They emphasised that equations like (2.5) related endogenous

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[22]Demsetz interpreted 'differential efficiency' in a very wide sense to include managerial insight, luck and so on. A more narrow interpretation is that lower costs reflect economies of scale and that firms earning high profits in concentrated markets are just enjoying an 'interger effect' in the same way as a natural monopoly does.

[23]This is often forgotten by those who dismiss the structure-conduct literature as a degenerate research program. See in particular Cable, 1972, and Strickland and Weiss, 1976.

variables to each other and that the underlying factors of consumer tastes, technology and the toughness of price competition were the parameters of interest. Specifying these conditions more explicitly and embedding them within the context of repeated, multistage or state-space games has hugely enriched the types of industrial behaviour which we can rationalise as the equilibrium of a game (see the survey by Shapiro, 1989, for example). The power of the literature has been to formalise many notions that were only stated vaguely before. For example, we can show how firms can earn positive profits even as the market becomes very large with free entry[24]. The weakness of the literature is that any generalisations across markets are increasingly difficult to make and we are left with a thousand stories for a thousand situations.

One way of cutting the Gordian Knot is to try and statistically control for endogeneity in (2.4) through using the dynamic aspects of a firm level panel - this is the strategy adopted in Chapter 3. The alternative is to limit oneself to particular markets. Having richer detail on the market means avoiding the necessity of equating the price-cost margin with the profit-sales ratio and enables the researcher to estimate marginal costs directly. Applebaum (1979,1982) pioneered the technique by using total cost and factor demand functions to estimate (2.4) and recover $1 + \lambda$ as a parameter for four manufacturing industries. The precision one buys in estimating marginal cost depends on the accuracy with which one measures capital and the validity of the assumption that the cost function is homogenous of degree one. Whereas the latter can be tested the former cannot, so all the Fisher-McGowan (1983) criticisms of accounting profits are

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[24] For an explanation stressing endogenous sunk cost in R&D and advertising see Sutton (1991), for another stressing the role of reputation see Kreps and Wilson (1982).

likely to reemerge.

Given the large data requirements, two short-cuts to testing market power have been suggested. Looking again at equation (2.3) one can see how shifts in costs could be used to examine whether revenue fell (as in monopoly) or stayed the same (as in long-run perfect competition). Panzer and Rosse (1977) have pursued this line of enquiry. The disadvantages are that it can only discriminate between extreme hypotheses and that its validity depend on the stability of demand conditions. Natural experiments might be the ideal implementation of the Panzar-Rosse statistic[25]. As an alternative short cut one could look at shifts in demand, noting the the residual demand curve of a competitive firm is horizontal whereas it is sloping downwards under imperfect competition. Again, the difficulty lies in being sure one's demand shifts are not also cost shifts. Bresnahan (1982) on the U.S. automobiles market uses price changes of rivals' differentiated products as the identifying restriction, but as he himself admits a lot depends on the accurate ranking of brands in quality space.

Even if one was satisfied with accurate measures of demand and cost conditions there is still the problem of modeling λ, tacit collusion. Rather than treat it as a simple parameter, many writers have tried to use simple models of oligopoly and solve for the appropriate values of λ_i. These theoretical predictions can be compared with the freely estimated values. Common examples would be price taking, Cournot, monopoly or leader-follower models (e.g. Gollop and Roberts, 1979). Another way to parameterise collusion and make it relevant to particular oligopoly models is to move away from a static approach and observe how collusion varies over time. Models of

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[25]Ashenfelter and Sullivan (1987) do exactly this by looking at the effect of tax changes on revenue in the U.S. cigarette market.

price wars are discussed in Chapter Three, but note that they tell us little directly about the level of collusion, but rather how it breaks down and reestablishes.

The use of time series information of short frequency also allows researchers to estimate strategic responses in a very direct fashion. For example, Margaret Slade (1987,1992) uses daily prices as the strategic variable in her model of the Vancouver retail gasoline market. Changes in own firm price cost margins are estimated as a function of the lagged values of rivals' average margins, and an asymmetry of response is allowed between major and independent retailers. The price reaction functions (equivalent of the conjectures terms) are the parameters on the rivals margins. Their values consistently reject Bertrand behaviour[26].

A less structural approach to market dynamics is that of the 'persistence of profits' school (see Mueller, 1990, for a representative sample). The idea here is that entry threats will, in the long-run, drive any rents to zero so one should expect to see convergence in firm's profit margins over the long haul. Any welfare judgments or assessment of the role of union rent-seeking, will depend on how long the process takes. The empirical methodology of taking autoregressions in accounting profits and relating them to structural characteristics has highlighted three facts: adjustment is very slow, profits persist in the long run and firms with high market share converge less rapidly than others (e.g. Geroski and Jacquemin, 1988). Despite measurement difficulties and theoretical worries, these results do not sit easily with a ruthlessly competitive view of the market economy.

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[26] See also the dynamic models of strategic interaction in prices and advertising in the cigarette market by Roberts and Samuelson (1988).

Indeed, whatever the methodology employed to detect monopoly power practically all studies reject price taking behaviour (see Bresnahan (1989) Table 17.1). As Geroski (1988) concludes:

"In short, It does not seem difficult to find industries where at least some monopoly power exists, and it is hard to believe that at least some degree of market power is not present in most industries" (p.116).

The existence of market power is one thing, its *source* is another. The assumption here has been that tacit collusion through the recognition of interdependence is the cause of higher margins. Another possibility is that innovation is the driving force behind rent creation.

3. Technological Rents

Since the effects of innovation are the major concern of the thesis, we must be clear on what an innovation is and how we can measure it. Only then can the nexus between new technologies and rents be tackled. Schumpeter (1939) distinguished three stages in technical change, that of invention (discovery), innovation (commercialisation of an invention) and diffusion (the spread of an innovation). Inventions are generally the original ideas of creative minds and thus are hard to predict from economic theory. For example, Jewkes, Sawers and Stillerman (1969) studied 61 major Twentieth Century inventions and found only twelve of these began in corporate laboratories.

A second important distinction is between process and product innovations. The former are cost reducing (a shift in the isocost curve), the latter expand the firm's occupation of product space (a shift in the demand curve). The separation is important in principle as one would expect union opposition to be more likely if costs are being reduced than if sales are expanded. In practice they are hard to empirically separate, as new products may be inseparable from a change in process technology[27].

Technical change is commonly measured in one of four ways: Total Factor Productivity (TFP), patents, research and development (R&D) and headcounts of innovations. TFP is the most common of these and the least satisfactory as it actually relates to any shift in the production function. Thus it is a measure of *diffusion* rather than *innovation* as we have defined it. TFP is usually estimated through the Solow (1957) residual:

$$\tau_t = \Delta\log(q/K)_t - \alpha_t\Delta\log(N/K)_t$$

q = output, K = capital, N = labour, α = labour's share of output, $\tau = \Delta\log A$ where A is Hicks neutral technology. This relationship is derived from a constant returns production function of the form $q = Af(K,N)$ *only* under the assumption of the equality of price and marginal cost (e.g. Hall (1986)). When price exceeds marginal cost

$$\Delta\log(q/K)_t - \alpha_t\Delta\log(N/K)_t = \Delta\log A_t + \rho_t\alpha_t\Delta\log(N/K)_t$$

Where ρ = the price-cost margin. In general then, unless one accounts for product market power or uses cost-shares instead of revenue shares estimates from the Solow residual are biased upwards[28]. This has an important bearing on studies which use the Solow Residual to claim that unions reduce productivity growth. These studies could actually be reflecting the union's reduction of firms market power.

The second preferred measure of innovation is R&D expenditures, usually normalised by sales or employment[29]. This has the advantage of being a

[27] The product innovation of a firm in the capital goods industry will become a process innovation for a downstream firm. The shutterless loom was a cost-saving innovation for the weaving industry but a product innovation for the textile machinery industry (see Davies, 1979, for a full discussion of this).

[28] Hall himself uses the bias induced in the Solow residual to test and reject the hypothesis of constant returns to scale for U.S manufacturing.

[29] For example, some studies divide the number (or total salaries) R&D

continuous measure and available from company accounts, but it has three disadvantages. First, R&D employment excludes flows of services from research equipment whilst R&D expenditures are expensed rather than capitalised under accounting rules[30]. Secondly, R&D is an input into the innovative process and not an output. Griliches (1979) has argued that the proper input measure should be the services of an accumulated knowledge stock from which the firm draws. Empirically dealing with the appropriate depreciation rate, lags between current R&D effort and the knowledge stock and inter-firm spillovers is a Herculean task. Finally, it is unlikely that formal R&D really captures the firm's total innovative effort (e.g. shopfloor learning-by-doing)) and certainly small firms do hardly any formal R&D. The latter gives rise to serious problems: Pavitt, Robson and Townsend (1987), for example, show that in 1975 firms with under 1000 employees accounted for only 3.3% of R&D expenditures but 39.9% of major innovations.

Patents are the most popular (intermediate) output measure of innovation, not least because their timing and content are largely unambiguous. However it is well known that not all innovations are patented (valuable information may be given away to rivals); not all patents are used (they may be merely a signal of success); and patents are of very variable quality[31]. In the words of Shepherd (1984) "Most of the 80,000 patents issued each year are worthless and never used. Many are of moderate value, and a few are bonanzas. Still others are of negative social value. They are used

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staff by the total employment (or wage bill).

[30]The definitions used in financial reporting give leeway to accountants to misrepresent the true level of R&D for tax purposes.

[31]One can attempt to get around this problem (which is after all always present to some degree in all quantity measures) by (i) looking at stock market responses (Griliches, 1990), (ii) looking at patent renewals (Shankerman and Pakes, 1986). The distribution of values is highly skewed.

as blocking patents to stop innovation or are simply used to keep competition out".

The preferred method, used in Chapters 4-6, is a headcount of innovations. These are compiled by asking various experts to identify major technological breakthroughs and so are heterogeneous in economic value. There is an unavoidable arbitrariness in selecting what counts as 'major', but this is mitigated by using many different specialists. There is a further problem in that the surveys are backward looking and correct identification of the year of innovation is more problematic as one moves further away from the survey date. Because of these difficulties Chapter 7 uses a measure of diffusion accessing a survey which asks establishments whether they had introduced micro-electronic technologies over the past three years.

Innovation bequeaths the firm economic rents almost by definition. To the extent that these are a 'normal' return on R&D investment, one could consider that the returns from innovation are only a form of quasi-rents. It seems inherently unlikely that the rate of return on R&D capital will be equalised across firms because of the extremely stochastic nature of the innovation process and the fact that knowledge has many aspects of a public good. The relationship between innovation and market power is a complex one which must be considered in in detail.

The fundamental problem with the knowledge capital of the firm is that it often spills over to other firms. This lack of appropriability will tend to mean that social rates of return are below private rates of return. The patent system arose out of this dilemma and grants firms a degree of temporary ex post monopoly power to give them a greater incentive to do R&D. It is now quite clear from the research of Levin at al (1987) that outside a few industries (e.g. pharmaceuticals) patents are a very poor way of protecting innovations. Not only do they reveal information to one's rivals but they can often be 'designed around'.

Recognition of the appropriability problem was an important component to Schumpeter's claim that "Perfect Competition is inferior and has no title in being set up as an ideal of efficiency" (1942,p.106). Although he is often ambiguous[32], his basic position was that ex post *and* ex ante market power encouraged technical change. He also believed that the static welfare deadweight losses associated with monopoly were easily overwhelmed by the dynamic gains from faster technical change.

Ex post market power is a reward for the costs of innovation and so offsets the appropriability problem. But actual, ex ante market power may also benefit innovation. Indirectly, it may be that a current period monopolist is well placed to erect future barriers to entry or that future innovations may be complementary to current ones. Directly, there are several other routes. First, there may be positive incentives as oligopolists are likely to be operating in a more stable and less uncertain environment. This is debatable in light of supergame models of oligopoly and the empirical evidence from Domowitz et al (1987) that prices have greater cyclical variation in concentrated industries. A more persuasive argument is that in a world of imperfect capital markets where external financing of R&D is difficult, large internally generated cash flows may be a sine qua non of innovative activity[33]. On the other hand there are serious disincentives under monopoly. There may be losses in X-efficiency associated with

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[32] Schumpeter's definition of innovation encompassed the inherently unpredictable and individualistic search for market opportunities and niches. In the Austrian view of the world it is seen as the fundamental dynamic of the capitalist system.

[33] There seems to be an inherent moral hazard problem in transferring information about a risky project from entrepreneur to investor. Additionally, firms may not want to reveal information to their competitors . Often this is linked informally to the 'short-termism' of capital markets in general and in Britain in particular.

bureaucratic inertia and an incumbent monopolist enjoying the rents generated from a previous innovation will lose them if a new innovation displaces the old one[34].

The game-theoretical approach to innovation shares the strengths (rigorous models) and weaknesses (too many delicate equilibria) of the modern approach to oligopoly in general. Two interesting points stand out, however. Dasgupta and Stiglitz (1980) emphasised that in tournament models (i.e. there is only one winner), the level of R&D is likely to be too *high* as firms duplicate each other's research in the race for the prize. Secondly, Sutton (1991) has shown that in markets where R&D is important there will be increases in concentration after some critical value of market size, with firms earning positive profits in free entry equilibrium. Thus, industries where R&D is important are earning a surplus even when their investments are netted out.

What is the evidence on the size of pay-offs to technical change? Although macro-economic estimates of Total Factor Productivity suggest it 'explains' a large part of growth (Denison, 1962) the paucity of data has meant that there is hardly any British evidence on this issue. In a recent survey of the (often badly determined, but almost always positive) relationship between R&D and productivity Mairesse and Sassenou (1991) do not quote a single British study.

Shankerman and Pakes (1986) have used information on annual patent renewals to infer the mean and variation of patent values for Britain, France

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[34] They are not reviewed them here, but tests of the Schumpeterian hypothesis that firms in concentrated industries or with high market shares innovate more have not been corroborated. Although large firms do more R&D, Geroski and Pomroy (1989) find that innovations tends to fragment industrial structure and that unconcentrated industries have a higher rate of innovation (Geroski,1990). The Cohen and Levin (1989) survey yields ambiguous results for U.S. studies.

and Germany. Given the open ended class of patents (those paying throughout the period) and the low and stable renewal fee schedules serious identification issues arise in these models. The authors have to impose strong functional form restrictions on the distribution on the truncated end of the distribution and the depreciation schedule. They find that the median value of a patent is low ($1,861 in 1980 prices), but very skewed (only 10% of the sample have values over $16,125) which suggests that large innovations may be an important source of high profitability.

An alternative approach is to use patent data explicitly in a market value or profits function and calculate their implied value which is analogous to what is done in Chapter 4 utilising data on counts of innovations. Using stock market data, Cockburn and Griliches (1988) found an average value of about $500,000 and Pakes (1985) a value of $810,000 for an 'unexpected' patent (Pakes,1985). This has the advantage that efficient stock markets will discount forward the value of a patent in the share price, but the disadvantage that these share prices are often very volatile. For example, Griliches (1990) estimates that patent numbers can account for at best 0.1% in the unexpected changes in the value of the firm.

All these estimates are returns to own patents, but a major unresolved area in estimating the value of new technology is the size of spillovers. One needs to have strong priors over who are the potential beneficiaries of whose research. Jaffe (1986) used firms patenting activity to construct measures of technological opportunity and examined the effects of rivals R&D on own-firm performance. Although the average effect was positive, this was only for firms who did *substantial* R&D. Firms one standard deviation below the mean lost out. This is consistent with Cohen and Levinthal's (1989) suggestion that a firm must do some R&D to share in the knowledge produced in other sectors. More recently work by Bernstein and Nadiri (1988,1989) has also uncovered substantial intra- and inter-industry spillovers. Although intra-industry spillovers could increase industry product market power, inter-industry spillovers will tend to have the opposite effect, so accounting for them is very important.

Chapter 4 investigates the profitability value of innovations, controlling carefully for other aspects of market structure. Spillovers are of particular interest as is the question of whether profitability differences between innovating and non-innovating firms resides purely in the fact of technological change *per se*. The chapter also examines whether the effects of market structure on margins is purely an innovations effect or whether collusion and market power exist independently as a source of rents. What is clear from this survey is that innovative rents deriving from own firm research and spillovers are a large potential pool for a supra-competitive surplus.

III The Capture of Rents

1. Capturing Product Market Rents

An attractive way to look for evidence of union appropriation of the gains from tacit collusion emerges naturally from the history of the Structure-Conduct-Performance paradigm[35]. Omitting union strength from a profitability equation will bias downwards the coefficient on proxies for market power if unions are sharing in the gains from collusion. In the long-run, the only industries where unions should depress profits is where market power exists and a surplus can be shared. Consequently, the importance of an interaction term between say, union presence and

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[35] We look at labour market evidence below in sub-section 3.

concentration should give some insight into how rents are divided between capital and labour.

The British evidence is generally favorable to the rent sharing hypothesis. At the industry level Conyon and Machin (1991a) find that the elasticity between profit margins and concentration rises from 0.089 to 0.146 when one controls for union coverage and industry unemployment. Furthermore, the depressing effects of union power seem confined to concentrated industries (Conyon and Machin, 1991b). One objection to their study is that the union interaction is merely another variable in disguise. Haskel and Martin (1992), using a similar dataset over the same period (1983-86) wipe out the union interaction by including an unemployment-concentration interaction. Nevertheless, they still interpret this as a bargaining effect due to unions being stronger when unemployment is low[36].

Fortunately, the rent-sharing story is supported by work at a lower level of aggregation. Using a two year panel of 145 manufacturing firms Machin (1991) found that the negative effects of union recognition on accounting profits were confined to firms with higher market shares or high levels of industry coverage. Similarly Machin and Stewart (1990) found that the union-induced reduction in a manager's perceptions of their plant's financial performance were only significant when the establishment had a high share of industry employment or faced few competitors.

A similar pattern appears in the U.S. literature. Early studies which found a significantly negative effect of unions only in concentrated industries (e.g. Karier, 1985) have been sharply criticised for being unrobust (e.g. Connoly, Hirsch and Hirschey, 1986). The micro evidence

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[36]The implication of countercyclical margins and higher productivity in a recession seems very peculiar and we discuss this further next chapter.

seems more secure (but see Clarke,1984 for an exception) but is given a sharply different interpretation. It is argued that organised labour skims off the rents from investment in general and innovative activity in particular. Rather than being a countervailing force to monopoly power, unions are prematurely harvesting long-lived capital and so destroying the economic crops. How is this done?

2. Quasi Rents from Capital Investment

"Frankly I can think of no reason why strongly organized workers, in an industry where huge investment is already sunk in highly durable assets, should ever permit a return on investment sufficient to attract new capital..."

(Simons,1944 p.8).

Firms generate rents through market power and new technologies. What happens if these quasi-rents are the returns from earlier capital investments? Consider a model where capital (think of it as knowledge capital from R&D investments) is determined at stage 1, then there is an efficient bargain over wages and employment at stage 2, and finally profits are determined in the product market. For simplicity perfect competition in the output and capital markets is assumed and the union is risk neutral. Define the capital revenue function as:

(2.6) $\mathcal{R}(K,P,\tilde{W}) = \max\ [Pf(N,K) - \tilde{W}N]$

i.e the profit function in a perfectly competitive labour market conditional on capital. Define the capital profit function as:

(2.7) $\mathcal{P}(K,P,\tilde{W},r) = \mathcal{R}(K,P,\tilde{W}) - rK$

where r is the cost of capital.

If the union bargains over capital then the problem is simply to maximise (2.7) which will mean the level of R&D is set the same as if there were no unions ($\partial\mathcal{R}/\partial K = r$) This is symmetric to the vertical contract curve result whereby the firm sets employment as if it was facing the outside wage. The wage merely splits the rents in proportion to bargaining power. Implicitly the union is sharing the costs of capital by taking a lower wage.

By contrast if the firm sets capital unilaterally, the relevant objective function is the capital revenue function (2.6) because capital is locked in at Stage 2. For a given K, the union is better off and the firm worse off. But now consider the determination of investment. Under the first scenario it is no different to perfect competition, but under the second case maximisation of (2.6) gives $\beta\mathcal{R}(K,P,\tilde{W}) = rK$ or $\partial\mathcal{R}/\partial K = r/\beta$ The rental price of capital is increasing in union power ($\beta \longrightarrow 0$). Stronger unions 'tax' capital by appropriating higher quasi rents and reducing the firm's incentive to invest. The union is better off by not bargaining over capital as it is no longer sharing in the costs of investment. This is offset by sub-optimal investment which lowers the surplus of the firm. Although strong unions would like to promise not to appropriate the quasi rents, in the absence of binding contracts these promises will not be credible and the perfect equilibrium will involve an inefficient level of capital investment (see Figure 2.4)[37].

A strong union firm pair has the pay-off structure of a prisioner's dilemma. Thus the folk theorem of repeated games will apply and cooperation may be sustained if the union values the future sufficiently highly[38]. Even

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[37]For the wage implications of this see Appendix 7.2

[38]Possibly through reputational equilibria as suggested by Van Der Ploeg (1987).

if long-term contracts were available there is still the problem that the union's time horizon is likely to be shorter than the replacement cycle of some forms of capital. Long-lived and immobile investments, like R&D, may be particularly vulnerable to capture (Baldwin,1983). The optimal response of the firm is to switch its asset structure towards shorter lived capital and more debt (Bronars and Deere, 1990).

The negative effects of unions on investment were formalised by Grout (1984), but the perspective was first clearly articulated by Simons. The model is an example of the general class of 'hold up' problems which arise when one party with a sunk investment bargains against another who does not, and as such its conclusions can be reversed. There is ample scope for the firm to exploit the firm specific human capital of the worker in an analogous manner which will lead to a lower level of human capital accumulation. By giving workers the ability to capture the returns from this human capital the union encourages training, and a higher level of productivity in the manner stressed by the Harvard School.

Another objection to Grout comes from generalising the model. When one takes into account i) the tournament nature of R&D, ii) risk aversion of trade unions, iii) strategic interaction in the product market, iv) multiple firm-union pairs it is possible to find situations were stronger unions encourage higher R&D investments in the absence of long-term contracts (see Hamnett and Ulph, 1990).

Even if one did believe that union power reduced investment substantially then the welfare effects are unclear. Some types of capital may be excessive due to entry deterrence, excessive advertising or duplication of research programs. It is true, however, that the general feeling is that 'more is better' in the case of innovations.

There is a growing literature on testing whether unions are associated with lower rates of investment and productivity growth. Table 2.2 summarises the micro-econometric results from this literature. The British evidence (with the exception of Denny and Nickell, 1992) would seem to flatly contradict the Grout story. Most of the studies find that unions are associated with more innovation and investment, or make no difference at all[39]. One reason to be wary of generalising these results is that most use data from the 1980s when unions were being weakened and it may be this weakening which is causing a positive response from investment and productivity growth. The finding of Nickell et al (1991) that firms with high union density have slower productivity growth in the 1970s but higher in the 1980s is in line with many industry studies (e.g. Metcalf, 1991).

American work tends to find that unions depress innovation, particularly Research and Development expenditures. Many of the studies are open to several objections, however. There seems to be a general lack of awareness of the fact that TFP estimates are biased upwards in the presence of market power or increasing returns to scale, so that unions may be reducing the benefits of these rather than real productivity growth (e.g. Link, 1982). A secondary problem is that most of the studies use industry level measures of unionisation, even in firm-level studies (e.g. Connoly, Hirch and Hirschey , 1986). When appropriate data is available the pattern of results is not as unfavourable to unions as the gloss the authors put upon them. For example, in the Hirsch (1989) monograph unions seem to boost the propensity to patent and lower the level of R&D expenditures[40]. Since we argued that patent

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[39] e.g Gregg,Machin and Metcalf (1991), Machin and Wadhwani(1991b) and Latreille (1992) find positive and significant effects, Machin and Wadhwani (1991a), Lintner et al(1987) and Geroski (1990) find insignificant ones.

[40] He argues that this is because unions find it more difficult to appropriate patent rents because they can be licensed or sold whereas disembodied knowledge from R&D cannot.

expenditures may be a superior measure of innovative output to R&D this does not necessarily signal that unions depress innovation. In addition, his results do not seem robust to attempts to account for the endogeneity of union status or for firm fixed effects.

The main objection towards this body of literature is that it cannot really discriminate between union effects working via quasi-rent seeking and union effects via organisational rent creation or destruction. If we are interested in rent-seeking, then rather than put the cart before the horse, we should see whether unions really are better at capturing rents from capital, by looking at wage gains. The few empirical studies attempting this are reviewed in Chapters 6 and 7 and our own methodology is outlined below.

3. Wages and Rent Capture

The framework of union-oligopoly bargaining has been the subject of much theoretical interest of late (e.g. Dowrick, 1989; Ulph and Ulph, 1990; Bughin, 1991). We consider a very simple model here to motivate looking at the empirical consequences for wages when there is union-oligopoly bargaining.

Consider a model where the contribution of the union and the firm to the Nash Bargain is $(W - \tilde{W})N^{\psi}$ and $P(Q)q - WN$ respectively (i.e. capital is installed at stage 1). Under a labour demand model employment will depend on the wage at the next stage of the game N(W). So the Nash Maximand is

$$\underset{\max\{W\}}{\Omega} = \log(W - \tilde{W}) + \psi \log N(W) + \beta \log \Pi_{w}/\Pi$$

This solves to :

$$(2.8) \quad W/(W - \tilde{W}) = \psi\eta_{NW} + \beta\eta_{\pi W}$$

The bargained wage is increasing in alternative wages, but decreasing in the relative power of the firm (β), the union preference for employment (ψ), the elasticity of labour demand (η_{NW}) and the elasticity of profit with respect to wages ($\eta_{\pi W}$). Consider any exogenous shift parameter J (e.g. a technology shock).

(2.9) $\text{sign}(\partial W/\partial J) = -\text{sign}\ \partial/\partial J\{\psi\eta_{NW} + \beta\eta_{\pi W}\}$

J will influence the bargained wage to the extent that it influences the elasticities (assuming that ψ and β are unaffected).

The elasticity between profits and the wage can be written $\eta_{\pi W} = -WN/\Pi$ by using Hotelling's Lemma, so that any decrease in labour's relative share is associated with an increase in wages. As is well-known (see Chapter 6) increases in monopoly power causes a decrease in labour's share and so an increase in the bargained wage. Although this seems the most likely link between wages and monopoly, and is one favoured by standard texts (e.g. Layard, Nickell and Jackman, 1991) an alternative route is more traditional. This operates through the Marshallian conditions for the derived demand for labour which depends on the firm's product demand curve, labour share and elasticity of substitution. The effect is more ambiguous under imperfect competition, however, as increased collusion means allocating more production to the lowest cost firm. This implies that small increases in wages can have big employment effects and η_{NW} may actually increase with market power if it is derived from an autonomous increase in λ (this is shown more formally in Dowrick , 1989, and Appendix 6.1). It may explain why concentration is poorly determined in wages equations[41]. Consequently, one must look more closely then at the empirical implications of rent sharing for the wage structure.

Perhaps the main reason for the interest in rent-sharing theories of

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[41]Employers with market power may also invest more in inventories and other activities to weaken the union's strike threat.

wage-bargaining derives from the perceived inability of standard competitive models to adequately explain the existing wage structure. Such models emphasis the equalisation of net advantages through the forces of competition in the labour market. Once one controls for human capital (both observed and unobserved) and compensating differentials, the present value of wages should, in long-run equilibrium, be the same. This emphasis on the supply-side seems inadequate in explaining many robust features of labour markets, in particular the remarkable persistence of inter- and intra-industry wage differentials over time within and between countries[42]. The temporal stability of differentials lends against an argument stressing random variations due to informational search costs. These costs may explain why higher inter-industry wage dispersions may persist over time, but not why the average level of wages could be persistently higher in some industries.

One strand in the applied literature seeks to side-step the problem of where rents come from and merely asks how important are internal (or 'insider') factors in wages determination compared to the standard external labour market influences. Wages are essentially determined by a weighted average of the 'alternative wage' and per capita profitability (Christofides and Oswald, 1989, Denny and Machin, 1991, revenue (Svenjar, 1986)[43] or average productivity (Gregg and Machin, 1991). An attractive feature of this modelling strategy is that it seems to fit the facts of wage determination from the industrial relations literature. Evidence from the Workplace Industrial Relations Surveys and the Confederation of British Industry's Pay

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[42]For a survey of inter-industry differentials for the U.S. see Krueger and Summers (1988) and for the UK, Haskel and Martin (1990). For intra-industry differentials see the survey by Groshen (1991)

[43]There are many ways to generate this sort of model. Consider the first order conditions for a Nash Bargain over wages between a risk neural union and firm, for example.

Databank (Gregory et al, 1985) strongly suggests that company performance is perceived to be a powerful force in pay setting. For example in WIRS, about three times as many managers thought firm performance (as measured by its productivity or profits) was a more important factor than merit. Interestingly, broadly the same factors influenced union and non-union settings although this may be for different reasons[44].

Empirical estimates of insider power have generally been small, but significant relative to outside influences. For example, in fitting an equation of the form

$$\text{Wages} = (1-\vartheta)(\text{alternative wage}) + \vartheta(\text{insider factors})$$

and allowing for partial adjustment in wages, Nickell and Wadhwani(1990) estimated $0.08 \leq \vartheta \leq 0.15$. They went on to argue that ϑ was positively associated with decentralised bargaining and not with unionism per se, which is what Nickell and Kong (1989) had found earlier on industry level data. Some caution must be exercised here as Nickell and Wadhwani only have 73 union firms and there are no overt controls for observed or unobserved human capital[45].

In order to look at rent sharing directly, some authors have tried to estimate variations of equation (2.8) linking wages directly with market power. The substantial literature provides evidence of a weak positive

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[44] e.g. Non-union firms may be operating nearer to bankruptcy so consider short-run profits a greater influence on all decisions.

[45] The debate over the persistence of inter-industry differentials in the U.S. (see Katz and Summers (1989) for a summary) has centered around the difficulty of controlling for unobserved heterogeneity in labour quality. Using the matched Current Population Survey one can look at individuals who have switched industries to control for the fixed effect of ability (Krueger and Summers, 1988, Murphy and Topel,1987). Gibbons and Katz (1992) point out that longitudinal data will fail to solve the problem if worker's productive ability differs by industry and the switching becomes endogenous as workers learn where they are best matched. Consequently they used the Displaced Worker Survey and still found industry specific differentials

correlation between wages and concentration, but this is generally not robust when measures of labour quality are included (Dickens and Katz, 1987 summarise the U.S., Blanchflower, 1986, does the same for the U.K.). It seems to have been overlooked that all of the main studies actually find negative effects of concentration on union mark-ups (Mellow,1982; Heywood, 1986; Stewart, 1983; Kwoka, 1983). This may well be due to non-linearities (Abowd and Tracy, 1989) arising from the dual effects of collusion on the different elasticities of labour demand and profitability as theory suggests.

As seems to be the general pattern, firm and establishment research is a lot more informative and supportive of rent-sharing. Stewart (1990) using the 1984 Workplace Industrial Relations Survey shows that union differentials are maintained only where managers perceive themselves to be faced by few or no competitors or where unions cover almost the entire industry. Vainiomaki and Wadhwani (1991) and Nickell et al (1992) examine a firm-level panel and find a much stronger role for market share than concentration in their wage equations[46]. Finally, Rose's (1987) event study of the deregulation of the trucking industry revealed that the Teamsters Union captured about two-thirds of the industry's rents, whereas non-unionists were substantially unaffected[47].

If innovation enhances the product market power of the firm then we will expect to see wages increased via the channels outlined above. The literature on this is reviewed in Chapter 6. This also has the advantage of

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[46] In contrast to Stewart, however, unionised firms seem no better at rent capture than non-union firms. A problem with their model is that it is choked by so many insider variables it becomes unidentified from the employment equation.

[47] Card's (1989) examination of airline deregulation did not find dramatic falls in the union mark-up, but it is not clear that monopoly power has been reduced in this industry.

explicitly considering the economic fundamentals in the link between market power and wages. There is of course the straightforward neoclassical route via the effects of technical change on the marginal products of different factors of production (non-neutral technical change). If the marginal productivity of labour increases then its price will rise, as reflected in 2.8 by an upwards movement of $\tilde{W}$. If we wish to isolate the rent-sharing phenomenon we have to make some sort of control for skill and this is what is attempted in Chapter 7.

It is worthwhile emphasising that there is no automatic link between new technology and higher skills. It is true that optimists of the 'Post-Industrial Society' (e.g. Kerr et al, 1964) have stressed the upgrading of the occupational structure over time as the demand by employers for more educated workers has increased. But pessimists point out that employers have a strategic incentive to implement new technologies which de-skill workers to weaken their bargaining power and so lead to lower labour costs (Braverman,1973). This is not mere paranoia as equation (2.8) makes clear - when management have unilateral control over technology, profit-maximising behaviour induces them to behave in such a manner. Most empirically minded social scientists take an agnostic view as the overall quantitative changes[48] have been very mixed with no systematic trend (see Spenner, 1988, for an excellent survey).

IV Conclusions

This chapter has presented the elementary building blocks for the studies which follow. Unions value higher wages and employment and seek to

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[48] 'Skill' is a very slippery concept. Not only do occupations change in their skill content over time, but is is as much a social as a technical category (consider the 'skill' of a Fleet Street printer in the days before Wapping).

raise these by bargaining with firms for some of the surplus. Unions survive because they capture economic rents and empirical studies suggest that these are more likely to emanate from the product market than from higher productivity (organisational rents). Micro-econometric studies have shown that many firms have market power and that workers are more successful in increasing wages and reducing profits under these conditions. The most informative studies have been those which have used information at the establishment or firm level, especially when the data tracks the evolution of market structure over time.

A major gap in the literature exists as to the sources of market power. One powerful candidate is innovation, a source which has not been the subject of careful study in the British empirical work on union-oligopoly bargaining. This thesis helps to fill the gap by examining the effects of innovation and market structure on profitability, employment and wages. The results are used to shed some light on the ability of unions to capture technological rents.

TABLE 2.1: TESTS OF UNION BARGAINING MODELS

Authors	Data	Conclusions[49]	Comments
1. Significance of Alternative Wage			
Brown and Ashenfelter (1986)	U.S. Typesetters-10 locals 1948-65 (ITU)	Efficient Bargs instrumenting $\tilde{W}$ weakens result	Data on number of ITU members - not total employment $\tilde{W}$ very unrobust
McCurdy and Pencavel (1986)	U.S. Typesetters in 13 towns 1956-73	Efficient Bargaining	Problems as above. MRP estimated via translog prodn. fn. General utility fn.
Bean and Turnbull (1988)	U.K. Coal Mining 12 coal boards 1967-83	Efficient Bargaining	Euler equation; takes account of coal being exhaustible resource; poor capital controls
Bean (1991)	U.K. Coal Mining 1967-89 (no '84) 8 coal boards	E.B. until 1983 Labour Demand after 1984 strike	Only 4 years of data post 1984
Card (1986)	U.S. Airline Mechanics 1969-76	Weak Efficiency	3 equation system for W,N,Departures; Future W via forecast Eqn.(Lucas critique)
Card (1990)	Canadian Contract data 1968-83;1300 union contracts	Labour Demand	Instruments W by unexpected ΔW
Oswald and Christofides (1991)	Canadian Contract data 1978-1984 1015 contracts	Strong Efficiency	Regional Wage -ve vs. product and consumption W
Martinello (1989)	British Columbian Woods Products 1963 - 1983 annual observations on 4 Industries	Can't accept EB or LD in non-nested J-test	Only 84 observations and 22+ parameters serious correlation probs across time and industries
Eberts and Stone (1986)	Public School Teachers in New York State 1972-1973;1976-1977	Efficient Bargains	Test to see if emp-security enters the N equation.But they are also likely to enter profit fn.

G.B.M. = Manning's General Bargaining Model; E.B. = Weak Efficiency; S.E = Strong Efficiency; L.D. = Labour Demand Model, R.T.M.= Right To Manage.

TABLE 2.1: TESTS OF UNION BARGAINING MODELS - CONT.

Author	Data	Test	Conclusion[50]	Comments
2. Sequential Bargaining Model				
Alogoskoufis and Manning (1991)	1954-83, Aggregate U.K.	Does union power, unemployment or own wage enter the employment equation?	General Bargaining Model	Too aggregate; arbitrary identification restrictions
Andrews and Harrison (1991)	WIRS Panel 1980-84 Skilled in Union Plants	Union power over jobs proxied by bargains over non-pay issues	L.D. and E.B cannot reject each other W and $\tilde{W}$ insignif	Only 99 plants in sample; not much variation in first diff model
Paci, Wag-staff and Holl (1992)	WIRS 1984 Private Mnfng. 224 plants	Structural model for W,N,union power over W,N (4 equations)	E.B. in 10 out of 12 inds	Identification of system ad hoc
Nickell and Wadhwani (1991)	EXSTAT firms N=219 1975-1982;Mfng.	Test for W,$\tilde{W}$,union power,$\Delta\tilde{W}$. $\Delta\tilde{W}$ is the efficiency wage effect	Efficiency Wages with no jobs bargains	$\Delta\tilde{W}$ could be in union utility; industry dens poor proxy for union job power
Machin,Manning and Meghir (1991)	DATASTREAM firms N=232 1980-86	Test for W,$\tilde{W}$, union power (industry density and coverage)	Right To Manage	Ad hoc parame-terisation of $\partial N_t/\partial W_{t-1}$. $\tilde{W}$ effect changes over time.
3. Other Methods				
Abowd (1989)	2228 union contracts in U.S. private 1976-1982	Is an unexpected change in union wealth offset 3 monthes later by equal change in shareholder wealth?	Strong Efficiency	All of wealth Δs measured properly? only an accounting identity?;
Hendricks and Kahn (1991)	1978 and 1979 850 City U.S. police depts.	Union recog, W, $\tilde{W}$ in emp equation No extra effect of union if $\tilde{W}$ is an efficiency wage effect	Efficient Bargains	Equally compatible with GBM; dubious instruments for union; police pay due to politics?

[50] G.B.M. = Manning's General Bargaining Model; E.B. = Weak Efficiency; S.E = Strong Efficiency; L.D. = Labour Demand Model, R.T.M.= Right To Manage.

TABLE 2.1: TESTS OF UNION BARGAINING MODELS - CONT.

Author	Data	Test	Conclusion	Comments
Wessels (1991)	3 datasets: 20 Canadian inds 1971-81; 20 U.S. inds by state 1972; 83 U.S. construction projects 1973-74	Union recognition in an equation for Marginal Revenue Product (CES prodn. Function)	Labour Demand Model	Very aggregate industries; small no. of projects
Abowd and Kramarz (1992)	French firm panel 1978-87 Disaggregated into 3 skill groups and if Accord (firm level deal > Ind level deal)	$\tilde{W}$ in N equation to distinguish EB from L.D. Splitting of quasi-rents to identify EB from efficiency wages	Labour Demand Model	S.E. not tested vs. EB No dynamics
De La Rica and Espinosa (1990)	Spain 1977-88 Quarterly, 16 Sectors	EB the equilibrium of repeated RTM game. Discount rate as proxied by interest rate signif in EB but not LD N equation	Most near E.B.	Interest rate too aggregate a measure of discount rate

TABLE 2.2: THE EFFECTS OF UNIONS ON INNOVATION

1. Econometric
United Kingdom

Authors	**Data**	**Measures**	**Result**
Lintner, Pokorny, Woods and Blinkhorn (1987)	155 plants 1983-4	CADCAM, CNC, FMS binary firm level dens; recog	Generally +ve insignificant
Machin and Wadhwani(1991a)	WIRS 1984 721 plants	Organisational Change	+ve union effect even with dummies for region & inds
Machin and Wadhwani(1991b)	WIRS 1984 630 plants	Advanced and Conventional Change	+ve correlation wiped out by wage, org. change and Joint Consultative Committee.
Latreille (1992)	WIRS 1984 418 plants Private Manufacturing	whether the plant is using new micro technology in its processes	+ve and signif. effect of union recog. No control for wages, though
Denny and Nickell (1992)	73 3-digit manuf. inds 1980-84 WIRS aggregated up	Investment rate Recognition, Density	-ve recognition +ve density, but not enough to offset recognition
Nickell, Wadhwani and Wall (1991)	127 Manuf. firms unbalanced panel 1975-86	Firm level density in 1987	-ve but insignif effect on ΔTFP in 1970s,+ve in '80s
Geroski (1990)	SPRU at ind level 73 MLH, 2 cross sections 1970-4; 1975-9	% of workers covered (NES)	-ve but insignif
Gregg,Machin and Metcalf (1991)	329 large firms 1984-1989 EXSTAT	Union recog, closed shop and changes in their status	Signif +ve union effect only in 1988-89,stronger if decline in TU presence/increase in competition

TABLE 2.2: THE EFFECTS OF UNIONS ON INNOVATION - CONT.

United States

Authors	**Data**	**Measures**	**Result**
Keefe (1991)	1983 non-electrical Machinery inds. 7 forms of advanced manuf. processes; 835 establishments	Coverage *and* by particular union. Controls: wages, shift, training, size	2 of 7 have -ve signif effect; if training + wages ommitted (TU boost) signif -ve CNC, +ve ROBOT
Link(1981)	51 major mfng. firms active in R&D	TFP from firm level regs; Ind Coverage	TFP on R&D/S; union -0.025(1.83)
Link(1982)	97 firms: chemicals machiney, petroleum	as above	union coefficient -0.103(1.98)
Connoly, Hirsch Hirschey (1986)	367 firms from 1977 Fortune 500	3 digit ind cov. categorized(4) Book value of tangible assets (Excess Value)	EV on R&D, TU & RD*TU; RD/S on TU. -ve effs consistently
Hirsch and Link (1984)	19 2 digit mfng. 1968-72	% of prodn. wkrs. covered Gollop's and Kendrick's TFP estimates	-ve impact of union level and growth
Hirsch and Link (1987)	315 mfng. firms in New York 1985	Ordered response to question over. Product innovation control for R&D, Π, labour-management relations; firm dens split into binary	Ordered Probit Union signif. -ve
Hirsch (1989) Chapter 5,3 Tables 5.4,5.5 5.6	452 firms pooled 1968-80	R&D Masterfile 3 digit coverage Firm level cov. 1972,1977,1987	1)-ve on R&D/ Sales; 2)+ve on patents; but the effects of 1) go in a model which controls for fixed effects & 2) Effects go in 2SLS runs
Bronars and Deere (1988)	1970-76 756 firms Compustat unbalanced panel	3 digit industry union density	unionised inds lower R&D, capital, capital-labour ratio
Bronars and Deere (1987)	Election data from 1962-80 PLCs	NLRB representation elects	Union win has no effect on R&D

TABLE 2.2: THE EFFECTS OF UNIONS ON INNOVATION - CONT.

Acs and Audretsch (1987)	US Small Business Admin 247 4 digit inds(38% no innov) 1982 innovs from trade journals	Headcount innov/ No.of employees or sales. LHS = diff in innov between small and large firms;	Ind density +ve but insignif. Controls for K, advertising, conc, industry growth & skills
Acs and Audretsch (1988)	same as above	Total no. of innov in an ind; no. of innovs in firms with emps>500 and emps <500	Ind density -ve and signif in all specifictns
Sveikauser and Sveikausken (1981)	138 inds 1967	TFP 1959-69 fr ind regs; CB cov dur/non-dur;RD	-ve but insig output growth +ve
Benvignati (1982)	241 textile mills 1979	binary variable: 1 if firm adopts any of 33 major textile innov Union=1 if 10%+ textile wkrs rep	+ve usu. insig. union effect except on a probit of the 'pioneering' mills (+ve)
Kelley and Brooks(1988)	1015 metal-working establishments 1986	binary var over whether any prog-rammable automtn. control for owner-type,size,wages	no union effect but +ve wage effect
Taymaz (1991)	US Engineering Industries 1979-83 (42 observations)	Share of Numerica-lly Controlled Machine Tools as % of all machine Tools	-ve but not significant
Betcherman (1991)	536 Canadian firms 1980-85	Computerised tech as % of sales; as % of emps working with new tech;	-ve but insig.

TABLE 2.2: THE EFFECTS OF UNIONS ON INNOVATION - CONT.

UK Case Studies

Willman (1986)	Literature Review	"no widespread evidence of trade union resistence". Some in certain areas, e.g public sector.
Northcott et al (1990)	Literature Review of PSI Surveys of 1200 manufacturing plants 1981,1983, 1985,1987	Unions generally supportive e.g of 776 micro-electronic using plants onlt 7% of managers cited opposition from trade unions as a problem
Daniel (1987)	Workplace Industrial Relations Survey II	Stewards and unions more enthusiatic than managers

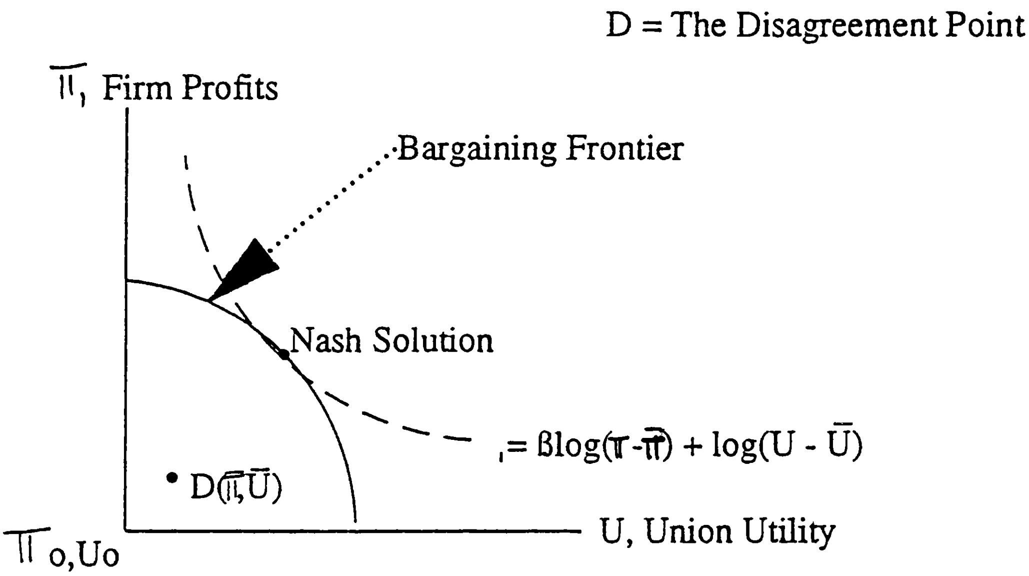


FIGURE 2.1 THE NASH BARGAINING PROBLEM

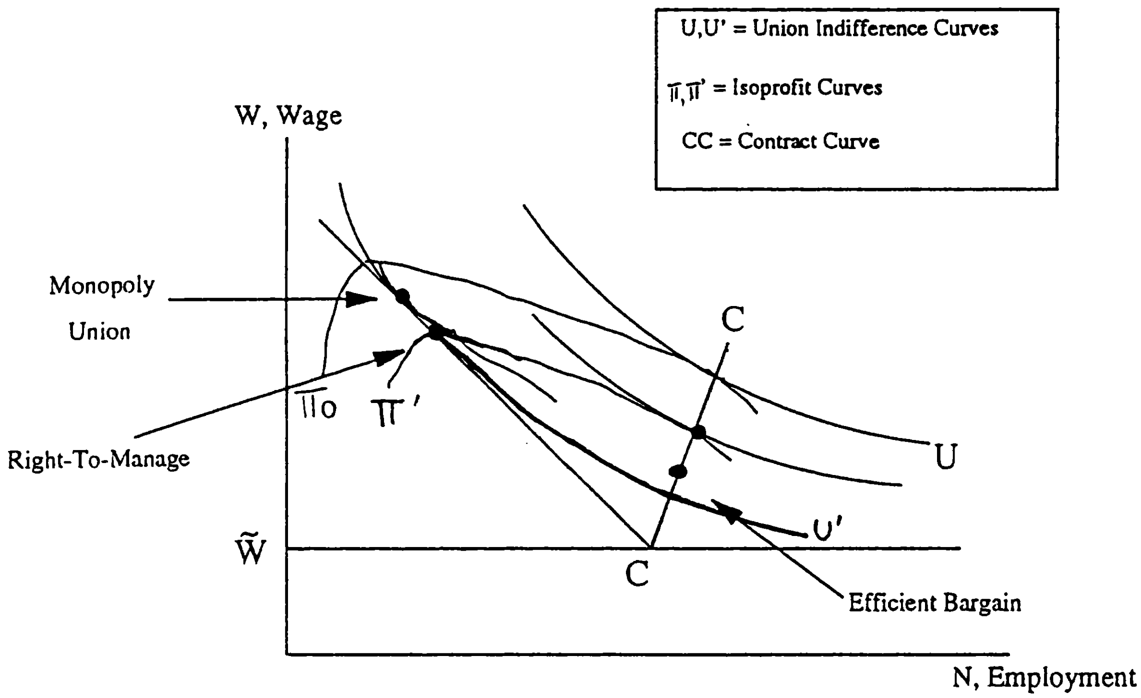


FIGURE 2.2 EFFICIENT BARGAINS AND LABOUR DEMAND MODELS

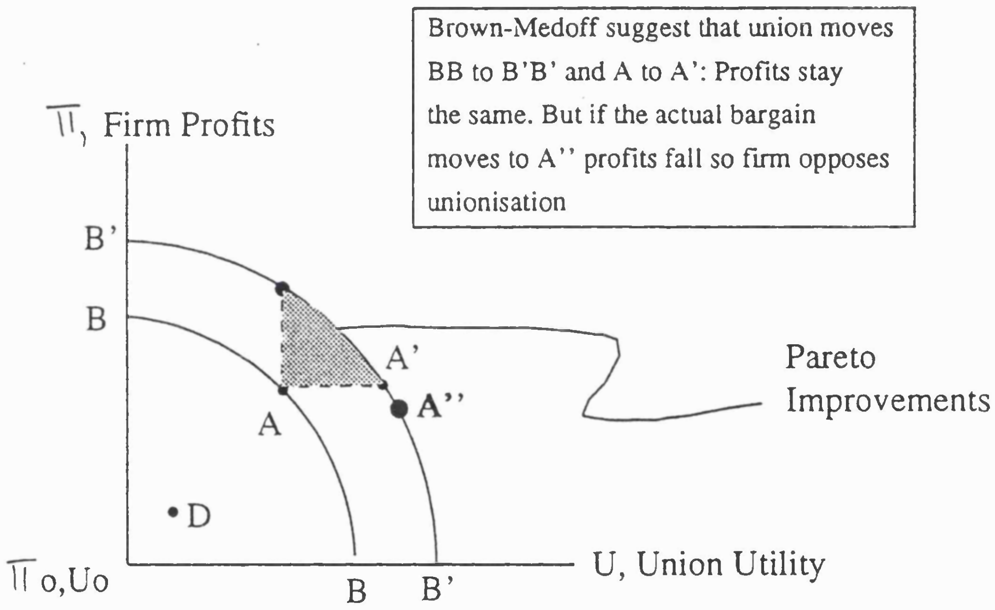
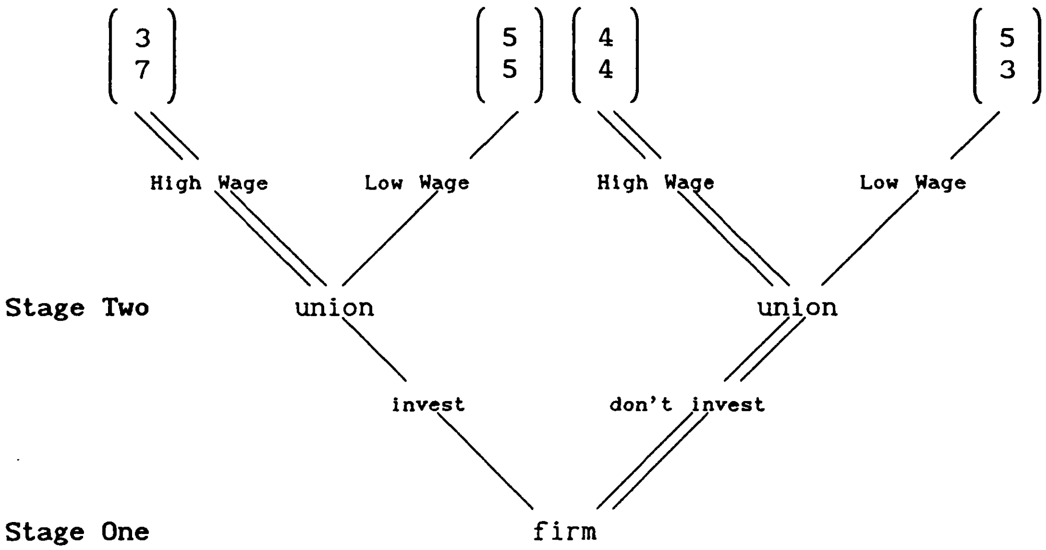


FIGURE 2.3 WHY THE FIRM OPPOSES UNIONISATION

Figure 2.4 Illustration of the Grout Effect

In the investment game below the sub-game perfect equilibrium is supported by the play(don't invest, high wage) as picked out by Zermello's Algorithm (the doubled lines indicate optimal choices at each sub-game node). NB. the first entry in the pay-off vector is the firm's.



CHAPTER 3:
THE CREATION OF RENTS I:
MARKET STRUCTURE, THE BUSINESS CYCLE AND PROFITABILITY

I. INTRODUCTION.

This chapter begins our investigation into the sources of rents which could constitute the firm's surplus available for bargaining with organised labour. We follow the classical oligopoly route of relating profit margins to measures of market structure, but unlike most of the literature we exploit panel data to overcome many of the problems that traditionally plague such studies. In particular we can account for the simultaneous determination of market structure and profitability, the presence of unobservable features of the firm that could give it efficiency advantages *and* overcome aggregation problems by going directly to the company level where micro-economic theory is based.

Recent game theoretic developments which focus on cyclical collusive behaviour emphasise the role that aggregate demand shocks may play in affecting firm profitability. Under quite general assumptions, these models have clearcut predictions regarding the behaviour of profit margins over the business cycle. Probably the most well-known of these models are the supergame models developed by Green and Porter (1984) and Rotemberg and Saloner (1986), the first of which predicts that margins should exhibit procyclical behaviour, whist the second suggests anti-cyclical margins.[1]

In this chapter, we use longitudinal data covering 709 U.K. companies over the period 1972-86, and attempt to evaluate some dynamic models of profitability in the light of such predictions.[2] Our two principal results

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[1] See also the extensions and developments by Abreu et al(1986), Haltiwanger and Harrington(1991), Kandori(1991) and Stenbacka(1991).

[2] Some recent empirical studies are reviewed in Geroski(1988),

are that (i) both market share and concentration exert a positive influence of firm-level profit margins and (ii) these margins exhibit quite strong procyclical behaviour, dipping considerably in the 1980/81 U.K. recession.

The layout of this chapter is as follows. Section II provides some preliminary data analysis, whilst Section III details the theoretical approach that adopted, and outlines its empirical implementation. Section IV briefly describes the data (more details are given in the Data Appendix). Section V presents the estimated models, and discusses some additional checks of the robustness of our results. Finally, Section VI evaluates the main findings and offers some conclusions.

II. Preliminary Data Analysis

Panel data is available on 709 large U.K. quoted companies over the period 1972 - 86 from the DATASTREAM databank of company accounts. The selection criterion used to obtain this sample is described (along with more data discussion) in the Data Appendix (Table DA4). Briefly, we restrict the sample to cover firms who operate in manufacturing industries (to facilitate the matching of industrial data) and who have at least 9 time series observations (the balance of the panel is also given in the Data Appendix). Apart from the fact that the firms are mainly large, we have no real reason to suspect that there is any serious sample selection bias and assume that these firms are representative of the Datastream population.[3] We do however discuss some estimates based on using balanced and unbalanced panels to check

Schmalensee(1989) or Salinger(1990). Older pieces are discussed in Scherer(1980). The relatively simplistic dynamic partial adjustment models usually used to study the persistence of profits are detailed in the series of papers in Mueller(1990).

[3] Although the fact that Datastream covers only large firms generates some selection bias in the whole population. This is something we really cannot do anything about, although we would argue that these (mainly) large firms are the ones on which a study looking at oligopoly power should focus on.

for any heterogeneity due to exiting from the data set before 1986.

The behaviour of margins over time is described in Figure 3.1, which plots firm-level averages for each year. The profit margin we use (Π/R) is the ratio of trading profits (profits inclusive of interest payments and depreciation) to sales. The use of accounting profits to measure economic rents is an issue of considerable controversy following the famous papers by Fisher and McGowan (1983) and Fisher (1987) which emphasised (to an extravagent degree) the divergence between accountants' depreciation conventions and the true user cost of capital[4]. Subsequently, authors have tried to overcome the problem by using stock market valuations such as Tobins's q which are by nature forward looking and risk adjusted (e.g. Salinger,1984) and have found similar correlations to the older literature. Below, we experiment with Fisher's transformation which is more robust than simple profitability. The basic position taken here is that all these proxies for the Lerner Index are noisy and one is forced to make a choice to concentrate on one of them. Even Tobin's q has the problem that share prices are very volatile being recurrently possessed by 'animal spirits'.

The time series pattern of (Π/R) is of some interest. Table 3.1 plots profit margins on a common aggregate cyclical indicator: the aggregate unemployment rate. Profit margins fell slightly through the 1970s, then more markedly to reach a low during the recession of 1981. Average margins then proceeded to rise in the 1980's, mirroring the trends observed in aggregate data. Unemployment rose sharply in the early 1980s and did not begin to fall until the mid 1980s. Figure 3.2 performs the same exercise but disaggregates the data by product group (producer goods, consumer durable and non-durables and a miscellaneous group). A broadly similar pattern emerges, though profit

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[4]This 'Hotelling valuation' would be the value of capital at the present value of the net revenue stream using the firm's risk-adjusted discount rate.

margins appear to be more strongly procyclical in the producer goods sample.

To examine the issue of cyclicality further we estimated simple regression models in which both firm-level and aggregate profitability were treated as a function of the unemployment rate (standard errors in parentheses)

Firm-level: $$(\Pi/R) = \underset{(0.001)}{0.124} - \underset{(0.021)}{0.345}\ URATE$$

(Sample size = 8151, estimation period 1972-86, $R^2 = 0.031$)

Aggregate : $$\overline{(\Pi/R)} = \underset{(0.004)}{0.119} - \underset{(0.082)}{0.323}\ URATE$$

(Sample size = 15, estimation period 1972-86, $R^2 = 0.545$, bar denotes annual average)

This exercise emphasises the procyclical nature of profit margins contained in the raw data. A sceptic might argue that this procyclical pattern itself forms a test between the supergame models mentioned in the introduction. We would be wary of this interpretation for at least two reasons: (i) time-varying factors other than aggregate demand may shape the intertemporal behaviour of firm-level margins; (ii) discriminating between supergame theories requires very detailed disaggregative (possibly subjective) data which is not available here (see Slade, 1990). Regarding (i), the next section develops more general models of profit margins to ascertain whether the procyclical pattern from the raw data remains intact when subjected to more rigorous econometric testing. On (ii), whilst we cannot provide tests to discriminate between the various hypotheses, we do go on to discuss whether or not the data is broadly consistent with one or other of the supergame models.

Whether there is any heterogeneity in the cyclical effect by industry and product group is also of interest (see Domowitz et al., 1986a, 1986b, 1987). We thus ran simple regressions for firms in producer, consumer durables, consumer non-durables and miscellaneous product groups. The following results emerged:

Producer goods

$$(\Pi/R) = \underset{(0.002)}{0.127} - \underset{(0.030)}{0.406}\ URATE$$

(Sample size = 3366, estimation period 1972-86, $R^2 = 0.053$)

Consumer durables

$$(\Pi/R) = \underset{(0.004)}{0.118} - \underset{(0.061)}{0.317}\ URATE$$

(Sample size = 1391, estimation period 1972-86, $R^2 = 0.019$)

Consumer non-durables

$$(\Pi/R) = \underset{(0.003)}{0.115} - \underset{(0.035)}{0.281}\ URATE$$

(Sample size = 2724, estimation period 1972-86, $R^2 = 0.023$)

Miscellaneous

$$(\Pi/R) = \underset{(0.007)}{0.140} - \underset{(0.091)}{0.358}\ URATE$$

(Sample size = 670, estimation period 1972-86, $R^2 = 0.023$)

Hence, the same pattern emerges across different product groups. However, there is some evidence of a stronger procyclical correlation for the producer goods companies. This is essentially the same as Domowitz et al (1986a) found on US industry level data. Note also the fact that the coefficient on URATE in the miscellaneous group (those companies in industries that could not be easily classified) is very similar to the average across all companies. This is reassuring but, due to the heterogeneity of the 54 companies in this group, we do not focus on them in the sub-sample results reported later.

Since the market share of the firm is our central structural variable we also checked that some relationship existed in the raw data. First ROR was regressed on MS for the whole sample, then by year. The results are in Table 3.2. A strong relationship exists in the pooled sample, and there is still a postive effect every year. The relationship seems to have strengthened in the 1980s, however, as the 1980s coefficients are about two to three times as large as those in the 1970s. One possible explanation for this pattern is that high unemployment during a recession weakens the ability of trade unions to extract rents from dominant firms. Unions stayed weak in the 1980s because of the persistence of relatively high levels of unemployment coupled with the political and legal onslaught of the Thatcher administration. Further supportive evidence for this hypothesis is offered in Chapters 4 and 6.

III. Modeling Structure and Estimation Methods

In terms of the sequential game played in Figure 1.1 we are looking at to solve stage 4, the determination of output in an oligopolistic product market conditional on costs. A great deal of previous empirical work on the determinants of profitability has been based on versions of a well-known homogeneous product oligopoly model (Cowling and Waterson, 1976). In this model the profit margin for a profit-maximising firm i is given as

$$(3.1) \qquad (\Pi/R)_i = MS_i(1 + \lambda_i) / \eta$$

where MS_i is market share, λ_i is a conjectural variation term (expressing what output changes firm i would expect from rivals on altering output) and η is the industry price elasticity of demand.[5]

The unobserved variable λ_i has received some attention when formulating

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[5] In (1) the left hand side is usually written as the price-cost margin: however, under the assumption of constant returns, this is equivalent to (Π/S) in long run equilibrium.

estimable models. Clarke and Davies(1982) model the conjecture term as $\lambda_i = \mu_i (1 - MS_i) / MS_i$ on the grounds that if firm i has a share MS_i, then the magnitude of the other firms' output responses will be given by the ratio of their summed market shares to i's share. Substituting for λ_i in (1) gives the convenient formulation

$$(3.2) \qquad (\Pi/R)_i = [\mu_i + (1 - \mu_i) MS_i] / \eta = [(1 - MS_i)\mu_i + MS_i] / \eta$$

In (3.2) margins are a weighted average of $1 / \eta$ (the margin under monopoly / perfect collusion) and MS_i / η (the Cournot case). So, given this formulation, μ_i has a neat interpretation : $\mu_i = 1$ implies total collusion, whilst $\mu_i = 0$ suggests Cournot behaviour, plus a whole range of intermediate cases (empirically, the key point is that the μ term only enters in an interactive fashion with (1 - MS) - see Kwoka and Ravenscraft, 1986).

In the above formulation λ is decreasing in MS, so that larger firms appear to have smaller conjectures (i.e. $\partial\lambda_i / \partial MS_i = - \mu_i / MS_i^2 < 0$ if $\mu_i \geq 0$). There are clearly reasons to expect that this may not hold in practice. To allow for this possibility, we consider the formulation $\lambda_i = \mu_{1i} (1 - MS_i) / MS_i + \mu_{2i} (1 / MS_i)$. Here there are two components shaping conjectures : the first is the Clarke-Davies strategy of matching output according to market share distributions and the second has conjectures shaped by own market share.[6] This generates the following more general margins equation

$$(3.3) \qquad (\Pi/R)_i = [(1 - MS_i) \mu_{1i} + \mu_{2i} + MS_i] / \eta$$

which simplifies to (3.2) if $\mu_{2i} = 0$.

To translate to an estimable formulation we need to make a number of

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[6] Schmalensee(1987) has also generalised the conjecture term as $\lambda_i = \lambda + \gamma(MS_i - 1/N)$ where N is the number of firms in the industry.

steps. First, we need to empirically model the μ coefficients in equations (3.2) and (3.3). In existing empirical work based on the Clarke-Davies approach (e.g. Kwoka and Ravenscraft, 1986) μ has been assumed to be a linear function of industrial concentration. We prefer a more general approach in which the μ parameters are treated as a time-varying function of industrial variables (concentration, import intensity and union power) and previous profitability.[7] This formulation of μ recognises that the gains from collusion are likely to be influenced by market structure, dynamic behaviour and by the rent-seeking activities of trade unions.[8]

Secondly, traditional studies have been plagued by problems of omitted variable bias. For instance, there are a number of unobservable determinants of profits whose exclusion may seriously effect estimated coefficients. The fact that we use panel data means that we can control for time-invariant unobservables via firm specific effects. We do this by confining unobservable effects like management style to a fixed effect, f_i.

Defining the μ parameters in (3.3) as $\mu_{kit} = X_{jt}'\Theta_{k1} + \Theta_{k2}(\Pi/R)_{i,t-1}$ (k = 1,2) where X_{jt} denotes the industrial variables of interest, equation (3.3) can be rewritten as

$$(3.4) \qquad (\Pi/R)_{it} = f_i + \varphi_1 MS_{it} + ((1 - MS_{it})*X_{jt})'\varphi_2 +$$
$$+ \varphi_3 (1 - MS_{it})*(\Pi/R)_{i,t-1} + X_{jt}'\varphi_4 + \varphi_5 (\Pi/R)_{i,t-1} + \upsilon_t + u_{it}$$

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7 Lagged profitability is included for a number of reasons. These include the empirically observed serial correlation structure of profit margin time series; the theoretical need to capture departures, and subsequent returns, to long run equilibrium; and the fact that current output conjectures may depend on previous performance.

8 The inclusion of trade unions in a profitability equation is not necessary under a right-to-manage model in the absence of productivity effects, as the definintion of marginal cost will include the bargained wage. However, if there are efficient bargains then unionisation will reduce the price-cost margin directly (see Dowrick, 1989).

where u_{it} is an i.i.d. error term and υ_t contains time-specific effects.

Of course, we can easily re-write equation (3) as

$$(3.5) \qquad (\Pi/R)_{it} = f_i + \beta_1 MS_{it} + (MS_{it}*X_{jt})'\beta_2 + $$
$$+ \beta_3 MS_{it}*(\Pi/R)_{i,t-1} + X_{jt}'\beta_4 + \beta_5 (\Pi/R)_{i,t-1} + \upsilon_t + u_{it}$$

where the β parameters are simple functions of the φ's in (3.4).[9] This formulation is adopted as it makes it somewhat easier to interpret estimated coefficients as it is a standard model incorporating interactions between market share and the other variables in the model.

Equation (3.5) is a fairly general model of profit determination which has the desirable property of nesting a number of popular models in the existing literature. For example, (3.5) can be compared to the more conventional (linear) static models often specified in the structure-performance literature by testing the statistical restriction of $[\beta_2\ \beta_3\ \beta_5] = 0$. Secondly, a slightly weaker restriction than this ($[\beta_2\ \beta_3] = 0$) simplifies the model to a standard linear model with a partial adjustment mechanism for margins. We present formal tests of these hypotheses in the empirical part of the paper.

There are several ways of modelling the aggregate demand effects υ_t. The most general way is to incorporate a set of time dummies which capture all economy-wide unobservable effects common to each firm. A more restrictive way is to actually incorporate observable aggregate variables (such as the cyclical indicator considered earlier). We follow both strategies in Section VI.

It is the effects of these aggregate variables that permit us to draw some conclusions regarding the relevance or otherwise of the supergame

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[9] Specifically, $\beta_1 = \varphi_1$, $\beta_2 = -\varphi_2$, $\beta_3 = -\varphi_3$, $\beta_4 = \varphi_2 + \varphi_4$ and $\beta_5 = \varphi_3 + \varphi_5$.

models. For our purposes, the key aspect of these models hinges on the observability of demand shocks in a repeated oligopoly game. One strand of the literature has assumed these shocks are perfectly observable. In Rotemberg and Saloner (1986), for example, the optimal collusive price falls in booms because there are relatively greater rewards from reneging on implicit agreements. By contrast, in recessions firms have greater excess capacity (or inventories) to punish firms chiselling the price level. Consequently, the Rotemberg-Saloner formulation points towards collusion, and by the same token margins, being counter-cyclical.

A second branch of the literature focuses on the problem of imperfect information and policing of firms' strategies. Oligopolists cannot directly and instantaneously observe each others' outputs and profits. Therefore they can never be sure whether their own falling margins are due to rivals' aggressive behaviour or downward demand shocks. In the model developed by Green and Porter(1984) firms always revert to punishment output levels when industry price falls below the 'trigger price'. Thus, collusion and margins are likely to display procyclical behaviour.

IV Data Description and Estimation Methods.

Other than previous period margins, the determinants of profitability introduced in the theoretical discussion are firm market share, industry concentration, import intensity and union density (sources, definitions and methods of construction are given in the Data Appendix). The annual means of these variables are given in Table 3.2 and plotted over time in Figure 3.3. The market share variable appears relatively stable over the sample period, with a mean of some 3%, but, as one would expect given the skewed nature of the size distribution of firms, there is quite a range of values (from very small up to a maximum of 79%). There is some evidence of slight growth of mean market share towards the end of the sample and quite a substantial growth in the variance (the standard deviation of market share grew from 0.47 in 1975 to 0.58 in 1986). The increased dispersion of market shares is interesting as it reflects the increased heterogeneity of performance also exhibited in earnings and other economic outcomes.

Turning to the industrial characteristics, average concentration has fallen and the imports variable is highly positively trended for the sample period. The other variable follows a pattern which is well known : unionism grew through the 1970's, and fell markedly during the 1980's with the advent of the Conservative government and the recession of 1980-81. We must balance the obvious conclusion that competition has risen by the market share data. The larger variance and higher mean suggests that some industries may be increasingly dominated by one or perhaps two leading firms at the expense of the others in the top five. Indeed, the strengthening of the market share-margins relationship in the 1980s reported in Section III may imply that the 'top dog' in an industry enjoyed an even greater competitive advantage in the 1980s than in the 1970s.

The data to be used is an unbalanced panel (i.e. we have varying numbers of time series observations - from a minimum of 9 to a maximum of 15 - over the period 1972 to 1986). Since all our models contain a fixed effect f_i, we adopt the usual first-differencing transformation for estimation purposes.[10] To estimate our first-differenced models we use Arellano and Bond's (1988, 1991) Generalised Method of Moments procedure (contained in their DPD package written in GAUSS). This enables us to obtain consistent

[10] If fixed effects were not important we could gain in efficiency by using a levels model. The estimates from such a specification are overwhelmingly dominated by the lagged dependent variable (asymptotic t-value over 100) which is clearly picking up the firm-specific effect. The diagnostics indicated first and second order serial correlation (N(0,1) statistics of -5.41 and -4.67 respectively).

instrumental variable estimates in the absence of serial correlation (we present tests for this in all our reported models).[11]

The advantage of the Arellano-Bond procedure over other commonly used panel estimation techniques (e.g. Anderson and Hsaio, 1982, Amemiya and MaCurdy, 1986) relates to its efficient utilisation of available instruments. The basic idea is that (in first-differenced models such as the ones we will estimate) observations dated t-2 or earlier act as valid instruments. Whilst Anderson and Hsaio recommend the simple use of variables dated t-2 either in levels or differences and Amemiya and MaCurdy propose the use of instruments stacked by year, the Arellano-Bond technique states that more instruments can be used as the panel progresses. So, as we estimate our models from 1975 to 1986, in 1975 we can use variables from 1972 and 1973 as valid instruments. In 1976 we can use variables from 1972 through 1974 as instruments and so on. This permits one to exploit both the cross-section and time-series elements of the data in constructing instruments and hence yields efficiency gains relative to other estimation methods for panel data models.

Turning now to the important issue of identification, the panel aspect of our data means that we can be careful in our selection of instruments for the endogenous variables in our model. As mentioned above, in first-differenced models, values of endogenous variables dated (t-2) or before are appropriate instruments. Since all the firm-level explanatory variables in our equations can be viewed as endogenous in period t, all are instrumented in our estimated models instrumented using the Arellano-Bond procedure outlined above. However, because they are highly autocorrelated we used instruments lagged at least three periods (hence, the reason why we

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[11] Note that since we present first-differenced models this generates an MA(1) error, so the appropriate test is for the presence of second order serial correlation.

estimate from 1975 to 1986). We also present Sargan tests of instrument validity to ensure that our instrument set is uncorrelated with the residuals from our estimated models.[12]

V. Estimated Models

1. Basic Model

Our estimated models are presented in Table 3.3 All are specified in first-differences and estimated using instrumental variables. The models differ in their treatment of the interaction terms in equation (3.5) and in their specification of the aggregate effects. Column (1) is a simple non-interactive linear (or 'shared assets') model using the aggregate unemployment rate as a cyclical indicator. Column (2) also uses the unemployment rate to capture aggregate fluctuations, but includes the interactions between market share and the explanatory variables suggested earlier. The third column is the linear model but incorporating a set of time dummies, whilst the final column is the most general specification, namely the interactive model incorporating time dummies to capture common macro shocks.

In the first column all variables take their theoretically predicted signs and are significantly bounded away from zero. Fragmented market structures and union power significantly reduce profit margins. The unemployment rate also attracts a negative significant coefficient which is very similar in both specifications. Hence, even after controlling for a whole range of determinants of profit margins, and allowing for interactive models as suggested by quite general theory (see Section III), the procyclicality of margins remains. Modelling cyclical behaviour using other

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[12] We also tried using earlier dated instruments (t-4) instead of (t-3) as an additional test on the validity of our instrument set. Even with these deeper lags, the coefficients were basically unaltered.

indicators of the business cycle produced very simiar results: in models comparable to those of column (1) we also included a real aggregate output growth variable which attracted a positive and highly significant coefficient (coefficient = 0.218, standard error = 0.019); we also used the Economics Trends indicator of the cycle[13], the estimated coefficient on which was 0.051 with a standard error of 0.006. The only drawback is the failure of the Sargan statistics in these models, suggesting model misspecification.

As a consequence, columns (3) and (4) model aggregate fluctuations utilising the most general framework which incorporates an annual dummy variable for each year of the sample. This remedies the diagnostic problems of the first two columns. Hence, our main focus from now on is on the time-dummy models.

In the linear model of column (3), the estimated coefficients generally have their expected signs. There is some reassurance for the traditional industrial economics literature as the effect of industrial concentration is estimated to be significantly positive, even after controlling for firm market share[14]. The raw correlation between profitability and market share remains positive and significant as does concentration, whilst import penetration and industrial union density both have negative signs, but are insignificant at conventional levels. The disappointing loss of precision on the latter two variables compared to column (1) is due to the presence of the time dummies. It seems that the depressing effects of import penetration and unionisation on margins was a phenomenon across all

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[13] The Composite Coincident Index uses GDP, output of the production industries, capacity utilisation, retail sales volume and the change in raw material stocks to track the business cycle

[14] This remains if we instrument the industry-level variables in the same manner as the firm-level ones. Doing so produces a coefficent (standard error) on concentration of 0.061 (0.028).

industries which cannot be separated from a macro-shock. In sheer quantititive terms we find (like much of the persistence in profits literature (e.g. Mueller, 1990)), the dominant influence is the lagged dependent variable which is very significant.[15]

Examination of the pattern of estimated coefficients on the time-dummies also points to a strongly procyclical pattern, with positive significant coefficients in most years with the exception of 1980 and 1981, the years which correspond to the trough of the deep recession that hit U.K. manufacturing. In these years the coefficients are estimated to be negative (and strongly significant in 1980). Note that the effect in each year after 1975 is the sum of the coefficient on the constant and the time dummy coefficient (the effect in 1975 is the coefficient on the constant alone). So, for instance, margins are predicted *ceteris paribus* to be 1.3 percentage points (or 13% of the sample mean) lower in 1980.

It is, however, possible that the linear model is misspecified. For example, the theoretical model discussed earlier implies an interactive relationship between the determinants of profitability. Hence, Table 3.2 presents a variety of model specification tests showing that the non-interactive model best describes the data.

In Table 3.3 we present our preferred models for both the full sample and disaggregated by product group. The Wald tests reported at the base of each column imply that the static model with partial adjustment is acceptable for the consumer goods samples, but that an additional interactive term needs to be included for the producer goods sector. In terms of market

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[15] Inclusion of the lagged dependent variable remedied the problems of serial correlation that occurred in the static analogue of the model (in a model excluding the lag, an N(0,1) statistic of -5.221 for second order serial correlation was obtained).

concentration, the consumer goods industries have larger marginal effects than the producer goods industries. This is a common finding and Bain's (1956) rationalisation remains plausible: consumer industries have larger leeway to differentiate their products as buyers are larger in number and less well informed. The same strongly procyclical pattern of profits appears across all sub-groups and we illustrate this by plotting out the individual year impacts (after adding the coefficient on the constant to those on the time dummies) in Figure 3.5. Unlike the simple regressions reported in Section 2, producer goods margins no longer seem to be more procyclical once we condition on other variables: if anything the time effects are larger for consumer goods groups (especially for consumer durables in 1980). The exception to this comes in 1981 when there is a big fall in margins for firms specialising in the manufacture of producer goods. Consumer industries, by contrast, felt the recessionary gale bite most strongly in 1980 (see Figure 3.5). A plausible explanation of this is that the consumer demand crash took a year to filter through to firms in upstream industries.

A recent U.K. industry-level study (Haskel and Martin, 1992) produced results suggesting counter-cyclical price-cost margins, albeit for a very short time period (1983 to 1986). Their results are based on a positive impact of industry unemployment rates on profitability. Aside from worries regarding the use of industrial unemployment rates to infer cyclicality, when we included this variable in our models it consistently attracted a significant negative coefficient (for instance in the full sample model it had a coefficient of -0.0009 with a standard error of 0.0004). Given both our use of a much longer time-series, and our use of firm-level data (which we would argue is the appropriate level of aggregation to consider these issues), some doubt is cast on the plausibility of such industry-level results.

There are also some interesting differences across different sub-groups. Union power is *only* significant in the producer goods sector, for example, which may appear surprising given our emphasis on union rent-seeking (Machin, 1990, Machin and Stewart, 1990). However, one should note that UNION is an industry-level variable and that our model has effectively constrained any firm-level union influence to work via the fixed effect f_i. Perhaps more interesting is the difference in dynamic adjustment across product groups: adjustment seems far more sluggish in the producer goods sector as compared to firms who manufacture consumer goods.

2. Alternative Models

With respect to market structure and cyclicality these results are very robust. Irrespective of econometric specification, estimation method and sample used we have strong evidence that firm-level profit margins rise with market power and exhibit procyclical behaviour.[16] We should, however, defer conclusions for a while since it is clear that some popular Industrial Organization models not considered thus far also generate alternative predictions regarding dynamic structure. We consider two generalisations here, the first which is based on entry, the second on adjustment costs.

The problem of entry can be considered in the following extension to our model. Simply add a term $\beta_6 e_{it}$ to our general estimating equation (3.5) where $\beta_6 < 0$ and e_{it} = entry threats facing firm i. Since the latter are unobservable we follow Geroski and Jacquemin(1988) in modelling the threat of

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[16] Additional experiments could not remove this conclusion: (i) estimation on a balanced panel of 219 companies between 1975 and 1986 produced the same pattern, suggesting that problems of attrition are not present; (ii) Inclusion of a (suitably instrumented) capital-sales ratio made little difference: it had a positive but very imprecisely determined impact; (iii) use of Fisher's (1987) transformation of the dependent variable (using $-\ln(1-\Pi/S)$) also produced the same results.

entry into i's industry as a linear function of i's past success ($\psi_{i,t-k}$)

$$(3.6) \qquad e_{it} = a + \sum_{k=1}^{K} b_k \psi_{i,t-k} + w_{it}$$

where w_{it} is a white-noise innovation. If $\psi_{i,t-k} = (\Pi/R)_{i,t-k}$ then, for the most general model, we have

$$(3.7) \qquad (\Pi/R)_{it} = f_i + \beta_6 a + \beta_1 MS_{it} + (MS_{it}*X_{jt})'\beta_2 + \beta_3 MS_{it}*(\Pi/R)_{i,t-1}$$

$$+ X_{jt}'\beta_4 + (\beta_5 + \beta_6 b_1)(\Pi/R)_{i,t-1} + \beta_6 \sum_{k=2}^{K} b_k (\Pi/R)_{i,t-k} + \upsilon_t + u_{it}$$

Hence, equation (3.7) incorporates extra dynamics. As such, the entry model may give an explanation of why the $MS*(\Pi/R)_{-1}$ interaction seemed important in column (4) of Table 3.1 and in the producer goods industries. Firms with high market share may be particularly vulnerable to new entrants who erode their market power faster than firms in a very fragmented market where there are few excess rents to be bid away.

In terms of discriminating between our model and an entry threat model, it is evident that (3.6) implies additional terms in $(\Pi/R)_{i,t-k}$ if $K > 1$ whereas our basic model does not. However, including t-2 lagged margins in our equations made little difference : when adding it to the specification of column (1) of Table 3, it attracted a coefficient of 0.070 (standard error = 0.075), and left other coefficients basically unaltered.[17]

A second class of dynamic models are those based on costs of adjustment. In Appendix 3.1, we present a simple Euler equation representation of the

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[17] Coefficients (standard errors) on t-2 lagged margins in producer, consumer durable and non-durable sub-samples were 0.022(0.052), 0.189(0.075) and -0.014(0.058) respectively. The precision of consumer durables may be spurious because diagnostics indicated the presence of second-order serial correlation.

determination of margins. This model assumes that the firm faces costs of adjusting output and results in an empirical model of the form[18]

$$(3.8)\quad (\Pi/R)_{it} = f_i + \beta_1 MS_{it} + (MS_{it}*X_{jt})'\beta_2 + \beta_3 MS_{it}*(\Pi/R)_{i,t-1} + X_{jt}'\beta_4 + \beta_5(\Pi/R)_{i,t-1} + \frac{\beta_7\Delta q_{it}}{P_{it}q^2_{i,t-1}} + \frac{\beta_8\Delta q_{i,t+1}q_{i,t+1}}{S_{it}q^2_{it}} + u_{it}$$

which includes two extra terms as a consequence of adjustment costs.

We estimated equation (3.8) for the full sample imposing $\beta_2 = \beta_3 = 0$ (as before, a valid statistical restriction) and used $q_{i,t-2}$ and $\Delta q_{i,t-2}$ as instruments for the additional terms. Both extra coefficients were estimated to be positive (β_7 = 0.015(0.013), β_8 = 0.004(0.005)), but were both individually and jointly insignificant ($\chi^2(2)$ = 0.57). The other estimates remained similar to those reported earlier. Indeed, the coefficients on the time dummies were practically identical. Similarly both terms were insignificant when included in the preferred models for each industry sub-samples reported in Table 3.5.[19]

It is also worthwhile to point out that these estimates were based on making the standard rational expectations assumption that expected future terms can be replaced with their actual values. We remain a little uncomfortable here as this assumption does not rest easily with those imperfect information models which predict pro-cyclicality of margins (especially Green and Porter, 1986). As a consequence, and because the

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[18] Of course, it would be desirable to permit costs of adjustment for different factor inputs, notably employment and capital. However, for empirical reasons, we use output adjustment costs (since employment data is not available for all firms, and only after 1976 in Datastream, and we have severe reservations regarding the quality of the capital stock data derived from company accounts).

[19] The appropriate Wald $\chi^2(2)$ statistics were 0.24, 4.03 and 2.13 for producer, consumer durable and non-durable industries respectively.

principal results remain largely unaffected, we prefer the models reported earlier.

VI. Conclusions

In this chapter we have estimated models of profitability using firm-level panel data on 709 U.K. manufacturing firms between 1975 and 1986. Two main results have been established. First, despite controling for fixed effects, simultaneity and dynamics the traditional measures of market power continue to have significant and positive effects on firm level profit margins. Secondly, margins are strongly procyclical, dipping considerably in the 1980/81 recessionary period. This raises strong question marks against theories which predict countercyclical profit margins since these results are remarkably robust to changes in econometric specification and are also observed across broad product group sectors. Finally, a subsidiary aspect of the raw data was that the correlation between market share and profitability improved in the 1980s compared to the 1970s especially during the recession. This may well be linked to the declining ability of unions to capture rents from dominant firms.

There are of course a number of caveats to the work presented in this chapter. For one thing, we only have data over one cycle, albeit a clear and major one. It would also be interesting to extend the time series dimension of the panel to see whether the results also hold for other cycles (notably the 1991 recession). Furthermore, in the absence of firm-level price data, we are unable to decompose our profit margins into price and cost components which may be a potentially important distinction (Bils, 1987). Finally, it may be that dominant firms or those in concentrated markets are able to raise prices above costs not because of 'unfair' competition, but rather because they are more innovative organisations. To examine this further, we must explicitly look at technological change.

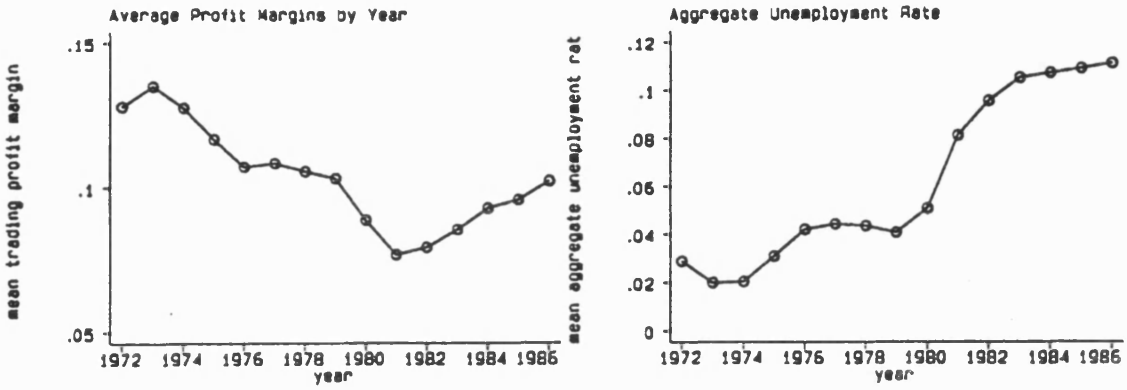

Figure 3.1: Average Profits and Unemployment

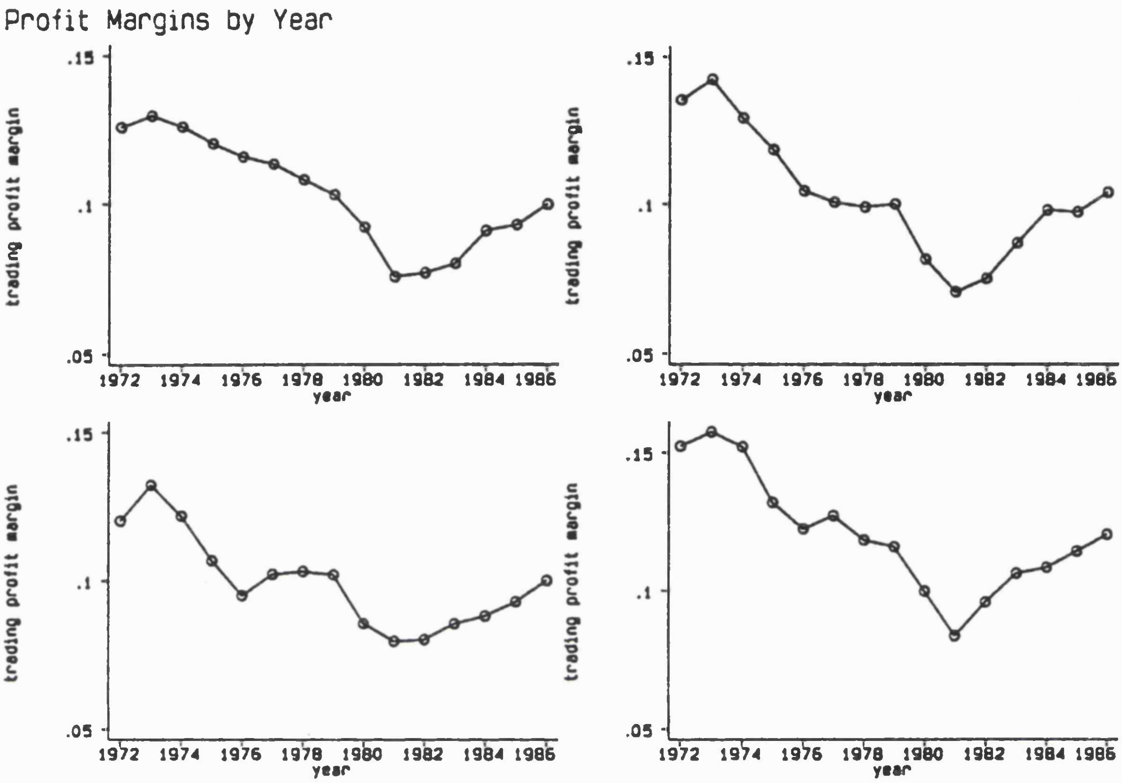

Figure 3.2: Average Profit Margins by Group

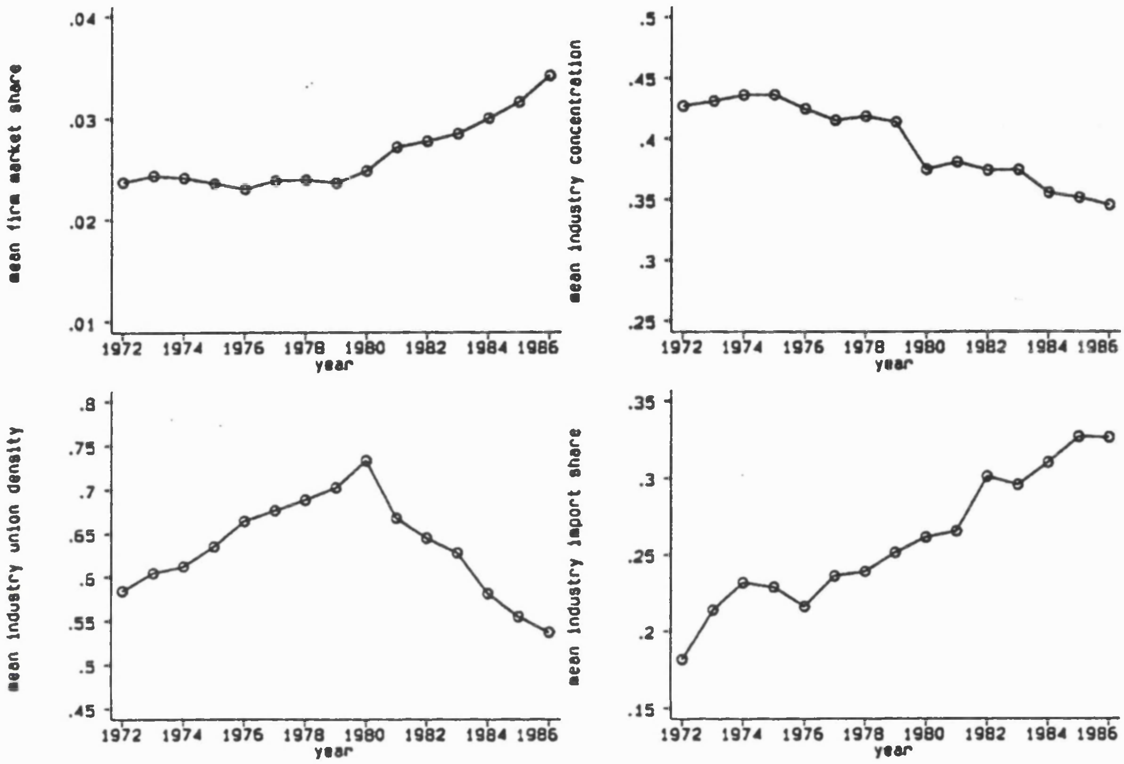

Figure 3.3: Means of Key Variables over Time

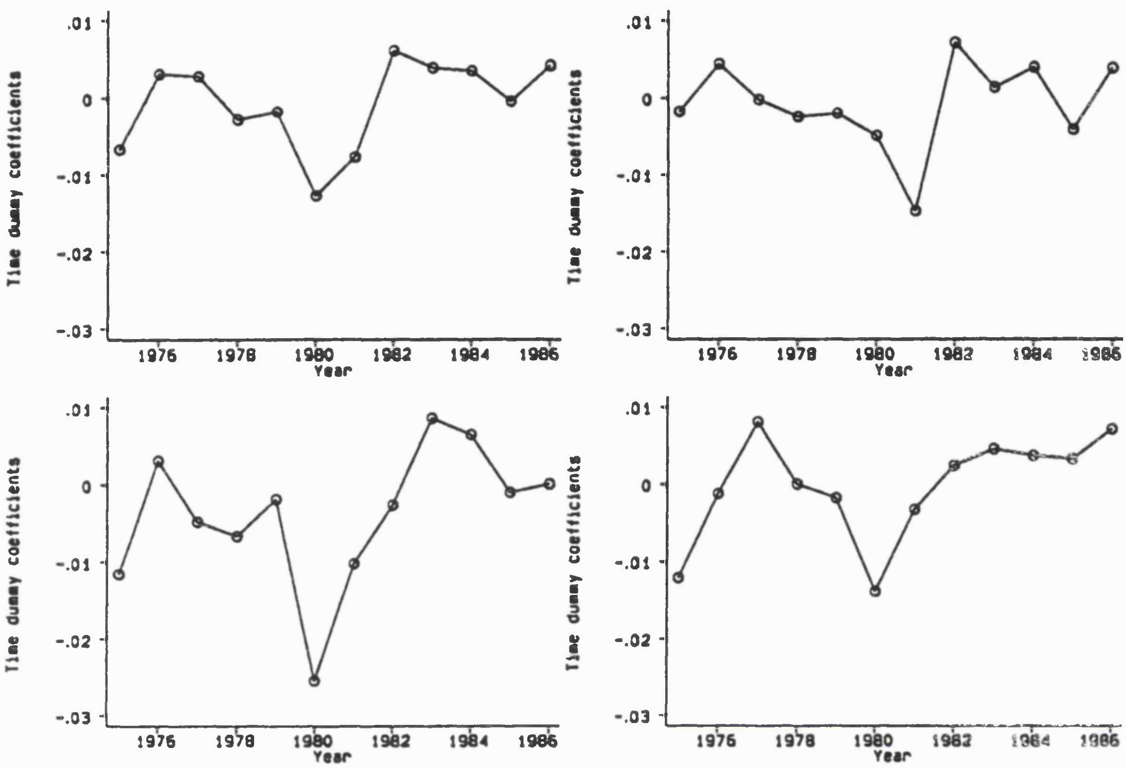

Figure 3.4: Time Dummy Coefficients from Table 3.4

Table 3.1: Market Share and Profit Margins

Year	MS	SE(MS)	N
1975	0.029	(0.034)	684
1976	0.040	(0.035)	695
1977	0.024	(0.033)	703
1978	0.009	(0.033)	709
1979	0.013	(0.034)	709
1980	0.050	(0.035)	707
1981	0.085	(0.036)	682
1982	0.077	(0.033)	659
1983	0.073	(0.033)	624
1984	0.077	(0.032)	579
1985	0.063	(0.031)	542
1986	0.043	(0.031)	477
1975-1986	0.049	(0.010)	7770 (NT)

Notes to Table 3.1
These are coefficients from an OLS regression of profit margins on market share and a constant. Standard errors in parentheses.

Table 3.2 Descriptive Statistics

Variable	Mean	Standard Deviation
Profit Margin (t)	0.103	0.063
Profit Margin (t-1)	0.104	0.064
Market Share	0.027	0.071
Concentration	0.401	0.180
Import penetration	0.250	0.147
Union density	0.634	0.115
Unemployment	0.057	0.033

TABLE 3.3: MODELS OF THE DETERMINANTS OF FIRM PROFITABILITY, 1975-86.

Constant	-	-	-0.007(0.002)	-0.007(0.002)
Linear Effects				
Market share	0.201(0.100)	0.221(0.113)	0.196(0.097)	0.142(0.112)
Concentration	0.057(0.013)	0.074(0.014)	0.024(0.012)	0.030(0.014)
Import intensity	-0.024(0.015)	-0.015(0.016)	-0.014(0.016)	-0.013(0.017)
Industry unionism	-0.083(0.011)	-0.075(0.010)	-0.005(0.016)	0.005(0.016)
Profit/sales (t-1)	0.444(0.070)	0.480(0.061)	0.438(0.060)	0.444(0.057)
Interaction Effects				
Market share X Concentration	-	-0.196(0.136)	-	0.033(0.131)
Market share X Import intensity	-	0.008(0.085)	-	0.061(0.081)
Market share X Industry unionism	-	-0.015(0.074)	-	-0.062(0.073)
Market share X Profit/sales (t-1)	-	-0.539(0.372)	-	-0.789(0.386)
Aggregate Effects				
Unemployment rate	-0.218(0.054)	-0.178(0.043)	-	-
1976 dummy	-	-	0.010(0.003)	0.010(0.003)
1977 dummy	-	-	0.010(0.002)	0.010(0.002)
1978 dummy	-	-	0.004(0.002)	0.004(0.002)
1979 dummy	-	-	0.005(0.002)	0.005(0.002)
1980 dummy	-	-	-0.006(0.002)	-0.005(0.002)
1981 dummy	-	-	-0.001(0.003)	0.000(0.003)
1982 dummy	-	-	0.013(0.003)	0.014(0.003)
1983 dummy	-	-	0.011(0.003)	0.011(0.002)
1984 dummy	-	-	0.010(0.003)	0.012(0.003)
1985 dummy	-	-	0.006(0.002)	0.007(0.002)
1986 dummy	-	-	0.011(0.002)	0.012(0.002)
Serial correlation	-1.679	-1.525	-1.444	-1.447
Sargan	185.98(94)	275.70(186)	100.87(94)	198.47(186)
Sample size	6829	6829	6829	6829
Number of firms	709	709	709	709

Notes.

1. The dependent variable is the trading profit margin, Π/R.
2. All models estimated in first-differences by instrumental variables (asymptotic heteroskedastic consistent one step standard errors in parentheses).
3. The instrument set used is lags of t-3 in each period on firm-level variables Π/R and MS and their interactions in the interactive models. Dividends paid out by the firm and the investment/sales ratio were also used as instruments in the same way.
4. The serial correlation test is an N(0,1) test for second order serial correlation and the Sargan test a χ^2 test of the overidentifying restrictions (degrees of freedom in parentheses).

TABLE 3.4 : WALD TESTS OF SIMPLIFYING GENERAL MODEL

Model : $(\Pi/R)_{it} = f_i + \beta_1 MS_{it} + (MS_{it} * X_{jt})'\beta_2 + \beta_3 MS_{it} * (\Pi/R)_{i,t-1} + X_{jt}'\beta_4 + \beta_5 (\Pi/R)_{i,t-1} + u_{it}$				
Simplification to :	Restrictions	$\chi^2(d)$	d	5% critical value
Linear static model	$[\beta_2\ \beta_3\ \beta_5] = 0$	63.72	5	11.10
Linear model plus partial adjustment	$[\beta_2\ \beta_3] = 0$	4.70	4	9.49
Linear model plus partial adjustment allowed to differ with market share	$[\ \beta_2] = 0$	1.26	3	7.81

Notes.
1. The χ^2 tests are Wald tests based on the null of the most general model reported in column (4) of Table 3.3
2. d is the number of degrees of freedom of the test.

TABLE 3.5: PREFERRED SPECIFICATIONS FOR ALL FIRMS AND BY PRODUCT GROUPS.

	All Firms	Producer Goods	Consumer Durables	Consumer Non-durables
Constant	-0.007(0.002)	-0.002(0.003)	-0.012(0.005)	-0.012(0.003)
Linear Effects				
Market share	0.196(0.097)	0.143(0.087)	0.036(0.096)	0.073(0.050)
Concentration	0.024(0.012)	0.052(0.019)	0.120(0.038)	0.045(0.027)
Import intensity	-0.014(0.016)	0.018(0.027)	0.086(0.054)	-0.064(0.041)
Industry unionism	-0.005(0.016)	-0.046(0.021)	0.004(0.048)	0.009(0.022)
Profit/sales (t-1)	0.438(0.060)	0.497(0.064)	0.161(0.100)	0.251(0.108)
Interaction Effects				
Market share X Profit/sales (t-1)	-	-1.619(0.532)	-	-
Aggregate Effects				
1976 dummy	0.010(0.003)	0.006(0.005)	0.015(0.008)	0.011(0.005)
1977 dummy	0.010(0.002)	0.002(0.004)	0.007(0.005)	0.020(0.004)
1978 dummy	0.004(0.002)	-0.001(0.003)	0.005(0.005)	0.012(0.004)
1979 dummy	0.005(0.002)	-0.000(0.003)	0.010(0.005)	0.010(0.004)
1980 dummy	-0.006(0.002)	-0.003(0.003)	-0.014(0.006)	-0.002(0.004)
1981 dummy	-0.001(0.003)	-0.013(0.004)	0.013(0.009)	0.009(0.004)
1982 dummy	0.013(0.003)	0.008(0.004)	0.009(0.007)	0.015(0.004)
1983 dummy	0.011(0.003)	0.003(0.004)	0.020(0.007)	0.017(0.004)
1984 dummy	0.010(0.003)	0.006(0.004)	0.018(0.007)	0.016(0.004)
1985 dummy	0.006(0.002)	-0.002(0.004)	0.010(0.006)	0.015(0.003)
1986 dummy	0.011(0.002)	0.006(0.004)	0.012(0.006)	0.019(0.004)
Serial correlation	-1.444	-1.113	-1.091	-1.775
Sargan	100.87(94)	194.64(189)	147.92(94)	98.13(94)
Sample size	6829	3042	850	2044
Number of firms	709	311	103	241
χ^2 test for simplification from most general model	4.70(4)	0.38(3)	3.27(4)	5.95(4)

Notes.
1. As for Table 3.3.

Appendix 3.1: Costs of Adjustment

We assume profits for firm i in year t are (suppressing the i subscript)

$$\text{(3A.1)} \qquad \Pi_t = P_t(Q_t)q_t - c(q_t) - H_t(q_t)$$

where H_t represents costs of adjustment, which we assume to be a function of output. The firm's intertemporal problem is to maximise the value function,

$$\text{(3A.2)} \qquad V_t = E_t \sum_{j=0}^{\infty} (1 + \delta)^{-(t+j)} \Pi_{t+j}$$

with respect to q_t where E_t is expectations conditional on information at t and δ is the discount rate (assumed constant across time). We can write (3A.2) as

$$V_t = \Pi_t + (1 + \delta)^{-1} E_t V_{t+1}$$

It follows that

$$\delta V_t/\delta q_t = -P_t(1 + \lambda_t)\eta_t^{-1} + P_t - c'(q_t) - \delta H_t/\delta q_t - (1+\delta)^{-1} E_t \delta H_{t+1}/\delta q_t = 0$$

Re-arranging yields the price-cost margin equation

$$(\Pi/R)_t = (P_t - c'(q_t))/P_t = \eta_t^{-1} (1 + \lambda_t) MS_t + \delta H_t/\delta q_t + (1+\delta)^{-1} E_t \delta H_{t+1}/\delta q_t$$

This is the same as our classical oligopoly model in equation (3.1) of the chapter plus two adjustment cost terms. Assuming a quadratic functional form for output adjustment costs, say $H_t = (b/2)\ (\Delta q_t/q_{t-1})^2$, then we obtain

$$\text{(3A.3)} \qquad (\Pi/R)_t = \eta_t^{-1} (1 + \lambda_t) \ MS_t + \frac{b\Delta q_t}{P_t \ q_{t-1}^2} - \frac{(1+\delta)^{-1} bE_t \Delta q_{t+1} q_{t+1}}{S_t q_t^2}$$

which corresponds to (3.8) in the text.

CHAPTER 4

THE CREATION OF RENTS II: INNOVATION AND PROFITABILITY

"The first point made in this study is that these conventional measures [market share, concentration, profit-sales ratio] *cannot help decision makers to infer whether or not some business strategies are pro- or anti-competitive. Instead, reference to some measures of innovation is necessary"*

Brenner (1989)

I. INTRODUCTION

The embodiment of new ideas in products and processes has long been thought the driving force of economic success in the 'new growth economics' associated with Paul Romer, the econometrics of decomposing national output and the Austrian School tradition. Policy makers have devised numerous schemes to stimulate the generation and diffusion of innovations under the assumption that private rates of return are below the social rates. This chapter seeks to shed some empirical light on these issues by examining explicitly the impact of innovations on firms' profits.

Three questions motivate this chapter. First is the issue of measurement - what is the short and long-run pay-off to the firm of innovating? Since the total size of the technological rents generated will depend not only on the firm's own efforts but also from the spillovers from other firms, accounting for this externality is vital as it is the major reason why a wedge is driven between private and social efficiency.

The second question relates to the previous chapter and the quote from Brenner. Is the observed correlation between high market shares and profitability merely due to the past and present innovative success of leading firms? Although we cannot capture every aspect of 'innovation' in the Demsetz critique, one would imagine that the influence of market structure would be severely attenuated by bringing new technologies directly into the picture. Acceptance of the critique would lead policy makers into being more cautious when directing competition policies against dominant firms and more sanguine about the future of unions if they are merely taxing success.

A final question arises concerning the difficult issue of the causal nexus between innovation and higher profits. There are essentially two views on this matter. The simplest is the one taken almost for granted in most of this thesis and the orthodox literature; it is that innovation strengthens the firm's competitive position as a pure *consequence* of technical change by generating lower costs or better products. The alternative view is that through the innovative process the firm transforms its internal *constitution* by building up its core competencies in a variety of ways; it becomes more flexible, adaptable and capable of dealing with an uncertain environment. This view of innovation signals the creation of organisational rents rather than a pure increase in product market rents. One can call these perspectives the **Consequentalist** view and the **Constitutionalist** view. On a statistical level the difference is whether the returns associated with a particular innovation are merely transitory or permanent reflecting generic differences between innovative and non-innovative firms.

The layout of the chapter is as follows. Section II details the data, section III sketches the primary modelling strategy, and section IV addresses the question of the size of technological pay-offs to the firm as compared to measures of market structure. Finally in section V we look at whether differences between innovating firms are essentially deep-rooted and permanent or basically transitory and offer some conclusions.

II. The Innovations Dataset

The basic dataset used here is very similar in construction to the firm-level panel described in the last chapter, and the variables exhibit broadly the same trends. The accounts data was spliced with information from the Science Policy Research Unit's (SPRU) database on innovations by matching company codes by name (see the Data Appendix for full details). The SPRU project identified significant technical innovations defined as "the successful commercial introduction of new or improved products, processes or materials" introduced in Britain 1945-1983. The innovations were selected by over four hundred scientists, engineers and academics over the course of the fifteen year study. The firms who commercialised them were contacted and more information was gathered on the company itself, the date of introduction and the industry where the innovation was first used.

The distinction between production and use of innovations is particularly important because many of the industries where the innovation was created and developed were not the same as where the innovation was first used[1]. Unfortunately one cannot tell if it was the same (possibly diversified) firm who commercialised the innovation as first used it. 'Why should we care about who comes up with a new idea?', a critic might argue, 'What matters is how quickly this idea gets spread around firms in the economy'. Now diffusion *is* important and an alternative measure of it is used in Chapter 7. However, there are good reasons for believing that the large private benefits of innovations are claimed by the firm who first commercialise an innovation. Consider the case of a perfect market for innovations, the price of an innovation would equal its expected present

[1]Largely anecdotal evidence suggests that many firms developed innovations in close consultation with the firms who eventually used them.

value for the purchasing firm. The licenser could in principle capture all the benefits by selling it and the purchaser would make essentially zero economic profits. Therefore, even if the firm not use it, an innovation would be reflected in its profit margins. Markets for new ideas are far from perfect, but the argument illustrates that an emphasis on the firms who commercialise ideas in the first place seems eminently sensible.

Three variables are constructed to measure innovations. INNOV is a count of the number of innovations produced by a firm in a particular year. To look at spillovers we also calculated the number of innovations produced (IPI) and used (IUI) in every two digit industry from the whole SPRU dataset. Figure 4.1 tracks the total number of innovations in the SPRU database over the entire period 1945-83. There appear to be discernible cycles of innovation which peak (roughly speaking) every five years. After 1971, there is at least one and perhaps two cycles, so that our data begins and ends approximately at trough points. Figure 4.2 again presents the number of innovations per year but this time for our own dataset which has publicly quoted manufacturing firms only. The pattern is broadly similar to the previous diagram although the decline after 1972 is much shallower.

It is interesting to look at the distribution of industry innovations. These are illustrated for four years - 1972, 1975, 1979 and 1983 - andbroken down by fourteen two digit industries in Figure 4.3 (see Table DA2 in Data Appendix for definitions). The distribution appears fairly stable over time with the bulk of innovations concentrated in three industries: mechanical engineering, electrical engineering and vehicles. This pattern is broadly correlated with the distribution of R&D intensities across industries as demonstrated in Figure 4.4. The low number of innovations in 1983 seems to have transposed the dispersion downwards rather than altering its structure.

The concentration of innovative activity in certain sectors implies that some measure of industry innovations is needed to control for trends in technological opportunity even if one were not interested in spillovers per se.

A more precise definition of the means and standard errors of all the variables for the whole sample of 721 firms (hereafter, 'the population') as well as the sample of 117 who innovated at any time 1972-1983 are given in Panel A of Table 4.1 and in the Data Appendix (Table DA3). The population is composed of large quoted manufacturing firms which accounted for about 55.3% of total manufacturing sales in 1979 according to the Census of Production. Panel B presents the raw correlation pattern by running OLS regressions of profit margins against INNOV by year. As with market share, innovations appear to have their strongest effect in the early 1980s, which again suggests that workers may have been less able to appropriate rents in these years.

III. Econometric Modelling Strategy

On the consequentalist view of innovation what are the transmission mechanisms between new technologies and higher profits? There are many possible routes. Market share would be expected to rise, but even in the absence of this, lower process costs would by themselves bring about more profits. Product innovations will only be reflected in market share to the extent that we have got 'the' market right, and this is unlikely to be the case if the firm has expanded the volume of product quality space. In addition, the firm may lease out the innovation which would lead to a pure increase in profits without any extra observable sales.

A simple device to capture these diverse routes is to see the industry elasticity of demand as having a firm specific element ϕ_i, which depends on technological change. We assume

$$\eta(\phi_i) = \eta + b_1 IPI_{it} + b_2 IUI_{it} + \sum_{j=0}^{6} c_j INNOV_{it-j} + \text{Time Dummies}$$

where $\eta'(\phi_i) < 0$. Substituting this into equation (3.5) from Chapter 3 and linearising gives:

$$(4.1) \quad (\Pi/R)_{it} = f_i + \beta_1 MS_{it} + \beta_2 CONC_{it} + \beta_3 IMPS_{it} + \beta_4 (MS*CONC)_{it} + \beta_5 IDENSITY_{it} + \beta_6 (\Pi/R)_{it-1} + \beta_7 IPI_{it} + \beta_8 IUI_{it} + \sum_{j=0}^{6} \lambda_j INNOV_{it-j} + \upsilon_t + \mu_{it}$$

Where f_i is the fixed effect and we allow firm innovations to have an effect for up to six years[2]. υ_t is a year specific effect to be captured by time dummies and μ_{it} is a serially uncorrelated error.

Equation (4.1) is estimated in first differences to remove the fixed effect but levels results are also presented for comparison. Again, we follow the practice of Chapter 3 using instrumental variables to control for the correlation between the lagged rate of return and market share with the error term. Innovations are not instrumented, however, despite their firm-level status and the fact that much of the economics of innovation seek to explain technical change by other economic variables. Although the *level* of innovations in a particular firm is undoubtedly affected by such variables as size (see Pavitt at al, 1987) it is highly unlikely that *changes* in profitability have a contemporaneous causal influence on *changes* in the propensity to innovate. Recall that these are major (and quite rare) advances, the result of intensive formal and informal research effort over many years in most cases. It is very plausible that profit increases today

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[2] We experimented with the lag structure on innovation and found this to be the best fit. Only the MS*CONC interaction emerged as significant so we included this as an additional control.

might finance R&D investment next year which lead to innovations the year after that, but then weak exogeneity of innovations in the profit function still holds good[3].

This theoretical reasoning is accompanied by a more practical problem. Preliminary attempts to estimate firm level innovations using this data have been made difficult by the fact that only a small part of the variance seems to be accounted for by observables[4]. Geroski (1990) found that at most, observables could only explain 30% of the inter-industry variance in innovations. Consequently, appropriate instruments are difficult to obtain. One possibility implemented below is that industry level R&D expenditures may be useful as these roughly capture the technological opportunities inherent within an industry. These opportunities should affect profits only insofar as they are associated with observed innovations, and we will use past levels of industry R&D will be used to ensure that current firm margins do not causally influence the instrument.

IV. Innovations and Profits: The Consequentalist View

The first four columns of Table 4.2 show estimates of (4.1) under different assumptions. The first three are in first differences and use instruments for the lagged dependent variable. The fourth column is a levels run which includes the fixed effects and is in OLS. Columns (1) and (2) only allow current margins to have an effect, whereas the next two columns add in five more lags. Column (3) instruments market share and its interaction with

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[3]In the Hall and Hayashi (1989) model technological shocks have an immediate impact on R&D (by assumption), but their most convincing estimation of the gestation lag between R&D and profits is at least two to three years.

[4]Although the correlation between innovations in consecutive years is high, this is mainly due to a large number of zeros. Inevitably, the lags are poor predictors of when a change in the number of innovations will occur.

concentration using the Arellano-Bond method (see the notes in Table 4.2 for more details).

As in the preferred model of Chapter 3 the effects of unionisation and import penetration are poorly determined. Despite the controls for innovative performance, market share and concentration continue to have well determined positive effects, although the interaction term is significantly negative. The exact impact of market share is slightly sensitive to the exogeneity assumption, but for the vast majority of firms fragmented market structures are associated with lower profit margins. For example, using the estimates in column (1) market shares are positively related to margins for all industries where CONC<0.6195, while concentration is positively related to margins for all firms where MS<0.0644. Only 11.8% and 8.7% of the sample of 721 firms have values of CONC and MS above these limits. The lagged dependent variable is very precisely determined in all three regressions and suggests that the long-run effects are about twice as large as the short-run effects.

So it seems that the association between market structure and profitability is not simply due to technical efficiency. For example, running a regression without the innovation terms yields a mean long-run effect of market share of 0.3489 compared to an average effect of 0.3472 in column (3). Since these are practically identical, the relationship of market share and margins seems to exist almost independently of innovations. Our definition of differential efficiency is quite narrow and we may be missing out on many of the smaller innovations that are driving the positive association[5]. Yet it is incumbent on those who take the extreme position of

[5] This seems unlikely as the effects of market share are stronger in the innovators sample (see Table 4.2 and the discussion below).

Brenner (see the quote I began this chapter with) to quantitatively specify exactly *what* is driving the relationship in a purely competitive world. Otherwise the imperfect competition standpoint seems the obvious and compelling position.

Both the spillover variables, IPI and IUI have very small positive effects on margins that are poorly determined. This is consistent with earlier work using this data at an industry level (Geroski,1991) but stands in contrast with other studies that have uncovered substantial spillover effects associated with R&D (e.g. Bernstein and Nadari, 1988,1989, Levin,1988, Levin and Reiss, 1988 and see Chapter 2). One interpretation of this result is that knowledge in general (as generated by R&D programs) spills over to adjacent firms, but not knowledge that is embodied in specific products or processes. Another possibility is that only firms who are innovating themselves have what Cohen and Levinthal (1989) term the 'absorptive capacity' to use innovations generated elsewhere. We explore this idea below in Section V.

As to the main question, all the results suggest that innovations ratchet up profitability at conventional significance levels and that this is robust across a wide range of experiments. Using column (1) the production of an innovation has a long-run effect of 0.0058 on margins, raising them by some 6.1% relative to the mean. Using (ii) the long-run effect is estimated to be 0.0069. Allowing a longer lag structure as in the third column generates a steady state effect of 0.0157 raising margins 16.5% relative to the mean. Since the six extra terms in column (3) cannot be eliminated without significantly reducing the fit ($\chi^2(6)=14.03$)), this is our preferred model. To get an intuition of the quantitative relevance of this, it is worth noting that average sales in 1979 were £125m implying that the instantaneous increase in profits is initially about £450,000 and rises to just under £2m in the long-run. This is far higher than the average value of the typical patent, and is consistent with the idea that the SPRU methodology has screened out the vast majority of (low value) patents[6].

The effects of innovations on margins proved to be quite robust to a wide range of re-specifications of column (3)[7]. Dropping the other observables yielded long-run estimates on the order of 0.009, and much the same results emerged when only time or industry dummies were included in the regression. Even in column (4), when fixed effects are included, the point estimates of innovations are unaltered (the standard errors are slightly smaller). Notice that the coefficients on the market structure variables are much smaller and the model is dominated by the influence of lagged margins. Even in the absence of diagnostic failure (there is evidence of first order serial correlation), the difference of coefficients suggests that fixed effects are important and failure to account for them will underestimate the influence of market structure on profitability.

Despite our belief that innovations are weakly exogenous we instrumented current innovations with the lagged values of industry level research and development expenditures normalised by industry sales. This made very little difference to column (3): INNOV was still positive and significant with a coefficient of 0.0042 and a standard error of 0.0017. The fact the coefficient was substantially unaltered implies that our exogeneity

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[6]Recall from Chapter 2 that although Shankerman and Pakes found that the median value of a U.K. patent surviving at least five years was $1861, the top 5% were worth a minimum of $28,435.

[7]Worries about the dependent variable led us to experiment with various alternatives. Using Fisher's transformation of $-(1-\ln(\Pi/S))$ or the profit-capital ratio gave very similar results. For example the coefficient and standard error on INNOV(t) in the latter equation was 0.0168 with a standard error of 0.0042). The larger coefficient reflects the fact that the mean of (Π/K) was smaller than the mean of (Π/S).

assumptions are reasonable.

The long-run effect of 0.0157 shown in column (3) in Table 4.1 is an average across all firms in the sample. Previous work tracing the effects of innovations sourced from different sectors on users productivity growth has detected substantial inter-industry variation (Geroski,1991). Also we saw in Figure 4.3 illustrated that the distribution of innovations is very concentrated in certain sectors. To pursue this further the preferred model was re-run across seven industry groups[8]. Table 4.2 shows the estimates of the size of long-run effects across these industry groups. There is a good deal of heterogeneity with the largest effects being in the low innovating industries of clothing and textiles, paper and printing and bricks and glass. It is surprising that chemicals actually has a mean negative effect, but the coefficient is very small and is in line with the Shankerman (1991) study on patent values in the chemicals industry has the lowest mean rate of return. Although broadly consistent with the hypothesis of diminishing returns, the estimates are sensitive to the exact industry definitions, so we are reluctant to read too much into this table.

V. Innovators and Non-Innovators: The Constitutionalist View

The third question concerns the distinguishing features between innovating and non-innovating firms. Is this simply a matter of firm specific technology shocks or are there some generic features which mean they have qualitatively different economic constitutions? The results

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[8]These had to be aggregated because of very low numbers of innovations in some sub-sectors. For example, although a third of pharmaceutical firms were innovators (very high) there were only nine of them which was too small a number with which to conduct any meaningful analysis.

reported in section IV were based on the consequentialist perspective, and the next step is to investigate the constitutionalist view. This rests on the premise that the firm is best seen as a bundle of human or non-human assets or distinctive capabilities. Competitive advantage arises whenever a firm accumulates a set of capabilities which more than match those of its rivals. Developing these existing skills, which are often firm specific, is a learning process often more important than purchases on factor markets. The process of innovation helps firms to enhance its capacity to learn, match technologies with demand and so sustain a successful market position.

Even a superficial scan of the data reveals that there is more to the innovation differential than simply the case were one kind of firm introduces an innovation and another does not. Table 4.4 revealed that innovators market shares were three times bigger than those of non-innovators. What is more, while an average differential in profitability of about 10% exists, it is not stable over time. Figure 4.5 plots the mean margins for both groups and demonstrates that although a clear profitability difference exists at the end of the sample, there is no such advantage in the early years. Additionally the differential widens appreciably in the early 1980s recession, which is consistent with the increasing strength of the profits-innovation correlation as reported in Table 4.1.

To delve deeper into the problem presented in Figure 4.5 we divided the sample into 117 innovators and 604 non-innovators. The split is statistically supported (p-value <0.001), and Table 4.4 contains the results which are based on an identical specification to column (3) of Table 4.2. Apart from the number of innovations, the main differences between the samples lies in the coefficients attached to market share, the lagged profit margin and the 1980 time dummy (not reported). The estimates of the latter are significant and negative for non-innovators but insignificantly different from zero and positive for innovators.

Although not a major contributor to the profitability differential, the coefficients on the industry innovations variables are larger and well determined *only* in the innovating sample[9]. We must revise our earlier conclusions regarding spillovers: they have small but significant effects on firms who are already 'in the running' in the technology race. This corroborates a speculation from some of the R&D studies that firm 1 can only effectively use the knowledge externality from firm 2 if it has invested resources in actively seeking, capturing and harnessing the spillovers[10].

To interpret Table 4.4 write (4.1) as $(\Pi/R)^I = X^I\beta^I + \mu^I$ when applied to the sample of innovators and $(\Pi/R)^N = X^N\beta^N + \mu^N$ when applied to the non-innovators. Then the predicted probability difference can be written as: $\hat{D} = \hat{\beta}^I(X^I - X^N) + X^N(\hat{\beta}^I - \hat{\beta}^N)$, where a hat denotes an estimated value[11]. Thus part of the difference between innovators and non-innovators profit margins comes from the fact that the latter have no innovations and have smaller market shares (these may not be independent events), but part of it comes from the different coefficients. One could call these differences 'transitory' (even though they may persist for long-periods of time) to distinguish them from the permanent firm fixed effect. Interpreting Table

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[9] Another experiment, instrumenting industry innovations with their own lag two years earlier was performed. As expected IPI was no longer significant taking a coefficient of 0.000032 and standard error of 0.00039. The industry innovations used measure, by contrast, retained its importance with point estimates of 0.000392 and standard error of 0.000123.

[10] For example, Jaffe (1986) found no R&D spillovers only for firms who invested less than one half of a standard deviation below the mean of R&D. Cohen and Levinthal (1989) find that appropriability encourages R&D to a greater extent in 'basic science' industries, because firms have to do more development to apply the spillovers from other firms.

[11] This is the same methodology used to calculate union differentials in *inter alia* Stewart (1987).

4.4 in this way produces the conclusion that the differences in the fixed effects are large and positive (the mean value for innovators is 0.048 and 0.030 for non-innovators), while transitory effects are small and overall negative. It is interesting that the transitory effects are very cyclical in impact, suggesting that innovating firms were much better at defending their margins in the recession of the early 1980s than their non-innovating counterparts (the transitory predicted differential was 0.009 higher in 1980-82 than it was on average over the earlier part of the period). Most of this is reflected in the 1980 and 1982 time dummies, but it is also possible to observe a small contribution originating from the market share and innovation variables.

Differences between innovators and non-innovators seem to reflect mainly generic differences between the two types of firms, but they are difficult to observe accurately because of cyclical factors. Isolating the causes of these generic differences is a great deal harder than merely measuring them, but it seems reasonable to assume that they are closely related to some aspects of the innovative process. In particular, regressing the estimated fixed effects on a number of observables suggests that they are higher for companies who innovate and for firms located in heavily producing (but not using) sectors. Denoting the fixed effect as $\hat{f}_i$, two typical regressions thrown up by this exercise were:

$$\hat{f}_i = \underset{(0.001)}{0.030} + \underset{(0.003)}{0.018\overline{INN}_i}$$

$$\hat{f}_i = \underset{(0.009)}{0.034} + \underset{(0.003)}{0.018\overline{INN}_i} + \underset{(0.001)}{0.003(\overline{IPI/10})_j} + \underset{(0.005)}{0.013(\overline{IUI/10})_j}$$
$$+ \underset{(0.014)}{0.009\overline{IDENSITY}_j} - \underset{(0.0186)}{0.0440\overline{MS}_i} - \underset{(0.0.009)}{0.005\overline{CON}_j} - \underset{(0.010)}{0.017\overline{IMPS}_j}$$

(Standard errors are in brackets, bars denote firm averages, INN is a 0,1 dummy indicating whether firm i innovated between 1972-83 or not).

This picture is congruent with the constitutionalist position that differences arise from some deep-rooted 'competitive ability'.

VI Conclusions

The chapter began with three questions concerning the size of the innovations effect, the robustness of the market structure-rents relationship and the the mechanisms linking technical change and profits. Some progress has been made in answering these questions. We have estimated that there are pay-offs to our major innovations of just below £2m in 1979 prices in the long-run. To this must be added some very modest spillover effects which are significant only amongst innovating firms. Firms with large market shares or in concentrated industries continue to benefit from higher rents even when we have taken their technological performance into account. Consequently, the basic framework of our study, that rents are created by product market power and innovative activity seems to have some empirical support.

This analysis has been based on what we have termed the consequentialist view of innovation which takes the black box approach to the internal constitution of the firm. This is not a totally adequate view. The profitability differential between firms who innovated at any time and those that did not are mainly due to permanent differences between the two types of companies. On the constitutionalist view, these companies have some deep-seated "competitive ability" associated with the process of innovations but not reducible to simply the numbers of innovations produced. The widening gap in the relative performance of innovators and non-innovators over our sample period is the result of cyclical effects working in conjunction with secular trends in market shares which overlay the generic differences between the two types of firms. The greater resilience of innovative firms in recession tempts one towards a Schumpeterian interpretation; but numerically speaking this is more of a bracing breeze than a cataclysmic gale of creative destruction.

Figure 4.1: Total Innovations, 1945-83

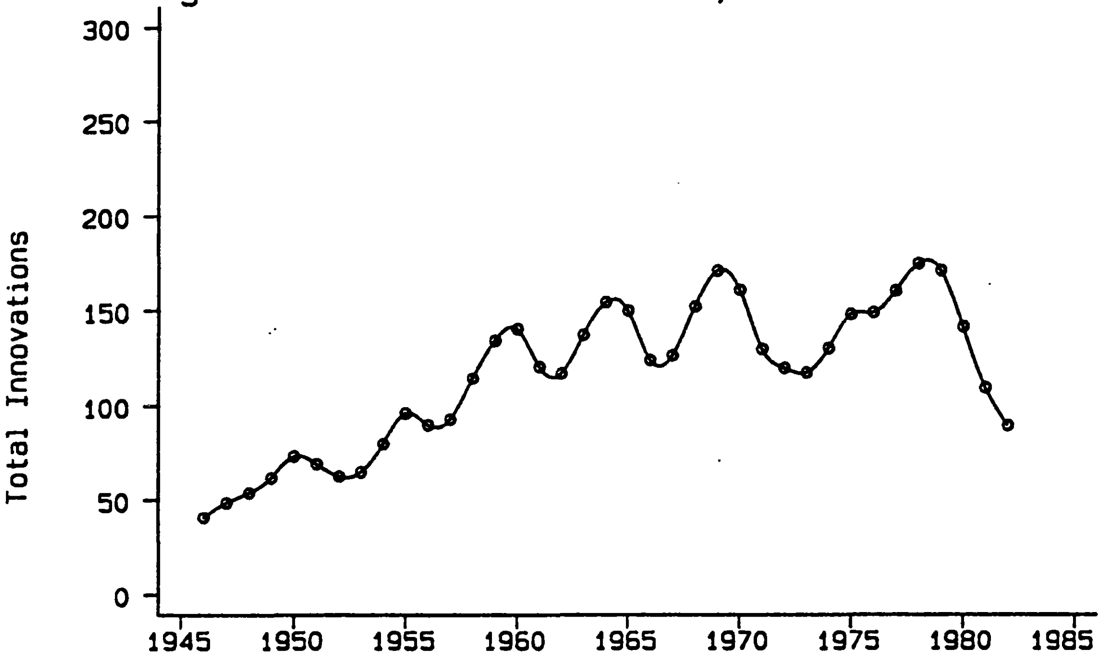


Figure 4.2: No. of Innovations in Dataset, 1972-83

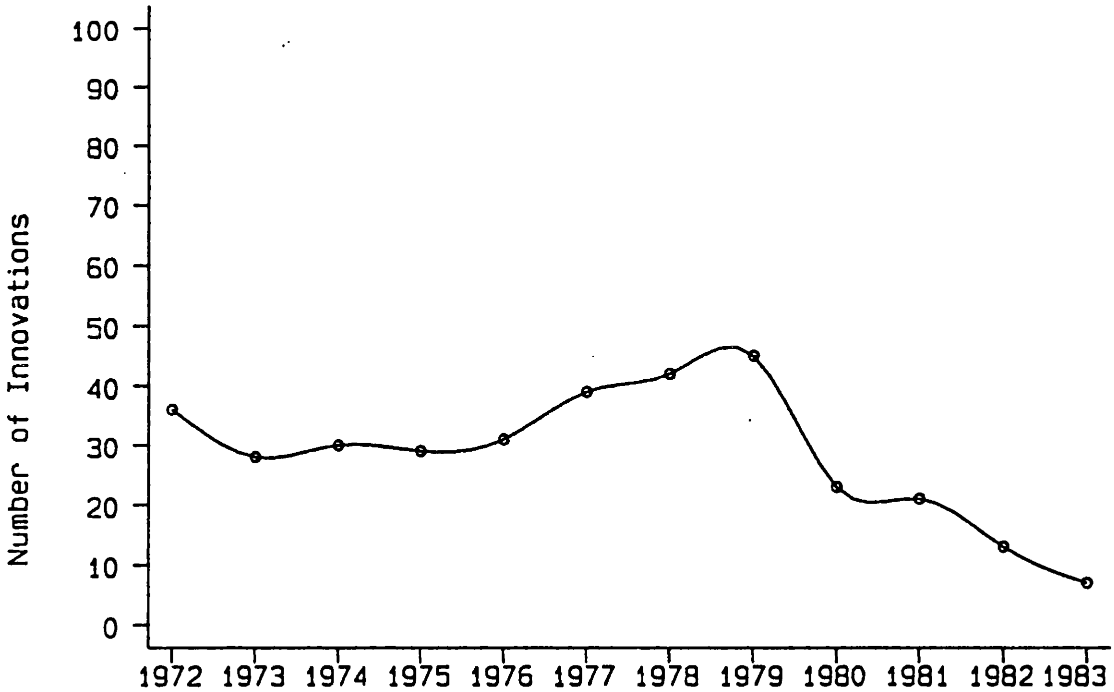
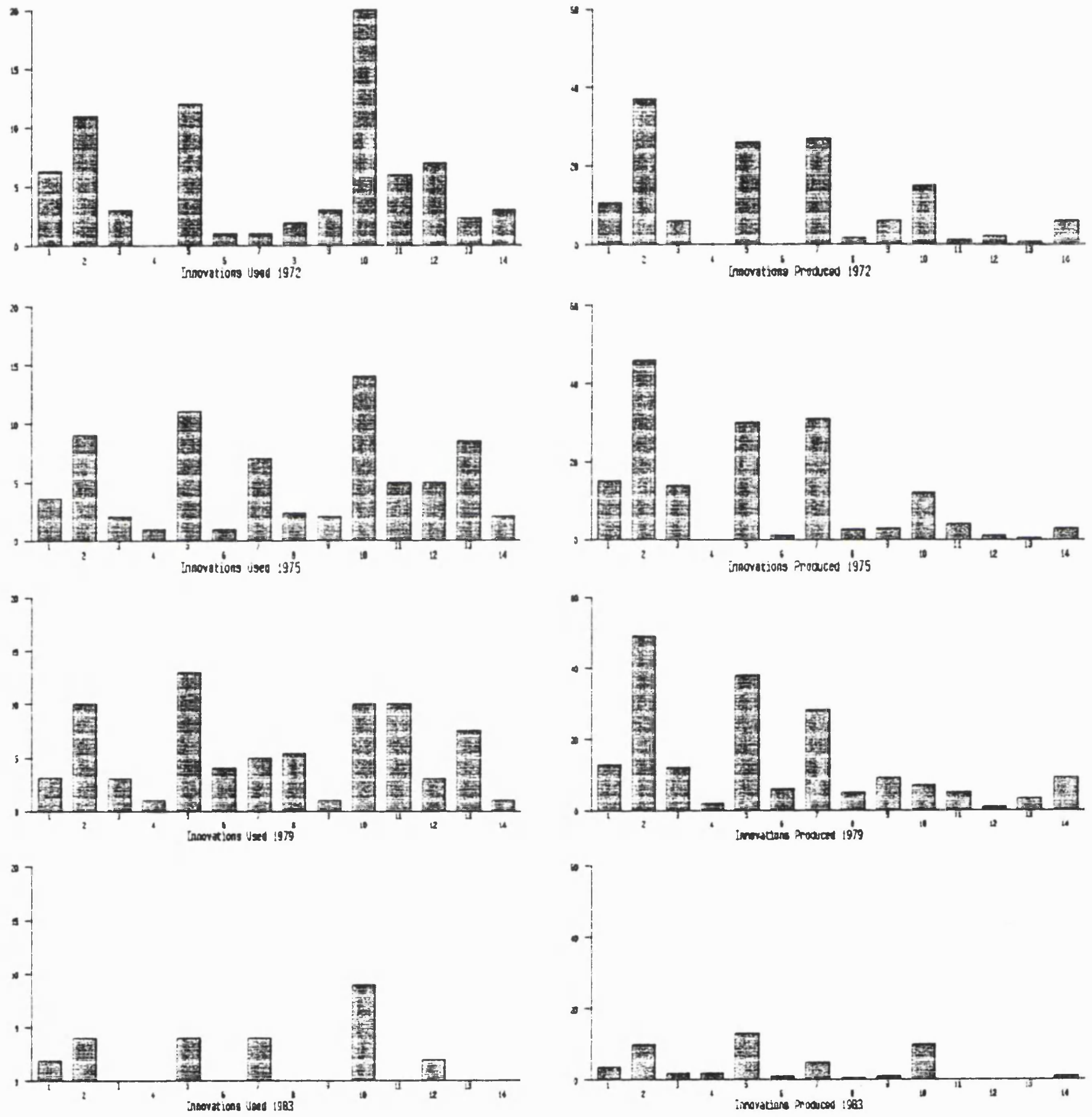


Figure 4.3 Industry Innovations 1972, 1975, 1979, 1983



See overleaf for Industry Key

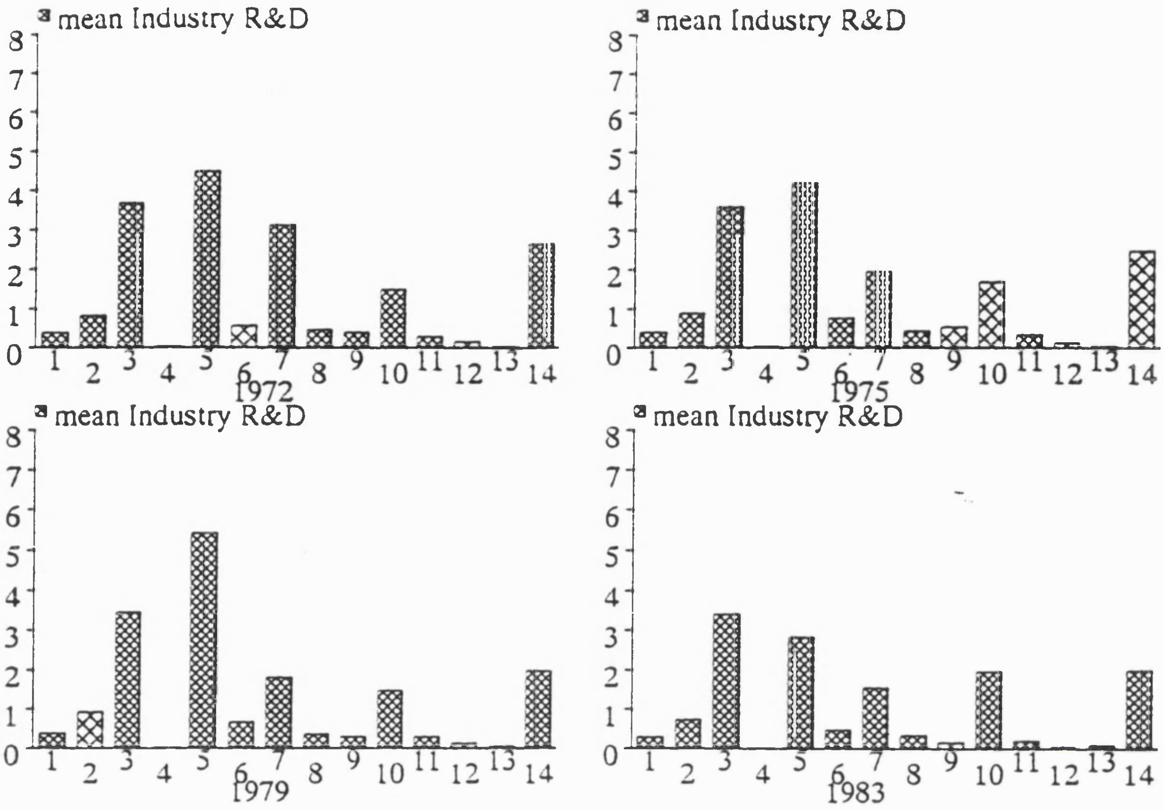


Figure 4.4 Industry R&D/Sales % 1972,1975,1979,1983

Industry Codes

1 = Bricks and Glass; 2=Mechanical Engineering; 3=Chemicals; 4=Timber; 5 = Electrical Engineering; 6 = Metal Manufacturing (1); 7 = Instrument Engineering; 8 = Metal Manufacturing (2); 9 = Carpets; 10=Vehicles; 11=Food,Drink and Tobacco; 12 = Paper and Printing; 13=Clothing and Textiles; 14= Other Manufacturing

Figure 4.5: Profit Margins of Innovators and Non-Innovators

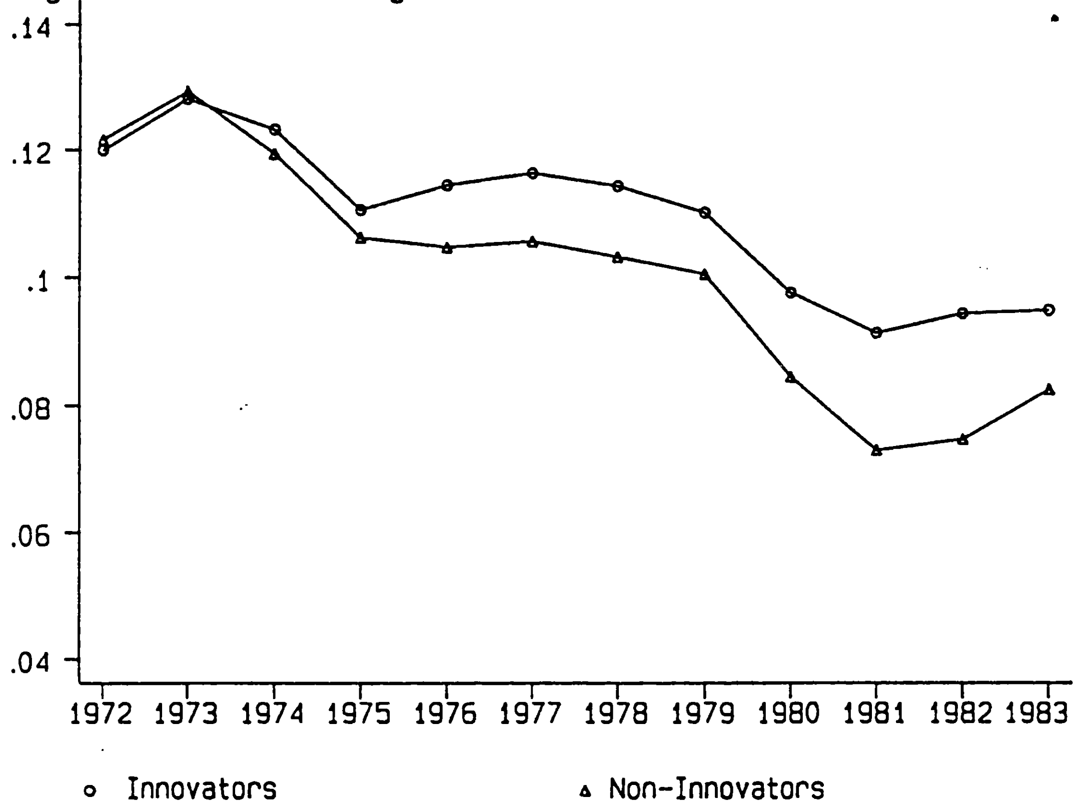


TABLE 4.1 DESCRIPTIVE STATISTICS

Panel A

Variable	721 Firm Sample		117 Firm Sample	
	Mean	Std. Dev.	Mean	Std. Dev.
Π/R	0.0950	0.0634	0.1049	0.0561
INNOV	0.0449	0.3041	0.2716	0.7063
IPI	12.98	15.23	16.97	15.96
IUI	6.400	5.88	7.37	5.781
IDENSITY	0.6761	0.1168	0.7033	0.094
MS	0.0254	0.0682	0.0723	0.1190
CONC	0.399	0.1776	0.4097	0.1675
IMPS	0.2506	0.1409	0.2625	0.1073

Panel B

Yearly Regressions of Profit Margins on Innovation

Year	INNOV(t)	No. of Firms
1972	-0.0010(0.0067)	627
1973	0.0015(0.0069)	667
1974	0.0102(0.0082)	692
1975	-0.0013(0.0066)	702
1976	0.0105(0.0075)	713
1977	0.0099(0.0058)	720
1978	0.0165(0.0062)	721
1979	0.0055(0.0055)	718
1980	0.0042(0.0108)	712
1981	0.0109(0.0090)	687
1982	0.0250(0.0146)	663
1983	0.0180(0.0177)	627
1975-1983	0.0089(0.0023)	8249

TABLE 4.2: PROFITABILITY AND INNOVATION IN THE POPULATION

	FIRST DIFFERENCES			LEVELS
	(1)	(2)	(3)	(4)
Constant	-0.0093(0.0014)	-0.0086(0.0012)	-0.0088(0.0012)	-0.0015(0.0034)
INNOV	0.0029(0.0010)	0.0036(0.0007)	0.0036(0.0007)	0.0031(0.0010)
INNOV(t-1)	-	-	-0.0005(0.0007)	-0.0026(0.0010)
INNOV(t-2)	-	-	0.0008(0.0009)	-0.0004(0.0012)
INNOV(t-3)	-	-	0.0012(0.0009)	0.0006(0.0013)
INNOV(t-4)	-	-	-0.0007(0.0010)	-0.0010(0.0017)
INNOV(t-5)	-	-	0.0024(0.0010)	0.0020(0.0011)
INNOV(t-6)	-	-	0.0014(0.0010)	-0.0001(0.0011)
IPI*(t)	0.0033(0.0106)	0.0050(0.0093)	0.0042(0.0094)	0.0074(0.0041)
IUI*(t)	0.0095(0.0112)	0.0131(0.0105)	0.0126(0.0105)	-0.0039(0.0100)
MS(t)	0.1780(0.0860)	0.3301(0.0690)	0.3823(0.0726)	0.0413(0.0134)
CONC(t)	0.0185(0.0159)	0.0294(0.0134)	0.0280(0.0136)	0.0060(0.0029)
MS*CONC(t)	-0.2872(0.1588)	-0.3608(0.1108)	-0.4577(0.1244)	-0.0681(0.0263)
IMPS(t)	0.0188(0.0184)	0.0152(0.3917)	0.0041(0.0153)	-0.0080(0.0036)
Π/R(t-1)	0.4988(0.0340)	0.4791(0.0284)	0.4834(0.0296)	0.8691(0.0143)

* Coefficent and standard error have been multipied by 100

No. of firms	721	721	721	721
Total Obs	6086	6086	6086	6086
Serial Corr.	-0.795(721)	-0.841(721)	-0.812(721)	-1.522(721)
Sargan(df)	36.95(25)	94.58(77)	94.20(77)	-

Notes to Table 4.2

1. Dependent variable in profit-sales ratio, asymptotic standard errors in parantheses.
2. Equations (1)-(3) are in first differences using instrumental variables in the Arenallo Bond in manner with lagged values from t-2 to t-4. In columns (1) only the lagged rate of return is instrumented, in columns (2) and (3) MS and MS*CONC are instrumented. All three columns have the difference of Dividends and Investment/Rales in (t-2) as outside indtruments
3. Equation (4) is in levels OLS.
4. Sargan is a Chi-Squared test of the overidentifying restrictions, Serial Correlation is an N(0,1) test of second order serial correlation for (1)- (3) and first order in column (4)

TABLE 4.3 RESULTS BY INDUSTRY GROUPING

Industry	Long-Run Innovation Effect		No. of Firms
All Firms	0.0081 / (1 - 0.4835)	= 0.0157	721
Chemicals	-0.0024 / (1 - 0.4911)	= -0.005	43
Bricks and Glass	0.0059 / (1 - 0.5527)	= 0.0133	34
Metals and Engineering	0.0040 / (1 - 0.5251)	= 0.0085	328
Food, Drink and Tobacco	-0.0125 / (1 - 0.0496)	= -0.0132	72
Clothing and Textiles	0.0431 / (1 - 0.2328)	= 0.0562	113
Paper and Printing	0.0126 / (1 - 0.3540)	= 0.0195	66
Miscellaneous	0.0046 / (1 - 0.1283)	= 0.0053	65

Notes to Table 4.3
Derived from specifications comparable to column (3) of Table 4.2

TABLE 4.4: PROFITABILITY AND INNOVATION IN THE SUB-SAMPLES

	(1) Innovators	(2) Non-Innovators
Constant	-0.0101(0.0008)	-0.0087(0.0014)
INNOV(t)	0.0032(0.0003)	-
INNOV(t-1)	-0.0010(0.0004)	-
INNOV(t-2)	-0.0000(0.0004)	-
INNOV(t-3)	0.0010(0.0003)	-
INNOV(t-4)	0.0001(0.0004)	-
INNOV(t-5)	0.0022(0.0003)	-
INNOV(t-6)	0.0005(0.0003)	-
IPI*(t)	0.0112(0.0049)	0.0049(0.0103)
IUI*(t)	0.0359(0.0114)	0.0159(0.0108)
MS(t)	0.0584(0.0226)	0.0863(0.0912)
CONC(t)	0.0142(0.0142)	0.0203(0.0139)
MS*CONC(t)	-0.2325(0.0428)	0.2012(0.1536)
IMPS(t)	-0.0294(0.0156)	0.0037(0.0167)
Π/R(t-1)	0.3989(0.0210)	0.4831(0.0301)

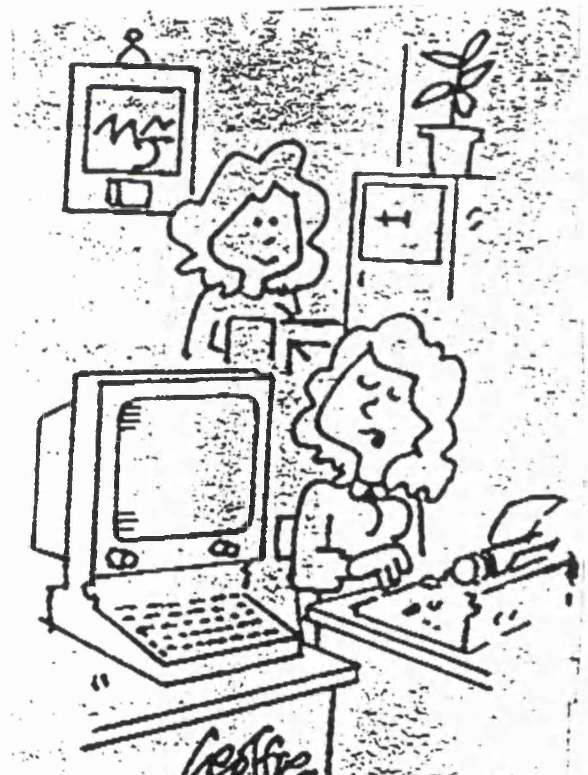
* Coefficent and standard error have been multipied by 100

No. of firms	117	604
Total Obs	1005	5081
Serial Corr.	1.077(117)	-1.756(604)
Sargan(df)	78.73(77)	94.78(77)

Notes to Table 4.4
1. As in Table 4.3 for estimating methods

The fear of unemployment means that most people have ambivalent feelings towards new technology.....

"We've decided to call it the neutron chip.
It eliminates jobs but leaves the factory intact."



"I preferred the ten men it replaced!"

CHAPTER 5

THE IMPACT OF INNOVATIVE ACTIVITY ON EMPLOYMENT

The opinion entertained by the labouring classes, that the employment of machinery is frequently detrimental to their interests, is not founded on prejudice and error, but is conformable to the correct principles of political economy.

Ricardo, 1821

Basically, cyclical unemployment is technological unemployment

Schumpeter, 1939

I. INTRODUCTION

A major factor in influencing the attitudes of trade unionists and the general public towards new technology is its impact on jobs. In response to the massive increase in unemployment in the early 1980s many commentators located a central cause as the gale of innovation associated with the micro electronics revolution. Apocalyptic and Utopian visions have been offered and recanted in the wake of evidence that the effects on innovation on joblessness have been greatly exaggerated[1]. This should hardly be a surprise to economists. Although the required labour per unit of output is lower, technical progress which reduces the effective cost of labour should also boost demand through reducing product prices ('the output expansion effect'). In addition there may be substitution into labour inputs from other factors

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[1] Jenkins and Sherman (1979) predicted a 23% reduction in jobs by 2003 directly as a result of new technology.

of production which are now relatively more expensive.

The analysis in this chapter is again at the firm level, so there are likely to be further spillover effects in industries downstream which use the products of the innovating firms and industries. As in Chapter 4, if innovation has positive spillover effects then the parameter estimates given here will understate the general equilibrium benefits of innovation on jobs. Additionally, a technologically leading nation will possess international comparative advantages - the example of Japan springs immediately to mind. However, at the aggregate level there may also be serious mismatch problems, especially for certain groups of workers such as those without skills or whose specialist abilities are no longer needed. Since technology has revolutionised itself over and over again down the centuries since industrialisation without growing aggregate unemployment, the fears of technological pessimists must really be grounded in the greater inequalities in unemployment durations and incomes that rapid innovation can produce. More will be said on this in Chapter 7.

Earlier chapters have shown that firms who have higher market shares, sell in concentrated markets, or first commercialise innovations enjoy higher rates of return. The theme of this chapter and the two which follow is the degree to which workers also benefit in terms of higher employment and wages[2]. To conduct a proper analysis of the conditions under which this will occur, the most popular union models are re-examined and it is demonstrated that positive employment effects are more likely when unions bargain over jobs. Some new tests are presented to distinguish efficient bargaining from efficiency wages.

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[2]Note that the theoretical interest here is whether individuals benefit *qua* workers rather than *qua* consumers in the form of lower prices.

The layout is as follows. Section I surveys briefly the relevant empirical work on technical change and jobs (the literature distinguishing between bargaining models was discussed in Chapter 2). The next section looks at the employment effects of innovation under (i) various union models, (ii) effort models, and (iii) oligopoly in the product market. It is shown that the elasticity of labour demand is a crucial parameter, with values above unity being generally associated with positive employment effects from labour augmenting technical change. Section IV presents the modeling strategy and Section V the data. Results are discussed in the sixth section and some conclusions are offered in the final section. To cut a long story short, firm employment is raised by innovations and a labour demand model best describes the data. Since the data covers the late 1970s and early 1980s, it does not lend support to the above claims of Schumpeter or Ricardo, at least at the micro-economic level.

II. Empirical Micro Work on Employment and Innovation

There is a huge empirical literature on technology and employment, so it is necessary to be somewhat selective. This survey will concentrate on micro-level studies, acknowledging the fact that the overall impact of technology on unemployment can only be addressed in a general equilibrium macro-model (see the survey by Newton and Leckie, 1987 or the attempt by Leontief and Duchin, 1984). Apart from the bias arising from failing to account for spillovers, micro studies only observe survivors. This probably causes an underestimation of the positive impact on jobs as those units who dropped out of markets were more likely to be those that could not take the technological pace. So both spillover and survivor biases will be downwards. If a positive innovation effect is discovered at the firm level we are probably estimating lower bounds. The more disaggregate approach is preferable on other grounds as this is the level where much theory is advanced and more detailed information is usually available. Even this restricted empirical space is large. Within it three basic methodologies have been used :'attitudinal' questionnaires asking individuals what they think has been the effect of technical change; case studies and, at least to economists, more orthodox statistical analyses.

1. Attitudinal

Many social scientists, less wedded to the methods of revealed preference, have analysed the effects of technical change by asking participants what they *thought* the consequences were. There are three large scale databases which have been used for this purpose and the relevant statistics from these are contained in Table 5.1. All suggest that job losses have been more common than job gains, but in most cases there has been no change associated with new technology. The British Social Attitudes Survey asked a random sample of just under 1300 employees various questions on micro-electronic technology in 1985, 1987 and 1990. Panel A of Table 5.1 shows that for the majority there were no job losses accompanying new technology, but that contractions were more common than expansions[3]. Similar findings are contained in the 1984 Workplace Industrial Relations Survey of 2019 British workplaces. Senior managers and shop stewards were asked what was the direct impact of advanced micro electronic changes in the establishments where it had occurred. As panel B shows, two-thirds of respondents answered that there was no change but decreases were two to three times as likely as increases. The negative effects seemed much more prevalent in private manufacturing and in unionised plants, which is interesting as this is the area where the empirical work will be focused.

An obvious criticism to this up/down style of questioning is that it will underestimate the overall loss of jobs if the average reduction is larger than the average gain. To address this problem the Policy Studies Institute (PSI) specifically asked technical managers to estimate the size of the employment changes directly connected to technological change. In all four of their manufacturing surveys (1981,1983,1985 and 1987) they found that it was indeed the case that the job 'losers' lost a lot more than the job 'winners' won. Moreover, the absolute size of this loss seemed to be increasing over time (see Panel C).

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[3] As an aside, another part of the questionnaire asked all individuals what they *thought* would be the overall impact of new technology; over 70% thought that jobs would be lost compared to 8% who thought there would be a net gain.

2. Case Studies

Christie et al (1990) also report the Policy Studies Institute's case studies of 26 plants affected by technical change. Although disentangling the employment effects of technological changes from organisational and demand changes is an uphill task, it seems that most of the employment losses were achieved through turnover rather than redundancies. This suggests that only a limited amount can be learnt from examining contractual provisions, like New Technology Agreements[4], directly. Although most case studies have uncovered output expansion at the same or lower employment levels (Rothwell and Zegveld, 1979, is a good representative example) they highlight the heterogeneity of innovation effects. In particular, there seems to have been a disproportionate amount of job shedding amongst less skilled occupations, and particularly those of clerical workers when computers are introduced.[5]

As tempting as it is to agree with Stigler that statistics are simply the plural of cases studies, there are well known problems inherent in the case study approach. There will be a natural tendency to concentrate on areas 'where the action is', so it is hard to know what the overall effect will be. Corroboration of observations in the more qualitatively inclined research is

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[4] NTAs grew rapidly in the late 1970s but faded away by the mid-1980s (Williams and Steward, 1985). Mostly these stipulated no compulsory redundancies (67% in the Labour Research Department's 1982 Survey) and often there were further restrictions on employment shedding. The major problem is that NTAs were never widespread and were concentrated heavily amongst four unions (APEX, ASTMS, NALGO and TASS). Significantly these are all white-collar unions and this signals the fact that micro-electronic technology was perceived to be a greater threat to these groups of workers.

[5] Even if this pattern was generally correct, one cannot conclude from this that there has been a general upgrading in the labour force as the skill content of different occupations may be changing (Spenner, 1988). On clerical workers see Bartel and Lichtenberg (1987) over many U.S. industries or Lynch and Osterman (1989) for an excellent study of 7 Bell Telephone companies.

also difficult as replication is rarely possible. Still, such studies are useful in emphasising the *mechanisms* through which job destruction or creation may take place, even if we are forced to turn to behavioural analysis for a rigorous appraisal of the evidence.

3. Statistical Studies

If the previous modes of inquiry help foster the layperson's view that the machine is a threat to jobs, when the statistical link between innovative activity and employment is carefully observed a different picture emerges, at the micro-economic level at least. Four 'micro' levels of aggregation will be considered: process, plant, firm and industry in turn.

Studies at the process level take a particular micro-electronic technique and get engineering estimates of job losses. For example, Fleck (1984) calculated that 1.4 jobs would be lost for each robot used in an 'average' plant. The equivalent figure was 0.6 employees in Japan (Watanbe, 1987) and one for one in the United States (Hunt and Hunt,1983). Early forecasters used these estimates to get extremely gloomy predictions about the fate of some manufacturing branches, but it is easy to see that optimists could point to the relatively slow progress of robots to forecast minimal estimates of job loss. These predictions are bogus in any case as first, they focus on sub-processes that are not applicable across all industries and secondly, the output expansion effect is ignored entirely.

Studies at the establishment level are more carefully documented. The 1984 Workplace Industrial Relations Survey (WIRS 2) and the PSI studies have data on both current and past employment, enabling researchers to look at innovation and employment changes. The PSI study shows that plants which used microelectronics experienced a mean employment growth of 1.9% between

1985 and 1987 whereas those who did not actually had a decline of 9.4%. Daniel's (1987) analysis of WIRS2, notes that although new technology was generally associated with declines in employment, there were larger falls in manual employment for non-users of micro-electronics in private manufacturing over 1980-1984 than for users (Table IX.18). Since the 1980s were a decade of dramatic change for British manufacturing, these simple correlations are unlikely to be convincing. Machin and Wadhwani (1991b) present employment equations from WIRS2 to see whether the correlations stand up to controls for unionisation, other types of change, industry and regional dummies, etc. The controls seem to strengthen the positive relationship and, taken at face value, imply a 2.7% employment growth effect associated with advanced technical change across the entire private sector[6].

Although an improvement, employment equations from WIRS must be treated with caution for, as Machin and Wadhwani (1991a) point out, there are no adequate controls for capital, sales or fixed effects. Firm level studies are more suited to this purpose but unfortunately there is a large gap in the literature here. An exception is Entorf and Pohlmeier (1991) who examine a sample of West German manufacturing firms in 1984. They construct a simultaneous probit model for innovation, employment and export share and estimate that product (but not process) innovations significantly increase employment even when treated as endogenous. The effects are small (just over two jobs per innovation) but this is probably due to a very broad definition of what constitutes a new product (57% of all firms realised at least one). Unfortunately, as the authors admit in their conclusion, the use of only one cross section prevents them from allowing for dynamics which are known to be

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[6]Note that the Blanchflower et al (1991) results reported in their appendix from a larger sample are practically identical.

vitally important in employment equations and the longer run effects of technical change[7].

By focusing on industrial data, economists have been able to combine cross sectional with time series analysis. Salter (1960) pioneered the way, reporting a long run positive effect of Total Factor Productivity (TFP) on employment. The relationship between the Solow residual and industry employment appears to have weakened since the Second World War; indeed it seemed to practically disappear in the 1970s (Wragg and Robertson,1978; Ball and Skeoch ,1981). More recently, Nickell and Kong (1989) have ambitiously estimated a four equation (production, pricing, demand and wages) imperfect competition model across nine manufacturing industries 1974-82. They use the Solow residual to proxy technology and recover the structural parameters, in particular the industry price elasticity of demand. Since the writers call their estimates of these demand elasticities 'the least reliable', they are calculated in various ways to give a plausible range of values. Only in Bricks and Glass and Textiles is technical change calculated to have a negative effect on employment.

The use of TFP has problems in these studies as part of it may be related to factors which do not reflect innovation (e.g. market power, higher worker effort, etc). Freeman and Soete (1987) have used the head count of innovations measure utilised in this and earlier chapters to distinguish different manufacturing sectors according to technological criteria. In the 1980s they uncovered a close relationship between the innovative

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[7]For example, Osterman (1986) studied the effects of increased computer power across 40 2 digit U.S. industries between 1972-1978. Overall there were decreases in employment for white collar workers, but these were concentrated very heavily in the first years after adoption. In subsequent years there was an increase in the industry's labour force.

'pervasiveness'[8] of a sector and employment growth. The credibility of their exercise depends on whether the definition of 'pervasiveness' was not influenced by the successful growth of the industry in question. Even if it was not, it is still essentially a correlation exercise merely whetting one's appetite for a closer analysis.

In summary, the evidence *at the micro-level* does not support the hypothesis that innovation is a major cause of unemployment. It must be stressed once again that the general equilibrium effect may well be different, even though the disaggregated behavioural studies reviewed here suggests that job opportunities have been enhanced by innovation. This conclusion must be tempered by the lack of existing studies which combine output measures of innovation with dynamic employment determination. The former seem available mainly at the firm level, and the latter at the industry level. Our empirical work seeks to fill this gap.

III. Employment and Technical Change: Theory

In this section we present some simple bargaining models and examine the employment effects of labour saving process innovations. Appendix 5.I looks at the more general case of non-neutral technical change, so the reader is directed there for a more general treatment. Additionally, we do not look at product innovations are not looked at directly as it is obvious that at the level of the firm (although not at the industry or economy level) that new products will expand employment if labour intensity of new production is no lower than in the existing product-range. If they do have a lower intensity

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[8]By pervasiveness they mean (i) those who produce more innovations than they use and (ii) supply more than 20 downstream three-digit industries. The computing, electronics and plastics industries fall within this sector.

then the analysis will proceed on the same lines as a process innovation. Finally, we are observing the effects of innovation *net* of any change in the elasticity of labour demand induced by new techniques.

Recall from Chapter 2 that the structural wage and employment equations can be written for the three main union bargaining models as:

Labour Demand Models	$W(\beta,X_1,X_2)$,	$N(W,X_1)$	(5.0a,5.0b)
Efficient Bargaining	$W(\beta,X_1,X_2)$,	$N(W,X_1,X_2)$	(5.0c,5.0d)
General Bargaining Model	$W(\beta^W,X_1,X_2)$	$N(W,\beta^N,X_1,X_2)$	(5.0e,5.0f)

Where β^N = firm's power over employment, β^W = firm's power over the wage, X_2= shifters in union utility. The primary concern in this section is to model the effects of one of the exogenous influences on profits (X_1) namely, technological innovations. A secondary concern will be the correct interpretation of one of the influences on one of the exogenous determinants of union utility (X_2) namely, the alternative wage ($\tilde{W}$). Each of the three union models are analysed in turn, then models of worker effort and product market power are brought in.

1. Labour Demand Models

The fundamental premise of Labour Demand models is that the wage is predetermined and the employer unilaterally sets employment. This could be the case under perfect competition in the labour market or a Right to Manage model. The usual first order condition for employment holds: the wage is set to equal the marginal revenue product of labour. It is convenient to write this as (subscripts denote partial derivatives):

$$\omega(N,W,X_1) = R_N = W$$

Since $\partial N/\partial A = -(\partial\omega/\partial A)/(\partial\omega/\partial N)$ and $R_{NN}< 0$ by the second-order condition the sign of $\{\partial N/\partial A\}$ is the same as the sign of $\{\partial \omega/\partial A\}$. Assume that technical change is labour augmenting so that the revenue function takes the standard multiplicative form $R = R(AN,K,X_1)$ where A = a productivity index which will depend on the state of technology. Using Young's Theorem we can write

$$R_{NA} = \partial R_N/\partial A = (N/A)R_{NN} + R_N/A$$

(since $R_N = (N/A)R_A$). This can also be written as

$$(5.1)\ R_{NA} = (R_N/A)(1 - \eta_{NW}^{-1})$$

Where $\eta_{NW} = -NR_{NN}/R_N$, the elasticity of the labour demand curve. The fundamental result (which holds across many models) is:

Proposition 1. *In Labour Demand Models, an innovation will increase employment if the elasticity of the labour demand is greater than unity.*

A second proposition particular to the current model is

Proposition 2. *In Labour Demand Models, an innovation will decrease employment if the elasticity of labour demand is less than unity*

This is illustrated for the simple case of linear demand in Figure 5.1. An innovation causes a clockwise shift in the demand curve about the point where the elasticity is unity. For high wage levels (W_1), we are on an elastic part of the demand curve and employment increases, the opposite happens at lower wage levels (W_2).

The intuition behind this result is straightforward. The effect of innovation on employment will depend on the relative profitability of increasing output in response to a decline in labour costs. If this is large increases in output will outweigh the fact that the same amount of production is feasible at a lower level of labour input. The output expansion effect will be greater the more elastic is product demand, the larger labour is in total costs and the easier it is to substitute labour for other factors.

These are the elements which make up the elasticity of labour demand through the Marshallian Rules.

For a revenue function with more general technology $R = R(A,N,K,X_2)$, condition (5.1) becomes

$$(5.2)\quad R_{NA} = (R_N/AR)(1 - \Theta_N/\sigma_{AN})$$

where $\Theta_N = WN/R$, labour's share in revenue and $\sigma_{AN} = R_A R_N/RR_{AN}$, the elasticity of substitution between labour and A, 'technical capital', (the meaning of A is discussed more closely later). A fuller analysis of this is given in Appendix 5.I, but the basic premise that higher elasticities are more likely to generate positive employment effects still holds.

2. Contract Curve Models

More structure needs to be placed on the model in order to analyse efficient contracts as employment is now an object of the bargain. Let the union's contribution to the Nash Bargain be $U = (W - \tilde{W})N^{\psi}$ and the firm's the usual $\Pi = R(AN,K,X_1) - WN$. Nash Bargains over employment and wages respectively yield the following first order conditions (assuming an interior solution):

$$(5.3)\quad W = \left(\frac{\psi}{\psi + \beta}\right)R/N + \left(\frac{\beta}{\psi + \beta}\right)R_N$$

$$(5.4)\quad W = \left(\frac{1}{1 + \beta}\right)R/N + \left(\frac{\beta}{1 + \beta}\right)\tilde{W}$$

Solving out for own wages gives the reduced form for employment under the Contract Curve Model:

$$(5.5)\quad \omega(N,W,X_1,\tilde{W},\psi) = R_N + \left(\frac{\psi - 1}{1 + \beta}\right)R/N - \left(\frac{\psi + \beta}{1 + \beta}\right)\tilde{W} = 0$$

As before, $\text{sign}(\partial\omega/\partial A) = \text{sign}(\partial N/\partial A)$, and

$$(5.6)\quad \partial\omega/\partial A = R_N/A\left(1 - \eta_{NW}^{-1} + \left(\frac{\psi - 1}{1 + \beta}\right)\right)$$

Thus, for any union which values employment more than wages (and we believe risk aversion, $\psi > 1$, is the rule), employment is more likely to increase under efficient bargaining than in labour demand models. This is quite reasonable: the union will take some of the rents from innovation in the form of higher employment if it is able to do this through bargaining. Positive effects are more likely the more the union values jobs (higher ψ), and the more power it has (lower β). In particular, although Proposition 1 holds under efficient contracting proposition 2 can be relaxed

<u>Proposition</u> <u>3</u> *In Contract Curve Models, an innovation will increase employment if and only if*

$$\eta_{NW} > 1 - \left(\frac{\psi - 1}{\psi + \beta} \right)$$

The usual theoretical restriction on the sign of $\partial N/\partial \tilde{W} = \text{sign}\{\partial \omega/\partial \tilde{W}\} \leq 0$ from (5.5) still holds. The various problems with using this as the test between the two models were discussed extensively in Chapter 2. Two of the main objections were that the tests are non-nested and that efficiency wage considerations generate the same predictions as efficient bargains *viz* the employment equation. Both of these objections are tackled in the following two sub-sections.

3. General Bargaining Model

In the Manning (1987) model wages are determined in the first stage and employment is then bargained over taking the wage as given. If innovations are installed before the wage negotiations (as is probably most likely) then the employment conditions are the same as under the efficient bargain described above. On the other hand, if the innovation occurs after wages have been set then there is a new condition. This can be derived by using an amended form of (5.3) for the job bargain

$$(5.7)\quad \omega(N,W,X_1,\tilde{W},\psi) = \left(\frac{\psi}{\psi + \beta^N}\right)R/N + \left(\frac{\beta^N}{\psi + \beta^N}\right)R_N = W$$

$$(5.8)\quad \partial\omega/\partial A = R_N/A\left(\frac{\psi}{\psi + \beta^N}\right)\left(1 + \left(1 - \eta_{NW}^{-1}\right)\beta^N/\psi\right)$$

Condition (5.8) illustrates that proposition 1 again holds: elastic labour demand will be associated with positive employment effects, but that a less stringent condition can be stated:

<u>Proposition 4</u> *In the General Bargaining Model, if an innovation occurs after the wage bargain but before employment negotiations, jobs will increase if and only if*

$$\eta_{NW} > 1 - \left(\frac{\psi}{\psi + \beta^N}\right)$$

Comparing propositions 3 and 4, the general bargaining model has even weaker conditions to get positive employment effects (assuming $\beta = \beta^N$). Even if the union is risk neutral (ψ=1), innovation and inelastic demand are compatible so long as the union has some power over job bargains. This is because the rents from innovation are taken solely in the form of higher employment due to the assumption that it occurs after the wage has been set, a situation which we regard as exceptional.

4. Effort, Innovation, Efficiency Wages

Until now the parameter A has been considered purely as an innovation effect, but the alert reader will have noticed that the results are entirely symmetric to those of a model where the parameter A represents 'effort'[9].

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[9]Effort is a catch-all phrase to represent the intensity of labour,

Higher effort and innovation will often come as a package, but there are radical differences between these modes of enhancing productivity. For one effort enters as a negative into the union utility function, and for another, effort is often easier to vary than innovation which is generally lumpy, stochastic and hard to predict. If management had perfect control over setting effort then there would be little scope for unions to help workers. If the union succeeded in raising wages above the competitive level, the firm could simply increase effort, driving the workers back to their reservation utility. Consequently the union will want to bargain over effort and the existence of restrictive practices seen in the workplace probably reflect this.

When there is a bargain over effort then it can be shown (e.g. Johnson, 1990) that wages and effort will be generally lower compared to a wage only bargain. Employment, by contrast, could be higher or lower[10]. Furthermore, if there is an efficient bargain over effort, employment and wages employment will also be unambiguously higher than in the wage-employment only bargain. These cases are not directly interesting to us in the current context as innovation does not seem to have disutility for unions - most workers welcome new technology[11]. In an Appendix 7.2 a model is discussed where the union bargains over innovation, but for now assume that innovation is an exogenous event. In this case the introduction of effort will make no difference in

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willingness to co-ordinate with other workers, motivation and so on.

[10]The decrease in wages will tend to increase employment, but this might be offset by the increased costs associated with lower effort.

[11]This is discussed in Chapter 2, Section III. Although attitudinal studies confirm that workers seem to be favorably inclined to new techniques (e.g. Daniel, 1987) this may still be because of the gains from innovation in the form of higher wages which outweigh the negative effects of higher effort.

looking at the *direction* of the effects of technological change. To the extent that effort must increase with new techniques, there will be a dampening effect on employment because of the compensating differential wage increase, but this is all.

To examine this more closely a particular model of effort will be looked at which was first formulated by Shapiro and Stiglitz (1984). It assumes that individual effort is unobservable to the firm. The degree of effort depends on the wages paid to the worker relative to the alternative wages on offer since the costs of getting caught 'shirking' are increasing in this differential. This is written as

$$A = A(e(W/\tilde{W}), I) \;;\; A_1, A_2 \geq 0, \; e' > 0.$$

where $e(W/\tilde{W})$ is the effort function and I stands for innovation. In the non-union sector the firm will pick wages and employment simultaneously to maximise profits:

$$\Pi = R(A(e(W/\tilde{W}), I)N, K, X_1) - WN$$

This leads to the standard 'Solow Condition' for efficiency wages which is

$$(W/\tilde{W})e'(W/\tilde{W}) = e(W/\tilde{W})$$

implying that the wage will be set as some proportion of $\tilde{W}$, call this $W = \kappa\tilde{W}$.

The first order condition for employment is simply that the marginal revenue product in efficiency units is equal to the real wage:

$$R_1 A_1 e(W/\tilde{W}) = W$$

or

$$R_1 A_1 e(\kappa) = \kappa\tilde{W}$$

Totally differentiating this term allows the standard result to emerge that employment will be reduced by increases in the outside wage.

$$dN/d\tilde{W} = \kappa/R_{11}A_1 e^2(\kappa) \leq 0 \text{ because } R_{11} \leq 0$$

The comparative statics for the alternative wage and innovation are:

$$(5.9)\quad \partial R_N \backslash \partial \tilde{W} = R_N(1 - \eta_{NW}^{-1})\ A_1 e_1 W/A\tilde{W}^2 \quad \le 0 \qquad \text{if } \eta_{NW} \ge 1$$

$$(5.10)\quad \partial R_N \backslash \partial I = R_N(1 - \eta_{NW}^{-1})\ A_2/A \quad \ge 0 \qquad \text{if } \eta_{NW} \ge 1$$

So, the basic result still holds that the sign of the innovation effect on employment will depend on the elasticity of demand. More worryingly, (5.9) implies that the alternative wage will enter the employment equation even without bargaining over jobs[13], so interpretations of the standard testing methodology for job bargains are muddied. However, the fact that innovations and the alternative wage enter with the opposite signs offers a possible method of discriminating between alternative explanations[14]. We formalise this as

Proposition 5: *Under a pure shirking model the coefficients on the alternative wage and innovations variables should take opposite signs.*

5. Oligopoly in the Product Market

The issue of product market imperfections has been side-stepped by looking at the revenue function rather than price and production functions. It is tempting to conclude that since inelastic demand enables monopolists to enjoy higher price-cost margins, monopoly power will reduce the employment effects of innovation. Unfortunately the case is not so clear cut as the closer oligopolists get to the joint maximising solution the closer they get to the fact that the monopolist will always produce on an elastic part of the demand curve. This is not always true for oligopolists.

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[13] It can enter with a positive sign whereas efficient bargaining suggests that it can enter only with a negative sign.

[14] For example, if there was a *negative* coeffient on the wage and a negative one on innovation this would be inconsistent with a pure shirking model.

Two major results are proven in Appendix 5.1. Result 3 shows that the innovation effect *will be independent of market structure when the price elasticity of demand is a constant.* Result 4b shows that for Hicks neutral technical change *a monopolist will always increase employment in response to an innovation.* In general however, the sign of the interaction between market power and innovation is very ambiguous, so although the empirical section discusses some experiments it will not be the focus of attention in this chapter.

IV. Modeling Strategy

1. The Testing Procedure

Based on the theoretical considerations in Section II the procedure starts from the General Bargaining Model and tests for the theoretical restrictions implied by the different models. The preferred model will be used to assess the impact of innovations on firm level employment. To do this we will have to face the problem that union power is not directly observable, so must be proxied by a vector of observables, Z. The Z vector must be partitioned into those variables which influence only wage power (Z_1), those that effect only job bargaining power (Z_2) and those that effect both (Z_3). Given this, we can write the reduced form wage and employment equations as:

(5.10) $W(Z_1, Z_2, Z_3, \tilde{W}, \psi, I, X_1)$

(5.11) $N(Z_1, Z_2, Z_3, \tilde{W}, \psi, I, X_1)$

To repeat, I is innovation, X_1 are all other shifters of the profit function, X_2 has been assumed to be solely a function of the union's relative weight to employment (ψ) and the alternative wage, $\tilde{W}$.

To transform the equations into an convenient form for testing note that one of the elements in Z_1 can be expressed as a function of all the variables in (5.10). Substituting this into (5.11) gives us

(5.12) $N = \mathcal{N}(Z_1^0, Z_2, Z_3, W, \tilde{W}, \psi, I, X_1)$

where Z_1^0 is a vector of all the variables except the one used to reparameterise the equation.

(5.12) will be the fundamental employment equation to be estimated. The implied theoretical restrictions of interest are given below

Model	**Theoretical Prediction**
General Bargaining Model[15]	$\mathcal{N}_4 \leq 0$
Efficient Bargaining (Weak)	$\mathcal{N}_1 = \mathcal{N}_2 = \mathcal{N}_3 = 0$; $\mathcal{N}_4 \leq 0$; $\mathcal{N}_5 \leq 0$
Efficient Bargaining (Strong)	$\mathcal{N}_1 = \mathcal{N}_2 = \mathcal{N}_3 = 0$; $\mathcal{N}_4 = 0$; $\mathcal{N}_5 \leq 0$
Labour demand model	$\mathcal{N}_1 = \mathcal{N}_2 = \mathcal{N}_3 = 0$; $\mathcal{N}_4 \leq 0$; $\mathcal{N}_5 = 0$
Pure Shirking Model	$\mathcal{N}_1 = \mathcal{N}_2 = \mathcal{N}_3 = 0$; $\mathcal{N}_4 \leq 0$; $\text{sign}\{\mathcal{N}_5\} = -\text{sign}\{\mathcal{N}_7\}$

All the models imply that $\mathcal{N}_7 \geq 0$ if $\eta_{NW} \geq 1$.

The testing procedure is contained in Table 5.2. It begins with the encompassing model (the General Bargaining Model) then tests (A) are the power terms jointly insignificant and then (B) are the power and alternative wage terms jointly insignificant. If we cannot reject (A) and (B) then the Labour Demand model is preferred. If we reject them both the General Model is preferred. If we reject (B) but not (A) the Contract Curve model is

[15] This assumes that union wage bargaining power is greater than job bargaining power ($\beta^W > \beta^N$).

provisionally accepted. One of the difficulties with the General Bargaining Model is that some dynamic versions of the Right-To-Manage Model suggest that union power should enter into the employment rule. One such model is presented in Appendix 5.2 (see also Lockwood and Manning, 1989) and some comments are made upon it are made in Section V.

If the alternative wage is significant but union power terms are not, one is faced with the question of whether the Shirking Model applies. Stage (C) of our testing procedure would be then to see if the innovation effect is of the opposite sign to the alternative wage effect. In terms of shirking models we have an additional theoretical prediction in the 'pure case': the impact of the alternative wage should appear in employment equations for union and non-union firms alike. Efficient Bargaining should be confined to the union sector, so there should be no role for the alternative wage in non-union sector employment determination. Looking at this should be regarded as stage (D) of the testing procedure if there is still no 'winning model'.

These stages are to be regarded as a general methodology not confined to this particular study. One immediate objection is that we have over-simplified by not allowing for the fact that some combination of models (e.g. efficiency wages and efficient bargains[16]) will weaken the theoretical restrictions. This must be granted, but the essence of economic anlaysis is enlightened simplification and the framework is complex enough already. One simply cannot test every model at once.

To empirically implement (5.12) a number of issues must be discussed relating to identification, unobservability, simultaneity, and dynamics.

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[16] Scaramozzini (1992) is an example of this.

2. Identification

Section IV.1 has discussed how to distinguish between the theoretical models. A related question is how can one be sure that a labour demand equation is being estimated and not a wage equation? One of the biggest problems of the General Bargaining Model is that (5.12) is not identified from the wage equation (5.10). In the structural model, it is the exclusion of wage bargaining power from the employment rule (equation 5.0f) which achieves identification, but this cannot be put into practice without convincing proxies for Z_1 and Z_2[17]. If the restrictions placed by the simpler models are rejected this problem becomes severe. In the Contract Curve model the exclusion of all the power terms achieves identification (and also the contract wage in the strong version). Finally the Labour Demand Model excludes power terms and the alternative wage from the (5.12). So the restrictions which distinguish the theoretical models from each other also serve as conditions to fulfill the order condition. The dual problem of identification of the *wage* equation from the employment equation is discussed in the next chapter.

3. Unobservability

<u>Union Power (1/β)</u>

Most studies in the literature are bedeviled by poor proxies for union power. This dataset, like practically all others, has no way of satisfactorily distinguishing different types of power so one is forced to combine them into the vector $Z^0 = Z_1^0 \cup Z_2 \cup Z_3$. The primary proxy for Z^0 is industry level union density as described in previous chapters, but an

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[17]As discussed before, empirical applications of this have been unsuccessful precisely because of this difficulty (e.g. Andrews and Harrison,1991).

alternative industry measure based on coverage is also presented.

The dataset used in this and the next chapter has additional information from three different cross sectional surveys of union presence (details are in the Data Appendix). Under the assumption that union recognition was fairly stable[18] over our time period the sample is split into union firms (where at least one union was recognised for wage bargaining purposes) and non-union firms. For a slightly smaller sample of firms there is also information on firm level union density and information from this is also exploited in the empirical section.

Alternative Wage

This is proxied by the industry wage and time dummies in the main empirical work, but experiments with industry unemployment, aggregate wages and unemployment and various combinations of all of these are also presented. Ideally the alternative wage should take into account the actual inside option (strike pay, temporary employment opportunities during a dispute,etc) and the outside option (occupation and region specific). Unfortunately, such information is not available and even if it was, one would need very detailed knowledge of the locations of multi-plant firms to utilise it.

Other Variables (I,ψ,X_1)

It is assumed that innovation, I_t, is a function of the same firm and industry innovations as described in the last chapter together with a firm specific, time specific and purely stochastic component. The union's weight to employment (ψ) is taken as a fixed effect, but we investigate an

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[18]The empirical evidence suggests this is quite a reasonable assumption (e.g. Claydon, 1989) as there were very few derecognitions until the mid 1980s. It is possible that we have included some firms in the union sector who were non-union in the early part of the sample.

alternative modeling strategy based on insider-outsider theory next chapter. The exogenous shifters of profits, X_1, are proxied by industry demand shocks (industry sales) and time dummies to represent aggregate shocks.

4. Simultaneity

Since there are good theoretical reasons to expect that the contract wage is endogenous, it must be instrumented. Each model implies a different set of instruments from the reduced form for wages, but since the encompassing model is the starting point, most of the current dated observables that could serve as instruments are also candidates for inclusion in the employment equation. Fortunately, panel data enables lagged values to be taken as valid instruments in style of Arellano-Bond as with previous chapters. The lagged dependent variable is also instrumented in this manner as the data is first differenced to control for fixed effects. Although capital has been assumed predetermined it is also instrumented (this time with just its value two periods earlier) to correct for measurement error and the fact that shocks may cause employment and capital to move together.

The other variables are assumed to be weakly exogenous. In order to placate the skeptics more than our own worries, some experiments are nonetheless offered in the text especially with regards to innovations and the alternative wage.

5. Dynamics

This is a potential mine field for employment equations given the considerable interest that has been shown in adjustment costs and the dynamics of union utility functions. One dynamic extension of our model based upon quadratic adjustment costs is given in Appendix 5.2. It offers the valuable insight that union power terms may enter the employment equation under a dynamic Right-to-Manage model and one must be aware of this when interpreting the results. The problem with the explicitly dynamic approach is that it leads to a quite tightly specified model that does not does not actually help very much in the interpretation of the structural parameters and whose underlying assumptions of quadratic adjustment are quite dubious. The emphasis here is therefore on a more relaxed formulation where the data is allowed to decide on the dynamic structure by including lags up to t-6 on firm innovations[19], t-2 on the other firm-level variables and up to t-1 on the industry level variables. This is suggested by previous empirical work on panel data (*inter alia* Arellano and Bond ,1991 and Nickell and Wadhwani, 1991). The longest and least significant lags are sequentially removed, testing for diagnostics at each iteration.

The empirical counterpart to (5.12) is therefore:

$$(5.13)\quad n_{it} = f_i + \sum_{h=0}^{2}\beta_{1h}n_{it-h} + \sum_{h=0}^{2}\beta_{2h}k_{it-h} + \sum_{h=0}^{2}\beta_{3h}w_{it-h}$$
$$+ \sum_{h=0}^{1}\beta_{4h}\tilde{w}_{jt-h} + \sum_{h=0}^{1}\beta_{5h}IDENSITY_{jt-h} + \sum_{h=0}^{1}\beta_{6h}INDSALES_{jt-h}$$
$$+ \sum_{h=0}^{1}\beta_{7h}IUI_{jt-h} + \sum_{h=0}^{1}\beta_{8h}IPI_{jt-h} + \sum_{h=0}^{6}\beta_{9h}INNOV_{it-h}$$
$$+ \text{time dummies} + \text{disturbance}$$

The lower case letters represent logs, i-sub-scripts for firms j-subscripts for industries, f_i = fixed effect.

The testing procedure described above is assumed to be the long-run

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[19]We allow such a long lag structure as we discovered it was important in the last chapter.

counterpart to the empirical model of (5.13) and is presented for future reference in Table 5.2.

V. Data Description

The main dataset used covers 154 recognised firms drawn from a sample of 181 where it was known whether or not a union was recognised for bargaining purposes in any part of the firm in 1986-87 (The Data Appendix has a full description). The 181 firms are in turn drawn from a larger sample of 603 firms based on the DATASTREAM/EXSTAT accounts as described in previous chapters. The main difference is that the time period runs 1976-83 as DATASTREAM only reported wage and employment data after 1975. Consequently the selection rule is relaxed to allow any firm that had at least six consecutive observations to be included in the sample.

The 27 non-union firms had too few innovators for a satisfactory analysis to be conducted, so the main comparisons are between the 154 and 603 samples.[20] The emphasis on union firms seems appropriate as the theory relates to explicit union collective bargains and not some implicit pseudo-bargain. In addition, few previous British studies have looked at unionised firms across a range of industries despite the fact that cross sectional evidence shows that the pattern of wage and employment determination differs substantively across the union and non-union sectors (e.g. Stewart,1987).

In terms of the measure of technical change, the main thing to recall here is that innovation in this study is very different from other work which simply examines the effects of newly installed micro electronics. The SPRU

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[20] There should really be an attempt to correct for selectivity bias, but this is an uphill task as identifying restrictions for the selectivity equation are far from obvious.

definition of innovation pinpoints the firm who first develops technologically significant and commercially successful new products and processes. It relates to the firm who first commercialised it, not necessarily used it (although we do have an industry level count of this). Clearly, if the technology is not used by the firm itself it is unlikely to have any direct employment effects in a model where the firm sets employment unilaterally[21]. However, when the union bargains over employment an increase in the size of the rents available will induce employment expansion directly.

The employment variable is total UK employment, which is preferred to total employment as unions are nationally based. The wage is total remuneration divided by employment and an aggregate consumer price index. This contains several potential biases: (i) the calendar year does not necessarily correspond to the bargaining period, which means we cannot treat wages as predetermined; (ii) there is no hours data at a firm level; (iii) the different groups of workers -skilled and unskilled, manual and non-manual, part-time and full-time are all lumped together. This causes problems because it is well known that there has been a systematic change in workforce compositions over this time period towards part-timers and women which varies in an unobserved unknown way across our sample of firms. Little can be done save to acknowledge the difficulty and refer the reader to Chapter 7 where a cross section is used with extensive controls for workforce composition. The fact that total labour costs are used rather than the contract wage could be seen as an advantage in that it includes various fringe benefits which are valued by the union and cost the employer. On the other hand, if employment is measured with error then this will impart a

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[21]Of course there could be second-order effects running from improved cash flow as a result of the innovation's sale to expansion of firm size.

spurious negative correlation between wages and employment.

The measure of capital is simply the sum of the historic costs of all the fixed assets in the firm deflated by an aggregate investment goods price index. This is obviously a crude measure as the valuation of capital will depend on many firm specific factors including innovation which will alter the implied value of different capital vintages. Instrumenting with lagged values and including fixed effects goes some way towards mitigating the problem, but one should not pretend that any capital measure derived from company accounts can be anything but a crude proxy for the true variable of interest.

Table 5.3 presents some descriptive statistics of the main variables for the large dataset, the union firms and for firms which have above average firm level density (134 firms had union density data). The smaller samples have higher real wages, employment and firm innovations. The variables used in this chapter that were not in previous data discussions are plotted in Figure 5.2[22]. Employment has been in steady decline since 1979 which reflects the general declining trend in the size of the manufacturing sector especially during the 'Great Squeeze' of the early 1980s. The capital stock, has been growing at a leisurely pace over the whole period. Similarly, after an initial decline associated with the very tight incomes policies in 1976, average wages have been consistently rising.

The distributions of employment, log employment and the change in log employment are given for both samples in Figure 5.3. Note that employment is highly skewed, as is usual with firm size distributions. Logging and differencing help to normalise the distribution which should lead to

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[22] Rather than for each sample this is from a balanced panel of the large sample.

efficiency gains. There appears to be a clustering of observations around zero changes in employment which is similar to that reported in other firm level panels. Rota (1992) finds that a large number of her panel of small Italian firms do not adjust employment at all and interprets this as evidence of fixed costs of adjustment[23]. In fact very few of our firms have no employment changes; for example in 1980 only three of the union firm sample and ten of the larger sample made fell into this category. This is undoubtedly because we are looking at very large firms, who can smooth their labour adjustment.

VI. Results

1 . Innovation and Employment: The Main Results

Table 5.4 reports the fundamental results of estimating equation (5.13). The first four columns use the union firm sample and the final two columns use the larger sample of 603 firms where exact union status is unknown. Column (1) has the most general model whereas column (2) deletes the longest lags and most insignificant variables. The Labour Demand and Efficient Bargaining models are in the next two columns, keeping the same instruments as the General Bargaining Model of column (2). The last two columns present the General Model and the (preferred) Labour Demand model for the larger sample.

The model of column (1) illustrates that the dynamic pattern of innovation effects is similar to those of the profitability equations of Chapter 4. An innovation has a large positive impact of employment in the

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[23] Fixed costs of adjustment mean that the firms's optimal decision rule for employment adjustment will be of the 'bang-bang' variety: the firm either adjusts a lot or not at all.

current year,but this gradually declines in impact over the next three years eventually becoming negative as (presumably) other firms imitate and catch up with the innovating firm. The spillover effects from other innovation producing firms are much stronger than they were for profitability, corroborating the Freeman and Soete (1987) claim that the 'pervasive innovation' sectors have the best employment performance. The long-run effect of a firm innovation (including spillovers) is therefore about 0.009 which is quite small (it implies that an innovation raises employment by about 1% above the mean). The long-run labour demand elasticity is 1.32 which is greater than the Nickell and Wadhwani (1991) and Arellano and Bond (1991) estimates, but closer to more aggregate studies. More crucially for our purposes is the fact that it exceeds unity and is therefore consistent with the empirical predictions from Section II. Finally, the fact that the coefficients on employment lags sum to less than unity means that there is a stable steady state solution for perturbations of the right-hand-side variables so meaningful tests of the comparative static results can be made.

The ability to make strong inferences from column (1) is limited by collinearity among the large number of 'independent' variables which contributes to their large standard errors. Consequently the longest and least significant[24] lags and variables were eliminated. Industry sales were very poorly determined which suggesting that aggregate shocks (as captured by time dummies) were more important than industry shocks (see also Chapter III). All firm innovations after the second lag were singularly and jointly insignificant, as were industry innovations used and lags of wages and capital so all these were deleted. Although the second lag of employment was

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[24] At the 5% level on a one tailed test where theory restricts the sign and a two-tailed test where it does not.

insignificant it could not be removed without inducing second order serial correlation[25]. Because of their importance in the testing procedure the alternative wage and union density were kept in the equation despite their poor precision. The resulting model which we call the 'Preferred General Bargaining Model' is in column (2), it is statistically preferred to column (1) with a $\chi^2(11) = 11.02$.

Now stages (A) and (B) of the testing procedure are implemented. The outcome of the test seems clear as the density terms are wrongly signed and together with the alternative wage, jointly insignificant. The Wald statistics are $\chi^2(2) = 1.520$ and $\chi^2(4) = 2.419$ respectively. Therefore the preliminary conclusion is that the labour demand model best describes the data and this is presented in column (3). There are few new surprises in this model. The coefficients on the lags of the dependent variable suggest that the long-run effects of a variable are about 38% as large as their short-run effects. The capital stock measure is well determined and has a long-run elasticity of 1.01; so imposing a long-run constant returns Cobb-Douglas production function may not do *too* much violence to the data (see *inter alia* Layard, Nickell and Jackman, 1991). Finally, the coefficients on innovations are much the same as before suggesting that innovation will raise employment by about 12.3% over the mean without spillovers and 12.7% with spillovers[26]. This is much higher than the initial estimates as our methodology has eliminated the longer lags which tended to

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[25] This suggests that long frequency dynamics are important in employment even if it is difficult to tie down their functional form at this level of temporal and spatial aggregation (see Hamermesh, 1992).

[26] If we replace the industry level variables by 14 2 digit dummies the innovation effects are hardly altered. The dummies are not jointly significant $\chi^2(13)=15.73$

be negative. This procedure may underestimate the catch up effects so we would be wise to regard this as near the upper bound of the innovation effect[27]. One disappointing feature of this specification is that although one cannot reject the hypotheses that the demand elasticity is greater than unity, its point estimate has fallen to 0.8. Again this is due to the deletion of longer lags on wages which if included would bring the elasticity back up to 1.22.

Do these conclusions hold good in the larger sample? Running the Preferred General Bargaining Model on the sample of 603 firms produces the same pattern as in the union sub sample. The effects of innovations are much larger (about 9% in the short-run and 40% in the long-run[28]), but then so is the elasticity of labour demand. The union power terms are still jointly insignificant, but the lagged alternative wage is now positive and weakly significant. This should not be perhaps so surprising as most of the studies which *do* find a role for outside wages in an employment equation also find that it is positive (e.g. Card, 1990; Brown and Ashenfelter, 1986). Nickell and Wadhwani (1991) rationalise this in efficiency wage terms as standard efficient bargaining models predict a negative impact. However, we argued in the theoretical section (Proposition 5) innovations should have an *opposite* sign to the alternative wage and in this example they clearly do not. Neither does the alternative wage appear robust when we instrumented it in the Arellano-Bond fashion; the lagged value has a coefficient of -0.197 (0.376). For both these reasons one is inclined to prefer column (6) which

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[27]Instrumenting current innovations using lagged values of industry R&D intensity and lagged innovations in the usual Arellano-Bond style marginally reduced the significance and size of the firm innovations effects. For example the coefficient and standard error on INNOV(t) was 0.0294 (0.0158).

[28]This is due to the smaller average size of the full smaple. Log employment was on average 0.312 compared to 0.892 amongst the union firms.

has the alternative wage terms excluded.

It is possible that the alternative wage has been mismeasured by simply using the industry wage, so various other measures were attempted with the results illustrated in Table 5.5. Column (1) introduces industry unemployment as a separate regressor; column (2) uses the convex combination of industry wages and unemployment benefit (the weights being the aggregate unemployment rate); column (3) uses aggregate wages and unemployment and column (4) aggregate wages alone. Finally (5) instruments the industry wages to remove a possible endogeneity arising from the fact many of these firms will be large wage-leaders. It is only when aggregate wages alone are used that there is any evidence of efficient bargaining. One must be wary about accepting this at face value as this model has excluded the time dummies which were always very significant (in Table 5.4 column (2) the $\chi^2(5)=21.6$) and economy wide wages may merely be reflecting these macro-economic shocks. Moreover, it seems unlikely that the fallback position of a union should be so broadly based. Union rhetoric over differentials, for example, is related to a reference group closer to home[29].

Table 5.6 presents some further experiments. Although Stage (D) of our testing procedure is redundant because of the absence of outside wage effects, it might still be of interest to look at the patterns of wage determination in non-union firms. There were only 27 of them and they had too few firm-level innovations to draw any meaningful comparisons, but the Preferred General Bargaining Model was run without this measure[30] for the non-union and union samples. The results are almost identical for the union

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[29] It is true to say that occupation-specific measures would be more appropriate, but we have no way of knowing the occupational mix of the firm.

[30] Identical to column (3) in Table 5.4.

sample, but in the non-union sector the industry wage *was* significant *and* negative. If anything, this suggests that the importance of the alternative wage in some studies may well be due to the inclusion of non-union firms whose employment patterns are shaped by outside wages for reasons unrelated to bargaining. The negative effects of industry innovations are inconsistent with proposition 5, but they are nowhere near significance. So it seems that a Right-To-Manage Model is appropriate in the union sector, but an efficiency wage model in the non-union sector. A similar conclusion is reached by Machin and Manning (1992b) who cannot reject an efficiency wage model in 'low union density' industries and a bargaining model in 'high density' industries. It is unwise to push the results too far given the small sample size, but the non-union results at least confirm that it is wise to separate out the union from the non-union sectors in examining employment determination.

The middle two columns of Table 5.6 contain two further experiments. Column (3) substitutes an alternative measure of union power (the number of workers in an industry covered by an industry level a collective agreement) in the Preferred General Bargaining Model. As can be seen, it made no difference, being still jointly insignificant ($\chi^2(2)=0.8$). Column (4) includes market share as a proxy for market power both linearly and interacted with the innovations measures. As expected market power is associated with lower employment ceterus paribus, but the linear and interactive terms were nowhere near being significant. Given the ambiguity of the theoretical signs this is hardly surprising. It may even reflect the fact that constant elasticity of product demand is a reasonable first order approximation (see Appendix 5.1 Result (3))[31]

Finally the models were run in levels and OLS first differences in the last two columns which gave less precise, but similarly patterned results. In particular, the OLS results have a positive and significant effect of current innovation, so the results are not due to any 'black magic' in the instrumenting techniques. The levels results did not suggest any diagnostic problems but efficiency seems to have been lost. This slightly surprising result is probably due to the fact that differencing helps 'normalise' the employment distribution (as shown in Figure 5.3) and offsets the reduction in efficiency generated by first differencing (cross-sectional variation that remains stable over time is lost).

2. Union Power and Innovation: A Further Exploration

The difficulty of testing the general bargaining model has been emphasised at many points in this chapter especially in the absence of detailed knowledge of the dynamics of union power over different aspects of the employment contract. As an alternative to industry density we have access to a cross sectional measure of union density at the firm level which may provide more information. The problem with this measure is that it is a firm-specific effect which will disappear in a first differenced model. Therefore it is used only as an interaction term with firm innovations in the estimating equations.

The theoretical interest centered around union models has been accompanied in Britain by a vigorous empirical debate over the role of unions in the great employment shakeout of the early 1980s. The 1984 Workplace

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[31] Experiments with other measures of market structure such as concentration and import penetration were also attempted, but no clear pattern emerged.

Industrial Relations Survey shows that employment contracted fastest where unions where strongest (Millward and Stevens, 1986, pp217-218) and this continues to hold good in multivariate regressions. Opinion divides over the reasons for this correlation. Blanchflower et al (1990) appear to claim there is a 'union growth differential' of about -3% whereas Machin and Wadhwani (1990b) argue that the association is due to management reasserting their control over restrictive practices. The latter authors produce evidence for this claim by looking at the interactions between union and organizational change. Consequently it is of great interest to see if a similar pattern holds good for technological innovations.

Table 5.7 presents the raw data on employment change, innovation and union power. Panel A displays a pattern gratifyingly similar to the establishment data - employment contracted by about 2.5% across the whole of manufacturing (see also Figure 5.2); this fall was greatest where unions were recognised and where firm level density was higher. In the density sample the falls amongst firms who had innovated at any time in our sample were slightly greater than the falls among the non-innovators but the difference is minute (about one fifth of one per cent). Panel B contains some much more surprising information. Job decline was *greater* amongst innovative firms with weak unions than in innovative firms with strong unions, but this pattern was reversed for non-innovators. In other words, firms who introduced major technological changes bucked the general trend of the negative association between unions and employment.

The regression results in Table 5.8 broadly confirm the raw correlations. Since 20 union firms had no density information the preferred Labour Demand model was run on the new sample in column (1) to make sure the results were robust - they actually appear stronger. The pattern of firm level density is most striking when the interaction term is introduced for current innovations only in column (2). The linear innovations term is significantly *negative* and the union interaction larger and significantly positive. On the basis of these results the average effect of an innovation is to reduce employment for firms where union density is below about 60%.

Although firm level density is pretty stable within firms (see Gregg and Yates, 1992 or Andrews and Harrison ,1991, for plants) there may be a misclassification for a minority of firms where density has changed dramatically. To mitigate this we used a dummy variable split at median density (85%) in column (3). Again, only the interaction is significantly positive, although the linear term is no longer negative. The next column adds in the first and second lags of innovation and their interactions with union density. The first lag reinforces the current effect with larger point estimates, but the third lag has the signs of linear and interactive terms reversed. Still, the long-run effects suggest that high density firms have large positive innovative effects on employment and low density ones small negative effects.

How should one interpret Table 5.8? It is of course possible that the density measure is too static, too endogenous and too crude a proxy for union power, so the results are merely a statistical artifact. Yet it is commonly used and seems to have the advantage of being more disaggregated than the industry level measures used earlier and less crude than the binary split of recognition.

One obvious explanation of the results is to resuscitate the model of union employment bargaining. Note that the reduced form for employment under the efficient contracts model has predictions[32] for the interaction terms between union power and the effects of technology : $\partial^2 N/\partial\beta\partial A$ = sign$\{\partial^2 N/\partial\beta\partial\omega\}$ = $-R_N/A\left(\frac{\psi - 1}{(1 + \beta)^2}\right) < 0$ (if $\psi>1$). This implies that innovation effects on employment are increasing with union power which is exactly what we appear to find. The absence of alternative wage effects in the employment equations may well be due to one of the problems alluded to in Chapter 2 (e.g. weak separability of the union utility function). Alternatively, the fact that this interactive effect exhibits a complex dynamic pattern may imply that all unions are doing is temporarily preventing the firm from adjusting to its desired level of employment. The innovation terms were allowed to take a longer lag structure and a representative regression is in column (5) where effects are allowed up to four years later. The essential pattern remains; for example a firm with 100% density has an average long-run innovations effect of 0.3376 whereas one with 25% density has a long-run mean effect of only 0.0162. On this reading of the data the effect of unions is not merely a short-run phenomena.

Column (6) offers a possible defense of the Labour Demand Model. Interacting own wages[33] with firm density revealed that the implied demand elasticity was greater in firms with higher density. Thus one could argue that larger innovation effects would be expected in these firms under a labour demand model. We remain a little unhappy with this explanation, despite the fact it ties up with our earlier conclusions. One would expect that unions can achieve higher wage gains when labour demand elasticities are

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[32] Differentiate (5.6) with respect to β.

[33] Density was also interacted with the other right hand side variables, in particular the alternative wage, but they were never significantly different from the linear term.

lower and this gives individuals greater incentives to join unions to share these gains (Table 5.3 shows that average wages are higher in firms with high density). On the other hand, this argument may be more true for recognition than density. Conditional on recognition, a few writers have found investment to be increasing with density (e.g. Denny and Nickell, 1992) and it is these increases which may be the source of wage gains rather than demand inelasticity[34].

Given the doubts about accepting a model based on interactive terms only, our conclusion that the Labour Demand model best describes the data still holds. Nonetheless, there is a need to look at these interactions more closely, especially with regard to wages, which is what will be done in the next chapter.

VI Conclusions

The main message from the analysis presented in this chapter is that innovations have a large positive effect on employment at the firm level raising it by up to 13% in union firms over the long haul. The positive effect is robust across all our main datasets to a wide variety of respecifications. It was argued that this should not come as a surprise as similar results have emerged from other careful studies using very different measures of innovative success. The theoretical prediction that technical change is associated with greater employment when labour demand elasticity is greater than unity is also broadly corroborated by our results.

On the subject of union models the absence of significant impacts of

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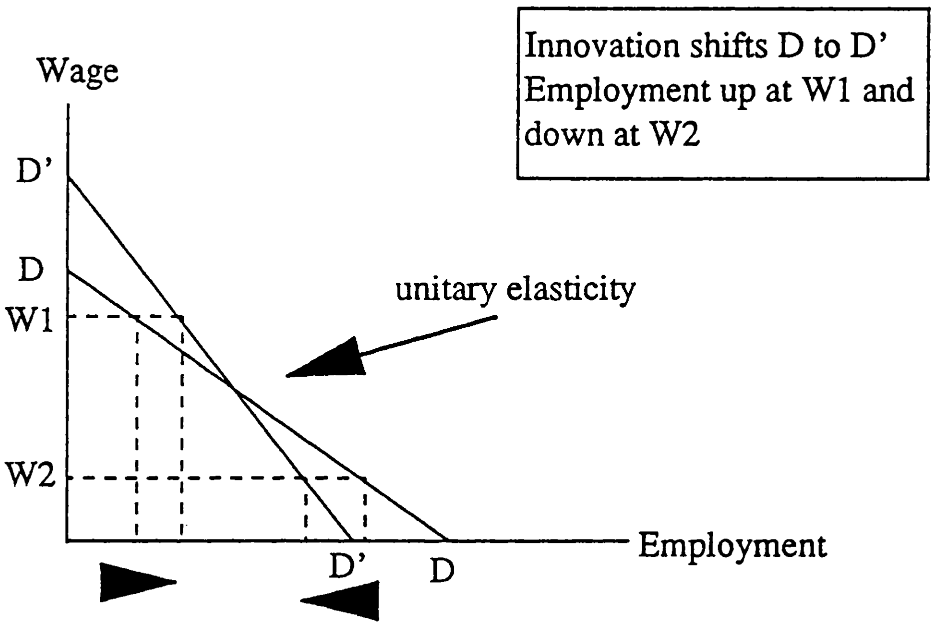
[34] One alternative means is to look at profitability equations again and ask the question: do unions reduce the rate of return to an innovation. The raw correlations in the data gave a positive answer to this question, but when subjected to a more rigorous examination they could not be sustained.

union power and the alternative wage in our employment equations implies that the labour demand model best describes the data for union firms. Things are less clear in the non-union sector, but there are a few signs that efficiency wage considerations may be of some importance. An unresolved issue is how to reconcile our main conclusions with the finding that firms with high union density enjoyed the greatest positive effects from innovation. Although consistent with unions spreading technological rents into higher employment it is also the case that demand elasticities seem higher in these firms and we would expect them to have greater increases in employment under a labour demand model too.

An obvious criticism of this study is that a short panel was used covering the 1979-83 period of severe recession and one must be cautious in generalising from this particular experience. However, this period is of particular interest both on the Schumpeterian grounds that the essential character of capitalist economies is often revealed during recessions and on the more specific grounds that it was a fascinating period of economic history. Our analysis suggests that the firms who emerged from the slump were not reducing employment on a large scale *because of technological innovations* but for for entirely different reasons (e.g. low demand, attacks on union 'over-manning',etc).

The eventual outcome of new technologies may well be greater economy wide unemployment, yet the spillover and survivor biases are more likely to cause an underestimation of the benefits of new technology on major innovations. The statistical picture detailed in this chapter is that major innovations create jobs and this is especially so when these firms have strong unions.

Figure 5.1: Effects of innovation on Employment



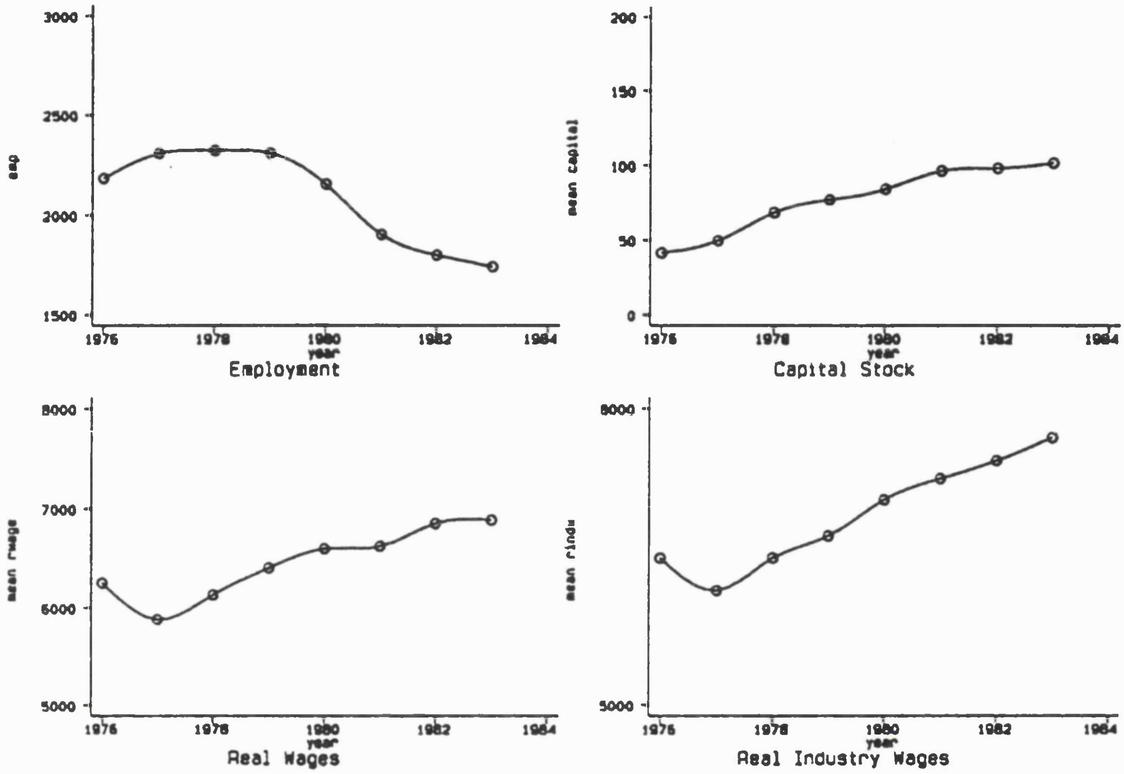


Figure 5.2: Means of Variables 1976-1983

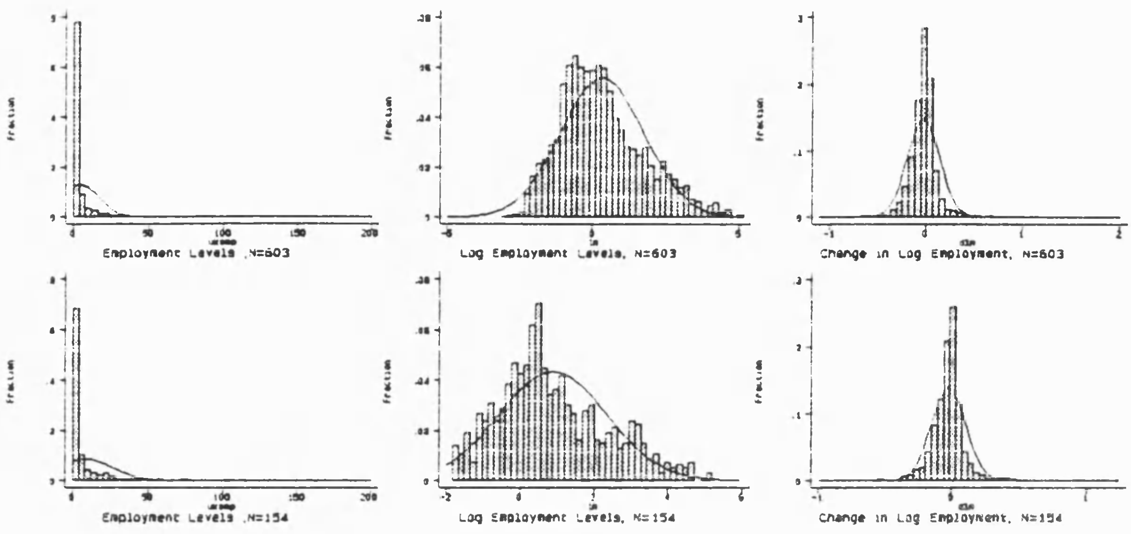


Figure 5.3: Employment Distributions

TABLE 5.1: ATTITUDINAL SURVEYS OF INNOVATION AND EMPLOYMENT

(All Figures in %)

Panel A *"Has the use of new technology at your workplace meant that the organisation has":*

	1985	1987	1990
Increased the number of employees	13	15	13
Decreased the number of employees	22	22	14
Made no difference	59	56	48

Source: British Social Attitudes Surveys 1985,1987,1990

Panel B *Manning Levels in Sections Affected by Advanced Technical Change*

	Managers' Response	Shop Stewards Response	Private Manufacturing	Manual Union Recognised
Increased	11	8	15	11
Decreased	19	24	40	22
Stayed the Same	70	68	45	67
No. of Plants	458	288	191	405

Source: Daniel (1987)

Panel C

Total Jobs lost directly due to micro electronics (summed from managers estimates of their own establishment)

	1981-1983	1983-1985	1985-1987
Net Job Loss	34,000	87,000	93,000

Source: Christie et al (1990) and PSI

TABLE 5.2 TESTING PROCEDURE

Model is :

$$(5.13)\quad n_{it} = f_i + \sum_{h=0}^{2}\beta_{1h} n_{it-h} + \sum_{h=0}^{2}\beta_{2h} k_{it-h} + \sum_{h=0}^{2}\beta_{3h} w_{it-h}$$

$$+ \sum_{h=0}^{1}\beta_{4h} \tilde{w}_{jt-h} + \sum_{h=0}^{1}\beta_{5h} IDENSITY_{jt-h} + \sum_{h=0}^{1}\beta_{6h} y_{jt-h}$$

$$+ \sum_{h=0}^{1}\beta_{7h} IUI_{jt-h} + \sum_{h=0}^{1}\beta_{8h} IPI_{jt-h} + \sum_{h=0}^{6}\beta_{9h} INNOV_{it-h}$$

$$+ \text{time dummies} + \text{disturbance}$$

Steps in Test:

Stage	H_0	**Restriction**	**Implied Model***
(A)	Are the union Power terms positive and Jointly Significant	$\beta_{51} + \beta_{52} = 0$	Contract Curve
(B)	Are the union Power terms and the alternative wage terms jointly significant	$\beta_{51} + \beta_{52} = 0$; $\beta_{41} + \beta_{42} = 0$	Labour Demand
(C)	Is the alternative wage the same sign as the innovation terms	$-\text{sign}\ \{\beta_{41} + \beta_{42}\} = \text{sign}\{\sum_{h=0}^{1}\beta_{7h} INI_{jt-h} + \sum_{h=0}^{1}\beta_{8h} IPI_{jt-h} + \sum_{h=0}^{6}\beta_{9h} INNOV_{it-h}\}$	Shirking Model (and others)
(D)	Are the alternative wage terms jointly **in**significant in the non-union sector	$\beta_{41}^{NU} + \beta_{42}^{NU} = 0$	Shirking model

* H_0 rejected

TABLE 5.3 DESCRIPTIVE STATISTICS

Variable	Recognised Union Sample All	Recognised Union Sample Dens>85%	Whole Sample Mean
Real Wage (£)	6720.8	6974.2	6465.1
UK Employment (1000s)	8.306	9.683	4.830
Innovation (t)	0.091	0.046	0.047
Industry Innovation:			
User	3.235	2.83	3.90
Producer	6.924	5.51	8.82
UNION (Firm Level Density)	0.75	0.91	-
Capital (£million)	263.0	224.7	138.8
Market Share	0.044	0.045	0.027
Industry Concentration	0.426	0.454	0.404
Import Intensity	0.239	0.243	0.197
Industry Sales (£million)	7555.8	7058.6	7861.1
Industry Coverage	0.327	0.326	0.333
Industry Wage (£)	6902.5	7090.9	6992.7
Industry Union Density	0.69	0.69	0.69
No. of Observations	1088	475	4187
No. of Firms	154	67	603
No. of innovating firms:			
(at least once) 1970-83	34	13	89
1976-83	26	11	64

TABLE 5.4: EMPLOYMENT EQUATIONS FOR DIFFERENT UNION MODELS

Variables	The 154 Union Firms				the 603 sample	
	(1) General	(2) Preferred	(3) LD	(4) EB	(5) Preferred	(6) RTM
Constant	-0.0005	0.0105	0.0115	0.0096	-0.0185	-0.0092
	(0.0347)	(0.0170)	(0.0177)	(0.0170)	(0.0154)	(0.0122)
INNOV(t)	0.0323	0.0341	0.0336	0.0342	0.0242	0.0267
	(0.0142)	(0.0123)	(0.0122)	(0.0123)	(0.0087)	(0.0144)
INNOV(t-1)	0.0131	0.0130	0.0125	0.0131	0.0230	0.0256
	(0.0272)	(0.0163)	(0.0163)	(0.0165)	(0.0098)	(0.0141)
INNOV(t-2)	0.0267	0.0346	0.0331	0.0335	0.0196	0.0277
	(0.0221)	(0.0161)	(0.0161)	(0.0159)	(0.0121)	(0.0144)
INNOV(t-3)	0.0080	-	-	-	-	-
	(0.0276)					
INNOV(t-4)	-0.0239	-	-	-	-	-
	(0.0356)					
INNOV(t-5)	-0.0023	-	-	-	-	-
	(0.0227)					
INNOV(t-6)	-0.0204	-	-	-	-	-
	(0.0159)					
IPI(t)	0.0008	0.0004	0.0004	0.0003	0.0002	0.0003
	(0.0016)	(0.0012)	(0.0012)	(0.0012)	(0.0008)	(0.0007)
IPI(t-1)	0.0025	0.0029	0.0030	0.0031	0.0010	0.0011
	(0.0012)	(0.0009)	(0.0009)	(0.0010)	(0.0007)	(0.0007)
IUI(t)	0.0002	-	-	-	-	-
	(0.0028)					
IUI(t-1)	0.0005	-	-	-	-	-
	(0.0020)					
n(t-1)	0.3914	0.3693	0.3438	0.3427	0.5469	0.5621
	(0.2522)	(0.2000)	(0.1936)	(0.2004)	(0.1382)	(0.0984)
n(t-2)	0.0369	-0.0780	-0.0684	-0.0679	-0.3217	-0.3196
	(0.2206)	(0.1720)	(0.1644)	(0.1710)	(0.0933)	(0.0710)
w(t)	-0.4275	-0.6009	-0.5680	-0.6094	-0.4143	-0.4089
	(0.3330)	(0.3221)	(0.3057)	(0.3260)	(0.2388)	(0.1689)
w(t-1)	-0.0924	-	-	-	-	-
	(0.2666)					
w(t-2)	-0.2355	-	-	-	-	-
	(0.3281)					
k(t)	0.8092	0.7134	0.7184	0.7126	0.7552	0.7120
	(0.1650)	(0.1257)	(0.1248)	(0.1236)	(0.1738)	(0.1365)
k(t-1)	-0.0559	-	-	-	-	-
	(0.2139)					
k(t-2)	-0.0940	-	-	-	-	-
	(0.0609)					
$\tilde{w}(t)$	0.0477	0.0837	-	0.0822	-0.0061	-
	(0.1312)	(0.1164)		(0.1151)	(0.1006)	
$\tilde{w}(t-1)$	0.0658	0.0226	-	0.0337	0.2208	-
	(0.1013)	(0.1064)		(0.1079)	(0.1254)	

(P.T.O)

TABLE 5.4: EMPLOYMENT EQUATIONS FOR DIFFERENT UNION MODELS - CONT.

IDENSITY(t)	-0.0044	0.0353	-	-	-0.0044	-
	(0.0943)	(0.0698)			(0.0528)	
IDENSITY(t-1)	-0.1328	-0.1053	-	-	0.0413	-
	(0.1141)	(0.0907)			(0.0612)	
IND SALES(t)	0.0004	-	-	-	-	-
	(0.0087)					
IND SALES(t-1)	-0.0042	-	-	-	-	-
	(0.0087)					
No. of Firms	154	154	154	154	603	603
Total Obs	626	626	626	626	2378	2378
SC(2)	-1.094	-0.877	-0.953	-0.937	0.284	0.281
Sargan	24.73(23)	36.08(27)	36.48(31)	34.11(29)	32.24(23)	41.6(31)
Time Dummies	yes	yes	yes	yes	yes	yes

Notes for Table 5.4

1. All estimates are in first differences using instrumental variables. Employment and the own wage are instrumented using the general method of moments using lagged values at least three periods but with not more than two moment restrictions. Capital is instrumented with its difference two years previously. All other variables are assumed pre-determined.
Thus, the instrument sets are identical for columns (2)-(6); the est includes the predetrmined variables, industry sales and IUI in column (1) includes
2. The estimation period is 1979-83
3. Robust asymptotic standard errors in parantheses

Table 5.5 Experiments with the Alternative Wage

		(1)	(2)	(3)	(4)	(5)
$\tilde{w}_{jt}$	Convex	0.085	-	-	-	
	Combinatn.	(0.117)				
$\tilde{w}_{jt-1}$		0.028	-	-	-	-
		(0.109)				
$\bar{w}_{jt}$	Industry	-	0.073	-	-	-0.846
	Wage		(0.115)			(0.616)
$\bar{w}_{jt-1}$		-	-0.032	-	-	0.475
			(0.098)			(0.398)
u_{jt}	Industry	-	-0.074	-	-	-
	Unemp.		(0.062)			
u_{jt-1}		-	-0.013	-	-	-
			(0.075)			
w_t	Aggregate	-	-	5.019	-1.995	-
	Wage			10.554	(1.161)	
w_{t-1}		-	-	-0.074	-3.578	-
				(3.056)	(0.886)	
u_t	Aggregate	-	-	0.238	-	-
	Unemp.			(0.363)		
u_{t-1}		-	-	0.186	-	-
				(0.176)		
N		154	154	154	154	154

Notes to Table 5.5

1. Columns (1) to (5) are identical specifications to those of column (2) in Table 2. These are union firms only.

TABLE 5.6: FURTHER EXPERIMENTS

Variables	(1)Non-Union	(2) Union	(3)Cover	(4) MS	(5)LEVELS	(6)OLS Δs
Constant	-0.0013	0.0184	0.0063	-0.0060	0.0403	0.0067
	(0.0370)	(0.0174)	(0.0186)	(0.0127)	(0.0454)	(0.0094)
INNOV(t)	-	-	0.0346	0.0244	0.0188	0.0220
			(0.0122)	(0.0297)	(0.0131)	(0.0133)
INNOV(t-1)	-	-	0.0130	-0.0478	-0.0200	0.0017
			(0.0165)	(0.0422)	(0.0251)	(0.0239)
INNOV(t-2)	-	-	0.0335	-0.0221	0.0193	0.0173
			(0.0161)	(0.0441)	(0.0303)	(0.0093)
IPI(t)	-0.0023	0.0003	0.0004	-0.0208	-0.0003	0.0406
	(0.0035)	(0.0012)	(0.0012)	(0.0519)	(0.1046)	(0.0897)
IPI(t-1)	-0.0006	0.0030	0.0032	0.0033	0.0050	0.0025
	(0.0034)	(0.0010)	(0.0009)	(0.0011)	(0.1013)	(0.0701)
n(t-1)	0.5496	0.3859	-0.3413	0.0280	1.1247	0.1137
	(0.1285)	(0.2062)	(0.2067)	(0.1777)	(0.2182)	(0.1053)
n(t-2)	-0.3074	-0.0607	-0.0601	0.0593	-0.1536	-0.0359
	(0.0723)	(0.1801)	(0.1794)	(0.1414)	(0.2096)	(0.0419)
w(t)	-0.3184	-0.7181	-0.6579	-0.2313	-0.0593	-0.2219
	(0.3171)	(0.3310)	(0.3316)	(0.2117)	(0.0343)	(0.0828)
k(t)	0.5188	0.7092	0.7131	0.4573	0.0197	0.4073
	(0.1642)	(0.1304)	(0.1293)	(0.1669)	(0.0099)	(0.0582)
$\tilde{w}$(t)	-0.1323	0.0896	0.1696	-	-	-
	(0.4824)	(0.1241)	(0.1707)			
$\tilde{w}$(t-1)	-0.5992	0.0001	0.0222	-	-	-
	(0.2403)	(0.1063)	(0.1144)			
IDENSITY(t)	-0.2079	0.0378	-	-	-	-
	(0.2079)	(0.0764)				
IDENSITY(t-1)	-0.2308	-0.1112	-	-	-	-
	(0.2280)	(0.0978)				
ICOVER(t)	-	-	-0.0090	-	-	-
			(0.2400)			
ICOVER(t-1)	-	-	-0.1822	-	-	-
			(0.2042)			
MS(t)	-	-	-	-0.5714	-	-
				(1.3233)		
MS(t-1)	-	-	-	-0.5089	-	-
				(1.4424)		
INNOV*MS(t)	-	-	-	0.0429	-	-
				(0.1663)		
INNOV*MS(t-1)	-	-	-	0.0033	-	-
				(0.0012)		
INNOV*MS(t-2)	-	-	-	0.1753	-	-
				(0.2296)		
IPI*MS(t)	-	-	-	-0.0012	-	-
				(0.0013)		
IPI*MS(t-1)	-	-	-	-0.1064	-	-
				(0.0490)		

(P.T.O)

TABLE 5.6: FURTHER EXPERIMENTS - CONT.

Variables	(1)Non-Union	(2) Union	(3)Cover	(4) MS	(5)LEVELS	(6)OLS Δs
No. of Firms	27	154	154	154	154	154
Total Obs	110	626	626	626	626	626
Serial Corr.	0.744	-0.990	-0.975	-1.908	0.136	-2.611
Sargan	28.87(27)	36.32(27)	34.22(27)	51.47(39)	0.903(27)	-
Time Dummies	yes	yes	yes	yes	yes	yes

TABLE 5.7: FIRM LEVEL DENSITY, INNOVATION AND EMPLOYMENT GROWTH

Panel A

	Average Employment Growth (ΔlogN)	Number of Firms
In The Whole Sample	-0.025	603
In the Smaller Sample	-0.019	181
Union Recognised Firms	-0.025	154
Non-Union Firms	0.001	27
In the Density Sample		
Overall	-0.029	134
Innovators	-0.031	21
Non-Innovators	-0.029	113
High Union Density	-0.035	67
Low Union Density	-0.017	67

Panel B

Interactions in the Density Subsample: Average Employment Growth

	Innovators	Non-Innovators
High Density (>85%)	-2.75% NT=68	-3.71% NT=340
Low Density (≤85%)	-3.69% NT=48	-2.17% NT=364

Notes to Table 5.7

1. The samples are all the observations except for the first year (i.e. if 8 continuous observations, 1976 not used)
2. Innovators are firms who had an innovation at some point between 1970-1983

Table 5.8 Firm Density, Innovations and Employment - Regressions

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Constant	0.0109	0.0184	0.0174	0.0137	0.0114	0.0312
	(0.0153)	(0.0174)	(0.0153)	(0.0158)	(0.0160)	(0.0206)
INNOV(t)	0.0301	-0.1136	-	-0.0495	-0.0456	-0.0966
	(0.0123)	(0.0589)		(0.066)	(0.0614)	(0.0265)
INNOV(t)*UNION	-	0.1888	-	0.1267	0.1200	0.1603
		(0.0846)		(0.0890)	(0.0799)	(0.0341)
INNOV(t)*UNION≤85%	-	-	0.0064	-	-	-
			(0.0123)			
INNOV(t)*UNION>85%	-	-	0.0556	-	-	-
			(0.0152)			
INNOV(t-1)	0.0174	-	-	-0.1592	-0.1282	-
	(0.0205)			(0.0838)	(0.0923)	
INNOV(t-1)*UNION		-	-	0.2572	0.1200	-
				(0.1198)	(0.0799)	
INNOV(t-2)	0.0346	-	-	0.1012	0.0984	-
	(0.0145)			(0.0599)	(0.0634)	
INNOV(t-2)*UNION	-	-	-	-0.0978	-0.0958	-
				(0.0835)	(0.0890)	
INNOV(t-3)	-	-	-	-	0.0467	-
					(0.0727)	
INNOV(t-4)*UNION	-	-	-	-	-0.0474	-
					(0.1006)	
INNOV(t-4)	-	-	-	-	-0.0036	-
					(0.0923)	
INNOV*UNION(t-4)	-	-	-	-	-0.0041	-
					(0.1172)	
IPI(t)	-0.0004	0.0003	-0.0006	-0.0003	-0.0003	-0.0010
	(0.0012)	(0.0012)	(0.0012)	(0.0011)	(0.0010)	(0.0013)
IPI(t-1)	0.0036	0.0006	0.0040	0.0036	0.0030	0.0035
	(0.0199)	(0.0012)	(0.0011)	(0.0010)	(0.0010)	(0.0009)
n(t-1)	0.4050	0.3732	0.3967	0.3279	0.2987	0.2826
	(0.2000)	(0.1997)	(0.2022)	(0.2133)	(0.2332)	(0.1885)
n(t-2)	-0.0261	-0.0103	-0.0034	-0.0159	-0.0212	-0.0882
	(0.1489)	(0.1507)	(0.1546)	(0.1400)	(0.1747)	(0.1473)
w(t)	-0.5360	-0.6381	-0.6440	-0.5702	-0.0559	1.0529
	(0.2787)	(0.2893)	(0.2921)	(0.2923)	(0.0294)	(0.7454)
w(t)*UNION	-	-	-	-	-	-2.2560
						(0.9617)
k(t)	0.5243	0.5359	0.5336	0.5050	0.5017	0.5057
	(0.1083)	(0.1186)	(0.1206)	(0.1137)	(0.1166)	(0.1224)
No. of Firms	134	134	134	134	134	134
Total Obs	552	552	552	552	552	552
Serial Corr.	-1.287	-1.308	-1.538	-1.505	-1.536	-1.162
Sargan	40.79(31)	41.84(31)	41.59(31)	41.69(31)	42.02(31)	36.25(31)
Time Dummies	yes	yes	yes	yes	yes	yes

Appendix 5.1
The Effect of Hicksian Technical Change with Imperfect Competition

In this Appendix general conditions are derived for the effects of Hicksian technical change (that is process innovations which are defined in terms of their effects on the capital-labour ratio). This is done for conjectural variations which nest perfect competition, Cournot and (effectively) monopolistic competition as special cases. We look at labour demand models only, but as the text shows, generalising to other union models is not difficult. The proofs draw substantively on the work of Katsoulacos (1986).

Assume that production has constant returns to scale and is defined over capital, labour and a technology parameter, A. If firms minimise costs factor demands are homogeneous of degree zero in factor prices W and r and can be written

(5A.1) $N(W,r,A)$ and

(5A.2) $K(W,r,A)$

(5A.3) $c(W,r,A) = W(N/q) + r(N/q)$ are unit costs

where q is firm output. Denoting the proportionate change in a variable with a circumflex (^) it is possible to derive

(5A.4) $\hat{q} = \theta_N\hat{N} + \theta_K\hat{K} + a$ where

(5A.5) $a = \theta_N\hat{b}_N + \theta_K\hat{b}_K$, this is the Hicksian measure of the *extent* of technical progress. The θ_is are the proportions of factor i in total cost and the b_is are the proportionate reductions in $(\hat{N/q})$ and $(\hat{K/q})$ arising from technical change. We also also define

(5A.6) $B = \hat{b}_N - \hat{b}_K$, the proportionate change in the capital-labour ratio at constant factor prices. This measure the Hicksian *bias* of technical change. $B > 0$ is *labour-saving*, $B < 0$ is *capital-saving* and $B = 0$ is *neutral*.

It is possible to write the change in costs (Katsoulacos, 1986, Appendix 3)

(5A.6) $\hat{c} = \theta_N \hat{W} + \theta_K \hat{r} - a$

So far these results are technical aspects of the production function. To introduce the product market we must allow for general quantity competition as in chapter 3. Recall the standard result for a firm's price-cost margin, i.e. that

(5A.7) $P(Q)(1 - MS(1 + \lambda)/\eta(Q)) = c$, where c is marginal (unit) cost.

Totally differentiating the cost function gives

$$(5A.8)\ \frac{dc}{dq} = P'(Q)\left(1 - \frac{MS(1+\lambda)}{\eta(Q)}\right) + (1+\lambda)P(Q)\left(\frac{\eta'(Q)MS}{\eta^2(Q)}\right)$$

$$= P'(Q)\left(1 - (1+\lambda)\left(\frac{MS}{\eta(Q)} + e(Q)MS\right)\right);$$

where $e(Q) = P\eta'(Q)/\eta$, the elasticity of the elasticity

$$\text{So if we define } Z(q,Q) = \left(1 - (1+\lambda)\left(\frac{MS}{\eta(Q)} + e(Q)MS\right)\right);$$

(5A.9) $cdc/dq = qP'(Q)\ Z(q,Q)\ dq/q$

We now want to define the elasticity of output with respect to changes in unit costs as

(5A.10) $\eta_{qc} = -\hat{q}/\hat{c} = c/(Z(q,Q)P'(Q)$

$= \eta(Q)(1 - \rho)/Z(q,Q)$; $\rho = (P - c)/P$

Now we are in a position to use (5A.4) and (5A.6) to derive

$$(5A.11)\ \left(\sigma\frac{\theta_N}{\theta_K\ \eta_{qc}} + 1\right)\hat{N} = -B + a\sigma(1 - \eta_{qc}^{-1})/\theta_K$$

Where σ = the elasticity of substitution between labour and capital. Since

Z(Q) is the first derivative of the firm's MRP curve we will assume it to be downward sloping so Z(q,Q) must be positive. This implies that $\eta_{qc} > 0$, which means that the term on the left hand side of (5A.11) is also positive.

Hence the fundamental condition is

(5A.12) $\hat{N} > 0$ if'f $a\sigma(1 - \eta_{qc}^{-1})/\theta_K > B$.

Results

There are several ceterus paribus results which can be established from equation (5A.12):

(1) The greater is η_{qc} the output effect of a technology shift, the more likely it is that employment will increase.

(2) The smaller is B (the less labour saving is the innovation), the greater is the chance that $\hat{N} > 0$.

(3) Only in the case of e(q,Q)=0 will market structure not influence the effect of technology on jobs. The sign of the interaction is ambiguous however and depends on the distribution of market shares and e(q,Q).

(4) **Special Cases** are as follows:

(a) In a competitive industry ρ=0. Therefore Z = 1 and $\eta_{qc} = \eta$.

$$\hat{N} \gtreqless \text{ iff } a\sigma/\theta_K\left(1 - \eta(Q)^{-1}\right) \gtreqless B$$

Positive employment effects are more likely, (i) the easier it is to substitute labour for capital (σ), the larger is the share of labour and the more elastic is product demand.

(b) Under monopoly, or monopolistic competition $\rho = 1/\eta$.

$$\hat{N} \gtreqless \text{ iff } a\sigma/\theta_K\left(1 - 1/\eta(Q) + e(Q)/(1-\rho)\eta(Q)\right) \gtreqless B$$

When B = 0 and e(Q) > 0 monopolist will always increase employment as she always produces where $\eta > 1$.

(5) B = 0 (neutral); $\hat{N} > 0$ iff $\eta_{qc} > 1$. This is the result given in the text for a special case.

APPENDIX 5.2:

DYNAMIC SEQUENTIAL BARGAINING

Generally, in estimating wage or employment equations based on the models presented in section III one puts in lags (usually on the dependent variable) without explicitly modeling the dynamics. Card (1986) made a pioneering attempt in modeling the short-run dynamics of bargaining for U.S. Airline Mechanics. Values of expected variables entered the employment equation through four forecasting equations for contract wage, industry wage, consumer prices and flights. An obvious problem with this kind of dynamic modeling is that it is subject to the Lucas (1976) critique since agents are not optimising on their use of all available information.

One recent attempt to rectify this lacuna is by Machin, Manning and Meghir (1992) who use an Euler equation approach. This model can also provide ways of distinguishing between a competitive model and right-to-manage model that was unavailable in the static paradigm. We begin from the sequential bargaining model of Manning (1987) and let wages be determined in the first stage of the game at t. The second stage bargain determines employment conditional on previous period wages.

The value function of the firm is

(5B.3) $V_t^f(N_{t-1}) = \Pi(N_t, W_t, N_{t-1}) + \delta E_t V_{t+1}^f$

δ = the discount rate (common to firm and union[35]). Profits are assumed to be:

(5B.3) $\Pi_t = P_t A_t N_t^{\alpha} - p_t \gamma H_t^2/2 - W_t N_t$

We assume quadratic adjustment costs in labour, $H_t = (N_t - (1-s)N_{t-1})^2$ which are priced at the firm's product price. If there are dynamics in the union

---

[35] Differences over and above this are picked up in the bargaining power parameter which is, in part, a measure of differential impatience (see Rubinstein, 1982)

utility function (Kidd and Oswald(1986), Blanchard and Summers(1986)) then U_t will depend on lagged employment.

$$(5B.3)\quad V^u_t(N_{t-1}) = U_t(N_t, W_t, N_{t-1}) + \delta E_t V^u_{t+1}$$

At the second stage the Nash maximand is

$$(5B.4)\quad \max_{\{N_t\}} \Omega = V^f_t(N_{t-1}) + b^N_t V^u(N_{t-1})$$

Where b^u_t = relative union power over employment. This generates a first order condition of

$$(5B.5)\quad \partial\Pi_t/\partial N_t + \delta\partial V^f_{t+1}/\partial N_t + b^N_t \left[\partial U_t/\partial N_t + \delta\partial V^u_{t+1}/\partial N_t \right] = 0$$

When solved this gives $N_t(w_t, N_{t-1})$. At the first stage the wage is chosen according to bargaining rule

$$(5B.6)\quad \max_{\{W_t\}} \Omega = V^f_t(N_{t-1}) + b^W_t V^u(N_{t-1})$$

b^W_t is the union's relative power in the wage bargain $[b^W_t = 1/(1+\beta^W)]$ This gives a second first order condition:

$$(5B.7)\quad \left[\partial\Pi_t/\partial N_t + \delta\partial V^f_{t+1}/\partial N_t\right]\partial N_t/\partial w_t + \partial\Pi_t/\partial W_t + b^W_t\left[\partial U_t/\partial N_t + \delta\partial V^u_{t+1}/\partial N_t\right]\partial N_t/\partial W_t + b^W_t\, \partial U_t/\partial W_t = 0$$

Noting that the first two terms in (5B.5) are the same as the first two terms in (5B.7) enables us to derive a wage equation:

$$(5B.8)\quad (b^W_t - b^N_t)\left[\partial U_t/\partial N_t + \delta\partial V^u_{t+1}/\partial N_t\right]\partial N_t/\partial W_t + \partial\Pi_t/\partial W_t + b^W_t\, \partial U_t/\partial W_t = 0$$

There are several scenarios that can now be considered corresponding to restrictions on (5B.8). Let us first consider the dynamic Right to Manage model which implies $b^N_t = 0$. Make the following assumptions:

(i) Parameterise $\partial W_{t+1}/\partial N_t = \theta_0 + \theta_1 UNION_t + \theta_2 UNION_t/N_{t+1}$, were UNION power is a proxy for labour market imperfections. There is no closed form solution for this term and theory yields ambiguous predictions of its sign (Lockwood and Manning ,1989, and Blanchard and Summers, 1986).

(ii) Parameterise $A_t = [(\tau_1 + \tau_2 INNOV + \tau_3 IPI + \tau_4 INI)^*(K/N)^{\alpha-1}]_t$, $\tau_k \geq 0$. INNOV is a firm level count of innovations, IPI and INI are counts of innovations produced and used respectively

(iii) That (5B.2) can be written in terms of real wages and profits (tacitly assuming perfect product market competition) so that bargaining is over $(W/P)_t$. One can derive an employment function of the form

$$(5B.9)\ N_{t+1} = \Psi_{11} INNOV_t + \Psi_{12} IPI_{t-1} + \Psi_{13} INI_t + \Psi_{14} (K/N)_t^{1-\alpha} + \Psi_{15} N_t + \Psi_{16} N_{t-1}\ \Psi_{17} W_t + \Psi_{18} UNION_t{}^*N_{t+1} + \Psi_{19} UNION_t$$

where

$\Psi_{1k} = -\Lambda\alpha\tau_k\delta(1 - s)$, $k = 1,2,3,4$

$\Psi_{15} = \gamma\Lambda[\delta(1 - s)^2 + 1]$

$\Psi_{16} = - \gamma\Lambda(1 - s)$

$\Psi_{17} = \Lambda$

$\Psi_{18} = - \Lambda\theta_1\delta$

$\Psi_{19} = - \Lambda\theta_2\delta$

$\Lambda = [\delta(\gamma(1 - s) - \theta_0)]^{-1}$

(5B.9) is unidentified in the sense that we cannot recover all the structural parameters of the model. However we can place some qualitative and quantitative restrictions on some of the Ψs. Specifically, $\Psi_{15}/\Psi_{16} < -2$; the signs of Ψ_k are all the same; and the signs of Ψ_{17} and Ψ_{16} are the same. The sign of Ψ_{11} is ambiguous unless $\theta_0 = 0$, in which case it is negative.

Turning now to the efficient bargaining model we have $b_t^N = b_t^W$ and (5B.7) simplifies to

$$(5B.11)\ N_{t+1} = \Psi_{21} INNOV_t + \Psi_{22} IPI_{t-1} + \Psi_{23} INI_t + \Psi_{24} (K/N)_t^{1-\alpha} + \Psi_{25} N_t + \Psi_{26} N_{t-1}\ \Psi_{27} W_t + \Psi_{28} \tilde{W}_t$$

$$\Psi_{2k} = -\alpha\tau_k / \delta(1 - s) \quad < 0, \qquad k = 1,2,3,4$$

$$\Psi_{25} = [\delta(1 - s)^2 + 1] / \delta\gamma(1 - s) > 2$$

$$\Psi_{26} = -1 / \delta \quad < -1$$

$$\Psi_{27} = (\theta-1)/ \delta(1 - s)$$

$$\Psi_{28} = \theta/ \delta(1 - s) \quad > 0$$

As is standard in these type of models $\tilde{W}$ appears in the efficient bargain employment relation, but not in that of the right-to-manage model. As an additional test, the union power terms are absent from (5B.11). These terms also identify the wage equation in this set-up. The innovation term should take an unambiguously negative sign, in contrast to the indeterminacy of (5B.9).

What does this execise prove? Three things stand out:

(1) It may be empirically possible to distinguish right-to-manage models from competitive models in an employment equation because of the presence of the $\partial W_{t+1}/\partial N_t$ term in dynamic wage bargains. If we assume this term depends on union power then there is a further corrolary:

(2) Union power may enter the employment rule even if the union does not bargain over jobs. This makes tests of the General Bargaining Models more problematic.

(3) It shows that tractable dynamic models can be developed and that labour demand models become will exhibit dynamics due to adjustment costs whereas efficient bargaining dynamics come through the union utility function. Unfortunately, although some quantitative predictions are delivered, exact estimates of structural parameters are not generally recoverable from the reduced form.

CHAPTER 6

THE IMPACT OF INNOVATIVE ACTIVITY ON WAGES

"Unions are fundamentally organisations that seek to create or capture monopoly rents available in an industry"

Farber (1986) p.1044

I. INTRODUCTION

The interest of looking at the relationship between technical change and wages stems not just from abstract theory, but from real questions of policy. Economists have traditionally been concerned that the creaming off of the fruits of technology into earnings would damage the long-run rate of technical progress. Salter (1966) claimed that "..the argument that an industry cannot 'afford' higher wages, is in the long-run, extremely dangerous" because such links implied that declining industries could be propped up by pay cuts. Being naturally alert to using employers' own arguments against them, workers would demand a slice of the gains when the future was rosier, dampening the incentive of successful firms to expand. On the other hand, refuting such a linkage could be more damaging than explicitly acknowledging it. As John Hodge, General Secretary of the U.S. Smelters put it: "we won't work against the machine if we get a fair share of the plunder" (Elbaum and Wilkinson, 1979).

The approach in this chapter is to model wage-determination as the outcome of a multistage game. In the final stage output is determined by oligopolistic rivalry, and factor prices are taken as predetermined. In the intermediate stages wages and employment are set, taking (uncertain) product market effects into account. The upshot of the last chapter was that the Right To Manage model is probably the best approximation to the union bargaining game, so it is assumed that contracts take the recursive structure where bargaining takes place over the wage and then the firm unilaterally sets employment.

Insofar as innovations, at least temporarily, enhance product market power (see Chapter 4) the literature relating pay to monopoly power discussed in the Survey Chapter is directly relevant. Rather than repeat the discussion we baldly summarise the main conclusions as three stylised facts

1. Profits per head are positively related to wages

2. Micro-studies of plants and firms find that monopoly power (market share, number of competitors) boosts wages.

3. The relationship between industry concentration and individual or industry wages is weak, tending to be positive in the non-union sector but negative in the union sector.

Section III.1 presents a simple bargaining model which tries to reconcile these three 'facts'.

Innovation may also effect wages for purely competitive reasons. Rigidities in labour supply, compensating differentials and skills upgrading may also lie behind a positive correlation between new technology and wages. Section III.2 discusses these three alternative competitive stories in more detail and outlines ways that we might distinguish between imperfect and perfect competitive readings of the data.

The focal questions which organise and motivate this chapter are: what is the size of technological wage differentials? How appropriate are rent-sharing models of wage determination? And what is the relationship between union power, technology and pay? The layout of the chapter is as follows. Section II looks at the relevant empirical literature and Section III presents the stylised theoretical model. An econometric model is specified in section IV and the results and interpretations are presented in Section V. The final section offers some conclusions.

II. Previous Empirical Work on Innovation and Wages

In reviewing the empirical work on wages and technology one is struck by both its sparsity and its sharp division into the field of economics and industrial relations. Although there *is* a growing concern over whether wage inequality has been exacerbated by technological shifts in the 1980s, this debate has generally shied away from looking *directly* at technology, being more concerned with relative than average effects[1]. In general, empirical wage equations look only *indirectly* at technical change by using Solow residuals or capital-labour ratios. There are a few honourable exceptions however, and we scrutinise them first.

1. Econometric Analyses

The Current Population Survey (CPS) has been the prime data source for investigating individual earnings and new technology in the United States. Bartel and Lichtenberg (1990) pooled the CPS data from 1960,1970 and 1980 and stratified the observations by age, sex, and education. Their basic estimates gave significant and positive effects for three technological proxies: purchases of electronic and computer equipment, R&D/sales, and age of industrial equipment. Only the final variable was significant in an industry fixed effect model, however. Similarly, Dickens and Katz (1987) pool the monthly CPS data from 1983 and regress individual wages against a battery of individual and locational characteristics and industry dummies. They take the coefficients of the industry dummies and regress them against various industry characteristics. "The variable R&D expenditures to sales was fairly consistently positively related to wages in the nonunion

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[1] It has also been centered on the other side of the Atlantic. I discuss it more fully next chapter.

sector.... *the results were reversed for union workers with most of the specifications having a negative coefficient* which was sometimes significant..[my italics]" (p.78).

An obvious problem with both of these studies is that only industry level measures of innovation are related to individual level pay. By contrast, Krueger (1991) uses CPS data from 1984 and 1989 when special questions were asked to workers concerning the use of micro electronics. He found that the premium for computer use was about 10-15% and lower in the union sector (7.8%) than in the non-union sector (20.4%). This is also in line with the findings of Betcherman that trade union mark-ups are lower in Canadian firms that have introduced micro-electronics in the early 1980s even though innovations appeared to boost wages overall. No study has actually related firm-level measures of innovation to wages, despite the fact that it is at this level that union bargaining theory usually assumes decisions are made.

Some recent studies of British wage determination and technology are summarised in Table 6.1. The only one to explicitly incorporate new technology is in the paper by Gregory et al (1987) who look at 212 settlement groups between 1980-84 in the Confederation of British Industry's pay databank. They regressed managers' expectations of wage growth against whether new technology had been introduced together with a large number of other variables. Of all the controls for the content of the contract only the innovation variables were significant: they positively boosted wage growth in 1980-81. Unfortunately, the fact that all the variables are purely subjective responses and the lack of important objective controls (e.g. size of firm) makes this suggestive research hard to evaluate.

In the absence of innovation measures, technological change has often been represented indirectly (if at all) by a trend term in the production function. This may be estimated separately from a simple regression of labour productivity on a time - trend (e.g Holmhund and Zetterberg, 1990) or from Total Factor Productivity estimates (e.g. Nickell and Kong, 1988). Time trends may capture aggregate movements in technical progress, but by definition these accrue across the board whereas we are interested in firm-specific quasi-rents. TFP estimates have well known problems as proxies for technical change (see Chapter 2, Section II.3). First there is the obvious danger of attributing a residual to an economic category in the presence of both endogeneity and omitted variables[2]. Secondly, TFP estimates are usually made under the assumption of marginal cost pricing which is inconsistent with the imperfect competition approach adopted in this study.

The generally accepted conclusion from the literature is that productivity growth has no long-term effect on the level of earnings at the sectoral level (Salter, 1966; Wragg and Robertson, 1978; Ball and Skeoch, 1981). This result emerges naturally from a model where there is less than total hysteresis, i.e outside wage opportunities do play *some* part in wage determination (e.g. Nickell and Kong, 1987).

Finally, if technical change is embodied in capital then changes in the capital-labour ratio should pick this up. Most studies find that there is a positive correlation (e.g. Denny and Machin, 1991) but it is very difficult to identify the separate effects of technology in this case, as labour productivity increases may be reaped merely from a higher quantity of capital. Added to which we have the well known problem of the proper measure of capital. Despite these problems at least two major studies have sought to

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[2]For example changes in effort may be responsible for the unexplained changes in productivity (Weisskopf, Bowles and Gordon, 1983).

The 1984 Workplace Industrial Relations Survey illustrates that there do seem to be gains. In 458 establishments where there were some manual workers 24% of managers claimed that there had been an increase in earnings where 'Advanced Technical Change' (ATC) had taken place (Daniel, 1987). This rose to 35% in private manufacturing. The accounts of workers representatives told a similar story.

Impact of Advanced technical change on earnings in relation to union recognition

	All Establishments	
	Manual Union Recognised	Union not Recognised
Implications of change for earnings (%)		
Increased	24	24
No change	72	76
Decreased	3	-
Not Stated	1	-
N (unweighted)	405	53

Source: Daniel (1987) Table X.3

The British Social Attitudes Survey (BSAS) has asked individuals an almost identical question to WIRS in 1985,1987 and 1990. The results were qualitatively similar: mostly no change, almost no decreases and a substantial minority of increases. What is quite remarkable in both studies is that there are practically no cases where wage reductions have occurred after a technical change.

New technology at work means those affected have:	**1985**	**1986**	**1990**
More Pay	13	13	13.4
No difference	67	70	55.6
Less Pay	2	1	1.1
Don't Know	18	15	8.8

Source: British Social Attitudes Survey 1985,1987,1990

The second approach is closer to the economist's heart. When one looks at the average levels of pay in plants using micro-electronics (from WIRS) they are generally higher (Daniel, 1987, Table X.9). These differentials appear larger for skilled workers, women and private manufacturing. Similarly there is a strong positive correlation between new technology and pay in British Social Attitudes Survey. In the next chapter I examine whether the WIRS correlations stand up to more detailed econometric scrutiny.

Content analysis of written bargains has also been popular. The Labour Research Development Unit (Williams and Steward, 1985) surveyed 163 Collective Bargaining agreements which related, at least in part, to new technology. 37% of union representatives said that pay had increased as a result of the change, and virtually none said it had decreased. These increases pertained to only those directly affected by the changes and there were no changes in fringe benefits.

Finally, there is the evidence from New Technology Agreements (NTAs). These were recommended by the TUC in 1979 to 'exert trade union influence as fully as possible over the whole process [of technical change]' (TUC 1979:64). In the inhospitable climate of the 1980s these were seen as unsuccessful in both numbers and quality. Williams and Moseley's (1982) survey of 86 NTAs found only 13 containing commitments to a shorter working week or higher pay. Manwaring's (1981) study of pay deals in 1979 and 1980 showed that NTAs "seldom saw increases in earnings"[4]. By contrast, a recent investigation by Noone (1991) finds that 75 of 76 agreements signed by the National Union of Journalists had 'technology payments'. The author attributes this both to the particularly fortunate circumstances of the journalists and their far-sighted strategic approach to sharing the gains

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[4]Similarly negative appraisals are recorded by Dodgson and Martin (1987) and Williams and Steward(1985)

from new technologies. Union density per se had no correlation with higher awards.

All in all, if one could summarise the existing empirical literature somewhat brutally, innovation is generally associated with increases in remuneration and almost never with decreases. A second 'stylised fact' is that union power often appears to coincide with smaller technological wage differentials. We will try to account for the first stylised fact in a simple bargaining model in the next section, leaving the second stylised fact for next chapter.

III. Theoretical Models of Wage Determination

1. A Bargaining Theory of Wages and Rents[5]

This section contains a simple model investigating the relationship between economic rents from innovation and wages using a framework similar to that of Nickell et al (1992) and Dowrick (1989).[6] In the light of the last chapter we will use a 'Right-To-Manage Model' embedded within a three stage game. In the first stage capital is installed and then innovations revealed (the investment decision is therefore predetermined). In the second stage wages are the object of a Nash Bargain between the union and the employer and in the final stage the firm sets employment. It is assumed that there is an industry with a fixed number of J firms where quantities are the strategic choice variable so when the firm chooses employment it implicitly chooses a level of expected output, capital being predetermined. Demand has a stochastic component $\tilde{\Gamma}$ whose distribution is common knowledge, but whose value is revealed ex post when the firm sets employment. Given constant elasticity of product demand price can be written as.

(6.1) $P = \tilde{\Gamma}Q^{-1/\eta}$, $Q = \Sigma q$ industry output.

Until now it has simply been assumed that the relative importance of employment for the union was simply a parameter ψ. This is unlikely to be the case if the union only represents a varying proportion of the potential workforce or if the risk of losing one's job is different for different workers. In the simplest model of this type all lay-off are by seniority, so

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[5] For simplicity we use a static framework. For a dynamic approach see Spinnewyn and Svenjar (1989).

[6] The model generalises Dowrick by allowing for firm asymmetries in an industry and capital in the production function. It generalises Nickell et al (1992) by allowing a role for industry-wide wage co-ordination by unions and the elasticity of market share with respect to wages.

that a democratic union will be unconcerned with the total number of jobs as the median member is insulated from lay-off. In a more realistic model the median member has a nonzero probability of lay-off (or equivalently, she is partly altruistic or the union is not a pure utilitarian democracy). Assuming lay-off is by random draw is also extreme, but probably closer to the truth. The probability of lay-off for an insider union member is

$$(6.2) \qquad L = Pr(N < N_I)E\left(\frac{N_I - E(N/N < N_I)}{N_I} \right)$$

Where N_I = number of insiders. We will assume that each firm in the industry bargains with a separate union, but there may be some collusion between unions as represented by a parameter $g = (W_i/W_j)(dW_j/dW_i)$ $i \neq j$. If $g = 1$ there is complete collusion, the equivalent of an industry wide union, if $g = 0$ it is as if the unions ignored the effects of their own bargains on others.

A constant returns Cobb-Douglas production function is also an assumption which seemed broadly consistent with the data analysed in the last chapter. If the employment elasticity with respect to output is α the first order condition can be written as follows (setting the wage equal to the marginal revenue product of labour):

$$(6.3) \qquad N/K = \left(\frac{W}{A\ \alpha P(1-\rho)} \right)^{-1/1-\alpha}$$

Note that the marginal productivity rule implies that labour's share in revenue will depend not only on α, but also on the degree of monopoly , ρ: $WN/PQ = \alpha(1-\rho)$ or[7]

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[7]Although this *exact* relationship is specific to our functional form the general principle that labour share declines with price-cost margins is quite robust. So as $\rho \longrightarrow 0$, and we approach perfect competition the usual Solow result of the equality of labour's share in revenue and the output elasticity of employment holds.

(6.4) $$\frac{WN}{\Pi} = \frac{\alpha(1-\rho)}{1-\alpha(1-\rho)}$$

Let the union contribution to the Nash Bargain be

$U - U_0 = [(1-L)W - L\tilde{W}] - \tilde{W} = (1 - L)(W - \tilde{W})$.

If the Nash Maximand is $\Omega = (1 - L)(W - \tilde{W})(\Pi^e)^\beta$, where the e superscript denotes an expectation, the first order condition reduces to

(6.5) $$W/(W-\tilde{W}) = \beta\eta_{\pi W} + \eta_{SW}$$

(6.6) $$\Rightarrow \quad \frac{W}{W-\tilde{W}} = \beta\frac{\alpha(1-\rho)}{1-\alpha(1-\rho)} + \frac{W}{(1-L)}\frac{\partial L}{\partial W}$$

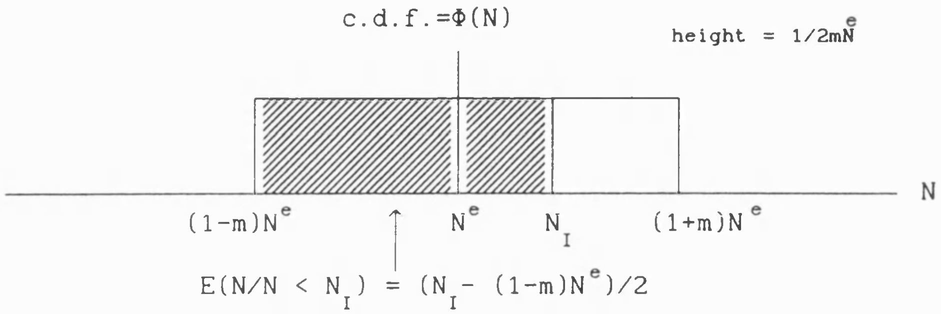
Where $\eta_{\pi W}$ is the elasticity of profits with respect to the wage and η_{SW} is the elasticity of survival rate of an insider with respect to the wage, survival being 1 - L. Below, we can demonstrate that this is a positive function of the insider density (N_{-1}/N^e). Thus, the larger the number of insiders, the greater is η_{SW} and the lower is upward wage pressure.

Equation (6.5) is familiar - it is identical to (2.8) in Chapter 2 except with a more general union utility function. The first term on the right-hand side of (6.6) can be interpreted as the product market rents of the firm weighted by bargaining power. Any change which boosts rents will also tend to boost the wage. As before we can write this as (remember that costs are predetermined) as

(6.7) $\rho = (MS(1 - \mu) + \mu)/\eta$

Where ρ = the price-cost margin, $\mu = (1-MS)\lambda/MS$, the conjectural elasticity term described in Chapter 3, MS = market share, η is the price elasticity of product demand and λ the conjectural variations of firm i. Under Cournot competition $\mu = 0$, and under monopolistic competition MS will be equal to unity. Product innovations, I, are expected to increase the inelasticity of overall firm demand, boosting potential surplus to be bargained over.

Assuming that N is distributed uniformly[8] over (1 + m) to (1 - m) then $L = N_I/4mN^e - N^e/4mN_I$, where N^e= Expected Employment. This is illustrated below



Since $\partial L/\partial N$ depends only on N_I/N^e it is convenient to split the survival elasticity into two parts: $\eta_{SW} = \eta_{SN}(N_I/N^e)\ \eta_{NW}$. If one was prepared to assume that labour demand elasticity was constant then the empirical wage equation would be simply of the form

(6.8) $W = \mathcal{W}(\tilde{W}, \beta, \rho, \alpha, N_I/N^e, \eta_{NW})$

The assumption that η_{NW} is invariant to changes in product market power will be relaxed. Traditionally the Marshallian 'Laws of Derived Demand' are invoked suggesting that increases in monopoly power (via a lower elasticity of product demand) will feed through into a higher wages through a lower elasticity of labour demand. These 'laws' are only true under perfect competition and need modifying when one considers generalised oligopoly.

Recall that the production function can be written as

$\log N = (\log q - \log A - (1-\alpha)\log K)/\alpha$

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[8]The result generalises to all symmetric single peaked distributions so long as $N_I/N^e \leq 1$ (Annex 2.3 in Layard, Nickell and Jackman, 1991).

Since q = MS.Q, the elasticity of labour demand is

$$(6.8)\quad \frac{\partial \log N}{\partial \log W} = \left(\frac{\partial \log MS}{\partial \log W} + \frac{\partial \log Q}{\partial \log W} \right) \alpha^{-1}$$

By using the price equation this becomes

$$- \frac{\partial \log N}{\partial \log W} = - \left(\frac{\partial \log MS}{\partial \log W} - \eta \frac{\partial \log P}{\partial \log W} \right) \alpha^{-1}$$

$$(6.9)\quad \eta_{NW} = (\eta_{(MS)W} + \eta_{PW}\eta)/\alpha$$

Where $\eta_{(MS)W} = -\partial \log MS/\partial \log W$ and $\eta_{PW} = \partial \log P/\partial \log W$.

The intuition behind (6.9) is straightforward. The sensitivity of employment to wage changes is greater (i) the larger is the the loss of market share from a wage increase ($\eta_{(MS)W}$) and the (ii) the bigger the increase in industry price (η_{PW}) weighted by consumers sensitivity to price (η). This can be rearranged in a form more conducive to comparative statics exercises.

<u>Claim 6.1</u>

$$(6.10)\quad \eta_{NW} = \left[\frac{\xi(g)}{MS} \left(\frac{\eta - \varepsilon}{1 - \varepsilon} \right) + \alpha\eta \left(\frac{(1 - g)\ MS + g}{\alpha + \eta\ (1 - \alpha)} \right) \right]$$

Where $\xi(g) \geq 0$ and $\varepsilon = (1 + (J-1)\mu)/J$

<u>Proof</u>

See Appendix 6.1

Substituting (6.10) into (6.6) the wage equation becomes

$$1 - W/\tilde{W} = \left\{ \eta_{SN}(N_I/N^e) \left[\frac{\xi(g)}{MS} \left(\frac{\eta - \varepsilon}{1 - \varepsilon} \right) + \frac{\alpha\eta}{\tilde{\Gamma}} \left(\frac{(1 - g)\, MS + g}{\alpha + \eta\,(1 - \alpha)} \right) \right] + \frac{\alpha(1-\rho)}{1 - \alpha(1-\rho)} \right\} \qquad (6.11)$$

From (6.11) we can make

<u>Claim 6.2</u>

$\partial W/\partial\eta \leq 0$; *An increase in the price elasticity of demand will (weakly) decrease the wage*

<u>Proof</u>

See Appendix 6.1

Claim 6.2. is hardly surprising as it conforms to common sense : decreases in the elasticity of product demand both increase rents and the survival chances of insiders. Unfortunately the comparative statics for market share and collusion on the wage are not so clear cut. We show in Appendix 6.1 that the elasticity of labour demand may be increasing in these variables, so the eventual impact on the wage will depend on whether these survival effects will outweigh the increase in rents that are associated with higher market power. The intuition behind the collusion is as follows. When unions do not co-ordinate their actions perfectly across a whole industry[9] (g<1) they have an incentive to undercut each others wages to allow their firm to capture greater market share. As firm collusion increases (μ higher)

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[9] Horn and Wolinsky (1988) showed that if workers are substitutes (which is probably true across firms in an industry) they are better off in an encompassing union, whereas if they are complements they are better off bargaining separately. See Machin, Stewart and Van Reenen (1993) for corroborating evidence.

production is increasingly allocated to the lowest cost firms until, at the joint maximising solution, the lowest cost firm gets the entire market. At this point there is no scope for any union mark-up as any cost increase will cause the firm to lose all its market share. Consequently the collusion-wage relationship will be hump shaped, with wages initially rising from the competitive wage, reaching a maximum and then falling as the demand elasticity effect outweighs the rent-sharing effect.

The market share effects on the elasticity of labour demand works somewhat differently. As the firm increases its domination of a particular industry increases in the firm's own costs will have a relatively larger effect on the industry price (this is reflected in a higher η_{PW}) and so a greater effect on reducing industry demand and the firm's own employment. There are good reasons for expecting this to be less of a problem than the collusion result. For one thing, a marginal increase in market share will have a larger impact on rents than a marginal increase in collusive behaviour because the benefits do not have to be shared with the other members of the tacit cartel. Furthermore, Appendix 6.1 shows that $\eta_{(MS)W}$ decreases with market share which implies that the effect of market share on labour demand elasticity is actually ambiguous[10].

How does one deal with the the insiders' weight to employment $\eta_{SN}(N_I/N^e)$? If we assume that $N_I = N_{-1}$ (the number of insiders this period equals those em[ployed last period) and assume rational expectations ($N^e = N + \nu$, ν is random error) then the 'hysteresis' term becomes N_{-1}/N. Suppressing the constants (g and α), noting that $\tilde{\Gamma}^e = 1$ and substituting out ρ using (6.7)

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[10]Nickell et al (1992) ignore the elasticity between market share and the wage so they argue that higher market shares will unambiguously decrease the survival chances of insiders (p.17).

, the wage equation is now of the form

(6.12a) $W = W(\tilde{W},\beta,N_I/N^e,MS,\mu,\eta(\phi))$

From (6.11) we can sign these as $W_1 \geq 0$, $W_2 \leq 0$, $W_3 \leq 0$, $W_4 \geq (\leq)$ 0, $W_5 \gtreqless 0$, $W_6 \leq 0$ (the brackets reflecting a possible but improbable sign). This will be the basic wage equation for the empirical work.

Notice that equation (6.12a) restricts innovations to work through the product market via η, let us say through a firm specific elasticity shifter ϕ. If we want to allow explicitly for process innovations then we can follow the standard practice of substituting around N_{-1}/N. We can unpack this term further since

$$N_{-1}/N = \left((N_{-1}/K)^{1-\alpha} \frac{W}{\alpha Ap(1-\rho)} \right)^{1/1-\alpha} \text{ and } N_{-1}/K = (N_{-1}/N)(N/K)$$

This gives a wage equation of the form

(6.12b) $W = W^1(\tilde{W},\beta,A,N_{-1}/N,N/K,\mu,MS,\eta(\phi))$ or

(6.12c) $W = W^2(\tilde{W},\beta,N_{-1}/N,R/N,\mu,MS,\eta(\phi))$ if we use the production function to eliminate the capital-labour ratio.

There is an obvious problem with this procedure emphasised most recently by Manning (1991). The wage and employment equations (6.12a) and (6.3) form an identified system as $\tilde{W}$ and β are excluded from (6.3) and A and K do not enter (6.12a). When we use (6.12b) or (6.12c) however, although the employment equation is identified, the wage equation no longer is. This occurs because we have not imposed the implied cross equation restrictions implicit in substituting around N_{-1}/N^e which is the general procedure followed by many empirical articles. One solution is to argue that the second lag of employment will not enter the wage equation but will enter employment determination through quadratic adjustment costs (for example see Appendix

5.2, equation 5B.9). This is a slightly dubious procedure as the our employment equations showed that N_{t-2} was only weakly correlated with N_t. Furthermore, ΔlogN enters the wage equation so any lags in this will generate an N_{t-2} term through the dynamic union utility function. As a general principle, identification off the dynamic structure is an inherently risky business especially since knowledge of adjustment processes is very limited. Consequently, although I will estimate models based on (6.12b) and (6.12c) the emphasis will be on (6.12a).

2. Alternative Theoretical Perspectives

The upshot of the theoretical section is that innovations will primarily have a positive effect on wages through increasing the market power of the firm. On top of the rent-creating effects technical change can alter the survival probability of the median member in ways which probably offset the primary effect. There are two lacunas in the model examined so far. Firstly, there are competitive reasons why innovations will affect wages in the absence of rent-sharing or union power. Secondly, there are rent sharing models predicting a relationship between market power and wages other than one based on union bargaining.

There are basically three ways that a purely competitive model might generate the same predictions as a bargaining model: either through fictions in labour supply, workforce composition, or compensating differentials. A purely competitive model predicts that the wage paid to a worker should be depend solely on her marginal product and not the product market conditions faced by the firm. In a modified competitive model the labour supply curve slopes upwards and the firm will have to pay higher wages to attract more workers (Hildreth and Oswald, 1992). As we have seen that there tend to be substantial increases in employment generated by innovations, this may be in operation. It is hard to believe that these effects could persist for very long, however, so this positive relationship could only be a very short-run phenomenon. This suggests that one way to discriminate between a bargaining story and a competitive story is to observe whether the wage increase associated with technical change occurs all in the first year or lasts into the medium run. Our panel does not cover enough years to examine the very long-run, but one would expect that by then imitation would have eroded away the rents from innovation.

A second competitive theory stresses the bundling of innovations and human capital. It may be that innovations shift the composition of the labour force systematically towards those workers with higher marginal products. This is most likely to happen if technical change leads to job shedding as the firm will want to lay off the least productive workers first. But last chapter we demonstrated that innovations were generally associated with an *increase* in the employment, so the only route could be through an upgrading in work force. This is interesting in itself and the argument is taken up more rigorously next chapter by looking within different skill groups. Yet it is far from obvious that there will an upgrading. The new technology could just as easily de-skill the workforce as re-skill it, effectively lowering the alternative wage available and reducing wages. Additionally, if the new skills are of a general rather than specific nature, the firm will expect the worker to absorb some or all of the costs of retraining which could result (temporarily) in a lower wage.

Finally, it is possible that innovations are associated with non-pecuniary disadvantages which will bring forth a compensating differential. In the last chapter we noted that this might occur if higher effort and technology came as a package. As with skills, there should be no presumption that innovation makes life harder - most workers seem to welcome new technology and say that it often enhances their job satisfaction[11]. There may be a transitionary period when greater effort and uncertainty surrounds the initial installation of a new machine, but one would not expect this to persist for a long period.

Modified competitive models suggest that there *may* be a positive relationship between innovation and wages. The connection is not a necessary one as it is with a bargaining model. Furthermore, it is not likely to last into the medium run or vary systematically with union power. These considerations will be used in interpreting the outcome of our experiments in section V.

The second class of alternative models have rent sharing in non-union firms. Four possibilities are:

(a) Expense Preference Theory (Smirlock and Marshall,1983); managers cease to profit maximise in monopoly firms because of weaker competitive threats. They may pay more wages to reduce the effort involved in monitoring workers. This argument may be applicable to some parts of the public sector, but seems unlikely over our time period as competition was increasing.

(b) Efficiency Wages (see Chapter 5 section III.4). Akerlof (1982) advances a sociological model where worker productivity declines when the firm makes large gains and workers do not because, of considerations of 'fairness'. Bartel and Lichtenberg (1990) advance the argument that even in

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[11]For example in 1985 the British Social Attitudes Survey recorded that 45% of employees claimed new technology affected their own work "for the better" compared to 6% who said it made their work less satisfying.

the absence of changes in the level of skill, the greater uncertainty involved in new techniques will require some degree of learning on behalf of the work force. This is a cost which requires a compensation or efficiency wage premium. They suggest that more educated workers learn more easily and this is why they tend to get a relatively higher pay-off to innovations. As the techniques become more established the advantage of more educated workers weakens, and this is consistent with their own empirical work[12].

(c) Regulation; Weiss (1966) suggested that spending monopoly profits on wages would keep the regulators at bay by promoting a 'good image' for the firm.

(d) Union Deterring (Dickens and Katz,1987); firms will pay higher wages to reduce the threat of unionisation (e.g. I.B.M.). This effect depends on having a strong unionised sector somewhere in the system, so theoretically it must be of second order importance.

None of these alternative explanations seem as appropriate as a bargaining model where the firm is *forced* to share wealth through the threat of collective action. This is particularly so in my sample where I focus almost exclusively on union firms in the small sample. Even in the larger sample industry density is over 69% and the proportion covered by a collective bargain should be even larger.

IV Econometric Issues and Data Description

To econometrically implement (6.12a) we have to deal with the usual issues relating to unobservability, endogeneity, dynamics and the data. Many of the same issues discussed in the last chapter are pertinent here, so this

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[12]There is a negative effect of age of capital equipment in their skilled workers pay equation.

section is quite brief.

1. Unobservables

Alternative wage ($\tilde{W}$)

Two variables are used to represent $\tilde{W}$, industry wages and industry unemployment. The means of these variables are plotted for each industry in Figures 6.2 and 6.3. There is a fair amount of inter-industry variability, and both are trending upwards over time. Unemployment has a more powerful cyclical element rising steeply in 1979 across all industry groups. We also experimented with a convex combination of industry wages and the average benefit level were the weight is the aggregate unemployment level.

Union wage bargaining power ($1/\beta$)

The main way to proxy this notoriously difficult variable is industry level union density. We also have cross sectional data on firm density so it is taken as a fixed effect and some interactions are presented based on its level. Other experimental proxies were coverage by major industry agreements and the aggregate union mark-up.

Oligopoly power (ρ)

Using results from Chapter 3, ρ = (P-MC)/P = $\rho(\mu(\text{CONC},\text{IMPS}), \text{MS},\eta(\phi))$. Both our theoretical analysis and our prior empirical work suggests that market share is the most important component of profit margins so attention was concentrated on this variable. The elasticity of product demand was parameterised (like Chapter 4) as: $\eta_i(\phi) = \eta_0 + \eta_1\phi_i + \eta_2\phi_j + \eta_3 T$. In the absence of more suitable data this is assumed to be captured by a firm constant (which will disappear when differenced), firm and industry product innovations (ϕ_i and ϕ_j) and time dummies (T).

Technical change (I)

The firm measure with six lags is used as are the usual industry measures. There is no reliable information on whether we observe a demand elasticity shifting (ϕ) or cost reducing (A) change, so both are taken as functions of the headcount of innovations, I.

Fixed Effects , (f_i).

Apart from η, there are many other variables important in wage-setting that are unobserved by the econometrician. In particular, job characteristics, the skill, race and gender mix of the firm are assumed to be different across firms but evolving in a way that is captured by aggregate and industry trends[13]. In this case we can represent them by a time-invariant firm-specific effect. All other unobservables are consigned to a white noise error term, ε_{it}.

2. Endogeneity

Several of the variables are potentially endogenous (this is almost certainly true of N_t and ρ_t). The approach taken here, as in previous chapters, is to use instrumental variables techniques, taking valid instruments to be the lags of firm-level variables from periods t-2 and before. The Arellano-Bond procedure is checked by looking at the Sargan Test of instrument validity, the SC(2) test and experimenting with deeper lags.

3. Dynamics

The only theoretical dynamics in our model arises from insider-outsider considerations. Alongside ΔlogN, lagged wages should enter the model as they may be used as a reference level in wage negotiations. Since preliminary experiments showed that dynamics were less important in wages than they were

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[13]We experimented with replacing the observable industry variables with two digit dummies and it made little difference to the results.

in the employment equation and competing models are not being formally tested we kept to a simpler basic model for presentational purposes, with only firm innovations entered with longer lags form.

Log linearising (6.12a) and substituting out for ρ

$$w_{it} = f_i + \zeta_1 w_{i,t-1} + \zeta_2 \bar{w}_{jt} + \zeta_3 u_{jt} + \sum_{j=0}^{6} \zeta_{4j} INNOV_{it-j} + \zeta_5 IUI_{jt} + \zeta_6 IPI_{jt} + \zeta_7 \Delta n_{it} + \zeta_8 IDENSITY_{jt} + \zeta_9 MS_{it} + \text{time dums} + \varepsilon_{it}$$

The fixed effect, f_i, will disappear when we estimate the equation in first differences. We include time dummies to pick up year-specific effects on all aggregate variables, except in equations which have aggregate unemployment. Monopolistic competition implies $\zeta_9 = 0$ and conjectural variations imply extra terms in CONC and IMPS.

4. The Data

We use the same datasets for this chapter as we did last chapter so the main descriptive statistics are in Table 5.3. Two 'new' variables used in this chapter, profits per head and the capital-labour ratio are plotted in Figure 6.3. Per capita profitability seems to be quite cyclical, picking up dramatically after its nadir in 1981, which mirrors the pattern of the rate of return on sales given in Figure 3.1. The capital-labour ratio appears to have trended upwards over this period.

As a prelude to our more detailed analysis Table 6.2 presents some simple correlations between wages and innovations. The two main themes are present here: innovations are associated with higher wages, especially in the union firm sub-sample, but this effect is mitigated at high levels of union density. In Panel (A) we simply break down the total number of observations into those were there were at least one innovation and those were there were not, a raw differential emerges of about 15% in the large sample. This grows to 18% in the 154 firms where we know a union was recognised, but *falls* to 10.8% when we look at union firms where 85% or more employees (the sample median) were in a union. A similar picture is sketched when we split the sample into union and non-union firms and look at their relative wage growth. Innovative firms in the large sample had an average wage growth of 2.6% in the large sample and 2.1% in the 'union density' sample of 134 firms. Wage growth was about 0.6% lower for innovative firms when their union density was high. This is interesting in relation to the raw innovation-employment growth figures of the previous chapter. Innovative firms have relatively higher employment and wage growth than non-innovators, but within the innovators it is the strongly unionised firms which seemed to show more wage restraint and grew faster.

V Results and Interpretations

1. The Innovation Differential

The primary results are in Table 6.3 which implements the bargaining model of section III.1. In column (1) a simple insider model is presented without innovations or market structure variables. There is considerable persistence in wage setting, as indicated by the coefficient on lagged wages. As predicted by competitive and bargaining models the industry wage[14] and

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[14]The measure of the alternative wage as a convex combination of industry wages and unemployment benefits yields almost identical results - coefficient of 0.162(0.058). Instrumenting the industry wage with its lags gives a positive but insignificant coefficient.

unemployment enter at conventional levels of significance with their expected signs. Contrary to our bargaining models industry density (although positive) is imprecisely determined. This may be due to its poverty as a measure of firm-level power being both too aggregated and of second-order importance to recognition[15]. Similarly, employment growth is negative (in line with some versions of a dynamic monopsony model) and is insignificant.

The baseline model is in column (2), which is the empirical counterpart of (6.12a). The estimated effects of the variables are largely unaltered, from the previous columns, although the wage persistence term seems less important now. As expected market share is positive and significant, suggesting that the rent-sharing effect outweighs the market share/survival elasticity effect.

Turning to the variables of most interest, firm-level innovations are associated with significantly higher wages for up to three years ($\chi^2(3)$ = 9.95, $\chi^2(7)$ = 31.84). The long-run[16] effect (0.044) is three times as large as the short-run effect (0.015). In more concrete terms a single innovation will ceterus paribus, raise the average annual wage by £99.53 immediately, and £295.7 after 6 years. Considering the average employment in the union firm is over 8000, these figures represent substantial increases to the wage bill[17].

From Geroski's (1991) work one would expect positive effects from the

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[15]Using a measure of industry coverage gives an insignificant and wrongly-signed coefficient.

[16]If the long-run effect is calculated just using the first three lags then the effect is 0.055 with a standard error of 0.020.

[17]These are in 1985 prices and are calculated using (exp(ζ) - 1)*average wage. The simulations are carried out under the assumption that the firm makes an insignificant contribution to the total number of industry innovations, which is clearly questionable in some cases. The industry effect will tend to depress the firm effect.

number of industry innovations used as this has positive productivity effects at the industry level indicating knowledge spillovers. As with the profit equations in Chapter 4, however, there does not appear to be a significant impact. The quantitatively small, but negative effect of industry innovations produced contrasts with the variable's positive employment effects. This indicates that firms in very innovative sectors are in a more ruthless race to grow quickly and this may dampen rent seeking behaviour on the part of unions. Perhaps the costs of failing to keep up in the technological race are relatively greater in hi-tech industries.

Column (3) adds the log capital-labour ratio as in equation (6.12b). The Wald test of the joint significance of the first three innovation terms is still easily accepted, and although the short-run effect is slightly smaller the long-run effect is larger (0.077). Recall from (6.12b) that the innovation term now reflects cost-reducing innovation (A) as well as demand expanding innovation (ϕ). It should not, therefore, be surprising that the effect is larger. The relatively small increase in the observed effect of technological change suggests that product innovations provide greater rents for the union to capture than process ones. This would seem plausible since product innovations have generally a longer gestation and so are relatively easier to capture by a myopic union. Ulph and Ulph (1991) have recently argued that this is more likely to be a problem in the U.K. where wage contracts are of short duration than in Japan or the U.S. A more mundane explanation would be that most process innovations are not disembodied and so we are picking them up by the capital-labour ratio term and underestimating the returns to workplace changes[18].

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[18] Similar results were obtained when we used equation (6.12c) with labour productivity as our insider term. Like Nickell and Wadhwani (1990) we use

The capital-labour term itself in column (3) is only weakly significant, but it has reduced the coefficient on market share by about half. This would seem to be due to some collinearity between these variables: when fixed capital costs are higher the market can support fewer firms (see Sutton,1991 for an extensive discussion of this). Indeed if we remove MS, the capital-labour ratio takes a coefficient of 0.223(0.080). Column (2) is still our preferred model, however, due to problems of identification and the high value of the SC(2) test.

The final column omits market share and includes a measure of profits per head directly as a measure of rents. In line with much previous work on aggregate (Carruth and Oswald, 1989) and micro (Denny and Machin, 1991) datasets, the variable is important in increasing average wages. This arises despite the fact that wages enter directly into accounting profits in the opposite direction to the theoretical bargaining effect. The effect of innovations conditional on profits per head is severely reduced and the $\chi^2(3)$ test signals that they are no longer jointly significant. This is to be expected as the profits term is reflecting the benefits of the innovation in a direct manner as we saw from Chapter 4. This seems inconsistent with a competitive story based on skills as one would expect an increase in the average wage even after controlling for any short-run profitability effect from new technologies.

So the message from Table 6.3 seems to support the notion that technical changes impact positively on wages, especially through product innovations.

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real sales per head and its lag (to control for inventory changes). MS is still significant in this case and productivity attracts a point estimate of 0.126 (0.067). The test for the joint significance of the current innovations and its two lags is strongly significant ($\chi^2(3) = 14.9$).

The next table looks at various checks of the robustness of the basic model. In the first column of Table 6.4 aggregate unemployment is used instead of industry unemployment and the time dummies as a measure of external labour market pressure. Industry unemployment may be a poor proxy as it could represent industries in long-term decline which are paying lower wages[19] or because it is highly correlated with the time dummies. The aggregate measure has an elasticity about one-third larger than the industry variable, similar in magnitude to the voluminous cross-country evidence reported in Blanchflower and Oswald's so-called 'wage curve' (1991). Including other aggregate measures met with varied success. For example, a specification including the long-term unemployed (LTU) and the aggregate union mark-up (MARK-UP) yielded an equation of the form:

$$
\begin{aligned}
w_{it} = \quad & \text{(firm and industry level variables)}_{ijt} \\
& -0.506{*}URATE_t + 0.443{*}LTU_t - 0.067{*}MARK\text{-}UP_t + \text{error} \\
& \quad (0.194) \qquad\quad (0.201) \qquad\quad (0.032)
\end{aligned}
$$

LTU works as expected: it is well documented that the longer an individual is unemployed the less able she is to effectively compete for jobs probably because employers use unemployment duration as a screening device to weed out 'low quality' applicants. The union power term is significantly in the wrong direction, however, which suggests it is a poor proxy for bargaining strength. It also highlights the fact that the model may be picking up many other aggregate effects with these variables. In any case the time dummies are strongly significant in the original equations[20], leading us to prefer a

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[19] Although this seems unlikely; judging from Figure 6.1 it seems to be quite cyclically sensitive, even though many industries appear to be in secular decline.

[20] A $\chi^2(6)$ test of their joint significance in column (2) of Table 6.3 is 146.54.

model without including economy-wide variables explicitly.

A worry with the data is that the number of firms and innovations falls off sharply towards the end of the sample. This is mainly due to the change in the way employment figures were reported in Datastream after 1982 (see Data Appendix). Consequently the standard model was run on the 1978-82 period only in column (2). The model is not substantially altered with a higher short-run (0.017) but lower long-run (0.031) effect of firm innovations.

The conjectural variations model implies that concentration and import penetration should enter the equation. Since the theoretical discussion emphasised that collusion and market share could exhibit non-linearities we experimented with logs and higher powers of the the current and lagged values of these variables. The preferred specification is in column (3) which includes the current industry concentration and lagged import penetration in quadratic form. The imports variable behaves exactly as expected by our theory. Assuming that monopoly power is low at high levels of import penetration, when imports decline wages will initially rise as workers share in the rents. There will come a point, however, when domestic oligopolists collude sufficiently well that the elasticity of demand effect outweighs the increased surplus. After this critical point wages decline as import penetration falls. According to column (3) the critical level is about 30%, about 5% above the mean[21].

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[21]This inverted 'U' shape between imports and wages is also contained in Abowd and Tracy (1989) whose data cover a similar period to our own (1976-80) in Canada. They rationalised their results by positing a quadratic relationship between profitability and industrial structure, an argument that receives no support from Chapter 3. The quadratic influence of quasi-rents on union recognition documented in Disney et al (1992) may also be explained in these terms.

Like almost every other study industrial concentration has consistently negative effects on wages in the union sector. It may appear surprising that non-linearities were not discovered in the light of the imports results, and the fact that Chapter 3 found concentration to be a much better predictor of profit margins than imports. The reason for this anomaly might be period specific: import penetration was very rapid in manufacturing over most of our sample period (1978-83) mainly because of the extremely strong pound. Consequently imports were far more important in determining firm strategies than domestic concentration. An alternative explanation would be that union firms are located in industries that have already passed the 'hump' in the inverted 'U' shaped relationship between wages and collusion, so wages can only go downwards.

Finally, the union sub-sample can be compared to the larger population of firms from which it was drawn. The final column of Table 6.4 presents the standard model run on the 603 firms. Most variables have lost significance and the point estimates on all the innovation variables are substantially lower, even if similar in sign to the union sample. The model seems driven by past wages, industry unemployment and the change in employment (which is now negative). More worryingly, the Sargan test fails at 5% so we must be wary about attaching great importance to the estimates from these results[22].

Many other experiments (not reported) were also tried to see if the innovations effects were secure. First, all the industry observables were replaced with 14 two digit industry dummies. As numerous studies have shown

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[22]Running the model on the 181 firms whose union status we know for certain lead to substantially the same results as the 154 firms with only slight reductions in the effects of innovations (e.g. the long-run effect was 0.029 compared with 0.044 from the union only sample). This is consistent with the idea that the effects of innovation are smaller in non-union firms.

these were jointly significant ($\chi^2(13) = 100$) but so were the firm innovation variables ($\chi^2(3)=14.8$). Secondly, running an OLS version of the model made little difference to the innovations effect but did reduce the effect of market share substantially (coefficient of 0.252 and standard error of 0.172). This illustrates the importance of instrumenting given that higher wage costs will, ceterus paribus, reduce market share. Thirdly, if fixed effects were not important efficiency could be gained by simply running a model in levels. When this was tried the equation was, as usual, dominated by the lagged dependent variable signaling the presence of firm-specific effects. Finally, the innovations measures were instrumented with lagged industry R&D intensity. Although still positive the variable was no longer significant at conventional levels. As before, the appropriate interpretation of this is the fact that innovation is extremely unpredictable, rather than simultaneously determined with the wage which seems unlikely on a priori grounds.

2. Union Power and Technological Rents

Do stronger unions capture more rents from innovation? There are two ways of addressing the issue at a rough macro- level and a more detailed micro level. The macro approach is given in Table 6.5 for both the union only sample and the population sample. The 'Thatcher Effect' was examined by interacting the innovation variables with a dummy variable for 1978-79 and 1980-83. The interactive effects for the INNOV(t) to INNOV(t-2) were positive and significant in the late 1970s but not the early 1980s. In the larger sample it was the earlier lags of INNOV between t-1 and t-4 that had the strongest effects on wages in the late 1970s, which is quite remarkable as over the whole time period no significant effects were found[23]. When one recalls that unemployment rose dramatically, aggregate density fell precipitously and a government strongly opposed to unions instigated many laws and policies specifically designed to weaken them, it seems clear that union influence waned[24].

The pattern in the raw data from the profitability chapters is very congruent with the weakening of the innovation-wage relationship in the early 1980s. Recall that Tables 3.1 and 4.1 illustrated the *strengthening* of the correlation between market share and margins (Chapter 3) and innovation and margins (Chapter 4) over the recession. Part of the improved relationship may well derive from the weakened ability of unions to extract rents from dominant innovating firms during cyclical downturns and this may be why the performance of innovators appears to improve in such periods. This clearly suggests that unions need to be strong before they can reap the gains from technical change directly. However, the number of innovations are fewer in the 1980s (see Figures 4.1 and 4.2), so the results should be interpreted with caution.

The micro approach begins by looking for a more finely grained measure of firm level union power. The sample of unrecognised firms has too few innovators to perform a satisfactory analysis, but a measure of firm level union density is available for 134 of the firms where a union was recognised for bargaining purposes. This measure of UNION power was interacted with the

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This suggests that unions may be accelerating the wage and employment gains from new technology as well as increasing their overall size.

[24]There is the paradox that the union non-union mark-up seems stable over these years (Stewart, 1990). This is compatible with a decline in union power viz management as there were off-setting effects due to the weakening of non-unionists' quit threats, the removal of restrictive practices and the devaluation of the pound.

INNOV variable to see if stronger unions were better at grabbing higher shares of technological rents. The correlations detailed in Table 6.2 suggest not and more detailed analysis on Table 6.6 confirms this. The first column runs the standard model producing similar results to before. Industry unemployment is less well determined, but the other variables seem estimated with, if anything, greater precision. Column (2) interacts INNOV and its lags with UNION. Even though the estimates are not well determined, in all time periods the interaction is negative which implies that firms with high union density get *lower* pay-offs. At face value, this suggests that although innovations never cause an average fall in wages, a firm with 100% union density will have almost no gain from a positive technical shock.

Could this be a statistical artifact because UNION is a poor measure of union power? Measurement difficulties arise because of (i) the assumption that unionisation across the firm has not varied much over time when we know that there was a significant drop in aggregate union density (the sample average was 66% in 1976, 74% in 1980 and 62% in 1983) and (ii) that it may be institutions such as the closed shop or multi-unionism that are the true basis of union economic strength[25]. Problem (ii) is tackled in the next chapter by using the Workplace Industrial Relations Survey, but some light can be shed on problem (i) by substituting the time-varying industry density for firm density. This is implemented in column (3) and it is clear that not only is the coefficient pattern the same, but the estimates are better determined[26]. The linear effect of innovation is positive and significant,

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[25]A third problem is that the data collected by Wadhwani and his associates is banded (unlike the other two surveys) and so we were forced to enter density as the midpoint of the band

[26]The interaction terms are jointly significant as are the linear terms. This was not true for firm level density.

but the density interaction is *negative.* It seems that union firms in strongly organised industries gained a relatively low share of the technological plunder.

3. Discussion and Interpretations

The main thrust of the previous section was that the empirical evidence showed that innovations are associated with higher wages. The influence of union strength is more ambiguous. On the one hand, the pay-offs from technical change are significant in the union sub-sample but not in the whole sample. On the other hand, the results from Table 6.6 were that firms with higher industry and firm-specific density were less able to gain from innovative rents.

Should the 'innovation differential' be interpreted in bargaining or competitive terms? Several pieces of evidence incline against a purely competitive reading of the data. Firstly, it was argued that labour supply frictions could only *temporarily* cause a positive correlation between innovation and wages. Yet it seems that the positive effects persist over several years. An innovation in 1978 had a positive and significant effect on wages in 1978, 1979 and 1980. In the very long run a differential remains, but it would be unwise to claim that Salter is refuted as there is only a short time dimension to the panel and, in any case, we would expect innovative rents to be eventually eroded.

If innovations increase the firm's skills requirements then one would expect this pattern of long-term higher wages, but two features of the data weigh against a wholly skills-based story. First, the evidence from column (4) in Table 6.3 showed that conditional on profits per head there is no significant effect of innovations on wages. This goes against a purely compositional argument as skilled workers should gain higher wages regardless of the profits of the firm. As remarked above, it *is* consistent with a bargaining model which posits the per capita profitability of the firm as a sign of rents up for grabs. Second, the fact that the wage-innovation relationship is much weaker in the 1980s when unions faced an increasingly hostile environment is in line with bargaining, but has no clear rationale under a competitive reading[27].

Although a certain level of worker power (union recognition) is needed to capture technological rents, at high levels of power (union density) the innovation differential decreases. This was not predicted by the theory as laid out in section III which implied quite the opposite. There are two classes of theories which could resolve this puzzle. One class stresses the rent-*destructive* implications of union bargaining which arise from union opposition to new technology or to strategic choices by management of sub-optimal innovations designed to reduce union bargaining power. The second class of models emphasis the desire and ability of stronger trade unions to spread the benefits of innovation beyond an immediate wage gains for the affected workers. This may be done by bargaining over an increased range of issues (such as the innovation process itself) or by redistributing the rents to other groups of workers. In the light of this, one would interpret the stronger effect of the industry density interactions (Table 6.6) as evidence of workers sharing technological rents with other workers in the industry (possibly via an industry wide agreement).

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[27]It would have to be demonstrated that 1980s innovations were different from previous ones in such a way that the comparative advantage of skilled workers has fallen. This argument contradicts the usual one advanced by theorists who wish to blame the increased 1980s inequality on higher gains to education and skills in a micro-electronic age.

The data in this panel is not really suitable to discriminate between these models. An evaluation of them will be postponed until the next chapter where data from the Workplace Industrial Relations Survey will be used to check the robustness of the stylised facts concerning wages and technology and the adequacy of the alternative explanations.

VI Conclusions

This chapter has examined the effects of innovative changes on average wages in a panel of union firms in the late 1970s and early 1980s. A model was presented which combined insider bargaining in the labour market with one of general oligopoly in the product market in order to derive an identified wage equation. The empirical results suggest that the boost technology gives to wages is important, robust to changes in specification, and stronger in the 1970s when unions were powerful compared to the 1980s when they were weakened. The greater impact in the early years, the persistence of innovative differentials into the medium run and the absence of an innovation effect conditional on profitability inclines us towards a bargaining model rather than a competitive one.

The second finding was that technical pay-offs are higher for firms with low union density. This seems consistent with the finding in Chapter 5 that employment growth in innovative firms was higher when density was high. *If* one took lower wage growth and higher employment growth are desirable objectives, the combination of technological dynamism and high levels of worker strength appears to be closely related to economic success at the firm level during periods of acute macro-economic distress. One possible explanation for the pattern is that firms in high union density industries share out technological rents to more workers. As opposed to the rent spreading view is the idea that union-oligopoly bargaining may actually destroy rents.

At least three other problems remain. Firstly, there are no controls in the wage equations for firm specific changes in the skill composition of a firm and this may be a fatal omission if innovations are upgrading the workforce. Secondly, only crude measures of union power were used and it was not possible to look at the effects of innovation in non-unionised firms due to small sample size. Thirdly, the measure of technology is only of major innovations, which are by their nature rare events. The next chapter looks at the Workplace Industrial Relations Survey which overcomes all these data deficiencies, albeit for a single cross section. The competing hypotheses for the two stylised facts over unions and the technological mark-up can be pursued with greater vigour.

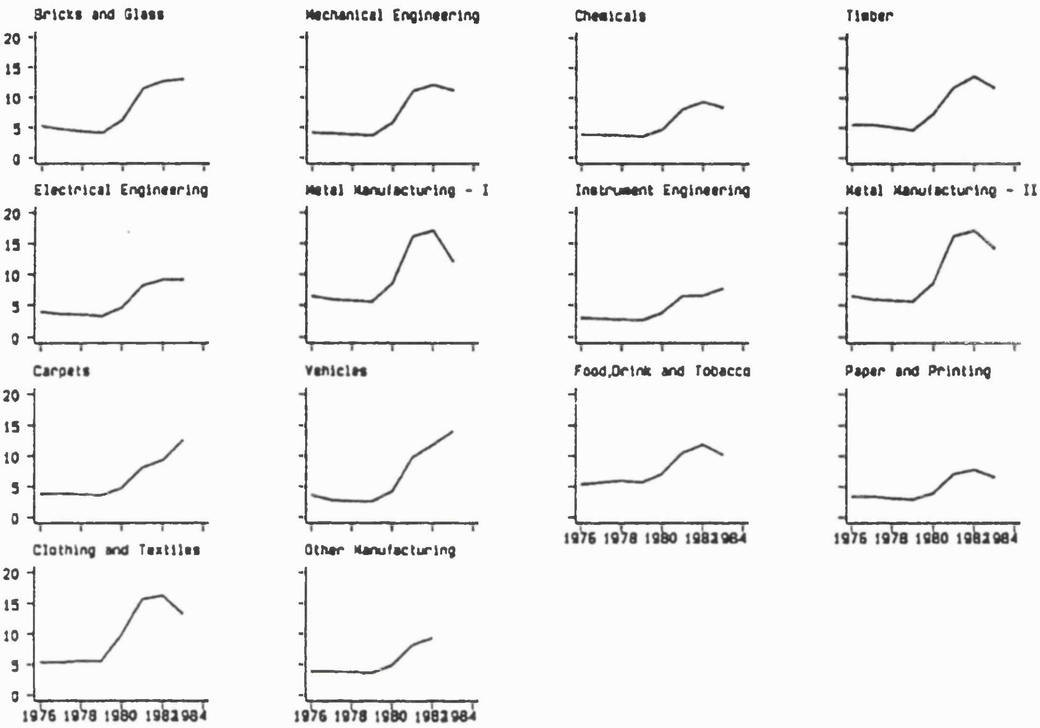

Figure 6.1: Industry Unemployment

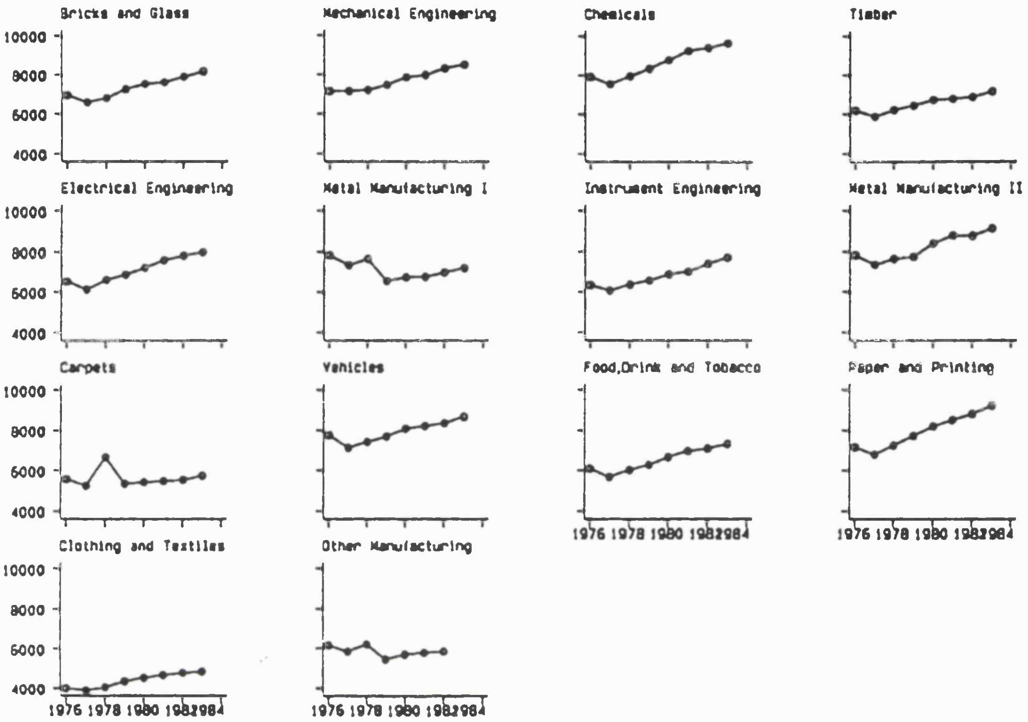

Figure 6.2: Industry Wage

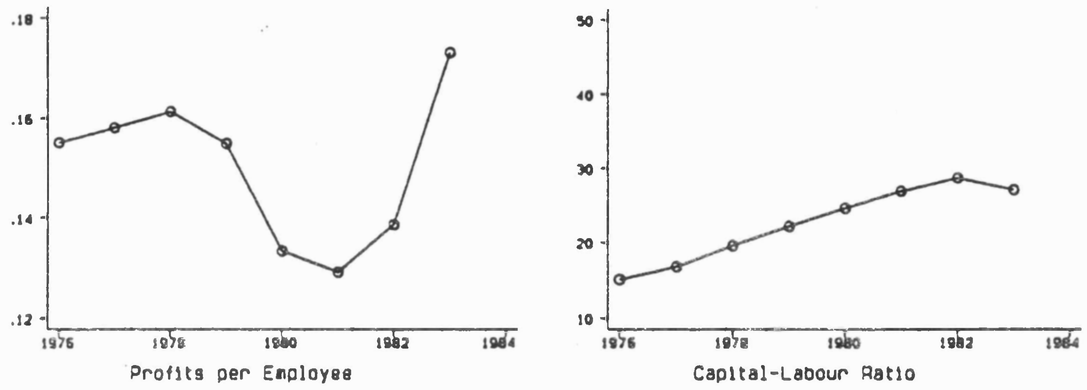

Figure 6.3: Means of Variables

TABLE 6.1 :BRITISH MICRO STUDIES OF WAGE DETERMINATION

AUTHORS	DATASET	MEASURE OF INNOV	RESULTS
Salter (1960)	28 mfng. inds 1924-50 pooled	output per head or per operative	In LR[28] no effect of Δoutput per head on Δearnings (p.115)
Wragg and Robertson (1978)	82 inds 1963-73; mainly in mfng. pooled.	labour productivity	Productivity signif. only in producer inds but elasticity small.
Ball and Skeoch (1981)	British Plants	Value Added/head	weak +ve correlation
Nickell and Kong (1988)	43 Inds agg. to 9 inds 1974-82	TFP from 3 digit ind regessions	TFP boosts wages in SR and jobs in LR Insider effects associated with ind concentration and union density
Nickell and Wadhwani(1990)	N=219 Dstream firms 1972-82 Panel	log real sales/ employment	sales/head +ve and significant .
Vainiomaki and Wadhwani (1991)	N=993 Dstream/ EXSTAT firms 1972-86	Value-added per head	strong and +ve
Nickell, Vainiomaki Wadhwani (1991)	N=814 Dstream/ Exstat firms 1972-86	Smoothed TFP:firm specific Solow residual cummulated and regressed on a cubic time trend	Positive effects,but does not vary with union status. Small compared to effects from outside vars
Denny and Machin (1991)	N=449 Dstream firms 1979-86	Capital-labour ratio	Π/N_{-1} 1979-80,'85 signif., ind wage in other years
Gregg and Machin (1991)	N=279 firms 1984-88, EXSTAT	Sales per employee	+ve and signif, unions assoc with slower wage growth
Wadhwani (1991) and Wall	219 Exstat firms 1972-86	capital-labour ratio (K/N)	Effect of K/N no different in high union density firms cf to others

[28] LR = Long-Run, SR = Short-Run

Gregory, Lobban and Thomson (1987)	CBI Pay Databank, analysis 212 settlement groups 1980-84 panel in expected wage growth.	'intro of new technology' cited by managers as an important factor	Technology the only signif. contract content variable, and this only imp in 1980-81
Holmund and Zetterburg (1990)	2 digit inds for 5 countries 1965-85	labour productivity regressed on a cubic time trend	+ve signif effects on wage in Germany, US and Sweden.
Beckerman and Jenkinson (1989)	14 2 digit inds 1973-86	Productivity	+ve in Short-Run neutral in LR, lagged profits signif

Table 6.2 Descriptive Statistics

Panel A Wage Levels

Real Wage Broken Down by innovation dummy

	Full Sample (603 firms)		Recognised Sample (154 firms)	
	Real Wage	No. of obs	Real Wage	No. of Obs
Innovator	7170.58	448	7481.11	167
Non-Innovator	6380.52	3739	6582.93	921
Raw Differential	£988.21		£898.2	
%	12.4		13.6	

Union Denisty Sub-Sample (134 firms)

	Firm Density<=85%		Firm Density > 85%	
Innovators	8032.67	81	7164.28	423
Non-Innovators	6307.44	394	6935.09	56
Raw Differential	£734.6		£229.19	
%	27.3		3.3	

Panel B Wage Growth (ΔlogW)

	Average Annual Wage Change	**No. of Obs**
In the Whole Sample	0.0242	3584
In the Density Sample		
Overall	0.0159	820
High Union Density	0.0191	408
Low Union Density	0.0127	412
Innovators (Overall)	0.0207	116
Interacted with....		
*** High Union Density**	0.0184	68
*** Low Union Density**	0.0240	48
Non-Innovators (overall)	0.0151	704
Interacted with....		
*** High Union Density**	0.0192	340
*** Low Union Density**	0.0112	364

Notes to Table 6.2

1. Innovators are firms who innovated at any point in the sample period.
2. 'High' union density is when more than 85% of the firm's workers are in a union and 'low' when the proportion is equal or less than 85%.

Table 6.3: Wage Equations for Recognition Sub-Sample

Dependent variable change in log real wage

Variables	(1)	(2)	(3)	(4)
Constant	0.057(0.013)	0.041(0.011)	0.023(0.014)	0.042(0.013)
$\underset{\sim}{w}$(t-1) (own wage)	0.477(0.144)	0.203(0.136)	0.141(0.119)	0.528(0.121)
$\tilde{w}$(t) (Ind. Wage)	0.155(0.063)	0.158(0.058)	0.144(0.058)	0.086(0.058)
iun(t) (ind unemp)	-0.055(0.026)	-0.060(0.023)	-0.036(0.022)	-0.063(0.029)
IDENSITY(t)	0.031(0.056)	-0.009(0.054)	0.027(0.053)	0.025(0.058)
MKT SHARE(t)	-	1.427(0.409)	0.714(0.400)	-
(k-n)(t) Capital/Labour		-	0.151(0.087)	-
Π/N(t)	-	-	-	0.017(0.007)
Δn (t)	-0.087(0.076)	-0.055(0.072)	0.045(0.062)	-0.008(0.078)
IPI(t)*	-	-0.023(0.007)	-0.019(0.008)	-0.019(0.061)
IUI(t)*	-	-0.005(0.012)	-0.008(0.011)	-0.004(0.014)
INNOV(t)*	-	0.147(0.074)	0.135(0.058)	0.079(0.051)
INNOV(t-1)*	-	0.131(0.051)	0.172(0.064)	0.087(0.062)
INNOV(t-2)*	-	0.133(0.055)	0.139(0.053)	0.102(0.062)
INNOV(t-3)*	-	0.002(0.089)	0.068(0.069)	0.056(0.079)
INNOV(t-4)*	-	-0.052(0.112)	0.045(0.103)	0.032(0.084)
INNOV(t-5)*	-	-0.001(0.007)	0.060(0.064)	0.015(0.075)
INNOV(t-6)*	-	-0.009(0.070)	0.048(0.067)	0.039(0.087)

* *Coefficient and standard errors have been multiplied by 10*

Years	1978-83	1978-83	1978-83	1978-83
No of Firms	154	154	154	154
Total Observations	780	780	780	780
2nd Order Serial correlation test	-0.309(154)	-1.040(154)	-1.700(154)	-0.128(154)
$\chi^2(3)$	-	9.95	9.90	4.244
Sargan	27.88(20)	39.46(30)	55.24(40)	33.19(30)
Time Dummies	yes	yes	yes	yes

Notes for Table 6.3

(i) All estimates are in first differences IV using the Arellano-Bond GMM technique. w_t, MS_t and Δn_t are instrumented in this way using only moment restrictions from (t-4) to (t-2). In col.(3) $(k-n)_t$ is instrumented this way and in col.(4) $(\Pi/N)_t$.

(ii) The results are one-step White-corrected robust estimates.

(iii) The serial correlation test is N(1,0) as in Arrelano and Bond(1991).

(iv) The $\chi^2(3)$ is a Wald Test of the joint significance of INNOV(t), INNOV(t-1) and INNOV(t-2). Critical value at 5% = 7.8

Table 6.4: Robustness Tests of Basic Wage Equation

Dependent variable change in log real wage

Variables	(1)	(2)	(3)	(4)
Constant	0.030(0.003)	0.035(0.011)	0.043(0.011)	0.053(0.007)
w(t-1) (own wage)	0.123(0.087)	0.167(0.143)	0.196(0.138)	0.322(0.087)
$\tilde{w}$(t) (ind Wage)	0.178(0.059)	0.167(0.058)	0.141(0.056)	0.035(0.039)
iun(t) (ind unemp)	-	-0.079(0.029)	-0.059(0.030)	-0.059(0.018)
urate (Ag unemp)	-0.084(0.018)	-	-	-
IDENSITY(t)	-0.001(0.035)	0.033(0.059)	-0.000(0.052)	-0.012(0.026)
MKT SHARE(t)	1.563(0.458)	1.447(0.429)	1.333(0.417)	0.356(0.293)
IMPORTS(t-1)	-	-	-0.763(0.305)	-
$IMPORTS^2$(t-1)	-	-	1.194(0.465)	-
CONC(t)	-	-	-0.225(0.092)	-
Δn (t)	-0.095(0.055)	-0.174(0.080)	-0.072(0.074)	-0.060(0.054)
IPI(t)*	-0.019(0.007)	-0.019(0.001)	-0.020(0.007)	-0.009(0.004)
IUI(t)*	-0.005(0.012)	-0.006(0.013)	-0.006(0.013)	-0.003(0.007)
INNOV(t)*	0.157(0.006)	0.166(0.071)	0.122(0.062)	0.045(0.041)
INNOV(t-1)*	0.122(0.005)	0.098(0.051)	0.114(0.050)	0.053(0.040)
INNOV(t-2)*	0.156(0.005)	0.160(0.076)	0.117(0.057)	0.059(0.043)
INNOV(t-3)*	0.014(0.008)	0.008(0.122)	0.024(0.081)	0.068(0.048)
INNOV(t-4)*	-0.073(0.009)	-0.128(0.119)	-0.047(0.105)	-0.030(0.050)
INNOV(t-5)*	-0.015(0.006)	-0.045(0.076)	-0.005(0.067)	0.025(0.044)
INNOV(t-6)*	-0.031(0.073)	-0.005(0.079)	-0.001(0.067)	-0.001(0.045)

**Coefficient and standard errors have been multiplied by 10*

Years	1978-83	1978-82	1978-83	1978-83
No of Firms	154	154	154	603
Total Observations	780	780	714	2981
2nd Order Serial correlation test	-1.337(154)	-1.496(154)	-0.909(154)	-0.390(603)
$\chi^2(3)$	8.89	8.87	8.88	2.22
Sargan	44.69(30)	33.65(24)	40.82(30)	54.07
Time Dummies	no	yes	yes	yes

Notes for Table 6.4

(i) All estimates are in first differences IV using the Arellano-Bond GMM technique. w_t, MS_t and Δn_t are instrumented in this way using only moment restrictions from (t-4) to (t-2).

(ii) The results are one-step White-corrected robust estimates.

(iii) The serial correlation test is N(1,0) as in Arrelano and Bond(1991).

(iv) The $\chi^2(3)$ is a Wald Test of the joint significance of INNOV(t), INNOV(t-1) and INNOV(t-2). Critical value at 5% = 7.8

TABLE 6.5 YEAR INTERACTIONS

Dependent variable log real wage

Variables	Period	(1) N=154 Sample	(2) N=603 Sample
Constant		0.040(0.011)	0.052(0.007)
w(t-1) (own wage)		0.202(0.137)	0.317(0.087)
w(t) (Ind. Wage)		0.164(0.058)	0.041(0.039)
u(t) (ind unemp)		-0.059(0.027)	-0.059(0.018)
IND DENSITY(t)		-0.007(0.054)	-0.011(0.027)
MKT SHARE(t)		1.417(0.431)	0.566(0.308)
$\Delta n(t)$		0.055(0.068)	-0.065(0.054)
IPI(t)*		-0.023(0.007)	-0.009(0.004)
IUI(t)*		-0.005(0.012)	-0.003(0.007)
Innovation Year Interactions			
INNOV(t)*	1978-79	0.195(0.099)	0.031(0.058)
INNOV(t-1)*	1978-79	0.212(0.097)	0.121(0.074)
INNOV(t-2)*	1978-79	0.154(0.065)	0.129(0.058)
INNOV(t-3)*	1978-79	0.122(0.121)	0.175(0.082)
INNOV(t-4)*	1978-79	0.092(0.138)	0.167(0.087)
INNOV(t-5)*	1978-79	0.130(0.137)	0.159(0.098)
INNOV(t-6)*	1978-79	0.194(0.212)	0.169(0.109)
INNOV(t)*	1980-83	0.094(0.094)	0.041(0.057)
INNOV(t-1)*	1980-83	0.069(0.087)	0.013(0.050)
INNOV(t-2)*	1980-83	0.082(0.112)	0.020(0.056)
INNOV(t-3)*	1980-83	-0.062(0.100)	0.022(0.058)
INNOV(t-4)*	1980-83	-0.145(0.143)	-0.117(0.062)
INNOV(t-5)*	1980-83	-0.066(0.119)	-0.029(0.056)
INNOV(t-6)*	1980-83	-0.080(0.082)	-0.079(0.049)

* *Coefficient and standard errors have been multiplied by 10*

	(1)	(2)
Years	1978-83	1978-83
No of Firms	154	603
total observations	780	2981
Serial correlation test	-0.997(154)	0.392(603)
Sargan	38.02(30)	54.21(30)
$\chi^2(3)$ 1978-79	7.75	5.63
$\chi^2(3)$ 1980-83	1.05	0.66
Time Dummies	yes	yes

Notes for Table 6.5

Same as Table 6.3 except firm innovation coefficients are allowed to differ with two time periods 1978-79 'Pre Thatcher' and 1980-83 'Post-Thatcher'.

TABLE 6.6: WAGE EQUATIONS FOR UNION DENSITY SUB-SAMPLE, 1978-83

Dependent variable change in log real wage

Variables	interaction with firm level density in these cols (1)	(2)	interaction with industry level density in (3)
Constant	0.051(0.011)	0.049(0.012)	0.049(0.012)
$\underset{\sim}{w}$(t-1)	0.291(0.133)	0.274(0.137)	0.277(0.136)
$\tilde{w}$(t) (Ind Wage)	0.153(0.060)	0.160(0.062)	0.151(0.060)
u(t) (Ind Unemp)	-0.046(0.029)	-0.050(0.030)	-0.046(0.029)
IND DENSITY	0.010(0.067)	0.014(0.070)	0.041(0.071)
MKT SHARE	1.559(0.433)	1.590(0.408)	1.593(0.452)
Δn(t)	-0.181(0.121)	0.005(0.072)	0.009(0.072)
IPU(t)*	-0.019(0.007)	-0.019(0.008)	-0.019(0.008)
IUI(t)*	-0.010(0.015)	-0.009(0.014)	-0.010(0.015)
INNOV(t)*	0.217(0.106)	0.571(0.363)	0.434(0.906)
INNOV(t)*UNION*	-	-0.477(0.394)	-0.335(1.186)
INNOV(t-1)*	0.205(0.058)	0.422(0.224)	0.783(0.383)
INNOV(t-1)*UNION*		-0.288(0.313)	-0.826(0.536)
INNOV(t-2)*	0.121(0.066)	0.411(0.366)	0.956(0.305)
INNOV(t-2)*UNION*	-	-0.375(0.534)	-1.226(0.046
INNOV(t-3)*	0.021(0.084)	0.560(0.329)	0.217(0.449)
INNOV(t-3)*UNION*	-	-0.741(0.458)	-0.234(0.644)
INNOV(t-4)*	-0.039(0.121)	0.482(0.382)	0.183(0.393)
INNOV(t-4)*UNION*	-	-0.749(0.509)	-0.425(0.570)
INNOV(t-5)*	0.030(0.085)	0.509(0.395)	0.783(0.576)
INNOV(t-5)*UNION*	-	-0.651(0.559)	-1.226(0.840)
INNOV(t-6)*	0.013(0.088)	0.234(0.300)	0.107(0.669)
INNOV(t-6)*UNION*	-	-0.312(0.391	-0.190(0.960)

** Coefficient has been multiplied by 10*

No of Firms	134	134	134
total observation	686	686	686
2nd Order Serial correlation test	-0.614(134)	-0.672(134)	-0.499(134)
Sargan	32.03(30)	33.17(30)	31.67(30)
χ^2(3) linear	13.28	3.58	18.42
χ^2(3) interactions	-	6.49	11.40
Time Dummies	yes	yes	yes

Notes to Table 6.6

(i) The estimation methods are identical to those in table 2

(ii) The innovation measures are interacted with UNION which is firm density in column (1) and (2) and industry density in column (3).

(iii) The χ^2(3) linear test is a joint significance test of INNOV(t) INNOV(t-1) and INNOV(t-2). The χ^2(3) interaction test is on the current and first three lags of INNOV*UNION.

Appendix 6.1
The Effect of Market Power on the Elasticity of Labour Demand

Proof of Claim 6.1

Combining the marginal revenue productivity condition with the production function enables us to write the price equation as $(l, i \in 1, \ldots, J)$

$$(6A.1) \qquad P = \left\{ \tilde{\Gamma} \sum_l \left(A^{1/(1-\alpha)} [(\alpha(1-\rho_l)/W_l]^{\alpha/(1-\alpha)} \right) \right\}^{-\frac{1-\alpha}{\eta(1-\alpha)+\alpha}}$$

$$\Rightarrow \frac{\partial \log P}{\partial \log W_i} = \left(\frac{1-\alpha}{\alpha + \eta(1-\alpha)} \right) \left(\frac{\alpha}{1-\alpha} \right) \frac{\sum_l (W_i/W_l)/(\partial W_l/\partial W_i)\, q_l}{\sum_l q_l}$$

And the elasticity of industry price with respect to the wage as

$$(6A.2) \qquad \eta_{PW} = \left(\frac{1-\alpha}{\alpha + \eta(1-\alpha)} \right) (MS_i(1-g) + g)$$

We can re-write the standard homogeneous product oligopoly condition in terms of market share as

$$(6A.3) \qquad MS_i = \left(\frac{P - MC_i}{P} \right) \left(\frac{\eta}{1-\mu} \right) - \frac{\mu}{1-\mu}$$

This can be aggregated across the whole industry and rearranged as

$$(6A.4) \qquad P = \eta \frac{\sum_l MC_l}{(\eta-\varepsilon)J}$$

Where $\varepsilon = (1 + (J-1)\mu)/J$, the measure of collusion adjusted for industry numbers.

Combining (6A.4) with (6A.3) enables us to write market share as

$$(6A.5)\quad MS_i = \left(\frac{\eta - \mu}{1 - \mu}\right) - (J-1)\left(\frac{\eta - \varepsilon}{1 - \varepsilon}\right)\frac{MC_i}{\sum MC_l}$$

The elasticity of market share with respect to the wage is therefore

$$(6A.6)\quad \eta_{(MS)W} = -\frac{\partial \log MS_i}{\partial \log W_i} = \frac{\xi(g)}{MS}\left(\frac{\eta - \varepsilon}{1 - \varepsilon}\right)$$

Where $\xi(g) = \left\{\dfrac{W_i \sum_l MC_l (\partial MC_i/\partial W_i) - W_i MC_i \, \partial \sum_l MC_l/\partial W_i}{(\sum_l MC_l)^2}\right\} \geq 0$

Note that $\xi(.)$ is a function of g because the main component of marginal costs is usually taken to be wages, and so the term $g = (W_i/W_l)\partial W_l/\partial W_i$ will be of primary importance. For instance, Dowrick (1989) imposes $\alpha=1$ and $MS=1/N$, so in symmetric industry equilibrium $\xi(g) = (1 - g)/N$.

We can now substitute these elasticities into (6.9) to get (6.10)

$$(6.10)\quad \eta_{NW} = \left[\frac{\xi(g)}{MS}\left(\frac{\eta - \varepsilon}{1 - \varepsilon}\right) + \alpha\eta\left(\frac{(1 - g)\,MS + g}{\alpha + \eta\,(1 - \alpha)}\right)\right] \quad \blacksquare$$

Proof of Claim 6.2

Now consider the comparitive statics of market power. Recall that we can write the wage equation as:

$$(6A.7)\quad W/(W-\tilde{W}) = \beta\eta_{\pi W} + \eta_{SN}\,(\eta_{(MS)W} + \eta_{PW}\eta)/\alpha$$

Anything which increases the elasticities will put downward pressure on wages. η_{SN} depends only on the relative employment of insiders, so the relevant elasticities to consider are $\eta_{\pi W}$, $\eta_{(MS)W}$ and η_{PW}.

(i) Product Market elasticity, η

$\partial\eta_{\pi W}/\partial\eta \ \geq 0$

(We know that anything that decreases market power increases labour's share in revenue and so tends to decrease the wage).

$$\partial(\eta.\eta_{PW})/\partial\eta = \alpha(1-\alpha)\frac{(1-g)\,MS + g}{(\alpha + \eta\,(1-\alpha))^2} \geq 0$$

$$\partial(\eta_{(MS)W})/\partial\eta = \xi(g)/MS(1-\varepsilon) \geq 0 \qquad \blacksquare$$

(ii) Collusion, μ

$\partial\eta_{\pi W}/\partial\mu \ \leq 0$

$\partial(\eta.\eta_{PW})/\partial\mu = 0$

$$\partial(\eta_{(MS)W})/\partial\mu = \left(\frac{\eta - 1}{(1-\varepsilon)^2}\right)\left(\frac{J-1}{J}\right)\frac{\xi(g)}{MS}$$

$$\geq 0 \quad \text{if } \eta \geq 1$$

(iii) Market Share

$\partial\eta_{\pi W}/\partial MS \ \leq 0$

$$\partial(\eta.\eta_{PW})/\partial MS = \frac{\eta^2\,(1-g)}{\alpha + \eta(1-\alpha)} \geq 0$$

$$\partial(\eta_{(MS)W})/\partial MS = -\left(\frac{\eta - \varepsilon}{1-\varepsilon}\right)\frac{\xi(g)}{MS} \leq 0$$

The the sign of $\partial W/\partial\eta$ is unambiguous - increases in market power arising from a greater inelasticity of demand (e.g. product innovations) associated with higher wages. However, the signs of $\partial W/\partial MS$ and $\partial W/\partial\mu$ are ambiguous.

Interestingly, if each firm contains a 'monopoly union' who sets the wage (β = 0), then wages are *strictly decreasing* with increases in collusion when demand is elastic repealing the traditional wisdom of the Marshallian Laws.

CHAPTER 7
WAGES AND ADVANCED TECHNICAL CHANGE:
EVIDENCE FROM THE 1984 WORKPLACE INDUSTRIAL RELATIONS SURVEY

I. INTRODUCTION

The last chapter explored the link between innovation and wages using firm level panel data from the late 1970s and early 1980s. This chapter continues the investigation using the 1984 Workplace Industrial Relations Survey (WIRS), a radically different dataset which can control for many of the factors omitted from the previous analysis. The primary aim is to see if there are still important technological pay-offs to workers when one explicitly takes into account the characteristics of the workplaces where employees work (such as the skills, part-time and gender mix). Having established that such a partial correlation exists, the chapter examines whether it is due merely to backwards causality (higher wages increase the incentive to innovate) or a compensating differential for some of the disamenities associated with technical change.

There are two subsidiary themes that shall also be looked at. The first leads on naturally from the last chapter which found that although unions were needed to capture rents, stronger unions did not gain progressively larger slices of the cake. If anything the opposite appeared to be true. In Section V some corroborating evidence is offered and alternative explanations evaluated. The second subsidiary theme to be examined is the argument that the increases in wage inequality experienced in the United Kingdom in the 1980s may be driven by new technology. Many authors have argued that the dramatic rise in wage dispersion in the United States has been due to large demand shifts in favour of skilled workers. These shifts are linked to the wide scale adoption of micro-electronics in which skilled and more highly educated workers are said to have comparative advantages (for example, in using computers). Since there is precious little direct evidence on these fundamentally important matters in the U.S. and none at all in Britain, it is an issue worth pursuing. To jump ahead a little, some support *is* found for this thesis here.

The layout of this chapter is as follows: Section II discusses the pros and cons of the WIRS data and Section III outlines the econometric modeling strategies. The initial results are presented in Section IV and in Section V, the complex relationship between union presence and the wage-innovation relationship is re-examined. Finally, Section VI examines the issues around the rise in inequality. The last section offers some conclusions.

II. The Workplace Industrial Relations Surveys: Pros and Cons

WIRS is a survey of over 2,000 British establishments with 25 or more employees (the data can be weighted to be nationally representative). Surveys have been conducted in 1980, 1984 and 1990 and have been used extensively by economists and industrial relations experts. There are a large number of questions on new technology in 1984, and the focus will be on the following two asked to senior managers over whether different types of technical change had been introduced over the last three years:

(i) "the introduction of new plant, machinery or equipment that includes the new microelectronic technology (including computer controlled plant, machinery or equipment)"

(ii) "The introduction of word processing or computer applications".

The first related to whether any manual workers were affected by it and the second to non-manual workers ('clerical,secretarial, administrative and typing staff'). The basic measure of advanced technical change (ATC) used is a dummy variable equal to 1 if the answer to question (i) is 'yes' in the manual pay equations and zero otherwise (manual ATC). For non-manuals, ATC is defined symmetrically, being 1 if the answer to question (ii) is 'yes' and zero otherwise.

This innovation measure is very different from the SPRU definition of previous chapters. ATC measures the **use** of a technology. Unlike the previous chapters WIRS innovators do not have to be the first producers nor even the first users of a new technique or product. ATC is properly regarded as a quantum of diffusion - over half of all establishments had experienced some sort of advanced technical change at some time between 1981-84. By contrast, only about 16% of the sample of firms in the firm panel had attained a SPRU innovation at any time in the 1970s or early 1980s. Clearly, the WIRS data captures a different part of the innovation cycle and one which is arguably more important to the British economy which is traditionally seen as good at coming up with innovations but poor at diffusing them.

The fact that ATC is not so radical and rare as the SPRU innovation measure makes the danger of backwards causality greater. For example, labour costs may have a big effect on whether numerically-controlled lathes are adopted, but very little on whether they are developed in the first place. Additionally, the fact that WIRS is a cross section makes the search for appropriate instruments much harder than with a panel. Nevertheless, there are advantages of the WIRS dataset which make the study worthwhile. The wage equations can be disaggregated into four different skill groups and the argument that post-innovation wage increases merely reflect a skill upgrading can be examined. There is richer information on the types of bargaining structures and the issues bargained over. Lastly, many of the workplace characteristics correlated with technical change can be controled for which would be falsely attributed to a rent-sharing effect of innovation in our previous analyses.

III. Modeling Strategy

As discussed in chapter 6 there are many theoretical rationales for the inclusion of technological shift parameters in wage equations. A bargaining model was presented where the effect entered primarily through the shift in the profit function. A similar modeling strategy is adopted here, entering the ATC dummy in a standard semi-log wage equation, which are estimated separately for skilled, semi-skilled, unskilled and clerical workers[1].

Since the pay data is banded, OLS applied to midpoints will in general be inconsistent. The appropriate maximum likelihood estimator is described by Stewart (1983). Assume the latent structure of the equation to be estimated is given by:

$$(7.1) \quad w_i = X_i'\beta + \varepsilon_i$$

and ε_i is i.i.d. $N(0,\sigma^2)$ the distribution of the unobserved latent variable is $w_i \sim N(X_i'\beta,\sigma)$. The observed information concerning w_i, the natural log of the weekly wage of a typical worker is that it falls between two bands w_i^{LB} and w_i^{UB} which may be equal to $-\infty$ or $+\infty$ at the open-ends. The likelihood of the observed sample is given by

$$(7.2) \quad L = \prod_{i=1}^{N} \left[\Phi\left(\frac{w_i^{UB} - X_i'\beta}{\sigma} \right) - \Phi\left(\frac{w_i^{LB} - X_i'\beta}{\sigma} \right) \right]$$

where Φ is the cumulative distribution of the standard normal. L(.) is concave so maximisation by an appropriate algorithm gives consistent estimates of β and σ.

One problem with (7.1) is that it does not allow for the fact that the

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[1] At an earlier point in the analysis supervisors and foremen were considered as a separate group. Although the same qualitative picture emerged, it was difficult to clearly assign this group to the manual or non-manual categories so they were dropped from the sample.

effects of innovation may vary systematically with the other observables. This seems quite plausible given the findings of Chapter 4, so providing that there are enough non-innovators in the sample (unlike the previous two chapters) a full set of interactions can be allowed for by splitting the sample by ATC. From these two sets of coefficients ($\hat{\beta}^{I}$ and $\hat{\beta}^{NI}$ for innovators and non-innovators) the estimated differential associated with an innovation is $\hat{D} = (\hat{\beta}^{I} - \hat{\beta}^{NI})\overline{X}^{NI}$, where $\overline{X}^{NI}$ is the vector of means taken from the non-innovators sub-sample[2].

A second problem with (7.1) is that there is a danger that ATC may be simultaneously determined with the wage. The simultaneous system can be written as:

$$(7.3)\quad w_{is} = \alpha_s ATC_{is} + X'_{is}\beta_s + \varepsilon_{1is}, \qquad \varepsilon_{1is} \sim N(0,\sigma^2_{1s})$$

$$(7.4)\quad ATC_{is} = \gamma_s w_{is} + Z'_{is}\Gamma_s + \varepsilon_{2is}, \qquad \varepsilon_{2is} \sim N(0,\sigma^2_{2s})$$

s = {skilled, semi-skilled, unskilled and clerical skill groups}

It is easily shown (see Appendix 7.1) that the direction of the bias in the estimation of α will depend on the term $1/\gamma - \alpha$. In general this will be of an ambiguous sign, but if a particular skill group is complementary with new technologies then $\gamma < 0$ and $\hat{\alpha}$ will be biased *downwards*. This fact is exploited below in interpreting the results in light of the human capital-new technology debate.

One way to surmount the reverse causality problem is, in the spirit of previous chapters, to refine the measure of ATC to only cover those innovations that definitely took place more than 12 months ago, the lifespan of a typical British wage contract. The problem with this is that a lot of

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[2]The conceptual experiment is what would happen if a non-innovating plant with a given set of characteristics became an innovating plant. The results from the alternative experiment of using means from the innovators gave similar results.

information is lost by ignoring all current (and presumably more productive) micro-electronic adoptions. Furthermore it may be that *changes* in wages are what matters for the incentive to innovate and not merely levels, or that the wage levels are serially correlated so that the simultaneity problem reappears.

An alternative method is to actually estimate both (7.3) and (7.4) jointly. This becomes very complex if both endogenous variables are allowed to be latent (Maddala (1983) p.244). A simpler method is implemented below by simply predicting ATC from a first stage linear probability model and using these predictions in the Maximum Likelihood wage equation. These should give consistent, but inefficient, estimates.

The major difficulty in trying to handle this issue with a cross section is that identification seems pretty arbitrary. One possibility is to use the presence of a JCC (Joint Consultative Committee) as an identifying variable. The greater flexibility and 'voice' provided by such an institution probably increases the probability of technological change taking place. However, in the absence of any such effects (the JCC may well be merely 'window dressing') there should be no independent impact on the wage. Since JCC will enter the innovation equation but not the wage equation, the order condition is satisfied. One can, of course, always imagine counter-arguments for almost any variable in Z to also be in X. Because of this difficulty the main text keeps to the assumption that technology is pre-determined, and that wage bargains are conditional on the choice of technology.

IV. ESTIMATION OF TECHNOLOGICAL MARK-UPS

1. Basic Results

Some descriptive statistics are given in Table 7.1 for the basic variables both overall and split by whether the plant had manual ATC or not.

The majority of establishments introduced some type of advanced technical technological change in the early 1980s and this type of change was more common than either of the other two forms of change available in WIRS (organisational or conventional). Innovating plants tended to be larger, but they also tended to have lost a larger proportion of their employees over the recession[3]. Although they appear to have a larger proportion of plants with above average financial performance (cf. Chapter 4), they also have a slightly larger percentage with lower performance. The appropriate interpretation is that plants adopting microelectronics are taking a risk and this is reflected in the greater variance in their financial performance. Finally, innovators appear more highly unionised, male-dominated and skilled.

These simple splits are used to calculate raw innovative mark-ups in Table 7.2. Wage bands gave been assigned midpoints so a feel for the magnitudes involved can be gleaned. There are higher wages in all skill categories and sectors where ATC has occurred. The effect is stronger in the public sector and, within the private sector, for unionised establishments especially in manufacturing. Since the last two chapters concentrated on large unionised private manufacturing firms, it may be that they exaggerated the wage gains to innovation. Consequently this chapter will sample the whole of the private sector. As regards skill, the picture is fairly clear: for manual workers the more skilled you are the greater is the pay-off from technical change. Figure 7.1 graphs these mark-ups for the union and non-union sectors by skill group to illustrate the main features of the data.

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[3]On the surface this goes against the picture painted in our chapter on jobs and technology, but is misleading. When one conditions on other variables, in particular, employment in 1980,a positive and significant effect of ATC and employment growth is usually uncovered (Blanchflower et al, 1991, Machin and Wadhwani, 1991a). This disproves the old folklore adage in industrial relations that econometric studies of WIRS have never overthrown a correlation.

Technological differentials are higher in the union sector and clearly ranked by skill being greatest for skilled workers and lowest for unskilled workers.

Table 7.3 subjects these correlations to more rigorous testing. Two semi-log wage equations (one for innovators and one for non-innovators)[4] are presented for each of the skill groups. The equations are for the private sector only and are net of all missing values (see Data Appendix) and the control variables generally take their usual signs[5] (see Machin, Stewart and Van Reenen , 1992, for example). Using these coefficients and the weighted sample means we can calculate the innovative differentials for each skill group using the methodology of section III. These implied mark-ups are tabulated in the first column of Table 7.4. They are positive across all groups, significantly so at the 5% level (on a two-tailed t-test) for skilled workers and at the 10% level for semi- and unskilled workers. Clerical workers do worst both in the size of the point estimate and the precision with which it is estimated. For manual workers at least, a technological mark-up emerges even when one controls for a whole host of workplace and worker characteristics.

Various criticisms could be made of these estimates. Recent American work on wage determination has stressed the importance of industry effects (see Chapter 2 Section III.3) possibly related to efficiency wages. There are no industry dummies into our original equations (only a crude manufacturing dummy) because such a procedure introduces a new and unknown

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[4]These sample splits are statistically supported by the data. The Likelihood Ratio statistics were 32.4, 39.2, 62.6 and 34.0 for skilled, semi-skilled, unskilled and clerical workers respectively. The critical value at the 10% level is $\chi^2(21) = 29.5$. Only the skilled group marginally misses significance at the 5% level of 32.7.

[5]There are the usual positive effects of employer size, closed shops and fragmented bargaining. Wage levels are lower the higher the proportion of women and part-time workers. Plants which are single-sited and those in the manufacturing sector have lower wages.

weighting scheme into the data. Consider the case of introducing 3-4 digit industry dummies (145 are available). In some of these industries there may be only one plant and in this case the variation of this plant's observable characteristics are effectively wiped out by the industry dummy. This argument is still true, although somewhat attenuated, when the dummies are more aggregated. On the other hand, the propensity to adopt new technology does vary substantively across industries, and there is a danger of simply picking up a between industry effect with ATC. The second column of Table 7.4 presents estimated mark-ups for equations with 9 industry dummies, and the third column includes 11 regional ones as well. As can be seen the estimates are only affected slightly, marginally *improving* the determinancy of the coefficients (all the manual groups are significant at the 5% level in columns (2) and (3))[6]. Splitting the sample is supported statistically by the data, but the results of using a simple ATC dummy are also presented in Panel B of Table 7.4. The estimates are smaller and much more poorly determined in the first column, but regain strength when we include dummy variables for industry and region.

A further criticism of Table 7.4 is that a change variable is used (over a three year period) in a wage levels equation. Two alternative measures of technology were available to deal with this objection. COMPUTER was a variable coded to one if there was a mainframe, micro or mini-computer either at the establishment or linked to another establishment in the organisation. PLANT<25 is another dummy variable which indicates whether the plant is under

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[6]Increasing the number of industry dummies tends to improve the estimation of ATC for skilled workers, but weakens it for other groups. For example, including all 145 industry dummies in the pay equations of Panel B and simply using a linear intercept for ATC yields coefficients (standard errors) of 0.046(0.021), 0.013(0.023), 0.037(0.029) and 0.004(0.018) for skilled, semi-skilled, unskilled and clerical groups respectively.

25 years old since younger plants will probably utilise more recent capital vintages. Running sample splits identical to those in Panel A of Table 7.4 replacing ATC by either COMPUTER or PLANT<25 rendered similar pattern of results (see Table below). The use of computers at the workplace is associated with increases in manual pay of the order of 4% and younger plants tend to have mark-ups in the range of 4-7% compared to older ones.

	Skilled	**Semi-Skilled**	**Unskilled**	**Clerical**
A. Use of Computer Systems in the Plant: Is there on-site main frame, mini or micro-computer or link to computer at another plant in the organisation?				
COMPUTER	0.041(0.016)	0.038(0.018)	0.034(0.024)	-0.002(0.015)
B. Youthfulness of Plant: Establishment has been in main activity for 25 years or less.				
PLANT<25	0.073(0.017)	0.069(0.019)	0.042(0.024)	0.027(0015)
No. of Plants	773	667	754	945

2. Attempting to deal with Simultaneity

For the previous chapters it was argued that technological innovations could also be seen as econometric innovations. Less confidence can be placed on the weak exogeneity of innovation in a WIRS wage equation, so some attempt to deal with the problem was made[7]. The first line of attack was to use the question of timing. Managers were asked when the technical change was completed, so it was possible to define ATC>12(MONTHS) as innovations taking

[7]Note that technical change is not the only problematic 'independent' variable. Employment also appears on the right hand side , albeit in spline form.

place one to three years in the past. Using this as a measure of innovation reduces the danger of reverse causality[8] but throws away a lot of information. In particular, firms which adopted microelectronics in the past year *and* in the previous two years would unavoidably be coded to zero technical change. Since more recent technical changes are likely to have a bigger impact on wages (cf. Chapter 6), this alone should reduce the estimated effects.

Panel C of Table 7.4 presents the mark-ups from lagged technical change. The first column splits the sample in the usual way, but this time the selection criterion is whether a plant has definitely experienced an advanced technical change between 1981-83. The calculated differentials are small and insignificant. Part of the reason for this is that there are now very few establishments which are classified to be 'innovators' (about 10%). Consequently we experimented with a linear intercept (as in Panel B) including dummies for industry and region. Comparing column (2) in Panel C to column (2) in Panel B, it is evident that skilled mark-ups have actually increased slightly in importance (up from about 4% to over 5%) whereas those for the other groups have disappeared. In particular, compared to Panel B the unskilled workers appear to receive no benefits whatsoever.

A possible reason for the differing size and direction of the simultaneity bias across skill groups is that human capital may be complementary with new technology. If skilled workers complement ATC then $\gamma_{SKILLED}$, the effect of skilled wages on the propensity to innovate, will be negative. This will tend to bias the original estimates of the skilled technological mark-ups ($\hat{\alpha}_{SKILLED}$) towards zero. If the unskilled are substitutes for new technology then the bias will be in the opposite

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[8] Also there is the problem that workers in innovating plants may permanently enjoy higher wages (cf. Chapter 4) making the use of timing dubious.

direction (for small $\gamma_{UNSKILLED}$) which is exactly what we observed. Appendix 7.1 fills in the theoretical argument behind this and the question of the new capital-skills complentarity hypothesis is further examined in Section VI.

The alternative way to deal with the endogeneity problem by using instrumental variables was outlined in section III. Table 7.5 presents the results for some ATC equations similar to those of Machin and Wadhwani (1991a) with some extra controls for skill composition, region and industry. The first two column presents the reduced form OLS equation for manual and non-manual technical change. The third a logit version of column (1) and the fourth a logit version with the inclusion of unskilled workers pay[9] and the associated marginal effects. There are few surprises here, but one big disappointment. A large impact of JCC, the identifying variable, on the probability of technical change was not found[10]. Consequently it is not surprising that when the wage equations were re-estimated using the predicted value of ATC from columns (1) and (2) the variable was insignificant and extremely unrobust to small changes in the ATC equation.

3. Are Technological Differentials Compensating Differentials?

In WIRS there is additional information concerning the perceived consequences of technical change, not only on jobs and wages (see the Table 5.1 and Section 6.2) but also on non-pecuniary aspects of the workplace.

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[9]Including skilled workers pay gave a positive but completely insignificant coefficient.

[10]Strictly speaking there are several variables in Table 7.5 that do not enter the wage equation (e.g. ABOVE and BELOW average financial performance). Unlike JCC there are strong reasons why these variables *could* theoretically enter the wage equation, however, so they cannot be treated as truly identifying variables.

This information can be used to see if innovative differentials are merely compensating differentials in disguise by observing the relationship between the disamenities produced by innovations and the wage pay-offs. Senior managers and workers' representatives were asked whether pay had gone up, down or stayed the same as a results of advanced technical change. Machin and Wadhwani (1992) cross tabulated these answers by the answers to changes on non-pecuniary job attributes and the results are presented in Table 7.6. There appear to be major differences between managers and workers responses with managers being generally more optimistic over the effects of technical change. The only clear evidence for compensating differentials is the 'more responsibility' answer where both sides saw this associated with higher pay. For 'control over pace of work' and 'more interesting job' the effects are in the wrong direction. For 'more subject to supervision' the effects are the right sign for managers but the wrong sign for workers' representatives. The workers' perception that supervision is likely to lead to wage reductions is quite compatible with a shirking model (see Chapter 5) or a bargaining model where unions are weakened by increased intensity of supervision[11]. It is incompatible with compensating differentials as a more intense monitoring regime should lead to a wage premium.

A second piece of evidence weighing against compensating differentials is the fact that there appear to be positive spillovers from non-manual technical change to the pay of manual workers, and from manual ATC to the pay of non-manuals. If a new variable for is defined for ATC taking the value of 1 if there has been *either* manual or non-manual technical change the previous analysis can be repeated. The new mark-ups are 0.057(0.022), 0.078(0.026) 0.057(0.033) and 0.063(0.020) for skilled, semi-skilled, unskilled and

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[11]The main flavour of the cross tabulations carries over in an ordered probit analysis.

clerical workers respectively (equivalent to column (1) in Panel A of Table 7.4). The pay-offs for the most skilled group decline slightly, but for all the other groups there has been an increase. This is particularly true for clerical workers who now enjoy large and significant technological mark-ups. It is not obvious why non-manual workers should be so highly compensated for a change which does not even affect them. On the other hand, if there is rent-sharing operating through a redistributive trade union one would expect to observe just these kind of spillover effects.

The upshot of this section is that the positive effect of technology on wages seems robust to controlling for human capital, gender, part-time status and other workforce and workplace characteristics. Furthermore, the alternative purely competitive explanation regarding compensating differentials does not seem particularly plausible. There is also a suggestion that the technology effect is underestimated for skilled workers, but over-estimated for unskilled workers due to simultaneity bias.

V Union Bargaining and the Innovation-Wage Effect

The last chapter found that innovation had a significant effect on wages in the union firms but not in the larger sample where union status was unknown. Moreover, this differential actually declined at higher levels of firm and industry union density. There was not have enough information on innovation in the non-union sector to draw a proper comparison and so it is necessary to delve deeper into this issue using WIRS. The establishments were split by union recognition[12] and the model was re-estimated on the sub-samples using just the ATC intercept. The results for manual technical change are presented in the top half of Table 7.7. Panel A has a

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[12] The total sample size is smaller as those plants where information on union density was missing were excluded.

straightforward interpretation. Technological differentials are (weakly) significant *only* in the union sector for skilled and unskilled workers. In the non-union sectors the coefficients on ATC are small and insignificant. This is consistent with the theoretical model presented in the previous chapter and the interpretation of the results from the firm panel: there is little or no rent-sharing if workers have no power.

Rather than use a simple intercept term for innovation the union and non-union establishments can be subdivided by ATC and the technological mark-ups are calculated as before. The same pattern appears: the mark-ups are only significant where there is a union recognised, and are about the same for all skill groups of manual workers[13] The simpler intercepts are preferred as these four-way sample splits (by innovation and union status) means that some of the cell sizes are very small (especially for non-union innovators).

The alternative technology measures are also presented in Panel A. For computer use, there is an identical pattern of results: the impact is large and significant only in the organised establishments. For age of plant no clear ranking can be discerned. Union plants do better for semi-skilled and clerical workers whereas non-union plants do better for skilled and unskilled workers. This ambiguity probably arises because plant age is the worst proxy for new technology of the three considered.

Panel B conditions on recognition and splits the ATC effect into plants where union density was 100% and plants where union density was below this figure via two interaction terms. For the manual groups low density plants got higher wage pay-offs from new techniques. The difference was greatest

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[13] The coefficients (standard errors) are 0.073(0.040), 0.068(0.036), 0.074(0.043) and 0.027(0.039) for skilled, semi-skilled, unskilled and clerical workers.

for the skilled group where the coefficient on the technical change dummy with 100% density was over three times as large as the coefficient on the technical change dummy when all workers in an establishment were organised.[14] If we replace 100% density by a closed shop dummy (final rows of Table 7.7) the asymmetry persists. Interestingly, the asymmetry is the opposite way around for white-collar workers who got *higher* wages when the technical change takes place within a closed shop establishment.

So the two primary findings from the last chapter generalise to evidence from the plant level for manual workers. Union recognition is associated with technological rent sharing *but* perhaps more surprisingly, very strong unions (high density or closed shops) extract lower shares of these rents than their weaker brethren. Obtaining broadly the same pattern as the firm panel in the last chapter is quite remarkable considering the very different types of data used, especially the different measures of innovation[15]. The negative interaction of union power with technological differentials has also been uncovered in North American work (see Chapter 6, Section II) the measure has always been recognition. In the British work reported here the negative interaction is with union density *conditional* on recognition[16].

Four possible explanations for the negative correlation between very strong unions and innovative differentials will be considered: (i) By opposing technical change unions dilute the quality of innovations adopted; (ii) management have incentives to introduce types of technical changes that

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[14]A formal test of the difference gives a $\chi^2(1) = 3.35$.

[15]We must reiterate that the time periods of the samples are very close, so generalising from the early 1980s experience must be done only with caution.

[16]This is surely tied into the different traditions of industrial relations. Switches of recognition status are far commoner in the Americas than in Britain and the general level of union presence much lower.

weaken workers' bargaining strength ('labour process theory'); (iii) unions redistribute the gains from technology to other workers; (iv) certain bargaining regimes smooth the wage gains from technical shocks because more issues are on the bargaining agenda. The first two view union bargaining as essentially *destructive* of rents, the second two view it as essentially *spreading* rents.

Possibilities (i) and (ii) are formally quite similar. If we write the wage equation as:

$$w_i = \alpha_1 ATC_i + \alpha_2 UNION + X_i' \beta + \varepsilon_{1i}$$

where UNION is high density or the closed shop. Then argument (i) can be represented by the equation

$$\alpha_1 = f(UNION,.);\; f_1 < 0$$

and (ii) by

$$\alpha_2 = g(ATC,.);\; g_1 < 0.$$

Both (i) and (ii) predict a negative ATC*UNION term, but since the αs are unobserved it is an uphill task to try and distinguish these positions. Despite having radically different policy implications the crucial parameters are unidentified. However, one corollary of these models would seem to be that unions should be having an impact not just on the quality but also on the likelihood of innovation. Under the lower quality argument unions will unambiguously depress the rate of technical change. Under the labour process argument technical change is primarily a way of weakening strong unions so we may expect a positive relationship especially when the ability of unions to maintain restrictive practices is being eroded, as it was in the early 1980s.

The existing empirical econometric work in this field summarized in the Survey Chapter (Table 2.2) suggests that unions have on average, no effect or are a spur to speedier adoption of new technology. All the existing work on WIRS points in this direction (Latreille, 1992, Machin and Wadhwani ,1991a,b) and a glance at Table 7.5 confirms this for the data here. Union recognition has a positive and significant effect on the probability of manual technical change. This does not give direct support to the labour process argument as it relates in this instance to union power over and above simple recognition. Additional terms in plant density or the closed shop were both small and insignificantwhen added to the ATC logit model in column (4) of Table 7.5. For example the coefficient on a closed shop dummy was 0.027 with a standard error of 0.028. Overall, then, there is little empirical support for either argument.

What of the union redistribution[17] story? The closest study to our own is by Betcherman (1991) who looks at the impact of process computerisation on the pay of blue-collar workers in 216 Canadian establishments 1980-85. Splitting the sample by two different measures of innovation (whether the plant introduced any computer-based processes 1980-85 and whether expenditure-sales ratio of computer-based process technologies exceeded 20%) he found that union mark-ups where about a third lower (and insignificant) in the innovation sub-sample[18]. His rationale for the results rests in the idea that unions redistribute the gains from technology in favour of unskilled workers. Whereas the 'adjusted union effect'[19] for skilled workers was merely 2.3% in innovating plants compared to 12.7% in the rest of the sample, for general manual workers this was reversed. It was 28.5% for innovators

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[17] For recent evidence on unions and inequality see Card (1991) for the U.S. and Meghir and Whitehouse (1992) for the U.K..

[18] Betcherman could be criticised for various econometric drawbacks - he has no establishment controls other than size, he uses wage levels despite the well-known skewed distribution of this variable

[19] Coefficient on union dummy divided by mean non-union wage

compared to 22% for non-innovators. Since these results also hold true for wage *growth* over this period the Betcherman hypothesis could be the basis for a sophisticated explanation of the rise in inequality. He does not draw this out[20], but the faster wage growth in innovative firms for skilled workers exacerbated by the decline in the presence and re- distributive powers of trade unions could explain a substantial part of the increase in wage dispersion.

The WIRS dataset gives some support to the view that unions redistribute economic rents from the more skilled to the less skilled. For example, when we calculated technological differentials in the union sector by splitting the sample by ATC, all the manual groups had the same mark-up of about 7%. By contrast, in the sample as a whole skilled workers did far better, as was concluded in the last section. The problem, however, is to explain lower mark-ups of strongly unionized plants *within* the union sector. Under a slight modification of Betcherman, redistribution implies that increases in union density should lower technological differentials for the skilled and and *increase* differentials for the unskilled. As noted above, the negative interaction between density and innovation is strongest in the skilled sector but it is neither significant nor positive in the unskilled sector as we would expect if the union was redistributing rents across skill groups. Only clerical workers buck the trend achieving a greater pay-off from ATC affecting them when there is a closed shop. For the Betcherman hypothesis to work one would have to argue that there is joint manual and non-manual bargaining redistributing the spillovers from skilled workers to clerical workers. The lack of direct data on this issue makes it difficult to

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[20]Perhaps because there was stable union density in Canada 1979-86 at about 36% (Freeman, 1988).

explicitly test[21]. A possible reason for the negative interaction even in less skilled groups is that unions are redistributing across different establishments in multi-plant firms. The negative interaction did weaken in firms where firm level bargaining took place, but the change was not particularly striking.

The redistributive trade union spreads the benefits of technological change across different groups of workers. The fourth rationalisation of the negative effect of 'stronger' unions on innovative mark-ups emphasises a different form of smoothing mechanism. Under this class of models the existence of institutions such as the closed shop signal the existence of qualitatively different types of bargaining regimes. The defining feature of these regimes is that the bargaining agenda covers more aspects of the workplace than merely wages (e.g. the level of employment and new technology). Workers may accept a lower level of wages in the short-term in order to have more job security and a higher investment levels in R&D in the longer term. This will tend to *smooth* the wage over technological shocks and so we will observe a smaller fluctuation in wages when the firm innovates.

There are two aspects to the theory that strong unions engender institutionalized wage smoothing. First, it is probable that as the bargaining agenda lengthens beyond wages the union will trade off lower remuneration for other desired objectives. For example the idea that bargaining over employment may lead to sticky wages over the business cycle was one of the original motivations behind the classic McDonald and Solow (1981) paper on efficient bargains. The second aspect is more subtle; if closed shops enhance the development of long-term contracts then they may

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21 Unfortunately only 1990 WIRS has direct information on this issue.

overcome some of the 'hold-up' problems associated with the Grout effect (see Chapter 2). To take a particular example, if there is 'ex ante' bargaining over R&D then part of the resulting deal will be that the union implicitly shares investment costs by taking a lesser proportion of the rents generated by innovation. A formal model of this which draws on the pioneering work of David and Alistair Ulph (1990, 1991) is given in Appendix 7.2, but the intuition is straightforward. The orthodox 'right' and 'left' positions discussed above concluded that there were inefficiencies in the sense that socially sub-optimal technologies were being used either due to union incalcitrence or managerial deviousness. One way around these inefficiencies would to be to involve unions in bargaining over investment in R&D and thus avoid the dissolution of rents associated with a move away from the Pareto frontier. This old idea is given a more precise theoretical analysis by the Ulphs.

The upshot of the Ulph model is that unions who bargain over R&D will have lower wages for any given technology relative to unions which bargain only over employment and the wage. Similarly, wage-employment bargaining will produce lower technological mark-ups than wage only bargaining ceterus paribus.

How should the theory be calibrated with the evidence? Chapter 5 tested for efficient contracts indirectly through using employment equations and concluded against the hypothesis. But as stated in that chapter and in the Introduction there are many deep-rooted problems with the testing procedures, so it is worthwhile using some more direct information rather than rejecting the possibility out of hand. Table 7.7 revealed that for skilled workers closed shops smooth out the wage effects of technology shocks. One can see if this smoothing is related to the presence of non-wage bargaining by using a variety of variables in WIRS relating to the existence of negotiation over the size of redundancy payments, redeployment, recruitment and staffing levels.

Bargaining over non-pay issues is closely correlated with the presence of a closed shop, so there is some prima facie plausibility for the smoothing argument. The union sector was split by these different dichotomous variables and it was observed whether the coefficients on the interactions of the closed shop with technical change substantially altered. There was a sizeable change in only one instance - over the question of whether there was negotiation over the size of redundancy payments. The pattern of Table 7.7 was repeated if there was bargaining over this issue, but in the absence of such bargaining the results were reversed. Skilled workers in closed shops got *higher* pay-offs from advanced technical change when there was *no* redundancy bargaining. As can be seen from Table 7.8, the coefficients are not determined very precisely, the interactions are significantly different from each other only when there was redundancy bargaining. The importance of redundancy payment bargains may be that they combine both aspects of union smoothing theory. On the one hand, higher redundancy payment offers a greater expected compensation package to the worker and this can be traded off in the form of lower wages. On the other hand, substantial levels of redundancy pay will reduce separations (the cost to the employer of laying off a worker increases and the redundancy payment will be lost to an employee who voluntarily quits). This will encourage the emergence of a stable core of workers who are more likely to have a longer time horizon and engage in the kind of ex ante bargaining described by the Ulph model[22].

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[22]An attempt to discriminate further between the different versions of the smoothing model by using the question of whether management consult workers over their investment plans (which was asked to both union and non-union workers). Although consultation is weaker than negotiation, it should be thought of as necessary to explicit R&D bargaining. Only 15% of managers and 10% of workers representatives said that such consultation occurred.

Within the union sector higher density leads to shrinking pay-offs to innovation. The explanation for this *does not* seem to be because the process of bargaining shrinks the size of the cake through union bloody-mindedness or strategic weakening by management. There *does* appear to be some support for the idea that strong unions spread rents (a) with workers who are not immediate beneficiaries of innovation (in other skill groups, plants or firms), (b) over non-pay issues, (c) over a longer time horizon. To slip into journalese, organised workers not only get more jam, but they make it spread further.

VI The Escalation of Wage Inequality

1. Literature Review

One of the most remarkable features of the evolution of the wage structure since the late 1970s has been the dramatic widening in earnings dispersion. Although less skilled workers (if in full-time employment) have seen their real wages rise in Britain (unlike the U.S. where they have fallen) the decline in their relative position is still substantial. This is illustrated in the upper part of Table 7.9 using data from the General Household Survey analysed extensively by Schmitt (1992). For men in full-time work both the standard deviation of log earnings and the decile ratio show a fall from 1974 which bottoms out in 1978-79 then consistently rises until 1987.

There is a large U.S. literature cataloging this change (for example, the Spring 1992 issue of the Quarterly Journal of Economics), but discriminating between hypotheses has proven to be much harder. The

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Unfortunately no conclusive result emerged one way or the other from this analysis.

competing explanations will be briefly considered under the headings of shifts in supply, demand and institutions. Supply side explanations would seem very unpromising as the groups which have benefited most have also increased most in supply. For example the rate of return to university degrees has moved upwards at the same time as an increase in the proportion of degree holders (up from 5% to 11% between 1974/6 to 1986/8 according to Schmitt, 1992).

On the demand side there are two positions have been taken in the debate. One stresses the growth of international competition leading to the decline of the manufacturing sector which traditionally provided relatively high paid jobs for workers with lower skills (Murphy and Welch, 1992). The other emphasizes new productive technologies which are complementary to more highly skilled labour[23]. This skills-based argument actually has two distinct strings to its bow. First, the new technologies which spread in the 1980s (as epitomised by the computer), are used much more efficiently by those with higher educations. The second string is the old idea (e.g. Nelson and Phelps, 1966) that during times of rapid technological change it is skilled workers who will be most in demand because they are better at coping with the uncertainty surrounding new production techniques. Whatever the intrinsic truth of *this* claim it seems an unlikely explanation of the growth of inequality in the 1980s as there is little evidence of a 'speed up' in innovative activity. In the United States this is obvious because of the poor productivity performance, whereas in the U.K. the number of major innovations dropped off in the early 1980s (see Figure 4.1)[24]. Distinguishing

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[23]The main advocates of this line are Mincer(1991), Bound and Johnson(1989) and Davis and Haltiwanger(1991)

[24]The UK productivity performance has been relatively impressive in manufacturing but *not* in services. The thesis that this is due to a gale of innovation has haad little empirical support relative to (e.g.) increased

between the two aspects of the skills based story is important as they have very different political implications. One suggests a vigorous re-training policy on grounds of efficiency as well as equity, the other promotes a more relaxed and laissez faire response.

Most tests have concentrated on the implication that the 'manufacturing decline' story implies that the inequality is a between industry affair whereas the skills based story should operate within industries. Since the majority of studies have found inequality to have risen at least as much within industries as between them (Blackburn, Bloom and Freeman, 1991; Bound and Johnson, 1992) it seems the consensus is moving towards the skills-based story.

Before criticising this conclusion the third group of arguments which stress institutional changes must be mentioned. The 1980s have witnessed a large decline in union presence (see Figure 3.3, for example) and presumably their redistributive powers. It must be noted that wage dispersion increased within the union sector in the 1980s, so it is likely that inequality would have risen even in the absence of unions albeit to a lesser degree. A second institutional reason could be the decline in the toughness and enforcement of the Wages Councils which set minimum wages for about 10% of the workforce. Machin and Manning (1992) have shown how a decline in the ratio of the minimum to the average wage was associated with increasing wage dispersion 1979-1990 after controlling for council specific fixed effects and changes in real GDP.

Although both institutional explanations have something to recommend them, they cannot seem to account for the general rise in inequality across all sectors as the effects of union power and minimum wages are concentrated

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effort from the weakening of trade unions. Metcalf (1991) contains a useful summary of the arguments.

in certain sectors of the economy and not others. A third possibility is incomes policies. Several flat-rate incomes policies in Britain in the 1970s seem to have had the effect of reducing wage dispersion (Ashenfelter and Layard, 1983). This argument has some plausibility in the 1970s and early 1980s (when the policy was relaxed) as it affected the entire economy. Incomes policies cannot do the trick in explaining the continuing rise into the 1980s, however, because they were publicly disavowed by the Thatcher administration.

Returning to the skills-based argument, what direct evidence is there that the 1980s new technologies raised wage inequality? There are two elements to the debate that are not always made analytically clear. Increases in inequality may be due to relatively larger employment in the extremes of the earnings distributions[25] or they may occur by changing wages within in a given employment distribution. Usually they are combinations of the two as a shift in relative demand for skilled labour will raise employment and wages (temporarily if human capital markets are perfect in the long-run) for the skilled compared to the unskilled. The last chapter used the average wage bill of the firm as our 'dependent' variable which clearly confutes the two effects. Increases in the average wage bill could be due to a relative increase in the proportion of better paid workers with unchanged skill-specific wages.

The first channel of 'technological inequality', the relative skills-employment effects of technical change has a voluminous and inconclusive literature summarised briefly in Chapter 2 (e.g. Spenner, 1988). The second channel which works through relative wage effects is much less studied. The most convincing study to date is that of Krueger (1991) who

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[25]The infamous 'hollowing out' of the Middle Classes described by Bluestone and Harrison (1988).

looks at computers as an archetypical new micro technology. He primarily uses the U.S. Current Population Surveys in 1984 and 1989 which had supplementary questions on computer use. As mentioned in chapter 6, he finds that using a computer at work boosts employee wages by about 10% to 15% and that this pay-off *increased* between 1984 and 1989[26]. Given that highly educated workers are more likely to use computers and that the technology has diffused more widely over time, Krueger concludes that "the proliferation of computers can account for between one-third and one-half of the increase in the rate of return to education observed between 1984 and 1989" (p.24).

The Krueger study is impressive but as the author himself admits (p.7) the CPS has poor information on employer characteristics. These are potentially very important omissions, size for example tends to have large effects on the propensity to innovate[27]. Indeed, Davies and Haltiwanger (1991) in their study of 50,000-70,000 U.S. plants 1963-86 cite the evidence of rising plant-size-wage effects as evidence *in favour* of a skills-based explanation of the rise in inequality[28]! In addition, we might want to look at micro-electronic advance as a whole as computer-use is concentrated in the non-manual sector.

The Betcherman (1991) study discussed in the previous section also found

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[26] To check that the differential is not merely due to more (unobservably) able workers using computers a variety of different models are fitted to control for selection: (i) he uses home use of computers as an additional control; (ii) he estimates for very narrow occupational groups (secretaries); (iii) he constructs a pseudo-panel, using the cohort to control for unobservables correlated with computer use; (iv) he cross-checks with longitudinal information from the High School and Beyond Dataset. The results remain robust across these different strategies.

[27] Krueger defends himself by pointing to Reilly's (1990) study which finds positive effects of computer use in 60 Canadian establishments despite size controls.

[28] The argument is unconvincing as there are far more plausible candidates for the employer size-wage effect, such as monopsony power (see Green, Machin and Manning (1992).

higher wage levels and wage growth for skilled workers amongst non-unionised plants who adopted computer-based innovations. The other main micro[29]-study is by Bartel and Lichtenberg (1987,1990). In their earlier paper they found that the relative labour costs of skilled workers in manufacturing increased with the youthfulness of capital and equipment (their measure of new technology). Although initially ascribing this to increased demand for skilled labour, their later paper uses wages as the dependent variable and finds that the positive wage-technology effect is greater for more educated workers[30].

The work of Bartel and Lichtenberg is often cited as evidence in favour of the 'technological inequality' story but really it is not so. Bartel and Lichtenberg pool the Censuses from 1960,1970 and 1980 when rates of return to education were static or decreasing, so their findings simply cannot be a convincing story for the 1980s. Even if the results were reproduced for the latter period, the claim from their 1987 paper that the differential erodes over time is inconsistent with Krueger's expanding differentials. Finally, the authors use industry level measures of their technological variables which necessarily lose the finer individual level innovation effects which would have to be an important part of any story explaining the rise in within-industry wage dispersion.

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[29] Mincer (1991) regressed the aggregate annual college -high school wage differential against relative supplies of these groups and two different measures of technical progress (twice lagged TFP growth and per capita R&D). Inferring support for the skills-based hypothesis from the significance of these variables is dubious, to say the least

[30] This is only significant for younger workers, however, suggesting that might merely be picking up a cohort effect.

2. The WIRS Results: A High-Tech Smoking Gun?

Is technological change a 'smoking gun' - the prime suspect in the 'crime' of rising inequality? A simple test of the theory can be made by looking at how the effect of advanced technical change differs across skill groups. This begs some important questions of course. For example it leaves out the increase in inequality within our four groups[31]. It is also a very different test to Krueger's who uses computer-use and individual level pay. Additionally, we are looking *directly* at skill based differentials (where the theoretical story is couched) rather than education/experience differentials (where the empirical analysis usually rests).

What light do the WIRS results shed on this debate? First, controlling for simultaneity in Section IV.2 changes the results in the way expected if skill and new technology are complements. Second, we have the fact that new technological differentials are more of a within industry phenomena than a between-industry (adding industry dummies strengthened the technology-wage relationship). This is encouraging as much of the increase in inequality seems to have occurred within industries. Third and most importantly, we can simply review the basic results in Panel A of Table 7.4 again. There is a clear division along the lines suggested by the skills-based explanation for inequality with skilled workers consistently achieving the largest pay-offs. Furthermore, technological differentials for the less skilled workers are only weakly significant (at the 10% level for the manual groups and not at all for the clerical group). This ranking should come as no surprise as the raw differentials presented in Table 7.2 and Figure 7.1 showed that in the private sector it was invariably skilled workers who got the highest pay-offs

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[31]The standard deviation of log wages does not seem to vary much with the presence of technical change. For example the standard deviation was 0.309 for skilled wages with technical change and 0.284 without.

overall and in the union, non-union and manufacturing sub-samples. Similarly, using the alternative measures of new technology gave the same story. For computer use (the closest WIRS can come to Krueger's study) and age of plant (the closest WIRS can come to Bartel and Lichtenberg) the hierarchy of technical pay-offs mirrors the hierarchy of human capital.

The higher innovative differentials for skilled workers are reinforced by the employment channel of inequality discussed above. Skilled workers were more likely to be employed in plants using advanced technology and therefore they will be the major beneficiaries of the technological pay-offs. It is difficult to gauge how important this effect is, but some evidence can be gleaned from the logit technical change equations in column (4) of Table 7.5. There is a positive and significant association of proportion skilled with the incidence of advanced change despite the large number of controls. On face value the estimates imply that a 10% increase in the proportion skilled increases the probability of ATC by about 3%. Given the difficulties surrounding causality we should interpret this Table as primarily one of partial correlations more than anything else.

One drawback of using WIRS to analyse the microelectronic theory of inequality relates to sample selection. The skill groups considered at are at the lower end of the wages distribution. In particular, clerical workers do not include managers and professionals and these groups have had the largest increases in remuneration (average clerical pay lies between unskilled and semi-skilled manual workers in WIRS). The lower panel of Table 7.7 illustrates that professional non-manuals enjoyed the fastest rate of employment growth and wage increase (24.4%). By contrast clerical workers wage growth was actually *below* that of unskilled manual workers. This is entirely consistent with the statistical picture of Table 7.4 - clerical workers had the lowest gains from new technology of all the skill groups.

Therefore, truncating at the lower end of the human capital distribution is likely to lead to an underestimate of the degree of inequality attributable to technical change.

A second criticism raises more fundamental problems. The approach in this section has been to seek explanations of the *changes* in inequality from a cross sectional snapshot. It is impossible to know whether the technological differential has always been higher for skilled workers as it was in 1984 and whether it fell, rose or stayed the same in subsequent years. The 1990 Workplace Industrial Relations Survey has recently been made available so a comparison over time would be of great interest. Preliminary analysis suggests that there are still important differentials but that they have not increased over time nor shifted dramatically at the expense of the unskilled. More confident statements will have to wait for all the data to become available, especially the 1984-90 panel.

An initial exploration of the direct evidence on technology and wage inequality was offered in this section. Skilled workers both have higher pay-offs from new technology and are more likely to be working in plants where it is adopted. Omitting employees further up the human capital hierarchy is likely to have biased the results *against* the skills-based hypothesis. The qualitative pattern is consistent with the hypothesis, but a quantitative assessment of the proportion of the increase in dispersion due to technical change would need a more thorough analysis of the time series patterns between the three Workplace Industrial Relations Surveys. In particular we need to analyse how *much* of the increase can be attributed to new technologies. The gun smokes, but where there is smoke there is not always fire.

VII CONCLUSIONS

This chapter has used the 1984 Workplace Industrial Relations Survey to further examine the question of the technology-wage relationship. The dataset has advantages over the firm level panel used previously because the analysis could be disaggregated to the plant level and by skill group; also extensive controls were available for workplace characteristics. The main disadvantage is that there is only a single cross section and the definition of technical change is wider and so not directly comparable with the earlier results.

Three questions have been tackled. The primary concern was to see whether the positive effect of technological change on wages was robust when controls for workforce composition at the plant level were introduced. The measure used related to the diffusion of micro-electronic technology over the 1981-84 period corresponding to the later part of our firm panel used in the previous two chapters. The positive relationship held up well across all manual skill groups even after the effect of workplace characteristics, industry and region were netted out. Furthermore, the more detailed questions on the nonpecuniary effects of technical change coupled with evidence of white collar-blue collar spillovers leans away from a compensating differentials explanation. Using lagged technical changes to control for simultaneity suggested that skilled workers' technological differentials are biased downwards, whereas those of less skilled workers are biased upwards.

Secondly, the finding from the last chapter that on average increases in union strength above the minimum of recognition, tended to reduce the size of innovative pay-offs was re-examined. Unionised workplaces were able to achieve greater gains, but within the recognised sector higher density and closed shops seemed to lower the technology differential, especially for skilled manual workers. This is a striking finding considering that the received wisdom is that stronger unions are better at siphoning off rents. Wage rent redistribution and the thesis of union wage smoothing contracts seemed to hold the most promise to theoretically resolve the anomalies, but the evidence is far from overwhelming and demands more careful research.

Finally, there was the question of whether skills-based technology differentials have caused a widening in the earnings distribution. We gave a qualified 'yes' to this question since innovation differentials generally did increase with skill in 1984 and skilled workers were more likely to experience technical change The main caveats to this were that the differential may have shrunk over time and it is difficult to assess now *much* of the widening in the wage distribution can be laid at the feet the microchip.

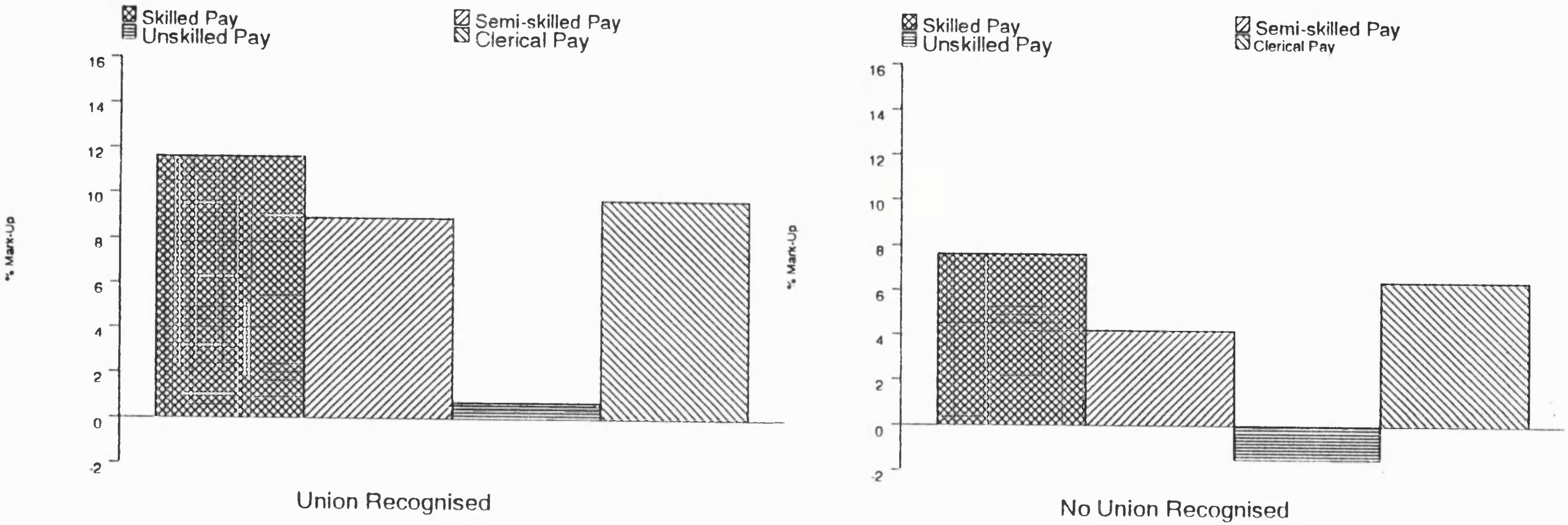

Figure 7.1: Technological Mark-ups in the Private Sector

TABLE 7.1 DESCRIPTIVE STATISTICS

	Private Sector Plants	Innovating	Non-Innovating
Advanced Technical Change:			
ADCH - Manuals	0.190(0.392)	1	0
ADCHNM - Non-Manuals	0.387(0.487)	0.484(0.501)	0.364(0.482)
ADCH>12*	0.056(0.230)	0.295(0.457)	-
YOUNG	0.461(0.499)	0.449(0.490)	0.463(0.499)
COMPUTER	0.515(0.500)	0.611(0.489)	0.492(0.500)
Conventional Change:			
CONVCH - Manuals	0.206(0.405)	0.329(0.471)	0.178(0.383)
CONVCH - Non-Manuals	0.108(0.311)	0.167(0.374)	0.094(0.293)
Organisational Change			
ORGCH - Manuals	0.200(0.400)	0.293(0.456)	0.178(0.383)
ORGCHNM - Non-Manuals	0.168(0.374)	0.301(0.459)	0.137(0.344)
Financial Performance:			
ABOVE - Above Average	0.464(0.499)	0.501(0.501)	0.455(0.499)
BELOW - Below Average	0.072(0.260)	0.095(0.294)	0.066(0.249)
Sales in Last 12 Months:			
DRISE - Rising	0.586(0.493)	0.592(0.492)	0.584(0.493)
DFALL - Falling	0.119(0.324)	0.110(0.314)	0.121(0.326)
Total Employment*	107.2(260.9)	206.7(524.76)	83.82(129.15)
Δ%Employment 1983-84	0.006(0.805)	-0.047(0.164)	0.004(0.889)
1980-84	-0.219(4.452)	-0.373(4.452)	-0.187(4.479)
Single-site	0.277(0.448)	0.233(0.423)	0.286(0.453)
UK Owned	0.926(0.261)	0.893(0.310)	0.934(0.248)
Emp Assoc.	0.263(0.440)	0.334(0.472)	0.246(0.341)
Shiftwork	0.397(0.490)	0.503(0.501)	0.372(0.484)
Manual %	0.624(0.258)	0.714(0.170)	0.603(0.270)
Part-time %	0.161(0.222)	0.140(0.215)	0.166(0.224)
Female %	0.235(0.191)	0.222(0.184)	0.154(0.207)
Skilled %	0.197(0.216)	0.241(0.218)	0.187(0.215)
Semi Sk. %	0.157(0.207)	0.171(0.206)	0.154(0.207)
Unskilled %	0.269(0.265)	0.302(0.297)	0.262(0.256)
Clerical %	0.162(0.166)	0.106(0.092)	0.175(0.177)
Recognition*	0.499(0.500)	0.704(0.457)	0.450(0.498)
Density	0.373(0.432)	0.583(0.434)	0.324(0.417)
Pre-entry closed shop	0.071(0.257)	0.140(0.348)	0.055(0.227)
Post-entry closed shop	0.192(0.394)	0.326(0.470)	0.202(0.402)
Separate Bargains	0.100(0.300)	0.184(0.389)	0.161(0.378)
Local Unemployment	0.129(0.045)	0.129(0.041)	0.129(0.046)
Joint Consultation Committee	0.298(0.458)	0.312(0.464)	0.295(0.456)
No. of Plants	713	258	455

* There are fewer observations on these variables due to missing values

Notes to Table 7.1

1. An innovating plant is one where there has been at least one advanced technical change (microelectronic technology) affecting manual workers in the last three years
2. These are weighted means, standard deviations in parantheses.

Table 7.2: Raw Technological Wage Differentials- WIRS 1984

All Wages in £

	All Sectors				Private Sector Only			
	ATC=1	ATC=0	%Mark-Up	**N**	ATC=1	ATC=0	Mark-Up	**N**
Skilled	146.7	127.0	15.5	1279	148.1	133.1	11.3	834
Semi-Skilled	113.8	101.2	12.4	1077	117.5	104.1	12.9	757
Unskilled	93.3	79.8	16.9	1430	93.6	89.5	4.5	844
Clerical	104.6	96.2	8.8	1701	105.1	97.3	7.9	1039

Private Sector :

	Union				Non-Union			
	ATC=1	ATC=0	%Mark-Up	**N**	ATC=1	ATC=0	Mark-Up	**N**
Skilled	125.1	112.1	11.6	545	135.1	125.6	7.6	214
Semi-Skilled	153.4	141.0	8.9	610	100.5	96.5	4.2	212
Unskilled	100.1	99.4	0.7	584	80.7	81.9	-1.5	240
Clerical	111.6	101.7	9.7	542	101.8	95.7	6.4	497

Private Manufacturing:

	Union				Non-Union			
	ATC=1	ATC=0	%Mark-Up	**N**	ATC=1	ATC=0	Mark-Up	**N**
Skilled	161.6	139.7	15.7	433	146.7	130.8	12.1	87
Semi-Skilled	127.2	112.5	13.1	396	112.0	101.1	10.7	79
Unskilled	107.0	101.7	5.2	408	91.8	91.8	-0.0	240
Clerical	108.8	98.6	13.5	329	98.8	95.8	3.2	219

Notes to Table 7.2

1. ATC=Advanced Technical Change that affects either manuals (for manual pay) and non-manual workers (for non-manual pay) - see text for full discussion.
2. Wage refers to the average weekly wage in 1984 pounds for a typical worker in each skill group. The original data is banded, so midpoints were allocated.
3. Union refers to recognition of one or more unions for pay bargaining.
4. Weighted means are used

TABLE 7.3 ADVANCED TECHNICAL CHANGE AND WAGES

	(1)	(2)	(3)	(4)
	SKILLED		SEMI-SKILLED	
	Innovators	Non-Innovators	Innovators	Non-Innovators
Constant	4.781(0.066)	4.811(0.080)	4.746(0.111)	4.472(0.084)
No.of employees:				
50-99	0.006(0.067)	0.039(0.030)	0.419(0.738)	0.124(0.036)
100-199	0.006(0.062)	0.078(0.034)	-0.018(0.070)	0.133(0.040)
200-499	-0.022(0.061)	0.010(0.037)	-0.028(0.067)	0.142(0.042)
500-999	-0.067(0.064)	0.158(0.042)	0.029(0.070)	0.230(0.050)
1000+	0.023(0.064)	0.132(0.052)	0.017(0.070)	0.197(0.059)
Manufng.	-0.032(0.040)	-0.020(0.024)	-0.092(0.043)	-0.025(0.028)
Single-site	-0.027(0.050)	-0.070(0.039)	-0.115(0.055)	-0.013(0.047)
UK Owned	-0.012(0.030)	-0.037(0.032)	0.009(0.031)	-0.090(0.040)
Emp Assoc.	-0.029(0.027)	-0.009(0.024)	-0.005(0.028)	-0.038(0.028)
PBR	-0.023(0.027)	-0.042(0.025)	0.005(0.028)	-0.016(0.027)
Shiftwork	0.104(0.039)	0.024(0.023)	0.046(0.040)	0.020(0.027)
Maj. male	0.208(0.086)	0.255(0.044)	0.177(0.046)	0.335(0.038)
Manual %	0.010(0.084)	0.019(0.053)	0.130(0.090)	0.127(0.663)
Part-time %	-0.267(0.115)	-0.578(0.070)	-0.893(0.157)	-0.477(0.072)
Female %	-0.405(0.087)	-0.316(0.063)	-0.249(0.102)	-0.112(0.078)
Skilled %	0.085(0.100)	-0.038(0.066)	-0.156(0.106)	-0.241(0.850)
Semi Sk. %	0.004(0.066)	-0.081(0.058)	-0.232(0.081)	-0.050(0.071)
Recognition	-0.028(0.046)	-0.024(0.028)	-0.064(0.048)	0.030(0.032)
Closed Shop:				
Pre-entry	0.170(0.044)	0.128(0.040)	0.182(0.045)	0.082(0.048)
Post-entry	0.042(0.032)	0.058(0.028)	0.030(0.034)	0.049(0.037)
Multi-unions: sep bargains	0.075(0.028)	0.060(0.030)	0.066(0.030)	0.034(0.035)
Local Unemp.	-0.234(0.267)	-0.120(0.233)	0.032(0.293)	-0.333(0.282)
Log L	-462.3	-1071.79	-396.4	-662.3
R^2	0.24	0.50	0.47	0.52
No. of plants	304	493	265	418

Notes to Table 7.3

1. Innovators are those plants where there was at least one advanced technical change affecting manual workers in the previous 3 years.
2. Estimates are by Maximum Likelihood grouped dependent variable estimation as described in Stewart (1983). This takes into account the open ended bands and the fact that some plant managers gave answers in more than one band.
3. The equations are in semi-logged form and the asymptotic standard error in parantheses.

Table 7.3 Advanced Technical Change and Wages -Cont.

	(1)	(2)	(3)	(4)
	UNSKILLED		**CLERICAL**	
	Innovators	**Non-Innovators**	**Innovators**	**Non-Innovators**
Constant	4.289(0.111)	4.348(0.102)	4.647(0.062)	4.470(0.072)
No.of employees:				
50-99	0.132(0.080)	0.012(0.047)	0.024(0.036)	0.024(0.031)
100-199	0.185(0.080)	0.028(0.051)	0.067(0.036)	0.062(0.036)
200-499	0.151(0.078)	0.092(0.055)	0.053(0.037)	0.038(0.041)
500-999	0.205(0.083)	0.168(0.065)	0.120(0.040)	0.005(0.060)
1000+	0.182(0.084)	0.067(0.082)	0.135(0.042)	0.197(0.059)
Manufng.	-0.071(0.048)	-0.007(0.064)	-0.044(0.024)	-0.062(0.030)
Single-site	-0.087(0.060)	-0.198(0.064)	-0.072(0.034)	-0.104(0.051)
UK Owned	-0.036(0.035)	-0.072(0.054)	0.065(0.024)	-0.104(0.051)
Emp Assoc.	-0.019(0.032)	-0.012(0.038)	-0.053(0.021)	-0.105(0.044)
PBR	0.029(0.032)	0.085(0.041)	0.026(0.032)	0.074(0.038)
Shiftwork	0.038(0.045)	-0.043(0.035)	0.013(0.025)	0.022(0.026)
Maj. male	0.233(0.044)	0.361(0.043)	0.197(0.027)	0.272(0.037)
Manual %	0.287(0.096)	0.206(0.076)	-	-
Non-Manual %	-	-	0.138(0.054)	0.093(0.058)
Part-time %	-0.743(0.152)	-0.765(0.100)	-0.308(0.070)	-0.473(0.061)
Female %	-0.153(0.110)	-0.099(0.102)	-0.244(0.067)	-0.106(0.060)
Skilled %	-0.196(0.117)	-0.334(0.107)	-0.009(0.070)	-0.120(0.062)
Clerical %	-	-	0.036(0.077)	-0.079(0.082)
Semi Sk. %	-0.267(0.081)	-0.283(0.093)	-	
Recognition	0.029(0.055)	-0.021(0.024)	-0.016(0.025)	0.030(0.032)
Closed Shop:				
Pre-entry	0.098(0.049)	0.094(0.064)	0.245(0.070)	0.082(0.031)
Post-entry	-0.003(0.038)	0.010(0.047)	0.033(0.027)	-0.087(0.085)
Multi-unions: sep bargains	0.039(0.033)	0.049(0.049)	0.024(0.026)	-0.032(0.039)
Local Unemp.	0.001(0.081)	-0.133(0.356)	-0.103(0.206)	-0.288(0.267)
Log L	-422.6	-871.1	-759.1	-536.8
R^2	0.45	0.49	0.35	0.39
No. of plants	276	499	563	400

Notes to Table 7.3-cont.

1. Innovators are those plants where there was at least one advanced technical change affecting manual workers in the previous 3 years in column (1) and vice versa in column (2). Innovators in column (3) contain plantswhere there was at least one advanced technical change affecting non-manual workers in the last three years.

Table 7.4 : Technological Mark-Ups

Panel A: Basic Mark-ups - Samples split by ATC

	(1) Table 7.3 Estimates	(2) Industry Dummies Included	(3) Regional and Ind. Dummies Included
Skilled	0.068(0.032)	0.072(0.025)	0.064(0.024)
Semi-skilled	0.046(0.027)	0.057(0.027)	0.052(0.026)
Unskilled	0.055(0.034)	0.064(0.033)	0.049(0.033)
Clerical	0.030(0.021)	0.028(0.021)	0.022(0.020)

Panel B Dummy Variable for ATC

	(1) No industry or regional dummies	(2) Industry dummies included	(3) regional and industry dummies included
Skilled	0.028(0.019)	0.037(0.018)	0.036(0.018)
Semi-skilled	0.007(0.021)	0.019(0.021)	0.022(0.020)
Unskilled	0.040(0.028)	0.058(0.027)	0.058(0.027)
Clerical	0.029(0.017)	0.024(0.017)	0.021(0.016)

Panel C ATC>12 (Advanced Technical Changes occuring 1-3 years ago)

	(1) Splits by ATC> 12; no dummies for ind or regs	(2) ATC>12 dummy + industry dummies	(3) ATC>12 dummy + regional dummies included
Skilled	0.029(0.032)	0.050(0.025)	0.047(0.024)
Semi-skilled	0.057(0.047)	0.016(0.028)	0.018(0.028)
Unskilled	0.005(0.051)	-0.006(0.038)	-0.001(0.037)
Clerical	0.003(0.026)	0.022(0.026)	0.019(0.025)

See overleaf for notes.

Notes to Table 7.4

1.% Mark-ups and standard errors (in brackets).

2. In Panel A mark-ups are calculated from the coefficients from regressions split into innovators and non-innovators sub-samples weighted by the means of variables in the non-innovating sub-samples. In column (1) the coefficients are from the regressions contained in Table 7.3. Column (2) adds 9 1 digit industry dummies to identical specifications and repeats the procedure. Column (3) adds both industry and 11 regional dummies.

3. In Panel B a simple dummy variable for innovation is used equal to 1 if there was an advanced technical change affecting manual workers (non-manual workers) in the manual (non-manual) pay equations.

4. In Panel C ATC>12 is equal to one only if the technical change in question certainly took place more than a year ago. The first column splits the sample into innovators and non-innovators, the second and third simply have a dummy variable for ATC>12.

TABLE 7.5 ADVANCED TECHNICAL CHANGE EQUATIONS

	(1)	(2)	(3)	(4)	
	Linear Probability Models		*Logit Models*		
ATC affecting:	Manual Workers	Non-Manual Workers	Manual Workers	Manual Workers	Marginal Effects
Effects					
Constant	-0.001(0.188)	0.065(0.212)	-3.253(1.149)	-7.267(1.987)	-1.678
ORGCH	0.110(0.039)	-0.022(0.040)	0.662(0.241)	0.656(0.242)	0.152
ORGCHNM	0.058(0.039)	0.108(0.038)	0.375(0.247)	0.316(0.250)	0.073
CONVCH	0.042(0.037)	0.008(0.038)	0.253(0.228)	0.231(0.229)	0.053
CONVCHNM	0.077(0.043)	0.012(0.042)	0.473(0.292)	0.456(0.295)	0.105
JCC	0.005(0.034)	0.025(0.033)	-0.047(0.219)	-0.067(0.220)	-0.015
Employees:					
50-99	-0.071(0.053)	0.012(0.047)	-0.623(0.405)	-0.656(0.406)	-0.152
100-199	-0.006(0.056)	0.125(0.052)	-0.052(0.397)	-0.082(0.400)	-0.019
200-499	0.088(0.058)	0.172(0.052)	0.459(0.390)	0.424(0.392)	0.098
500-999	0.199(0.064)	0.410(0.062)	0.941(0.422)	0.860(0.425)	0.199
1000+	0.393(0.067)	0.466(0.067)	2.124(0.458)	2.071(0.460)	0.488
DRISE	0.069(0.035)	0.010(0.035)	0.445(0.235)	0.467(0.236)	0.110
DFALL	0.013(0.050)	0.049(0.051)	0.004(0.333)	-0.041(0.333)	-0.009
ABOVE	0.003(0.033)	0.036(0.032)	0.068(0.219)	0.042(0.220)	0.010
BELOW	-0.109(0.056)	0.030(0.035)	-0.717(0.369)	-0.738(0.370)	-0.170
UK Owned	-0.088(0.045)	-0.117(0.043)	-0.506(0.281)	-0.473(0.283)	-0.109
Manual %	0.127(0.079)		1.063(0.567)	1.083(0.578)	0.250
Non-Manual %	-	0.213(0.083)	-	-	
Semi Sk. %	-0.010(0.084)	-	0.118(0.537)	0.206(0.538)	0.048
Skilled %	0.184(0.098)	0.098(0.089)	1.277(0.633)	1.280(0.634)	0.296
Clerical %	-	0.324(0.113)	-	-	
Recognition	0.093(0.040)	0.003(0.035)	0.757(0.292)	0.701(0.294)	0.162
Log Wages:					
Unskilled	-	-	-	0.813(0.328)	0.188
Dummies:					
Industry(9)	yes	yes	yes	yes	
Regional(11)	yes	yes	yes	yes	
R^2	0.36	0.264	-	-	
Pseudo R^2	-	-	0.320	0.327	
No. of plants	713	866	713	713	

Notes to Table 7.5

1. Col (1) and (2) are linear probability models, so ATC is estimated by OLS. Column (3) is by logit as is Column (4) with marginal effects following.

2. Marginal effects calculated as $\bar{p}(1-\bar{p})\hat{\beta}$ where $\bar{p}$ = observed probability of ATC and β is the estimated coefficient from the logit model.

TABLE 7.6 ARE TECHNOLOGICAL DIFFERENTIALS COMPENSATING DIFFERENTIALS?

	Earnings of manual workers directly affected by change					
	Management questionaire			Manual Workers representative questionaire		
	up	same	down	up	same	down
	0.29	0.67	0.04	0.30	0.63	0.07
Most Manual Workers affected by change: (proportions stating Yes for each change in earnings catergory)						
Are subject to more supervision	0.30	0.15	0.08	0.09	0.18	0.20
Have more responsibility	0.43	0.29	0.00	0.66	0.37	0.46
Have to work at a more skilled level	0.47	0.31	0.00	0.47	0.40	0.49
Have more control over pace of work	0.36	0.20	0.00	0.44	0.30	0.36
Have more control over how to do job	0.28	0.22	0.05	0.33	0.25	0.40
Have more interesting jobs	0.49	0.42	0.37	0.48	0.33	0.39
Have wider range of tasks to do	0.46	0.37	0.22	0.58	0.39	0.46
Sample Size unweighted (weighted)	138 (90)	347 (210)	16 (12)	108 (49)	186 (101)	24 (12)

Notes to Table 7.6
1. These are weighted sample proportions - weights used are related to plant size as WIRS oversamples larger plants (see Millward and Stevens, 1986).

Source: Machin and Wadhwani (1992)

Table 7.7 - How Technological Payoffs Differ with Union Status

	(1) Skilled	(2) Semi-Skilled	(3) Unskilled	(4) Clerical
Panel A Comparing Effects of Technical Change in Union vs. Non-Union Sectors				
Advanced Technical Change Coefficients				
Union Sector	0.043(0.023)	0.010(0.025)	0.062(0.030)	0.020(0.024)
No of Plants	488	399	428	431
Non-Union Sector	0.003(0.044)	-0.009(0.052)	0.015(0.073)	0.035(0.29)
No. of Plants	208	191	249	466
Computer Used at Workplace Coefficients				
Union Sector	0.042(0.021)	0.053(0.022)	0.055(0.027)	0.033(0.020)
No of Plants	477	390	416	425
Non-Union Sector	0.016(0.032)	0.033(0.037)	0.036(0.050)	-0.037(0.024)
No. of Plants	203	187	245	457
Youthfulness of Plant Coefficients				
Union Sector	0.068(0.022)	0.088(0.024)	0.038(0.029)	0.033(0.020)
No of Plants	477	390	416	425
Non-Union Sector	0.080(0.032)	0.018(0.037)	0.068(0.050)	0.027(0.024)
No. of Plants	203	187	245	457
Panel B Union Density and Closed Shop Interactions (Union Sector only)				
Den100	0.084(0.029)	0.044(0.033)	0.061(0.037)	-0.019(0.041)
ATC*(Den100)	0.008(0.030)	0.008(0.079)	0.048(0.037)	-0.012(0.057)
ATC*(1-Den100)	0.084(0.033)	0.010(0.036)	0.072(0.043)	0.022(0.026)
No of Plants	488	399	428	431
Closed Shop	0.088(0.029)	0.063(0.033)	0.045(0.037)	-0.062(0.035)
ATC*(Closed Shop)	0.024(0.027)	-0.002(0.030)	0.048(0.034)	0.087(0.035)
ATC*(1-Closed)	0.079(0.039)	0.028(0.044)	0.079(0.051)	-0.020(0.029)
No of Plants	488	399	428	431

Notes to Table 7.7
1. Panels A and B are the same Maximum Likelihood estimates as Table 7.3 with an interaction term. There are no additional union measures other than the ones tabulated.
2. Sample size differs in Panel A because of missing values on density.
3. Den100 is a dummy variable equal to 1 if all manual workers are in a union and zero otherwise; Closed Shop = 1 if there is a post or pre entry closed shop, zero otherwise.

Skilled Workers in Union Recognised Plants

Bargaining over Redundancy Pay?	No	Yes
Closed Shop	0.041(0.042)	0.114(0.042)
ATC*(Closed Shop)	0.064(0.048)	0.011(0.032)
ATC*(1-Closed)	-0.019(0.059)	0.126(0.054)
Industry Dummies	No	No
No of Plants	194	289
$\chi^2(1)$ test of the equality of the interaction terms	1.296	3.79

TABLE 7.9: THE INCREASE IN INEQUALITY

Earnings Dispersion for Male Full-Time Employees aged 16-64

	S.D. Log Real Earnings	90-10
1974	0.437	0.980
1975	0.429	0.976
1976	0.429	0.970
1977	0.418	0.928
1978	0.412	0.942
1979	0.408	0.948
1980	0.424	0.978
1981	0.440	1.023
1982	0.443	1.028
1983	0.436	1.040
1984	0.493	1.109
1985	0.505	1.138
1986	0.505	1.133
1987	0.535	1.214
1988	0.525	1.175

Changes in Weekly Pay and Proportions employed 1984-88

	1984			1988			1984-88
	Pay	**S.D**	**%Employed**	**Pay**	**S.D.**	**% Employed**	**Pay Growth**
Non-Manual:							
Professional	119.15	74.60	16.1	147.91	91.90	18.1	24
Non-Professional	59.78	36.17	36.8	74.00	51.56	38.1	24
(Clerical)	51.36	26.32	18.9	63.94	37.49	24.5	13
Manual							
Skilled	75.30	33.24	21.3	90.34	41.36	19.1	20
Semi-Skilled	45.41	27.87	18.6	55.39	37.07	17.6	22
Unskilled	34.98	26.85	7.3	40.89	35.6	7.1	17

Source: Schmitt (1992)

Notes to Table 7.9
These figures are for all employees from the General Household Survey

Appendix 7.1:

Simultaneity Bias in the Wage-Innovation Equations

Recall from equations (7.3) and (7.4) that the wage and innovation equations for each of the skill groups can be written (ignoring all other variables for simplicity) as

$w_i = \alpha ATC_i + \varepsilon_{1i}$ and $ATC_i = \gamma w_i + \varepsilon_{2i}$, or in terms of wages as

$w_i = (1/\gamma)ATC_i - (1/\gamma)\varepsilon_{1i}$. Now our estimate of α is essentially

$$\hat{\alpha} = \frac{\sum ATC_i w_i}{\sum ATC_i^2} = \alpha + \frac{\frac{1}{N}\sum ATC_i \varepsilon_{1i}}{\frac{1}{N}\sum ATC_i^2}, \text{ and}$$

$$\text{plim } \hat{\alpha} = \alpha + \frac{\text{plim} \frac{1}{N}\sum ATC_i \varepsilon_{1i}}{\text{plim} \frac{1}{N}\sum ATC_i^{2}}$$

The numerator of the second term of plim $\hat{\alpha}$ should be zero for consistency but of course is not. We can substitute out for wages in the simultaneous equations to write ATC_i as:

$$ATC_i = \frac{\varepsilon_{1i} + (1/\gamma)\varepsilon_{2i}}{1/\gamma - \alpha}$$

Under the assumption that the error covariance term, $\sigma_{12} = \text{cov}(\varepsilon_{1i}, \varepsilon_{2i}) = 0$, we can write the numerator as $(1/\gamma - \alpha)^{-1}(\sigma_1^2 + (\sigma_2/\gamma)^2)$. The denominator also converges to its expected value, namely,
$(1/\gamma - \alpha)^{-2}(\sigma_1^2 + (\sigma_2/\gamma)^2)$. Therefore,

$$\text{plim } \hat{\alpha} = \alpha + (1/\gamma - \alpha)\left(\frac{\sigma_1^2}{\sigma_1^2 + (\sigma_2/\gamma)^2}\right)$$

The bias associated with the failure to take simultaneity into account will depend on γ since α is almost certainly positive. If $\gamma < 0$, as would be the case if a particular type of labour was complementary to new technology, then $\hat{\alpha}$ is biased towards zero, and we can take our estimates as lower bounds. If $\alpha > 0$ (labour a substitute for new technology) then the sign of the bias is ambiguous. For small γ relative to α we would expect it to be positive, so we will be overestimating the true values of α.

APPENDIX 7.2

THE ULPH MODEL: BARGAINING OVER R&D

The specific model is as follows. Contrast two types of union bargaining model, in one '*ex post bargaining*' the firm and union bargain over wages and employment at the second stage of the game and the firm invests in R&D at the first stage. As a result of the investment stochastic innovations occur and the bargainers bargain on the basis of these. In the second model there is *ex ante* bargaining and the union is involved in a fully efficient bargain[32] at stage one as well. Let us make the following simplifications to the model of chapter 6:

(1) Technology: q_i units of output require q_i^2/A units of labour, N.

(2) Oligopoly: Cournot duopoly in the product market.

(3) Demand: Linear demand of the form $P = M - Q$, $Q = q_1 + q_2$.

(4) Union contribution to the Nash Bargain is the usual $(W - \tilde{W})N^{\psi}$ and the Nash Maximand itself is $\underset{(W,N)}{MAX}\,\Omega = \Pi^{\beta}(W - \tilde{W})N^{\psi}$.

Solving this for W and q (implicitly for employment) gives a wage function of the form:

$$(7.1) \qquad W = \frac{(2\psi + \beta)\tilde{W} + A}{2\psi + \beta - 1}$$

So clearly under ex post bargaining the wage is a positive function of technology (A), union power ($1/\beta$) and the alternative wage ($\tilde{W}$). It is decreasing in the union's risk aversion parameter (ψ). This is essentially a special case of the results in the previous chapter

To consider ex ante bargaining the nature of innovation must be

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[32]The wage results hold for the right-to-manage model so nothing of substance hinges on this.

specified. Assume there is an R&D tournament to discover a new technology C which is superior to the existing technologies used by the firms (firm one uses A and firm two, A'). Firms invest in R&D by choosing a hazard rate, q and h for firm 1 and 2 respectively, which determines the probability of winning the race in each period. Assume further thatthe expenditure to obtain a hazard rate q is q^2. There are therefore three states of nature: state 0 when neither firm has won, state 1 when firm 1 has won and state 2 when firm 2 has won. Denote the different states by the subscripts k = 0, 1, 2. Let Π_k (U_k) be the flow rate of profits (utility) in state k. Then if the hazard rates chosen are q and h is is easy to show that the present values of profit (utility) from the above flows are:

$$\hat{\Pi} = \frac{q\Pi_1/r + h\Pi_2/r + \Pi_0 - q^2}{q + h + r} \qquad \hat{U} = \frac{qU_1/r + hU_2/r + U_0}{q + h + r}$$

The flow rates of profit which give the same expected present value are $r\Pi$, and rU, where r is the common interest rate.

The Nash Bargain at stage one is $\underset{(q,W,N)}{\mathrm{MAX}} \log(rU) + \beta\log(r\Pi)$. Solving for wages and substituting in the wage and profit functions from stage 2 enables the wage to be written as:

$$W = \frac{(2\psi + \beta)\tilde{W} + \bar{A} - rq^2/N^e}{2\psi + \beta - 1}$$

$N^e = qN_1 + hN_2 + rN_0$, expected employment and $\bar{A} = [qN_1C + hN_2A + rN_0A]/N^e$, an employment weighted average of productivity.

There are at two interesting things to note about this wage equation:

(1) it is independent of state k : the bargain smooths out the potential utility gains over the three states. We would not therefore expect to see

as big a wage hike from the firm winning the patent race as we would under ex post bargaining[33].

(2) We can see that the difference in the two wage equations relates to two things:

(i) the shared cost of R&D expenditures under ex ante bargaining ($r\varphi^2$). This is the 'cost sharing' effect of ex ante bargaining. The union bears $r\varphi^2/(2\psi + \beta - 1)$ of the R&D costs: thus the *stronger* the union the greater the R&D costs it will have to bear and the *lower* will be the wage for any given technology.

(ii) The fact that actual productivity is replaced by average productivity. This is the 'risk spreading' aspect of ex ante bargaining.

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[33] Formally this is symmetric to the wage rigidity result of first generation implicit contract models. Note also that we cannot make any general statements about the relative size of the wage in states 0 and 2

CHAPTER 8

CONCLUSION

Innovation is at the heart of competitiveness

Michael Heseltine, *The Independent*, 9 June 1992

Product and process innovation will affect both the nature of technology and the set of goods available , and as such technological change fundamentally affects economic behaviour. However it is not fundamental to the writings of most economists.

Paul Stoneman, *Social Sciences* July 1992

We have the bullets now

Public Service Manager on union opposition to technical change in 1980s (Northcott et al, 1985)

Economists are notoriously conservative creatures. Part of this conservatism derives from the natural desire of all social scientists to construct models that escape history, that are in principle applicable to the deep structures of capitalist societies. Although natural, the objective of ahistoricity has often blinded the profession to distinct *phases* in the evolution of modern industry. The era of unbridled competition between a multiplicity of small entrepreneurial firms if it existed at all, had by the 1970s given way to an economy characterised by huge firms in concentrated markets facing the countervailing power of trade unions. This was especially true of British manufacturing. It seems that in the late Twentieth Century we may be entering a new historical phase, a post-modern epoch. In a remarkable intellectual convergence, many writers speak of 'disorganised capitalism', 'Post-Fordism' and 'flexible specialisation' to distinguish the new socio-economic ecology of the 1990s (see Wood, 1989, for example). A common characteristic of these accounts is that markets have become radically unstable and competition is increasingly centered on extreme product differentiation and the acceleration of innovative capacities. The investigations in this study span the purported transitionary period and so made it imperative that our theoretical framework combined innovation with union-oligopoly bargaining.

So much for the macro-sociological background. What are the main empirical regularities thrown up by the study and their theoretical and political implications? The primary regularity is that innovation in British manufacturing increases profitability, employment and wages. These benefits are moderately large, persist over several years and seem quite robust to controls for fixed effects, heterogeneity and product and labour market

TABLE 8.1 THE EFFECTS OF INNOVATION ON PROFITS, EMPLOYMENT AND WAGES

% Short Run and Long-Run Effects of Innovation

		Union only		Whole Sample	
		Short-Run	**Long-Run**	**Short-Run**	**Long-Run**
Profits/Sales (SPRU)		-	-	3.8	16.5
Employment (SPRU)		3.8	12.3	8.9	40.0[1]
Wages (SPRU)		1.7	5.0	0.5	3.6
Wages (WIRS)	- **Skilled**	7.6	-	6.8	-
	- **Semi-Skilled**	7.0	-	4.6	-
	- **Unskilled**	7.7	-	5.4	-
	- **Clerical**	3.0	-	2.7	-

Source: SPRU innovation effects are calculated as (coefficient/mean)*100%; WIRS mark-ups compare plants in 'innovative sector' to those in 'non-innovative sector' (see Chapter 7.3). Table 4.2 column (3); Table 5.4 columns (3) and (6); Table 6.3 column (2), Table 6.4 column (4); Table 7.3, Chapter 7 fn 13.

[1]The very high employment effect is due to the mean of log employment being much lower in the general sample. It was 0.312 compared to 0.892 in the union sector. The equivalent figures for log wages were 8.75 and 8.79.

structure. Table 8.1 summarises the estimated short and long-run effects. Admittedly, these are partial equilibrium results, but it seems likely that in general equilibrium the benefits of technical change are *larger* as we have not been able to account for all the spillover and survivor biases. The results contradict the argument that British economic difficulties in the 1980s were caused by a gale of innovation sweeping through the economy - in fact quite the opposite would seem true.

The success of innovative firms over their non-innovative counterparts is only partly due to their commercialisation of invention per se. Chapter 4 argued that there are permanent and deep-rooted differences between the two types of firms reflected in innovators' consistently higher profit margins. These firms were able to shield themselves from the worst effects of the severe early 1980s recession which hit all firms in all product groups very hard (Chapter 3). As the ability of firms to enjoy collusive prices declined (in line with most supergame predictions) the rent-generating capacity of the high-tech firms increased. This may be due to the decreased ability of unions to capture the benefits of innovation and high market share as the balance of economic power swung towards capital. Whereas the correlation between profitability, innovation and market share increased in the early 1980s (Table 3.1, Table 4.1) the technological wage mark up was no longer evident in union firms (Table 6.5). An important question for future research is whether the effects were reversed in the subsequent upturn or whether we have actually moved into a new regime where managers are fully in the driving seat.

What is certain is that union presence has enabled workers to share directly in the benefits of technical change. This appears mainly in the form of higher wages as unions do not seem to be bargain over jobs (Chapter

5). No significant innovative mark-up could be detected outside the union sector regardless of whether we used the SPRU headcount of major new products and processes or the WIRS definition of plants which adopted new microelectronic technology. The innovative wage mark-up could not be explained away in conventional competitive terms either by short-term labour supply frictions, compensating differentials or skills upgrading. For example, in Chapter 6 (Table 6.3) innovation appeared to have no effect on average wages once we conditioned on profits per capita (as a measure of firm-specific rents). Whilst an obvious corollary of a bargaining model, this seems difficult to reconcile with a purely competitive story. Chapter 7 did reveal, however, that skilled workers gained the largest technological differentials and this may give some credence to the micro-electronic theory of rising wage inequality.

These empirical regularities offer support for a model where the rents generated by oligopolistic power and innovation are shared with workers if organised in trade unions. Well determined effects of product market power (market share and concentration) on price cost margins were detected in Chapter 3 and the same was true for counts of innovation in Chapter 4. One finding which fitted less neatly in this framework was that the wage pay-off to innovation declined at high levels of union density. This seemed to be best explained by the theory that unions smooth the gains of new technology over other groups of workers, other non-wage benefits and over time.

Policy has not been a major focus of this study, although the analysis does have political implications. First and foremost, innovation appears to have substantial benefits not only for consumers in terms of lower prices and enhanced product quality but also for the firms who enjoy higher profit margins and their workers who, on average, enjoy higher pay and greater job security. It vindicates the emphasis of many who stress technological outputs (rather than just R&D inputs) as crucial to prosperity. One must recall, however, that it is the process of innovation which may be at work reinvigorating the constitution of the firm rather than the innovative output per se and therefore the promotion of these *types* of firm is the crucial issue.

An organisational feature of the most successful firms were is that they both innovated and had strong unions. The "promiscuous expropriation" (Simons,1944) of technological rents by workers does not necessarily mean that incentives to innovate fall with union power. Much hinges on the precise nature of strategic interaction between firms. Stronger unions who engage in long-term contracts may actually boost technological advances. Quantitatively, no significant effects were discovered from unions on the propensity to innovate in the WIRS data in Chapter 7. Powerful unions appear to have moderated their wage claims in these companies and establishments compared to innovators with a lower level of union presence, and this seems especially true for workers with higher levels of human capital. Since the world is moving into a phase of capitalism characterised by greater shocks (at least at the level of national economies integrated in a global market) the evolution of 'shock-absorbing' companies seems vital to economic prosperity. In such a world, the belief that union power is antipathetic to innovative success and flexibility (as epitomised by the quote from the public service manager above) seems very outmoded.

Identifying some of the correlates of success is different from isolating the causes of it. An important area of future research is the specification of the causal mechanisms linking new technologies and economic strength at the micro level. This will need to go further in dilineating the different stages of the innovative cycle beyond the innovation and diffusion stages analysed here back to the process of R&D. One must ask what *aspects* of union organisation mediate between the occurrence of innovation and the transmission into wages, jobs and prices? What particular institutions and contracts bolster the greater flexibility of innovators? One possibility is that there may be some kind of implicit long-term contracting over technology between the firm and the workforce as noted in Chapter 7. The existence of these super-strongly efficient contracts has been given as a reason for the success of the Japanese economy by the Ulph brothers (1992) and deserves a more careful consideration.

A second and related avenue of future research follows naturally from the question: *'You claim to have found that innovation has benefits for profits, jobs and pay. Fine. But how can I get more innovation?'*
Union strength by itself does not seem an obstacle, but the only way to directly tackle the question is to explicitly solve the game of Figure 1.1 for innovation and begin estimating 'innovation equations'. The rarity of SPRU innovations in the firm panel makes the question harder to answer, but by extending the panel backwards through time and sideways into non-manufacturing we could gather a large enough sample to looks seriously at the problem of poor innovative performance, one of the perennial malaises of British industry. Given the importance of cyclical factors in many of the chapters, the issue of whether recessions cleanse or permanently scar the ability of firms to make technological advances would be a primary concern.

Finally, the evidence of the last chapter suggested that the fruits of innovation are shared very unequally among different classes of workers. In particular skilled workers in the 1980s appeared to gain much higher pay (and employment) increases than their less skilled counterparts, especially in the non-union sector. Whether this can account for any substantial part of the dramatic increase in wage dispersion (as appears to be the fashionable view in the United States) remains to be seen. Given that there was some evidence that unions redistributed technological rents in Chapter 7, the interaction between union decline and microelectronic change may be the fundamental driving force behind escalation of inequality in the 1980s. A thorough comparison of the 1990 Workplace Industrial Relations Survey with the one analysed here would be a major step in confronting this controversial claim directly with the data.

Marx's characterisation of the capitalist by his compulsion to 'accumulate, accumulate, accumulate' has, in recent times, been displaced by the Schumpeterian command to 'innovate, innovate, innovate'. Whether policy-makers can put their money where their mouths are and encourage the emergence of organisations which can deal creatively with uncertainty, institutionalise the ongoing technological revolution and so navigate the epochal shifts between historical conjunctures is an entirely different matter. Failure to do so will certainly be at the expense of wages, employment and profitability and give Britain one further push towards entering the ranks of the semi-industrialised nations - from the wrong direction.

Data Appendix

There are two main databases for the thesis. One was compiled by the author and is analysed in Chapters 3, 4, 5 and 6. The other is the 1984 Workplace Industrial Relations Survey. I describe the data construction for each chapter separately and sequentially.

Chapter 3

The primary source accessed is the DATASTREAM databank of company accounts which holds information on quoted firms from the late 1960s onwards. I also drew on information from the EXSTAT database which covers essentially the same sample of companies. Manufacturing firms who had at least 9 years of continuous records between 1972 and 1986 were selected. These firms are classified to 50 industrial groups in the EXSTAT database which we used as the basis to match in various industry-level variables.[2] The data actually runs from 1970 onwards (and the panel balance is based on this) but information in 1970-71 was not used because there were few firms who were in the database in these early years.

Concentration, import penetration and industry sales were matched in using the schema in Table DA1 (which is similar to that given in Nickell and Kong(1989). Union density and industry unemployment were matched in at a more aggregated two digit level as in Table DA2. Table DA3 has the definitions and sources of all variables. Note that PRODUCER GOODS are groups 14-34; CONSUMER DURABLE GOODS are groups 35-44; CONSUMER NON-DURABLE GOODS are groups 45 to 65; OTHER GROUPS are 66-69.

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[2]After 1980 DATASTREAM began reporting the (multiple) industries where firms operated whereas EXSTAT has codes throughout the sample period, but only for the firm's principle operating industry.

TABLE DA1: EXSTAT INDUSTRIAL MATCHING

EXSTAT	Description	MLH(1968)	SIC(1980)
11	Industrial materials	order VII	32
12	Brick and roof tiles	461,469(2)	241,245,248
14	Building Materials	469	243,244
15	Cement and Concrete	469(2),464	242,243
16	Paint	274	255
17	Timber	471	461,463
19	Electricals (Excluding radio and TV)	order IX	34
20	Cold Formed Fastening	399	316
21	Founders & Stampers	313,322,393	311,312
22	Industrial Plant	333,339(3,4) 339(9),349(2,3)	328
23	Mechanical Handling	336,337,339(1)	325
24	Pumps and Valves	333,339(3,4) 339(9),349(2,3)	328
25	Steel and Chemical Plant	461,469(2)	241,245,248
26	Wires and Rope	362	341
27	Misc. Mechanical Engineering	order VII	32
28	Machine Tools	332,390	322
29	Misc. engineering Contractors	333,339(3,4) 339(9),349(2,3)	328
30	Heating & Ventilation	368	346
31	Instruments	323,354	224

32	Metallurgy	321,322,323	224
33	Special Steels	311	221
34	Misc. Metal Forming	323	222,223
35	Electronics	363-369	34
36	Radio and TV	364,365(2),368	342,246
37	Floor Covering	419	438
38	Furniture & Bedding	472,473,474	467
39	Household Appliances	368	346
40	Cutlery	order XII	31
41	Motor Components	381	351-3
42	Motor Distributors	381	351-3
43	Motor Vehicles	381	351-3
44	Security & Alarm Services	363-369	34
45	Breweries	231,232-39	424,426-9
46	Wines and Spirits	231-39	424,426-9
49	General Food Mnfg.	211-29	411-23,428
50	Milling and Flour	211-13	416,419
52	Newspapers & Periodicals	485-86,489	475
53	Publishing & Printing	485-86,489	475
54	Packaging and Paper	481-84	471-72
59	Clothing	441-9	453
60	Cotton and Synthetic	order XIII*	43
61	Wool	order XIII*	43
62	Miscellaneous Textiles	order XIII*	43
63	Tobacco	240	429
64	Footwear	450	451
65	Toys and Games	494	494
66	Plastics and rubbers	492,496	483

67	Pharmaceuticals	272	257
68	General Chemicals	271,276,278	251,256
69	Office Equipment	338,366	330

* Excluding MLH 411,422(1,2),429(1)

Table DA2 Two Digit Industrial Matching

Industry Code	Industry Definition	EXSTAT Group
1	Bricks and Glass	12,14,15,25
2	Mechanical Engineering	11,22,23,24,27,29
3	Chemicals	16,67,68
4	Timber	17,38
5	Electrical Engineering	19,26,30,35,36, 39,44,67
6	Metal Manufacturing I	20,21,28,40
7	Instrument Engineering	31
8	Metal Manufacturing II	32,33,34
9	Carpets	37
10	Vehicles	41,42,43
11	Food, Drink and Tobacco	45,46,49,50,63
12	Paper and Printing	52,53,54
13	Clothing	59,60,61,62,64
14	Other Manufacturing	65,66

Table DA3: Variables Used in Chapter 3

Mnemonic	**Definition**	**Source**
Π	Trading profits; Net profits derived from normal trading activities before tax and interest payments	DATASTREAM Item 21
R	Total sales revenue	DATASTREAM item 104.
INDSALES*	Total sales and work done	Table P1002a, Census of Production (C of P)
CONC*	5 firm sales concentration ratio Where a DATASTREAM industry comprised two or more SIC industries, the SIC industry CONC was weighted by industry sales.	Table P1002a, C of P
IMPS	Imports/Home Demand weighted by output weights.	Table MQ12 , Business Monitor
IDENSITY	Industry union density across 15 2-digit industries.	Price and Bain (1983) Updated using WIRS.
PRICE	Aggregate producer prices base 1985	Monthly Digest of Statistics
MS	UK Sales ÷ INDSALES	

*Since there was no data for 1974, CONC and INDSALES in this year were taken as the average of 1973 and 1975.

Sample Selection Criteria

Industries 21 (a "miscellaneous" category) and 23 were excluded from the final analysis due to matching problems (there was a large discontinuity in 1980 following the switch to the SIC(1980) classification). An additional problem with the construction of MS (market share) was that some firms operate in multiple industries. Thus, our measure of MS may be biased upwards as the denominator is sales from the principle operating industry. The tobacco industry (group 63) was excluded from the final sample due to this reason (it is dominated by BAT Industries). Industries 20 and 65 had large attrition problems and were dropped from the analysis.

We also dropped firms whose sales or profits figures exhibited such large change that they were certainly due to large scale merger activity. Companies whose accounting dates could not be clearly placed in sequential years were also dropped. After the selections had been made we were left with 709 firms who were allocated to 45 industries. The balance of the panel is shown in Table DA4

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TABLE DA4 : BALANCE OF PANEL (CHAPTER 3)

No. of Years	No. of Companies
9	27
10	20
11	45
12	39
13	49
14	72
15	197
16	41
17	219
Total	709

CHAPTER 4

The primary datasource was based upon the firm level panel described above. The Science Policy Research Unit's Database of Innovations was then matched in. This dataset is lodged at the ESRC data archives and is composed of (in principle all) 4378 significant technological innovations commercialised in British industry between 1945 and 1983. Over 400 experts from industry, science and academia were contacted and asked to locate (in their field) what they thought the most important innovations had been since the Second World War and which companies had commercialised them. The companies were then contacted and further information was gathered on technical specifications and some economic features of the company (such as firm size). The whole process of telephone and postal surveys took place over a period of fifteen years.

SPRU innovations are defined by a code for the innovating unit where they were developed and the 'parent code' of the company to which the unit belongs. Often these are the same. I attempted to match each company in the accounts dataset to a SPRU company by name. I had to check that some of the innovating firms were not subsidiaries of our DATASTREAM firms by using 'Who Owns Whom'. All innovations in subsidiaries were counted as innovations for a particular parent firm. If a DATASTREAM firm could not be matched to a SPRU code it was assumed that the firm had not innovated.

The industry level information was matched in a different way. The SPRU data contains information at the four digit level as to the location where an innovation was first produced and where it was first used. These were aggregated and summed these across fourteen two digit industries and then matched into the dataset using the schema in Table DA2. A higher level of aggregation was chosen to capture spillovers from a large a group as possible, but also for reasons of economising on labour time. Industry Research and Development intensity was matched in using Table DA1.

Table DA5 Variables for Chapter 4

Mnemonic	Definition	Source
INNOV	Count of the number of innovations for a particular firm (and all its subsidiaries)	SPRU Datatape
IPI	Total Innovations produced in 2 digit industry	SPRU Datatape
IUI	Total Innovations used in 2 digit industry	SPRU Datatape
R&D	Research and Development costs over industry sales. Figures lineraly interpolated for missing years	Business Monitors Tables M014 1972,1975, 1978,1981,1985

Sample Selection

The sample selection is exactly the same as Chapter Three except that we only have data up until 1983 and we relax the panel restriction, allowing any firm that has seven or more continuous observations to be included within the sample.

Table DA6 : Balance of Panel (Chapter 4)

No. of Years	No. of Companies
7	10
8	7
9	19
10	44
11	69
12	539
Total	721

CHAPTER 5

Datasets used

The prime data source for this chapter is an unbalanced panel of 603 firms 1976-83. It was created by matching several data sets together:

(i) Firm accounts from the DATASTREAM on-line service and EXSTAT records of company accounts. EXSTAT information was used based on a datafile given to me by Mark Walsh and Sushil Wadhwani. The sample selection criteria are the same as chapter 3 except any firm which had at least six consecutive records was included.

(ii) The Science Policy Research Unit's dataset of 'significant technical innovations in the UK' as described in Chapter 4. (iii) Three different surveys of union presence were used as conducted by Sushil Wadhwani, Steve Machin and Paul Gregg. Measures of recognition and firm density were taken from these are held to be fixed effects over the sample period. This is a reasonable assumption to make since there were very few de-recognitions in 1979-83 (Claydon, 1990) There are two problems with the matching of the firm level union density. First, Gregg 's survey was conducted in 1990 and asked retrospective questions whereas the other two were conducted in 1987. In a small number of firms in Gregg's survey data was only available for 1990, so this figure was used. Increasing these figures by 1.5% (the average decline in these firms 1987-90) made no difference to the results. Second, the figures in Wadhwani are banded 0-25, 25-50, 50-75, 75-100. We were forced to allocate values to midpoints for these firms.

The basic dataset has 154 firms with recognised unions in at least some parts of the company. We have density data on 134 of these firms. If we use only (i) and (ii) then we have access to a larger panel of 603 firms. The variables used in this dataset which have not been already described are in Table DA5 and the balance of each of these panels is in Table DA6.

Table DA7 Variables for Chapter 5

Mnemonic	Definition	Source
W_i	Real Wage; Average renumeration in firm deflated by an aggregate product price index	DATASTREAM item C16 EXSTAT item 214
$\bar{W}_j$	Industry Wage; Average real wage in 2 digit industry	
U	Aggregate Unemployment	Economic Trends
W	Aggregate real wage	Annual Supplement
$\tilde{W}_j$	Alternative Wage; $(1 - U)^* \bar{W}_j + U^*$(benefit rate)	
IUN	Industry Unemployment at 2 digit level	
UNION	Firm specific union density	Surveys by Gregg, Machin and Wadhwani
N_i^3	Total no. of UK employees	DATASTREAM item 216 EXSTAT item C15.
K	Capital is the historic cost of capital assets in land/building, plant/machinery and other fixed assets deflated by an investment goods price deflator.	DATASTREAM items 327, 328 and 329
ICOVER	Proportion of 2 digit industry covered by major industry-wide collective	Unpublished Dept. of Employment data supplied by Martin Conyon

[3] Until July 1982 companies were required to disclose the number of UK employees and UK renumeration. As from this date, the requirement was for group totals only. However DATASTREAM report figures for those firms with no overseas activities. This explains the fall-off in the sample after this date.

Figure DA8: Balance of Panel (Chapter 6)

The panel balance is given below.

No. of records	6	7	8	total
No. of Firms	145	347	111	603
No. of Firms	32	80	42	154
No. of Firms	23	72	39	134

Figure DA9: Number of Companies by Year

Companies By Year

	N = 154		N=603
	No. of Firms	No. of Innovators	No. of Firms
1976	121	18	315
1977	130	25	580
1978	154	25	603
1979	154	25	603
1980	154	25	603
1981	153	25	602
1982	136	22	560
1983	66	5	321

Chapter 6

Identical datasets to those in Chapter 5 were used in this chapter. Capital-Labour Ratio and Profits per head were simply ratios of the variables already defined.

Chapter 7

Three Workplace Industrial Relations Surveys have been carried out in 1980, 1984 and 1990 under the supervision of the Economic and Social Research Council, the Department of Employment, the Advisory Conciliation and Arbitration Service and the Policy Studies Institute. The 1984 survey used the 1981 Census of Production for its sampling frame and the 1990 survey used the 1987 Census. There were 2019 and 2049 plants with 25 or more employees in the respective surveys. Large establishments were deliberately over sampled to guarantee their presence and a weighting system was devised to allow for this. The results in this chapter are mainly taken from the managers' questionnaire. More details can be found in Millward and Stevens (1986).

Due to the large number of variables used in this chapter, we summarise them not in a single table but by thematic group.

1. Wages

The dependent variable is coded into 10 bands for the typical pay of a worker in the majority sex group. The cut-off points for these bands were £35,£59,£78,£97,£116,£136,£155,£193,£231,£290 the intervals being open ended at the top and bottom. Managers were allowed to tick multiple intervals and the maximum likelihood estimation allows for this. Midpoints were allocated for the raw technological mark-ups in Table 7.2 (the bottom catergory was allocated to £39 and the top to £290).

The wage question is asked to senior managers for each of five skilled groups. We do not use the 'supervisors, foremen and forewomen' catergory because of ambiguity surrounding their white collar-blue collar status. The clerical group includes secretarial and administrative staff. The manual groups are for skilled, semi-skilled and unskilled workers, the exact definition was left open to managerial interpretation so there is some scope for ambiguity especially amongst the semi-skilled group.

2. Technological Variables

For manual workers the question was *Changes made during past three years directly affecting the manual workforce:*

	YES	NO
(i) New Plant involving microelectronics	ADCH=1	ADCH=0
(ii) New plant not involving microelectronics	CONVCH=1	CONVCH=0
(iii) None of these.	ORGCH=1	ORGCH=0

For non-manuals the question was *Changes during past three years affecting clerical/secretarial/administrative/typists:*

	YES	NO
(i) Word Processing or computer applications	ADCHNM=1	ADCHNM=0
(ii) New Machinery or equipment	CONVCHNM=1	CONVCNNM=0
(iii) Other Changes	ORGCHNM=1	ORGCHNM=0

The variable we use for innovation is ADCH for the manual pay equations and ADCHNM for the non-manual pay equations. We sometimes refer to them as ATC for Advanced Technical Change.

After the *Changes in the last three year....* question managers were asked about the *Recency of the last major change* and asked to tick one of eight possible time bands. If the 12-18 months ago, 18 months - 2 years ago or 2-3 years ago bands were ticked *and* ATC had occurred then ATC>12=1 and 0 otherwise. There are two possible sources of missclassification here. First, a plant which has had ATC in the last year and in the previous 2 years would be classified to no technical change. Second, a plant which only had

ADCH 1-3 years ago but had some other sort of change in the last year would also be classified to zero. Since more recent changes are likely to have larger positive effects on the current wage level these missclassifications will bias the coefficient on ATC towards zero.

Variable	**Definition**
ADCH	Advanced Technical change affecting manual workers
ADCHNM	Advanced Technical change affecting non-manual workers
ATC	Advanced Technical Change; Shorthand for ADCH and ADCHNM.
ATC>12	Advanced Technical Change taking place between 1-3 years in the past.
CONVCH	Conventional Change affecting manual workers
CONVCHNM	Conventional Change affecting non-manual workers
ORGCH	Organisational change affecting manual workers
ORGCHNM	Organisational change affecting non-manual workers
COMPUTER	Dummy variable equal to one if the plant has on-site main frame, micro, or mini-computer. Also equals one if there is a limk to another computer in the organisation
PLANT<25	The plant has been engaged in the production of its main product or service for less than 25 years

3. Union Variables

These were all asked separately for manual and non-manual workers.

Den100	Dummy variable equal to 1 if all manual (non-manual) employees are in a trade union. Density calculated from detailed breakdowns by male, female part-time, etc. So there are more missing values on this variable than on the recognition variable.
RECOG	*Are any unions recognised by management for negotiating pay and conditions for any sector of the workforce in this establishment?* This question was only asked if there were some workers who were members of a trade union.
CLOSED	Closed shop. *Do the manual* (non-manual) *workers at this establishment normally have to be members of a union to keep their jobs?* If the answer to this was Yes, all or Yes,some then CLOSED=1
PRE	Pre-Entry Closed Shop. *Do recruits for any of the jobs covered by this closed shop agreement have to be union members before starting work.* If the answer to this question is yes,all or Yes,some and CLOSED=1 then PRE=1
POST	Post-Entry Closed Shop: CLOSED - PRE.
MULTSEP	There is more than one union recognised for bargaining purposes and managers answered Separate Negotiations to the question *Whether representatives of manual* (non-manual) *unions negotiated separately.*

4. Control Variables in Wage Equations

No. of Employees	These were grouped into 6 bands 25-49, 50-99, 100-199, 200-499, 500-999, 1000+. The base catergory is 25-49 as no plants with below 25 workers was sampled
Manufng.	A dummy variable equal to one if the main operating activity of the parent organisation was in manufacturing.
Single Site	Establishment is the only unit in the firm
UK Owned	Establishment/parent company is more than 50% UK owned
Emp. Assoc.	Employer is a member of an employers' association
Shiftwork	Are a majority of employees on shiftwork
Manual %	The proportion of total employees who are manual workers. Non-manual employees are those defined as managerial, professional or clerical. All other workers are in the manual catergory.
Part-time %	Proportion of workers who are part-time
Female %	Proportion of workers who are female
Maj. Male†	A dummy variable equal to 1 if there is a majority of men
Skilled %	Proportion of workers who are skilled
Semi Sk. %	Proportion of workers who are semi-skilled
Unskilled %	Proportion of workers who are unskilled
Clerical %	Proportion of workers who are in the clerical group
PBR†	Are the majority of workers (in a specific skill group) covered by a payment by results scheme.
Local Unemp	Percentage unemployed in the local labour market matched in by region

† *These questions were asked separately for the four different skill groups*

5. Other Control Variables

JCC (Joint Consultative Committees)	*Apart from Health and Safety Committess, do you have any joint committees composed of managers and employees, primarily concerned with consultation rather than negotiation?.* JCC=1 if answer is Yes.
DRISE	*Over the last 12 months, would you say that demand for the main products or services of this establishment has been Increasing, Falling or neither.* If Increasing DRISE=1
DFALL	If answer to last question is Falling, DFALL=1
ABOVE	*How would you assess the financial performance of this works compared with other establishments in the same industry? Would you say it was better than average, below average or about average?* If Better then ABOVE=1.
BELOW	If answer was below to the last question then BELOW = 1.

Industry Dummies:	Mining; chemicals; metals and engineering; food,drink and tobacco; construction; distribution, hotels and catering, transport and communication, banking and finance, other services. Mining is the base catergory.
Regional Dummies:	Scotland, Wales, North-East, East-Midlands, South-West, South-East, London, Wales, East Aglia, West Midlands, North. Scotland is base.

Selection Criteria

The analysis is confined to the private sector but includes manufacturing and non-manufacturing establishments.

All 'don't knows' were classified as missing and excluded from the analysis. The sample sizes differ by skill group due to missing values on three different variables: (i) the pay variable (this was not asked if there were no members of a particular skill group in the establishment), (ii) the majority sex variable and (iii) the payment-by-results variable. Over and above this, there are different questions for manual and non-manual groups.

In the union subsamples we excluded those plants were there were any missing values on the density variable.

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