THE EFFECT OF UNIONS ON INVESTMENT AND INNOVATION DECISIONS THEORY AND EMPIRICAL EVIDENCE

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SUMMARY

The aim of this thesis is to analyse the effect of unions on investment and innovation decisions, both at the theoretical and the empirical level.

The theoretical analysis deals with the choice of adoption of a new technology in the presence of an oligopolistic product market. A duopoly is considered for the ease of exposition. Unions are assumed to affect innovation decisions only via wage bargaining. The results show that environments where unions have a relatively strong (and not very spread) bargaining power tend to harm, *ceteris paribus*, innovation. If, instead, there is enough spread between unions in terms of their bargaining power, so that only one firm innovates, this firm is, *ceteris paribus*, the one facing the less powerful union. A firm may be the only one to innovate when facing the more powerful union, if this union is relatively more concerned with employment than the "rival". In general, environments where unions prize the defense of employment above pay rises tend to be more conducive to innovation. These results show the effectiveness of the "rent-seeking" mechanism outlined by Grout. Finally, there are cases where no firm would innovate should the labour market be competitive (non-unionised), while one firm would adopt the new technology, *ceteris paribus*, when firms face unions.

The main results of the analysis are robust to the consideration of collusion in the product market. The generalisation to a model in which firms choose the quantity of capital also confirms the main results.

The empirical analysis is based on data from a sample of British non-agricultural quoted companies over the period 1982-89. Data on investment have been constructed from the budget data and matched with information on unionisation and indutrial relations at the company level. Panel data estimation techniques (mostly Random Effects) have been employed. The results show that union recognition has, *ceteris paribus*, a significantly negative effect on the companies' propensity to invest. This negative impact is robust to the consideration of product market conditions, but seems to be concentrated in the first part of the period under study (1982-85). No separate effect on investment is detected for the presence of closed shop arrangements. There is evidence that the higher the union density at the company level, the lower the investment performance, but the results show also some evidence of non-linear effects. Finally, there is some evidence that companies that have partially derecognised during the eighties have benefited in terms of investment over the short-run.

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INTRODUCTION

Trade unions play an important role in the economic life of every industrialised country. Even in countries in which membership has contracted (such as the U.K.) and where union power has been weakened, the presence of trade unions and collective bargaining is still pervasive. Economists have long been interested in the impact of unions on economic performance. In particular, a considerable amount of work has been devoted to the study of the effect of unionisation on wages. It is now acknowledged that the effect of unions on innovation, R & D, investment and technical change is also a very relevant matter and interest in this area has recently increased. This increased interest reflects the recognition that the effect of unions on investment and innovation is indeed of crucial importance in the evaluation of the overall effect of unions on firms', and the economy's, performance. The aim of this thesis is to present some new results concerning the effect of unions on innovation and investment, both at the theoretical and the empirical level.

In the past some commentators have believed unions to have an unambiguously negative impact on the propensity of firms to innovate and invest. It should be pointed out, however, that the existing theory does not provide any such clear-cut prediction. Richard Freeman (1992, 158) has neatly summarised three ways in which unions can affect innovation, investment and technical change as follows:

"(1) *By raising wages*, unions can induce management to introduce new technologies more quickly than they otherwise might do. The substitution of technology (possibly embodied in capital) for labor can be socially beneficial or costly, depending on whether the introduction of that technology would have been optimal in any case.

(2) *By capturing the quasi-rents from productivity-increasing investment*, unions reduce the incentive of firms to invest in R & D and other long-lived forms of capital. Because investments in R & D are critical to economic progress, this potential impact is important.

(3) *By negotiating work rules or related labor relations policies*, unions can encourage or discourage the introduction of new technologies. The belief that union work rules limit technological change underlies much traditional criticism of unionism on the productivity front. "

On the other hand, empirical evidence on the effects of unions on investment and innovation for the U.K also gives rather mixed results and no "stylised facts" seem to have emerged so far. Hence the scope, as well as the need, for additional studies on the subject.

The theoretical and empirical literature on the effects of unions on investment and innovation is critically surveyed in Chapter 1. The chapter also includes a brief introductory review on the theory of bargaining. The emphasis on bargaining stems from the fact that the thesis concentrates on the effect of unions on investment and innovation via wage bargaining between the union and the firm. This is referred to as the "indirect effect" of unions in the thesis, as opposed to the unions' ability to prevent innovation or technical change from taking place through direct workers' opposition. Cases of open opposition to technical change are veritable exceptions, although they easily make the news when happening.

The emphasis on the "indirect effect" dates back to the seminal paper by Grout (1984) which is considered as the main reference point for the theoretical model of technology adoption in the presence of unions developed in chapter 2. In the model firms have to decide whether to adopt or not a new, more productive technology. In the Grout (1984) vein the firm bargains with the union over the wage. The main innovation with respect to Grout is the consideration of oligopolistic competition in the product market. As a matter of fact, there has been in recent years an increasing interest in the study of the links between the labour and the product markets. There is now significant evidence, for instance, that product market conditions constrain the ability of unions to raise wages above the "competitive" level. This work extends the analysis to cover also the choice of technology. The obvious question to be asked in this framework is which firm will innovate when a new technology is available (assuming a duopoly): the firm facing the more or the less powerful union ? The answer depends on which of the union effects described by Freeman (the "substitution" effect or the "rent-seeking" effect, see (1) and (2) above) is prevailing. More generally, the model analyses how union bargaining power and unions' relative preferences over wage and employment affect the firm's adoption choice.

It is worth pointing out that the model does not deal with R & D decisions. Firms are instead assumed to choose whether to buy a new technology made exogenously available in the market at a given price. Moreover, firms do not bid to obtain an exclusive right to use the technology. Hence, unlike some similar models, both firms, and not only one, may adopt the new technology.

Some extensions of the model are analysed in Chapter 3. Firstly, it is interesting to assess how the results of Chapter 2 are affected by the existence of implicit collusion among firms in the product market. The model is then generalised to allow for the choice of the capital stock, i.e. a continuous variable, instead of the discrete choice between innovating and sticking to the existing technology. The latter extension makes the solution of the model rather cumbersome. As a consequence no claim to generality is made for these results. The main purpose of this extension is to asses the robustness of the basic model as well as to provide an additional link between the theoretical and the empirical part which deals with investment, not innovation, decisions.

An important drawback of the empirical work on the effect of unionisation on investment in the U.K. has been the inability to match data on investment at the company (or establishment) level with information on unionisation at the same level of disaggregation. In this thesis data on investment, as well as other relevant economic variables, and unionisation are available for a large sample of U.K. companies over the period 1982-89. The empirical analysis in the thesis refers to investment decisions, rather than the technology adoption decision as in the theoretical model, but the predictions obtained from the adoption model carry over to the investment case.

Chapter 4 provides a description of the data, illustrates how a measure of investment has been computed from the budget data, and presents some introductory descriptive statistics. The econometric analysis is carried out in Chapter 5. In the light of the nature of the data a wide range of questions concerning the impact of unionisation on investment can be investigated. The primary task is to assess quantitatively how companies recognising unions for the purpose of wage barganing fare, *ceteris paribus,* in terms of investment performance relative to non- union firms. A thorough analysis of the union effect on economic performance should also take into account, as stressed above, the nature of product markets, i.e. the degree of competition as well as its changes during the period of interest. Moreover, union recognition alone provides only a partial picture of industrial relations conditions at the company level. The extent of unionisation as measured by union density (conditional on recognition) and the presence of closed shop arrangements, and their influence on investment performance are also worthy of analysis. Last, but not least, it is very interesting to assess whether changes in union status (such as partial or total derecognition of unions) during the eighties, had any effect on investment decisions. Is there any evidence that companies that have decided to derecognise unions have experienced *ceteris paribus* a better investment performance in the short run ? The answer to this question is clearly of some moment, not least in the evaluation of the legislative changes affecting industrial relations enforced by the British government during the eighties.

CHAPTER 1

THE EFFECT OF UNIONS ON INVESTMENT AND INNOVATION

A CRITICAL SURVEY

1.1 INTRODUCTION

The aim of this chapter is to provide a critical survey of the literature concerning the effects of unionisation on firms' investment and innovation. Some original further developments are also presented. The analysis deals mostly with theoretical rather than empirical papers, thereby reflecting the balance of the scientific production in the subject. The cornerstone of the literature is the well-known under-investment result in the presence of unions put forward by Grout (1984). Grout's model and related extensions are analysed in section 1.3 and an effort is made to elucidate the general intuition behind the result. The section is preceded by a brief introduction to the theory of bargaining (section 1.2), since the Nash Bargaining Solution is extensively referred to throughout the thesis. Particular attention is paid to the distinction between cooperative (or axiomatic) and non-cooperative (or strategic) approaches. The latter approach is explicitly adopted in the papers analysed in section 1.4 (mainly Moene (1990)) that focuses on the effects of alternative industrial relations arrangements, with specific reference to the forms of industrial action, on the optimal stock of capital and the choice of techniques. A simple model based on Moene (1990) is presented in section 1.5 in order to highlight some problems involved with the approach. Attention moves in section 1.6 to the effect of unions on innovation, mainly defined as the choice as to whether to adopt or not a new, more productive, technology made available in the market. Alternative industrial relations arrangements are again considered, this time with reference to the extension of the bargaining agenda, i.e. whether unions are allowed to bargain also on the adoption of the new technology or its introduction in the production process. Finally, the results of the not very large empirical literature on the effects of unionisation on investment and innovation in the U.K. are presented (section 1.7). Some remarks on the direction of research on the subject (section 1.8) conclude the chapter.

1.2 THE THEORY OF BARGAINING: AN INTRODUCTION

§1.2.1 The cooperative approach to the theory of bargaining

The cooperative approach to the analysis of bargaining dates back to the papers by J. Nash in the early '50s (Nash (1950, 1953)). The cooperative approach is built around the definition of a set of axioms (or properties) a bargaining solution should satisfy in order to be deemed sensible. The outcome is known as the "Nash Bargaining Solution". The aim of this section is to present the axioms and describe the ensuing solution[1] (without proofs).

The first step is the formal definition of a "bargaining problem". Two agents, 1 and 2, are considered, each with the utility function $u_i(\cdot)$, i=1,2. The

[1]This section is based on Osborne - Rubinstein (1990, chs. 2-4), and, to a lesser extent, on Binmore et al. (1986) and Sutton (1986). A very readable analysis of the subject is provided by Gravelle-Rees (1992, ch. 14).

feasible set, i.e. the set of all agreements the two parties can strike, is labelled A. If the parties fail to agree allocation d obtains. Both A and d are defined in terms of quantity. By moving to the analysis in terms of utility the "utility pay-off set" can be defined as

$$U = \{u_1(a), u_2(a) \mid a \in A\}$$

The utility in the case of disagreement is $u_i(d)$, $i = 1,2$. Let's also define $\overline{u} = (u_1(d), u_2(d))$.

The definition of a "bargaining problem", denoted by $(U,\overline{u})$, requires that:

(a) U is a closed, bounded and convex set;

(b) the disagreement outcome, d, belongs to the feasible set, i.e. $\overline{u} \in U$;

(c) cooperation can be mutually beneficial, i.e. $u^* = (u_1^*, u_2^*) \in U$ exists such that $u_i^* > \overline{u}_i$, $i = 1,2$.

The parties are only interested in the outcome of bargaining and the utility they get from it. They are not concerned with the procedure used to obtain a given result. The axioms (or properties) upon which the "Nash Bargaining Solution" is based are the following.

(1) PARETO EFFICIENCY. If (s_1, s_2) is the solution of the bargaining problem $(U,\overline{u})$, then there is no $u \in U$ such that $u_i \geq s_i$, $i = 1,2$, and $u_i > s_i$ for at least one of the parties.

(2) INVARIANCE TO LINEAR TRANSFORMATIONS. The solution of the bargaining problem is not affected by positive linear transformations of the utility

functions. Therefore the solution of the bargaining problem $(U,\overline{u})$ is the same as the solution of the problem $(V,\overline{v})$ if v_i and u_i obey $v_i = \alpha_i + \beta_i \cdot u_i$ $\beta_i > 0$. In utility terms, if (s_1, s_2) is the solution of the problem $(U,\overline{u})$, then (v_1^*, v_2^*), with $v_i^* = \alpha_i + \beta_i \cdot s_i$, $i = 1,2$, will be the solution of $(V,\overline{v})$.

(3) SYMMETRY. A bargaining problem is said to be symmetric when $(u_1,u_2) \in U$ if and only if $(u_2,u_1) \in U$, i.e. if the utility-payoff set is symmetric with respect to the 45° line, and if $\overline{u}_1 = \overline{u}_2$. In such a situation it is deemed sensible to require that in the solution both parties receive the same share: $s_1(U,\overline{u}) = s_2(U,\overline{u})$.

(4) INDEPENDENCE FROM IRRELEVANT ALTERNATIVES. Let's assume that the following two bargaining problems are compared: $(U,\overline{u})$ and $(U^*,\overline{u})$ where $U^* \subset U$. If the solution of $(U,\overline{u})$ is defined as $s(U,\overline{u})$ and it follows that $s(U,\overline{u}) \in U^*$, then $s(U^*,\overline{u}) = s(U,\overline{u})$. The axiom requires the behaviour of the parties to be consistent. If the choice is restricted due to the elimination of some alternatives that were not chosen as a solution before, then the solution must stay the same and it is unaffected by the irrelevant alternatives.

The Nash theorem states that there is a unique solution to the bargaining problem $(U,\overline{u})$, denoted $s(U,\overline{u})$, that satisfies axioms (1) to (4). The "Nash Bargaining Solution" is defined as

(1.1) $$s(U,\overline{u}) = \operatorname{argmax}\ (u_1 - \overline{u}_1) \cdot (u_2 - \overline{u}_2) \qquad u_1, u_2 \in U$$

$$\text{subject to} \quad u_1 \geq \overline{u}_1 \quad \text{and} \quad u_2 \geq \overline{u}_2$$

where $(u_1 - \overline{u}_1) \cdot (u_2 - \overline{u}_2)$ is known as the "Nash product".

Osborne and Rubinstein stress that none of the axioms is redundant. Alternative solutions with respect to (1.1) arise if one of the properties is removed[2]. An interesting solution obtains when the axiom of symmetry (3) is removed. In such a case it is possible to show that the solution that satisfies the axioms of Pareto Efficiency, Linear Invariance, and Independence from Irrelevant Alternatives for the bargaining problem $(U,\overline{u})$ is

$$(1.2) \quad s^{\alpha}(U,\overline{u}) = \operatorname{argmax} \ (u_1 - \overline{u}_1)^{\alpha} \cdot (u_2 - \overline{u}_2)^{1-\alpha} \qquad u_1, u_2 \in U$$

$$\text{subject to } u_1 \geq \overline{u}_1 \text{ and } u_2 \geq \overline{u}_2 \qquad \text{with} \quad 0 < \alpha < 1$$

This solution is known as Generalised (or Asymmetric) Nash Bargaining Solution. The Nash solution, (1.1), clearly obtains when $\alpha = \frac{1}{2}$.

No mention is made in the Nash solution (1.1) of the bargaining ability of the parties insofar as this ability is not captured by the very definition of the problem $(U,\overline{u})$. Therefore in a symmetric problem the Nash solution maximises the product of the parties' deviations from the "reservation" utilities $(\overline{u}_1, \overline{u}_2)$. The Generalised or Asymmetric solution can be thought of as arising from the consideration of different bargaining abilities between the two parties. This difference is captured by the value of the parameter α.

The Generalised Nash Bargaining Solution can be applied to the case of bargaining over the wage between a union and a firm in the following way. The

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[2] An interesting solution, not analysed here, is provided by Kalai and Smorodinski (1975).

union is assumed to have M members and the utility function

$$(1.3) \qquad U = w \cdot L + (M - L) \cdot \overline{w}$$

where L = employment, w = wage, and $\overline{w}$ = wage outside the firm. The firm maximises the profit $\Pi = f(L) - w \cdot L$. In case of disagreement $U_0 = \overline{w} \cdot M$ and $\Pi_0 = 0$. If α defines union bargaining power, then the Generalised Nash Bargaining Solution, w^*, is given by

$$(1.4) \qquad w^* = \underset{w}{\operatorname{argmax}} \, [(w - w_0) \cdot L]^{\alpha} \cdot [f(L) - w \cdot L]^{1-\alpha}$$

§1.2.2 **The strategic approach to the theory of bargaining**

Two main criticisms can be addressed to the cooperative approach.

1. It seems reasonable to think of bargaining as a process in which the parties exchange offers and counter-offers.

2. There are costs involved in the bargaining process, for instance the cost arising from the delay in reaching an agreement.

Both these elements are not analysed in the cooperative approach.

From the early '80s strategic models of bargaining have been developed based on the idea that parties exchange offers. The seminal contribution to this literature is Rubinstein (1982). The aim of this section is to describe the assumptions underlying the model and provide the main results (without proof). The implications for the analysis of union-firm bargaining will also be presented. Finally, the cooperative approach will be compared with the strategic analysis

(§1.2.3) with a particular attention to the implications for wage bargaining.

RUBINSTEIN MODEL. Let's assume that two players, 1 and 2, are faced with the problem of bargaining over the division of a unit of surplus. The set of feasible agreements is therefore defined as

$$(1.5) \qquad X = \left\{(x_1,x_2) \in \mathbb{R}^2 \mid x_1 + x_2 = 1, x_i \geq 0 \quad i = 1, 2\right\}$$

where x_i is the share accruing to player i (i=1,2).

Bargaining is modelled in the way described in figure 1.1. Player 1 starts with an offer in period 0, i.e. with a proposal about how to share the unit of surplus: He will get x_0 and the other player will obtain the rest of the "cake" (see figure 1.1). Player 2 either accepts the offer, so that the game is over in period 0, or rejects the proposal and makes a counter-offer in period 1. Player 1 will evaluate the offer made by 2 and will either accept it or reject it, and so on. Thus player 1 makes an offer in even periods (0, 2, 4,...) and replies YES or NO to offers made by 2 in odd periods (1, 3, 5, ...). The symmetric holds for player 2. The game has an infinite horizon.

Let D denote the failure to reach an agreement, i.e. the situation characterised by an infinite sequence of rejections to every offer made by the other party. Each player can suggest whatever feasible sharing of the surplus when he has the right to make an offer irrespective of the history of past offers. Each player knows all the offers made in the past by both parties. Finally, the surplus to be divided is not affected by the length of the bargaining process.

The description of the players' preferences is crucial. The outcome of bargaining can be denoted by (x, t), where x is the share accruing to player 1, 1-x the share received by 2, and t is the period when agreement is reached ($t \in T$). Each player is assumed to possess a preference ordering, represented by "$\succeq$", defined on the set of feasible outcomes $(X \times T) \cup D$. This ordering is assumed to be complete, reflexive and transitive. The following additional assumptions are made.

A1. For each player failure to reach an agreement represents the worst possible outcome:

$$(x, t) \succeq_i D \quad i = 1, 2 \quad \forall (x, t) \in X \times T$$

A2. Monotonicity:

$$(x, t) \succ_i (y, t) \Leftrightarrow x_i > y_i \quad \forall x, y \in X, \forall t \in T$$

A3. Players are temporally impatient. The sooner a given agreement is reached, the better. Therefore

$$(x, t) \succ_i (x, s) \quad \text{if } t < s \quad \forall t, s \in T, \ x \in X \quad x_i > 0$$

A4. The preference ordering is continuous.

A5. Stationarity:

$$(x, t) \succ_i (y, t+1) \Leftrightarrow (x, 0) >_i (y, 1)$$

$$\forall t \in T \quad \forall x, y \in X$$

The following utility function satisfies assumptions A1 to A5[3]:

[3]Osborne and Rubinstein (1990) add an assumption on the nature of the losses arising from delays in reaching the agreement. This assumption is not needed for the results obtained below.

(1.6) $$u_i(x_i) = \delta_i^t \cdot x_i$$

where δ_i defines the discount factor for player i $(0<\delta_i<1)$. The results presented below are derived using this functional form (for a more general analysis see Osborne-Rubinstein (1990, ch. 3)).

The definition of the players' strategies is the remaining crucial element of the model. A strategy for a player specifies an action for each node where that player is supposed to make a choice, i.e. either the definition of an offer or the acceptance/rejection of an offer made by the counterpart. A strategy specifies an action for each possible history of the game up to the node where the player is making the choice, including histories that are ruled out by previous choices of the players.

Once players' preferences and strategies have been defined the equilibria of the game can be analysed. Nash equilibria will be considered first. It is easily seen that every feasible division of the surplus between the two players at period 0 represents a Nash equilibrium. Thus Nash equilibrium does not restrict the solution in a sensible way. This result can be shown by considering the following strategies for players 1 and 2 that can be called "intransigent"[4]. In each period player 1 offers a division of the "cake" that gives him $\overline{x}_1$ and he accepts an offer made by 2 only if he obtains at least $\overline{x}_1$. Similarly, player 2 offers the division $(\overline{x}_1, 1 - \overline{x}_1)$ and accepts an offer made by 1 only if she receives at least $1 - \overline{x}_1$. As a result an

[4]For the rest of the section player 1 is treated as male and player 2 as female.

equilibrium arises at period 0 when player 1 suggests the division $(\overline{x}_1, 1 - \overline{x}_1)$, with $\overline{x}_1 > 0$, which is readily accepted by player 2[5].

The notion of Nash equilibrium does not represent an appealing solution for the game. Moreover, it is also easily shown that there are conditions such that it is not credible for a player to stick to an "intransigent" strategy as seen above. Let's assume that player 1 offers a division that gives him $\overline{x}$ and that he accepts an offer made by 2 only if he gets at least $\overline{x}$. On the other side, player 2's offer gives her 1-$\overline{x}$, and she accepts an offer by 1 only if she receives $1 - \overline{x}$. Let's now assume that player 2 has to evaluate at period t the offer $(\overline{x} + \epsilon, 1 - \overline{x} - \epsilon)$ made by player 1. This possibility stems from the way strategies are defined in the game. If player 2 rejects 1's offer and makes her own counteroffer she will get $1 - \overline{x}$ at time $t + 1$. If instead she accepts the offer she will get $1 - \overline{x} - \epsilon$ at time t. Based on the utility function $u(x_i,t) = \delta_i^t \cdot x_i$ introduced above, it is easily verified that when $0<\epsilon<(1-\overline{x}) \cdot (1-\delta_2)$ player 2's threat to stick to an "intransigent" strategy is not credible.

A solution which requires threats to be always credible, i.e. that the solution is a Nash equilibrium for every subgame, is the subgame perfect equilibrium. Let's consider the following strategies for the players. Player 1 offers $x^*= (x_1^*, x_2^*)$, i.e. a division of the "cake" such that he receives x_1^* and the other player gets x_2^*, and accepts an offer made by 2 if and only if he receives at least y_1^*. Similarly, player 2 offers $y^* = (y_1^*, y_2^*)$ and accepts an offer by 1 if and only

[5]Osborne and Rubinstein (1990) show that there are also Nash equilibria where the agreement is reached after period 0.

if she receives at least x_2^*. It is now determined under which conditions on x^* and y^* these strategies are credible.

Let's start with player 2. An offer x made by player 1 at period 0 with $x_2<x_2^*$ is credibly rejected by 2 if $(x, 0) \preceq_2 (y^*,1)$, $\forall\ x_2 < x^*$. Continuity (assumption A4) then requires that $(x^*, 0) \preceq_2 (y^*, 1)$. On the other hand, $(x^*,0) \succeq_2 (y^*,1)$ holds, otherwise player 2 is better off rejecting 1's offer (and proposing y^* which will be accepted by player 1 next period). Therefore $(x^*,0) \sim_2 (y^*,1)$. If the utility function $u(x_i,t)=\delta_i^t \cdot x_i$ is used, this condition can be written as

$$x_2^* = \delta_2 \cdot y_2^* \qquad (1.7)$$

A similar argument for player 1 gives

$$y_1^* = \delta_1 \cdot x_1^* \qquad (1.8)$$

The solution of the system of equations (1.7), (1.8) and

$$(1.9) \qquad x_1^* + x_2^* = 1$$

$$(1.10) \qquad y_1^* + y_2^* = 1$$

provides the values of the offers in the strategies defining a subgame perfect equilibrium. These are as follows:

$$(1.11) \qquad x^* = \left(\frac{1 - \delta_2}{1 - \delta_1 \cdot \delta_2}, \frac{\delta_2 \cdot (1 - \delta_1)}{1 - \delta_1 \cdot \delta_2} \right)$$

$$(1.12) \qquad y^* = \left(\frac{\delta_1 \cdot (1 - \delta_2)}{1 - \delta_1 \cdot \delta_2}, \frac{1 - \delta_1}{1 - \delta_1 \cdot \delta_2} \right)$$

Moreover these strategies represent the only subgame perfect equilibrium for the game (see Osborne - Rubinstein (1990, 45-48) for a proof). Thus player 1 offers a division at period 0 that gives him $\frac{1 - \delta_2}{1 - \delta_1 \cdot \delta_2}$. This offer is readily accepted by player 2. If the discount factors is the same $(\delta_1 = \delta_2 = \delta)$, player 1 receives $\frac{1}{1 + \delta}$, whereas player 2 gets $\frac{\delta}{1+\delta}$. This outcome shows the existence of a first-mover advantage: Player 1 offers first, by assumption, and gets a bigger share of the surplus. If the discount factor is the same for both players, the only asymmetry in the model arises from the "right" to make the first move (offer). It has been shown (Binmore (1987)) that as the time gap between offers and counter-offers becomes small the solution tends to be symmetric. More specifically, if Δ is defined as the time gap between two offers

$$\text{as} \quad \Delta \rightarrow 0 \qquad \lim x^*(\Delta) = \left(\frac{\log\delta_2}{\log\delta_1 + \log\delta_2}, \frac{\log\delta_2}{\log\delta_1 + \log\delta_2} \right)$$

The characteristics of the solution depend crucially on the relative impatience of the bargaining parties. The player who is more patient will receive a bigger share of the "cake".

The model now described can be extended to take into account the fact that players may quit the bargaining process thereby obtaining an exogenously given level of utility. In such a case it is said that an "outside option" is available. For instance player 2 may have the choice to leave each time she rejects an offer made by 1. The availability of this choice acts as a threat imposed on the other party. As such the threat needs to be credible: The utility gained leaving the barganing table has to be greater than the utility to be reached as a result of bargaining. The availability of such threat increases the share obtained by player 2 in the solution (see Osborne - Rubinstein (1990) for a proof).

§1.2.3 **Relation between the axiomatic and strategic approaches**

Much attention has been devoted to the determination of strategic foundations for the cooperative Nash solution described above (see §1.2.1)[6]. A very relevant related problem is how to correctly interpret the disagreement outcomes ($\overline{u}_1$, $\overline{u}_2$) in the Nash solution (see (1.1)). Binmore, Rubinstein and Wolinski (1986) (but see also Sutton (1986) and Osborne - Rubinstein (1990, chap. 4)) tackle the problem by defining the following two games which incorporate some slight modifications with respect to the model described in the previous section.

GAME A. A Rubinstein type game is assumed where players are not time impatient. It is also assumed that in each period there is an exogenous probability q that the game will end with an outcome, g say, disliked by the players. For instance, a third party intervenes and forces a settlement. In this game it is the threat of an exogenous interruption of the bargaining process (and not impatience) which motivates the players to reach an early agreement. Binmore et al. (1986)

[6]The "Demand Game" (Nash 1953) was an early attempt by Nash himself at such foundation.

show that as $q \to 0$ the subgame perfect equilibrium is given by the Nash solution (1.1) for the bargaining problem $(U, \bar{u})$ where U is suitably defined on the basis of the set of feasible outcomes and $\bar{u} = (u_1(g), u_2(g))$[7].

GAME B. A Rubinstein type model is now considered where offers and counter-offers are exchanged with a time gap of Δ. Binmore et al. (1986) show that as $\Delta \to 0$ the subgame perfect equilibrium is given by the Nash solution of the bargaining problem (U^*, u^*) where U^* is suitably defined and $(u_1^*, u_2^*) = (0, 0)$.

Games A and B represent alternative strategic foundations for the use of the Cooperative Nash solution. The specific form of the maximand in the Nash problem varies according to whether the force driving the agreement is the threat of an exogenous interruption of bargaining (game A) or temporal impatience (game B). In the former case $\bar{u}_1$ and $\bar{u}_2$ in solution (1.1) reflect the utility players receive when the game is interrupted (outcome g arises). Therefore $\bar{u}_1 = u_1(g)$ and $\bar{u}_2 = u_2(g)$. For the latter case Osborne and Rubinstein (1990, 89) suggest that "the disagreement point should correspond to an outcome H with the property that each side is indifferent to the period in which H is received". In the specific case of union-firm bargaining over the wage, for instance, "it might be appropriate to let H be the outcome in which the profit of the firm is zero and the union members receive a wage that they regard as equivalent to the compensation they get during a strike". In both cases it is not accurate to identify the disagreement point $(\bar{u}_1, \bar{u}_2)$ with the

[7] $\bar{u}$ can be set equal to (0, 0) without any loss of generality.

"outside option", i.e with an outcome parties can choose to impose as a solution. The "outside option" represents instead a constraint imposed on the Nash solution. In the case of bargaining between the union and the firm workers may have the "outside option" of being hired in another firm (or sector) with the ensuing wage. This wage level represents a constraint for the Nash solution. If the union is assumed to be a wage maximiser with no concern for employment, the Nash solution can be written (assuming symmetry) as

(1.13) $$w^* = \underset{w}{\operatorname{argmax}} \, (w - w_0) \cdot (\Pi - \Pi_0)$$

$$\text{subject to} \quad w \geq \overline{w}$$

where w_0 = solidarity-fund in the event of a strike

$\Pi_0 = 0$ (there is no production if a strike is called)

and, as above, $\overline{w}$ = wage outside the firm

This expression can be compared with solution (1.4) presented above.

1.3 NON-BINDING WAGE CONTRACTS AND INVESTMENT DECISIONS

§1.3.1 The "Grout mechanism": The basic model

Grout (1984) represents the seminal paper in the literature about the effects of unionisation on firms' investment decisions. According to Grout wage agreements between the firm and the union can be either binding or non-binding:

The consequences of each scheme in terms of investment choice are then analysed. A union-firm wage contract is said to be non-binding when the union can renege on the contract without incurring any direct loss or penalty. Conversely, in the case of binding contracts, the union, as well as the firm, is committed or obliged to stick to the contract terms for the specified period. As a result, a binding agreement can be thought of as a "long-term" decision of the same kind as the choice of the optimal combination of productive inputs. It makes sense therefore in the formal model to assume that, in the presence of binding contracts, negotiation over the wage takes place simultaneously with the firm's choice of capital and employment. On the other hand, the presence of non-binding agreements can be modelled by assuming that wage bargaining takes place after the optimal quantities of capital and labour have been chosen.

Grout (1984) analyses the consequences of the two types of wage agreements presented above on the firm's investment decision. Wage bargaining is modelled according to the cooperative version of the Generalised Nash Bargaining Solution. The benchmark for the evaluation of the results is the situation where no unions exist in the labour market (i.e. a competitive labour market). The outcomes with binding wage agreements will be considered first[8].

BINDING WAGE AGREEMENTS[9]. The union is assumed to be "rent maximiser"

[8]What follows is a simplified version of Grout (1984). Unlike Grout it is assumed that both employment and capital are set by the firm in the first stage (instead of having employment set along the labour demand curve). The results from Grout (1984) are not affected by this assumption.

with the utility function $U = (w - \overline{w}) \cdot L$ where w = wage and L = employment, and $\overline{w}$ = competitive (or alternative) wage. The firm's production function is given by $Q = f(K,L)$ where K = capital stock and $f_k>0$, $f_l>0$. Perfect competition prevails in the product market[10]. The product price is set equal to 1.

With binding wage agreements there is no distortion in the choice of inputs with respect to a competitive labour market. As a matter of fact, it is in the interest of both the union and the firm to maximise the size of the "rents" to be divided in the wage bargaining. The firm's profit is defined as

$$\Pi = p \cdot Q - w \cdot L - r \cdot K \qquad \text{where} \quad r = \text{cost of capital}$$

and, using the assumptions above,

$$= Q - \overline{w} \cdot L - r \cdot K - (w - \overline{w}) \cdot L$$

$$(1.14) \qquad = Q - \overline{w} \cdot L - r \cdot K - U$$

Therefore $\Pi + U = Q - \overline{w} \cdot L - r \cdot K$. Hence each party (and especially the firm) has an incentive to maximise the quantity $\Pi + U$ which is divided on the basis of the relative bargaining power parameter. As a result, the choice of inputs made by the firm is efficient, i.e. the same as under perfect competition in the labour market:

$$(1.15) \qquad Q_k(K^*, L^*) = r$$

$$(1.16) \qquad Q_l(K^*, L^*) = \overline{w}$$

The relative union bargaining power of the parties (the parameter α in the

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[9]See also De Menil (1971) for this part of the analysis.

[10]The capital market is assumed to be competitive.

Generalised Nash Solution (1.4)) only affects the way in which the "rents" $\Pi+U$ are divided between the union and the firm. The higher the union bargaining power, the greater the share accruing to workers and the smaller the share obtained by the firm.

NON-BINDING WAGE CONTRACTS. The presence of non-binding wage contracts can be dealt with by assuming a two-stage model. In the first stage the firm chooses the quantities of capital and labour in order to maximise profits, and in the second stage the union and the firm bargain over the wage according to the Generalised Nash Bargaining Solution. The firm takes into account the outcome of wage negotiation in the second stage when deciding the optimal choice of inputs.

The second stage is analysed first. Grout assumes that both parties are able to prevent production from taking place. If this happens workers can receive $\overline{w}$ outside the firm, while the firm suffers a loss of $r \cdot K$ since the cost of capital has already been sunk. For the ease of exposition the capital is assumed to be completely firm-specific so that the possibility of resale is ruled out. Therefore in the second stage the solution of wage negotiation is given by

$$(1.17) \qquad \max_{w} \, [(w - \overline{w}) \cdot L]^{\alpha} \cdot [f(K,L) - w \cdot L - r \cdot K - (-r \cdot K)]^{1-\alpha}$$

and, taking logarithms,

$$(1.18) \qquad \max_{w} \, \alpha \cdot \log(w - \overline{w}) + (1 - \alpha) \cdot \log[f(K,L) - w \cdot L] + \text{constant}$$

The first order condition is:

$$(1.19) \qquad \frac{\alpha}{w - \overline{w}} = \frac{(1-\alpha) \cdot L}{f(K,L) - w \cdot L}$$

Thus,

$$(1.20) \qquad w = \alpha \cdot \frac{f(K,L)}{L} + (1 - \alpha) \cdot \overline{w}$$

The wage is increasing in the quantity of capital, in the competitive (or alternative) wage $\overline{w}$, and in union bargaining power, α. When $\alpha = 0$ the model reverts to the competitive case: $w = \overline{w}$. When $\alpha = 1$ the union "reaps" all the rent, $w \cdot L = f(K,L)$, and $\Pi = 0$.

In the first stage the firm maximises profits by choosing the optimal combination of K and L, "seeing through" the solution of wage bargaining. Hence the firm maximises $\Pi = f(K,L) - w \cdot L - r \cdot K$, or, from (1.20),

$$(1.21) \qquad \Pi = (1-\alpha) \cdot f(K,L) - (1-\alpha) \cdot \overline{w} \cdot L - r \cdot K$$

The first order conditions are given by

$$(1.22) \qquad f_l = \overline{w}$$

$$(1.23) \qquad f_k = \frac{r}{1-\alpha}$$

With non-binding wage agreements the quantity of capital chosen by the firm is smaller then in the competitive case (provided $\alpha > 0$). Moreover, the quantity of capital decreases as union bargaining power increases.

The model can be extended to include the case where the capital is not completely firm-specific. If this is the case the capital can be sold off and a fraction, say ρ, of the original cost can be recouped. Therefore the "disagreement payoff" for the firm is now given by $\Pi_0 = -(1-\rho)\cdot r\cdot K$ where ρ $(0 \leq \rho<1)$ measures firm-specificity of capital. The case analysed before obviously entails $\rho = 0$. It is reasonable to think that the optimal stock chosen by the firm will depend inversely on the degree of firm-specifity (given union bargaining power), i.e. it will depend directly on ρ.

The result obtained in the presence of non-binding wage contracts is based on the fact that the firm is not willing to engage in a specific investment because of the fear of being at the mercy of the opportunistic or predatory behaviour on the part of the union. Once the capital has been installed, the union will be in the position to obtain increased wages, the more so the more the firm is "locked in" by the specificity of its capital. Since the firm realises the fact that in such a case the union will skim most of the rents accruing from capital expansion, the incentive to invest is reduced or eliminated altogether.

The sort of mechanism described above is known in the literature as the "Hold-up problem" (Williamson (1975), Tirole (1988, 21-27) and Milgrom-Roberts (1992, 134-40)), an issue of "Post-contractual opportunism". If, when devising a contract, the party that will engage in a specific investment believes that he/she will not be able to obtain the expected rents because of the possibility of opportunistic behaviour of the other party, then there is no incentive to enter the contract and operate the investment. For instance, a worker will be reluctant to invest in training which is firm (or task) specific, if he/she believes that by so doing his/her "bargaining power" towards the firm will be reduced.

A different interpretation (but somewhat complementary) of the model put forward by Grout will be presented in §1.3.3 with reference to a dynamic setting.

§1.3.2 The "Grout Mechanism": Extensions

The model presented in the previous section has been extended by Grout (1985) and by Manning (1987) on the basis of the approach known as "sequential bargaining". In this framework it is assumed that the union and the firm bargain not only over the wage but also over issues such as capital and employment.

In Grout (1985) the union and the firm bargain in the first stage over the quantities of inputs, capital and labour, to be employed. The wage is bargained over in the second stage. In both stages the Generalised Nash Bargaining Solution is adopted and it is assumed that the relative bargaining power of the two parties is the same irrespective of the issue bargained over. Therefore the parameter α in the Nash solution is the same both in the first and the second stage. Grout (1985) establishes that the predictions of the model presented in §1.3.1 are robust to this extension: The quantity of capital is lower than in the competitive case and increases in union bargaining power cause the capital stock to be reduced.

Manning (1987) further generalises the model by resorting to the more realistic assumption that union bargaining power is not the same whatever the issue bargained over. It should be noted, though, that Manning, as well as Grout, does not explain how the union can be involved in the process of negotiation over the capital stock. This remark has to be coupled with the scepticism about the hypothesis that unions are able to directly bargain over employment.

In Manning (1987) the outcome of the union-firm bargaining over capital and employment solves (using the same notation and the same union's utility function as in §1.3.1)

$$(1.24) \qquad \max_{k,l} \; q \cdot \log[(w-\overline{w}) \cdot L] + (1-q) \cdot \log[f(K,L) - w \cdot L - r \cdot k]$$

where q = union bargaining power over capital and employment.

The second stage of the model (wage bargaining) solves

$$(1.25) \qquad \max_{w} \; p \cdot \log[(w-\overline{w}) \cdot L] + (1-p) \cdot \log[f(K,L) - w \cdot L]$$

where p = union bargaining power over the wage.

The model is solved by obtaining the wage as a function of p, K, and L from the second stage, and by entering this solution in the optimisation problem of the first stage. Some manipulations show that first order conditions for the solution (K^*, L^*) are:

(1.26) $f_l(K^*,L^*) = \overline{w}$

(1.27) $f_k(K^*,L^*) - r = r \cdot \frac{p \cdot [f(K^*,L^*) - \overline{w} \cdot L^*] - q \cdot [f(K^*,L^*) - \overline{w} \cdot L^* - r \cdot K^*]}{(1-p) \cdot [f(K^*,L^*) - \overline{w} \cdot L^*] - q \cdot r \cdot K^*}$

Efficient allocation of resources requires $f_l = \overline{w}$ and $f_k = r$ which obtains if and only if

(1.28) $p \cdot [f(K^*,L^*) - \overline{w} \cdot L^*] = q \cdot [f(K^*,L^*) - \overline{w} \cdot L^* - r \cdot K^*]$

Since $r > 0$ the efficient (or competitive) solution cannot be reached whenever $p=q>0$, the case when union bargaining power is the same in both stages. This represents the result in Grout (1985) described above. The situation where $p = q$ is quite clearly a special case. Condition (1.28) shows that an efficient allocation of resources is not incompatible with the union being able to appropriate some of the rents in the bargaining process. But a necessary condition for such result is that $q>p$, i.e. union bargaining power in the negotiation over capital and employment is greater than union bargaining power in the negotiation over the wage. For instance, if a Cobb-Douglas production function is adopted like

(1.29) $f(K, L) = K^{\beta} \cdot L^{\theta}$ with $\beta > 0$ $\theta > 0$ $\beta + \theta < 1$

it can be easily shown that if the union bargaining power parameters p and q obey the following relationship

(1.30) $q = \frac{1-\theta}{1 - \beta - \theta} \cdot p$

then "sequential bargaining" determines an efficient (competitive) solution.

Manning stresses that overinvestment (with respect to the competitive solution) can also arise when the value of q is sufficiently large compared to p. The intuition for this result is the following. In the limit case when q, union bargaining power over capital and employment, is 1, it is up to the union only to determine the capital stock and the employment level. The union does so in order to maximise its utility and if the wage is increasing in the quantity of capital it is in the union's interest to push the capital stock above the "efficient" level.

Grout's underinvestment result has also been questioned in a Monopoly Union framework by Anderson and Devereux (1988). Anderson and Devereux refer to a noncooperative game whose strategy variables are the capital stock and the wage rate for the firm and the union respectively, employment being determined along the labour demand curve. Which of the players is strategically dominant is a crucial feature of the model. Strategic dominance means ability to commit itself to a given irreversible investment (on the part of the firm) or to a given wage rate (on the part of the union). Being strategically dominant (or Stackelberg leader) coincides with being the first mover so that the dominant union case parallels the existence of binding contracts and the dominant firm case parallels the reverse situation. Thus in the latter case the firm chooses the capital level in the first stage, the union determines the wage in the second, and the firm sets employment in the third.

Having derived the reaction functions for the players, Anderson and Devereux show that if the firm is the Stackelberg leader (i.e. if contracts are not binding) undercapitalisation arises when the union's reaction function is upward sloping in the wage - employment space (the converse obviously holds). A horizontal reaction function implies efficiency. However, it is difficult to provide an intuitive explanation of this result in a nontechnical way[11].

§1.3.3 **A dynamic extension**

Van der Ploeg (1987) extends the analysis of the effects of unionisation on investment decisions to an intertemporal setting. The analysis is based on Grout's distinction between binding and non-binding wage contracts. In his basic model Van der Ploeg assumes that the wage is set according to the Monopoly Union hypothesis. Therefore the firm and the union do not bargain over the wage as in Grout (1984, 1985) and Manning (1987)[12], but the union chooses the sequence of wages in the knowledge that the firm will then set employment along the labour demand curve.

As far as the firm side is concerned, Van der Ploeg employs a standard infinite-horizon model of investment with convex adjustment costs and capital depreciation. The product market is assumed to be perfectly competitive with the product price set equal to 1. The firm chooses the quantities of capital and labour. Therefore the maximisation problem of the firm is:

[11] A counter-example to the inefficiency outcome in Grout (1984) is provided by Devereux and Lockwood (1991) in the context of a general equilibrium model with overlapping generations.

[12] Van der Ploeg analyses wage bargaining in one of the extensions of the model.

$$(1.31) \qquad \max_{l,i} \int_0^\infty e^{-rt}[f(k,l) - w \cdot l - q \cdot i - \psi(i)]dt$$

subject to

$$\dot{k} = i - \delta \cdot k \qquad k(0) = 0$$

with $f_l > 0$ $f_k > 0$ $f_{ll} < 0$ $f_{kk} < 0$, constant returns to scale

and $\psi(0) = 0$, sign $(\psi') =$ sign (i), $\psi'' > 0$ [13]

where i = investment, k = capital stock, l = employment, q = cost of capital, δ = depreciation rate, r = discount rate.

On the other side, the union maximises an intertemporal "utilitarian" objective function

$$(1.32) \qquad \max_{w} \int_0^\infty e^{-rt}[u(w) \cdot l + (m - l) \cdot u(\overline{w})]dt$$

with $u' > 0$, $u'' < 0$ $m \geq l$

where m = union membership (exogenously given). Union membership has no effect on the first order conditions.

In order to solve the model optimal control techniques must be applied to problem (1.32) adding as constraints the first order conditions from problem (1.31) (because of the Monopoly Union assumption). This solution is known as "open loop Stackelberg equilibrium" where the firm represents the follower. Van der Ploeg shows that the optimal wage sequence chosen by the union is time inconsistent.

[13] Assumptions on $\psi(\cdot)$ reflect convexity of adjustment costs.

Therefore if $w^*(\tau,\sigma)$ defines the optimal wage for period τ as of period σ, then t and s exist such that

$$w^*(t,s) \neq w^*(t,0) \qquad s > 0, \; t > s$$

If wage agreements are not binding it is in the union's interest in period s to choose a wage level for period t that is different from the optimal level chosen for period t at period 0. Van der Ploeg (1987, 1472) stresses that without binding wage agreements "there is an incentive to renege for the union, because by announcing the intention of demanding low wages in the future it can persuade the firm to invest in a relatively large capital stock. Once the machines are installed, the union has an incentive to cheat and to claim higher wages than promised".

In the absence of long-term contracts a time consistent solution in which union's strategies, i.e. wage sequences, are credible is computed using the "dynamic programming solution" that determines what is known as "Feedback Stackelberg equilibrium". Van der Ploeg shows that under this solution wages are greater and capital and employment lower than under binding contracts thereby confirming the results obtained by Grout (1984). "The reason is that in the absence of binding contracts the trade union is unable to convince the firm that it will stick to a strategy of low wages" (Van der Ploeg (1987, 1473)). On the other hand, without binding contracts and an infinite horizon reputational equilibria can sustain the optimal solution[14].

[14] This analysis is a direct application of Barro-Gordon (1983) model.

1.4 INDUSTRIAL RELATIONS ARRANGEMENTS AND CHOICE OF TECHNIQUES

§1.4.1 Types of industrial action and choice of techniques

Grout (1984) and related extensions analyse the effect of union-firm wage bargaining on the firm's investment (or capital) decision. In these papers bargaining is modelled according to the Generalised Nash Bargaining Solution. Grout focuses in particular on the comparison of the outcomes arising from binding and non-binding wage agreements. Moene (1990) has further analysed the effect of alternative systems of industrial relations on the choice of techniques. More specifically, Moene aims at comparing "soft" (or "collaborative") forms of industrial action during wage negotiations, such as "go-slows" or "work-to-rule", with more drastic forms such as strikes, in terms of their effects on the choice of techniques[15]. To this purpose Moene, unlike Grout, explicitly adopts, the non-cooperative version of the Generalised Nash Solution.

The sequence of moves in Moene (1990) mirrors Grout (1984). The model features two decision stages. In the first stage the firm chooses capital and employment, in the second the firm and the union bargain over the wage. Unlike Grout, Moene assumes that the union is only interested in the wage received by its

[15] The alternative types of industrial action are analysed more thoroughly in Moene (1988).

members. All workers are also assumed to be union members. The firm's revenue function is:

$$(1.33) \qquad R = R(K,L) \text{ with } R_k > 0 \quad R_l > 0 \quad R_{kk} < 0 \quad R_{ll} < 0$$

Moene assumes that the revenue function is homothetic in such a way that it can be rearranged as

$$(1.34) \qquad R = \Phi(L \cdot g(k)) \quad \text{where} \quad k=\frac{K}{L} \quad \text{and} \quad \Phi' > 0 \quad g' > 0 \quad g'' < 0.$$

The second stage is solved first. The Generalised Nash Bargaining Solution is given by:

$$(1.35) \qquad w^* = \underset{w}{\text{argmax}} \, [w - w_0]^{\alpha} \cdot [\Phi - w \cdot L - r \cdot k \cdot L - \Pi_0]^{1-\alpha}$$

$$\text{subject to} \qquad w \geq w_b$$

where w_0 and Π_0 define the "inside options" for the union and the firm, respectively, and w_b represents the "outside option" for workers.

The first order condition is

$$(1.36) \qquad \frac{\alpha}{w - w_0} = \frac{(1 - \alpha) \cdot L}{\Phi - w \cdot L - r \cdot k \cdot L - \Pi_0}$$

and therefore

$$(1.37) \qquad w^* = \alpha \cdot \frac{(\Phi - r \cdot k \cdot L - \Pi_0)}{L} + (1\text{-}\alpha) \cdot w_0$$

Thus the profit can be written as

$$(1.38) \qquad \Pi = (1 - \alpha) \cdot [\Phi(L \cdot g(k)) - r \cdot k \cdot L - w_0 \cdot L] + \alpha \cdot \Pi_0$$

Moene analyses the results which obtain in the following cases:

a) the union can call a strike during wage negotiations;

b) the union can resort to either "go-slows" or "work-to-rule" but not to a strike during negotiations.

The values taken by the "inside options" w_0 and Π_0 differ in the two cases. It is important to stress that, as typical with applications of Rubinstein (1982) model, the forms of industrial action described above represent the threats the union can address to the firm during the negotiation. These threats are not carried out in equilibrium. An immediate agreement is instead reached and no industrial action is taken under the general assumptions in Rubinstein (1982).

When the strike represents the form of industrial action available to the union the values of the "inside options" are the following:

$$(1.39) \qquad w_0 = z \qquad \text{and} \qquad \Pi_0 = -r \cdot k \cdot L$$

where z = per capita union solidarity-fund (z is exogenously given). Using these values in the definition of profit (1.38) gives:

$$(1.40) \qquad \Pi = (1-\alpha) \cdot [\Phi(L \cdot g(k)) - z \cdot L] - r \cdot k \cdot L$$

The firm maximises profits by choice of k and L. The first order conditions for a maximum can be rearranged to give:

$$(1.41) \qquad H(k) = \frac{(1 - \alpha) \cdot z}{r}$$

where H(k) = marginal rate of substitution between K and L (made positive)

$$(1.42) \qquad H(k) \equiv \frac{\frac{\partial R}{\partial L}}{\frac{\partial R}{\partial k}} = \frac{g(k)}{g'(k)} - k \qquad \text{with } H'(k) > 0$$

It can be easily seen that as α, union bargaining power, increases the optimal capital/labour ratio decreases. This result is at variance with the traditional view (supported by Marx, among others) according to which as workers' militancy grows capitalists will respond by choosing more capital-intensive production techniques. In Moene (1990) the union bargaining power, α, depends not only on the relative temporal impatience of the parties involved, as in Rubinstein (1982) (see §1.2.2), but also on how many periods the union is able to commit to a strike. A stronger union will therefore be able to commit to longer strikes thereby determining a reduction in the optimal capital/labour ratio.

When "go-slows" and "work-to-rule" are the available form of industrial action, Moene assumes that the union will determine a reduction in output by a fraction 1 - λ suffering only a partial loss in the wage (the fraction 1 - τ is lost). In the case of "work-to-rule" Moene assumes that the wage cannot be reduced, so that $\tau = 1$. The values of the "inside options" can therefore be written as follows

$$(1.43) \qquad w_0 = \tau \cdot \overline{w} \qquad \Pi_0 = \lambda \cdot \Phi - \tau \cdot \overline{w} \cdot L - r \cdot k \cdot L$$

with $\lambda < 1$, $0 \leq \tau \leq 1$ and $\overline{w}$ being the wage at the beginning of negotiations (the wage determined in the previous contract which is valid until a new agreement is reached).

The profit can be written as

$$(1.44) \qquad \Pi = [1 - \alpha \cdot (1 - \lambda)] \cdot \Phi(L \cdot g(k)) - \tau \cdot \overline{w} \cdot L - r \cdot k \cdot L$$

First order conditions are

$$(1.45) \qquad H(k) = \frac{\tau \cdot \overline{w}}{r}$$

This condition does not depend on α, union bargaining power. Unlike the case of strikes, variations of bargaining power do not affect the optimal capital/labour ratio if "go-slows" represent the form taken by industrial action. Moreover, if $\tau \cdot \overline{w} \geq (1-\alpha) \cdot z$[16], the optimal capital/labour ratio will be larger with "go-slows" than with strikes. This outcome is also interesting. The most collaborative[17] system of industrial relations determines a greater capital intensity of techniques with respect to more drastic forms of industrial action.

§1.4.2 **Extensions: Different types of workers and different types of capital**

Moene has extended his model to account for the existence of two different types of workers. To this purpose it can be assumed that only a subset of the workforce, for instance the skilled workers, is able to form a union and thereby bargain with the firm over the wage. The remainder of the workers do not unionise and receive the alternative wage w_b (the "outside option"). Both types of workers are necessary (together with capital) for production to take place. The profit can thus be written as follows

$$(1.46) \qquad \Pi = \Phi(L_1, L_2, K) - w \cdot L_1 - w_b \cdot L_2 - r \cdot K$$

[16] This is likely to apply in the "work-to-rule" case when $\tau = 1$.

[17] Insofar as it is less prone to disruptions of production.

where L_1 and L_2 are the unionised and non-unionised workers, respectively.

Moene assumes that during the negotiation with the union representing workers L_1 the firm is able to temporarily lay-off only a fraction c of the non unionised workers. The values of the "inside options" for the problem can therefore be written as:

$$(1.47) \quad \Pi_0 = -(1 - c) \cdot w_b \cdot L_2 \qquad \text{and} \qquad w_0 = z$$

The profit is then given by

$$(1.48) \quad \Pi = (1\text{-}\alpha) \cdot [\Phi - z \cdot L_1 - \frac{1 - \alpha \cdot c}{1 - \alpha} \cdot w_b \cdot L_2 - \frac{r}{1 - \alpha} \cdot K]$$

The assumption stated above does not imply that the firm keeps on producing during a strike by relying on the non-unionised workers, but only that wages must be paid to some of these workers.

From the analysis of the first order conditions Moene concludes that as union bargaining power becomes larger L_1 and K increase while L_2 decreases. Moene (1990, 316) thus claims that the increased union bargaining power does not bring about a substitution of non-unionised workers for unionised ones: "As long as it is optimal to have some militant workers it is profitable to have relatively many to prevent them from reaping most of the rent because of the high average productivity $\frac{\Phi}{L_1}$".

Moene (1989) represents another extension of the basic model. In this case labour is homogeneous, but two types of capital can be defined according to whether capital is a substitute or a complement for labour in the production function. These two types of capital differ in the sign of the cross partial derivatives in the production function $X = f(L,K_1,K_2)$. If capital is complement to labour (denoted by K_1) then $\frac{\partial^2 X}{\partial L \partial K_1} > 0$. As a consequence, demand for labour is increasing with K_1, for any given value of the wage and K_2. The opposite applies to K_2 which is substitute to labour. Wage bargaining is modelled as in the previous model, but employment is now determined by the firm along the labour demand curve according to the "Right-to-Manage model". Both types of capital have the same price.

Moene shows that the optimal input combination chosen by the firm has $K_1^* > K_2^*$. There is no distortion in favour of the type of capital which is substitute for labour: "As a matter of fact this equipment (K_2) would increase the average productivity of the remaining workers such that the equilibrium wage increases" (Moene, 1989, p. 381).

1.5 CHOICE OF PRODUCTIVE INPUTS AND WAGE BARGAINING: A SIMPLE MODEL

In this section a new model is developed and the results are compared with Moene (1990). The model includes the assumption that not all workers are union members. Union density is assumed to be exogenously given. There are no other sources of heterogeneity among workers. The purpose of the model is to analyse the effect of both union bargaining power and union density on the optimal choice of capital, employment and the capital/labour ratio. A simple specific form will be adopted for the production function in order to highlight that the choice of productive inputs made by the firm is also aimed at influencing the outcome of wage bargaining with the union. More specifically, as union bargaining power or union density increase, solutions may arise where employment is greater and the capital stock lower than in a competitive labour market. The Generalised Nash Bargaining Solution adopted by Moene (1990) is such that the firm will choose the aforementioned combination of capital and labour so as to keep the wage at the alternative (or competitive) level. The very strong nature of this result casts some doubts on the relevance of Moene's model.

The sequence of moves is assumed to be the same as in Moene (1990) and Grout (1984). Therefore in the first stage the firm chooses the quantities of capital (K) and employment (L) in order to maximise profits. In the second stage the firm and the union bargain over the wage with the outcome being given by the Generalised Nash Bargaining Solution. As seen above the wage is thus

$$\text{(1.49)} \qquad w^* = \underset{w}{\operatorname{argmax}} \, [U(w) - U_0]^{\alpha} \cdot [\Pi(w) - \Pi_0]^{(1-\alpha)}$$

$$\text{subject to} \quad U(\underline{w}) \geq U(\overline{w}) \qquad 0 \leq \alpha \leq 1$$

where $U(\cdot)$ = union's utility function and $\Pi(\cdot)$ = firm's profit

The model is based on the following assumptions:

1. The analysis concerns a single firm. The market for capital is perfectly competitive with the capital price defined by r. Once the capital has been bought, the firm is assumed to be unable to resell it (at whatever price)[18].

2. The union is wage maximiser so that $U = w$[19]. In the event of a strike workers receive a per capita solidarity fund equal to z. It is assumed that z is a fraction ϕ $(0 \leq \phi \leq 1)$ of the alternative (or competitive) wage, $\overline{w}$[20].

3. In the models presented above union bargaining power has been "measured" by the parameter α in (1.4). There are solid grounds, though, for believing that, additionally, union density represents a valid indicator of the union's ability to influence the outcome of wage negotiations. The non-cooperative approach to wage bargaining suggests that union density (labelled δ in the model) matters because it affects the "inside options", particularly on the firm's side. Those who refer to the cooperative approach (see Svejnar (1986), for instance) believe instead that union membership can be treated as a determinant of union bargaining power: the larger unionisation, the greater the value of α in the Nash solution. This approach has been employed in empirical research aimed at establishing the determinants of union power with α being treated as the dependent variable.

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[18]See below for the assumptions relating to the product market.

[19]The "median-voter" model with "seniority rule" for lay-offs, for instance, brings about this objective function (see Oswald (1985)).

[20]See below (assumption 4) for the definition of $\overline{w}$.

The model assumes that the firm is able to produce even if a strike is called by resorting to its non-unionised workers. The "inside option" for the firm is thus obtained as (assuming also that all union members go on strike[21])

(1.50) $\Pi_0 = R(K, (1\text{-}\delta)\cdot L) - (1\text{-}\delta)\cdot w_0 \cdot L - r\cdot K$

where R(K,L) represents revenues ($R_l>0$, $R_k>0$) and w_0 is the initial wage which is received by non-union workers.

4. It is assumed that in the initial situation the wage is at the competitive level, $w_0=\overline{w}$. The initial situation matters in the definition of the "inside options". As a consequence, the model can be thought of as an analysis of the changes brought about by a move from a competitive labour market to wage bargaining between the union and the firm.

5. Labour costs incurred by the firm for every worker exceed the wage by a fraction μ. This assumption refers to the existence of additional costs (see hiring costs, or other forms of institutional effects) in such a way that in the "inside option" the firm is bearing costs also for the workers on strike.

6. The form of industrial action considered in the model is the strike.

As a result of assumptions 1 to 6 the following can be defined and employed in expression (1.49). On the union side:

(1.51) $U(w)=w \quad U_0=z$ where $z = \phi\cdot\overline{w}$ is the solidarity fund

On the other hand, the profit is defined as

[21] Alternatively, δ could be thought of as the proportion of workers prepared to strike.

$$(1.52) \qquad \Pi(w)=R(K,L) - (1+\mu)\cdot w\cdot L - r\cdot K$$

In the light of (1.50) and assumption 5 the "inside option" for the firm is

$$\Pi_0=R(K,(1\text{-}\delta)\cdot L)\text{-}\overline{w}\cdot(1+\mu)\cdot(1\text{-}\delta)\cdot L\text{-}\mu\cdot\overline{w}\cdot\delta\cdot L\text{-}r\cdot K$$

$$(1.53) \qquad = R(K,\ (1\text{-}\delta)\cdot L) - \overline{w}\cdot(1+\mu\text{-}\delta)\cdot L - r\cdot K$$

The solution of (1.49) using (1.51), (1.52) and (1.53) gives the outcome of wage bargaining as

$$(1.54) \quad w^*= \frac{\alpha}{1+\mu}\cdot\frac{R(K,L) - R(K,(1\text{-}\delta)\cdot L)}{L} + \alpha\cdot\overline{w}\cdot\left(1 - \frac{\delta}{1+\mu}\right) + (1\text{-}\alpha)\cdot z$$

The alternative wage workers obtain quitting the firm (the "outside option", $\overline{w}$) acts as a constraint for the solution. In the first stage the firm chooses K and L in order to maximise profits taking into account that in the second stage $w = \max(w^*, \overline{w})$.

The model has been solved using a Cobb-Douglas production function (see (1.29)). Revenues can then be written as

$$(1.55) \quad R(K,\ L) = K^{\beta(1-1/\eta)}\cdot L^{\theta(1-1/\eta)} \qquad\qquad (\beta+\theta)\cdot(1\text{-}\tfrac{1}{\eta}) < 1$$

where η = price elasticity of demand (made positive) with $\eta>1$.

It is acknowledged that the choice of this specific functional form is restrictive. The purpose of this choice is twofold:

a) to emphasize the exposition of the results;

b) to make clear, unlike Moene's papers, the strategic nature of the choice made by the firm when determining the inputs' quantities. As a matter of fact, the choice made in the first stage is also aimed at influencing the outcome of wage bargaining in the second stage. This element is not captured when assuming, as Moene does, that the "outside option" constraint ($w \geq \overline{w}$) is never binding. The firm may instead find it profitable to set the inputs in such a way that the bargained wage is kept at the same level as the initial wage. To this purpose it is worthwhile stressing that with a Cobb-Douglas production function as in (1.55) the outcome of wage bargaining, w^*, is decreasing in the quantity of labour.

The main results of the analysis are the following[22].

If some conditions are met the initial (competitive) solution for wage, employment and capital stock (as well as output and profits) survives the introduction of wage bargaining. The conditions are the following:

(1.56) $$\alpha \cdot \frac{c}{\theta} + p \leq 1$$

where $c = 1 - (1-\delta)^{\theta}$ and $p = \alpha \cdot \left(1 - \frac{\delta}{1+\mu}\right) + (1-\alpha) \cdot \phi$ (1.57)

Therefore the solution differs from the competitive one only if *ceteris paribus* the parameter describing union bargaining power, α, is above the threshold determined by conditions (1.56) and (1.57). The two cases where all the workforce is unionised ($\delta = 1$) and not all workers are unionised are treated separately. The former situation is referred to as "closed shop", the latter as "open shop".

[22] The solution of the model when the Cobb-Douglas revenue function (1.55) is adopted is presented in the Appendix where it is assumed that $1/\eta = 0$, i.e. perfect competition in the product market.

CLOSED SHOP. In this case the model is very close to Moene (1990). It is assumed to start that no solidarity fund exists ($\phi = 0$) and that the firm is incurring no additional labour cost on top on the wage ($\mu = 0$). Hence from condition (1.57) c = 1 and p = 0. It is easily seen that the initial competitive solution applies for $\alpha \leq \theta$, where θ is the elasticity of output with respect to employment in the production function. For values of the union bargaining power above θ the solution differs from the initial (competitive) one, but the wage is still set at $\overline{w}$. Table 1.1 shows some numerical examples. For values of α above .4 employment rises first and then declines, and the same applies to output and profits, whereas the capital stock decreases monotonically and so does the capital/labour ratio. The latter result is thus in line with Moene (1990) (see subsection 1.4.1).

If all workers are unionised ($\delta = 1$) the wage can be pushed above $\overline{w}$ only either in the presence of positive "hiring costs", $\mu > 0$, or when union members receive a solidarity fund, $\phi > 0$ (or both). This result is shown in table 1.2, where μ=.1 and ϕ=.2, and in table 1.3, where μ=.2 and ϕ=.5. The behaviour of employment, capital stock, capital/labour ratio mirrors table 1.1, but for $\alpha > .4$ the wage increases with union bargaining power.

The results markedly differ when a "Right-to-Manage" model (Nickell-Andrews (1983)) is used. With such model the wage monotonically increases with union bargaining power starting from the competitive level (w = $\overline{w}$ when $\alpha = 0$) up to the situation in which, for $\alpha = 1$, the union receives all the rents. The "Right-to-

Manage" model represents a special case of the model presented above arising when $\phi = 1$, i.e. when the "inside option" for unionised workers is the same as the competitive (initial) wage. In this case the bargained wage is always above $\overline{w}$, for $\alpha>0$. Employment, production, capital stock, profits and capital/labour ratio decline as α becomes larger, while the wage increases.

OPEN SHOP. In this case the main interest is in the effects of changes in union density upon the solution of the model for alternative sets of parameters (see tables 1.4 and 1.5). In table 1.4, where $\alpha = .8$ and $\mu = .1$, the increase in union density does not affect the initial solution for values of δ below .65 (approximately). Above this threshold output and employment increase first and then drop, while the wage is unaffected ($w=\overline{w}$). Profits, capital and the capital/labour ratio decrease monotonically. In table 1.5 it is assumed that $\alpha = .5$ $\phi = .25$ $\mu = .1$. In this case the initial (competitive) solution still applies for values of δ below .9 (approximately). When δ is above .9 the wage stays at $\overline{w}$, while employment increases and the capital stock decreases.

The analysis of the closed and open shop cases presented above shows that Moene's view that increases in union bargaining power do not tend to bias the choice of techniques in a capital-intensive direction can be supported, but some qualifications need to be made.

1.6 INDUSTRIAL RELATIONS AND INNOVATION POLICIES

Sections 1.3 to 1.5 have been concerned with the effects of wage bargaining on the choice of capital stock (or the level of investment) for a single firm. The following new features are introduced in this section:

a) Oligopoly is assumed to prevail in the product market. For the sake of the argument a duopoloy is analysed with an homogeneous good being produced.

b) The analysis focuses on the innovation decision, i.e. the firm's choice concerning either the adoption of a more productive technology newly available in the market or the determination of the amount of R & D expenditure.

The main purpose of the papers surveyed in this section is to determine how the asymmetries in unionisation across firms in the same industry affect the innovative performance. The following question appears to be of particular interest: If a non-unionised firm faces a unionised firm which one will adopt a new technology or will spend more in R & D ? This question is tackled by Tauman and Weiss (1987). A related question is which firm will innovate (or spend more in R & D) when both firms in the market are unionised but union bargaining power differs across firms. This question is analysed in a series of paper by A. and D. Ulph (1988, 1989, 1991, 1994). More specifically Ulph and Ulph (1988, 1989) analyse whether unions are able to impose delays on the innovation process, a topic deemed to be very relevant with reference to the introduction of new labour-saving technologies based on microelectronics during the eighties.

§1.6.1 The effects of unionisation on the adoption of a new technology: Tauman and Weiss (1987)

Tauman and Weiss' (1987) starting point is that if a firm bargains with a union over the wage two opposite effects can arise as far as the propensity to innovate is concerned. On one hand, the higher wage paid represents an incentive for the firm to substitute capital for labour. On the other hand, the reduction in profits may undermine the ability to invest in new technologies, especially if they are characterised by huge fixed costs.

Tauman and Weiss refer to a duopoly. One firm is assumed to be unionised with the wage determined according to the Monopoly Union model, while in the other workers receive the competitive wage ($\overline{w}$). As in Grout (1984) (see §1.3.1) the union's utility function is given by $U = (w - \overline{w}) \cdot L$. Labour is assumed to be the only variable input. Production possibilities are entirely summarised by average labour productivity. Tauman and Weiss assume that in the initial situation both firms are endowed with the same technology which has productivity α, and that a "superior" technology is made exogenously available in the market with productivity β ($\beta > \alpha$) and a given adoption cost.

Taumann and Weiss aim at determining which firm will adopt the new technology when it is made available. The following two sequences of moves are analysed.

A. In the first stage the union determines the wage and the firm decides whether to adopt the new technology or not. These choices are made simultaneously. In the second stage the firm sets the quantity to be produced according to Cournot assumptions. As far as the non-unionised firm is concerned, on the other hand, the wage is given by $\overline{w}$ and only the firm makes choices. Taumann and Weiss show that a subgame perfect equilibrium exists where only the unionised firm adopts the new technology, β. For this to be the case market demand for the product needs to be sufficiently large[23] *ceteris paribus*. Conversely, no asymmetric solutions can be obtained where only the unionised firm innovates if the new technology is "drastically superior" to the existing one (roughly, if the ratio between β and α is sufficiently high).

B. If it is assumed that the determination of the wage on the part of the union follows the innovation decision made by the firm, then no equilibria can result such that the unionised firm is the only one to innovate. Hence the two assumptions under A and B lead to conflicting outcomes. As Taumann and Weiss stress "Wages are determined after the choice of technology when a change in technology is very costly, while the cost change in the wage contract is relatively small. This would be applicable in industries in which the costs of installment are large and innovations

[23] In a sense that is made precise in the article.

are infrequent. A simultaneous choice is applicable to industries in which technological change occurs frequently, the cost of adoption is relatively low, and hence the horizon of a given technology is short" (Taumann and Weiss (1987, 486)).

§1.6.2 **Wage bargaining and innovation decisions: Ulph and Ulph**

In a series of papers A. and D. Ulph (1988, 1989, 1991, 1994) analyse the effects of various systems of industrial relations on the firms' propensity to innovate (or to spend in R & D). The industrial relations arrangements under scrutiny differ with respect to which issues are bargained over between the firm and the union. In the basic case, the firm and the union bargain simultaneously over wage and employment, after the firm has decided whether or not to innovate (or the amount of R & D expenditure). This case is labelled "Ex Post Bargaining" by Ulph and Ulph. But the union may be allowed to bargain also over issues concerning innovation (or R & D), and not only over the determination of wage and employment. Ulph and Ulph devise two such cases. In the first scenario the firm decides whether to innovate or not (or the amount of R & D expenditure), but once the innovation has been acquired there is bargaining with the union over the date in which the new technology will be implemented in the production process. The union is then in a position to cause delays in the introduction of a new technology, or in the limit, even to prevent innovation from taking place. This arrangement is labelled "Post Auction Bargaining" by Ulph and Ulph[24]. In the other case, the decision whether to innovate or not is itself on the bargaining agenda between the union and the firm, together with wages and employment. This arrangement is labelled "Ex Ante Bargaining".

Ulph and Ulph believe that the case where the bargaining agenda covers all issues ("Ex Ante Bargaining") approximates the Japanese type of industrial relations arrangements. On the other side the two cases where the agenda is incomplete better resemble the U.S. ("Ex Post Bargaining") and European, especially UK, ("Post Auction Bargaining") systems of industrial relations.

In the rest of this section the outcome of the two arrangements where the agenda is incomplete are compared ("Ex Post" vs. "Post Auction" bargaining) with specific reference to Ulph and Ulph (1988, 1989). Then "Ex Ante" and "Ex Post" bargaining will be briefly analysed based on Ulph and Ulph (1991). The purpose of these models is to assess how the extension of the bargaining agenda affects the propensity to invest starting from the basic case of "Ex Post" bargaining. Grout's (1984) result that propensity to invest is reduced as union bargaining increases provides a benchmark for the analysis. Two main features separate the models here surveyed from Grout (1984):

1. As in Tauman and Weiss (1987) two firms are assumed to compete in the product market according to Cournot assumptions. Each firm bargains at least over wages and employment with a union. Bargaining is completely decentralised in the

[24] The reason for the name will be clear below.

sense that it takes place at firm level and no link or collusion exist between the two unions and firms in the bargaining process. Bargaining is modelled according to the Generalised Nash Bargaining Solution. Union bargaining power is allowed to differ across firms but it is the same irrespective of the issue bargained over within each firm. The latter assumption is very drastic and unrealistic. Equally, it is difficult to understand how the union can affect the innovation choice in the way described by the Nash Solution.

2. In Ulph and Ulph (1988, 1989) innovation is defined as the availability of a new technology, a patent for instance, which is more productive than the technology operated by the firms in the initial situation. Firms bid to obtain an exclusive and infinite license over the new technology with an auction type mechanism. The firm with the highest bid gets the license. One firm only is thus able to innovate.

The union facing firm i (i = 1,2) has a "utilitarian" objective function with the following specification (variables have been introduced before):

$$U_i = L_i(w_i - \overline{w})^{1-m} \qquad (1.58)$$

First the outcomes with "Ex Post Bargaining" and "Post Auction Bargaining" are compared. The main results are the following.

EX POST BARGAINING. The results in Grout (1984) are robust, in general, to the extensions, particularly the consideration of an oligopolistic product market.

Therefore an increase in union bargaining power lowers the ability of the firm to win the auction for the new technology. The case where workers are not risk averse is considered first (m = 0 in (1.58)). It is also assumed that firm 1 will obtain the new technology should the labour market be competitive. Ulph and Ulph show that when unions and bargaining over the wage are introduced a threshold exist, $\overline{s}$ say, for the union bargaining power in firm 1 such that for values above $\overline{s}$ the firm will lose the innovation auction.

The analysis is far less straightforward when workers are risk averse (0<m<1 in (1.58)). Some cases arise where as union bargaining increases the firm is then in the position to win an auction it would have lost for lower values of the parameter. This outcome is clearly at variance with Grout (1984). A necessary condition for this outcome to arise is for the parameter m to be very close to 1 so that unions are almost only concerned with employment in their objective function. The union bargaining power also needs to be very low. This special case is depicted in figure 1.2 (based on Ulph and Ulph (1989)). For a given value of union bargaining power in firm 1 ($\overline{s}$), as union bargaining power in firm 2 (parameter t) increases, a range of values exist such that firm 2 adopts the new technology which would not have been adopted for values of t nearer to 0.

POST AUCTION BARGAINING. Under these assumptions the firm that has won the auction for the new technology bargains with the union over the date of introduction in the production process. Bargaining over the timing of introduction takes place simultaneously with bargaining over wage and employment. As expected, bargaining over the timing of introduction takes place only in the case when the union is damaged by the adoption of the innovation. This is the situation when employment losses more than offset the increase in the wage. Otherwise it is in the union's interest to readily accept the new technology.

Ulph and Ulph show that if the union is very powerful $(s > \frac{\overline{w}}{a \cdot m}$, where a is the average productivity of the existing technology) innovation is totally impeded. Wages and employment are the same as with "Ex Post Bargaining" under the initial technology. Conversely, if the union is not very influential ($s < \frac{\overline{w}}{c \cdot m}$, where c is the average productivity of the new technology, with $c > a$), workers are not able to delay the introduction of the innovation. Wages and employment are the same as with "Ex Post Bargaining" under the new technology. For the intermediate range of values of union bargaining power (s) a delay in the adoption of the technology occurs with a length increasing with s.

In order to compare the two Industrial Relations arrangements described above Ulph and Ulph assume that one of the firms extends the bargaining agenda thereby switching from "Ex Post Bargaining" to "Post Auction Bargaining". Numerical solutions show that there is no evidence that a firm losing the adoption race under "Ex Post Bargaining" may win the auction when adoption itself becomes a bargaining issue. The opposite outcome very often arises when union bargaining power is high: Switching from "Ex Post Bargaining" to "Post Auction Bargaining" would impair the firm's ability to innovate. This result can be easily interpreted. Extending the bargaining agenda so as to include the timing of introduction allows the union to impose costs to the innovation process through delays in adoption. If some conditions are met these additional costs can make innovation unprofitable for the firm. A mechanism similar to Grout (1984) is still working although in a different context.

EX POST VERSUS EX ANTE BARGAINING. In a later paper Ulph and Ulph (1991) compare "Ex Ante Bargaining" (unions and firms bargain simultaneosly over innovation, wages and employment) with "Ex Post Bargaining" (the innovation decision is taken by the firm). In this specific model firms choose the R & D expenditure. The probability that a firm will "discover" first a new, more productive, technology depends on the amount spent on R & D and it is modelled according to a Poisson distribution.

It is well known that under competitive labour and product markets this model of R & D expenditure determines an equilibrium with over-investment (Brander and Spencer (1983)). Strategic considerations, i.e. the aim to prevent the rival from innovating, imply that the amount of R & D chosen by a firm exceeds the quantity that would be chosen solely for the purpose of profit maximisation. Under the assumption that m = 0 in the union's utility function (1.58), Ulph and Ulph show that with "Ex Post Bargaining" R & D expenditure is reduced with respect to a competitive labour market. This result confirms Grout (1984). When

"Ex Ante Bargaining" is instead employed, i.e. when also the amount of R & D expenditure is bargained over, the same quantity of R & D is obtained in equilibrium as under competitive labour markets. Ulph and Ulph stress that the "short-run solution" ("Ex Post Bargaining") Pareto dominates the "long-run solution" ("Ex Ante Bargaining"), with all the gains accruing to one party, the union. As a matter of fact, under "Ex Post Bargaining" the Grout mechanism simply "distorts" an initial situation characterised by over-investment in R & D thereby freeing resources that were employed for stategic purposes beforehand. These rents are then appropriated by the union.

1.7 THE EFFECTS OF UNIONISATION ON INVESTMENT AND INNOVATION IN THE U.K. : A SURVEY OF THE EMPIRICAL LITERATURE

Interest in the quantitative analysis of the effects of unionisation on investment and innovation in the U.K. has risen recently and diverging results have emerged so far. This section provides a survey of the papers on the subject. Particular attention will be paid to the description not only of the results, but also of the data used in these papers. This will make evident that one of the drawbacks of the empirical analysis of the effects of unions on investment in the U.K. has been the unavailability of data on investment (or innovation) and unionisation (or information on industrial relations arrangements) at the same disaggregation level.

Denny and Nickell (1992) represent the most important contribution to the subject. Two separate datasets are employed by Denny and Nickell.

(a) A group of 72 3-digit industries merged with information on union and industrial relations arrangements from WIRS 1980 and 1984. The dependent variable (investment) is given by the 'Acquisitions of Plant and Machinery' (source is the Census of Production). The unionisation measures employed in the estimations are the following: manual trade union recognition, manual trade union density conditional on recognition, existence of joint consultative commitees, existence of pre-entry closed-shop among manual workers.

(b) A group of 54 3-digit industries from 1973 to 1985. The measure of investment and the source are the same as above. Unionisation is now proxied by the percentage of workers covered by collective agreements (from New Earnings Survey).

Denny and Nickell adopt a standard adjustment-cost framework for modelling investment coupled with an asymmetric Nash bargaining model of wage determination. The main result of their analysis is that union recognition has a negative and significant effect on investment[25]. On the other hand, according to Denny and Nickell, union density conditional on recognition has a positive effect on investment in such a way that "if there is a union ... it is helpful if as many workers as possible are members. The management then need deal only with union representatives rather than having to make separate arrangements for a substantial

[25]The results now described are particularly clear for dataset (a).

body of non-union workers" (Denny and Nickell (1992, 880-81)). As a consequence the worst possible case is the situation where a union is recognised but only few workers are union members. The impact of union recognition on investment when wages and total factor productivity are held constant is estimated by Denny and Nickell at around 23%[26].

Machin and Wadhwani (1991a and 1991b) analyse both Organisational Change and Investment using data for 721 private sector establishments from WIRS 1984[27]. As far as the former is concerned, the question in WIRS relates to whether organisational change (for either manual or non-manual workers) has occurred in the three years before the survey (1981-84). Organisational change is defined as 'Substantial changes in work organisation or work practices not involving new plant, machinery or equipment'. Machin and Wadhwani also analyse investment decisions. Investment is defined as either 'Conventional Technical Change', i.e. the introduction of new plant, machinery, or equipment not incorporating microelectronics, or as 'Advanced Technical Change', i.e. introduction of new plant, machinery or equipment that includes the new microelectronics technology. As above, the dependent variable is dichotomous.

Machin and Wadhwani find that union recognition has a positive and

[26] Denny and Nickell stress that, since unions tend to increase wages and lower productivity, the total effect of unionisation will be lower, depending also on the nature of the product market.

[27] WIRS 1980 does not include any information on adoption of new technologies or investment.

significant impact, *ceteris paribus*, on organisational change. Union recognition has also a positive effect on investment (both for conventional change and advanced technical change), but this result is not robust to the introduction of regional and sectoral dummies. Machin and Wadhwani (1991b, 329) are therefore in a position to conclude that "unionism has no significant, *ceteris paribus* effect on investment or the introduction of new technology"[28].

Wadhwani and Wall (1990) use investment data from published accounts for 133 UK manufacturing companies, adjusted according to the procedure detailed in Wadhwani and Wall (1986), over the period 1972-86. The authors have firm-specific information on union coverage only at a point in time. Hence industry union density is employed to proxy movements of firm-level union coverage over time. As for Machin and Wadhwani (1991b) the authors stress that "there is no evidence for union rent-seeking behaviour inhibiting investment in union firms ... Increases in the unionisation rate have no effect on investment (or, if anything, increase investment)" (Wadhwani and Wall (1990, 15)).

Latreille (1992) analyses the effects of unions on the adoption of new microelectronic technology in the British private manufacturing sector using data for 418 establishments from WIRS 1984. The difference between his analysis and Machin and Wadhwani (1991a,b) is that the latter focuses on adoption only in the three years prior to the survey, while the question in WIRS employed by Latreille

[28] Machin and Wadhwani also acknowledge that their data refer to a period (1981-84) where unions were particularly weak. Hence the need for results based on alternative data.

refers to whether a new technology has ever been adopted (and was currently used) in the plant[29]. Latreille finds a positive and significant effect of union recognition on the probability of adoption. This result is robust to the introduction of industry and regional effects. Results are also unaffected by product market considerations or by the existence of a (pre-entry) closed shop[30]. Latreille (1992, 48) thus suggests that "the relationship between union presence and microelectronic adoption actually amounts to something more than simple acquiescence".

A recent paper by Menezes-Filho et al. (1995) provides an explicit attempt to test the theoretical predictions deriving from the R&D models of Ulph and Ulph surveyed in section 1.6[31]. The following two datasets are used:

a) Company account data for 469 British companies in the private sector over the period 1982-1990 (including information on R&D expenditure) merged with union and industrial relations informations at the company level gathered by the NIESR in 1990[32];

b) Data for 379 establishments from WIRS 1990[33].

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[29]The question in WIRS 1984 is the following: "Are you at present using the new microelectronics technology in any of your production processes here, including computer controlled plant, machinery or equipment ?" Daniel (1987, Appendix A, 291-301) includes the questions in WIRS 1984 about the use and introduction of new technologies.

[30]The existence of a closed shop is insignificant also in Denny and Nickell (1992).

[31]In the survey of Ulph & Ulph models in section 1.6 attention has been focused on the race to adopt a new, more productive technology, made exogenously available in the market, rather than the choice of internal R&D efforts made by the firms. The paper by Menezes-Filho et al. deals with the latter, not the former.

[32]These are the same data sources used in the empirical part of this thesis (see chapters 4 and 5) but applied here to the analysis of R&D instead of investment.

Menezes-Filho et al. show that the simple negative correlation between R&D and unionisation turns out to be spurious, being accounted by the fact that companies with more non-manual workers (and a greater R&D activity) are less likely to be unionised. The authors conclude that "there is no compelling evidence that union bargaining has, on average, a detrimental effect on R&D" (Menezes-Filho et al. (1995, 24)). However, they find support for the existence of a non-linear relationship (for both datasets) between union density and R&D intensity. With low levels of density unionisation does not hinder R&D activity, but the reverse holds for high density. According to Menezes-Filho et al. (1995, 24-25) this empirical finding is in line with the predictions of Ulph and Ulph: "Although highly unionised enterprises generally invested less, small increases in unionisation from a low base were positively associated with R&D. There was a hump-shaped relationship which could be due to the process of strategic interaction in the product market"[34].

Addison and Wagner (1994) provide some additional evidence on innovative activity. They find a positive association between innovative activity (R&D expenditure / gross value added) and union density for U.K. "low-tech" industries[35], using cross-correlations based on industry data for 1988. The question

[33] The questions on R&D from WIRS 1990 employed by Menezes-Filho et al. are the following: "Is any research and development activity carried out at this establishment ?", and, for those who answered Yes, "Roughly, what proportion of total current expenditure is spent on R&D?".

[34] Menezes-Filho et al. treat union density as a "measure" of union bargaining power. See sections 1.5 (assumption 3) and 5.1 for the theoretical and empirical problems involved with this approach.

[35] See the paper for the definition of such industries.

then arises as to whether a causal link can be established. Addison and Wagner compare the U.K. data with the relative industry data for Germany. They conclude that their evidence does not support the existence of a causal link and that "structural factors may well underpin any such favourable correlation between union density and investment in intangible capital" (Addison and Wagner (1994, 94)).

As this survey confirms, the results are mixed and far from definitive. More specifically, no paper matches continuous data on investment (as opposed to dichotomous variables on innovation, as in Machin and Wadhwani[36], and Latreille) with union information at the company or establishment level[37]. This type of information would prove extremely valuable especially in order to analyse the effects on investment of the changes in unionisation and industrial relations during the eighties. As Booth (1994, 211) has stressed, "it is clear that substantially more empirical studies need to be carried out before the findings ... of the impact of trade unions on investment activity acquire the status of stylised facts".

[36] Wadhwani and Wall (1990) have company level investment data, but they lack a suitable unionisation measure.

[37] Menezes-Fihlo et al. (1995) do so using data on R&D expenditure.

1.8 CONCLUSIONS. "DIRECT" AND "INDIRECT" EFFECTS OF UNIONS ON INVESTMENT AND INNOVATION

The underinvestment outcome when a union and a firm bargain over the wage in Grout (1984) represents the reference point for the papers surveyed in this chapter. Attempts have been made to extend Grout's framework in order to assess the robustness of its predictions[38]. Cases have been found that suggest outcomes conflicting with Grout's main message. But these models do not go without problems either. For instance, Manning (1987) relies on the assumption that unions bargain with firms in the way described by the Generalised Nash Bargaining Solution not only over the wage and employment, but also over the capital stock. This assumption appears troublesome and scarcely realistic. On the other side, the contributions from the "Scandinavian School" (mainly K.O. Moene) are extremely interesting in pointing out the relevance of the choice between the approaches to bargaining theory, but the ensuing results do not seem to represent a clear-cut criticism of Grout's outcomes. The most important and promising advance in the field has probably been the switch from single firm to oligopolistic product market settings in the analysis of innovation adoption in the presence of unions (the papers

[38] The general issue of the robustness of the predictions arising from the thoretical models of union behaviour when it is assumed that the ex-post substitutability between capital and labour is less than the ex-ante substitutability (i.e. when the putty-putty assumption is rejected in favour of the putty-clay or putty-semi putty assumptions) is not addressed here. See Manning (1994) for the analysis of the problem.

by Ulph and Ulph and by Tauman and Weiss). Once again, though, the main message from Grout (1984) seems to survive well.

It has probably been noticed that all the papers analysed in this survey refer to the effects of unionisation on investment and innovation through the channel of wage bargaining between unions and firms. No mention is made of what can be called instead the "direct effect" of unionisation on investment and innovation working through workers' resistance and opposition to new technologies. In the empirical literature on the subject it is sometimes suggested that the presence of unions affects the adjustment costs of the firm for the installation of new capital (see, for instance, Denny and Nickell (1992) and Van der Ploeg (1987) could also be modified in such a vein). No theoretical treatments are available of this "direct effect" that seems to be left to the attention of scholars of Sociology and Industrial Relations.

An interesting start on the analysis of this subject has been made by Dowrick and Spencer (1994). Dowrick and Spencer provide a detailed analysis of the conditions under which the adoption of a new labour-saving technology benefits or damages the union, when the product market is oligopolistic. Dowrick and Spencer consider alternative assumptions as far as wage determination (efficiency wages, Monopoly Union, Right-to-Manage model with Generalised Nash Bargaining Solution) and wage bargaining (local versus centralised) are concerned. The conditions under which unions favour or dislike innovation are thus determined.

The analysis of what unions can do if they are damaged by the innovation goes beyond the scope of Dowrick and Spencer (1994). The analysis of such case should take into account that the opposition to the new technology is likely to be costly for the workers. They might have to go on strike, for example. A drastic opposition to the new technology may also impair the competitiveness of the firm relative to rivals in the product market. In general, it appears very difficult to assess how opposition to innovation can be organised. For instance, once the innovation has been installed and introduced in the productive process, any decision taken by the union to oppose the new technology will involve only costs (the loss of wages during strikes, for example). These issues should not be overlooked if a formal analysis of the "indirect effect" of unions on innovation is to be carried out[39].

[39] The literature on the reactions to the introduction of new equipments based on microelectronics during the '80s in the UK shows that unions have usually not openly opposed the introduction of innovations (the well known case of the typografic industry being an exception). On the other hand, there is evidence of workers' opposition to new forms of work organisation that did not entail the adoption of new technologies. See Daniel (1987), Northcott et al. (1985), and Cornfield (1987).

FIGURE 1.1

THE FIRST TWO PERIODS OF A BARGAINING GAME

OF ALTERNATING OFFERS

(from Osborne-Rubinstein (1990))

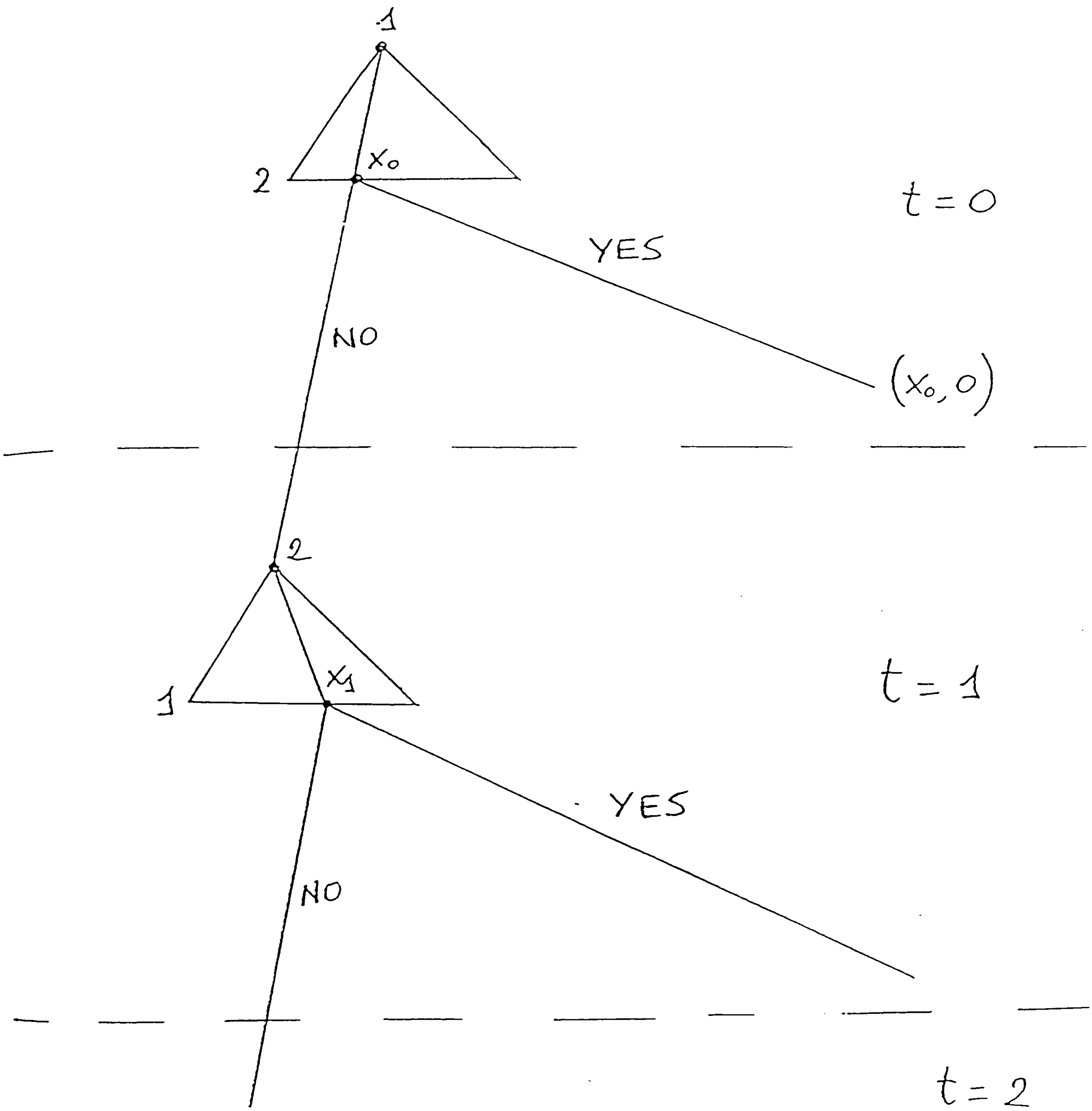
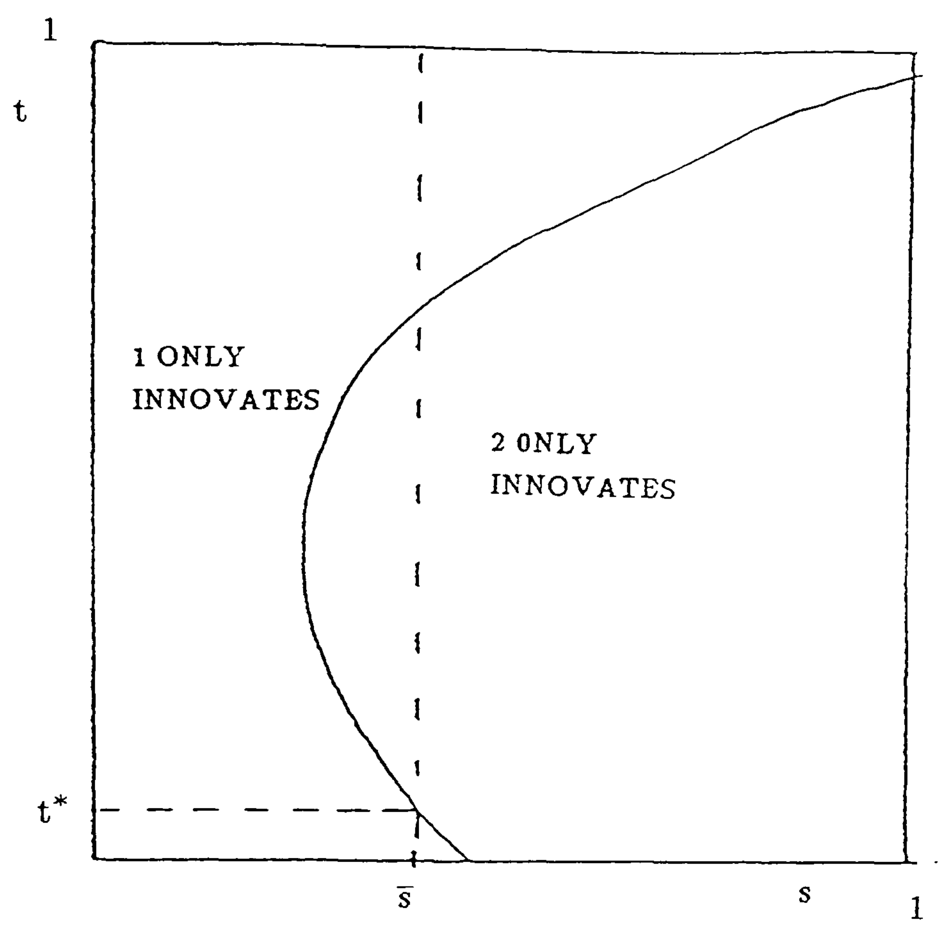


FIGURE 1.2

INCREASES IN UNION BARGAINING POWER

AND CHOICE OF TECHNOLOGY

(from (Ulph-Ulph (1990))



For values of the union bargaining power, t, between 0 and t^* firm 2 loses the innovation race. But, as t increases above t^*, firm 2 adopts the new technology. The result is based on the assumption that m=.999 in (1.58).

TABLE 1.1

CLOSED SHOP
(β=θ=0.4, μ=0, ϕ=0, r=$\bar{w}$=0.1)

union power(=α)	employment	capital	cap/lab ratio	wage	output	profit
0.4	1024.0	1024.0	1.00	0.1	256.0	51.2
0.5	1388.9	925.9	0.66	0.1	277.7	46.3
0.6	1536.0	682.6	0.44	0.1	256.0	34.1
0.7	1372.0	392.0	0.28	0.1	196.0	19.6
0.8	910.2	151.7	0.16	0.1	11.7	7.6
0.9	324.0	24.0	0.07	0.1	36.0	1.2

TABLE 1.2

CLOSED SHOP
(β=θ=0.4, μ=0.1, ϕ=0.2, r=$\bar{w}$=0.1)

union power(=α)	employment	capital	cap/lab ratio	wage	output	profit
0.1	769.3	846.3	1.10	0.100	211.6	42.30
0.4	984.2	800.5	0.81	0.100	228.3	40.00
0.5	1151.4	598.7	0.52	0.100	216.4	29.90
0.6	1046.7	339.6	0.32	0.100	166.0	17.00
0.7	689.1	127.3	0.18	0.100	94.9	6.40
0.8	171.8	21.3	0.12	0.124	26.6	1.00
0.9	7.3	0.8	0.11	0.240	2.0	0.04

TABLE 1.3

CLOSED SHOP
(β=θ=0.4, μ=0.2, ϕ=0.5, r=$\bar{w}$=0.1)

union power(=α)	employment	capital	cap/lab ratio	wage	output	profit
0.1	592.6	711.1	1.20	0.10	177.7	32.500
0.3	803.7	643.0	0.80	0.10	192.9	32.100
0.4	879.5	410.4	0.46	0.10	167.1	20.500
0.5	500.0	200.0	0.40	0.11	100.0	10.000
0.6	224.7	80.9	0.36	0.14	50.5	4.000
0.7	75.9	24.3	0.32	0.18	20.2	1.200
0.8	14.9	4.2	0.28	0.25	5.2	0.200
0.9	0.7	0.2	0.24	0.47	0.4	0.008

TABLE 1.4

OPEN SHOP
($\beta=\theta=0.4$, $\mu=0.1$, $\phi=0$, $r=\bar{w}=0.1$, $\alpha=0.8$)

density (=δ)	employment	capital	cap/lab ratio	wage	output	profit
0.100	769.3	846.3	1.10	0.1	211.6	42.31
0.650	794.1	845.7	1.06	0.1	214.2	42.28
0.700	866.1	837.9	0.97	0.1	220.9	41.90
0.800	1012.1	785.8	0.78	0.1	229.2	39.28
0.900	1138.4	646.7	0.57	0.1	222.2	32.33
0.950	1145.1	499.5	0.47	0.1	200.9	24.97
0.975	1077.5	373.9	0.35	0.1	174.6	18.69
1.000	403.9	47.1	0.12	0.1	51.5	2.35

TABLE 1.5

OPEN SHOP
($\beta=\theta=0.4$, $\mu=0.1$, $\phi=0.25$, $r=\bar{w}=0.1$, $\alpha=0.5$)

density (=δ)	employment	capital	cap/lab ratio	wage	output	profit
0.10	769.3	846.20	1.10	0.1	211.6	42.1
0.95	870.7	837.02	0.96	0.1	221.3	41.8
1.00	1153.9	557.70	0.48	0.1	210.5	27.9

APPENDIX

The following solutions for capital (K) and labour (L) can arise from profit maximisation with the revenue function (1.55) and assuming $1/\eta = 0$.

1. A solution (K, L) such that $\overline{w} > w^*$. In this case $w = \overline{w}$ and

$$L = \left[\frac{\theta^{1-\beta} \cdot \beta^{\beta}}{r^{\beta} \cdot [(1+\mu) \cdot \overline{w}]^{1-\beta}}\right]^{\frac{1}{1-\beta-\theta}} \quad \text{and} \quad K = \left[\frac{\beta^{1-\theta} \cdot \theta^{\theta}}{r^{\theta} \cdot [(1+\mu) \cdot \overline{w}]^{1-\theta}}\right]^{\frac{1}{1-\beta-\theta}}$$

provided $1 \geq \alpha \cdot \frac{c}{\theta} + p$ (p and c as defined in (1.57))

2. A solution (K, L) such that $w^* = \overline{w}$ and

$$L = \left[\frac{\beta^{\beta} \cdot (1\text{-}p\text{-}\alpha \cdot c)^{\beta} \cdot (\alpha \cdot c)^{1-\beta}}{r^{\beta} \cdot [(1+\mu) \cdot \overline{w}]^{1-\beta} \cdot (1\text{-}p) \cdot (1\text{-}\theta)^{1-\beta}}\right]^{\frac{1}{1-\beta-\theta}} \quad \text{and}$$

$$K = \left[\frac{\beta^{1-\theta} \cdot (1\text{-}p\text{-}\alpha \cdot c)^{1-\theta} \cdot (\alpha \cdot c)^{\theta}}{r^{1-\theta} \cdot [(1+\mu) \cdot \overline{w}]^{\theta} \cdot (1\text{-}p) \cdot (1\text{-}\theta)^{1-\theta}}\right]^{\frac{1}{1-\beta-\theta}}$$

3. A solution (K, L) such that $w^* > \overline{w}$

$$L = \left[\frac{\theta^{1-\beta} \cdot \beta^{\beta} \cdot (1\text{-}\alpha \cdot c)}{r^{\beta} \cdot [(1+\mu) \cdot \overline{w}]^{1-\beta} \cdot p^{1-\beta}}\right]^{\frac{1}{1-\beta-\theta}} \quad \text{and}$$

$$K = \left[\frac{\beta^{1-\theta} \cdot \theta^{\theta} \cdot (1\text{-}\alpha \cdot c)}{r^{1-\theta} \cdot [(1+\mu) \cdot \overline{w}]^{\theta} \cdot p^{\theta}}\right]^{\frac{1}{1-\beta-\theta}} \quad \text{provided} \quad \alpha \cdot p \cdot c \geq (1\text{-}p) \cdot (1\text{-}\alpha \cdot c) \cdot \theta$$

CHAPTER 2

UNIONS AND THE ADOPTION OF A NEW TECHNOLOGY

A MODEL WITH OLIGOPOLISTIC PRODUCT MARKETS

AND WAGE BARGAINING

2.1 INTRODUCTION

As shown in section 1.7 there is a growing empirical interest in the effects of unions on the introduction of new technologies[1]. The evidence stemming from this literature is at the moment largely inconclusive. Less attention has been paid to the theoretical analysis of the alternative ways through which unions can affect the choice of a new technology (but see Tauman and Weiss (1987)) until the work recently conducted by Ulph and Ulph (1988, 1989, 1991, 1994) in a series of papers[2]. The relation between these papers and the model presented in this chapter will be discussed later. The main aim of this chapter is to develop a theoretical model which captures the effects of unions on the adoption of a new, more productive and labour-saving technology in an oligopolistic product market when unions and firms bargain over the wage.

The effect of unions on innovation is undoubtedly a matter of some concern well beyond the discussions in academia alone. Furthermore, the question of whether the presence of powerful unions tends to inhibit innovation has long been debated. In the light of the multiple facets of the subject, it is primarily important to state which issues the following model is not going to deal with.

---

[1]See Machin-Wadhwani (1991b), Latreille (1992), Hirsch (1992) and the papers surveyed in section 1.7.

[2]See section 1.6 for a survey and a discussion of the findings in both Tauman and Weiss (1987) and Ulph and Ulph (1988, 1990, 1991, 1994).

The model is not concerned with the "direct" effect of unions on the innovation choice of the firm[3], i.e. it is assumed that the union has a passive role towards the choice of technology. The union effect works instead through wage bargaining. Therefore, issues such as union resistance or opposition to the introduction of a new technology (see Dowrick and Spencer (1994)) are not addressed in the model. This stems from the fact that it is the sole responsibility of the firm to choose whether or not the innovation should be adopted. Once this adoption decision has been taken by the firm there is no way for the union to affect the decision: resisting the innovation would only involve losses on the union side. Moreover, the model assumes that the union is not involved in any way in the decision about the adoption. This means that there is no negotiation between the union and the firm on whether (or when) the technology should be introduced. Negotiation of this type can be found for instance in the analysis developed by Ulph and Ulph (1988, 1989). In a somewhat different setting from the one presented below, Ulph and Ulph argue that extending the agenda of bargaining between the union and the firm to include innovation activity - or at least the actual date of implementation once introduction has been decided - might result in a loss of efficiency, i.e. in new technologies not being introduced that would have been had bargaining concerned only wages (and possibly employment) but not innovation[4].

In connection with the above discussion it is worth noticing that the model

[3]See the discussion on the "indirect" effect of unions in section 1.8.

[4]See section 1.6.2 for a discussion of this result.

is not dynamic. Firms in the model choose simultaneously whether or not to innovate and no adjustment costs hinder the introduction of the technology once the decision has been taken. In a dynamic setting, once the innovation appears in the market (time 0, say), firms would choose in which time period they will adopt (if any). This analysis has been developed for the general case by Reinganum (1981)[5]. Since no dynamics are involved in the choice, the model does not cope with the issue of unions causing the firm to delay its innovation[6], an issue that has been considerered of some empirical relevance in the industrial relation literature.

Instead, the model deals with the "indirect" effect of unions on the introduction of a technology. The effect is said to be indirect because unions affect wage determination, which influences the firm's innovation decision, without explicitly affecting the choice of innovation of the firm. As seen in chapter 1, this idea dates back to the paper by Grout (1984) on the effect of unions on investment and is widely accepted in the literature. Wage determination and union power are modelled according to the Generalised Nash Bargaining Solution.

A relevant feature of the model is the duopolistic setting. In recent years there has been an increased interest in the modelling of union behaviour in the multi-firm case[7]. Competition between firms in the product market is modelled here according to Cournot assumptions, i.e. each firm sets its own quantity taking its

[5]See Tirole (1988, ch. 8) for a summary of this literature and Reinganum (1989) for a thorough survey.

[6]This result can arise in some of the models analysed in section 1.6 (see Ulph and Ulph (1988, 1989)). Some limitations of these models are also pointed out in the same section.

rival's quantity as given.

Section 2.2 sets out the main assumption and the structure of the model. The solutions to each stage of the game are worked out in section 2.3. Numerical solutions (and their graphical representations) and comments to the results are provided in section 2.4. It is important to stress that the behaviour of the model is robust to changes in the set of parameters used in section 2.4. Finally, the main conclusions are restated in section 2.5.

2.2 THE MODEL: BASIC ASSUMPTIONS

The analysis of the adoption of a new technology in the presence of unions developed in this chapter is based on a three stage game. The decision stages of the game are as follows.

- Stage 1. At the beginning of the period each firm is endowed with the same technology. Once a new, more productive (and labour-saving) technology is made exogenously available to the firms in the industry, each should decide whether or not to adopt the new technology. Each firm aims at maximising profits. The adoption choice depends (among other things) on the price of the technology which

[7] Stewart (1990) provides evidence on the effect of product market conditions on the union - non union wage differential using establishment data from WIRS (see section 5.5 for a more detailed discussion of the results). On the theoretical side, Dowrick (1989) analyses the outcome of wage bargaining between the firm and the union when the product market is oligopolistic.

is exogenously given. The outcome of this stage is a Nash equilibrium with the strategies available to the firms being {innovate, not innovate}.

- Stage 2. Given the technology adopted in the first stage each firm bargains with its (firm level) union to determine the wage level (given the wage in the rival firm)[8]. The outcome of bargaining inside each firm is described by the Generalised Nash Bargaining Solution, with the wage settled in one firm depending on the wage in the rival firm. The complete solution for the wage in this stage is again a Nash equilibrium: the Nash equilibrium in the two Nash Bargaining Solutions (see Hoel (1991) and De Fraja (1991) for an example of this type of solution).

- Stage 3. Finally each firm sets the quantity in order to maximise profits[9] in a typical Cournot game.

This setup has some common features with both Dowrick and Spencer (1994) and the papers by Ulph and Ulph (1988, 1989, 1991). The sequence of moves is the same as in Dowrick and Spencer[10]. However, Dowrick and Spencer are not concerned with modelling the choice of innovation. They detail conditions under which unions will be worse off by the introduction of a new, labour saving, technology, but it is beyond the scope of their paper to analyse how unions can

[8]Hence the model assumes decentralised wage bargaining.

[9]Because of the assumptions on the production function (see (2.2)) and the structure of the game, setting quantity is the same as setting employment. Since employment is determined by the firm along the demand for labour, the model belongs to the "Right-to-Manage" approach.

[10]It seems to have some realistic appeal to structure the stages this way. This is the case since the adoption of a new technology can be thought of as being a long-term decision. Technologies are also likely to be less flexible than wage settlements (especially if wage agreements are non-binding, see section 1.3).

actually oppose an innovation they dislike, whether it is credible for them to do so, and, finally, whether the innovation will be adopted in the first instance by the firm if such threats exist[11].

On the other hand, the approach in Ulph and Ulph (1988, 1989, 1991) focuses on the effect of unions on R&D expenditures more than on the adoption of a given technology available on the market. Moreover, in Ulph and Ulph's set of models there is only one firm able to innovate (for instance, by winning the auction which enables it to get the patent). The case where both firms innovate cannot be accounted for. It could be argued that the analysis of adoption suggested in the model developed in this chapter suits better the understanding of the effects of unionisation on, say, computer-based technologies which have been the focus of some recent work.

In the model, firms may differ *ex ante*, i.e. before the innovation is introduced in the market, only according to their union characteristics, remaining features being the same across firms. Two union parameters are relevant:

1. The union bargaining power as described by the bargaining parameter in the Generalised Nash Bargaining Solution (α_i say, where the subscript denotes firm i);

2. The union perceived trade-off between employment and the wage, i.e. the weight on wage and employment, respectively, in the union objective function. To this purpose a Stone-Geary utility function is adopted of the following form (see, for

[11]See section 1.8 for more on the issue.

instance, Pencavel (1985) for the choice of this specific functional form):

$$(2.1) \qquad U_i = (w_i - r)^{\delta_i} \cdot L_i^{1-\delta_i} \qquad 0 \leq \delta_i \leq 1$$

(where r is the "reference" or "competitive" wage, with r>0)

Many interesting cases are encompassed by this specification[12].

In the model, the values of the parameters α and δ are not restricted to the symmetric case (i.e. $\alpha_1=\alpha_2$ and $\delta_1=\delta_2$) but any combination can be considered.

The main aim of the model is to assess the consequences of union power and its distribution across firms on the adoption of a new technology in a duopoly. The problem can also be stated as follows: for a given combination of union bargaining powers (parameters α_1 and α_2) and union perceived trade-offs (parameters δ_1 and δ_2) in the two firms, will a new, more productive technology be adopted by both firms, by neither, or by one only ? Furthermore, in the case of just one firm innovating, which union characteristics are relevant in determining this result ? If union power differs across firms, which firm is more likely to innovate, the one facing the more powerful union or the other ?

As the empirical evidence has repeatedly shown the answer to these questions is not straightforward (see section 1.7). Similarly, *a priori* intuition suggests that the theoretical result is likely to be ambiguous. As a matter of fact, when a firm is confronted with a union two forces could drive the choice of adoption:

[12] See Booth (1994, 105-06).

(a) If faced with a powerful union a firm is likely to have higher labour costs. As a consequence a heavily[13] unionised firm is more willing to resort to labour saving innovation in order to cut its costs.

(b) The expected rents from introducing a new technology might be (at least partially) skimmed by the union via an increase in wage demands. The anticipation of this "opportunistic" behaviour on the part of the union might deter the firm from innovating (this is best known as the "Hold-up mechanism", see section 1.3). In this case the prediction is opposed to case (a).

The aim of the model is to determine which effect is prevailing and under what conditions. Moreover, it is also interesting to determine what happens when union bargaining power changes[14]. Is there any possibility of an innovation being adopted at a given value of α that it wouldn't have been for a lower value ?[15] Or, might adoption be more likely the more powerful are unions ?

Given the assumptions of the model (which I have outlined above) it is possible to determine for every combination (α_1, α_2, δ_1, δ_2) the choice of the firms towards the adoption of the new technology. For given values of δ_1 and δ_2 a diagram can be drawn on the space of union bargaining powers (α_1, α_2) which illustrates the

[13] Throughout this chapter union power always refers to union bargaining power, as described by the parameter of the Generalised Nash Bargaining Solution, and never to union density. All workers are assumed to be union members in both firms.

[14] Although it is difficult to think of α_i changing because the parameter is related to the relative impatience of the parties involved in wage bargaining if the non-cooperative approach to bargaining is accepted.

[15] This issue is raised by Ulph and Ulph (1988, 1989) and discussed in section 1.6.2.

outcome of the innovation game of the first stage (see figure 2.3 for an example).

2.3. THE MODEL

This section introduces some additional assumptions needed for the solution of the model and describes how the subgame perfect equilibrium for the game is obtained. Hence the solution of the model is analysed backwards starting from stage 3, competition in the product market, and then moving to stage 2 (wage determination) and stage 1 (choice of technology).

§2.3.1 **Stage 3. Cournot competition in the product market**

The analysis draws on a number of (simplifying) assumptions[16]:

A1. The production function for firm i is described by the following expression:

$$(2.2) \qquad q_i = a_i \cdot L_i \qquad i=1,2$$

where:

q_i = output of firm i,

L_i = quantity of labour employed by firm i

The parameter a_i (the average productivity of the firm) describes the technology of the firm. This parameter has a crucial role in the ensuing analysis.

[16] Assumptions A1 to A3 ensure the existence of an explicit (linear) solution for the wages in stage 2. In section 3.2 some extensions of the model will be considered, relaxing particular assumptions.

A2. Firms produce a totally homogeneous product.

A3. The demand for the product is assumed to be linear:

$$(2.3) \qquad p = A - b \cdot (q_1 + q_2)$$

where

p = price of the product, and A and b are given parameters.

A4. The technology a_i employed by firm i has a cost z_i (this assumption will be specified more fully later).

Each firm is faced with the problem of maximising its profits by choosing an appropriate quantity, i.e. using $L_i = \frac{q_i}{a_i}$, firm i chooses

$$(2.4) \qquad q_i^* = \arg\max_{q_i} \ \Pi_i = p \cdot q_i - \frac{w_i}{a_i} \cdot q_i - z_i$$

$$= [A - b \cdot (q_1 + q_2)] \cdot q_i - \frac{w_i}{a_i} \cdot q_i - z_i$$

Under Cournot assumptions, first order conditions for profit maximisation for firm 1 are given by

$$(2.5) \qquad A - b \cdot (q_1 + q_2) - b \cdot q_1 = \frac{w_1}{a_1}$$

An analogous expression holds for firm 2.

Therefore, the reaction function of firm 1 is:

$$(2.6) \qquad q_1 = \frac{1}{2 \cdot b} \cdot (A - b \cdot q_2 - \frac{w_1}{a_1})$$

The reaction function is linear. From the analogous expression for firm 2 the Cournot-Nash equilibrium in quantity levels can be derived. In equilibrium,

$$(2.7) \qquad q_1 = \frac{1}{3 \cdot b} \cdot (A + \frac{w_2}{a_2} - 2 \cdot \frac{w_1}{a_1})$$

(2.8) $$q_2 = \frac{1}{3 \cdot b} \cdot (A + \frac{w_1}{a_1} - 2 \cdot \frac{w_2}{a_2})$$

See Tirole (1988, ch. 5) for more comments on this very standard result.

§2.3.2 **Stage 2. Wage determination**

Each firm is assumed to bargain with its local union over the wage. The outcome of wage negotiation is described by the Generalised Nash Bargaining Solution as in most of the models of chapter 1. The sequence of moves in the model ensures that the solution for the wage lies on the labour demand curve (a "Right-to-Manage model"). The employment level is implicitly determined in the third stage by choosing the quantity to be produced, given the technology in (2.2).

The union's utility function (2.1) can be rewritten in terms of production instead of employment as follows:

(2.9) $$U_i = (w_i - r)^{\delta_i} \cdot L_i^{1-\delta_i} = (w_i - r)^{\delta_i} \cdot (\frac{q_i}{a_i})^{1-\delta_i}$$

The Generalised Nash Bargaining Solution determining the wage in firm i is solved by choice of w_i as:

(2.10) $$\max_{w_i} \ [(w_i - r)^{\delta_i} \cdot (\frac{q_i}{a_i})^{1-\delta_i}]^{\alpha_i} \cdot [p \cdot q_i - \frac{w_i}{a_i} \cdot q_i]^{1-\alpha_i}$$

subject to the constraint that the profits of firm i are nonnegative, $\Pi_i \geq 0$, where α_i is union bargaining power $(0 \leq \alpha_i \leq 1)$[17] and values of q_i are given by the solution to the third stage, (2.7) and (2.8).

Taking logarithms and labelling the maximand V_i the problem can be rewritten as

$$\max_{w_i} \; V_i = \alpha_i \cdot \delta_i \cdot \log(w_i - r) + \alpha_i \cdot (1 - \delta_i) \cdot \log q_i + (1 - \alpha_i) \cdot \log q_i +$$

$$(2.11) \qquad + (1 - \alpha_i) \cdot \log(p - \frac{w_i}{a_i}) + \text{constant}$$

First order conditions (in the case of firm 1) are given by:

$$(2.12) \qquad \frac{\alpha_1 \cdot \delta_1}{w_1 - r} = [2 - \alpha_1 \cdot (1 + \delta_1)] \cdot \frac{2}{a_1} \cdot \frac{1}{A + \frac{w_2}{a_2} - 2 \cdot \frac{w_1}{a_1}}$$

This result stems from the fact that $p - \frac{w_1}{a_1}$ can be rewritten using the solutions from stage 3 for q_1 and q_2 as

$$p - \frac{w_1}{a_1} = A - b \cdot (q_1 + q_2) - \frac{w_1}{a_1} = A - \frac{1}{3} \cdot (2 \cdot A - \frac{w_1}{a_1} - \frac{w_2}{a2}) - \frac{w_1}{a_1} =$$

$$(2.13) \qquad = \frac{1}{3} \cdot (A + \frac{w_2}{a2} - 2 \cdot \frac{w_1}{a_1})$$

Rearranging (2.12) and taking into account the non-negativity of profits

[17] The model encompasses the two extreme cases of competitive (non-unionised) labour markets, if $\alpha = 0$, and of Monopoly Union, if $\alpha = 1$.

constraint a solution for the wage in firm 1 can be obtained as follows

$$(2.14)\quad w_1 = \frac{1}{2\cdot(2\text{-}\alpha_1)}\cdot\left\{\alpha_1\cdot\delta_1\cdot a_1\cdot(A + \frac{w_2}{a_2}) + 2\cdot r\cdot[2 - \alpha_1\cdot(1+\delta_1)]\right\} \quad \text{if } w_2 \geq \overline{w}_2$$

$$= \frac{a_1}{2}\cdot\left(A + \frac{w_2}{a_2} - 3\cdot(z\cdot b)^{-1/2}\right) \qquad \text{if } w_2 < \overline{w}_2$$

where

$$(2.15)\qquad \overline{w}_2 = 3\cdot a_2\cdot(z\cdot b)^{-1/2}\frac{(2\text{-}\alpha_1)}{2\text{-}\alpha_1\cdot(1+\delta_1)} + a_2\cdot\left(\frac{2\cdot r}{a_1} - A\right)$$

and z is the cost of the technology (see section 2.4.4).[18]

If the wage set in the rival firm is below $\overline{w}_2$ the solution of the wage is set so as to ensure that the profit is nonnegative, i.e. $\Pi_1 = 0$ for $w_2 < \overline{w}_2$. As a result the solution for the wage in firm 1 as a function of w_2 has a kink at $w_2 = \overline{w}_2$ as depicted in figure 2.1(a).

The remainder of this chapter focuses on the unconstrained solution, i.e. with positive profits only. The constrained case is analysed in Appendix 2D.

Equation (2.14) gives the outcome of wage bargaining between firm 1 and its local union. The solution depends on the characteristics of the local union in firm 1 (α_1, δ_1), the type of technology operated by firm 1 (a_1), the position of the product demand curve (A), the reference wage (r) as well as the wage set by the firm and the union in firm 2 and a_2, the productivity of firm 2. Therefore equation (2.14) can be regarded as a reaction function relating to each value of w_2 the level

[18] An analogous expression holds for firm 2.

of the wage attained through bargaining in firm 1 according to the Generalised Nash Bargaining Solution.

Figure 2.1(b) depicts the reaction functions for firm 1 and 2 in the space (w_1, w_2). The reaction functions are linear. At $w_2 = 0$

$$(2.16) \qquad w_1 = \frac{1}{2\cdot(2-\alpha_1)}\cdot\left\{\alpha_1\cdot\delta_1\cdot a_1\cdot A + 2\cdot r\cdot[2 - \alpha_1\cdot(1+\delta_1)]\right\} > 0$$

for either $\alpha_1 > 0$ or $r > 0$.

It is easily seen from inspection of equation (2.14) that, *ceteris paribus*,

a) a more efficient technology adopted by firm 1,

b) a positive shift in the product demand, and

c) an increase in the reference wage

shift the reaction function of firm 1 upwards (i.e. $\frac{\partial w_1}{\partial a_1} > 0$, $\frac{\partial w_1}{\partial A} > 0$, and $\frac{\partial w_1}{\partial r} > 0$).

On the other hand, the adoption of a more productive technology by firm 2 causes the reaction function of firm 1 to move backwards, *ceteris paribus* (i.e. $\frac{\partial w_1}{\partial a_2} < 0$).

The comparative statics effects of a change in either union power (α_1) or union weight on wage (δ_1) can be derived by means of some algebra. It follows that

$$\frac{\partial w_1}{\partial \alpha_1} > 0 \quad \text{and} \quad \frac{\partial w_1}{\partial \delta_1} > 0$$

for the relevant range of the parameters. As expected , an increase in either union bargaining power or the weight on the wage in union preferences bring about, *ceteris paribus*, an increase in the bargained wage.

Figure 2.2 depicts the effects of an increase in efficiency in the technology operated by firm 1 (an increase in a_1 while firm 2's technology remains unchanged) starting from the initial equilibrium E_0. A change in a_1 affects both reaction functions. As seen before the reaction function for firm 1 is shifted upwards, thereby implying, *ceteris paribus*, a higher level for the wage in firm 1. On the other hand, an increase in a_1 reduces the wage obtained by workers in firm 2, thereby shifting the reaction function for firm 2 backwards. The ensuing equilibrium is labelled E_1. At the new equilibrium the wage in firm 1 which has "innovated" has increased, whereas the wage in the rival firm has decreased.

The solution for the wage determination stage involves finding the Nash equilibrium in the Nash Bargaining Solutions derived above for firms 1 and 2. Using the same type of reasoning as in the Cournot model (section 2.3.1), the solution for the wage in firm 1 is given by

$$w_1 = \frac{1}{4\cdot(2-\alpha_1)\cdot(2-\alpha_2) - \alpha_1\cdot\alpha_2\cdot\delta_1\cdot\delta_2}\cdot\Big\{\alpha_1\cdot a_1\cdot\delta_1\cdot A\cdot[2\cdot(2-\alpha_2) + \alpha_2\cdot\delta_2] +$$

$$+\ 2\cdot r\cdot\Big\{2\cdot(2-\alpha_2)\cdot[2 - \alpha_1\cdot(1+\delta_1)] + \alpha_1\cdot\delta_1\cdot\frac{a_1}{a_2}\cdot[2-\alpha_2\cdot(1+\delta_2)]\Big\}\Big\}$$

(2.17)

This is the unconstrained wage solution where both firms gain positive profits[19].

Hence the wage in firm i is completely described by the parameters relating to the technology (a_i), to unions' power (α_i) and perceived trade-off between wage and employment (δ_i) in both firms, to the characteristics of the product demand (the intercept A), and to the reference wage (r).

Two interesting special cases are listed below.

1. $\alpha_1 = 0$ implies $w_1 = r$. In this case firm 1 is not confronted by a union and the model reverts to the competitive labor market assumptions.

2. $\delta_1 = 0$ implies $w_1 = r$. In this case the union cares only about employment. As a result the wage is squeezed to its minimum attainable level in order to maximise the demand for labour.

Turning again to the effects of an increase in efficiency of the technology operated by firm 1 equation (2.17) rules out the occurrence of equilibria qualitatively different from the one depicted in figure 2.2. If firm 1 only adopts a more productive technology (i.e. a_1 increases, for given a_2), then w_1 increases while w_2 decreases.

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[19] See Appendix 2D for the constrained case.

§2.3.3 Stage 1. Choice of technology

The choice of the technology the firm will operate in the production process constitutes the basic decision made by the firm before competing with other firms on the product market and before bargaining with the local union over the wage. Each firm chooses its production technology in order to maximise its profits seeing through the following stages of the game according to the results depicted above for stages 2 and 3.

At the beginning each firm is assumed to operate the same technology which is labelled a_0. Each unit of labour employed by the firm produces a_0 units of output. In order to simplify the analysis it is assumed that the costs for the existing technology have already been sunk. Thus, if firm i chooses to operate the technology a_0, then $z_i = 0$. Firms are faced with the choice between the existing technology and a new, "superior", i.e. more productive, technology, which enables the firm to produce $a^* = \gamma \cdot a_0$ units of output for each unit of labour employed ($\gamma > 1$). On the other hand, the new technology does not come free to firms: the cost of adoption is labelled z. The cost of adoption, z, is invariant across firm.

As has been stressed before, this setup fits the case where an innovation is exogenously introduced in the market and firms are confronted with the decision whether or not to adopt the new technology. The model does not address the question of how much firms are willing to spend in R&D activities (or patent races) since the innovation originates completely from outside the firm. The model does not prevent both firms from simultaneously innovating as is the case, for instance, in the auction model outlined by Ulph and Ulph (1989, 1990) where the firm with the highest bid is the only one to get the innovation.

It is assumed that the choice of the technology is made simultaneously by firms 1 and 2. Hence the type of solution arising from this stage of the model is the Nash equilibrium of the game where both players (the firms) are endowed with the strategies: {Stick to the existing technology, Adopt the new technology}. The aim of the model is to analyse to what extent the union characteristics of the firm (particularly, union power) determine its adoption policy.

It can be easily seen that profits, net of innovation costs, for firm i are given by the following formula:

$$\Pi_i = \frac{1}{9 \cdot b} \cdot \left(A + \frac{w_j}{a_j} - 2 \cdot \frac{w_i}{a_i}\right)^2 \tag{2.18}$$

Hence the payoff to firm i from operating the technology a_i when firm j operates the technology a_j is given by Π_i - cost of innovation, where the cost of innovation is equal to either z (if the firm operates the new technology a^*) or 0 (if the firm operates the existing technology, a_0).

Therefore, the payoff matrix for the game can be represented as follows, where $\Pi_i(a_i,a_j)$ indicates the profits accruing to firm i when it operates the technology a_i while firm j operates technology a_j.

FIRM 2	Innovation	No Innovation
FIRM 1		
Innovation	$\Pi_1(a^*,a^*)$-z, $\Pi_2(a^*,a^*)$-z	$\Pi_1(a^*,a_0)$-z, $\Pi_2(a^*,a_0)$
No Innovation	$\Pi_1(a_0,a^*)$, $\Pi_2(a_0,a^*)$-z	$\Pi_1(a_0,a_0)$, $\Pi_2(a_0,a_0)$

The following is obtained from the pay-off matrix.

1. Firm 1 prefers to innovate (in the case that firm 2 innovates) if and only if

(2.19) $\Phi_1 \equiv \Pi_1(a^*,a^*) - \Pi_1(a_0,a^*) > z$

2. Firm 1 prefers to innovate (in the case firm 2 does not innovate) if and only if

(2.20) $\Phi_2 \equiv \Pi_1(a^*,a_0) - \Pi_1(a_0,a_0) > z$

3. Firm 2 prefers to innovate (in the case firm 1 innovates) if and only if

(2.21) $\Phi_3 \equiv \Pi_2(a^*,a^*) - \Pi_2(a^*,a_0) > z$

4. Firm 2 prefers to innovate (in the case firm 1 does not innovate) if and only if

(2.22) $\Phi_4 \equiv \Pi_2(a_0,a^*) - \Pi_2(a_0,a_0) > z$

The expressions Φ_k (k=1,...4) depend on all the parameters included in the wage equation (2.17) (with b, the slope of the demand curve, added) but do not depend on the cost of innovation, z.

Appendix 2A shows that the following relationships hold (for $\gamma>1$):

- as far as firm 1 is concerned, $\Phi_2 > \Phi_1$
- as far as firm 2 is concerned, $\Phi_4 > \Phi_3$

These conditions simply state that additional profits (net of adoption costs) accruing to the firm from innovating are greater when the rival firm does not innovate as well.

Drawing on these results it is easy to show that the following types of Nash equilibria in pure strategies can arise under the conditions on Φ_k and z listed below.

1. Both firms innovate in equilibrium if

(2.23) $\Phi_1 > z$ (hence $\Phi_2 > z$) and $\Phi_3 > z$ (hence $\Phi_4 > z$)

2. Neither firm innovates if

(2.24) $\Phi_2 < z$ and $\Phi_4 < z$

3. Firm 1 innovates while firm 2 does not if

(2.25) either $\Phi_1 > z$ (and $\Phi_2 > z$) and $\Phi_3 \leq z \leq \Phi_4$

or $\Phi_2 > z$ and $z > \Phi_4$ ($> \Phi_3$)

4. Firm 2 innovates while firm 1 does not if

(2.26) either $\Phi_2 < z$ and $\Phi_4 > z$

or $\Phi_1 \leq z \leq \Phi_2$ and $\Phi_3 > z$ (and $\Phi_4 > z$)

5. Two Nash equilibria in pure strategies arise, i.e. {1 innovates, 2 does not innovate} and {1 does not innovate, 2 innovates} if

(2.27) $$\Phi_1 \leq z \leq \Phi_2 \quad \text{and} \quad \Phi_3 \leq z \leq \Phi_4$$

These conditions are employed below to determine which firm (firms) innovate, depending on the characteristics (parameters α and δ) of the unions they face.

§2.3.4 **The cost of innovation**

The results of the game obviuosly depend on the cost of innovation z (see conditions (2.23) to (2.27)) which has been treated so far as a given parameter. This kind of approach is obviously not very appealing. The problem arises as to whether the cost of innovation can be "endogenised" in some way into the analysis, i.e. whether it can be expressed in terms of other parameters of the model. A sensible approach can be stated as follows. The cost of innovation might be expressed in terms of the maximum price of the new technology a^*, z^* say, such that both firms would adopt the new technology if the labour market were perfectly competitive (i.e. without unions)[20]. The reason this assumption is appealing will become clearer in section 2.4.

If both firms face a competitive labour market in which the cost of labour is given by r, the reference or competitive wage, the expression for the profit in firm i simplifies from (2.18) to:

[20]Note that if the labour market is competitive (i.e. $\alpha_i = 0$, i =1,2) the two firms become identical.

(2.28) $\Pi^c_i = \frac{1}{9 \cdot b} \cdot [\, A + r \cdot (\frac{1}{a_j} - \frac{2}{a_i})\,]^2$ since $w_1 = w_2 = r$

The payoff matrix for the game changes according to the new assumptions. For this case Appendix 2B shows that the condition on the cost of innovation, z, for a Nash equilibrium where both firms innovate is as follows:

$$z < \frac{4 \cdot r \cdot (\gamma - 1)}{9 \cdot b \cdot a_0 \cdot \gamma} \cdot \left(A - \frac{r}{a_0}\right) \equiv z^* \tag{2.29}$$

assuming $A - \frac{r}{a_0} > 0$.

If the cost of innovation is just below z^* and the labour market is competitive, then both firms will innovate[21].

Thus the cost of innovation will be represented in terms of its relationship with the price z^* which is entirely described by the parameters relating to the product demand curve (A and b), by the characteristics of the technology (a_0 and γ), and by the reference (or competitive) wage (r). It is therefore assumed that the cost of innovation, z, faced by the firms can be restated as

$$z = \beta \cdot z^* \tag{2.30}$$

Most of the time the analysis will deal with the case $\beta < 1$, i.e the case where both firms would innovate should the labour market be competitive, but

[21] If the cost of innovation is instead set exactly at z^*, then three Nash equilibria result. Only the case where neither firm innovates does not represent a Nash equilibrium.

some results also refer to the case where β exceeds 1.

2.4. SOLUTION OF THE MODEL AND DISCUSSION OF THE RESULTS

This section describes the solution to the model (full details are contained in Appendix 2C) and then provides comments on the results.

The model has been solved numerically according to the following idea. The focus of the analysis is on the effects of union bargaining power in firms 1 and 2 on the choice of technology simultaneously made by the two firms. Given the value of β (i.e. given some assumptions on the cost of the new technology), it is possible to determine the areas in the space (α_1, α_2) where inequalities (2.23) to (2.27) are satisfied, provided values are chosen for all the parameters involved in the model. From the knowledge of which inequalities are satisfied for a given pair (α_1, α_2) it is then possible to determine the type of solution, i.e. the Nash equilibrium prevailing for that combination of union bargaining powers in the two firms.

As Appendix 2C shows, once the cost of innovation is expressed in terms of z^* (i.e. in terms of the parameters of the model) conditions (2.23) to (2.27) can be rearranged to give quadratic inequalities in either α_1 or α_2. The areas where these inequalities are satisfied can then be easily drawn in the (α_1, α_2) space. Given specific values for the parameters of the model the type of solutions arising as union bargaining power in the two firms varies can then be determined by simple inspection on the (α_1, α_2) diagram.

According to the method outlined above it is possible to show which of the firms will adopt the new technology in the space (α_1, α_2) of the union bargaining parameters for given values of the remaining parameters of the model.

CASE 1: $\delta_1 = \delta_2$. The analysis begins with the case where the relative weights of wage and employment in the union's utility function are the same across the two firms, i.e. $\delta_1 = \delta_2$. It is worth noticing that δ_i represents the only source of asymmetry between the firms in the model apart from union bargaining power. In particular, it is assumed as a basic case that $\delta_1 = \delta_2 = 1/2$. This is known as the "rent maximisation" assumption in the literature (Booth (1994, 90)). Figure 2.3 depicts the solution of the model when the remaining parameters take the following values:

(2.31) $\gamma = 2, \ \ a_0 = 1, \ \ A = 10, \ \ b = 1, \ \ r = 1,$ and $\beta = 0.8$

Hence the new technology is twice as productive as the original one and its price is 20 % cheaper than the maximum price that would allow the firms to adopt the technology in a competitive labour market.

It is important to stress that the results presented below are robust to changes in the values of the parameters in (2.31) that have been chosen only for convenience in computations.

For each pair (α_1, α_2) of the union bargaining powers figure 2.3 tells which firm/s will be able to adopt the new technology. According to the conditions on Φ_k and z given above in ((2.23) - (2.27)), there are five types of Nash equilibria (the functions $\Phi_k = z$, k = 1, ..4 , are drawn in the figure). As expected the solution is symmetric, i.e. if both firms innovate (or neither does it) for $(\alpha_1, \alpha_2) = (x^*, y^*)$, the same outcome arises for $(\alpha_1, \alpha_2) = (y^*, x^*)$. If instead one firm only adopts the innovation for the pair $(\alpha_1, \alpha_2) = (x^*, y^*)$, then only the rival firm will get the new technology when $(\alpha_1, \alpha_2) = (y^*, x^*)$, and *vice versa*.

The following properties of the results can be defined.

PROPERTY 1: *When α_1 and α_2 are relatively high in both firms, neither innovates. On the other hand, if there is a discrepancy between the bargaining powers of the two unions, the firm faced with the less powerful union is more likely to be the only one to adopt the new technology. Finally, if union bargaining powers are not very high and not widely spread across firms, then both firms innovate.* This result is illustrated by figure 2.3.

PROPERTY 2: *The analysis in Tauman and Weiss (1987)*[22] *represents a very special case of this model.* Tauman and Weiss assume that only one firm is unionised and that the wage in this firm is set according to the Monopoly Union model. Hence the solution to their model can be checked by inspecting the outcomes in the top left hand corner, where $(\alpha_1, \alpha_2) = (1,0)$, or in the bottom right hand corner, where $(\alpha_1, \alpha_2) = (0,1)$, according to whether firm 1 or firm 2 is unionised. The analysis of

[22] See section 1.6.1.

this section will show that a Nash equilibrium where only the unionised firm adopts the new technology cannot be supported by the model as is expected from the work of Tauman and Weiss.

PROPERTY 3: *As the concern over the wage increases in both unions, the region in the space* (α_1, α_2) *where both firms innovate shrinks, while the region where neither firm adopts the technology becomes larger.* Figure 2.4 shows the solution of the model in the symmetric case where the weight on the wage $(\delta_1 = \delta_2)$ takes the value 3/4, i.e. both unions are more sensitive to the wage with respect to the basic case (where $\delta = 1/2$). This result is reinforced if the limit case is taken where both unions care only about the wage irrespective of the employment level $(\delta_1 = \delta_2 = 1)$. On the other hand, the opposite outcome is obtained when δ_1 and δ_2 are allowed to decrease. Given the set of parameter values in (2.31) it is possible to show that if the unions care almost only about employment levels, i.e. for low values of δ_1 and δ_2 (less than 0.1 approximately), both firms will innovate for every pair (α_1, α_2). This outcome is not surprising because as δ gets close to 0 for both unions the model tends to revert to the competitive labour market case, where both firms would adopt at the price.

An interesting feature of the model relates to the comparison between unionised and competitive labour markets. PROPERTY 4: *Situations exist in which an innovation would be adopted in a unionised labour market, whereas, at the same price of the new technology, no firm would innovate in a competitive labour market.* This case is depicted in figure 2.5, where $\delta_1 = \delta_2 = 1/2$ and $\beta = 1.06$, so that the price of the new technology is $z = \beta \cdot z^* = 1.06x2 = 2.12$ (see Appendix 2B). It is easily seen from Appendix 2B that at this price of the new technology, i.e at this value of β, no firm would innovate in a competitive labour market (no firm would innovate for a price greater than 19/9 given the parameter values in this example).

Figure 2.5 shows that as union bargaining powers become very spread across the two firms, i.e. when α_1 gets very large while α_2 stays low or *vice versa*, the firm facing the less powerful union will adopt the new technology. For the remaining values of α_1 and α_2 neither firm innovates. This result coupled with the previous analysis confirms that union bargaining power has a negative impact on the innovation decision of the firm via a loss in profitability (through the higher wages the union can achieve in case of innovation) and the Grout mechanism (outlined in section 1.3). This effect is stronger the more the union is concerned with the wage rather than the employment level (see the limit cases where $\delta_1=\delta_2=1$ and $\delta_1=\delta_2=0$).

CASE 2: $\delta_1 \neq \delta_2$. It is now assumed that the values of the weights on the wage and the employment in the union's utility function as well as the union bargaining power can differ across firms. Figure 2.6 depicts the results of the model for the case where $\delta_1 = 0.7$ and $\delta_2 = 0.25$. The remaining parameter values are as in figure 2.3 (see (2.31)). As expected, firm 1 which is faced with the union more concerned with the wage, is now penalised in the adoption decision (with respect to the base case, i.e. figure 2.3).

Figure 2.6 introduces a new feature with respect to the case where $\delta_1=\delta_2$. In the previous analysis there was no evidence of a firm being the only one to innovate while faced with the more powerful union. Hence in the case where $\alpha_i > \alpha_j$ either both firms would innovate (or none) or only firm j would do so. This result does not hold if the values of δ_i vary across firms. In the shaded area in figure 2.6 $\alpha_2>\alpha_1$ but only firm 2 buys the new technology. The result is made clearer in figure 2.7 where $\delta_1 = 1$ and $\delta_2 = 0$. Again in the shaded area $\alpha_2 > \alpha_1$ but firm 2 only innovates. Hence a new result can be defined. PROPERTY 5: *A firm can be the only one to adopt the new technology, even if faced with the more powerful union, provided this union is more concerned about employment than the union in the rival firm.* As seen above the concern for employment makes the union less prone to rent-seeking activities and benefits the innovation performance of the firm.

The results so far show that an increase in bargaining power of union i has either no impact on the choice of the technology of firm i (the equilibrium stays in the same region) or a negative effect which means that above a critical level $\bar{\alpha}_i$ the firm is prevented from innovating. PROPERTY 6: *There is no evidence for the argument suggested by Ulph and Ulph (1988, 1989) that an increase in union power might allow a firm to adopt a technology it would have not adopted for lower levels of the parameter*[23]. Given the power of the "rival" union an increase in union

[23] See section 1.6.2.

bargaining power is most of the time likely to damage the innovation performance of the firm.

The final step is to analyse what happens to the solution when the values of the non-union parameters of the model are changed, i.e. when the "environment" changes. This amounts to comparing the decision on innovation made by the firms in a situation where product demand is high as opposed to the situation where demand is low, or to comparing a situation where the new technology is very superior to the existing one as opposed to the case where the difference is small, and so on. Throughout this analysis the reference solution is given by figure 2.3 and parameter values are changed one at each time. The price of innovation is always the same as in figure 2.3 and so are δ_1 and δ_2 (= 1/2).

The case where demand is higher than in figure 2.3 is taken into account first. The parameter A has now a value of 20 instead of 10. Figure 2.8 shows that for given values of (α_1, α_2) a situation of high demand has a positive impact on innovation. In particular the region where both firms innovate becomes definitely bigger.

If the competitive or reference wage, r, is increased, the direction of change is the same as in the case of an increase in demand. This may reflect, for instance, an increase of the minimum wage or, more generally, an increase of the reference wage in the negotiation. The same result arises if γ, which gives the ratio between the productivities of the new technology and the existing one, goes up. This is not surprising since the firm can now get a greater productivity increase while paying the same price for the technology. Finally a result of the type outlined in figure 2.8 is also ensured by a decrease in b, the slope of the demand curve.

2.5 CONCLUSIONS

In this chapter a model of technology adoption in the presence of an oligopostic product market and trade unions has been presented. Firms have been allowed to differ only with respect to their union characteristics. The new technology has been assumed to be more productive and labour saving with respect to the existing one as well as exogenously available in the market at a given price. The main results of the analysis can be summarised as follows.

1. *Ceteris paribus*[24], both firms adopt the new technology if both unions are "relatively weak". If both unions are instead "relatively strong", neither firm innovates. If only one firm innovates it is the firm faced by the less powerful union. Hence the "rent-seeking mechanism" suggested by Grout (1984) seems very effective. The analysis in Tauman and Weiss (1987) also turns out to be a special case of the model.

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[24] For a given price of the new technology and if both unions have the same relative concern over wage and employment, i.e. when firms differ only with respect to union bargaining power.

2. The firm faced by the most powerful union can be the only one to innovate if and only if its union is more concerned about employment than the union faced by the rival firm. In general, environments where unions care more about employment than the wage are more conducive to innovation.

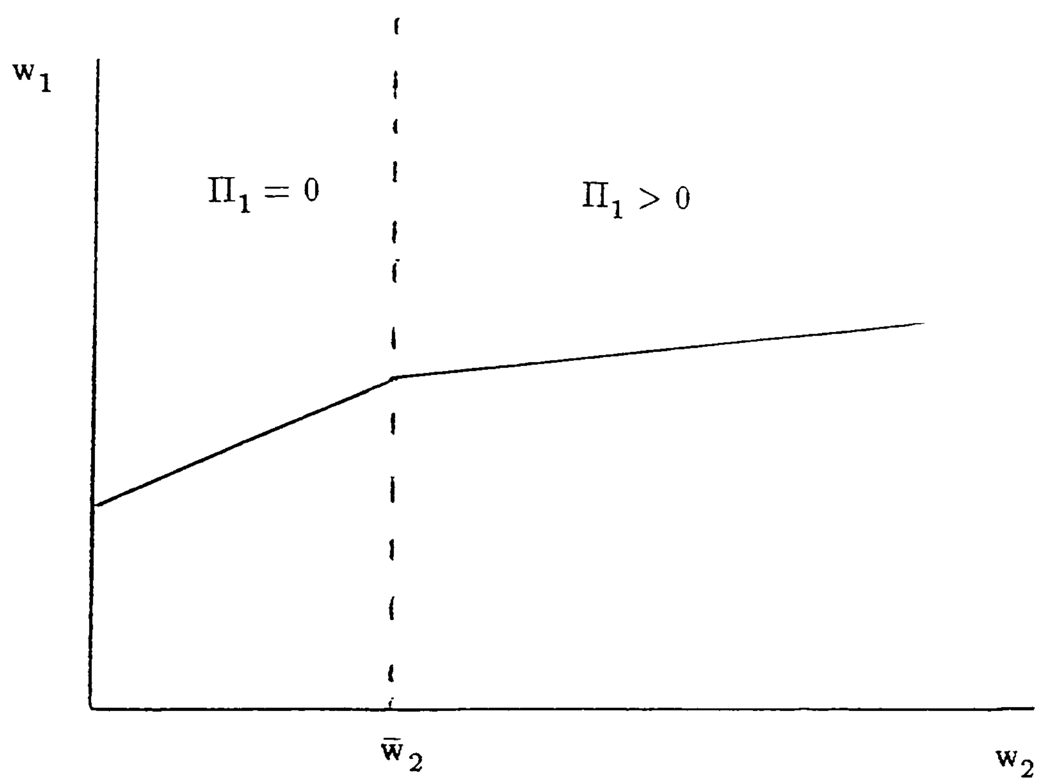
3. There are cases (i.e. prices of the new technology) such that one firm would innovate in a unionised labour market, while no firm would innovate in a competitive (without unions and wage bargaining) labour market.

4. There is no evidence for the argument suggested by Ulph and Ulph (1988, 1989) that an increase in union power might lead a firm to adopt a new technology it would have not adopted with a weaker union. Given the power of the rival union, an increase in union bargaining power does not improve the firm's innovation ability.

The issue of the robustness of the results to extensions and changes in the functional forms will be addressed in the next chapter.

FIGURE 2.1(a)

REACTION FUNCTION FOR FIRM 1



where $\bar{w}_2 = 3 \cdot a_2 \cdot \sqrt{z \cdot b} \cdot \frac{(2 - \alpha_1)}{2 - \alpha_1 \cdot (1+\delta_1)} + a_2 \cdot (\frac{2 \cdot r}{a_1} - A)$

FIGURE 2.1(b)

REACTIONS FUNCTIONS IN THE WAGE SPACE

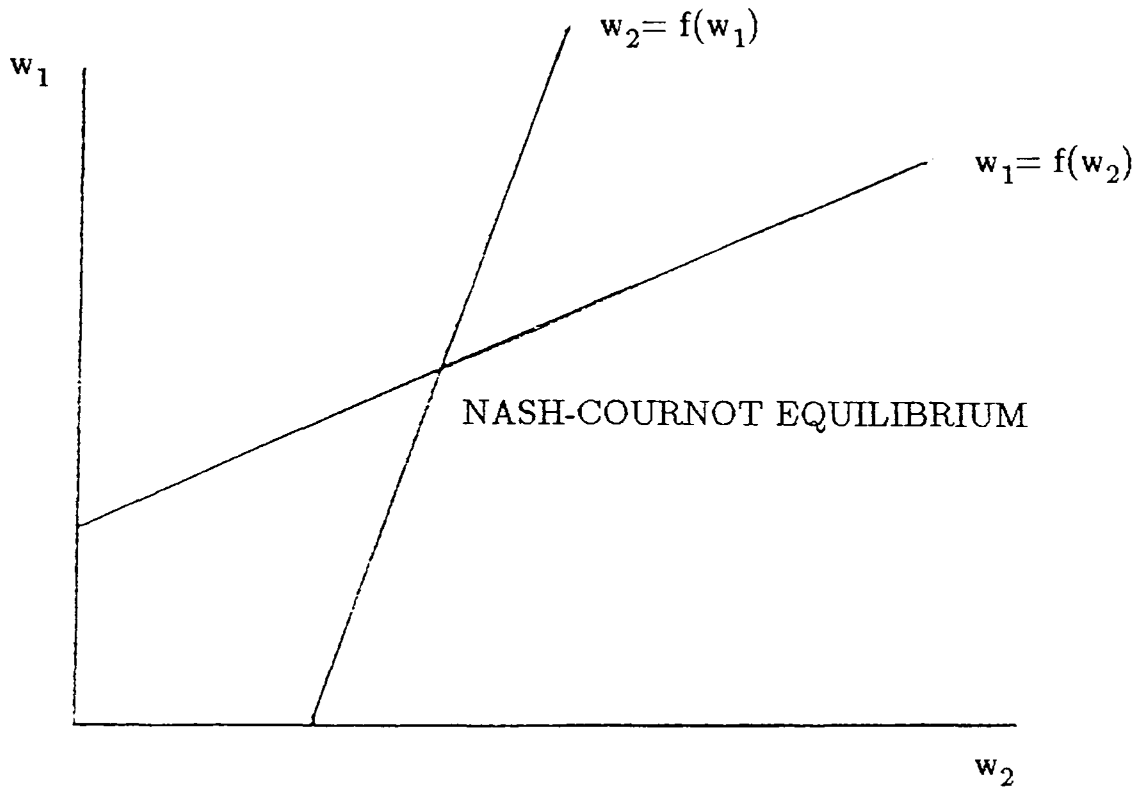
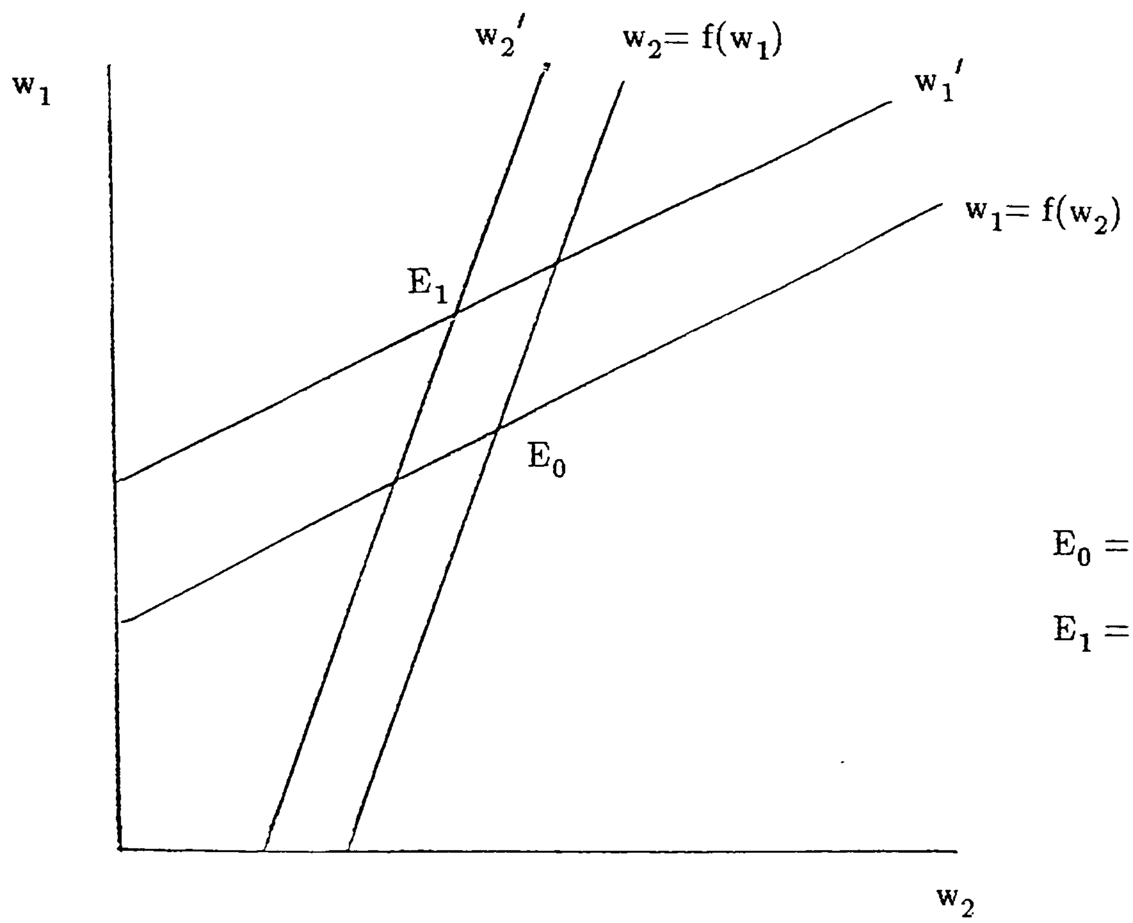


FIGURE 2.2

COMPARATIVE STATICS FOR A CHANGE IN THE TECHNOLOGY

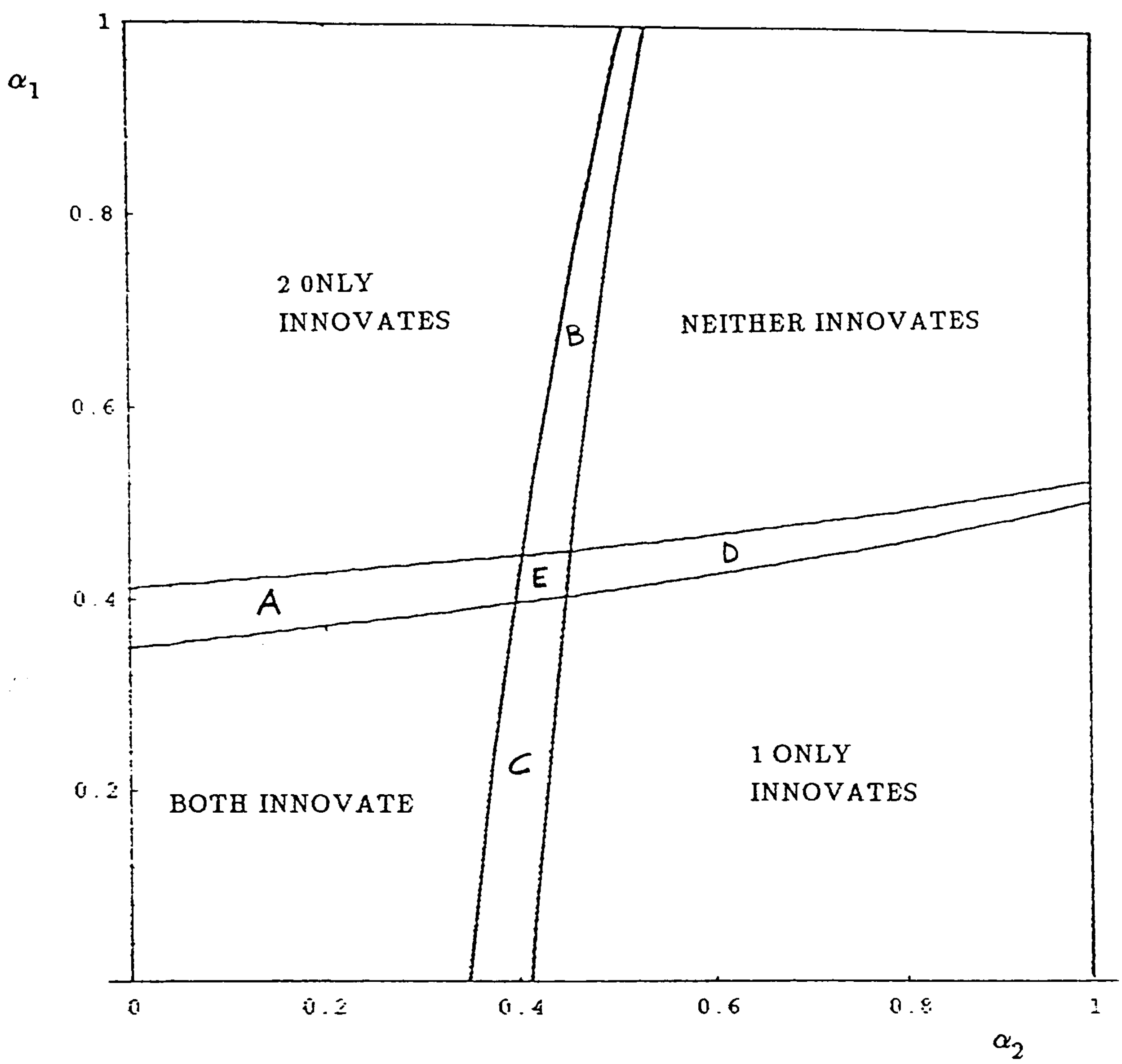
OPERATED BY FIRM 1



E_0 = initial equilibrium

E_1 = final equilibrium

FIGURE 2.3



$\delta_1 = \delta_2 = 1/2$

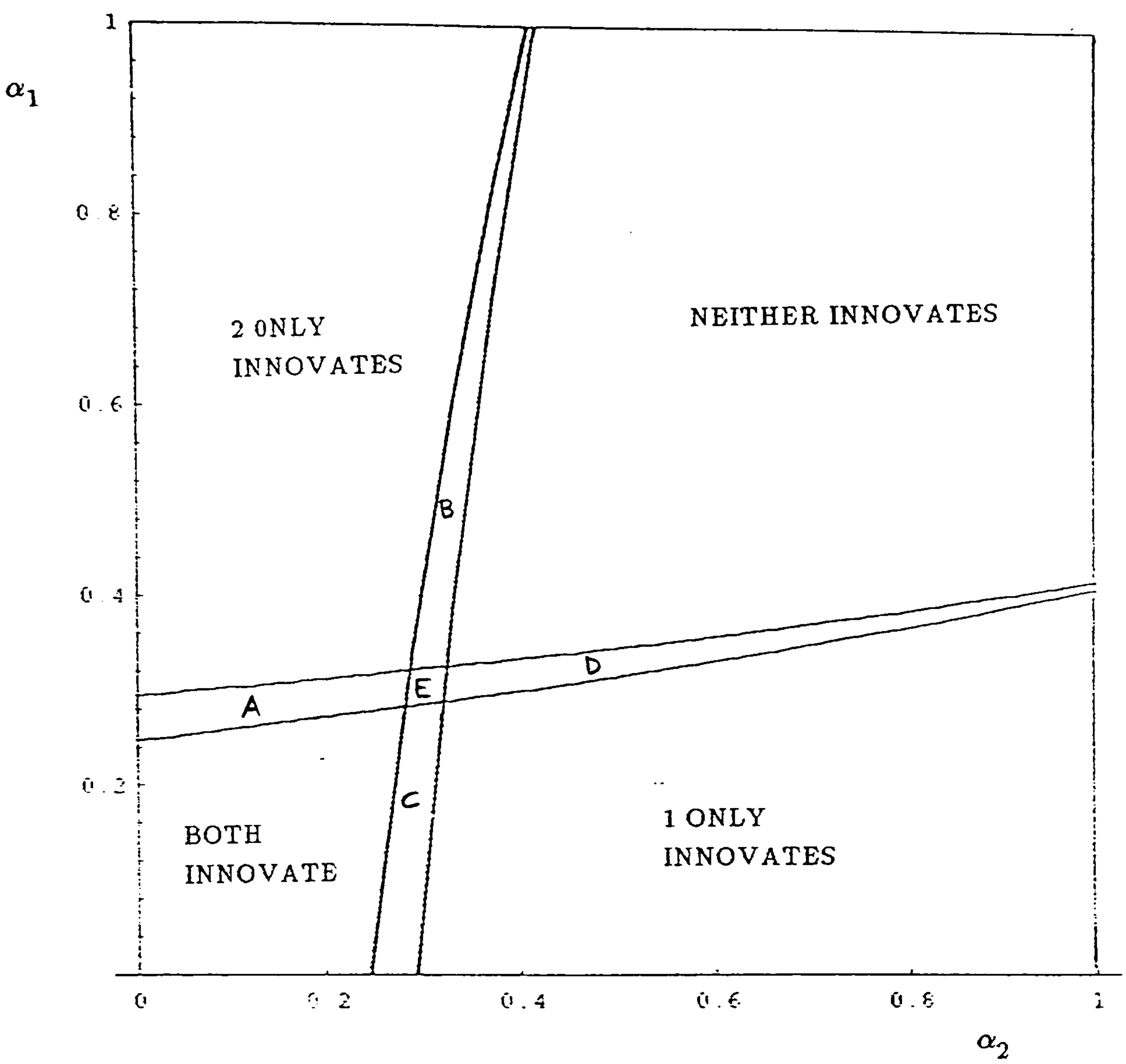
$\gamma = 2$ $a_0 = 1$ $\beta = .8$ A= 10 b = 1 r = 1

Note: A and B: 2 only innovates

C and D: 1 only innovates

E: two Nash equilibria

FIGURE 2.4



$\delta_1 = \delta_2 = .75$

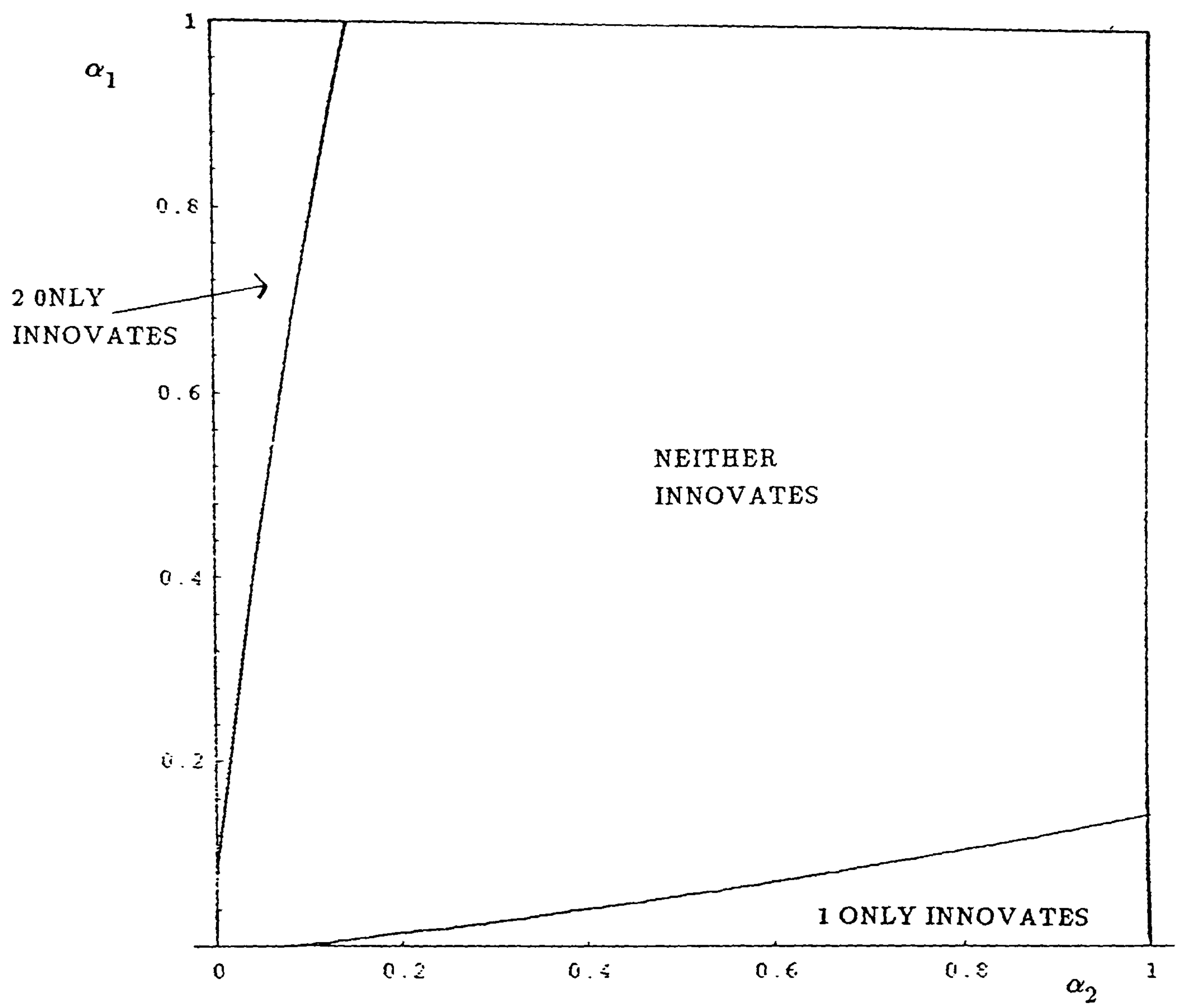
$\gamma = 2$ $a_0 = 1$ $\beta = .8$ A= 10 b = 1 r = 1

Note: A and B: 2 only innovates

C and D: 1 only innovates

E: two Nash equilibria

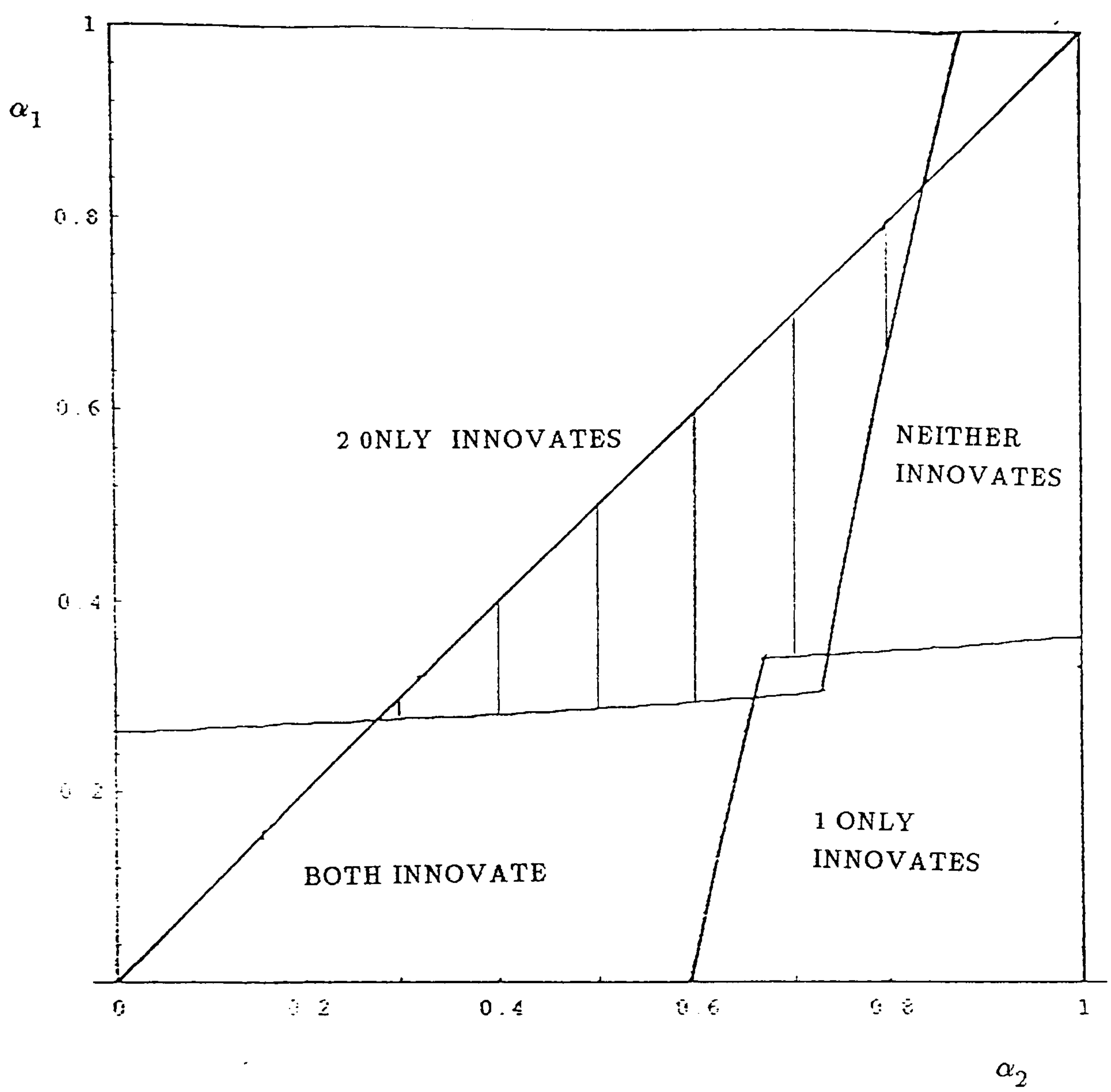
FIGURE 2.5



$\beta = 1.06$

$\delta_1 = \delta_2 = 1/2 \quad \gamma = 2 \quad a_0 = 1 \quad A = 10 \quad b = 1 \quad r = 1$

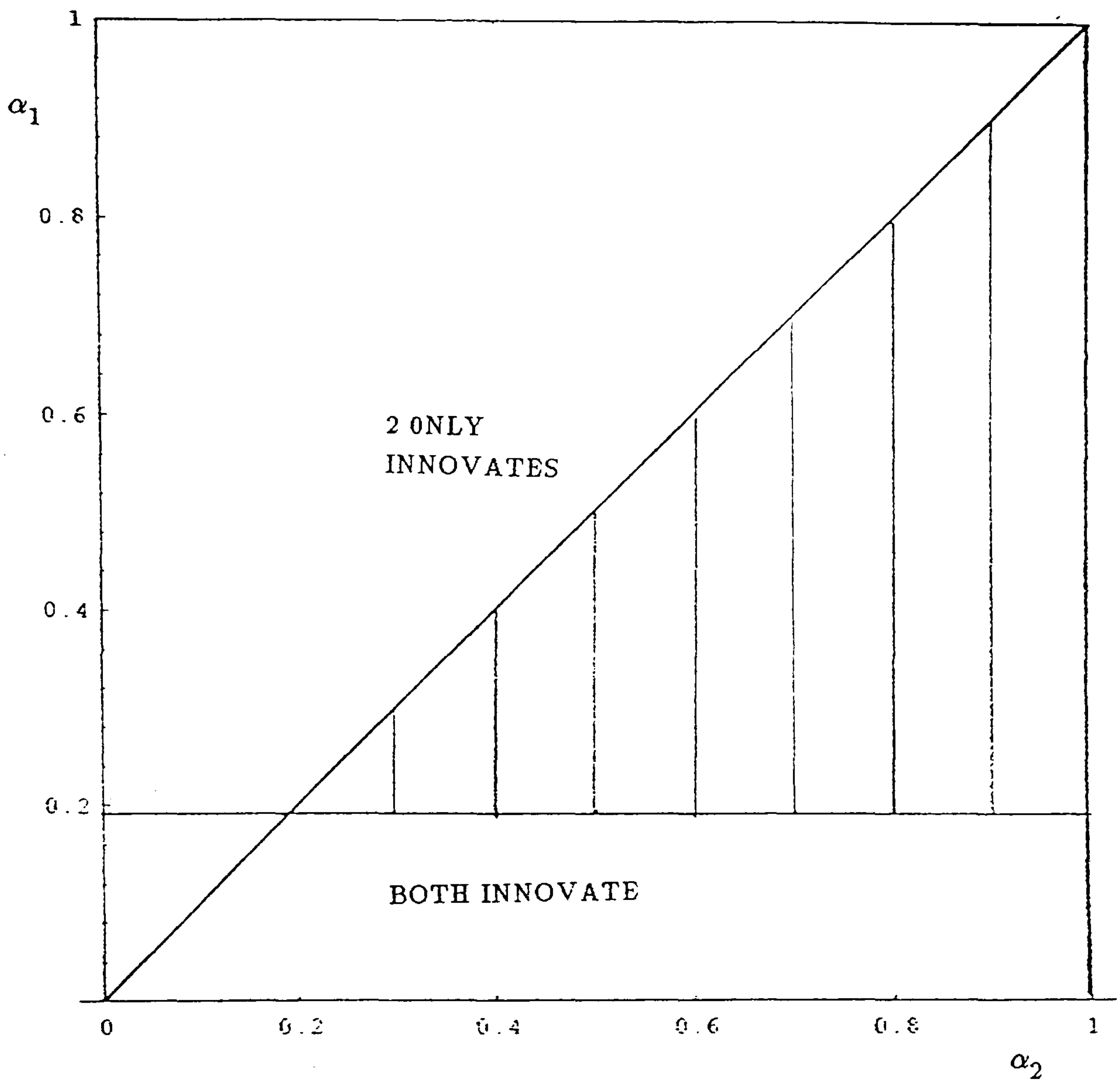
FIGURE 2.6



$\delta_1 = .7 \quad \delta_2 = .25$

$\gamma = 2 \quad a_0 = 1 \quad \beta = .8 \quad A = 10 \quad b = 1 \quad r = 1$

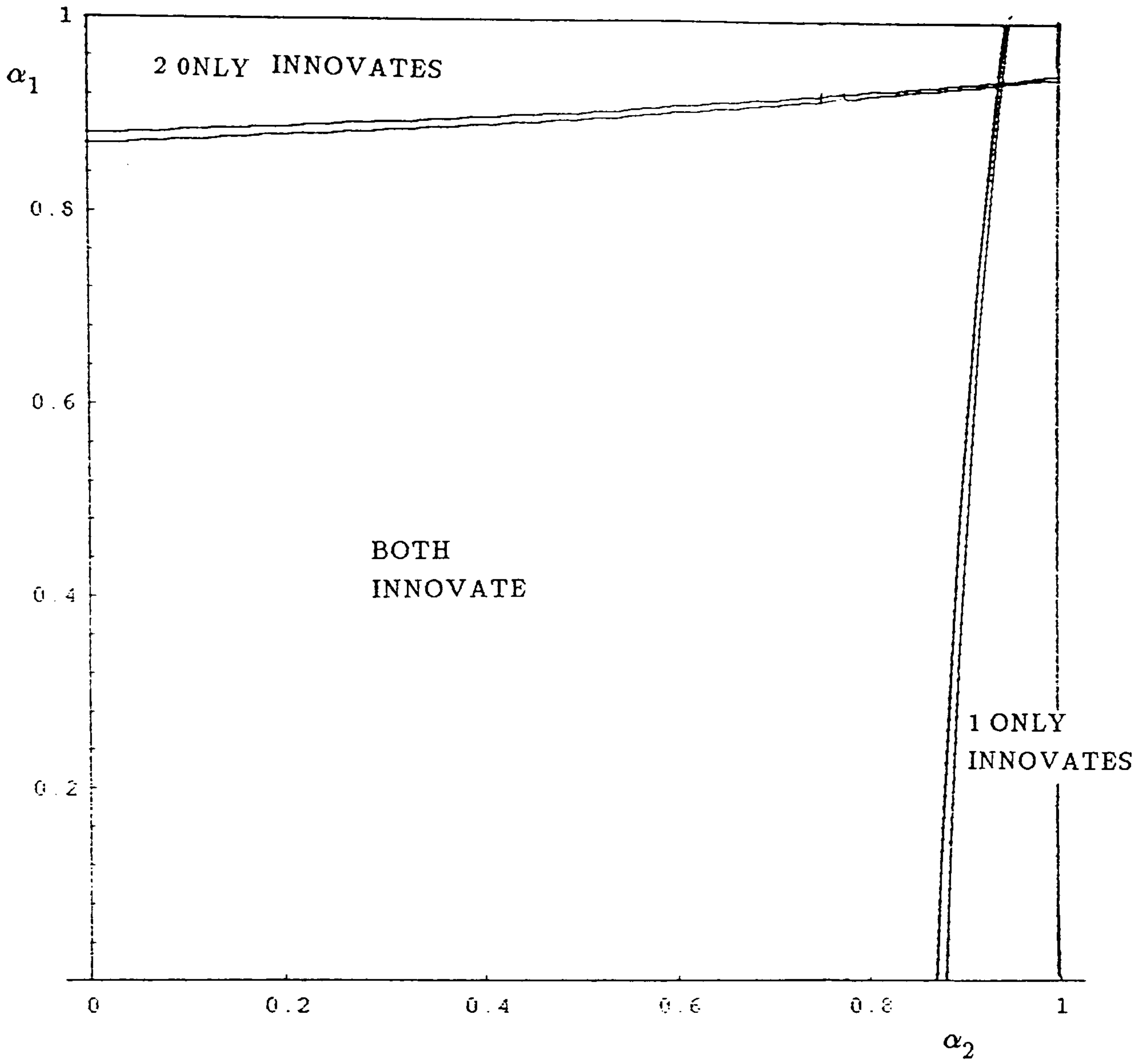
FIGURE 2.7



$\delta_1 = 1 \qquad \delta_2 = 0$

$\gamma = 2 \quad a_0 = 1 \quad \beta = .8 \quad A = 10 \quad b = 1 \quad r = 1$

FIGURE 2.8



$A = 20$ $\delta_1 = \delta_2 = 1/2$

$\gamma = 2$ $a_0 = 1$ $b = 1$ $r = 1$

APPENDIX 2A

According to the notation introduced in subsection 2.3.3

(2A.1) $\Phi_1 \equiv \Pi_1(a^*,a^*) - \Pi_1(a_0,a^*)$ and

(2A.2) $\Phi_2 \equiv \Pi_2(a^*,a_0) - \Pi_1(a_0,a_0)$

Using the solution for the profit net of innovation cost (see (2.18)) in (2A.1) and (2A.2) yields

$$\Phi_1 = \frac{1}{9 \cdot b} \cdot \left\{ [A + \frac{w_2(a^*,a^*)}{a^*} - 2 \cdot \frac{w_1(a^*,a^*)}{a^*}]^2 - [A + \frac{w_2(a_0,a^*)}{a^*} - 2 \cdot \frac{w_1(a_0,a^*)}{a_0}]^2 \right\}$$

(2A.3)

$$\Phi_2 = \frac{1}{9 \cdot b} \cdot \left\{ [A + \frac{w_2(a^*,a_0)}{a_0} - 2 \cdot \frac{w_1(a^*,a_0)}{a^*}]^2 - [A + \frac{w_2(a_0,a_0)}{a_0} - 2 \cdot \frac{w_1(a_0,a_0)}{a_0}]^2 \right\}$$

(2A.4)

where, according to (2.17), $w_i(a_i,a_j)$ and $w_j(a_i,a_j)$ represent the wage bargained in firm i and j when the technologies adopted by the two firms are a_i and a_j respectively.

The solution for the wage turned out to be quite cunbersome (see (2.17)). Computation is somewhat eased by the following notation. Let

(2A.5) $K = 4 \cdot (2 - \alpha_1) \cdot (2 - \alpha_2) - \alpha_1 \cdot \alpha_2 \cdot \delta_1 \cdot \delta_2$

(2A.6) $B_i = \alpha_i \cdot \delta_i \cdot [2 \cdot (2 - \alpha_j) + \alpha_j \cdot \delta_j]$

(2A.7) $$C_i = 4 \cdot [2 - \alpha_i \cdot (1 + \delta_1)] \cdot (2 - \alpha_j)$$

(2A.8) $$D_i = 2 \cdot \alpha_i \cdot \delta_i \cdot [2 - \alpha_j \cdot (1 + \delta_j)]$$

where K, B_i, C_i, and D_i are combinations of the parameters α_1, α_2, δ_1, δ_2, which refer to the union characteristics of the two firms. Drawing on this notation the solutions for w_1 and w_2 can be entered in Φ_1 and Φ_2 to give

$$\Phi_1 = \frac{1}{9 \cdot b} \cdot \Bigg\{ \Big\{ A + \frac{1}{a^* \cdot K} \cdot [B_2 \cdot a^* \cdot A + (C_2 + D_2) \cdot r] - \frac{2}{a^* \cdot K} \cdot [B_1 \cdot a^* \cdot A + (C_1 + D_1) \cdot r] \Big\}^2 - \Big\{ A + \frac{1}{a^* \cdot K} \cdot [B_2 \cdot a^* \cdot A + (C_2 + D_2 \cdot \frac{a^*}{a_0}) \cdot r] - \frac{2}{a_0 \cdot K} \cdot [B_1 \cdot a_0 \cdot A + (C_1 + D_1 \cdot \frac{a_0}{a^*}) \cdot r] \Big\}^2 \Bigg\}$$

(2A.9)

This expression can be rearranged as follows (using also the definition $a^* = \gamma \cdot a_0$)

$$\Phi_1 = \frac{r \cdot (1 - \gamma) \cdot (D_2 - 2 \cdot C_1)}{9 \cdot b \cdot K^2 \cdot \gamma^2 \cdot a_0^{\,2}} \cdot \Big\{ r \cdot (1 + \gamma) \cdot (D_2 - 2 \cdot C_1) + 2 \cdot A \cdot \gamma \cdot a_0 \cdot (K + B_2 - 2 \cdot B_1) + 2 \cdot (C_2 - 2 \cdot D_1) \cdot r \Big\}$$

(2A.10)

Rearranging the expression for Φ_2 in the same way yields

$$\Phi_2 = \frac{r\cdot(1-\gamma)\cdot(D_2-2\cdot C_1)}{9\cdot b\cdot K^2\cdot\gamma^2\cdot a_0{}^2}\cdot\Big\{r\cdot(1+\gamma)\cdot(D_2-2\cdot C_1)+2\cdot A\cdot\gamma\cdot a_0\cdot(K+B_2+$$

$$-\ 2\cdot B_1)+\ 2\cdot(C_2-2\cdot D_1)\cdot\gamma\cdot r\Big\}$$

(2A.11)

The only difference between Φ_1 and Φ_2 is in the third term inside brackets (the expression for Φ_2 has a γ added). From (2A.7) and (2A.8) $C_2-2\cdot D_1$ can be rearranged to give

(2A.12) $\quad C_2 - 2\cdot D_1 = 4\cdot[2-\alpha_2\cdot(1+\delta_2)]\cdot[2-\alpha_1\cdot(1+\delta_1)]$

Hence $C_2 - 2\cdot D_1$ is always positive apart from the case where $\alpha_1 = \alpha_2 = \delta_1 = \delta_2 = 1$ when it takes a value of 0. It then follows from $\gamma > 1$ that $\Phi_2 > \Phi_1$. By symmetry it follows that $\Phi_4 > \Phi_3$.

APPENDIX 2B

In a competitive labour market, i.e. with no unions bargaining over the wage, $w_1 = w_2 = r$. The solution for the profit of firm i (equation (2.18)) can thus be rearranged to give

$$\Pi_i = \frac{1}{9 \cdot b} \cdot [\, A + r \cdot (\frac{1}{a_j} - \frac{2}{a_i})]^2$$

As a result the payoff matrix of the innovation game can be written as

FIRM 2	Innovation	No Innovation
FIRM 1		
Innovation	σ, σ	τ, ϕ
No Innovation	ϕ, τ	ψ, ψ

where

$$\sigma = \frac{1}{9 \cdot b} \cdot (\, A - \frac{r}{\gamma \cdot a_0}\,)^2 - z$$

$$\tau = \frac{1}{9 \cdot b} \cdot [\, A + \frac{r}{a_0} \cdot (1 - \frac{2}{\gamma}\,)]^2 - z$$

$$\phi = \frac{1}{9 \cdot b} \cdot [\ A + \frac{r}{a_0} \cdot (\frac{1}{\gamma} - 2)]^2$$

$$\psi = \frac{1}{9 \cdot b} \cdot (\ A - \frac{r}{a_0}\ )^2$$

The following conditions guarantee a unique Nash equilibrium at {Innovate, Innovate}:

(a1) $\sigma > \phi$

(a2) $\tau > \psi$

Assuming $A > \frac{r}{a_0}$, condition (a1) implies

$$\frac{4 \cdot r \cdot (\gamma - 1)}{9 \cdot b \cdot \gamma \cdot a_0} \cdot (A - \frac{r}{a_0}) > z$$

Condition (a2) implies

$$\frac{4 \cdot r \cdot (\gamma - 1)}{9 \cdot b \cdot \gamma \cdot a_0} \cdot (A - \frac{r}{a_0 \cdot \gamma}) > z$$

Since $\gamma > 1$, $\frac{r}{a_0 \cdot \gamma} < \frac{r}{a_0}$. As a result condition (a1) on the cost of innovating ensures that there is a unique Nash equilibrium where both firms innovate.

If the cost of innovation is $\frac{4 \cdot r \cdot (\gamma - 1)}{9 \cdot b \cdot \gamma \cdot a_0} \cdot (A - \frac{r}{a_0}) \equiv z^*$, then $\sigma = \phi$. Under this assumption it is easily checked that three Nash equilibria exist in pure strategies (i.e. only the case where both firms do not innovate is not a Nash equilibrium).

APPENDIX 2C

It is possible to show by means of some algebra that the condition (see (2.19))

$$\Phi_1 = \Pi_1(a^*, a^*) - \Pi_1(a_0, a^*) \geq z$$

$$\text{where} \quad z = \beta \cdot z^* = \beta \cdot \frac{4 \cdot r \cdot (\gamma - 1)}{9 \cdot b \cdot \gamma \cdot a_0} \cdot (A - \frac{r}{a_0})$$

can be rearranged to give the following inequality, quadratic in α_1 for given values of all the other parameters in the model, including α_2 :

$$\text{(2C.1)} \qquad (N \cdot R + G \cdot Z) \cdot \alpha_1^2 + (G \cdot V - F \cdot Z - N \cdot Q) \cdot \alpha_1 + (N \cdot P - F \cdot V) \leq 0$$

where

$F = 16 \cdot (2 - \alpha_2) - 4 \cdot \alpha_2 \cdot \delta_2$

$G = (1 + \delta_1) \cdot \frac{F}{2}$

$N = 4 \cdot \beta \cdot (A \cdot a_0 - r) \cdot \gamma$

$P = 64 \cdot (2 - \alpha_2)^2$

$Q = P + 16 \cdot (2 - \alpha_2) \cdot \alpha_2 \cdot \delta_1 \cdot \delta_2$

$R = 16 \cdot (2 - \alpha_2)^2 + (\alpha_2 \cdot \delta_1 \cdot \delta_2)^2 + \gamma \cdot (2 - \alpha_2) \cdot \alpha_2 \cdot \delta_1 \cdot \delta_2$

and

$V = 2 \cdot A \cdot \gamma \cdot a_0 \cdot H - 2 \cdot L \cdot r - r \cdot (1 + \gamma) \cdot F$

$$Z = r \cdot (1 + \gamma) \cdot G - 2 \cdot A \cdot \gamma \cdot a_0 \cdot I - 2 \cdot M \cdot r$$

where

$$H = 8 \cdot (2 - \alpha_2) + 4 \cdot \alpha_2 \cdot \delta_2$$

$$I = \frac{H}{2} + 4 \cdot (2 - \alpha_2) \cdot \delta_1 + 2 \cdot \alpha_2 \cdot \delta_1 \cdot \delta_2$$

$$L = 16 - 8 \cdot \alpha_2 \cdot (1 + \delta_2)$$

$$M = (1 + \delta_1) \cdot \frac{L}{2}$$

Inequality (2C.1) can be used to determine the areas in the space (α_1, α_2) where the condition $\Phi_1 \geq z$ is satisfied. The same type of analysis can be applied to the condition $\Phi_2 \geq z$ (the results are not presented here). Conditions $\Phi_3 \geq z$ and $\Phi_4 \geq z$ are then derived by symmetry.

APPENDIX 2D

The wage reaction function of firm i is given by the following expression (see (2.14)):

$$w1 = \frac{1}{2\cdot(2-\alpha_1)}\cdot\left\{\alpha_1\cdot\delta_1\cdot a_1\cdot(A + \frac{w_2}{a_2}) + 2\cdot r\cdot[2 - \alpha_1\cdot(1 + \delta_1)]\right\} \quad \text{if } w_2 \geq \overline{w}_2$$

$$= \frac{a_1}{2}\cdot\left\{A + \frac{w_2}{a_2} - 3\cdot(z\cdot b)^{-1/2}\right\} \quad \text{if } w_2 < \overline{w}_2$$

where $\overline{w}_2 = 3\cdot a_2\cdot(z\cdot b)^{-1/2}\frac{(2-\alpha_1)}{2-\alpha_1\cdot(1+\delta_1)} + a_2\cdot\left(\frac{2\cdot r}{a_1} - A\right)$ and z is the cost of the technology operated by firm 1.

On the other hand, the profit (net of adoption costs) of firm 1 is given by (see (2.18)):

$$\Pi_1 = \frac{1}{9\cdot b}\cdot\left(A + \frac{w_2}{a_2} - 2\cdot\frac{w_1}{a_1}\right)^2$$

If firm 1 adopts the new technology, a*, the profits are reduced by the cost of the technology, i.e. z.

Analogous expressions can be derived for firm 2 by symmetry.

From the definition of the profit it is immediate to see that if no firm adopts the new technology, and hence z=0, profits are always nonnegative. Therefore, the outcome of wage determination in stage 2 is given by the unconstrained solution (equation (2.17)). A firm can be constrained on the profit side only if it adopts the new technology thereby incurring the cost z ($z > 0$).

If both firms are constrained in equilibrium, i.e. $\Pi_1 = 0$ and $\Pi_2 = 0$, the solution for the wage is given as follows:

$$w_1 = a_1 \cdot \left\{A - 3 \cdot (z \cdot b)^{-1/2}\right\}$$

$$w_2 = a_2 \cdot \left\{A - 3 \cdot (z \cdot b)^{-1/2}\right\} \qquad (2D.1)$$

with $a_1 = a_2 = a^*$ (i.e. both innovate).

If firm 1, say, is constrained in equilibrium but not firm 2, i.e. $\Pi_1 = 0$ but $\Pi_2 > 0$, the solutions for the wage are given by the following expressions:

$$w_1 = \frac{a_1}{4(2-\alpha_2) + \alpha_2 \cdot \delta_2} \cdot \Big\{2 \cdot (2-\alpha_2) \cdot (A - 3 \cdot (z \cdot b)^{-1/2} + \alpha_2 \cdot \delta_2 \cdot A + \frac{2 \cdot r}{a_2} \cdot (2-\alpha_2 \cdot (1+\delta_2))\Big\}$$

and

$$w_2 = \frac{a_1}{4(2-\alpha_2) + \alpha_2 \cdot \delta_2} \cdot \Big\{(3 \cdot (z \cdot b)^{-1/2} + A \cdot a_2 \cdot \alpha_2 \cdot \delta_2 + 4 \cdot r \cdot (2-\alpha_2 \cdot (1+\delta_2))\Big\}$$

(2D.2)

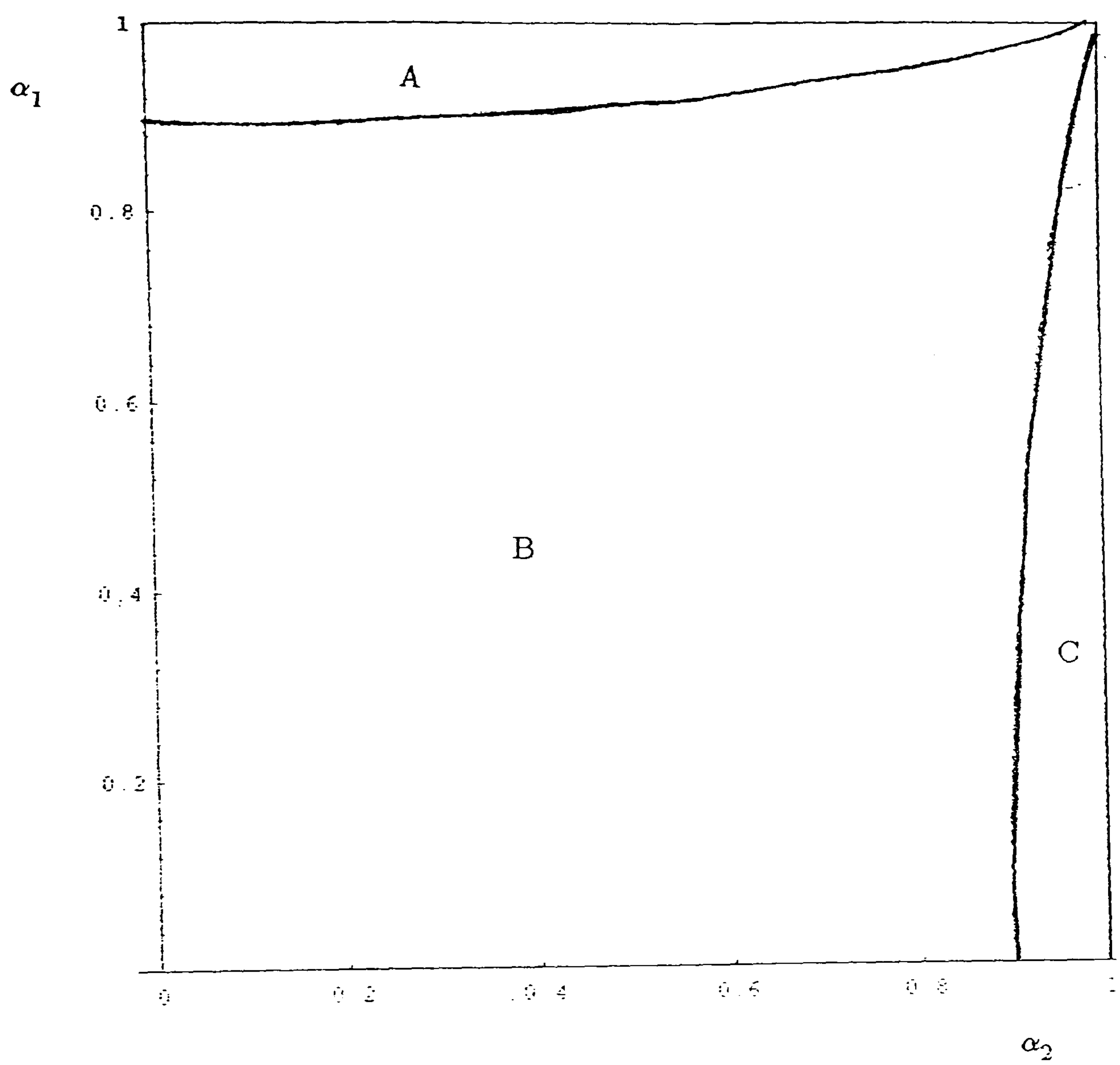
and firm 1 only is adopting the technology in this case.

Symmetric results are valid if firm 2 only is constrained.

A couple of numerical examples are now provided. It is assumed to start that the parameter values are given in (2.31) and that $\delta_1 = \delta_2 = .75$. It is also assumed that both firms have adopted the new technology. Figure 2D.1(a) shows the region in the (α_1,α_2) space where firm 1 only is constrained (the area is labelled A). Therefore the wage outcome is given by (2D.2) above. In region C firm 2 only is constrained and a solution symmetric to (2D.2) applies. Finally, in the remaining area, profits are positive for both firms and the unconstrained solution applies. Figure 2D.1(b) applies to the case where firm 1 only has adopted the new technology. In region A the outcome of wage determination is given by (2D.2). In the remanining area the solution for the wage is the unconstrained one.

Figure 2D.2 refers to the case where both unions are concerned only with the wage $(\delta_1 = \delta_2 = 1)$ and both firms have adopted the new technology, remaining parameters being the same as above. In region D both firms are constrained on the profit side $(\Pi_1=\Pi_2=0)$ and the wage is given by equations (2D.1). As a consequence, for high values of union bargaining power $(\alpha > .858)$ the wage is not responsive to increases in union power. In region A firm 1 only is contrained, while in region B firm 2 only is constrained. In the remaining area the unconstrained solution applies.

FIGURE 2.D1(a)



Note:

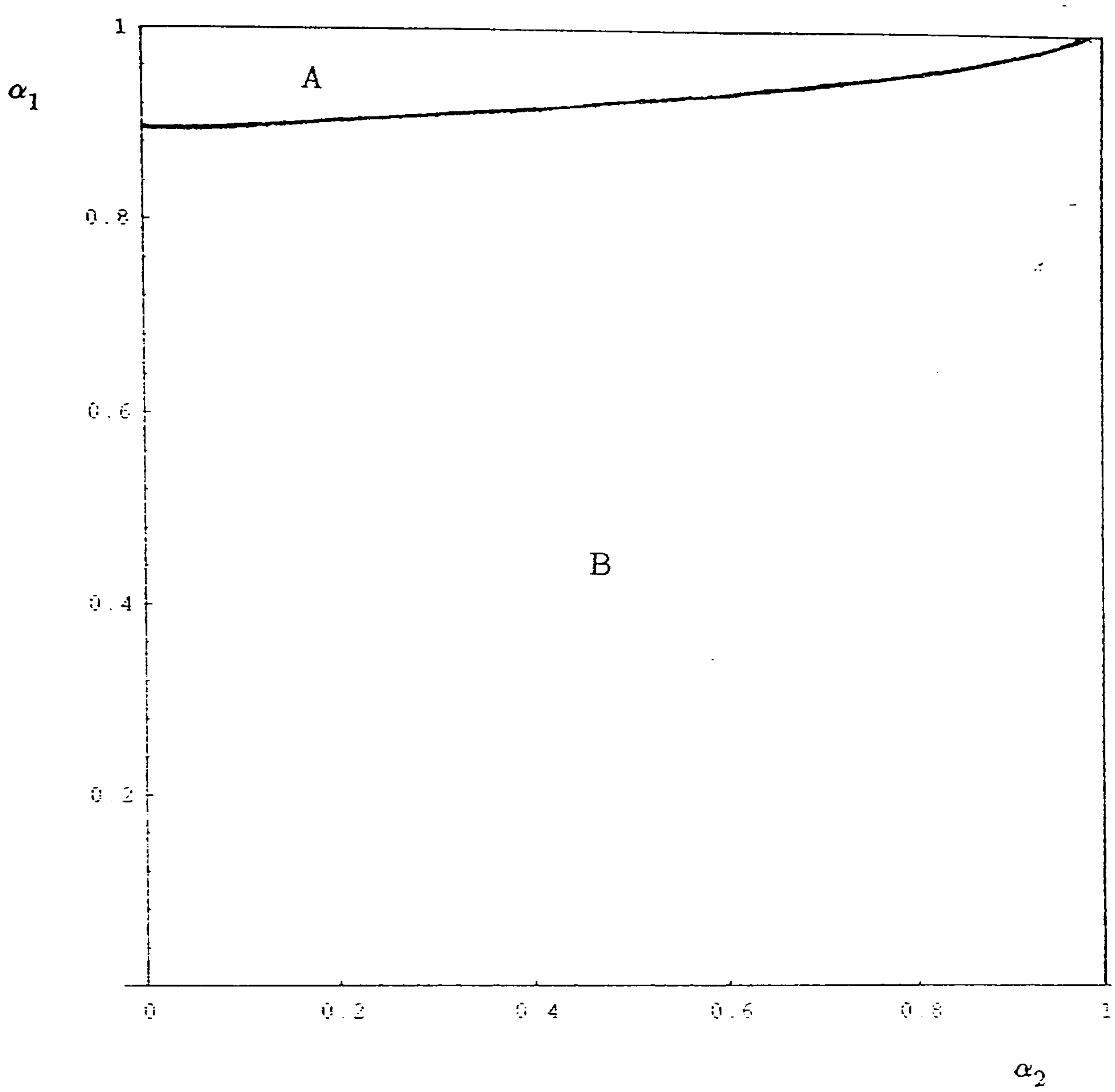
Both firms innovate

A: $\Pi_1 = 0$ $\Pi_2 > 0$

B: $\Pi_1 > 0$ $\Pi_2 > 0$

C: $\Pi_1 > 0$ $\Pi_2 = 0$

FIGURE 2.D1(b)



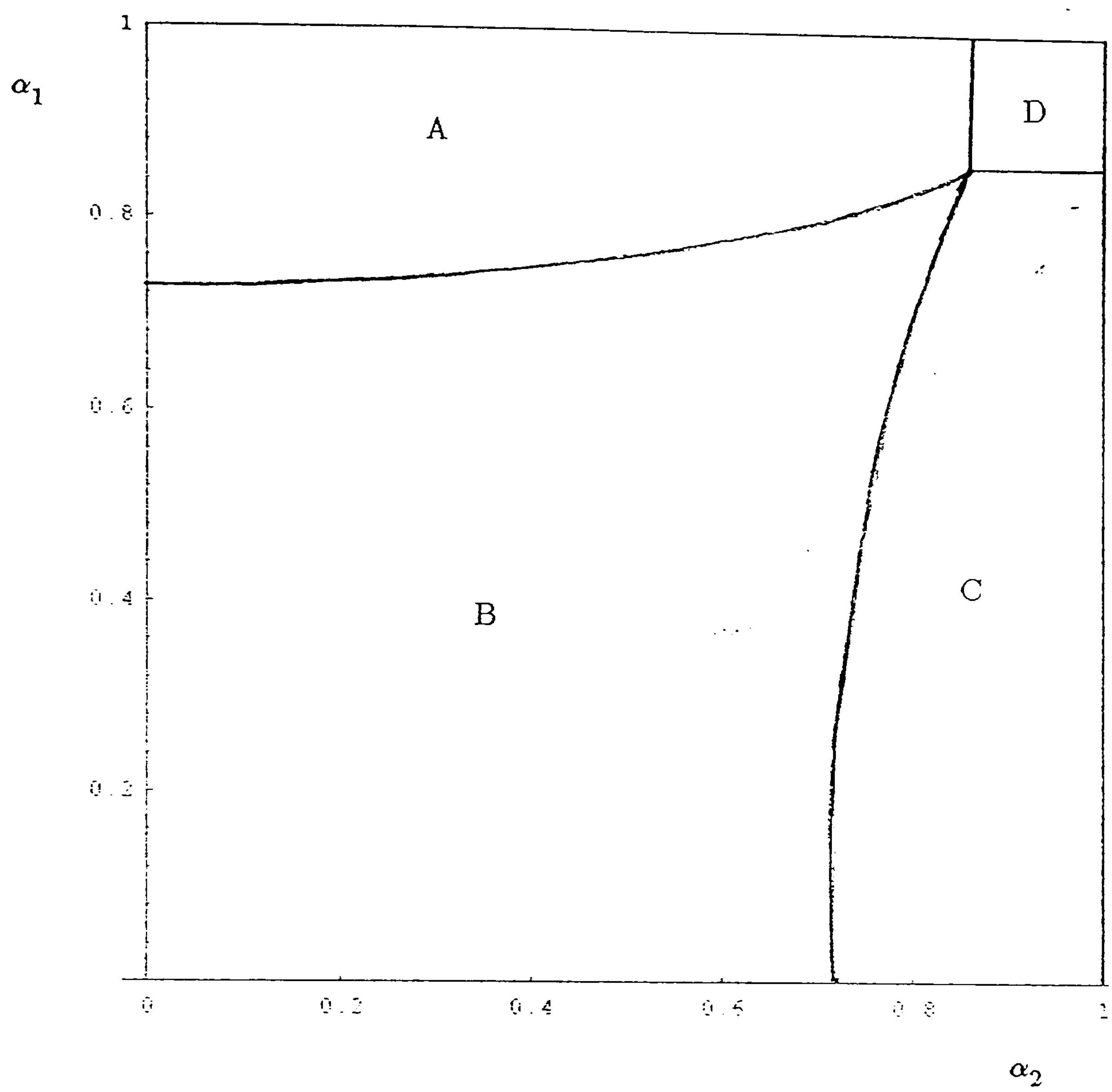
Note:

Firm 1 only innovates

A: $\Pi_1 = 0$ $\Pi_2 > 0$

B: $\Pi_1 > 0$ $\Pi_2 > 0$

FIGURE 2.D2



Note:

Both firms innovate

A: $\Pi_1 = 0$ $\Pi_2 > 0$

B: $\Pi_1 > 0$ $\Pi_2 > 0$

C: $\Pi_1 > 0$ $\Pi_2 = 0$

D: $\Pi_1 = 0$ $\Pi_2 = 0$

CHAPTER 3

UNIONS AND THE ADOPTION OF A NEW TECHNOLOGY

EXTENSIONS

3.1 INTRODUCTION

This chapter elaborates on the analysis of the effects of unions on innovation and investment by considering two extensions of the model presented in chapter 2. Firstly, the adoption model of the previous chapter is modified and extended by considering a concave production function as well as by allowing for implicit collusion among firms in the product market (section 3.2). The latter extension is based on the "conjectural variations" approach. Secondly, the discrete choice scenario of the adoption game is abandoned and firms are now assumed to choose the quantity of capital, i.e. a continuous variable (section 3.3).

The main purpose of these extensions is to establish whether the findings of the basic model of chapter 2 are robust to changes in the assumptions. The effect of collusion in the product market on bargained wages is an issue of interest *per se* (see sub-section 3.2.2). As a consequence of the removal of the assumption of linearity of the production function, the model turns out to be less tractable with respect to chapter 2, since explicit solutions for the wages in the second stage cannot be obtained. As a result only numerical solutions will be used in the analysis of section 3.2. The results presented below, though, have been shown to be robust to changes in the parameter values used.

As far as section 3.3 is concerned, the analysis of the continuous capital case is particularly meant to determine the extent to which the results of the discrete choice model survive in this more general setting. As expected, the model is computationally rather complicated and again only numerical solutions are provided. It is important to stress that, unlike the results in chapter 2 and section 3.2, no claim to generality can be made for the results presented in section 3.3.

3.2 A MODEL OF TECHNOLOGY ADOPTION: EXTENSIONS

The aim of this section is to extend the model presented in chapter 2. Two extensions are considered. The assumption of linearity of the production function (see (2.2)) is removed and a concave production function is now adopted. Collusion among firms in the product market is also analysed[1]. As a consequence, the analysis of this section will focus first on the determination of the extent to which the outcomes of the model presented in chapter 2 are robust to the change in the specification of the production function, while maintaining the assumption of Cournot competition in the product market (sub-section 3.2.1). Secondly, some analysis will be devoted to assessing the effect of collusion in the product market on the wage outcomes in the two firms (see sub-section 3.2.2). Finally, the effect of product market collusion on the choice of the technology will be analysed (sub-section 3.2.3).

[1]It should be noticed that collusion cannot be properly analysed using the linear production function of chapter 2 (see (2.2)) since the resulting marginal costs are constant.

§3.2.1 **Effects of a change in the production function**

The production function of firm i is now assumed to be:

(3.1) $q_i = (a_i \cdot L_i)^{1/2}$ $\qquad i = 1, 2$

where the notation is the same as in chapter 2 and, the technology of firm i is again entirely described by the parameter a_i.

The demand for the product is as in equation (2.3):

(3.2) $P = A - b \cdot (q_1 + q_2)$

The introduction of implicit collusion among firms into the analysis follows the "conjectural variations" approach (see Clarke-Davies (1982)). A generalisation of the Cournot case discussed in the previous chapter is therefore provided (see also Waterson (1984)).

Let the conjecture of firm i concerning the reaction of the rival firm, j, to changes in its output be described by:

(3.3) $\frac{dq_j}{q_j} = \phi \cdot \frac{dq_i}{q_i}$ $\qquad$ where $\quad 0 \leq \phi \leq 1$

The same holds symmetrically as far as the conjectures of firm j are concerned.

It is easily recognised that when $\phi = 0$ the Cournot assumption used in chapter 2 is obtained. On the other hand, when $\phi = 1$ (3.3) amounts to assuming perfect collusion between the two firms, i.e. joint profit maximisation, since firm i (j) believes that firm j (i) will react to changes in output so as to keep its market share constant. Values of the parameter ϕ in the range between 0 and 1 "represent the degree of implicit collusion inherent in the market: lower values of ϕ imply that firm i believes that there is some scope for improving its market share; i.e. that rivals will not react by as much proportionately. So as ϕ tends to 0, we tend to the Cournot case, while perfect collusion is approached as ϕ tends to 1" (Clarke-Davies (1982, 279))[2].

Drawing on the assumptions concerning the production function (3.1), the demand function (3.2) and the conjectural variations (3.3), it is straightforward to show that the equilibrium quantities in the product market, i.e. the outcome of the third stage of the game, are

$$(3.4) \qquad q_1 = A \cdot \frac{b \cdot (1 - \phi) + 2 \cdot \frac{w_2}{a_2}}{4(b + \frac{w_1}{a_1}) \cdot (b + \frac{w_2}{a_2}) - b^2 \cdot (1 + \phi)^2}$$

$$(3.5) \qquad q_2 = A \cdot \frac{b \cdot (1 - \phi) + 2 \cdot \frac{w_1}{a_1}}{4(b + \frac{w_1}{a_1}) \cdot (b + \frac{w_2}{a_2}) - b^2 \cdot (1 + \phi)^2}$$

The Cournot outcomes obtain when $\phi = 0$.

The outcome of wage bargaining in firm 1 involves the choice of w_1 so that (assuming profits are positive at the solution):

$$(3.6) \qquad \max_{w_1} \; [(w_1 - r)^{\delta_1} \cdot L_1^{1-\delta_1}]^{\alpha_1} \cdot [p \cdot q_1 - w_1 \cdot L_1]^{1 - \alpha_1}$$

[2] In Clarke and Davies (1982) the degree of collusion is not denoted by ϕ. Hence some liberty has been taken with the quotation.

Taking logarithms and noticing that, from (3.1), $L_1 = \frac{q_1^2}{a_1}$, the solution of wage bargaining in firm 1 chooses w_1 to maximise

$$V_1 = \alpha_1 \cdot \delta_1 \cdot \log (w_1 - r) + 2 \cdot \alpha_1 \cdot (1 - \delta_1) \cdot \log q_1 + (1 - \alpha_1) \cdot \log q_1 +$$

$$(3.7) \qquad + (1 - \alpha_1) \cdot \log (p - \frac{w_1}{a_1} \cdot q_1)$$

which can be rearranged as follows

$$V_1 = \alpha_1 \cdot \delta_1 \cdot \log (w_1 - r) - 2 \cdot (1 - \alpha_1 \cdot \delta_1) \cdot \log\left\{4 \cdot (b + \frac{w_1}{a_1}) \cdot (b + \frac{w_2}{a_2}) - b^2 \cdot (1 + \phi)^2\right\}$$

$$+ \qquad + (1 - \alpha_1) \cdot \log \left\{b \cdot (1 + \phi) \cdot [b \cdot (1 - \phi) + \frac{w_1}{a_1}] + 2 \cdot \frac{w_2}{a_2} \cdot (b + \frac{w_1}{a_1})\right\} + C$$

(3.8)

(where $C = 2 \cdot (1 - \alpha_1 \cdot \delta_1) \cdot \log A + [1 + \alpha_1 \cdot (1 - 2 \cdot \delta_1)] \cdot \log[b \cdot (1 - \phi) + 2 \cdot \frac{w_2}{a_2}]$ is a term independent from w_1)

by noticing that from the solutions of product market competition (3.4) and (3.5)

$$(3.9) \qquad p - \frac{w_1}{a_1} \cdot q_1 = A \cdot \frac{b \cdot (1 + \phi) \cdot [b \cdot (1 - \phi) + \frac{w_1}{a_1}] + 2 \cdot \frac{w_2}{a_2} \cdot (b + \frac{w_1}{a_1})}{4 \cdot (b + \frac{w_1}{a_1}) \cdot (b + \frac{w_2}{a_2}) - b^2 \cdot (1 + \phi)^2}$$

First order conditions for the maximisation therefore are:

$$\frac{\alpha_1 \cdot \delta_1 \cdot a_1}{w_1 - r} - \frac{8 \cdot (1 - \alpha_1 \cdot \delta_1) \cdot (b + \frac{w_2}{a_2})}{4 \cdot (b + \frac{w_1}{a_1}) \cdot (b + \frac{w_2}{a_2}) - b^2 \cdot (1 + \phi)^2} +$$

$$(3.10) \qquad + \frac{(1 - \alpha_1) \cdot [b \cdot (1 + \phi) + 2 \cdot \frac{w_2}{a_2}]}{b \cdot (1 + \phi) \cdot [b \cdot (1 - \phi) + \frac{w_1}{a_1}] + 2 \cdot \frac{w_2}{a_2} \cdot (b + \frac{w_1}{a_1})} = 0$$

A symmetric expression holds for firm 2. Equation (3.10) gives (in an implicit form) the wage reaction function of firm 1. Because of the assumption of concavity of the production function (see (3.1)) the wage reaction functions are no longer linear in the wage of the rival firm as was the case in the basic model of chapter 2.

Figure 3.1 depicts the reaction functions of firms 1 and 2 in the space (w_1, w_2) when firms are identical. The outcome of the wage determination stage is denoted by E. As pointed out above the concavity of the reaction function stems from the assumptions on the production function[3].

§3.2.2 **Collusion in the product market and wage outcomes**

Before moving to the analysis of technology choice in the extended model some results are presented concerning the effect of implicit collusion in the product market on the outcomes of wage bargaining (the second stage of the game). In order to make the analysis more manageable, firms are assumed to be identical. Therefore the unions in firms 1 and 2 have the same bargaining power as well as the same trade-off between wage and employment[4]. Hence $\alpha_1 = \alpha_2$ $(= \alpha)$ and $\delta_1 = \delta_2$ $(= \delta)$.

[3]Unreported numerical results show that the wage reaction function (3.10) is shifted downwards, ceteris paribus, as the degree of implicit collusion among firms (the parameter ϕ) increases.

[4]As pointed out in chapter 2, firms may differ only with respect to their union characteristics.

Symmetry also implies that the two firms operate the same technology, i.e. $a_1 = a_2$ $(= a)$[5]. Furthermore, the following assumptions are made about the numerical values of the parameter involved in the model:

(3.11) $\qquad b = 1, r = 1, \;\; \delta = 1/2 \;, a = 2$

It is important to note that unlike the basic model of chapter 2 the position of the demand curve, i.e. the parameter A, has no role in the determination of the wage.

The numerical values in (3.11) are chosen in order to keep the analysis as close as possible to the basic case described in the previous chapter (see the set of parameters defined in (2.31)). It is assumed that both firms operate with what was defined as the new technology in chapter 2, i.e. that a = 2. The results presented below concerning the effect of collusion in the product market on wage outcomes refer to the specific set of parameter values in (3.11). But the qualitative description of the relationship between implicit collusion and wage outcomes which emerges from the numerical example is general and not restricted in any way by the specific choice of the parameter values. The same is also true as far as the analysis of technology adoption in subsection 3.2.3 is concerned.

Figures 3.2(a) to 3.2(d) depict the solution to wage bargaining as a function of the degree of implicit collusion in the product market, ϕ, for alternative values of

[5] As was the case in chapter 2, the reservation (or alternative) wage, r, is assumed to be invariant across firms.

the union bargaining parameter (α). The parameter α, the same for both unions, ranges from 1/4 (in figure 3.2(a)) to 1 (in figure 3.2(d)), the case where $\alpha = 0$ giving the competitive solution for the wage, i.e. w = r (hence w = 1 in this case, according to the assumptions in (3.11)). The equilibrium wage is the same for both firms according to the assumption of symmetry introduced above. An increase in the degree of (implicit) collusion among firms, i.e. an increase in ϕ, is associated with a lower level of the wage bargained over in the two firms, *ceteris paribus* (in particular for a given union bargaining power)[6]. For any given level of the wage, collusion tends to restrict output and, therefore, employment. In the light of this outcome, unions reduce their demands during wage bargaining.

§3.2.3 **The choice of technology in the extended model**

This section is devoted to the analysis of the adoption decision in the extended model. The removal of the assumption of linearity of the production function implies that it is no longer possible to explicitly determine the equations of the regions in the space (α_1, α_2) of the union bargaining powers where the different Nash equilibria apply according to the technique detailed in the basic model (see section 2.4). As a result the outcome of the technology adoption game must be evaluated separately for every pair (α_1, α_2) of interest.

To begin with it is worthwhile assessing whether the removal of the

[6]See footnote 3.

linearity assumption for the production function alone makes any relevant change in the qualitative nature of the results in chapter 2. To this purpose it is assumed that:

- the production function is given by (3.1),
- there is no collusion in the product market between the two firms (i.e. ϕ=0) as was assumed in the basic model of chapter 2,
- the numerical values of the parameters are the following:

$$a_0 = 1,\ \gamma = 2,\ \delta_1 = \delta_2 = 1/2,\ b = 1,\ A = 10,\ r = 1 \qquad (3.12)$$

It is also assumed that the price of the new technology is z = 2[7]. Hence the model is very close to what has been labelled the basic case in the previous chapter (see assumptions in (2.31) and figure 2.3). Figure 3.3 depicts the results of the innovation decision in the two firms for the set of parameter values in (3.12). It is easily noticed that the qualitative nature of the results presented in section 2.4 is not changed when the assumption of linearity of the production function is removed in favour of a concave production function. Also the remaining results of the basic model carry over in this different setup.

It is now interesting to compare the outcomes of the innovation decision shown in figure 3.3, where it is assumed that $\phi = 0$, with the case where the two firms perfectly collude in the product market, i.e. $\phi = 1$. The analysis of the effect of the degree of collusion in the product market on the outcomes of wage bargaining

[7] Using the same method as in Appendix 2B it is possible to show that the maximum price of the new technology at which both firms innovate in a competitive labour market (i.e.with no unions) given the parameter values in (3.12) is z = 3.15. Using the notation of the basic model (see subsection 2.3.4) this amounts to assuming that β = .635.

(see the comments on figures 3.2) revealed that a higher degree of collusion is associated with lower equilibrium levels of the wages. As a consequence, the existence of collusion in the product market erodes the ability of the unions to extract rents in the wage bargaining process. Hence, in the presence of perfect collusion in the product market, the threat of opportunistic behaviour on the part of the union when a firm makes a decision on the adoption of a new, "superior" technology is not as effective as in the no-collusion Cournot assumptions. For instance for the parameter values in (3.12) and $\phi = 1$, both firms always adopt the new technology whatever the extent of union bargaining power in the two firms. This result should be compared with the outcomes in figure 3.3 which is relative to the complete absence of collusion.

The argument can also be reasserted by picking a higher price for the technology. Let $z = 2.5$, instead of 2. Figure 3.4 compares the equilibrium solutions when $\phi = 0$ (part a) and when $\phi = 1$ (part b). It is easily seen that the area where both firms innovate expands moving from the Cournot assumptions to perfect collusion.

3.3 A MODEL OF CAPITAL CHOICE

In the model of adoption of a new technology presented in chapter 2 firms are faced by a discrete choice. They can either innovate and buy the new technology or stick to the existing technology. In this section the assumption of discrete choice is relaxed. In the first stage of the model firms are now assumed to choose the quantity of capital, a continuous variable, in order to maximise profits. The solution of this stage is again given by a Nash equilibrium. Assumptions about the second and the third stage (wage determination and competition in the product market, respectively) are unchanged.

The analysis of the continuous capital case turns out to be computationally rather cumbersome. As a consequence this section concentrates on some numerical results for the model. As will be clearer below the findings of the basic discrete choice model (and its extensions) are confirmed by the continuous capital case.

The following assumptions are made about the product demand and the production function. Product demand is linear as throughout the rest of the analysis (see (3.2)).

As in section 3.2 the production function is

$$(3.13) \qquad q_i = (K_i \cdot L_i)^{1/2} \qquad \text{hence } L_i = \frac{q_i^2}{K_i}$$

where K_i, the quantity of capital chosen by firm i, simply replaces a_i, the productivity of the technology. This specific functional form is chosen for computational ease.

The per unit cost of capital is given by q and it is the same for both firms.

The outcome of the third stage, i.e. Cournot competition in the product market, is

$$(3.14)\qquad q_1 = A\cdot\frac{b+2\cdot\frac{w_2}{K_2}}{4\cdot\left(b+\frac{w_2}{K_2}\right)\cdot\left(b+\frac{w_1}{K_1}\right)-b^2}$$

$$(3.15)\qquad q_2 = A\cdot\frac{b+2\cdot\frac{w_1}{K_1}}{4\cdot\left(b+\frac{w_2}{K_2}\right)\cdot\left(b+\frac{w_1}{K_1}\right)-b^2}$$

This is the same result obtained in the previous section (see (3.4) and (3.5)) with a_i, the productivity of the techology operated by firm i, being now replaced by K_i[8]. The comments made above on this result equally apply.

The outcome of wage determination (stage 2) is obtained by computing the Nash equilibrium in the Generalised Nash Bargaining Solutions. The following first order conditions for the problem are obtained:

$$(3.16)\qquad \frac{\alpha_1\cdot\delta_1\cdot K_1}{w_1-r} - \frac{8\cdot(1-\alpha_1\cdot\delta_1)\cdot\left(b+2\cdot\frac{w_2}{K_2}\right)}{4\cdot\left(b+\frac{w_2}{K_2}\right)\cdot\left(b+\frac{w_1}{K_1}\right)-b^2} + \frac{1-\alpha_1}{b+\frac{w_1}{K_1}} = 0 \qquad \text{firm 1}$$

$$(3.17)\qquad \frac{\alpha_2\cdot\delta_2\cdot K_2}{w_2-r} - \frac{8\cdot(1-\alpha_2\cdot\delta_2)\cdot\left(b+2\cdot\frac{w_1}{K_1}\right)}{4\cdot\left(b+\frac{w_2}{K_2}\right)\cdot\left(b+\frac{w_1}{K_1}\right)-b^2} + \frac{1-\alpha_2}{b+\frac{w_2}{K_2}} = 0 \qquad \text{firm 2}$$

[8]And assuming that there is no collusion in the product market, i.e. ϕ=0. The same remark applies to equations (3.16) and (3.17) below.

Again these are the same first order conditions obtained above in the extension of the discrete choice model with a_i being replaced by K_i (i = 1, 2).

The first stage of the model has the two firms maximising profits by choosing the quantity of capital. Hence the problem of firm 1 can be written as

$$\max_{q_1} \ \Pi_1 = p \cdot q_1 - w \cdot L_1 - q \cdot K_1 =$$

from (3.14)-(3.15)

$$(3.18) \qquad = A^2 \cdot \left\{ \frac{b + 2 \cdot \frac{w_2}{K_2}}{4 \cdot \left(b + \frac{w_1}{K_1}\right) \cdot \left(b + \frac{w_2}{K_2}\right) - b^2} \right\}^2 \cdot \left(b + \frac{w_1}{K_1}\right) - q \cdot K_1$$

subject to the outcomes of wage bargaining (equations (3.16) and (3.17)).

An analogous problem is solved by firm 2.

The rest of this section decribes some numerical results obtained with this model. Some details on the technical aspects of the solution are given in Appendix 3.

The case in which the two firms are identical is considered first, i.e. the union bargaining power (parameter α) and the weights on wage and employment in the union utility function (parameter δ) are the same in both firms. Table 3.1 presents the results obtained for the symmetric case where $\delta_1 = \delta_2 = 1/2$ as union bargaining power varies. It is also assumed that the following values are taken by the remaining parameters of the model:

(3.19) $A = 5,\ b = 1,\ q = 1,\ r = 1$

Assumptions in (3.19) are maintained throughout the rest of this section.

Table 3.1 shows that as union bargaining power increases (in both firms simultaneously according to the assumption of symmetry), moving from the competitive solution, $\alpha = 0$, to the Monopoly Union case, $\alpha = 1$, the equilibrium wage goes up while the optimal quantity of capital shrinks. These are the results expected from the analysis of the discrete choice of innovation conducted in chapter 2. Table 3.1 also shows that as union bargaining power increases employment and output decrease, while the product price increases. It can be seen that the response of employment and capital decisions to an increase in union bargaining power is such that the capital-labour ratio increases as α increases. This outcome does not confirm therefore the results in Moene (1990)[9]. Moene suggests that his results stand as a criticism of the "common sense" view according to which increases in union power tend to bias the choice of techniques in a capital-intensive direction. The results in table 3.1 show instead that in the model presented above the techniques operated in equilibrium by the two firms become more capital intensive as union power increases.

Finally, table 3.1 shows that, as expected, profits decrease when union power increases and union's utility grows with α.

[9] Moene's analysis refers to a single firm setting. See section 1.4 for a discussion of Moene's results.

Tables 3.2 and 3.3 present the equilibrium outcomes of the model for the cases where the unions are more concerned with employment (namely, $\delta = 2/5$) and for the case where unions are more concerned with the wage (namely, $\delta = 3/5$) respectively. The assumption of symmetry across firms is maintained. It is easily seen that the qualitative nature of the results is the same as for table 3.1[10]. Thus the comments made above still apply.

The combination of the results in tables 3.1, 3.2 and 3.3 provides some information on the effects of alternative union objectives, i.e. different weights on wage and employment in the utility function, on the equilibrium outcomes for a given value of union bargaining power in the two firms. First, as union concern over the wage increases (from $\delta = 2/5$ to $\delta = 3/5$) the bargained wage increases and the optimal capital quantity decreases. These results hold whatever the value of the union bargaining power parameter α. Hence the predictions of the model of discrete choice of technology (see section (2.4)) are confirmed. It is also easily seen that, as δ increases, the equilibrium levels of employment, output and profits decline. The output fall determines an increase in the equilibrium product price. On the other hand, as δ increases the optimal capital-labour ratio increases. Hence for a given union bargaining power more capital intensive techniques are associated with environments where unions are more concerned with the wage.

[10]The only difference is that union utility is decreasing as union bargaining power increases for high values of α (α>.8 approximately) when the unions are more concerned with the wage (δ=3/5, see table 3.3).

The final part of this section refers to the case where the two firms are not identical. The following two cases are studied.

1. To start union bargaining power is assumed to be the same, but firms differ with respect to the relative concern over wages and employment of the unions they face. The result for this case are given in table 3.4 where it is assumed that $\delta_1 = 1/2$ and $\delta_2 = 2/5$. The table shows the equilibrium outcomes as union bargaining power (same in both firms) varies. As expected the wage is higher in firm 1 which confronts the union relatively more concerned with the wage. On the other hand, the quantity of capital, as well as employment and thus output, is higher in firm 2. The capital-labour ratio is also higher in firm 2 and the same is true for profits and unions' utilities[11].

2. It is now assumed that the weights on wage and employment are the same for both unions but that union bargaining power is allowed to vary in one of the firms holding constant the value of α in the other. More specifically, α_1 is allowed to vary while $\alpha_2 = 1/2$ and $\delta_1 = \delta_2 = 1/2$. Table 3.5 presents the results for this case. An increase in union bargaining power in firm 1 brings about an increase in the wage in the same firm and a decrease in the capital quantity associated with a decrease in employment (and hence of output) and profits. It is interesting to note that in this case the capital-labour ratio in firm 1 decreases as α_1 increases according to the result suggested in Moene (1990), but not uniformly, since for high values of α_1 a

[11] These results hold irrespective of the value of α.

further increase in union bargaining power causes K_1/L_1 to grow (see the change from $\alpha_1 = .9$ to $\alpha_1 = 1$). Above it was pointed out that simultaneous changes in union bargaining power in both firms result instead in an increase of the capital intensity of the techniques operated in equilibrium by the firms (see table 3.1 where $\delta_1 = \delta_2 = 1/2$ as in table 3.5).

The following remarks can be made as far as firm 2, whose bargaining power is held constant, is concerned. The bargained wage increases as α_1 increases and the same is true for the equilibrium capital quantity. Employment in firm 2 is increasing in α_1 unless α_1 becomes very high. Output is uniformly increasing as well as the capital-labour ratio. Finally profits increase for values of α_1 below .6 approximately.

3.4 CONCLUSIONS

The results of the model of technology adoption described in chapter 2 are robust to the changes and extensions considered in this chapter. Firstly, the use of a concave production function does not bring about any major modification in the results.

Collusion among firms in the product market is then analysed. The results show that the existence of collusion facilitates, *ceteris paribus*, the adoption of the new technology. This result stems from the fact that the bargained wages decline with the degree of implicit collusion in the market, thereby making the threat of opportunistic behaviour on the part of the unions less harmful to firms. The effect of collusion on wages is a noticeable result on its own.

Finally, the main results of the basic model of chapter 2 seem to be preserved when firms are assumed to choose the quantity of capital. Increases in union bargaining power negatively affect, *ceteris paribus*, the stock of capital. No evidence is found for a positive relationship between union power and capital levels (at least in the available numerical solutions). As expected from the discrete choice model, firms tend to have a larger stock of capital when the unions they face are more concerned with employment than the wage. Hence the main results of section 2.4 are replicated in the continuous capital case.

FIGURE 3.1

WAGE REACTION FUNCTIONS

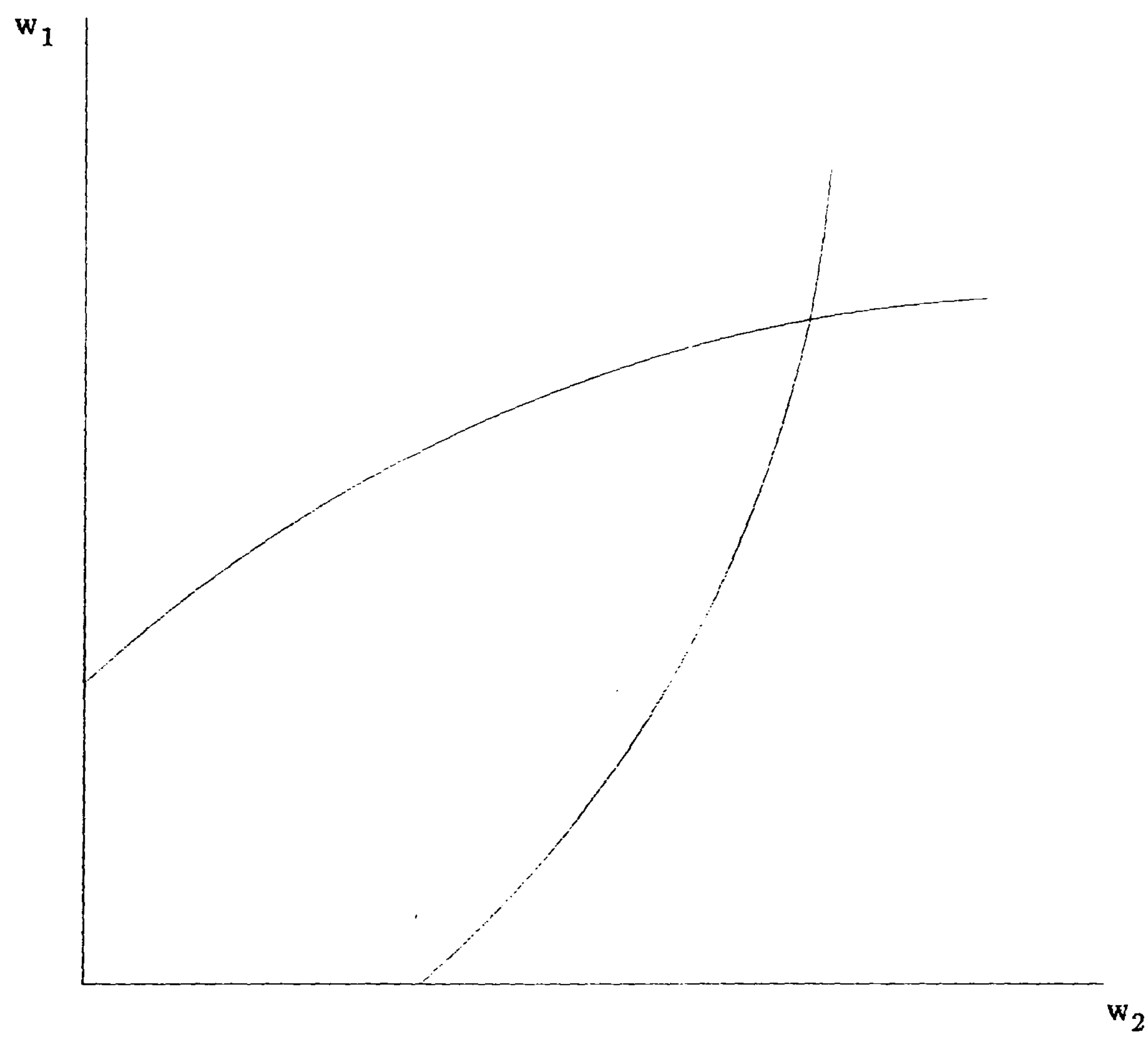


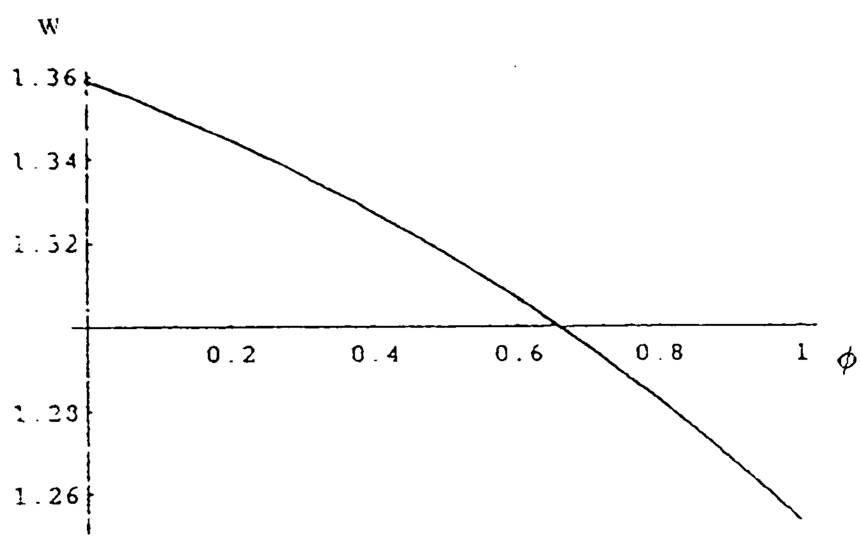
FIGURE 3.2

EFFECT OF COLLUSION IN THE PRODUCT MARKET ON WAGES

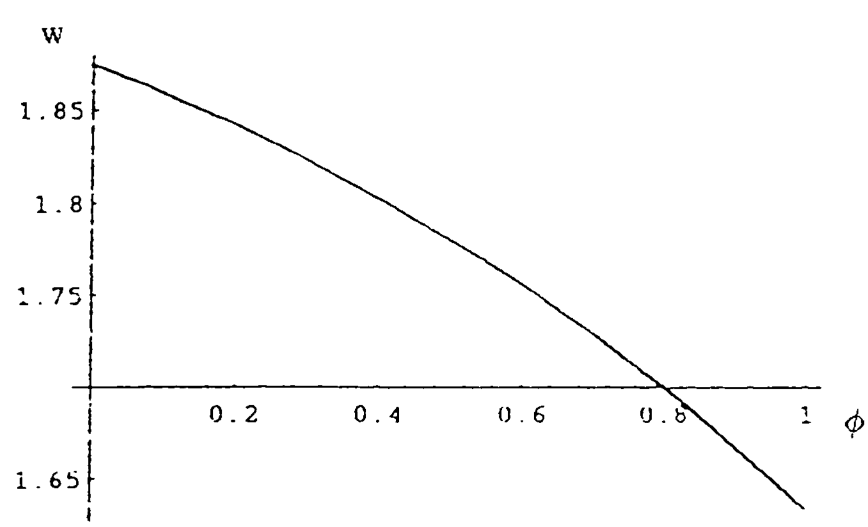
(see (3.11) for the parameter values)

Note: w = bargained wage, ϕ = degree of collusion, α = union bargaining power

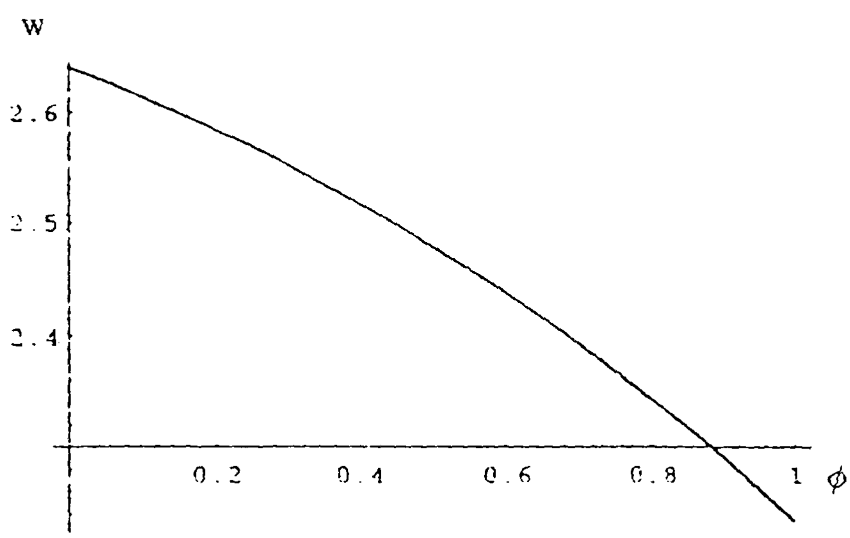
(a) $\alpha = 1/4$



(b) $\alpha = 1/2$



(c) $\alpha = 3/4$



(d) $\alpha = 1$

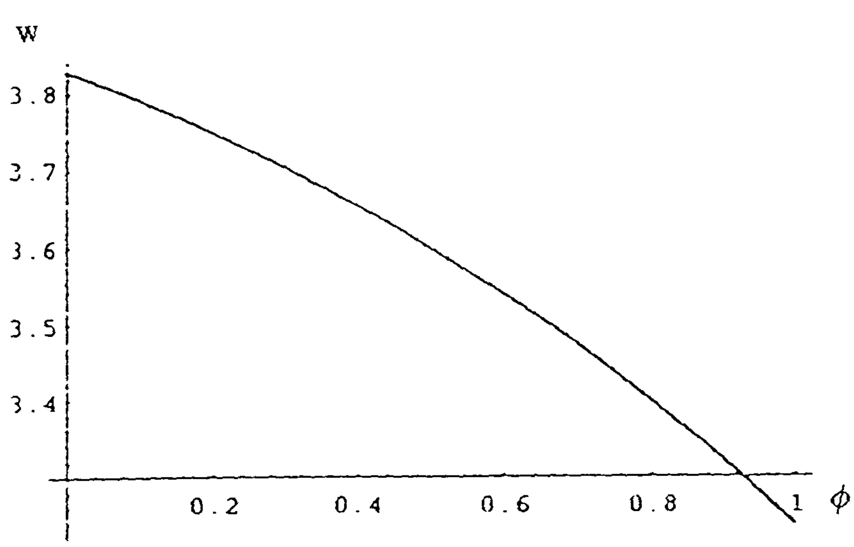
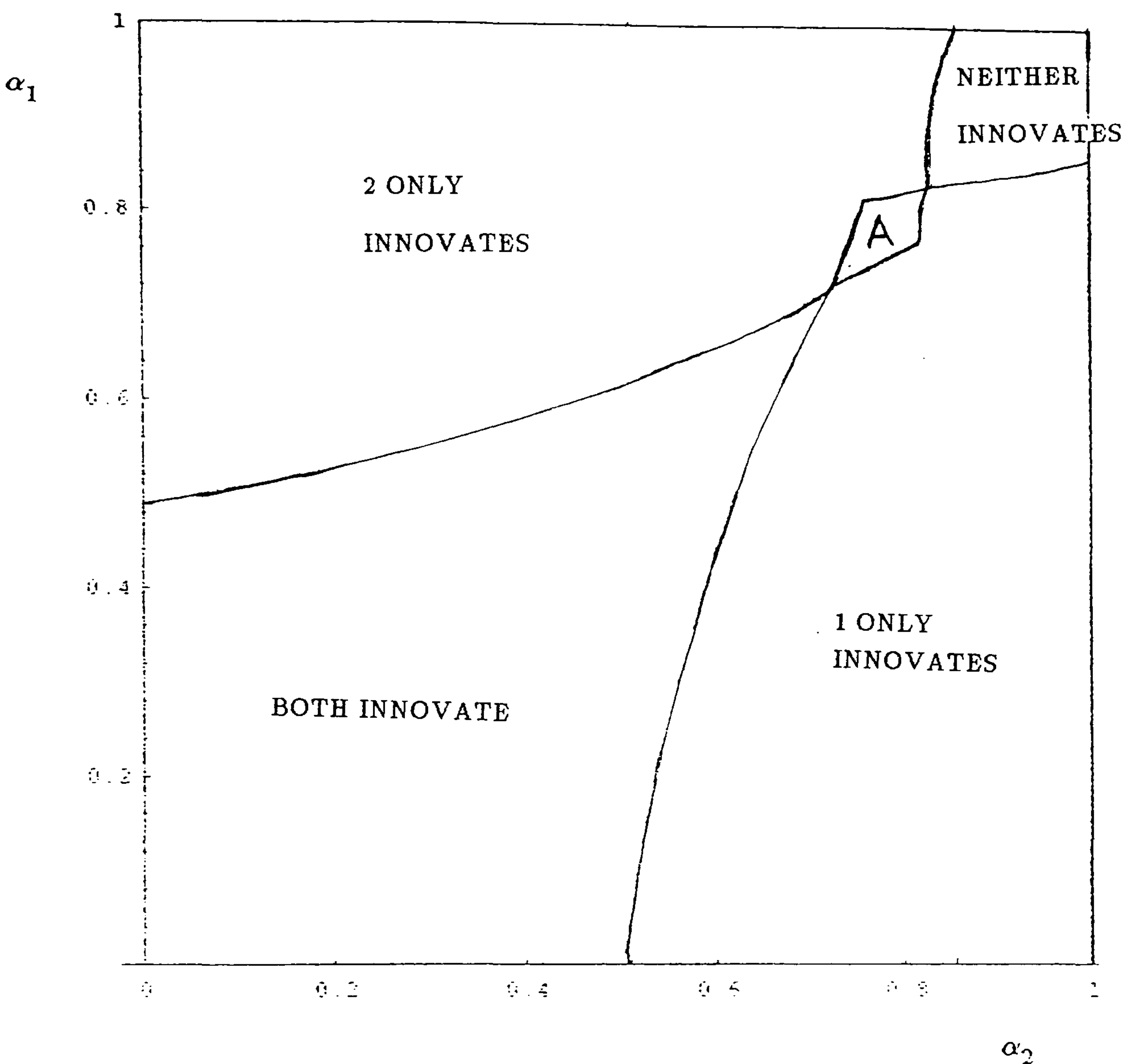


FIGURE 3.3

(Assumptions: No collusion ($\phi = 0$) and price of technology ($\equiv$ z) = 2,

see (3.12) for the remaining parameter values)



Note:

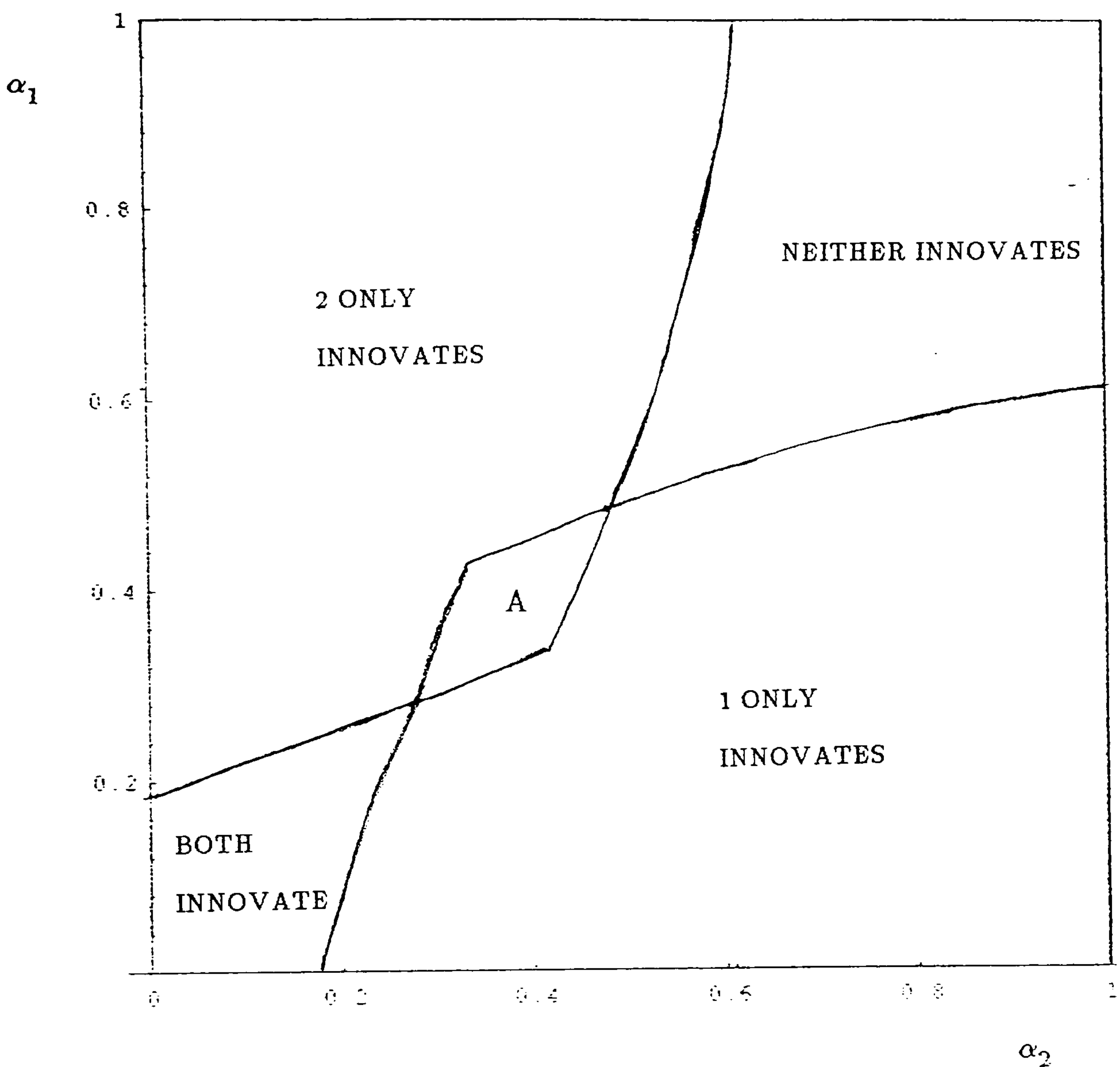
A = two Nash equilibria

FIGURE 3.4

(a)

(Assumptions: No collusion ($\phi = 0$) and price of technology ($\equiv$ z) = 5/2,

see (3.12) for the remaining parameter values)



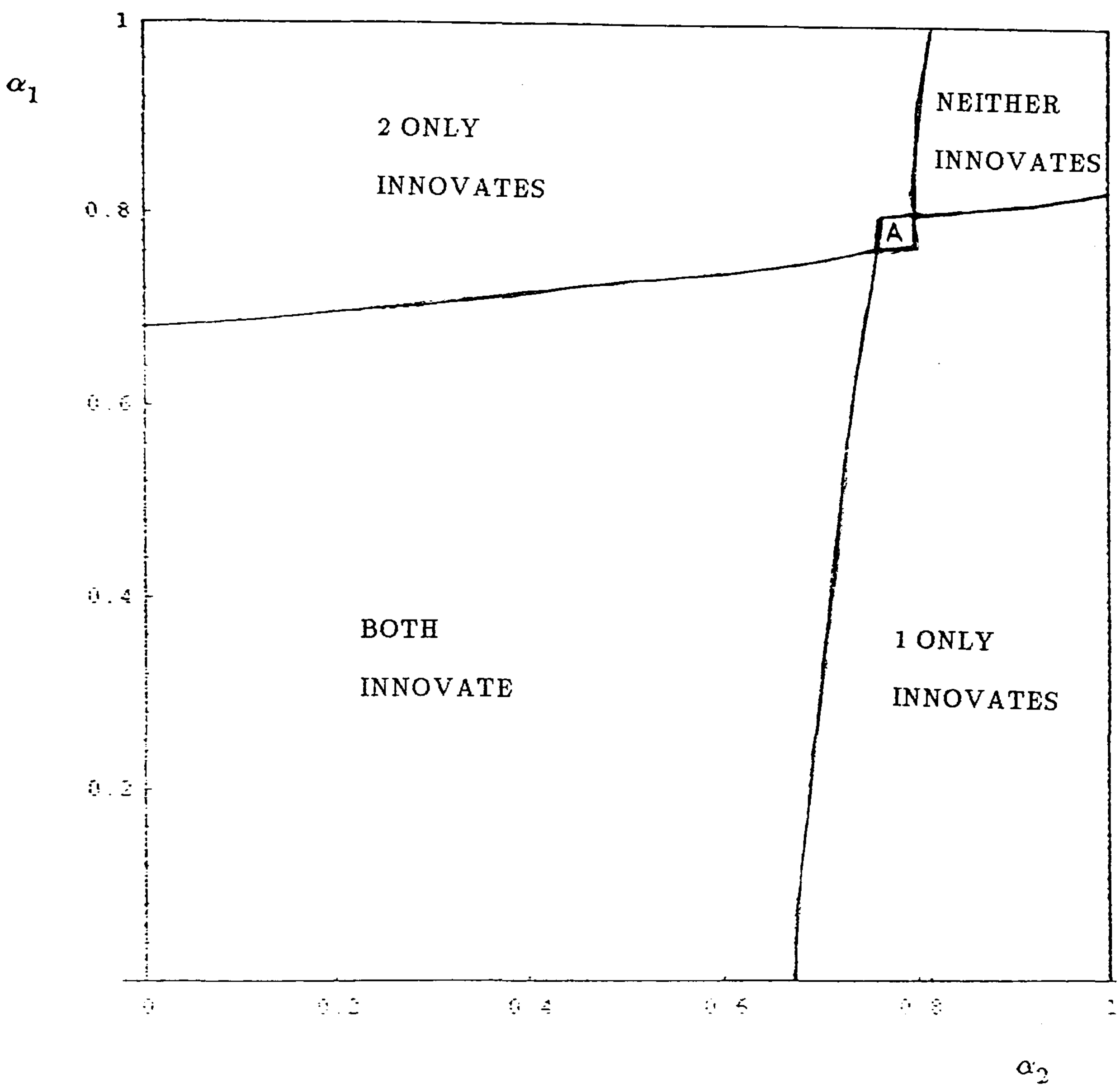
Note:

A = two Nash equilibria

(b)

(Assumptions: Perfect collusion ($\phi = 1$) and price of technology ($\equiv$ z)=5/2,

see (3.12) for the remaining parameter values)



Note:

A = two Nash equilibria

TABLE 3.1

(same union power in both firms and $\delta=1/2$ in both firms)

union power (=a)	wage	capital	output	labour	price	profits	cap/lab	utility
0.0	1.000	1.747	1.206	0.833	2.587	0.541	2.097	0.000
0.1	1.120	1.736	1.165	0.783	2.669	0.499	2.218	0.306
0.2	1.256	1.719	1.121	0.731	2.758	0.455	2.352	0.432
0.3	1.410	1.696	1.072	0.678	2.855	0.410	2.502	0.527
0.4	1.584	1.666	1.020	0.624	2.960	0.364	2.668	0.604
0.5	1.781	1.627	0.963	0.571	3.073	0.318	2.852	0.668
0.6	2.002	1.578	0.903	0.517	3.194	0.272	3.054	0.720
0.7	2.249	1.516	0.838	0.463	3.324	0.227	3.275	0.761
0.8	2.524	1.442	0.769	0.410	3.462	0.185	3.515	0.791
0.9	2.827	1.353	0.697	0.359	3.607	0.146	3.774	0.809
1.0	3.160	1.248	0.620	0.308	3.760	0.110	4.052	0.816

Note: for the remaining parameter values see (3.19)

TABLE 3.2

(same union power in both firms and $\delta=0.4$ in both firms)

union power (=a)	wage	capital	output	labour	price	profits	cap/lab	utility
0.0	1.000	1.747	1.206	0.833	2.587	0.541	2.097	0.000
0.1	1.093	1.738	1.174	0.793	2.651	0.508	2.191	0.336
0.2	1.192	1.727	1.141	0.754	2.717	0.475	2.289	0.436
0.3	1.297	1.713	1.108	0.716	2.785	0.442	2.393	0.504
0.4	1.409	1.696	1.073	0.678	2.855	0.410	2.500	0.554
0.5	1.526	1.676	1.037	0.642	2.926	0.379	2.612	0.593
0.6	1.649	1.654	1.001	0.606	2.998	0.348	2.728	0.623
0.7	1.777	1.628	0.965	0.572	3.071	0.319	2.847	0.646
0.8	1.909	1.599	0.928	0.539	3.144	0.290	2.969	0.664
0.9	2.046	1.567	0.891	0.507	3.218	0.264	3.093	0.677
1.0	2.187	1.532	0.854	0.476	3.292	0.238	3.219	0.686

Note: for the remaining parameter values see (3.19)

TABLE 3.3

(same union power in both firms and δ=0.6 in both firms)

union power (=α)	wage	capital	output	labour	price	profits	cap/lab	utility
0.0	1.000	1.747	1.206	0.833	2.587	0.541	2.097	0.000
0.1	1.148	1.732	1.156	0.771	2.688	0.489	2.246	0.287
0.2	1.328	1.709	1.098	0.705	2.804	0.433	2.423	0.445
0.3	1.548	1.673	1.031	0.635	2.938	0.373	2.633	0.581
0.4	1.817	1.619	0.953	0.561	3.093	0.310	2.885	0.703
0.5	2.149	1.542	0.864	0.484	3.272	0.245	3.186	0.813
0.6	2.557	1.433	0.761	0.404	3.478	0.180	3.544	0.908
0.7	3.057	1.282	0.643	0.323	3.713	0.120	3.967	0.981
0.8	3.668	1.076	0.509	0.241	3.981	0.068	4.463	1.020
0.9	4.407	0.801	0.357	0.159	4.286	0.028	5.035	1.000
1.0	5.293	0.439	0.185	0.078	4.631	0.005	5.669	0.862

Note: for the remaining parameter values see (3.19)

TABLE 3.4

(same union bargaining power with δ1=0.5 and δ2=0.4)

union power (=α)	w1	w2	K1	K2	q1	q2	L1	L2
0.0	1.000	1.000	1.747	1.747	1.206	1.206	0.833	0.833
0.1	1.117	1.095	1.679	1.797	1.141	1.199	0.776	0.800
0.2	1.244	1.201	1.604	1.849	1.073	1.190	0.718	0.766
0.3	1.381	1.320	1.523	1.901	1.002	1.180	0.659	0.732
0.4	1.530	1.452	1.436	1.955	0.927	1.168	0.599	0.698
0.5	1.690	1.599	1.341	2.008	0.851	1.155	0.540	0.664
0.6	1.862	1.760	1.240	2.060	0.772	1.140	0.480	0.631
0.7	2.046	1.936	1.132	2.111	0.690	1.124	0.421	0.598
0.8	2.243	2.128	1.017	2.158	0.608	1.106	0.363	0.567
0.9	2.453	2.336	0.896	2.202	0.523	1.086	0.306	0.536
1.0	2.677	2.558	0.767	2.241	0.438	1.065	0.250	0.506

union power (=α)	p	profit1	profit2	K1/L1	K2/L2	U1	U2
0.0	2.587	0.541	0.541	2.097	2.097	0.000	0.000
0.1	2.660	0.490	0.516	2.163	2.247	0.301	0.341
0.2	2.737	0.440	0.488	2.235	2.413	0.418	0.449
0.3	2.818	0.390	0.458	2.312	2.597	0.501	0.526
0.4	2.904	0.341	0.424	2.396	2.800	0.563	0.587
0.5	2.994	0.294	0.388	2.486	3.022	0.610	0.637
0.6	3.088	0.249	0.350	2.584	3.265	0.643	0.680
0.7	3.186	0.206	0.311	2.690	3.527	0.664	0.716
0.8	3.287	0.166	0.270	2.804	3.809	0.672	0.746
0.9	3.391	0.129	0.229	2.929	4.109	0.667	0.772
1.0	3.497	0.095	0.189	3.065	4.426	0.648	0.794

Note: for the remaining parameter values see (3.19)

TABLE 3.5

(variable union bargaining power in firm 1 and $\alpha 2=1/2$ and $\delta=0.5$)

union power (firm 1)	w1	w2	K1	K2	q1	q2	L1	L2
0.0	1.000	1.498	3.389	0.688	1.732	0.514	0.885	0.384
0.1	1.184	1.542	2.961	0.844	1.569	0.607	0.832	0.436
0.2	1.350	1.591	2.575	1.016	1.411	0.699	0.773	0.481
0.3	1.502	1.647	2.226	1.204	1.257	0.790	0.710	0.519
0.4	1.645	1.711	1.911	1.408	1.108	0.879	0.642	0.548
0.5	1.781	1.781	1.627	1.627	0.963	0.963	0.571	0.571
0.6	1.915	1.859	1.370	1.859	0.825	1.044	0.497	0.586
0.7	2.048	1.942	1.136	2.102	0.692	1.119	0.422	0.596
0.8	2.184	2.032	0.923	2.352	0.566	1.189	0.347	0.602
0.9	2.324	2.125	0.728	2.605	0.447	1.254	0.274	0.603
1.0	2.471	2.222	0.548	2.857	0.335	1.312	0.204	0.603

union power (firm 1)	p	profit1	profit2	K1/L1	K2/L2	U1	U2
0.0	2.754	0.496	0.152	3.829	1.789	0.000	0.438
0.1	2.824	0.486	0.197	3.561	1.934	0.391	0.486
0.2	2.890	0.459	0.239	3.331	2.111	0.520	0.533
0.3	2.953	0.420	0.275	3.137	2.321	0.597	0.579
0.4	3.014	0.371	0.302	2.977	2.568	0.643	0.624
0.5	3.073	0.318	0.318	2.852	2.852	0.668	0.668
0.6	3.131	0.262	0.320	2.758	3.172	0.674	0.709
0.7	3.188	0.207	0.309	2.694	3.526	0.665	0.750
0.8	3.244	0.155	0.285	2.660	3.910	0.641	0.788
0.9	3.299	0.109	0.249	2.655	4.317	0.603	0.824
1.0	3.353	0.069	0.204	2.681	4.741	0.548	0.858

Note: for the remaining parameter values see (3.19)

APPENDIX 3

According to the assumptions in (3.19) the slope of the product demand (=b) is set equal to 1 in this Appendix.

Profits for firm 1 are defined as

$$\Pi_1 = p \cdot q_1 - w_1 \cdot L_1 - q \cdot K_1 =$$

from $L_1 = \frac{q_1^{\,2}}{K_1}$ (see 3.13)

(3A.1) $$= [p - \frac{w_1}{K_1} \cdot q_1] \cdot q_1 - q \cdot K_1$$

From the solutions for q_1 and q_2 in the quantity competition stage (see (3.14) and (3.15)) it is easily seen that

(3A.2) $$p - \frac{w_1}{K_1} \cdot q_1 = A \cdot \frac{\left(1 + 2 \cdot \frac{w_2}{K_2}\right) \cdot \left(2 + \frac{w_1}{K_1}\right)}{4 \cdot \left(1 + \frac{w_1}{K_1}\right) \cdot \left(1 + \frac{w_2}{K_2}\right) - 1}$$

Hence

(3A.3) $$\Pi_1 = A^2 \cdot \left\{\frac{1 + 2 \cdot \frac{w_2}{K_2}}{4 \cdot \left(1 + \frac{w_1}{K_1}\right) \cdot \left(1 + \frac{w_2}{K_2}\right) - 1}\right\}^2 \cdot \left(1 + \frac{w_1}{K_1}\right) - q \cdot K_1$$

This expression can be rearranged to give

(3A.4) $$\Pi_1 = K_1 \cdot \left\{A^2 \cdot (K_1 + w_1) \cdot \left\{\frac{K_2 + 2 \cdot w_2}{4 \cdot (K_1 + w_1) \cdot (K_2 + w_2) - K_1 \cdot K_2}\right\}^2 - q\right\}$$

In the first stage of the game (choice of capital stock) profit maximisation for firm 1 implies $\frac{\partial \Pi_1}{\partial K_1} = 0$. After some manipulations this condition can be written as follows

$$A^2 \cdot (K_1 + w_1) \cdot (K_2 + 2 \cdot w_2)^2 \cdot [4 \cdot (K_1 + w_1) \cdot (K_2 + w_2) - K_1 \cdot K_2] + K_1 \cdot A^2 \cdot \Big\{ (1 + \\ + \frac{\partial w_1}{\partial K_1}) \cdot (K_2 + 2 \cdot w_2)^2 \cdot [4 \cdot (K_1 + w_1) \cdot (K_2 + w_2) - K_1 \cdot K_2] + 2 \cdot (K_1 + w_1) \cdot (K_2 + \\ + 2 \cdot w_2) \cdot \Big\{ 2 \cdot \frac{\partial w_2}{\partial K_1} \cdot [4 \cdot (K_1 + w_1) \cdot (K_2 + w_2) - K_1 \cdot K_2] - (K_2 + 2 \cdot w_2) \cdot [4 \cdot (1 + \\ + \frac{\partial w_1}{\partial K_1}) \cdot (K_2 + w_2 \; + 4 \cdot (K_1 + w_1) \cdot \frac{\partial w_2}{\partial K_1} - K_2] \Big\} \Big\} = q \cdot [4 \cdot (K_1 + w_1) \cdot (K_2 + w_2) + \\ - K_1 \cdot K_2]^3$$

(3A.5)

A symmetric expression holds for firm 2. As seen above ((3.16) and (3.17)) the first order conditions for the solution of the wage determination stage are

(3A.6) $$\frac{\alpha_1 \cdot \delta_1 \cdot K_1}{w_1 - r_1} - \frac{8 \cdot (1 - \alpha_1 \cdot \delta_1) \cdot (b + 2 \cdot \frac{w_2}{K_2})}{4 \cdot (b + \frac{w_2}{K_2}) \cdot (b + \frac{w_1}{K_1}) - b^2} + \frac{1 - \alpha_1}{b + \frac{w_1}{K_1}} = 0 \qquad \text{firm 1}$$

(3A.7) $$\frac{\alpha_2 \cdot \delta_2 \cdot K_2}{w_2 - r_2} - \frac{8 \cdot (1 - \alpha_2 \cdot \delta_2) \cdot (b + 2 \cdot \frac{w_1}{K_1})}{4 \cdot (b + \frac{w_2}{K_2}) \cdot (b + \frac{w_1}{K_1}) - b^2} + \frac{1 - \alpha_2}{b + \frac{w_2}{K_2}} = 0 \qquad \text{firm 2}$$

They can be rearranged to give

$$4\cdot(K_1 + w_1)\cdot(K_2 + w_2)\cdot(\alpha_1\cdot\delta_1\cdot K_1 - A_1\cdot w_1 + B_1\cdot r) - K_1\cdot K_2\cdot[\alpha_1\cdot\delta_1\cdot K_1 +$$

$$+C_1\cdot w_1 - (1 - \alpha_1)\cdot r] = 0 \qquad (3A.8)$$

$$4\cdot(K_1 + w_1)\cdot(K_2 + w_2)\cdot(\alpha_2\cdot\delta_2\cdot K_2 - A_2\cdot w_2 + B_2\cdot r) - K_1\cdot K_2\cdot[\alpha_2\cdot\delta_2\cdot K_2 +$$

$$+C_2\cdot w_2 - (1 - \alpha_2)\cdot r] = 0 \qquad (3A.9)$$

where

$$A_i = 1 + \alpha_i\cdot(1 - 3\cdot\delta_1)$$

$$B_i = 1 + \alpha_i\cdot(1 - 2\cdot\delta_1) \qquad i = 1, 2$$

$$C_i = 1 - \alpha_i\cdot(1 - 2\cdot\delta_1)$$

From (3A.8) and (3A.9) the effects of the choice of capital on the bargained wages, i.e. $\frac{\partial w_1}{\partial K_1}, \frac{\partial w_1}{\partial K_2}, \frac{\partial w_2}{\partial K_1}, \frac{\partial w_2}{\partial K_2}$, needed in (3A.5) and in the symmetric condition for firm 2 can be computed.

Hence solutions for w_1, w_2, K_1, and K_2 can be obtained by solving the system of equations (3A.8), (3A.9), (3A.5) and the symmetric of (3A.5) for firm 2. To this purpose the procedure Findroot in Mathematica has been used to determine the numerical solutions.

CHAPTER 4

THE EFFECT OF UNIONS ON INVESTMENT FOR BRITISH COMPANIES

DESCRIPTION OF THE DATA AND INTRODUCTORY RESULTS

4.1 INTRODUCTION

This chapter and the next deal with the empirical analysis of the effects of unionisation on investment. The main purpose of this chapter is to describe the data used in the empirical work as well as to present some basic statistics obtained from the data. Chapter 5 will then focus on the econometric analysis based on a sub-sample of the data used in this chapter.

The empirical analysis is based on the merging of companies' budget data with the findings from a survey on industrial relations in the U.K. over the eighties for the same companies. The two datasets are described in section 4.2. In section 1.7 it was pointed out that the main drawback of the empirical analyses on the effects of unionisation on investment in the U.K. was the lack of sources combining data on investment at the firm level with information on unionisation and other industrial relations arrangements at the same level of disaggregation. This requirement is met by the data used in this thesis which makes the results of the analysis particularly interesting.

No investment variable was originally available in the data. The investment measure has then been computed applying a technique suggested by Wadhwani and Wall (1986) and based on the information available in the account data. The technique is presented in Appendix 4A and the effects of its application on the size and characteristics of the sample are described in section 4.2. In the same section some evidence is provided on the pattern of the Investment/Sales ratio obtained from the data across the eighties. Some care is also taken to show that the data are representative by comparing the movement in the Investment/Sales ratio in the sample with the actual figures for the Manufacturing sector available from official statistics.

Subsections 4.3.2 and 4.3.3 get the empirical analysis of the effects of unions on investment started. First, investment performance is compared across unionised and non-unionised companies, and then the relationship between union density (and relative union strength) and investment performance is analysed. The remarks made in these sections should not be overemphasized. The results are based on descriptive statistics, mostly comparisons of means (or medians) across the cross-sections of years available in the sample. The results provide some interesting, introductory, information about the characteristics of the data, before moving to the regression analysis of chapter 5.

One of the salient features of the union information available in the data is that it is known whether companies underwent a change in their union status (derecognition or recognition, abolition of closed shop, and so on) during the period of interest. It then appears natural to divide the sample between the companies who did not experience any change in union status[1] during the eighties and those who

[1] In this chapter changes in union status will refer only to moves (partial or complete) towards or away from union recognition.

did. Whenever comparisons of investment performance are made in this chapter based on union characteristics, for instance between recognised and non-recognised companies, or between unionised companies with a different extent of union density, the relevant sample is always that comprising only companies experiencing no changes in union status. Descriptive statistics for companies affected by changes in union status will be presented in the next chapter, in section 5.9. They are not dealt with in this chapter to avoid additional complications to the analysis and because of the relatively small proportion of firms that experienced the changes.

4.2 DATA DESCRIPTION

The empirical investigation of the effects of unionisation on investment carried out in this thesis is based on British company level data over the period 1982-89. The dataset merges information from U.K. quoted companies' budget data (the source is the Exstat databank) with the findings of a survey on industrial relations arrangements and the extent of unionisation at the company level carried out by the NIESR in July 1990[2]. The former dataset contains information on economic variables, such as sales, profits, employment, total wages, financial indicators, etc. as well as the set of variables needed for the computation of an

[2]The data have been kindly supplied by P. Gregg, NIESR, London. See Gregg-Yates (1991) for the analysis of the main findings of the survey. The companies in the survey account for about 2.9 million employees (13% of all U.K. employees in 1987), see Gregg-Yates (1991, 362-363). See Gregg-Machin (1991a,b), Gregg-Machin (1992), Gregg et al. (1993), and Menezes-Filho et al. (1995) for other papers based on the NIESR survey.

investment measure (see below). Each company level variable used in the empirical analysis belongs to the Exstat database. Data have been collected for 558 non-agricultural companies.

The survey carried out by the NIESR has allowed the matching of the budget data with a huge amount of information on the union status and the characteristics of industrial relations at the company level. The main aim of the NIESR survey is to deal with the changes in the industrial relations arrangements in the U.K. across the Eighties. Because of this feature the NIESR survey provides a great deal of valuable information for the analysis of the effects of unionisation and industrial relations on investment performance in the U.K. during the eighties. For instance, it is possible to know whether companies were recognising unions for the purpose of wage bargaining at the end of the period (1990), but also whether changes towards recognition or derecognition (partial or complete) took place during the eighties. Similar information is available for the existence (and related changes) of closed shop arrangements, as well as other bargaining issues. The survey also aims at temporally locating the changes in unionisation across the eighties. To this purpose most of the questions in the survey are spelled out with reference to two separate time periods: 1980-84 and 1985-89[3]. This feature of the data should be borne in mind when moving to the econometric analysis of chapter 5. Another important advantage of the NIESR dataset is that it also provides annual union

[3]Some studies point to a different behaviour in the two parts of the decade. See, for instance, Claydon (1989) on union derecognition.

density figures at the company level for a large proportion of the recognised companies.

For the sake of simplicity a description of the variables originating from the NIESR survey is not carried out here but each time a variable is newly introduced into the analysis. Definitions and sources for all variables used in the empirical analysis are provided in Appendix 4B. Descriptive statistics for these variables are presented in Appendix 4D.

The budget data do not include a measure of investment. Nonetheless they provide the information needed to apply the technique described in Wadhwani and Wall (1986). This procedure aims at adjusting accounting data in order to provide estimates of gross investment at replacement value[4]. The construction of this investment measure is described in Appendix 4A.

The investment variable used in this chapter and the next can then be defined as[5]

$$\text{INV} = \frac{\text{Investment}}{\text{Sales}} * 100$$

Hence INV represents investment as a percentage of total sales.

As a result of the application of the technique some negative values for the investment measure (i.e. disinvestment) arose (see footnote 8). Moreover, as a consequence of the adjustment technique investment values could not be computed

[4]It is important to notice that the capital stock cannot be computed using this technique, because more, unavailable, information would be required for this purpose.

[5]Both Investment and Sales in this definition are at constant prices (see Appendix 4A).

for some companies or for some years within the same company, mostly because of the lack of the accounting information needed to carry out the procedure.

After the computation of the investment measure and the matching with the NIESR union dataset, the sample comprises 2148 observations for 365 companies over the period 1982-1989[6].

Because of the way the dataset has been built (see the comments above on the application of the Wadhwani and Wall technique) the panel turns out to be highly unbalanced. As a matter of fact the panel includes companies with just one observation available up to companies with a continuous record of information for every year between 1982 and 1989[7]. Moreover, the panel includes information on companies irrespective of whether records are continuous or not. More precisely, out of 365 companies 105 have non-continuous records of variable length. The way this problem is tackled in the estimation process will be detailed in chapter 5. As far as the analysis of the descriptive statistics and cross- correlations in the next section is concerned all the available information will be exploited.

4.3 A LOOK AT THE DESCRIPTIVE STATISTICS

§4.3.1 Investment Performance: Basic Statistics

Figure 4.1 shows the time pattern of INV, the investment-sales ratio (mean

[6]Observations for years before 1982 are lost because variables such as sales, wages, employment, etc. are not available in the dataset before that year. Moreover, the definition of wage in the source underwent a change that would make inconsistent the use of wage data before 1982.

[7]Nine companies have just one observation.

and median) for the whole sample over the period 1982-89.

It should be pointed out that the median appears a more reliable indicator of central tendency for these data than the mean since the latter is more sensitive to the presence of a few very extreme values[8]. It is easily seen looking at the median in figure 4.1 that the investment-sales ratio is fairly stable during the period 1982-86 and then rises steadily over the period 1986-89. The plot of the mean confirms the rise at the end of the eighties, but also points out an increase over the years 1984-86[9].

Figures 4.2(A) and 4.3 present plots of the mean and median of the investment-sales ratio disaggregated between manufacturing and services[10]. Since companies in the manufacturing sector account for a major share of the sample (see table 4.1 and the comments below) it is no surprise that figure 4.2(A) confirms the findings of figure 4.1. The only noticeable differences are the following: the mean shows a sharp increase in 1984-85 and a marked decline in 1986 as well as a decline in the last year of the sample.

As far as commercial services are concerned, figure 4.3 shows a greater variability in the investment indicator with respect to manufacturing. A cyclical

[8] Over the whole sample INV takes values between -27.45 and 124.9, a range which does not appear to be "unreasonable".

[9] Note that the two years which provide less observations are the two extremes (1982 and 1989).

[10] Manufacturing is defined as one-digit sectors 2, 3 and 4. See Appendix 4C for the definition of the sectors.

pattern is evident over the period 1982-86 and a sharp increase then follows from 1986 to 1989. Figure 4.3 also shows that the mean is even more cyclical and provides no evidence of a lasting "boom" of investment in the late eighties. Comparison of data from figures 4.2(A) and 4.3 readily shows that the value of the mean of the investment-sales ratio is far higher in the Services than in manufacturing. This result holds true for the median only in the second part of the eighties (1986-89).

It is obviously of some interest to compare the investment outcomes in the sample with the actual investment performance of the economy, notwithstanding the differences in the accounting definition of investment. Data on net capital expenditure[11] from the Business Monitor Series (establishment analysis) can be used to this purpose. The data refer to the manufacturing sector only. Figure 4.2(B) presents the investment/sales ratio thus obtained. The investment-sales ratio increases over the period 1984-85 and even more sharply over the years 1988-89. The latter result is especially mirrored by the data in the sample (see figure 4.2(A) above).

Finally, table 4.1 details the composition by sectors (i.e. one-digit SIC industries) of the sample[12]. Almost 2/3 of the companies and of the observations in

[11] Investment or "Net Capital Expenditure" is defined as follows:
Net Capital Expenditure = value of new building work + (additions - disposals) of land and existing buildings + (additions - disposals) of vehicles + (additions - disposals) of plant and machinery.
Source is Business Monitor (Summary Tables). Data for sales are taken from the same source.

[12] See Appendix 4C for the definition of sectors.

the sample belong to the manufacturing sector (industries 2, 3 and 4). Just above 1/4 of the companies and observations come from the commercial services (sector 6). Construction companies account for about 6% of the data, while just a few companies belong to the extraction industry and to the public services.

§4.3.2 **Investment performance in unionised and non-unionised companies**

This section provides some basic statistics relating to the comparison of investment performance in unionised and non-unionised companies. For the sake of consistency the comparison is carried out for the subsample of companies which did not undergo a change of union status (recognition or derecognition, partial or complete) over the period of interest.

Figure 4.4 compares the median of the investment-sales ratio year by year in unionised companies (i.e. companies recognising at least one union for the purpose of wage bargaining) and non-unionised companies (i.e. companies not recognising any union) across all sectors. It is readily seen that apart from one year (1988) figures are higher for non-unionised companies. A similar result is obtained using the mean (figures are not reported).

Figure 4.5 provides a disaggregation by sector of the results by looking at the comparison of investment performance for Services. As expected, (unreported) figures for manufacturing mirror the findings in figure 4.4. On the other hand, no clear-cut conclusion on the comparison of investment performance between unionised and non-unionised companies can be drawn from figure 4.5 which refers to Services.

In the evaluation of these results it is important to notice that the large majority of the companies in the manufacturing sector are unionised while the reverse is true in the Services (see for more on this issue table 5.2 in chapter 5).

§4.3.3 **Union density and investment**

The results in the previous subsection seem to provide some evidence for a gap in investment propensity between unionised and non-unionised companies at least for the manufacturing sector. This section further investigates whether there is any additional evidence of an effect of union density on investment performance. Annual union density figures are not available for all companies in the sample. Hence a sub-sample of the unionised companies dealt with in subsestion 4.3.2 is taken[13]. Data again refer to companies that did not experience a change in union status during the eighties.

Table 4.2 shows that union density conditional on recognition (weighted by company employment) in the whole sample declines slowly but steadily (from 62.1 % in 1982 to 58 % in 1988) with a big final jump in 1989[14] [15]. The same results are

[13]Non-unionised companies are not taken into account even when figures for density are available. This is consistent with the fact that the analysis concentrates on the effects of unions on investment through wage bargaining. Without recognition, i.e. without explicit wage bargaining, it is difficult to see how unions can affect the firm's investment decision.

displayed by the unweighted mean and by the median. The table also shows that the decline in union density is accompanied across the years by an increase in the investment-sales ratio irrespective of whether the median or the mean is looked at. The last year of the sample makes an exception (but see footnote 15).

Table 4.3 provides figures for union density and investment in manufacturing. The comments made above still apply. It can also be noticed that, as expected, union density is higher in manufacturing than in the rest of the sample.

The findings of table 4.2 and 4.3 raise the question of whether investment performance is affected by the degree of unionisation as measured by union density at the cross-section level. As a matter of fact, it is particularly interesting to assess whether there is evidence that heavily unionised companies have a different (worse) investment performance with respect to less unionised companies. This is carried out by splitting the sub-sample of unionised companies between firms with union density above and below 70 %[16].

Figures 4.6(A) and 4.6(B), which refer to the median and mean respectively, show some evidence of a better performance for less unionised companies especially if the mean is looked at, but no sign of uniform superiority.

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[14] This jump could be partially accounted for by the sharp reduction in the number of companies available in the sample for 1989.

[15] In the period 1982-89 union density (= total union memebership / wage earners and salaried employees) in the U.K. has fallen from 54.1 to 44.8 % (source: Employment Gazette (1991, 338) and Census of Employment). For a survey on the determinants of the fall see Mason-Bain (1993).

[16] Results do not markedly vary if the threshold is changed.

The results are confirmed, as expected, for the manufacturing sector (figures are not reported).

The information available in the industrial relations dataset can be additionally exploited in order to assess the relationship between the degree of unionisation and investment performance. Managers interviewed in the NIESR survey were asked to assess whether according to their own judgement union strentgh in their companies had increased, decreased or had undergone no change during the eigthies[17]. As mentioned above, the question was actually spelled out with separate reference to the periods 1980-84 and 1985-89. Table 4.4 compares investment performance (in terms of median of the variable INV) in companies that experienced no change in union strentgh, as assessed by their managers, during the eighties and in companies that experienced declining union strentgh. Two alternative definitions of "union declining strength" are employed (see DOWN(1) and DOWN(2)[18] in table 4.4). There is no evidence of a relationship between decreased union strength and increased investment. The results for the mean (not reported here) corroborate this conclusion.

[17]The question was asked only to managers whose companies were recognising unions at the end of the period.

[18]According to definition DOWN(1) in table 4.4 union strength is declining if:
a) union strength was assessed as declining by managers for both periods 1980-1984 and 1985-89, or
b) union strength was assessed as declining in the period 1980-84, but unchanged over the period 1985-89.
According to DOWN(2) union strength is declining if one of the two cases in DOWN(1) happens or if
c) union strength was assessed as unchanged in 1980-84, but declining in 1985-89.

Similarly, while some managers were not able to exactly pinpoint the yearly figures of union density in their companies during the eighties, they could assess whether union density was decreasing, increasing or stable over the periods 1980-84 and 1985-89. This information is exploited in table 4.5 to look for evidence of a relationship between decline in membership and investment performance[19]. No such outcome seems to arise. Indeed, some evidence points to a better performance for companies with unchanged union density.

§4.3.4 **Analysis of correlation**

This section is mainly concerned with the analysis of correlations between the main variables available in the dataset. Definitions and sources for these variables are provided in Appendix 4B. Table 4.6 presents correlation matrices for the whole sample of companies (table 4.6(A), 2148 observations[20]) and the following sub-samples:

- companies with unchanged union status during the Eighties (table 4.6(B), 1764 observations);
- unionised companies, i.e. recognising unions (table 4.6(C), 1057 observations);

[19] In table 4.5 union membership is declining if one of the following has happened over the two sub-periods 1980-84 and 1985-89:
a) union density was declining in both periods;
b) union density was declining in the period 1980-84, but was unchanged in the period 1985-89;
c) union density was unchanged during the period 1980-84, but was declining over the period 1985-89.
On the other hand density was stationary if there was no change in both periods.
As a consequence of the above definition of declining membership, the main stress in the interpretation of the results should be on the period 1985-89.

[20] In table 4.6(A) all companies are used irrespective of whether changes in union status took place in the period.

- non-unionised companies (table 4.6(D), 707 observations)[21];

- unionised companies with unchanged union status whose annual union density figures are known (table 4.6(E), 811 observations).

Some evidence exists, as expected, for a positive correlation between profitability[22] and investment: The sample correlation coefficient, r, is between .16 and .21 in the tables. On the other hand wages (in levels) and investment-sales ratios are inversely related with values of r ranging between -.08 and -.11 over the different samples. The sign of the correlation coefficient, although very small, accords with the expectations of the theory.

Profits, in turn, appear to be positively correlated with the liquidity position of the company as described by the Cash-Liability ratio (variable CLR), with r taking values between .3 and .36. There is also a positive linkage between profits and wages that may be claimed as evidence of rent-sharing, but the value of the correlation coefficient in the whole sample and in the subsample of companies with unchanged union status masks two opposite scenarios for unionised and non-unionised companies. For the unionised companies there is evidence of a positive correlation between wages and profits (r=.21 in table 4.6(C)), while for non-unionised companies the sign of the relationship is reversed (r=-.05 in table 4.6(D)).

The positive relationship between wages (in levels) and sales is also sensitive

[21]Data in in tables 4.6(C) and 4.6(D) refer only to companies whose union status has not changed.

[22]Profit is defined as (before tax profits/sales).

to the union status of the company, the correlation coefficient being .24 for unionised companies (table 4.6(C)), but a mere .03 for non-unionised companies[23] (table 4.6(D)).

The results in table 4.6 show that sales (in levels) are very strongly correlated with total employment (r is always around .9). Finally table 4.6(E) shows that the correlation of union density with wage levels and investment performance has the expected sign but it is almost not noticeable (r=.08 and r=-.07, respectively).

Table 4.7 mirrors the contents of the tables above but including now annual wage growth and annual sales growth among the variables[24]. As a consequence the sample size is reduced. The comments made above for table 4.6 still apply in the reduced sample and the following can be added. There is evidence of a positive link between sales growth and propensity to invest (r ranges between .19 and .32 in table 4.7). On the other hand, the coefficient of correlation between wage growth and investment is always negative, but extremely small (between -0.4 and -.12). Finally, there is no evidence of positive association between union density and wage growth (r=-.02 in table 4.7 (E))

[23] The correlation coefficient between wage level and company size, where the latter is proxied by total employment, is .08 for unionised companies and -.07 for nou-unionised companies.

[24] These two variables are used in the econometric analysis of chapter 5.

4.4 CONCLUSIONS

This chapter has provided a description of the data used in the empirical analysis. The appealing feature of these data is that information on investment at the company level is matched with information on unionisation at the same disaggregation level. Moreover, data are not restricted to a cross-section.

The method used to obtain a measure of investment from account data has been outlined. Some descriptive statistics have been provided which show that the data are representative of the pattern of investment and unionisation in the U.K. economy in the period. The data have also been used to give some basic statistics on the (year by year) comparison between unionised and non-unionised firms as well as across recognised companies with different extent of unionisation. These simple exercises seem to point to a better performance for non-unionised companies over recognised. On the other hand, the results do not give any precise result when it comes to comparisons within unionised companies (see results for levels and changes of union density or union strength as perceived by companies' managers). A more accurate analysis will be carried in the next chapter applying panel data techniques to a sub-sample of the data used in this chapter.

FIGURE 4.1

INVESTMENT-SALES RATIO (WHOLE SAMPLE)

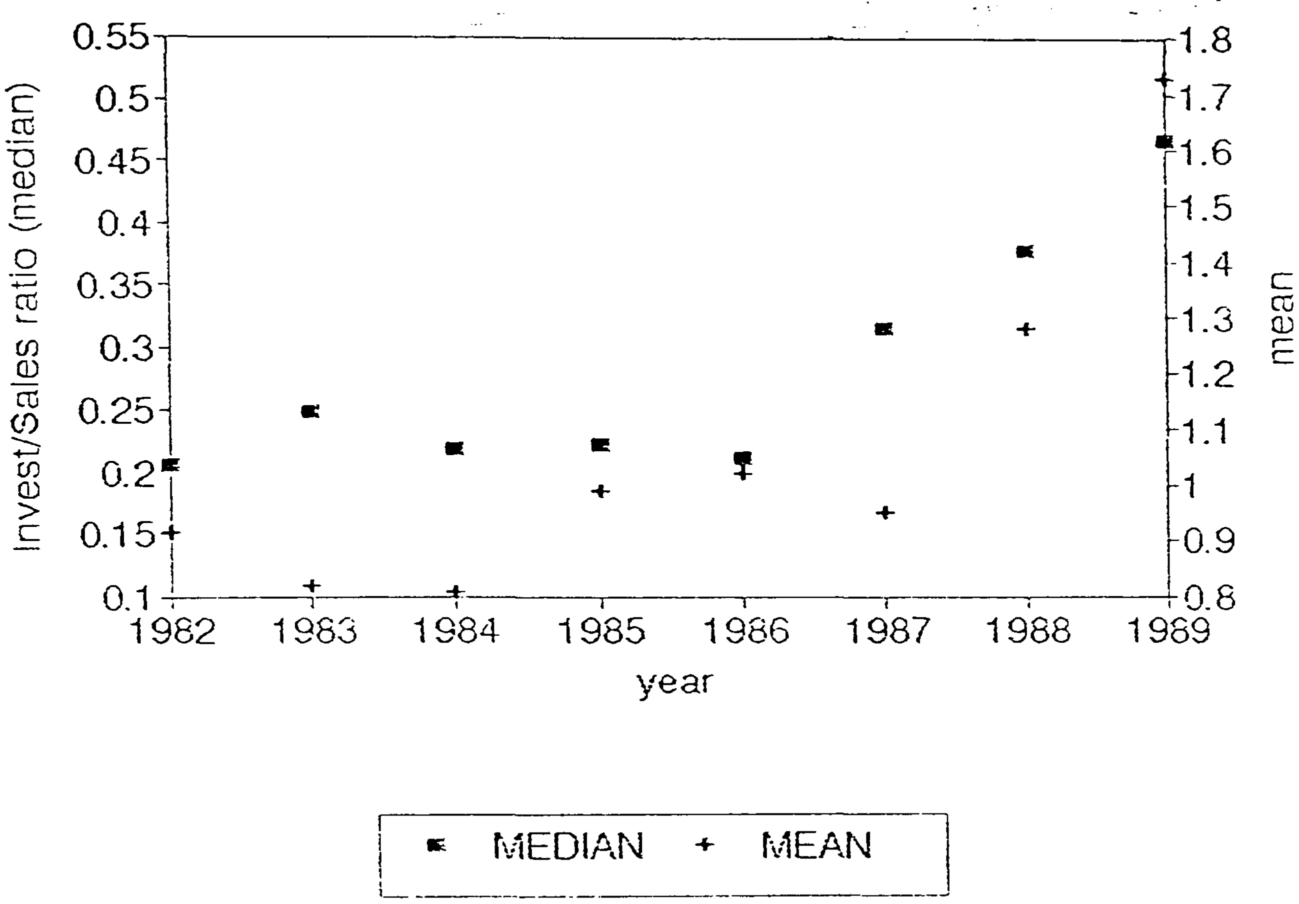

FIGURE 4.2(A)

INVESTMENT-SALES RATIO (MANUFACTURING)

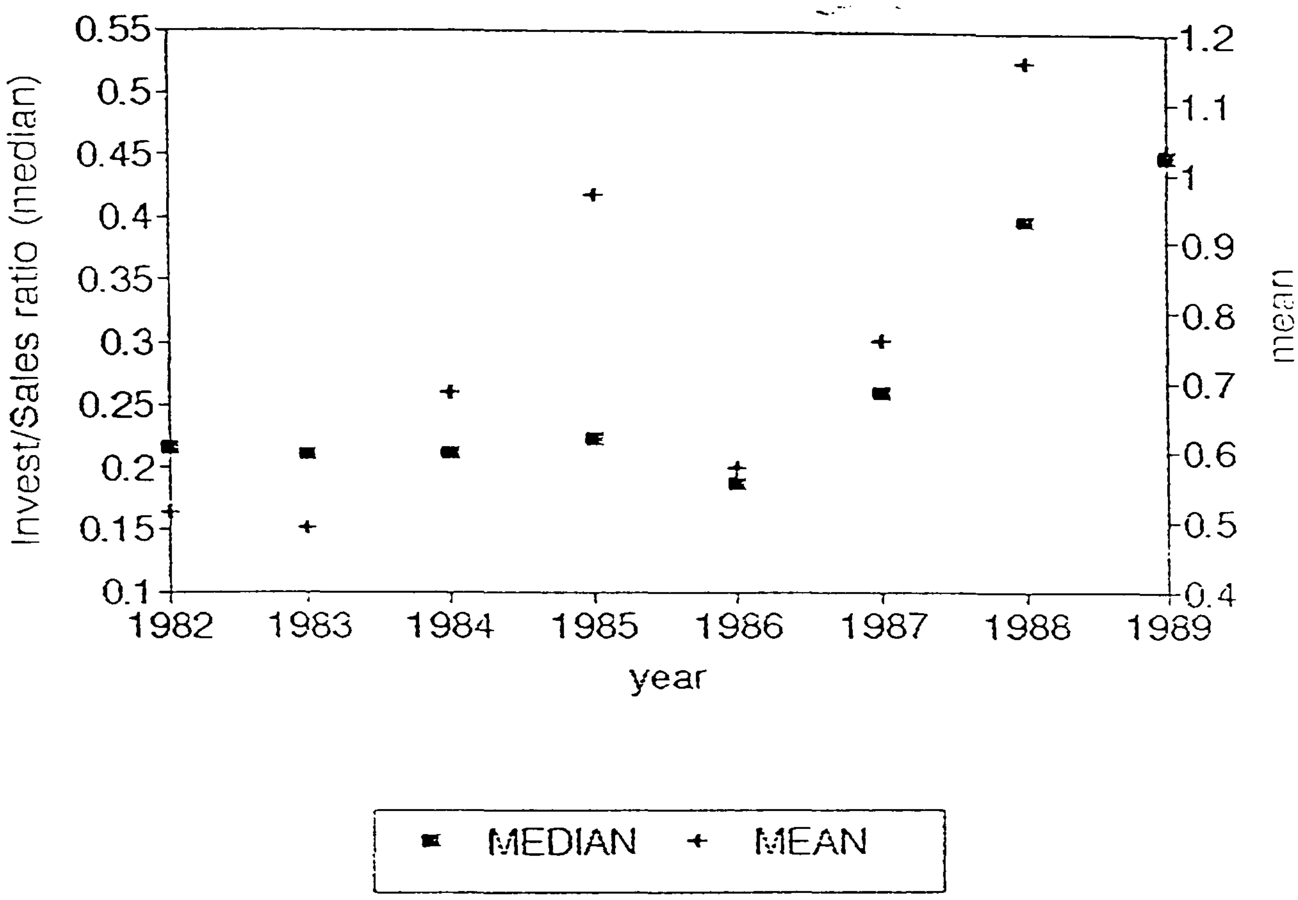

FIGURE 4.2(B)

INVESTMENT-SALES RATIO IN MANUFACTURING

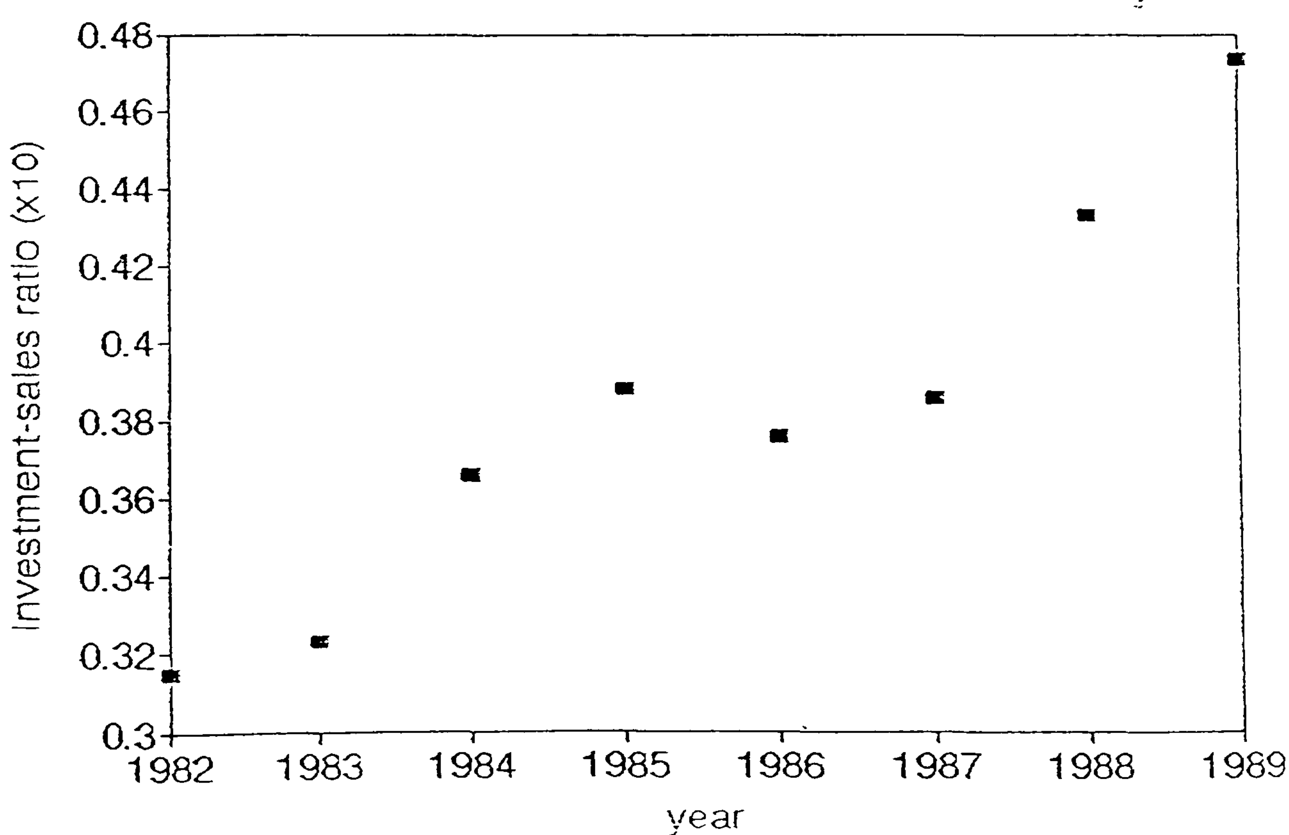

FIGURE 4.3

INVESTMENT-SALES RATIO (SERVICES)

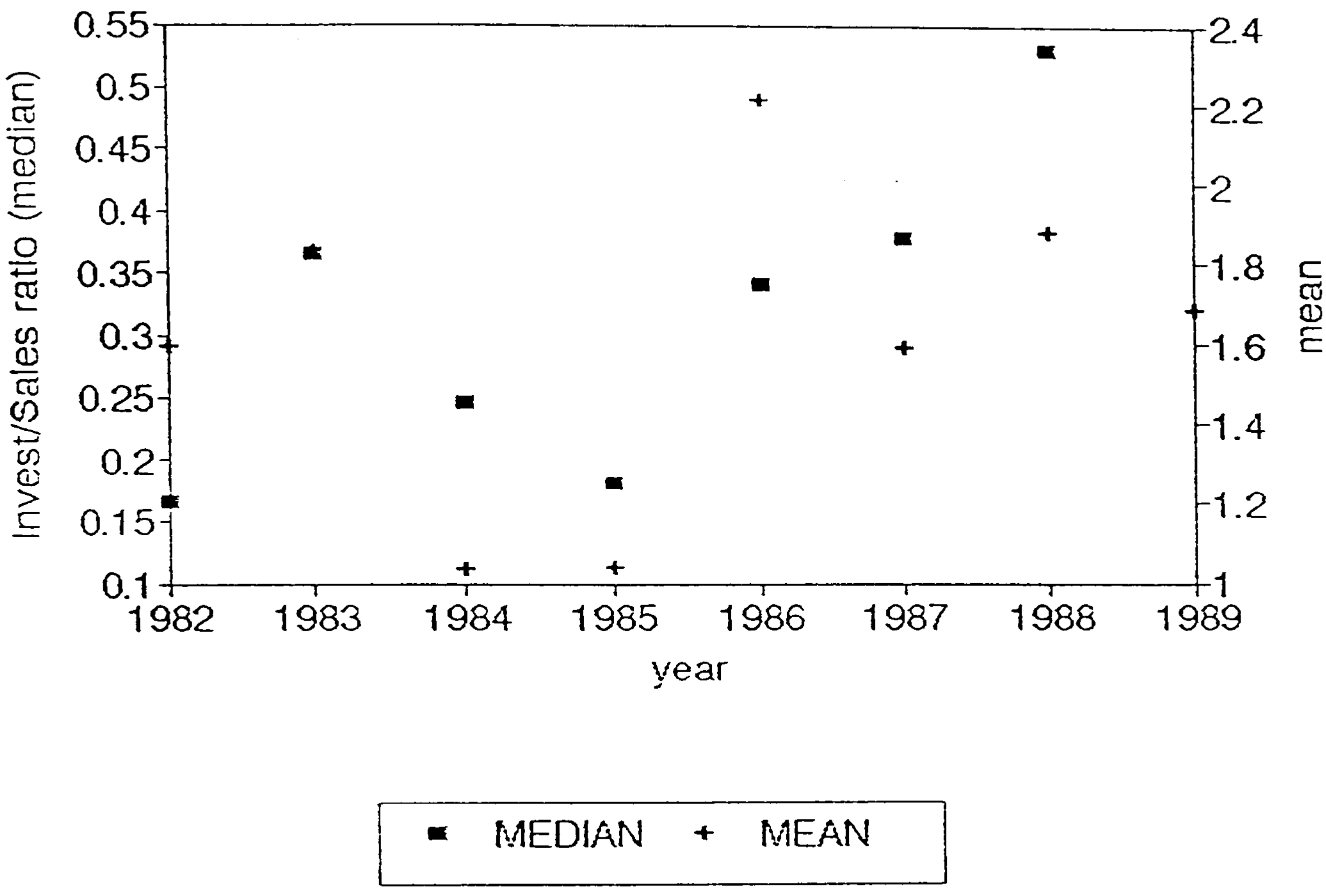

FIGURE 4.4
COMPARISON OF INVESTMENT PERFORMANCE

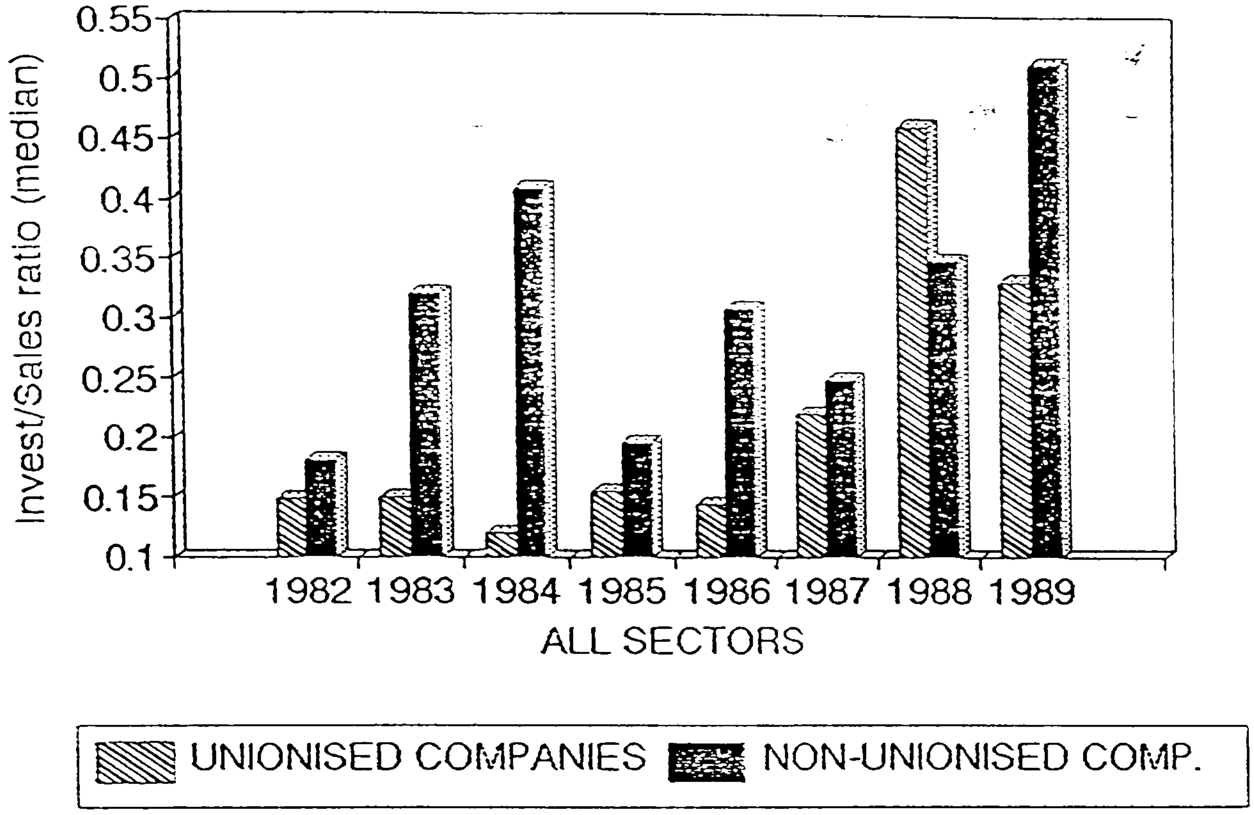

FIGURE 4.5
COMPARISON OF INVESTMENT PERFORMANCE

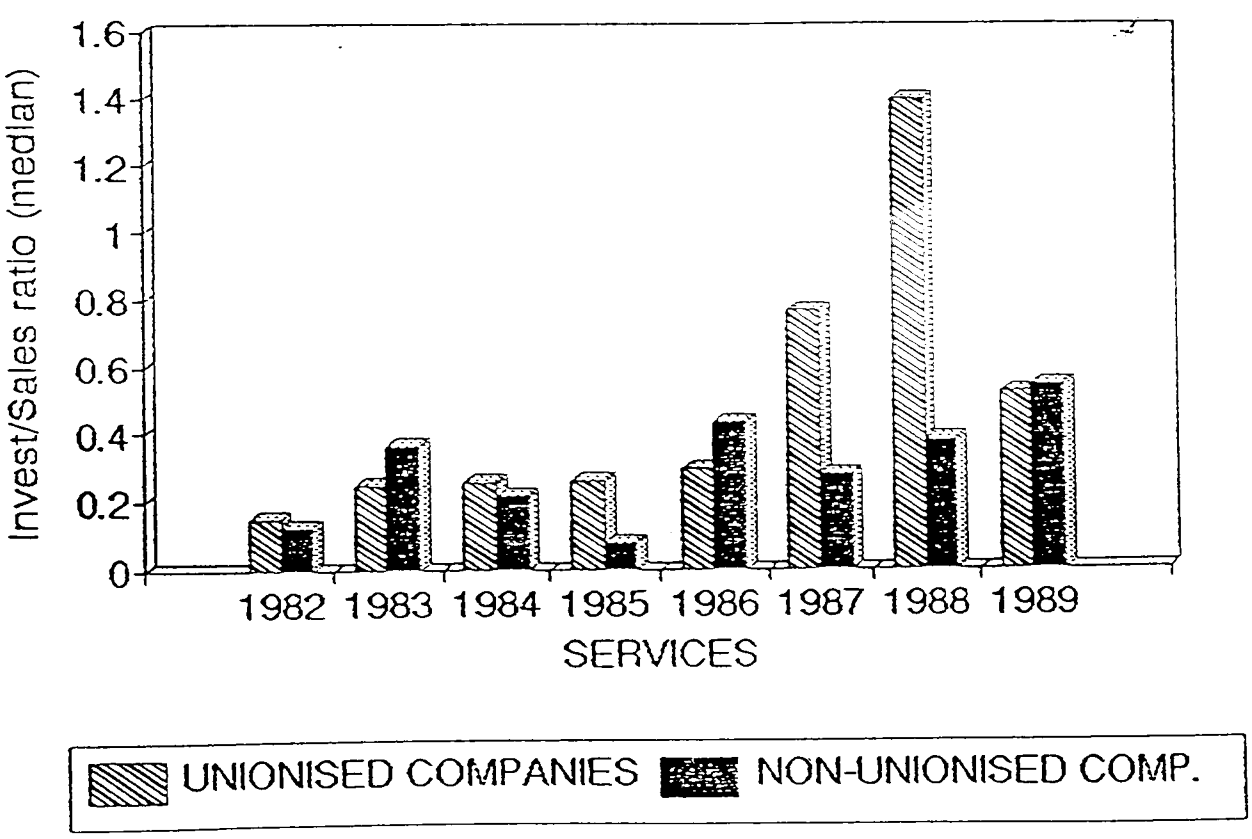

FIGURE 4.6(A)
COMPARISON OF INVESTMENT PERFORMANCE

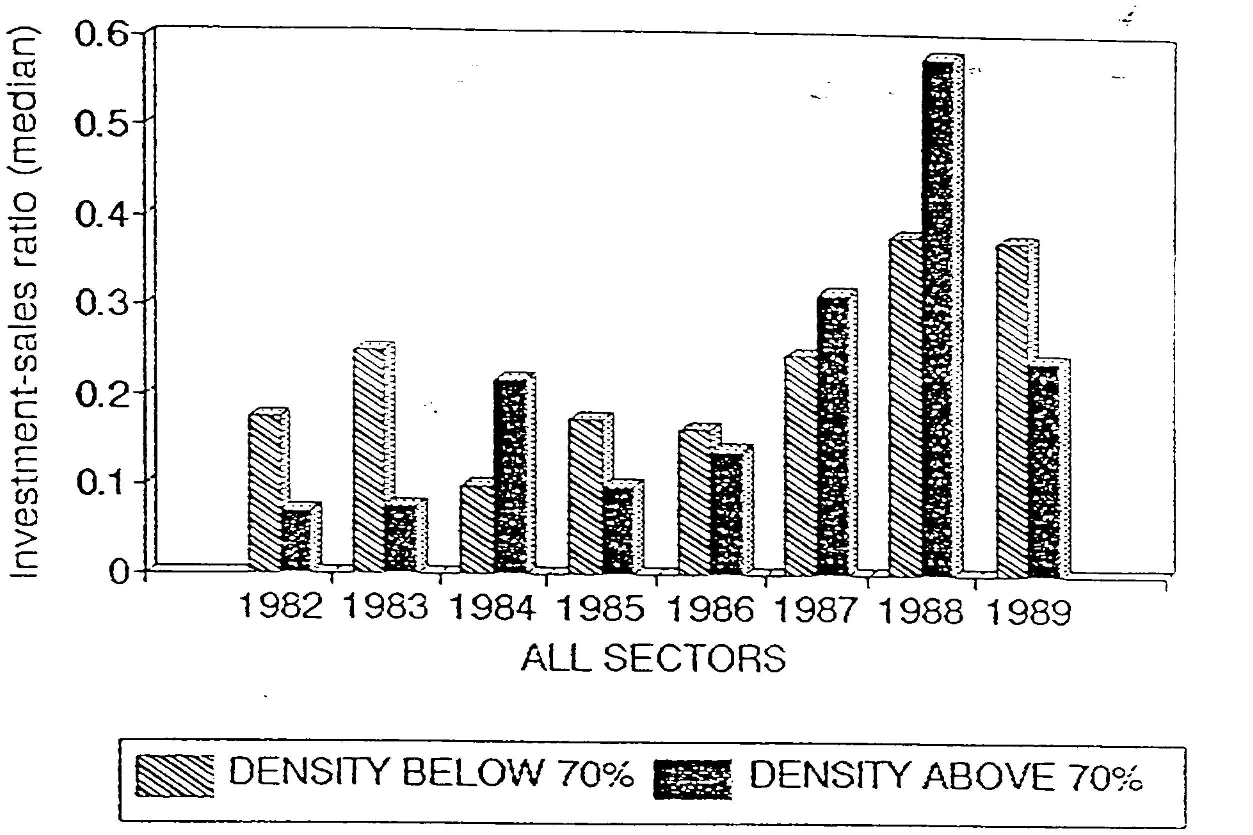

FIGURE 4.6(B)
COMPARISON OF INVESTMENT PERFORMANCE

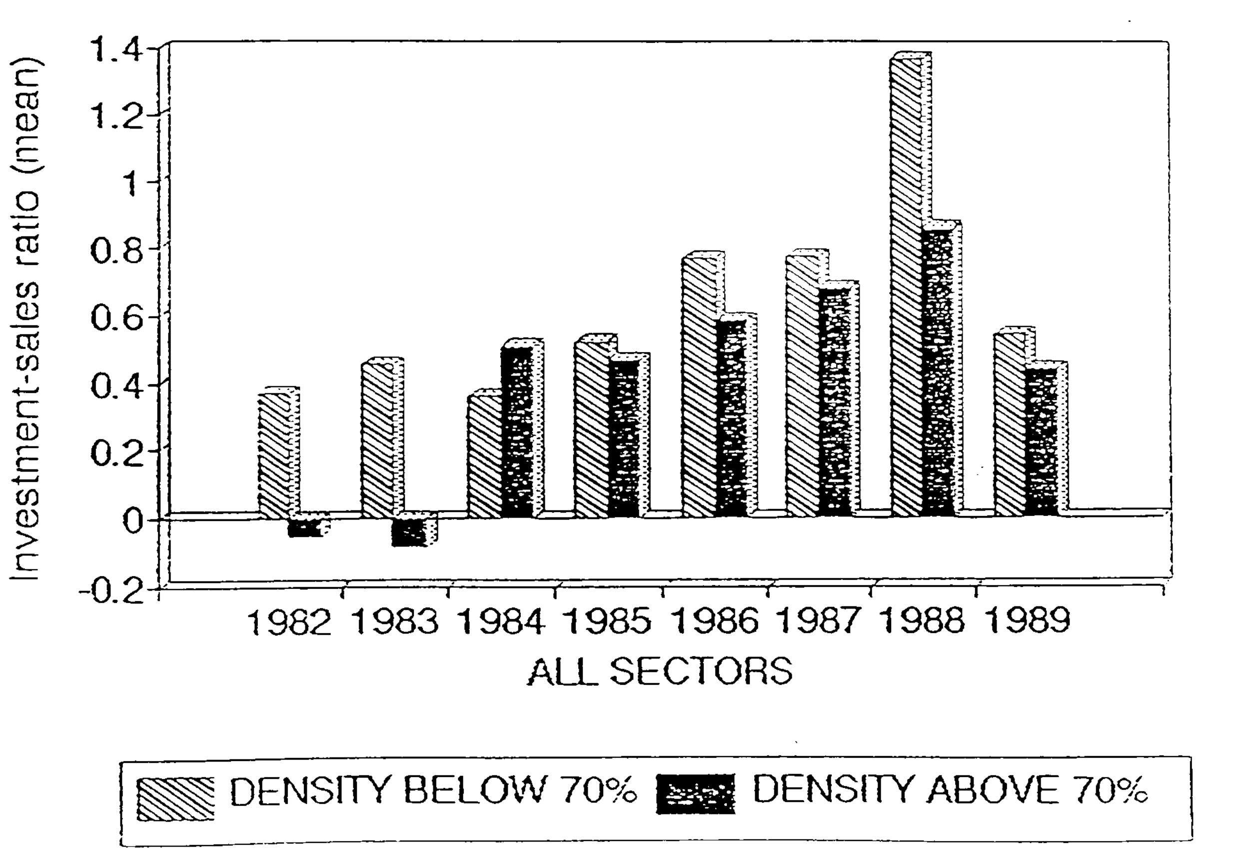

TABLE 4.1

DISTRIBUTION OF COMPANIES AND OBSERVATIONS BY SECTOR (ONE-DIGIT SIC INDUSTRY)

SIC sector	1	2	3	4	MANUFACT. (2+3+4)	5	6	7	total
companies	5	38	85	106	229	25	100	6	365
observations	31	248	501	608	1357	147	576	37	2148

TABLE 4.2

UNION DENSITY AND INVESTMENT PERFORMANCE
ALL SECTORS (sample size = 811)

year	cases	UNION DENSITY weighted mean	unweighted mean	median	INVESTMENT/SALES RATIO median	mean
1982	75	62.1	62.1	70.0	0.100	0.156
1983	95	61.2	59.2	67.0	0.107	0.206
1984	100	60.6	58.0	65.0	0.110	0.427
1985	113	60.3	58.0	65.0	0.164	0.506
1986	115	59.3	58.1	64.0	0.161	0.694
1987	116	58.4	58.7	65.0	0.281	0.737
1988	119	58.1	57.7	63.0	0.486	1.161
1989	78	54.2	53.0	58.5	0.282	0.507

TABLE 4.3

UNION DENSITY AND INVESTMENT PERFORMANCE
MANUFACTURING

year	cases	UNION DENSITY weighted mean	unweighted mean	median	INVESTMENT/SALES RATIO median	mean
1982	58	64.6	69.6	71.5	0.091	0.187
1983	76	64.9	64.8	70.0	0.094	0.181
1984	80	63.0	63.1	69.0	0.105	0.458
1985	91	62.8	62.8	68.0	0.174	0.549
1986	94	62.0	62.3	67.3	0.153	0.709
1987	96	61.1	62.6	65.0	0.218	0.580
1988	98	60.7	61.7	65.0	0.470	1.175
1989	63	57.5	58.6	61.0	0.322	0.496

TABLE 4.4

COMPARISON OF INVESTMENT PERFORMANCE IN COMPANIES WITH DECLINING VS. UNCHANGED UNION STRENGTH (MEDIAN)

year	no change	cases	down(1)	cases	down(2)	cases
1982	0.169	26	0.276	30	0.347	51
1983	0.178	32	0.209	38	0.160	64
1984	0.137	36	0.104	42	0.110	67
1985	0.375	34	0.017	43	0.125	73
1986	0.237	38	0.050	40	0.066	71
1987	0.247	35	0.212	42	0.291	78
1988	0.586	38	0.340	45	0.427	77
1989	0.242	23	0.454	28	0.392	49

Note: see footnote 19 for definition of DOWN(1) and DOWN(2)

TABLE 4.5

COMPARISON OF INVESTMENT PERFORMANCE IN COMPANIES WITH DECLINING VS. UNCHANGED UNION DENSITY

year	no change	cases	decreased density	cases
1982	0.127	47	0.433	27
1983	0.107	55	0.148	38
1984	0.128	59	0.109	39
1985	0.219	59	0.263	40
1986	0.127	60	0.141	39
1987	0.359	60	0.348	43
1988	0.511	62	0.423	46
1989	0.336	38	0.188	30

Note: see footnote 20 for the definition of decreased density

TABLE 4.6

CORRELATION MATRICES

A: TOTAL SAMPLE (sample size = 2148)

	INV	PROFIT	SALES	WAGE	TOTEMP	DER	CLR
INV	1.00						
PROFIT	0.16	1.00					
SALES	-0.01	0.13	1.00				
WAGE	-0.09	0.10	0.08	1.00			
TOTEMP	0.00	0.14	0.90	-0.05	1.00		
DER	0.00	-0.01	0.00	0.03	0.00	1.00	
CLR	0.03	0.30	0.02	0.06	0.04	-0.02	1.00

B: SAMPLE WITH NO CHANGES IN UNION STATUS (sample size = 1764)

	INV	PROFIT	SALES	WAGE	TOTEMP	DER	CLR
INV	1.00						
PROFIT	0.20	1.00					
SALES	0.00	0.09	1.00				
WAGE	-0.10	0.08	0.16	1.00			
TOTEMP	0.01	0.08	0.89	0.02	1.00		
DER	0.01	-0.01	0.00	0.03	0.00	1.00	
CLR	-0.00	0.34	-0.01	0.05	-0.01	-0.02	1.00

C: SAMPLE WITH NO CHANGES IN UNION STATUS:UNIONISED COMPANIES (sample size = 1057)

	INV	PROFIT	SALES	WAGE	TOTEMP	DER	CLR
INV	1.00						
PROFIT	0.17	1.00					
SALES	0.00	0.11	1.00				
WAGE	-0.11	0.21	0.24	1.00			
TOTEMP	0.01	0.07	0.89	0.08	1.00		
DER	0.04	-0.05	0.10	0.07	0.10	1.00	
CLR	-0.02	0.36	-0.05	0.06	-0.06	-0.06	1.00

D: SAMPLE WITH NO CHANGES IN UNION STATUS:NON-UNIONISED COMPANIES (sample size = 707)

	INV	PROFIT	SALES	WAGE	TOTEMP	DER	CLR
INV	1.00						
PROFIT	0.25	1.00					
SALES	0.01	0.07	1.00				
WAGE	-0.10	-0.05	0.03	1.00			
TOTEMP	0.04	0.12	0.91	-0.08	1.00		
DER	0.00	-0.01	-0.01	0.03	-0.00	1.00	
CLR	0.03	0.31	0.09	0.04	0.08	-0.02	1.00

E: SAMPLE WITH NO CHANGES IN UNION STATUS AND UNION DENSITY FIGURES AVAILABLE (sample = 811)

	INV	PROFIT	SALES	WAGE	TOTEMP	DENSITY	DER	CLR
INV	1.00							
PROFIT	0.21	1.00						
SALES	0.00	0.13	1.00					
WAGE	-0.09	0.22	0.29	1.00				
TOTEMP	0.01	0.10	0.90	0.16	1.00			
DENSITY	-0.08	-0.07	-0.01	0.08	0.01	1.00		
DER	0.11	-0.04	0.15	0.13	0.15	-0.07	1.00	
CLR	0.01	0.36	0.05	0.03	-0.07	0.02	-0.05	1.00

TABLE 4.7

CORRELATION MATRICES
(including variables WAGEGR and SALESGR)

A: TOTAL SAMPLE (sample size = 1900)

	INV	PROFIT	SALES	WAGE	TOTEMP	WAGEGR	SALESGR	DER	CLR
INV	1.00								
PROFIT	0.16	1.00							
SALES	-0.01	0.13	1.00						
WAGE	-0.09	0.07	0.06	1.00					
TOTEMP	0.00	0.14	0.90	-0.07	1.00				
WAGEGR	-0.06	0.01	-0.02	0.14	-0.03	1.00			
SALESGR	0.34	0.23	-0.05	0.00	-0.06	0.03	1.00		
DER	0.03	-0.07	0.10	0.03	0.09	-0.02	0.03	1.00	
CLR	0.03	0.30	0.02	0.03	0.04	0.01	0.01	-0.06	1.00

B: SAMPLE WITH NO CHANGES IN UNION STATUS (sample size = 1560)

	INV	PROFIT	SALES	WAGE	TOTEMP	WAGEGR	SALESGR	DER	CLR
INV	1.00								
PROFIT	0.20	1.00							
SALES	-0.00	0.09	1.00						
WAGE	-0.11	0.06	0.15	1.00					
TOTEMP	0.01	0.08	0.90	0.01	1.00				
WAGEGR	-0.08	0.00	-0.00	0.12	-0.01	1.00			
SALESGR	0.35	0.26	-0.03	-0.01	-0.05	0.01	1.00		
DER	0.03	-0.08	0.07	0.04	0.08	-0.02	0.02	1.00	
CLR	-0.01	0.34	-0.01	0.04	-0.01	-0.00	0.00	-0.06	1.00

C: SAMPLE WITH NO CHANGES IN UNION STATUS: UNIONISED COMPANIES (sample size = 931)

	INV	PROFIT	SALES	WAGE	TOTEMP	WAGEGR	SALESGR	DER	CLR
INV	1.00								
PROFIT	0.17	1.00							
SALES	-0.00	0.11	1.00						
WAGE	-0.13	0.19	0.23	1.00					
TOTEMP	0.01	0.07	0.90	0.07	1.00				
WAGEGR	-0.10	0.01	-0.02	0.04	-0.02	1.00			
SALESGR	0.48	0.20	-0.03	-0.02	-0.04	0.08	1.00		
DER	0.04	-0.05	0.09	0.06	0.09	-0.03	0.06	1.00	
CLR	-0.02	0.37	-0.05	0.05	-0.06	0.02	0.01	-0.06	1.00

D: SAMPLE WITH NO CHANGES IN UNION STATUS: NON-UNIONISED COMPANIES (sample size = 629)

	INV	PROFIT	SALES	WAGE	TOTEMP	WAGEGR	SALESGR	DER	CLR
INV	1.00								
PROFIT	0.27	1.00							
SALES	0.01	0.07	1.00						
WAGE	-0.09	-0.07	0.01	1.00					
TOTEMP	0.05	0.12	0.90	-0.09	1.00				
WAGEGR	-0.04	-0.01	0.31	0.20	0.02	1.00			
SALESGR	0.22	0.32	0.00	-0.02	-0.03	-0.04	1.00		
DER	0.02	-0.11	0.04	0.01	0.06	-0.01	-0.02	1.00	
CLR	0.01	0.31	0.09	0.03	0.08	-0.03	0.00	-0.06	1.00

E: SAMPLE WITH NO CHANGES IN UNION STATUS AND UNION DENSITY FIGURES AVAILABLE (sample size = 720)

	INV	PROFIT	SALES	WAGE	TOTEMP	WAGEGR	SALESGR	DENSITY	DER	CLR
INV	1.00									
PROFIT	0.22	1.00								
SALES	-0.01	0.12	1.00							
WAGE	-0.12	0.20	0.29	1.00						
TOTEMP	0.01	0.09	0.90	0.15	1.00					
WAGEGR	-0.12	-0.01	-0.02	0.03	-0.01	1.00				
SALESGR	0.25	0.21	-0.04	0.01	-0.04	0.08	1.00			
DENSITY	-0.06	-0.06	-0.01	0.10	0.02	-0.02	-0.02	1.00		
DER	0.12	-0.04	0.15	0.13	0.15	-0.06	0.04	-0.08	1.00	
CLR	0.01	0.37	-0.05	0.01	-0.07	0.02	0.03	0.01	-0.05	1.00

APPENDIX 4A

DEFINITION AND CONSTRUCTION OF THE INVESTMENT VARIABLE

The empirical analysis presented in chapters 4 and 5 is based on data on gross investment[1] at its replacement value. This measure of investment has been computed using information from the Exstat databank. This appendix describes how the investment variable has been constructed on the basis of the technique described in Wadhwani and Wall (1986).

When accounting data are used to construct a measure of investment, it appears inappropriate to compute investment simply by subtracting disposals (and related items) from additions (and related items) to the capital stock. The problem that arises is that both additions and disposals are recorded at their historical cost. As far as additions are concerned this cost can be regarded as the market price at current values. Disposals, on the other side, are recorded at the cost incurred in the past and this creates a problem, in the presence of inflation, if there is no knowledge of the year/s they refer to. As a result, the computation of an investment measure at replacement cost requires some adjustments to the accounting data, based on assumptions on the average life of capital assets. The adjusted level of investment at

[1] It is acknowledged that, while a gross investment measure is employed in the empirical analysis, the theoretical model presented in Appendix 5A deals, as is the case with Van der Ploeg (1987) and Denny and Nickell (1992), with net investment. It should also be mentioned that the distinction between net and gross investment does not seem to have attracted enough attention in the existing literature. Denny and Nickell, for instance, do not clarify in their data appendix, whether net or gross investment is employed in the empirical analysis.

current values at time t, I_t^C, is defined as (see Wadhwani and Wall (1986, 48-50))

$$(4A.1) \qquad I_t^C \equiv (AD_t + NSC_t) - (DISP_t + SDISP_t) \cdot \frac{P_t}{P_{t-A}}$$

where

AD_t= additions during period t

NSC_t= capital stock of new subsidiary companies acquired during period t

$DISP_t$= disposals during period t

$SDISP_t$= capital stock of subsidiary companies disposed of during period t

P_t= price of assets at time t

A= average life of assets

The variables AD_t, NSC_t, $DISP_t$, and $SDISP_t$ in (4A.1) are available in the company account data information provided by the Exstat dataset (Exstat items CC3, CC5, CC4, and CC6 respectively[2]). The price of capital (= P_t) has been computed using indices for the cost of capital at the industry level[3] (mostly 2-digit SIC industries). As far as the average life of assets, A, is concerned, Wadhwani and Wall stress (1986, 48) that there are many ways to approximate it. The following definition has been adopted in the construction of the investment measure (life of assets is measured in years[4]):

$$(4A.2) \qquad A = \frac{1}{T} \sum_{t=1}^{T} \left(\frac{PADA_t}{PDCYR_t} \right)$$

[2]Other movements in property (Exstat item CC9) have been treated as additions (if positive) or disposals (if negative).

[3]The source for this variable is Price Indices For Current Cost Accounting (PINCCA, Business Monitor Series).

[4]The limited information available on the price of capital imposes an upper bound of six years on the average life of capital.

where

$PADA_t$ = accumulated depreciation on property at time t,

$PDCYR_t$ = current year property depreciation,

and T is the number of observations available for each company[5].

PADA and PDCYR are also available in the Exstat dataset (items C85 and CC19, respectively).

On the basis of (4A.1) Investment at replacement value at costant prices, I_t, is defined as[6]

$$\text{(4A.3)} \qquad I_t \equiv I_t^C \cdot \frac{P_0}{P_t} \equiv (AD_t + NSC_t) \cdot \frac{P_0}{P_t} - (DISP_t + SDISP_t) \cdot \frac{P_0}{P_{t-A}}$$

with the base year (0) being 1980.

The final step is to define the investment-sales ratio employed in chapters 4 and 5, i.e.

$$\text{(4A.4)} \qquad INV_t \equiv \frac{I_t}{Sales_t} \cdot 100$$

with Sales at constant prices (producer price deflator from British Business).

---

[5] The assumption behind the definition of A is that, given the short time horizon considered, the average life of capital does not vary considerably from year to year. Wadhwani and Wall instead have $A_t = \frac{PADA_t}{PDCYR_t}$.

[6] The "correction" for disposals in the formula reported in Wadhwani and Wall (1986, 50) should read $\frac{P_0}{P_{t-A}}$ instead of $\frac{P_t}{P_{t-A}}$.

APPENDIX 4B

DEFINITION OF VARIABLES

INV = Investment / Sales (*100) at the company level. Sales are from Exstat dataset (see below). Investment computed according to the Wadhwani and Wall technique (see Appendix 4A).

SALES = Current value of sales (from Exstat, C31) at the company level.

SALESGR = Annual percentage growth of sales. Source as for Sales.

TOTEMP = Total employment at the company level. Source is Exstat (C19).

WAGE = Per capita average wage at the company level. Wage is defined as the ratio of total labour costs (from Exstat, C63) over total employment.

WAGEGR = Annual percentage growth of per capita average wage. Source as for Wage.

PROFIT = Pre Tax Profit / Sales at the company level. Source for profit is Exstat (C34).

DENSITY = Union density (percentage) at the company level. Source is NIESR survey.

CLR = Cash - Liabilities ratio at the company level (from Exstat, C111 and C158).

DER = Debt - Equity ratio at the company level (from Exstat). Debt is defined as Loan stock of parent company (C138) + Loan stock of subsidiary companies (C139) + Other loans (C141) + Bank loans and overdrafts (C148). Equity as Ordinary capital (C123) + Deferred capital (C124) - Deferred tax (C134).

CAPPGR = Annual percentage growth of the cost of capital at the industry level (mostly two-digit SIC sectors). Computed from Price Indices for Current Cost Accounting.

APPENDIX 4C

DEFINITION OF ONE-DIGIT S.I.C. SECTORS

Sector 1: Energy and water industries.

Sector 2: Extraction of minerals and ores other than fuels, manufacture of metals, mineral products and chemicals.

Sector 3: Metal goods, engineering, and vehicle industries.

Sector 4: Other manufacturing industries (including food, drink and tobacco, textile and clothing industries, paper and plastics industries).

Sector 5: Construction

Sector 6: Commercial services and distribution

Sector 7: Public utilities.

APPENDIX 4C

DESCRIPTIVE STATISTICS

WHOLE SAMPLE (n=2148)

Vars.	Mean	St.Dev.	Min	Max
INV	1.06	4.91	-27.45	124.90
PROFIT(x10)	0.65	0.75	-7.43	6.21
SALES	345730	1052200	1173.00	13170000
WAGE	10.09	3.63	2.61	28.54
TOTEMP	6647	20703	26	242700
DER	1.07	18.37	0.00	847.00
CLR	0.14	0.23	0.00	2.20

SAMPLE WITH NO CHANGES IN UNION STATUS (n=1764)

Vars.	Mean	St.Dev.	Min	Max
INV	0.93	4.22	-27.45	109.10
PROFIT(x10)	0.61	0.73	-7.43	6.21
SALES	253040	873500	1173	13170000
WAGE	10.27	3.59	2.61	28.54
TOTEMP	4113.6	12331	26	133800
DER	1.13	20.26	0.00	847.00
CLR	0.14	0.23	0.00	2.20

SAMPLE WITH NO CHANGES IN UNION STATUS
UNIONISED COMPANIES (n=1057)

Vars.	Mean	St.Dev.	Min	Max
INV	0.74	4.49	-15.26	109.10
PROFIT(x10)	0.59	0.66	-7.43	2.92
SALES	302500	1014800	1451	13170000
WAGE	10.01	3.38	2.61	25.87
TOTEMP	5404	13765	52	133800
DER	0.64	1.93	0.00	38.37
CLR	0.14	0.23	0.00	2.20

SAMPLE WITH NO CHANGES IN UNION STATUS
NON-UNIONISED COMPANIES (n=707)

Vars.	Mean	St.Dev.	Min	Max
INV	1.22	3.76	-27.45	52.48
PROFIT(x10)	0.63	0.82	-4.23	6.21
SALES	175070	595760	1173	5949000
WAGE	10.67	3.86	2.95	28.54
TOTEMP	2148.40	9490.70	26.00	84150.00
DER	1.86	31.91	0.00	847.00
CLR	0.13	0.24	0.00	1.87

SAMPLE WITH NO CHANGES IN UNION STATUS
AND UNION DENSITY AVAILABLE (n=811)

Vars.	Mean	St.Dev.	Min	Max
INV	0.59	2.76	-15.26	40.94
PROFIT(x10)	0.58	0.68	-7.43	2.92
SALES	300050	1097100	1472	13170000
WAGE	10.17	3.51	2.61	25.87
TOTEMP	4933.8	13910	5.2	133800
DENSITY	58.13	28.05	0.50	100.00
DER	0.55	1.50	0.00	25.05
CLR	0.14	0.24	0.00	2.20

DESCRIPTIVE STATISTICS
(including variables WAGEGR and SALESGR)

WHOLE SAMPLE (n=1900)

Vars.	Mean	St.Dev.	Min	Max
INV	1.03	4.90	-27.45	124.90
PROFIT(x10)	0.67	0.74	-7.43	6.21
SALES	3565620	1094800	1173	13170000
WAGE	10.41	3.63	2.61	28.54
TOTEMP	6862.3	21068	26	242700
WAGEGR	8.40	10.20	-34.71	105.80
SALESGR	16.04	26.88	-90.49	280.20
DER	0.67	1.96	0.00	38.37
CLR	0.14	0.24	0.00	2.20

SAMPLE WITH NO CHANGES IN UNION STATUS (n=1560)

Vars.	Mean	St.Dev.	Min	Max
INV	0.86	4.10	-27.45	109.10
PROFIT(x10)	0.62	0.73	-7.43	6.21
SALES	268830	919470	1173	13170000
WAGE	10.59	3.58	2.61	28.54
TOTEMP	4226.4	12791	26	133800
WAGEGR	8.46	10.24	-34.71	105.80
SALESGR	16.26	27.36	-90.49	280.20
DER	0.66	2.11	0.00	38.37
CLR	0.14	0.24	0.00	2.20

SAMPLE WITH NO CHANGES IN UNION STATUS
UNIONISED COMPANIES (n=931)

Vars.	Mean	St.Dev.	Min	Max
INV	0.74	4.61	-15.26	109.10
PROFIT(x10)	0.62	0.66	-7.43	2.92
SALES	326940	1074500	1451	13170000
WAGE	10.36	3.35	2.61	25.87
TOTEMP	5570.3	14378	57	133800
WAGEGR	8.51	9.58	-34.71	90.51
SALESGR	12.34	21.79	-41.32	280.20
DQR	0.66	2.04	0.00	38.37
DLR	0.15	0.24	0.00	2.20

SAMPLE WITH NO CHANGES IN UNION STATUS
NON-UNIONISED COMPANIES (n=629)

Vars.	Mean	St.Dev.	Min	Max
INV	1.13	3.19	-27.45	28.74
PROFIT(x10)	0.64	0.82	-4.23	6.21
SALES	182830	613740	1173	5949000
WAGE	10.94	3.87	3.20	28.54
TOTEMP	2237.20	9665.40	26.00	84150.00
WAGEGR	8.39	11.15	-25.95	105.80
SALESGR	22.07	33.14	-90.49	239.50
DER	0.65	2.22	0.00	33.48
CLR	0.13	0.24	0.00	1.87

SAMPLE WITH NO CHANGES IN UNION STATUS
AND UNION DENSITY FIGURES AVAILABLE (n=720)

Vars.	Mean	St.Dev.	Min	Max
INV	0.57	2.63	-15.26	40.94
PROFIT(x10)	0.60	0.69	-7.43	2.92
SALES	320690	1159000	1472	13170000
WAGE	10.48	3.49	2.61	25.87
TOTEMP	5067.2	14527	57	133800
WAGEGR	8.18	9.01	-34.71	76.70
SALESGR	11.45	18.63	-41.32	185.70
DENSITY	57.69	27.95	0.50	100.00
DER	0.56	1.57	0.00	25.05
CLR	0.15	0.25	0.00	2.20

CHAPTER 5

THE EFFECT OF UNIONS ON INVESTMENT FOR BRITISH COMPANIES

AN ECONOMETRIC ANALYSIS

5.1 INTRODUCTION

The main result of the theoretical models presented in chapters 2 and 3 can be summarised as follows. If a firm bargains over the wage with a labour union in an oligopolistic product market, then, *ceteris paribus*, the firm's ability to adopt a new, more productive technology is likely to be impaired. This negative result is more evident, the stronger the union bargaining power and the more firm specific the technology to be adopted by the firm. The result, while being subject to some important qualifications (see chapters 2 and 3), confirms, in a more general setting, the findings from Grout (1984), namely, the effectiveness of the union rent-seeking mechanism.

The purpose of this chapter is to provide an econometric analysis of the effects of unionisation on the propensity to invest for a sample of U.K. quoted companies during the eighties. The nature of the data allows an accurate analysis of the predictions stemming from the theoretical models. Some caveats, though, about the relationship between the theoretical and the empirical analysis are in order.

The theoretical models in chapters 2 and 3 deal with the (discrete) choice of adoption of a new technology, while the empirical analysis refers to investment performance. The numerical results in section 3.3 have shown the extent to which the main findings obtained from the adoption models extend to a (static) model of determination of continuous capital. Moreover, the empirical model of investment with adjustment costs and wage bargaining employed in this chapter (see Appendix 5A), based on Denny and Nickell (1992), shares the basic feature of the adoption models of chapters 2 and 3.

As far as the comparative statics properties of the models in chapters 2 and 3 are concerned, most of the analysis concentrated on determining the effect of changes in union bargaining power in one of the two firms (or in both) competing in the product market on the choice of adoption of a newly introduced technology (or on the choice of the optimal quantity of capital, as in section 3.3). As such, the main result summarised above could be restated as follows: If union bargaining power increases, then, *ceteris paribus*, less investment is undertaken in equilibrium (or a new technology might now not be adopted which would have been before). Hence a proper or "direct test" of this prediction would involve analysing fims' investment performance against some "measure" of union bargaining power.

Although some attempts have been made to "measure" union bargaining power on the basis of the first order conditions of the Nash bargaining problem by making suitable assumptions on the properties of the bargaining process between the firm and the union (see, particularly, McDonald and Suen (1992)), these efforts do not seem convincing. As a consequence, the route taken in section 5.4 and elsewhere in the chapter is to focus on the straight comparison, as far as investment performance is concerned, between unionised companies, i.e. companies where a union (or more than one) is recognised for the purpose of wage bargaining, and non-unionised companies. The empirical analysis then builds upon the information available in the NIESR dataset to provide a more accurate account of the impact of additional industrial relations conditions on investment. To this purpose the companies in the sample have been divided in two groups: Those that have experienced some changes in union status during the period of interest and those that have not. In sections 5.4 to 5.8 only the latter are utilised in estimation[1]. The complete sample including companies affected by changes is then used in section 5.9.

The first issue addressed by the analysis is whether there is a significant "long-run" effect of union presence, i.e. union recognition for the purpose of wage bargaining, on investment performance when controlling for the variables suggested by the empirical model of Appendix 5A. In this basic case union and industrial relations conditions are entirely captured by the existence of one (or more than one) recognised union[2] at the company level (section 5.4).

There is an increasing interest in the literature for the role of product market considerations in shaping the ability of unions to push up wages, and more generally, affect the performance of the firm. This issue appears of particular

[1]The descriptive statistics for recognised firms presented in chapter 4 also refer mainly to the subset of companies that have experienced no changes in union status. These basic statistics are briefly reassessed in section 5.3 to take also into account some workforce composition indicators not analysed in chapter 4. The list of variables used in the regression analysis is presented in Appendix 5C.

[2]An additional distinction will be also considered between companies where all establishments have recognised unions and companies where recognition is not complete. The issue of the effects of multiunionism is, instead, not tackled.

relevance here because of the explicit oligopolistic nature of the product market in the theoretical model. The data supplied by the NIESR provide detailed information for the analysis of the extent of the effects of product market competition on investment performance (section 5.5). Therefore the robustness of the findings of section 5.4 can be ascertained. The data refer to "static" competition, i.e. the number of rival firms at the time the survey was carried out, as well as "dynamic" competition, i.e. the changes in domestic and foreign competition faced by each company during the period of interest.

Union recognition alone represents a partial picture of the industrial relations conditions in a given company. It is therefore of interest to determine whether the results obtained are affected by the consideration of additional elements. Two features of industrial relations are specifically taken into account:

a) The extent of unionisation at the company level, as measured by union density (section 5.6);

b) The existence of closed shop schemes at the company level (section 5.7).

The existing empirical literature for the U.K. suggests that the latter has no appreciable effect on investment and/or innovation performance[3]. As far as union density is concerned, no clear-cut findings are available, although Denny and Nickell (1992) show that if a union is recognised than it benefits investment to have a high union density. It should also be noticed that where the previous remark about union

[3] See the survey in section 1.7.

bargaining power is of the utmost relevance is in the interpretation of the results involving union density conditional on recognition. In accordance with the non-cooperative theory of wage bargaining, union density cannot be thought of as a "proxy" or determinant of union bargaining power. Indeed, by determining the inside option for the firm in the event of a strike, union density contributes, together with union bargaining power itself, to determine the wage outcome (see the model in section 1.5). This is the stance taken in chapter 1. Accordingly, the results on the effects of union density on investment performance presented in section 5.6 should not be interpreted as providing the "direct test", i.e. in terms of union bargaining power, of the predictions mentioned above. It is to be remarked, though, that the opposite view could be supported should the cooperative approach to bargaining theory be accepted (with the ancillary assumption that union density alone is a valid proxy for union barganing power[4]).

The next step of the analysis is to include in the sample also the companies that have experienced some changes in union status during the eighties in order to provide a more exhaustive picture (section 5.9). The most interesting issue here is to determine whether there is a significant "short-run" impact on investment performance arising from derecognition (either partial or complete) which is most usually the form taken by changes in union status during the period. The extent of derecognition in the sample is by no means large, but still sufficient to carry out an

[4]See Svejnar (1986) on the issue of determining explanatory variables for union power inside the cooperative approach.

accurate statistic analysis of its effects. The issue of the impact of changes in union status on the propensity to invest of U.K. companies is of clear relevance for the evaluation of the new industrial relations policies introduced by the British governments during the eighties.

Finally, it should also be noticed that the theoretical models presented in chapters 2 and 3 deal exclusively with the effect of unions on innovation and investment performance through wage bargaining. In section 1.8 this channel has been labelled as the "indirect effect" of unionisation to be distinguished from the ability of unions to directly affect innovation and investment, for instance via workers' resistance to technical progress or other similar mechanisms which impose direct costs on the adoption of new technologies or capital equipment. For example, union power can be thought to affect the adjustment costs for the installation of new capital. The distinction between direct effects and effects through the wage is a relevant issue for the estimation process. A quantitative assessment of the direct and indirect union effects will be carried out in section 5.10. The main findings are summarised in section 5.11.

5.2 THE INVESTMENT EQUATION

A formal model of investment from which the estimated equations are derived is presented in Appendix 5A. The model follows Denny and Nickell (1992).

A standard intertemporal optimising decision over investment in the presence of adjustment cost is coupled with period by period wage bargaining between the firm and the union modelled according to the Generalised Nash Bargaining Solution in a Right-to-Manage framework. The formal analysis of the model is developed in Appendix 5A. In the absence of strong guidance from the theory linear approximations are taken and the following empirical investment equation is derived[5] (leaving aside the concern with union variables for a moment):

$$\mathrm{INV}_{it} = \alpha_i + \beta_1 \cdot \mathrm{SALESGR}_{it} + \beta_2 \cdot \mathrm{WAGEGR}_{it} + \beta_3 \cdot \mathrm{PROFIT}_{it} + \\ + \beta_4 \cdot \mathrm{EMPLOYMENT}_{it} + \beta_5 \cdot \mathrm{PCAP}_{it} + \beta_6 \cdot \mathrm{DLR}_{it} + \beta_7 \cdot \mathrm{DQR}_{it} \qquad (5.1)$$

(subscript i refers to companies)

Where, as introduced in the previous chapter,

INV = Investment-Sales ratio (x100)

WAGEGR = Annual percentage growth of per capita average wages.

SALESGR = Annual percentage growth of sales (using current values)

PROFIT = Pre tax profit/Sales

EMPLOYMENT = Total employment at the company level

PCAP = Price (index) of capital

[5] Financial indicators, i.e. the debt/equity and the cash/liabilities ratios, are added to the equation derived from the formal model.

CLR = Cash - Liabilities Ratio

DER = Debt - Equity ratio

All variables but PCAP[6] are defined at the company level. The α's are company specific effects.

This represents a very standard approach to modelling investment (see in addition to Denny and Nickell (1992), Machin and Wadhwani (1991b), Hirsch (1990, 1992), Urga (1991)).

In equation (5.1) the growth of sales and the profit variable are meant to capture the demand side, with profits being also relevant for the financing of new capital equipment. The growth of labour cost is captured by the wage variable. Once again it is stressed that the wage in the data is defined as the ratio between total labour costs and the number of employees, hence it is not the same as the bargained wage. The role of the employment variable is mainly to control for size effects. Finally, variables related to the financial situation of the company are also included in the equation[7].

The questionnaire set up by the NIESR includes also information on the

[6]Regression results presented below do not include PCAP, an industry level price of capital and investment index computed using the Price Indices for Current Cost Accounting (PINCCA), whose coefficient is always statistically not significant.

[7]Sources for all these variables have been given in Appendix 4B. See Appendix 5C for the definition of all the variables involved in the regression analysis for whom data are reported in this chapter. In section 4.2 it was also pointed out that a measure of the capital stock at the beginning of the period is not available (see the discussion about the application of the Wadwhani and Wall (1986) technique). It should also be recalled that as a result of the same technique some entries for the investment variable are negative (see descriptive statistics in the same chapter).

composition and characteristics of the workforce. This information proves very valuable for the analysis of investment performance because it can be reasonably assumed that workforce composition is related to the type of technologies employed by the firms. More specifically, the following indicators can be obtained:

PTIM = Percentage of part-time employees in the company's total workforce. Part-timers are defined as employees working less than 30 hours a week.

SKIL = Percentage of skilled manual employees. These are defined in the questionnaire as workers who require special training, involving formal certificates or qualification recognised by many employers as appropriate to their work.

NMAN = Percentage of non-manual employees, i.e. employees involved in clerical, administrative, secretarial, supervisory, professional or managerial tasks.

FEM = Percentage of female workers.

Only time varying variables at the company level have been analysed in the descriptive statistics presented above.

Unlike all the variables appearing in equation (5.1), only the values at the time the questionnaire was carried out (July 1990) are known for the workforce composition indicators[8]. Moreover, the inclusion of the workforce composition variables involves a reduction in the sample with respect to the data used for the analysis of the descriptive statistics in the previous chapter, since for a set of companies information is not available for some or, mostly, all of the four variables

[8] Hence no question was asked about the changes in the composition of the workforce during the eighties.

defined above.

For the sake of the understanding of the estimation techniques used below it is important to stress again the different nature of the workforce composition variables with respect to the regressors appearing in equation (5.1). The former are end of period values and, as such, these regressors are time invariant within each company. The latter are in contrast time varying[9].

5.3 THE DATA: A REASSESSMENT

Before proceeding to the econometric analysis, this section is aimed at providing some basic information and descriptive statistics, especially for the workforce composition variables, also in light of the change in the sample size with respect to the previous chapter.

As in chapter 4 the starting sample will include all the companies that did not experience any change in union status (i.e. partial or complete move towards derecognition, or conversely, towards recognition). Once companies are deleted because of the lack of information on workforce characteristics, the sample comprises 253 companies with 1322 observations over the period 1983-89[10]. This is

[9]But see below for some comments on the financial measures CLR and DER.

[10]One (unionised) company has been additionally deleted from the sample at this stage because of the unreliability of its investment/sales entries which proved to be suspiciously too high (all the values were far higher than 1) and such as to distort the statistical properties of the sample (the coefficient of skewness was 3.83 without this company and 13.91 when the company was included).

the sample used in the first set of estimations in section 5.4. The rest of this section provides some descriptive statistics with a particular emphasis on the analysis of workforce composition that has not been covered in the previous chapter.

Table 5.1 provides the distribution of the firms in the sample by the number of time periods available (with a minimum of 2 to a maximum of 7 observations)[11]. More than half the companies (138 out of 253) have 6 or 7 available observations. Table 5.2 gives the distribution of the companies by SIC sectors (see Appendix 4C for the definition of the sectors). Out of 253 companies, 162 belonged to the manufacturing sector (SIC sectors 2, 3 and 4), with sector 4 (including the food, drink, tobacco, textile, chothing and paper industries) being the most heavily represented. Some 28 % of the companies belonged to the commercial services sector (sector 6). Table 5.2 also provides information on the number of companies recognising a union (or more than one) for the purpose of wage bargaining. This information is also disaggregated by sector in the same table.

About 56% of the companies are unionised. The percentage in the manufacturing sector is around 64 %, with unionisation reaching 3/4 of the available companies in sectors 2 and 4, whereas only about 28% of the companies in the commercial services sector are unionised.

From the questionnaire carried out by the NIESR, it is also possible to

[11]Records of observations need not be continuous over the years (see section 4.2).

determine the number of companies recognising unions in all establishments, and not only in some (this variable is labelled RECALL in subsequent regressions.) Recognition is complete, in the sense now specified, in about 56 % of the unionised companies (see table 5.2), with the ratio being close to 1/2 in every sector, with the exception of sector 4, where it is about 2/3.

Tables 5.3, 5.4 and 5.5 present basic descriptive statistics for the variables involved in the estimated equations. Table 5.3 shows some basic statistics for the workforce composition and unionisation variables. These represent the time invariant, but company specific, variables used in the estimation process. The statistics in table 5.3 refer to the group values (253 cases are used), while tables 5.4 and 5.5 give results based on the pooling of all observations (1322 cases are used). The results differ, but only slightly, because of the unbalanced nature of the panel.

The results on unionisation in table 5.3 simply repeat the findings discussed above. As far as the composition of the workforce is concerned, the mean (across companies) of the incidence of part-time workers out of the total workforce is about 5 %[12]. The means for non manual, skilled and female workers are 46, 31, and 18 %, respectively. It can also be shown that, as expected, part-timers and non-manual workers are more easily found in the commercial services (with means of 9.5 and 54.5%, respectively), while the incidence of skilled workers does not differ much across manufacturing and services (these statistics are not reported).

[12] The table reports means not weighted by company employment levels.

Table 5.3(A) also highlights a feature which will be relevant in the estimation process. While non manual and female workers are represented in every company's workforce (minimum is 1 % for both), there are some companies that do not employ any part-timers and some companies that do not employ any skilled workers. This subset of companies proves to be substantial. This can be checked by looking at the statistics for PTYES and SKILYES. These two variables are dummies taking a value of 1 if the company was employing some part-time or skilled workers respectively (i.e. if PTIM>0 and SKIL>0). It is easily seen from table 5.3(A) that 1/4 of the companies do not employ any part-timers, and almost 15 % do not employ any skilled workers.

Table 5.3(B) gives the correlation matrix for the workforce composition variables. The proportion of female workers is positively correlated with the percentage of part-timers, as would be expected, and with the percentage of non manual workers, while being negatively related to the presence of skilled employees. There is also evidence of a negative correlation between skilled and non manual workers.

To complete this analysis means for unionised and non-unionised companies are reported in table 5.3(C). As far as workforce composition variables are concerned, unionised companies appear to employ relatively more skilled workers, and less female and non manual workers, while no striking difference appears as far as part-time workers are concerned.

Finally, two other dummy variables are added to the data. The rationale for this is the fact that both financial variables present a substantial grouping of observations around zero. As a consequence the following variables are defined:

DCLR= 1 if CLR > 0, 0 otherwise

DDER = 1 if DER >0, 0 otherwise.

As table 5.4 shows, the Debt-Equity ratio (DER) has a value of zero for nearly 40% of the observations. The correspondent figure for the Cash- Liabilities ratio (CLR) is above 25 %. It should also be noticed that, unlike PTYES and SKILYES[13], DCLR and DDER are not necessarily time invariant at the company level.

5.4 THE EFFECT OF UNION RECOGNITION ON THE PROPENSITY TO INVEST

The results presented in this section, as well as in sections 5.5 to 5.8, refer to the sample of companies that did not experience any change in union status (in the sense introduced above) during the eighties. The basic estimated equation can be summed up as follows

$$\mathrm{INV}_{it} = \alpha_i + \beta \cdot \mathrm{X}_{it} + \gamma \cdot \mathrm{Z}_i + \delta \cdot \mathrm{U}_i \qquad (5.2)$$

[13] And indeed unlike all variables whose statistics are reported in table 5.3(A).

where, as pointed out in section 5.2,

X = (SALESGR, WAGEGR, PROFIT, EMPLOYMENT, DCLR, CLR, DDER, DER)

represents the set of time varying (at the company level) explanatory variables, and

Z = (PTYES, PTIM, SKILYES, SKIL, NMAN, FEM)

represents the set of workforce composition indicators. They are company specific as well, but time invariant (they are end of period values or related dummies). Finally, U will refer to unionisation measures (union recognition, the variable REC, to start with), all defined at the company level. Hence equation (5.2) adds the following set of regressors to equation (5.1) presented in section 5.2:

a)dummies for financial indicators (DCLR and DDER),

b) workforce composition indicators (the regressors in Z),

c) unionisation measures (U).

As a reference point for the ensuing analysis table 5.6 presents the estimation results from equation (5.2) omitting any unionisation regressor. Results are provided for the estimated equation without sector dummies first (first and second columns), and then with dummies (third and fourth columns)[14]. Sectors are defined as one-digit SIC aggregations (see above and appendix 4C). More on the issue of industry dummies will follow later.

The coefficients in table 5.6 are obtained according to two alternative

[14]Coefficients for industry dummies are not reported in the tables.

estimation techniques:

(1) OLS on the pooled data without group dummy variables. This is labelled OLS in the tables.

(2) Feasible GLS estimates for the Random Effects Model. These are labelled as FGLS in the tables[15].

Appendix 5B gives technical details on the estimation procedures introduced above[16].

The choice of Random Effects panel data techniques stems from the inability to use fixed effects modelling, due to the presence of time invariant (within companies) regressors, i.e. all the regressors in Z, and, more importantly, most of the unionisation measures used in the analysis (recognition, above all).

The results in table 5.6 show quite vividly the positive effect of demand growth (as measured by company sales) as well as profitability on companies' propensity to invest. Since the dependent variable, INV, is defined as (investment/sales)x100, the investment-sales ratio increases by roughly .00018, *ceteris paribus*, when sales growth increases by one point[17]. This result entails that an acceleration of sales growth of one percentage point affects the investment-sales ratio by around 2.5 % of its value, when evaluated around the sample mean. On the

[15] The same pattern is followed throghout the chapter in the presentation of the results unless otherwise stated.

[16] A third estimation technique has been employed according to the suggestion in Hsiao (1986), see Appendix 5B. No results are reported for this technique.

[17] Figures from the FGLS estimates without sector dummies are used.

other hand, an increase of one point in profitability, measured as a percentage of sales, would increase the investment performance, as measured by INV, by .083, i.e. by around 1/10 of the investment/sales ratio when evaluated at the mean. Finally, an increase in wage costs affects investment negatively (and significantly) with roughly the same order of magnitude as for sales growth. No effect of size (as proxied by total employment) on the investment-sales ratio is detected.

As far as the financial variables are concerned the results show that the propensity to invest decreases as the cash/liabilities ratio (CLR) increases. On the other hand, a positive debt/equity ratio (cf. DDER) brings about higher investment, *ceteris paribus*, and this effect is positively dependent on the relative amount of debt (cf. DER).

As far as the workforce composition measures are concerned, it is easily seen that the propensity to invest is positively and significantly affected by the incidence of skilled workers among the employees. This result can be seen to favour the view that technologically advanced companies, as proxied by a high percentage of skilled workers, invest relatively more. The results for female workers and, especially, part-timers, seem, though, surprising when interpreted in a "technological" perspective. The coefficients for both categories of workers are positive and significant. No variable is available in the dataset to provide a more in depth analysis of these results. Finally, the percentage of non-manual workers does not affect in a noticeable way the propensity to invest.

Inspection of the results in table 5.6 suggests the two following remarkable features. First, switching from OLS to FGLS estimates generally brings about only a slight change in the magnitude of the coefficients. Second, the inclusion of sectoral dummies does not affect the sign and the size of the coefficients in a noticeable way. It will be seen that these remarks also apply to most of the rest of the analysis.

Unionisation is introduced into the picture by adding a recognition dummy (= REC) to the estimated equation. Results are presented in table 5.7. It is easily seen that the comments made above on the coefficients of the non-union variables still apply with the only modest exception of the female workers percentage which is now barely significant at the 10% level.

According to the results of table 5.7 investment as a percentage of sales is lowered by almost half of a point (.45), *ceteris paribus*, if companies recognise a union (or more than one). This result is not modified when sector dummies are included. The estimated coefficient for REC indicates a reduction of around 40% in the investment-sales ratio for unionised companies relative to the non-union mean. This negative union recognition effect is smaller than the raw union - non-union difference based on sample means (.62). At present no attempt is made to comment on the disaggregation of this result by sectors and across time. The reader is referred to section 5.8 for this analysis.

As pointed out in the previous section the dataset also contains information the results shown above. On the other hand, the route can be suggested of using the original three-digit values provided by the dataset. The trouble arising from this choice is that, as expected, the disaggregation turns out to be very fine with the drawback that for some cases industry dummies and company specific effects cannot be distinguished. This creates problems in the estimation process (the FGLS estimates cannot be obtained).

It has then been decided to try to strike a happy medium by grouping companies into two-digit SIC industries in such a way as to avoid the aforementioned problem and reach a suitable degree of disaggregation. This grouping procedure is obviously arbitrary, but it has been done to investigate the robustness of the estimation results presented above.

Table 5.9 presents the results when these two-digit dummies are included in the equation. The list of the actual two-digit industries employed is given in the note following the table. Coefficients for the dummies are not reported. The results must be compared with the findings of tables 5.7 and 5.8. Two interesting results can be noticed. First, the coefficient for recognition is now reduced (from around -0.45 to -0.35) and it is statistically significant at the 10 % (not 5 %) level. Second, the coefficients for both the incidence of female and part-time workers, which were deemed as surprising before, are now not statistically different from zero.

Inspection of the results in table 5.6 suggests the two following remarkable features. First, switching from OLS to FGLS estimates generally brings about only a slight change in the magnitude of the coefficients. Second, the inclusion of sectoral dummies does not affect the sign and the size of the coefficients in a noticeable way. It will be seen that these remarks also apply to most of the rest of the analysis.

Unionisation is introduced into the picture by adding a recognition dummy (= REC) to the estimated equation. Results are presented in table 5.7. It is easily seen that the comments made above on the coefficients of the non-union variables still apply with the only modest exception of the female workers percentage which is now barely significant at the 10% level.

According to the results of table 5.7 investment as a percentage of sales is lowered by almost half of a point (.45), *ceteris paribus*, if companies recognise a union (or more than one). This result is not modified when sector dummies are included. The estimated coefficient for REC indicates a reduction of around 40% in the investment-sales ratio for unionised companies relative to the non-union mean. This negative union recognition effect is smaller than the raw union - non-union difference based on sample means (.62). At present no attempt is made to comment on the disaggregation of this result by sectors and across time. The reader is referred to section 5.8 for this analysis.

As pointed out in the previous section the dataset also contains information the results shown above. On the other hand, the route can be suggested of using the original three-digit values provided by the dataset. The trouble arising from this choice is that, as expected, the disaggregation turns out to be very fine with the drawback that for some cases industry dummies and company specific effects cannot be distinguished. This creates problems in the estimation process (the FGLS estimates cannot be obtained).

It has then been decided to try to strike a happy medium by grouping companies into two-digit SIC industries in such a way as to avoid the aforementioned problem and reach a suitable degree of disaggregation. This grouping procedure is obviously arbitrary, but it has been done to investigate the robustness of the estimation results presented above.

Table 5.9 presents the results when these two-digit dummies are included in the equation. The list of the actual two-digit industries employed is given in the note following the table. Coefficients for the dummies are not reported. The results must be compared with the findings of tables 5.7 and 5.8. Two interesting results can be noticed. First, the coefficient for recognition is now reduced (from around -0.45 to -0.35) and it is statistically significant at the 10 % (not 5 %) level. Second, the coefficients for both the incidence of female and part-time workers, which were deemed as surprising before, are now not statistically different from zero.

5.5 UNIONISATION, PRODUCT MARKET CONDITIONS AND INVESTMENT PERFORMANCE

It has been suggested that a rigorous assessment of the impact of unionisation, or, more generally, industrial relations arrangements on firms' economic performance should incorporate some features relating to the product market conditions companies are faced with[19]. As far as union effects on wages are concerned, Stewart (1990) has stressed the relevance of the extent of product market competition in determining the ability of unions to raise wages. Stewart uses data from WIRS 1984 to show that unions are unable to achieve any wage premium, *ceteris paribus*, if the firm they face operates in a competitive product market[20]. Conversely if the firm has some degree of market power, the mean union (recognition) - non-union wage differential is, *ceteris paribus*, around 8-10 %[21]. Stewart also shows that when firms operate in international markets the ability of unions to raise wages is impaired. Finally, Machin (1991a) has stressed the relevance of product market conditions to the ability of unions to affect profitability.

When the U.K. experience of the eighties is looked at, some analysts have

[19] As Booth stresses (1994, 58), it has been customary in the analysis of union effects to assume perfectly competitive product markets as well as closed shop conditions. See Dowrick (1989) for a model of union-firm wage bargaining under oligopoly.

[20] Data refer to gross weekly pay for semi-skilled workers in the private sector.

[21] Mishel (1986, 103) using U.S. data concludes that "union wage gains are greater where entry barriers, concentrated markets and low import competition give employers discretionary power". But see Stewart (1990) for some limitations of Mishel's analysis.

pushed the relevance of product market competition to such extent to claim that product market conditions have completely outweighed unionisation arrangements as a key determinant of companies' performance and success in the period. This stance is taken by Brown and Wadhwani (1990). They claim that "there has been a tendency to exaggerate the impact of trade unions on both wages and employment" (Brown - Wadhwani (1990, 68)). Moreover they suggest that "it has been competitive pressure that has forced employers to act and the stance they have adopted towards their trade unions has been of secondary importance" in such a way that "the driving force has been increased product market competition ... which has obliged employers to put their own houses in order".

Gregg and Machin (1992) in their analysis of the impact of unionisation on wage growth during the eighties share the view that product market competition has been the foremost factor. They conclude that "the majority of firms which experienced negative relative wage growth effects are those that faced an intensification of competition through the 1980's" (Gregg and Machin (1992, 66)).

The purpose of this section is to assess the robustness of the findings on the effects of unionisation on companies' investment behaviour by drawing on the information on product market conditions available in the dataset. Two different pieces of information are considered.

1. Information on the product market situation (more specifically, the number of competitors) at the time the NIESR questionnaire was carried out. This is analysed

in subsection 5.5.1.

2. Information on the changes in the extent of competition from both domestic and foreign market rivals during the eighties. This is analysed in subsection 5.5.2.

§5.5.1 **The "Static" Analysis**

The NIESR dataset provides information about the number of direct competitors each company was facing in its major domestic product market (or markets). More precisely, it is known whether the company was facing more or less than five direct competitors, or no competitors at all. This information is available for all companies used in the previous section but one.

Table 5.10 shows the distribution of companies (and observations) in terms of the extent of competition. About 85% of the companies were faced by more than five direct domestic competitors. Conversely, only 5 companies out of 252 were operating in monopolistic conditions. The following two dummy variables have been constructed and added to equation (5.2). MONOP takes a value of 1 if the company faces no competitors. FEWCO takes a value of 1 if the company faces less than five competitors (including the case of no rivals). The aim is to assess whether the extent of (static) product market competition affects the propensity to invest. Results are reported in table 5.11.

There seems to be evidence that, *ceteris paribus*, companies facing a restricted competitive pressure fare better in terms of investment performance[22]. Again it is important to stress the limitation, in view of its static nature, of this indicator of product market conditions. The comments made above on the other regressors, and, particularly, on the sign and size of union recognition, still apply[23].

§5.5.2 **The "Dynamic" Analysis**

The dataset also provides information as to whether companies faced increased or decreased competition during the eighties in their major product markets from both domestic and foreign rivals. As for much of the available information[24], this question was spelled out with reference to two distinct time periods, namely 1980-84 and 1985-89. The sample size is restricted with respect to sub-section 5.5.1 because answers are not available for some companies[25].

Table 5.12(A) shows that the share of companies in the sample that experienced an increase in competition from domestic rivals went up from around 57 to 72 % moving from the first to the second half of the decade. This result stems from the percentage of companies unaffected by changes in competition falling from 35 to 20 % in the same periods, with the share of firms faced with decreased

[22]The coefficient for MONOP is not significant, but it should be taken into account that just a handful of companies fall in this category.

[23]Interactions between product market conditions and recognition have not proved significant and results are not reported.

[24]See particularly section 5.9.

[25]It should also be noticed that the question on domestic competition received more answers than the one on foreign competition. Hence the different sample size in the tables below.

competition being the same over time. It is also easily seen from table 5.12(A) that about half the companies experienced increased competition in both periods. Related results for changes in foreign competition are presented in table 5.12(B). These results mirror the ones for domestic competition with around half the companies experiencing an increase of rivalry during both periods and an increase in the percentage of companies faced by more foreign competition from 59 to 71 % over the two periods.

The information on the changes in the strength of competition over time has been added to the estimation analysis by defining the following new variables. UKCOUP takes a value of 1 for all the years a given company has experienced an increase in domestic competition, i.e. either the years 1983-84 or 1985-89 or both[26], if such change was experienced at all. UKCODO is defined by the same token for the case of decreased domestic competition. Definitions for increased and decreased foreign competition, FCOUP and FCODO respectively, follow the same pattern[27]. It is worthwhile noticing that these new regressors are not necessarily time invariant at the company level, since, as stressed in table 5.12, companies can fall in one category in a sub-period and in a different one in the other sub-period[28].

Table 5.13 presents estimation results when the regressors relating to

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[26] Since years 1980-82 are not included in the sample.

[27] See below for the reasons why UKCODO and FCODO do not appear in the tables.

[28] The alternative route could be taken to define company specific (time invariant) dummies by using the disaggregation provided in tables 5.12, with 9 categories for UK competition and 6 for foreign competition. Estimation results have been obtained also using this method. They did not differ noticeably from the results presented in tables 5.13 and 5.14.

domestic competition are added to equation (5.2). Tables 5.14 presents the results on foreign competition. Results including also interactions between domestic and foreign competition are not presented because they do not add any useful information. Estimation results including both the increase and decrease in competition from either domestic rivals (UKCOUP and UKCODO) or foreign rivals (FCOUP and FCODO) respectively, clearly show that the coefficients for UKCODO and FCODO are very imprecisely estimated, whatever the estimation technique. As a consequence these regressors have been dropped from the estimated equations presented here (only UKCOUP and FCOUP are used).

The results show that the strengthening of competition from domestic rivals does not seem to affect, *ceteris paribus*, the companies' investment performance (the coefficient for UKCOUP in table 5.13 is not significant). On the other hand, this effect appears to be achieved by an increase in competition from foreign rivals, although this result is slightly less pronounced when sector dummies are added (see table 5.14).

As was the case for the "static" analysis (see previous subsection), the magnitude of the union effect on investment is not noticeably altered by the inclusion of controls for product market conditions.

5.6 UNION DENSITY AND INVESTMENT

The analysis of the effects of unionisation on investment carried out so far has been limited to the comparison between companies that recognise a union (or more than one) and those that do not. The purpose of this section and the next is to attempt to distinguish between unionised companies in terms of the differences in union density (this section) as well as in terms of the presence of additional industrial relations arrangements such as closed shop schemes (next section). In both sections the analysis continues to concern the sample of companies that did not experience any change (partial or complete) in union recognition. In both cases, though, some companies will be lost with respect to the dataset used in section 5.4 because of lack of answers.

Union density represents an indicator of the extent of unionisation, but the discussion in section 5.1 has provided a warning towards the interpretation of density as a "measure" of bargaining power. In this section information on union density conditional on recognition will be employed to assess if any valuable insight is added to the explanation of investment performance. No claim is made that the results obtained refer to the effect of union power on companies' investment behaviour.

An important feature of the NIESR data is that, unlike the union recognition variables in sections 5.2 to 5.5 (cf. REC and RECALL), union density is not necessarily time invariant at the company level since annual figures are available. Indeed, out of 122 recognised companies whose union density figures are provided, 57 (47%) experienced some variation in the extent of unionisation in the periods for which data are available[29]. More specifically, there has been an increase in union density in 13 companies (11%) and a decrease in 43 (35%) with unionisation staying unchanged in the remaining 66[30].

Table 5.15 gives the distribution of union density across firms using company means over time. For a more in depth analysis of the descriptive statistics on union density readers are referred to chapter 4[31].

The results of estimation when union density conditional on recognition (variable DENSITY) is added to equation (5.2), with REC being omitted, are shown in table 5.16. DENSITY has a significantly negative coefficient. Investment, as a percentage of sales, is lowered by around .0059, *ceteris paribus*, by an increase of one point in union density. Hence, the contraction brought about by a one point increase in density accounts for about .5% of the mean non-union investment-sales ratio[32].

The question is now open as to whether non-linearities and/or

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[29] Obviously the time periods in question may differ from company to company.

[30] For one company the end period figure of density is the same as the initial value but some variation occurred in the meanwhile.

[31] The companies analysed here represent a subset of those employed in chapter 4, because of the lack of information on workforce characteristics.

discontinuities exist in the effect of union density on investment performance. The existence of discontinuities and threshold effects in union density has been established by the theoretical literature on endogenous union membership in the presence of "social customs" (see Naylor (1989, 1990), Naylor-Cripps (1993), and Booth-Chatterji (1993)). For instance, Naylor (1990) shows that a "critical mass" of joiners needs to be reached in order to bring about unionisation in a "social custom" model with fixed wage. On the other hand, Naylor and Cripps (1993) show, by drawing on the non-cooperative approach to wage bargaining, that a threshold must be reached by union membership for the union to be able to raise wages above the outside option. Stewart (1990, 1991) has provided empirical evidence for the existence of such thresholds using data from WIRS 1984. The results are neatly summarised in Metcalf-Stewart (1992). Stewart shows that the wage premium associated with union recognition (between 7 and 10 %[33], *ceteris paribus*) is obtained only when union density is above 95 %. Below this threshold the wage in unionised establishments is in line, ceteris paribus, with non-unionised establishments. Moreover, Stewart shows that the existence of a pre-entry closed shop involving at least some of the workforce roughly doubles the wage differential with respect to comparable non-unionised establishments on top of the high density effect. No such

[32] The reduction in investment, as a percentage of sales, for recognised companies, relative to non-union firms, is around 1/3 of a point when evaluated at the mean density conditional on recognition (56.7 %). This amounts to a reduction of about 30% in the investment-sales ratio relative to non-union companies.

[33] Figures refer to semi-skilled workers in the private sector.

additional effect is instead detected for post-entry closed shops.

After experimenting with the data on the basis of various assumptions, some evidence, but definitely not overwhelming, seems to suggest that the negative effect of union density on investment is mostly originated by companies with an intermediate extent of unionisation. Conversely, very highly and poorly (in terms of density) unionised companies both seem not to perform differently from firms that do not recognise unions. To substantiate this suggestion with numerical figures it can be claimed that the lower threshold is situated around 25 % with the upper limit being established at around 90 %.

Table 5.17 shows the estimation results when variables UD<25, which takes a value of 1 whenever the annual figure of union density is strictly below 25%, and UD>90, a dummy for values of union density (strictly) greater than 90 %, are added to REC in equation (5.2). The estimated coefficients for UD<25 and UD>90 are positive, with the latter not very precisely estimated, and of such magnitude to counteract the effect on investment of the recognition coefficient. A series of experiments have been carried out by varying the upper and, especially, the lower threshold for union density in order to determine the extent to which the results presented above are sensitive to the definition of the boundaries. The main suggestion seems to be preserved, albeit less clearly as the threshold moves upwards away from 25 % (see table 5.18 where the lower threshold for density is equal to 30%)[34].

In terms of investment performance, therefore, a company facing a union with a low density fares roughly the same, *ceteris paribus*, as a company facing no union. This result is in line with the theoretical and empirical findings that a threshold for density is needed for unions to be able to affect the wage. The data do not seem to support Denny and Nickell's (1992) view that if a union is recognised then it benefits investment to have a large density (see section 1.7), since "the management need deal only with union representatives rather than having to make separate arrangements for a substantial body of non-union workers" (Denny and Nickell (1992, 880-81)). This result seems to hold only for a high level of union density (above 90 %). It is only for a union with high density that the rationale suggested by Denny and Nickell, or, alternatively, the internalisation by the union of the company's objectives, seems to apply. For intermediate values of density, investment performance is negatively affected by the extent of unionisation at the company level.

5.7 CLOSED SHOP ARRANGEMENTS AND INVESTMENT PERFORMANCE

The purpose of this section is to assess whether the additional presence of closed shop arrangements in unionised companies has a separate effect on investment behaviour. For instance, if closed shop schemes entail restrictive work practices[37], then a negative effect on investment or innovative activity could be thought to arise. Machin (1991b), for instance, using data on British engineering firms over the period 1978-1982, finds some evidence for a negative impact of the closed shop on productivity for large firms.

A closed shop scheme in the NIESR data is defined as the presence of "an arrangement with any trade union (or unions) that some or all of the workforce would normally be members of a trade union to get or keep their jobs"[38].

On the basis of this information a new dummy variable has been defined, CLOSED, which takes a value of 1 for companies where such schemes exist (and 0 otherwise). Out of 131 unionised companies[39] closed shop arrangement existed in 32 (24.4 %). Table 5.21 presents the distribution of union density for companies with a closed shop scheme[40] (using group means for union density). It is easily seen that the existence of a closed shop is not necessarily related with a large union density at the company level.

Estimation results for the equation with the CLOSED dummy added to recognition are presented in table 5.22. No effect of closed shops per se can be

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[37]See Dunn-Gennard (1984) for a study of the closed shop in British industry.

[38]Separate information is provided as to whether all workers are covered by the scheme or just some. This additional information did not prove useful and it is disregarded in this section. See Gregg-Yates (1991, 366-68) for the analysis of the presence of closed-shop schemes in the NIESR survey.

[39]For consistency with the "static" nature of the analysis of the effects of union recognition presented above, companies that experienced changes in their closed shop arrangements (abolition, for instance) during the eighties have been dropped from the sample.

[40]The percentages in table 5.21 do not represent the proportion of workers covered by closed shop schemes, but union density at the company level where such schemes exist. Note also that for three companies with closed shop information on union density is not available.

detected. This result confirms the findings in Denny-Nickell (1992) and Latreille (1992) that closed shop arrangements have no significant separate effect on either investment or innovation (see section 1.7).

The results of the previous section have provided some evidence that unionised companies with a high union density (above 90 %) have a different investment performance, *ceteris paribus*, with respect to companies with an intermediate level of unionisation. It can be of some interest to assess whether this effect can be related to the presence of closed shop schemes involving a large section of the workforce. In table 5.23 CS>90 interacts the presence of a closed shop with a percentage of unionisation above 90%[41]. It is easily seen that the differential behavior of companies with very large unionisation is not affected by controlling for the existence of a closed shop.

5.8 DISAGGREGATION ACROSS TIME AND SECTORS

This section presents some remarks on the disaggregation of the results across time and sectors.

First, unreported annual cross-sections results have suggested a differential effect of union recognition on investment performance between the first and second

[41]Needless to say the companies fulfilling the conditions defining this regressor are just a handful. Hence the results must be interpreted very cautiously. Only OLS estimates are reported for these equations.

half of the period of interest. This outcome is confirmed in table 5.24 which separately reports the results for periods 1983-85 and 1986-89 (only FGLS estimates are reported)[42]. The coefficient for union recognition, albeit negative, is much smaller and not significant in the second part of the eighties[43]. Moreover, wage growth turns out not to be significant in the first period, while part-time and female workers' percentages affect investment only in the second period.

One of the features of the dataset used in this chapter is the range of groupsizes (from a minimum of 2 to a maximum of 7). It could then be interesting to assess whether results are affected by the presence in the data of companies with an extremely small number of observations. This is achieved by deleting all companies whose groupsize is (strictly) below 6. The results of estimation (without sectoral dummies) and the disaggregation over time when only companies with either 6 or 7 observations are kept in the data are shown in table 5.25 (138 companies and 883 observations survive). Unionisation still has a negative, albeit slightly reduced, effect, but the t-ratio is now just below the critical value for significancy at the 10 % level when FGLS estimates are used. All comments made before still apply also with respect to the comparison between the two time periods.

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[42]The sample size differs from section 5.4 because companies are kept in the dataset only if at least two observations (and not just one) are available in either sub-period (or both). Hence the slight reduction in the number of companies and observations.

[43]The null hypothesis of stability of all parameters (including the intercept and the sectoral dummies) over the two periods is accepted using the F-test at the 10 % significance level. The test statistics are $F_{16,1244} = 1.43$ and $F_{22,1232} = 1.13$ for the equations with and without dummies respectively.

Finally, table 5.26 provides a quick sketch of the disaggregation across sectors. Only OLS estimates are provided[44]. It is easily seen that results are not homogeneous with union recognition having a negative (and significant) impact only in sectors 3 (Metal Goods, Engineering and Vehicle Industries) and 6 (Commercial Services).

5.9 CHANGES IN UNION STATUS AND INVESTMENT BEHAVIOUR

The analysis carried out so far has concerned only the set of companies that did not undergo any change in union recognition during the eighties focusing mostly on the comparison between unionised and non-unionised firms. In this section the analysis is extended to take into account changes in union status, i.e recognition, during the period 1980-89. This is made possible by the quite extensive range of information available from the NIESR dataset. As a result, a chance is provided to assess if the changes in the industrial relations arrangements during the Eighties have brought about any consequence in terms of companies' investment performance[45]. Although no direct link can be made between these changes in the extent of unionisation and the ongoing transformation of industrial relations and

[44] For some sectors FGLS could not be estimated because one of the estimated variance components was negative (see Appendix 5B). Sectors 1 and 7 are omitted because of the insufficient number of observations.

[45] See on this debate Brown-Wadhwani (1990), Metcalf (1993, 1994) and Blanchflower-Freeman (1994).

labour market legislation enacted by the British Government since 1979, the results described below can at least shed some light on some of the basic claims that motivate those policies. In particular, it is interesting to assess whether a reduced influence of trade unions (a move towards derecognition, for instance) is likely to lead to an increase in efficiency at the firm level, namely, in the case studied here, an improved investment performance.

Data from WIRS show that some derecognition has occurred in the eighties. The proportion of establishments with recognised unions for manual workers has fallen from 61 % in 1980 (and 62 % in 1984) to 48 % in 1990[46]. The fall in private sector manufacturing has been from 69 % to 44%. Gregg and Yates (1991) using the full data from the NIESR survey on which this work is based find that 13 % of the companies that recognised (at least) a union in 1984 have derecognised. They also point out that complete derecognition has been rare. These data confirm more "anecdotal" evidence gathered by Claydon (1989). Claydon's view that derecognition was far more frequent in the second part of the eighties is supported by the studies quoted above[47]. Claydon also reported that derecognition tended to be "grade-specific", i.e. involving only particular grades or sections of the workforce within the organisation. Disney et al. (1994, 7) summarise their view by stressing that "existing evidence suggests that recognition is usually a once and for

[46]According to the computations in Disney et al. (1993, 23). Recognition has fallen in the period also for non-manual workers.

[47]Hall and McKay (1994) claim, on the basis of survey evidence, that the extent of recognition has even increased after 1988.

all decision made at some point early in the lifetime of the establishment. Recognition changes in existing establishments have remained uncommon even in the 1980's".

The first part of this section will be devoted to a brief analysis of the extent of the changes in recognition in the available data. To this purpose it seems helpful to recall the procedure for gathering that information used in the NIESR questionnaire.

If a company was recognising a union (or more than one) at the end of the period (1990), questions were asked to establish whether any of the following had happened over the years 1980-89.

a) An increase in recognition, i.e an increase in the number of the company's establishments were a union (or more) was recognised for the purpose of wage bargaining;

b) a decrease in recognition, i.e a reduction in the number of establishments where unions were recognised but such that some establishments were still unionised at the end of the period;

c) None of the above, i.e the company experienced no change in union recognition.

Companies in categories a) and b) were not included in the sample used in the previous analysis.

If a company falls in category a), i.e an increase in recognition was experienced, it is also known whether this meant the company was recognising unions for the first time (i.e a new recognition).

As was the case with the change in domestic and foreign competition, all the information just detailed is available in the dataset with a separate reference for the sub-periods 1980-84 and 1985-89. For instance, if a company recognised a union for the first time in the period, it is then known in which of the two sub-periods the change took place. The exact year of the changes, though, is not known. The spread of the information over the two sub-periods is an important feature of the data to be kept in mind in the ensuing analysis.

On the other hand, if a company was not recognising any union at the end of the period the following is then known:

d) derecognition took place sometime over the period, i.e the company was indeed unionised at the beginning of the eighties;

e) no change took place.

Companies in category d) were not included in the sample used in the previous analysis. Again, it is possible to know whether derecognition, if any was experienced, took place in the first or in the second sub-period.

Table 5.27 provides a summary of the information on the extent of the changes in union recognition in the data. All figures refer to the number of companies falling in any specific category. The first column in the table refers to the largest sample for which information about union status and its changes was gathered (see the sample in chapter 4). The second column refers to the sample employed below in the estimation process[48]. The difference between the two sizes is accounted for by the companies dropped because no information was available on the workforce composition characteristics.

The table first shows the number of companies recognised at the beginning and at the end of the period (RECBEG and RECEND, respectively)[49]. The unionisation rate is almost unchanged at the end of the period at around 60%. Hence the fall in union recognition mentioned above is not mirrored in this particular sample, the reason probably being that figures in table 5.27 refer to companies and not establishments as in the WIRS survey. As a matter of fact, changes have taken place, as the rest of the table shows. It can be noticed, to start with, that the percentage of companies affected by changes, of whatever type, is just above 15 %. The total number of companies experiencing a decrease in union recognition is given by LESSREC which is made up by the sum of the companies where (complete) derecognition took place (DEREC) and of those where derecognition was only partial (PARDEREC) thereby affecting only some, but not all, of the establishments that were unionised at the beginning. It is easily seen that

[48]The distribution by sectors is also reported in the table.

[49]Beginning of period here always refers to 1980 and end of period to 1990. RECBEG is obtained from the number of companies recognised at the end (RECEND) minus the companies that newly recognised unions (NEWREC) plus the companies that ceased to recognise unions in the period (DEREC).

(complete) derecognition was not common at all (affecting only 10 and 7 companies in the two samples) and that the decline in recognition, experienced by some 10 % of the companies, was mostly arising from partial derecognition.

In table 5.27 changes are also disaggregated across the two sub-periods in order to highlight that most of the movement towards partial and complete derecognition took place between 1985 and 1989.

Finally, the extent of the move towards increased recognition (see MOREREC which includes companies that were unionised at the beginning of the eighties as well as companies where new recognition was experienced) is about half as much as the opposite tendency towards derecognition (around 5%). This result is again mainly accounted for by an increase in the number of establishments involved rather than by new recognition (see NEWREC)[50]. Also in this case the bulk of the changes is concentrated in the second half of the eighties.

The estimated equation has been reformulated to keep up with the changes in information now available. Instead of the unionisation variable employed above (REC), a dummy for recognition at the beginning of the period is introduced (RECBEG, as defined above where its opposite, RECEND, has been introduced as well). The estimated equation tries to capture the effect of decreased recognition (see variable LESSREC defined before) and, more specifically, whether a separate effect

[50]It can be noticed that the number of companies that newly recognised a union is not too different from the number of those ceasing to recognise.

could be detected for a decrease in recognition that leads to non-unionisation at the end of the period (i.e complete derecognition, represented by variable DEREC). On the other hand it is interesting to assess the effect of increased recognition (variable MOREREC), and more specifically of new recognition (NEWREC, a change which modifies the union status of the companies with respect to the initial situation).

The estimated equation can then be written as follows:

$$\mathrm{INV}_{it} = \alpha_i + \beta \cdot \mathrm{X}_{it} + \gamma \cdot \mathrm{Z}_i + \delta_1 \cdot \mathrm{RECBEG}_i + \delta_2 \cdot \mathrm{LESSREC}_{it} +$$
$$+ \delta_3 \cdot \mathrm{LESSREC}_{it} * (1 - \mathrm{RECEND}_i) + \delta_4 \cdot \mathrm{MOREREC}_{it} + \delta_5 \cdot \mathrm{MOREREC}_{it} *$$
$$* (1 - \mathrm{RECBEG}_i) * \mathrm{RECEND}_i$$

or, more neatly,

$$\mathrm{INV}_{it} = \alpha_i + \beta \cdot \mathrm{X}_{it} + \gamma \cdot \mathrm{Z}_i + \delta_1 \cdot \mathrm{RECBEG}_i + \delta_2 \cdot \mathrm{LESSREC}_{it} +$$
$$+ \delta_3 \cdot \mathrm{DEREC}_{it} + \delta_4 \cdot \mathrm{MOREREC}_{it} + \delta_5 \cdot \mathrm{NEWREC}_{it} \qquad (5.3)$$

LESSREC takes a value of 1 in year t if in that year, or in any of the years before, the company experienced a decrease in recognition (complete or partial)[51]. Similarly MOREREC takes a value of 1 in year t if in that year, or in any of the years before, the company experienced an increase in recognition (including the event of a new recognition). Finally, DEREC and NEWREC are accordingly defined for the case of (complete) derecognition and new recognition, respectively.

[51] As pointed out before the exact year of the changes is not known. Therefore the definition has to be worked out with reference to the two sub-periods 1980-84 and 1895-89. Since years 1980-82 are omitted, the definition implies that LESSREC (and any similarly defined regressor) can take a value of 1 in either periods 1983-84 and 1985-89 or only in the second.

This definition of the regressors stems from the assumption that changes in union status have a lasting effect on investment performance. To be more specific, if, for instance, a company changed its recognition arrangements in the first half of the eighties, it seems sensible to assume that the effect, if any exists on investment, would not die away in one or two years, but should persist for longer. This route is also taken in view of the lack of information on the exact date of the changes in union status.

It should also be noticed that a consequence of the definition of the variables is that regressors LESSREC, MOREREC, DEREC, and NEWREC need not be invariant at the company level. For example, if a company chose to (partially) derecognise unions in the period 1985-89, the value of LESSREC will switch from 0 to 1 moving from years 1983-84 to 1985-89[52].

On the other hand, RECBEG is obviously unchanged over time, since a company was either unionised or non-unionised at the beginning of the period.

As seen above, derecognitions have been more common in the sample (and in the U.K. economy) than increases in recognition and therefore evidence on the effects of the former on investment is of greater interest. Firstly, equation (5.3) has been estimated omitting DEREC and NEWREC. Results are presented in table 5.28. The coefficient for recognition at the beginning of the period is negative and

[52]The use of this type of definition seems to have a more intuitive appeal over a company specific time invariant definition because it preserves a temporal dimension in the effect of the changes which is otherwise lost.

significant. This outcome confirms, also in the order of magnitude, the results found in section 5.4 about the marginal effects of union recognition on investment performance. On the other hand, the coefficient for LESSREC "measures" whether a decline in recognition (either complete or partial) affects investment, *ceteris paribus*. The coeffiecient is statistically not different from zero. The same result is shared by the coeffiecient for increased recognition (MOREREC, either partial or new recognition). Tables 5.29 and 5.30 provide results when the information is added about whether decreased (or increased) recognition was partial or complete. First, DEREC is added to LESSREC in the equation in order to capture whether "complete derecognition" makes a difference in the results (table 5.29). Then NEWREC is also added to assess the differential effect of new recognition, so that equation (5.3) is fully estimated (see table 5.30).

The results in table 5.28 have shown that there is no significant separate effect of derecognition on investment. But the picture changes when a distinction is made between partial and complete derecognition (see table 5.29). There is evidence of a positive and significant impact on investment for companies that have experienced partial derecognition[53]. The magnitude of this effect is such that their investment performance is, *ceteris paribus*, in line with the results of non-unionised companies (the positive coefficient for LESSREC entirely compensates for the the negative effect arising from recognition, see the coefficient for RECBEG).

[53] Estimates improve for these coefficients when sector dummies are used.

Conversely, the investment performance of the companies that have abandoned union recognition during the period is significantly worse than that of the companies with only partial derecognition. As a matter of fact, these companies represent the group that fared least well in terms of investment, *ceteris paribus,* during the period. The coefficient for DEREC shows that for these companies investment, measured as a percentage of sales, is, *ceteris paribus*, around one point smaller than for non-unionised companies and half a point smaller than for unionised companies with unchanged status. However, the result for DEREC has to be considered very cautiously because of the very small number of companies (namely 7) falling in this category[54].

Finally, the marginal effect on investment of increased recognition appears to be positive as well[55], but not precisely estimated. No better estimates are obtained when a distinction is made between partial increase in recognition and totally new recognition.

As was done in section 5.8, equations have been re-estimated using the following sub-samples:

(a) data for all companies with at least 6 available observations over the period 1983-89;

(b) data covering the period 1986-89, whatever the group size.

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[54]The same warning applies to the variable NEWREC below.

[55]As described above this effect operates here with respect both to companies non unionised at the beginning (if it refers to new recognition) and unionised (if it refers to a partial increase).

Results for these regressions are not reported here.

The results for (a) and (b) share the feature that union regressors do not perform very well. RECBEG is never statistically different from zero at the 10% significance level when FGLS estimates are considered. This result comes as no surprise in the light of the evidence presented in the previous section, where it was pointed out that the negative impact of union recognition was dying away in the second part of the eighties. The estimate of the effect of recognition in the sample of firms with more than six observations, though, turns out to be less precise than in the previous section. All other union explanatory variables have no significant impact with the only exception of LESSREC in the estimation restricted to period 1986-89. Decreased recognition, either partial or complete, seems to positively affect investment, *ceteris paribus*, with no significant evidence of the counteracting effect of total derecognition which was detected before[56].

5.10 THE "INDIRECT" EFFECT OF UNIONS ON INVESTMENT: AN ASSESSMENT

The results on the effects of unions on investment presented in sections 5.4 to 5.9 can be criticised for providing only a partial account. In particular, if the view is held that unionised firms pay higher wages than non-unionised firms, then

[56] Unreported results show that changes in closed shop arrangements (either abolition or reduction) do not have any impact, ceteris paribus, on investment.

the union effect on investment detected above may turn out to be underestimated. In this section an attempt is made to evaluate the total effect of unions on investment by taking into account the impact of unionisation on the wage[57]. The total effect on investment is then defined by[58]

$$\frac{dI}{dU} = \frac{\partial I}{\partial U} + \frac{\partial I}{\partial w} \cdot \frac{\partial w}{\partial U}$$

The results presented above show that the annual rate of growth of wages at the company level (WAGEGR) has a negative and significant impact on investment. This result is consistent through the alternative specifications used in sections 5.4 to 5.9. It is therefore interesting to evaluate the impact of union recognition, to start with, on wage growth. No separate effect of unionisation on WAGEGR is obtained and, overall, the wage growth equations (not reported here) turn out to be very poor[59]. On such grounds no "indirect effect" of unions is determined.

Attention has been turned to wage levels instead of rates of growth. In this case the wage equation is definitely improved. Table 5.31[60] (see first and second

[57]The problems involved with the construction of the wage variable, defined as total wage costs over total employment, should be taken into account in the evaluation of the results.

[58]For estimation purposes a recursive structure is assumed whereby investment does not enter the wage equation.

[59]Results for these regressions are not reported. The null hypoyhesis of no joint significance of the regressors in the wage growth equation is easily accepted, irrespective of the specification adopted, with both pooled OLS and the two-step estimates (see Appendix 5B on the latter). No results can be obtained using FGLS estimates since the estimated variance turns out to be negative (see Appendix 5B for this problem).

[60]All regressions in tables 5.31 and 5.32 include sector dummies.

columns) shows that wage levels are positively affected *ceteris paribus* by demand side factors like profitability and sales. Size, as measured by total employment, has a negative effect. Unsurprisingly, increases in the percentage of part-time and female workers lower the wage. The reverse holds for the percentage of non-manual workers. No significant effect is associated with skilled workers. Most importantly, the coefficient for union recognition is not significant. Although additional attempts could be made to improve the wage equation, they are frustrated by the fact that the wage level, unlike wage growth, seems not to significantly affect the investment-sales ratio (see variable WAGE in table 5.32[61]). Once again no significant "indirect effect" of unions is identified. The result that the effect of unionisation on investment in the data seems to be confined to the direct impact analysed in section 5.4 to 5.9 is confirmed also when union density conditional on recognition is taken into account. Union density given recognition has a positive impact on wage levels[62] *ceteris paribus* (see table 5.31, third and fourth columns), but no "indirect effect" of union is evident because the wage level, as above, fails to affect the propensity to invest (see table 5.32, third and fourth columns).

[61]Alternative specifications for the investment equation have been used but the the wage level is consistently not significant.

[62]The inclusion of union density in the regression for wage growth, instead, does not improve the fit. As above, results for this case are not reported.

5.11 CONCLUSIONS

The results presented in this chapter show that there is evidence that union recognition has, *ceteris paribus*, a negative and significant effect on the propensity to invest of U.K. companies over the period 1983-89. This result is robust to the consideration of product market conditions as well as to the changes in the strength of both domestic and foreign competition during the period of interest. This negative effect, though, seems mainly concentrated in the first part of the period (namely, 1983-85).

The results confirm the prediction of the thoretical models of chapter 2 and 3. It is important to notice, though, that the attempt to distinguish between "direct" and "indirect" effects of unions is not successful. The evidence presented in this chapter points to the existence of, at least, a significant "direct" effect of unionisation. Better data on the wage variable (see footnote 58) are needed for a further investigation of the "indirect effect".

The presence of closed shop arrangements has no separate effect on companies' investment. This result confirms the findings of previous work (see Denny and Nickell (1992) and Latreille (1992)).

The extent of unionisation at the company level, as measured by union density conditional on recognition, has a negative effect on investment. This result does not accord with the findings of Denny and Nickell (1992) discussed in section 1.7. There is some evidence, but definitely not overwhelming, that this negative effect operates only for intermediate values of union density. As a result, recognised companies with either very low or very high union density do not seem to perform differently, *ceteris paribus*, from non-unionised firms.

As far as the effect of changes in union status during the eighties is concerned, there is evidence of a positive and significant effect of partial derecognition on investment performance. Hence, at least in the short-run, partial derecognition tends to award a premium in terms of investment with respect to comparable unionised firms with unchanged status. Conversely, complete derecognition is associated with poor outcomes in terms of investment, but this result should be treated cautiously because of the rather rare occurrence of this type of change in union status.

NOTE ON TABLES

- Absolute value of t-statistics in parentheses.

- Coefficient for EMPLOYMENT multiplied by 10^5 in all tables but 5.31 where it is multiplied by 10^3.

- If sector dummies are used they refer to one-digit SIC industries in all tables but 5.9.

- In tables 5.16, 5.19, 5.20, 5.31 and 5.32 union DENSITY figures have been divided by 100, hence the coefficient is multiplied by 100.

- In table 5.31 coefficient for SALES is multiplied by 10^5.

TABLE 5.1

DISTRIBUTION OF COMPANIES BY NUMBER OF OBSERVATIONS

Number of observations	2	3	4	5	6	7	Total	Mean
Number of companies	14	31	32	38	83	55	253	5.22
Percentage	5.53	12.25	12.65	15.02	32.81	21.74		

TABLE 5.2

DISTRIBUTION OF COMPANIES BY S.I.C. SECTOR AND UNION STATUS

SIC Sector	1	2	3	4	MANUFACT. 2+3+4	5	6	7	Total
Number of companies	2	30	57	75	162	15	72	2	253
Percentage	0.79	11.86	22.53	29.64	64.03	5.93	28.46	0.79	
Unionised companies	2	23	30	58	111	9	20	0	142
Percentage	100.00	76.67	52.63	77.33	68.52	60.00	27.78	0.00	56.13
Complete recognition	1	12	14	39	65	4	10	0	80
Percentage	50.00	52.17	46.67	67.24	58.56	44.44	50.00	-	56.34

TABLE 5.3

(A) DESCRIPTIVE STATISTICS FOR WORKFORCE COMPOSITION AND UNION VARIABLES
(Number of cases = 253)

	Mean	Median	St.Dev.	Minimum	Maximum
REC	0.5612	1	0.4972	0	1
RECALL	0.3162	0	0.4659	0	1
PTIM	5.0356	2	10.392	0	74
SKIL	17.81	10	19	0	90
NMAN	46.04	40	25.925	1	100
FEM	30.763	28	20.028	1	90
PTYES	0.743	1	0.4378	0	1
SKILYES	0.8656	1	0.3417	0	1

(B) CORRELATION MATRIX FOR WORKFORCE COMPOSITION VARIABLES
(Number of cases = 253)

	Ptim	Skil	Nman	Fem
Ptim	1.00			
Skil	-0.13	1.00		
Nman	0.03	-0.27	1.00	
Fem	0.42	-0.25	0.20	1.00

(C) COMPARISON BETWEEN UNIONISED AND NON UNIONISED COMPANIES
(number of cases = 253)

	MEAN		MEDIAN		STAND. DEV.	
	union	no union	union	no union	union	no union
PTIM	4.97	5.12	1.00	2.00	11.09	9.47
SKIL	20.13	14.85	12.50	9.00	19.09	18.54
NMAN	38.43	55.77	32.50	56.00	20.82	28.53
FEM	27.59	34.82	20.00	35.00	20.11	19.26

TABLE 5.4

DESCRIPTIVE STATISTICS (TOTAL SAMPLE)
(sample size = 1322)

	Mean	Median	St.Dev.	Minimum	Maximum
INV	0.75	0.25	2.82	-27.45	40.94
SALESGR	15.93	11.70	25.99	-90.49	239.50
WAGEGR	8.37	7.65	10.10	-34.71	105.80
PROFIT	0.06	0.05	0.74	-0.74	0.62
EMPLOYMENT	3409	866	11732	38	133800
CLR	0.14	0.04	0.24	0.00	2.20
DER	0.60	0.06	1.98	0.00	38.37
DCLR	0.74	1.00	0.44	0.00	1.00
DDER	0.61	1.00	0.49	0.00	1.00
REC	0.58	1.00	0.49	0.00	1.00
RECALL	0.33	0.00	0.47	0.00	1.00
PTIM	5.43	2.00	11.20	0.00	74.00
SKIL	18.76	12.00	19.25	0.00	90.00
NMAN	45.22	39.00	25.29	1.00	100.00
FEM	20.41	25.00	20.13	1.00	90.00
PTYES	0.76	1.00	0.42	0.00	1.00
SKILYES	0.89	1.00	0.32	0.00	1.00

TABLE 5.5

COMPARISON BETWEEN UNIONISED AND NON UNIONISED COMPANIES (MEANS)

	UNION	NON UNION
INV	0.489	1.112
SALESGR	11.565	21.982
WAGEGR	8.450	8.267
PROFIT	0.058	0.062
EMPLOYMENT	4682	1642
CLR	0.143	0.134
DER	0.604	0.588
DCLR	0.752	0.725
DDER	0.664	0.527
PTIM	5.410	5.451
SKIL	20.770	15.964
NMAN	37.960	55.273
FEM	27.443	34.520
PTYES	0.768	0.759
SKILYES	0.972	0.765
RECALL	0.568	-
DENSITY	56.700 (*)	-
n. obs.	768	554

(*) 651 valid observations for union density.

TABLE 5.6

Estim. Tech.	OLS	FGLS	OLS	FGLS
Companies	253	253	253	253
Observations	1322	1322	1322	1322
CONSTANT	-0.575 (1.50)	-0.571 (1.35)	-0.695 (1.74)	-0.692 (1.57)
SALESGR	0.019 (6.67)	0.018 (6.17)	0.019 (6.49)	0.018 (6.04)
WAGEGR	-0.018 (2.55)	-0.017 (2.42)	-0.018 (2.55)	-0.017 (2.44)
PROFIT	8.326 (7.50)	8.309 (6.88)	8.619 (7.67)	8.315 (7.05)
EMPLOYMENT	-0.245 (0.38)	-0.241 (0.33)	-0.251 (0.38)	-0.246 (0.34)
DCLR	0.175 (0.97)	0.199 (1.00)	0.202 (1.11)	0.226 (1.13)
CLR	-0.866 (2.49)	-0.889 (2.42)	-0.851 (2.44)	-0.876 (2.38)
DDER	0.270 (1.73)	0.286 (1.65)	0.293 (1.85)	0.308 (1.76)
DER	0.070 (1.84)	0.074 (1.87)	0.064 (1.70)	0.069 (1.76)
PTYES	-0.075 (0.40)	-0.068 (0.33)	-0.045 (0.24)	-0.038 (0.18)
PTIM	0.026 (3.52)	0.025 (3.12)	0.023 (3.00)	0.022 (2.66)
SKILYES	-0.439 (1.63)	-0.454 (1.52)	-0.404 (1.49)	-0.421 (1.40)
SKIL	0.023 (5.62)	0.023 (5.09)	0.023 (5.50)	0.023 (5.00)
NMAN	-0.001 (0.10)	-0.001 (0.11)	-0.001 (0.22)	-0.001 (0.23)
FEM	0.011 (2.58)	0.011 (2.37)	0.010 (2.29)	0.010 (2.13)
sector dummies	no	no	yes	yes
R^2	0.146	0.146	0.151	0.153
rss	8954.7	8957.3	8901.7	8904.2

TABLE 5.7

Estim. Tech.	OLS	FGLS	OLS	FGLS
Companies	253	253	253	253
Observations	1322	1322	1322	1322
CONSTANT	-0.327 (0.83)	-0.318 (0.73)	-0.394 (0.94)	-0.380 (0.82)
SALESGR	0.018 (6.08)	0.017 (5.69)	0.018 (6.15)	0.017 (5.75)
WAGEGR	-0.018 (2.52)	-0.017 (2.41)	-0.018 (2.53)	-0.017 (2.42)
PROFIT	8.388 (7.57)	8.101 (6.96)	8.507 (7.58)	8.210 (6.97)
EMPLOYMENT	-0.060 (0.09)	-0.048 (0.06)	-0.095 (0.14)	-0.083 (0.11)
DCLR	0.198 (1.10)	0.223 (1.13)	0.220 (1.21)	0.245 (1.22)
CLR	-0.853 (2.46)	-0.877 (2.40)	-0.867 (2.48)	-0.890 (2.42)
DDER	0.305 (1.95)	0.321 (1.85)	0.319 (2.01)	0.334 (1.91)
DER	0.068 (1.79)	0.072 (1.83)	0.064 (1.70)	0.069 (1.75)
PTYES	-0.075 (0.40)	-0.067 (0.33)	-0.043 (0.23)	-0.036 (0.17)
PTIM	0.027 (3.64)	0.026 (3.24)	0.025 (3.28)	0.025 (2.94)
SKILYES	-0.303 (1.11)	-0.313 (1.04)	-0.296 (1.07)	-0.306 (1.01)
SKIL	0.023 (5.57)	0.023 (5.05)	0.024 (5.61)	0.024 (5.10)
NMAN	-0.002 (0.72)	-0.002 (0.69)	-0.002 (0.56)	-0.002 (0.54)
FEM	0.010 (2.27)	0.010 (2.09)	0.009 (1.95)	0.009 (1.80)
REC	-0.451 (2.74)	-0.465 (2.56)	-0.415 (2.31)	-0.434 (2.18)
sector dummies	no	no	yes	yes
R^2	0.151	0.151	0.155	0.154
rss	8903.4	8905.5	8865.3	8867.4

TABLE 5.8

Estim. Tech.	OLS	FGLS	OLS	FGLS
Companies	253	253	253	253
Observations	1322	1322	1322	1322
CONSTANT	-0.323 (0.82)	-0.315 (0.72)	-0.376 (0.89)	-0.362 (0.78)
SALESGR	0.018 (6.04)	0.017 (5.66)	0.018 (6.12)	0.017 (5.73)
WAGEGR	-0.018 (2.52)	-0.017 (2.41)	-0.018 (2.53)	-0.017 (2.42)
PROFIT	8.393 (7.58)	8.103 (6.96)	0.850 (7.57)	8.201 (6.97)
EMPLOYMENT	-0.139 (0.21)	-0.127 (0.17)	-0.170 (0.25)	-0.158 (0.21)
DCLR	0.197 (1.10)	0.223 (1.13)	0.222 (1.22)	0.246 (1.23)
CLR	-0.857 (2.47)	-0.881 (2.41)	-0.872 (2.50)	-0.895 (2.44)
DDER	0.299 (1.91)	0.315 (1.82)	0.313 (1.97)	0.328 (1.88)
DER	0.069 (1.81)	0.072 (1.84)	0.065 (1.71)	0.069 (1.77)
PTYES	-0.085 (0.46)	-0.078 (0.38)	-0.054 (0.29)	-0.046 (0.22)
PTIM	0.026 (3.53)	0.026 (3.15)	0.024 (3.18)	0.024 (2.85)
SKILYES	-0.311 (1.14)	-0.321 (1.06)	-0.301 (1.09)	-0.311 (1.02)
SKIL	0.023 (5.63)	0.023 (5.10)	0.024 (5.67)	0.024 (5.15)
NMAN	-0.002 (0.77)	-0.002 (0.74)	-0.002 (0.60)	-0.002 (0.58)
FEM	0.010 (2.42)	0.010 (2.23)	0.009 (2.07)	0.009 (1.91)
REC	-0.309 (1.54)	-0.322 (1.46)	-0.276 (1.31)	-0.293 (1.26)
RECALL	-0.243 (1.25)	-0.244 (1.14)	-0.248 (1.27)	-0.249 (1.15)
sector dummies	no	no	yes	yes
R^2	0.152	0.152	0.156	0.155
rss	8892.7	8894.8	8854.2	8856.3

TABLE 5.9

Estim. Tech.	OLS	FGLS	OLS	FGLS
Companies	253	253	253	253
Observations	1322	1322	1322	1322
CONSTANT	-0.408 (0.78)	-0.394 (0.70)	-0.387 (0.74)	-0.373 (0.66)
SALESGR	0.017 (5.94)	0.017 (5.67)	0.017 (5.92)	0.017 (5.65)
WAGEGR	-0.017 (2.50)	-0.017 (2.42)	-0.017 (2.50)	-0.017 (2.42)
PROFIT	8.543 (7.55)	8.311 (7.09)	8.537 (7.55)	8.302 (7.08)
EMPLOYMENT	-0.553 (0.83)	-0.543 (0.75)	-0.632 (0.94)	-0.621 (0.86)
DCLR	0.255 (1.40)	0.274 (1.40)	0.259 (1.43)	0.278 (1.42)
CLR	-0.807 (2.31)	-0.830 (2.28)	-0.811 (2.32)	-0.834 (2.29)
DDER	0.220 (1.37)	0.233 (1.35)	0.218 (1.36)	0.230 (1.33)
DER	0.063 (1.67)	0.067 (1.72)	0.064 (1.69)	0.067 (1.73)
PTYES	-0.081 (0.41)	-0.075 (0.35)	-0.096 (0.48)	-0.089 (0.42)
PTIM	0.012 (1.50)	0.012 (1.37)	0.011 (1.45)	0.011 (1.32)
SKILYES	-0.138 (0.49)	-0.149 (0.49)	-0.144 (0.51)	-0.155 (0.51)
SKIL	0.021 (4.80)	0.021 (4.48)	0.021 (4.87)	0.021 (4.54)
NMAN	-0.002 (0.61)	-0.002 (0.60)	-0.002 (0.66)	-0.002 (0.65)
FEM	0.007 (1.42)	0.007 (1.34)	0.007 (1.50)	0.007 (1.42)
REC	-0.343 (1.82)	-0.355 (1.74)	-0.212 (0.97)	-0.223 (0.95)
RECALL			-0.237 (1.20)	-0.238 (1.12)
two-digit dummies	yes	yes	yes	yes
R^2	0.179	0.179	0.180	0.180
rss	8607.5	8608.7	8597.9	8599.1

Note:
The following two-digit industry dummies have been defined

DUMMY	THREE-DIGIT SIC SECTORS INCLUDED					
D14	140					
D21	210					
D22	223	224				
D23	231					
D24	240	241	242	243	247	
D25	251	255	256	257	258	
D31	310	311	312	313	316	
D32	320	322	323	326	328	329
D33	330					
D34	340	341	342	343	344	345
D35	351	352	353			

D36	361	362	364						
D37	370	371	372						
D41	412	413	414	416	418				
D42	420	422	423	424	426	427	428	429	
D43	431	432	435	436	437	438	439		
D44	442								
D45	451	453							
D46	464	465	467						
D48	480	481	483						
D49	491	494	495						
D50	500								
D61	611	612	613	614	615	616	617	618	619
D62	622								
D63	630								
D64	640	641	643	645	646	648			
D65	651	654	656						
D66	661	662	665	667					
D67	671								
D72	723								

The following two-digit dummies defined above are used in the regressions of table 5.9:
D14, D25, D31, D32, D33, D34, D35, D50, D61, D72
together with the following aggregations of two-digit dummies:

D2124 = D21+D22+D23+D24
D3637 = D36+D37
D4142 = D41+D42
D4344 = D43+D44
D4546 = D45+D46
D4849 = D48+D49
D6264 = D62+D63+D64
D6567 = D65+D66+D67

TABLE 5.10

DISTRIBUTION OF COMPANIES ACCORDING TO PRODUCT MARKET CONDITIONS
(NUMBER OF COMPETITORS)

	Number of companies	%	Number of observations
NO COMPETITORS	5	2	26
FEW COMPETITORS (between 1 and 5)	33	13	162
MANY COMPETITORS (more than 5)	214	85	1129
TOTAL	252	100	1317

TABLE 5.11

Estim. Tech.	OLS	FGLS	OLS	FGLS
Companies	252	252	252	252
Observations	1317	1317	1317	1317
CONSTANT	-0.357 (0.90)	-0.350 (0.80)	-0.461 (1.10)	-0.448 (0.97)
SALESGR	0.017 (5.90)	0.016 (5.52)	0.017 (5.93)	0.016 (5.55)
WAGEGR	-0.016 (2.37)	-0.015 (2.26)	-0.017 (2.38)	-0.015 (2.27)
PROFIT	8.366 (7.61)	8.091 (6.99)	8.539 (7.67)	8.249 (7.05)
EMPLOYMENT	-0.042 (0.06)	-0.033 (0.04)	-0.059 (0.09)	-0.049 (0.06)
DCLR	0.196 (1.10)	0.222 (1.12)	0.220 (1.22)	0.245 (1.23)
CLR	-0.935 (2.71)	-0.956 (2.63)	-0.944 (2.72)	-0.964 (2.64)
DDER	0.302 (1.93)	0.321 (1.85)	0.319 (2.02)	0.337 (1.93)
DER	0.068 (1.82)	0.072 (1.85)	0.064 (1.71)	0.069 (1.76)
PTYES	-0.109 (0.59)	-0.103 (0.50)	-0.077 (0.42)	-0.072 (0.35)
PTIM	0.027 (3.76)	0.027 (3.35)	0.025 (3.36)	0.025 (3.01)
SKILYES	-0.241 (0.88)	-0.250 (0.83)	-0.232 (0.84)	-0.242 (0.79)
SKIL	0.023 (5.55)	0.023 (5.01)	0.023 (5.55)	0.023 (5.03)
NMAN	-0.002 (0.86)	-0.003 (0.82)	-0.002 (0.71)	-0.002 (0.68)
FEM	0.009 (2.28)	0.010 (2.09)	0.009 (2.00)	0.009 (1.84)
FEWCO	0.377 (1.67)	0.377 (1.51)	0.391 (1.72)	0.391 (1.55)
MONOP	-0.391 (0.70)	-0.396 (0.64)	-0.359 (0.63)	-0.365 (0.58)
REC	-0.450 (2.76)	-0.464 (2.57)	-0.395 (2.21)	-0.413 (2.09)
sector dummies	no	no	yes	yes
R^2	0.149	0.149	0.153	0.153
rss	8680.5	8682.5	8641.2	8643.3

TABLE 5.12

(A) DISTRIBUTION OF COMPANIES ACCORDING TO CHANGES IN DOMESTIC COMPETITION

Period 1985-89

		UP	NO CHANGE	DOWN	TOTAL
	UP	118 (50.42%) 615	9 (3.84%) 56	6 (2.56%) 33	133 (56.83%)
Period 1980-84	NOCHANGE	47 (20.08%) 235	28 (11.96%) 153	6 (2.56%) 31	81 (34.61%)
	DOWN	4 (1.70%) 16	9 (3.84%) 44	7 (2.99%) 36	20 (8.69%)
	TOTAL	169 (72.22%)	46 (19.65%)	19 (8.11%)	234

Note: For each category figures refer to the number of companies (and relative percentage) and to the number of observations

TABLE 5.13

Estim. Tech.	OLS	FGLS	OLS	FGLS
Companies	234	234	234	234
Observations	1219	1219	1219	1219
CONSTANT	-0.309 (0.71)	-0.294 (0.62)	-0.448 (0.97)	-0.427 (0.85)
SALESGR	0.019 (6.02)	0.018 (5.68)	0.019 (6.08)	0.018 (5.76)
WAGEGR	-0.017 (2.32)	-0.016 (2.25)	-0.017 (2.31)	-0.016 (2.24)
PROFIT	8.612 (7.30)	8.351 (6.77)	8.823 (7.39)	8.556 (6.87)
EMPLOYMENT	0.165 (0.24)	0.172 (0.23)	0.191 (0.28)	0.198 (0.26)
DCLR	0.137 (0.73)	0.155 (0.76)	0.165 (0.87)	0.183 (0.89)
CLR	-0.751 (2.01)	-0.762 (1.94)	-0.750 (1.99)	-0.762 (1.94)
DDER	0.218 (1.32)	0.231 (1.28)	0.239 (1.43)	0.251 (1.38)
DER	0.057 (1.43)	0.064 (1.54)	0.051 (1.28)	0.058 (1.41)
PTYES	-0.082 (0.41)	-0.077 (0.35)	-0.037 (0.18)	-0.033 (0.15)
PTIM	0.029 (3.87)	0.029 (3.50)	0.027 (3.43)	0.027 (3.13)
SKILYES	-0.366 (1.26)	-0.377 (1.18)	-0.351 (1.20)	-0.362 (1.13)
SKIL	0.025 (5.76)	0.025 (5.28)	0.026 (5.73)	0.026 (5.28)
NMAN	-0.002 (0.82)	-0.003 (0.79)	-0.002 (0.63)	-0.002 (0.62)
FEM	0.007 (1.65)	0.008 (1.53)	0.006 (1.27)	0.006 (1.20)
UKCOUP	0.142 (0.84)	0.142 (0.77)	0.185 (1.08)	0.185 (0.99)
REC	-0.446 (2.57)	0.458 (2.42)	-0.380 (1.99)	-0.397 (1.91)
sector dummies	no	no	yes	yes
R^2	0.155	0.155	0.160	0.160
rss	8465.2	8466.8	8416.1	8417.6

(B) DISTRIBUTION OF COMPANIES ACCORDING TO CHANGES IN FOREIGN COMPETITION

Period 1985-89

		UP	NO CHANGE	DOWN	TOTAL
	UP	123 (55.90%) 661	5 (2.27%) 26	2 (0.90%) 7	130 (59.09%)
Period 1980-84	NOCHANGE	33 (15.00%) 163	55 (25.00%) 275	0	88 (40.00%)
	DOWN	2 (0.90%) 13	0	0	2 (0.90%)
	TOTAL	158 (71.81%)	60 (27.27%)	2 (0.90%)	220

Note: For each category figures refer to the number of companies (and relative percentage) and to the number of observations

TABLE 5.14

Estim. Tech.	OLS	FGLS	OLS	FGLS
Companies	220	220	220	220
Observations	1145	1145	1145	1145
CONSTANT	0.062 (0.14)	0.069 (0.15)	-0.056 (0.11)	-0.047 (0.09)
SALESGR	0.015 (5.16)	0.015 (5.04)	0.015 (5.11)	0.015 (4.98)
WAGEGR	-0.020 (2.65)	-0.019 (2.66)	-0.019 (2.65)	-0.019 (2.65)
PROFIT	8.257 (7.28)	8.203 (7.12)	8.359 (7.23)	8.294 (7.06)
EMPLOYMENT	-0.159 (0.25)	-0.159 (0.24)	-0.190 (0.29)	-0.189 (0.28)
DCLR	0.003 (0.01)	0.006 (0.03)	0.015 (0.08)	0.018 (0.09)
CLR	-0.520 (1.45)	-0.526 (1.44)	-0.535 (1.48)	-0.542 (1.47)
DDER	0.253 (1.53)	0.256 (1.50)	0.260 (1.55)	0.264 (1.52)
DER	0.074 (1.88)	0.075 (1.90)	0.072 (1.84)	0.743 (1.86)
PTYES	-0.171 (0.90)	-0.170 (0.86)	-0.145 (0.76)	-0.144 (0.73)
PTIM	0.045 (4.07)	0.045 (3.95)	0.044 (3.99)	0.044 (3.85)
SKILYES	-0.501 (1.65)	-0.506 (1.61)	-0.483 (1.57)	-0.487 (1.53)
SKIL	0.016 (3.63)	0.016 (3.53)	0.016 (3.65)	0.016 (3.54)
NMAN	-0.002 (0.72)	-0.002 (0.71)	-0.002 (0.49)	-0.002 (0.49)
FEM	0.004 (0.91)	0.004 (0.89)	0.004 (0.91)	0.004 (0.88)
FCOUP	0.348 (2.01)	0.351 (1.98)	0.293 (1.60)	0.298 (1.57)
REC	-0.425 (2.41)	-0.429 (2.37)	-0.375 (1.93)	-0.381 (1.90)
sector dummies	no	no	yes	yes
R^2	0.131	0.131	0.133	0.133
rss	7196.7	7196.7	7180.2	7180.3

TABLE 5.15

DISTRIBUTION OF UNION DENSITY ACROSS COMPANIES

RANGE FOR DENSITY (d)	NUMBER OF COMPANIES	RELATIVE FREQUENCY (%)
d<=10%	9	7.37
10%<d<=25%	18	14.75
25%<d<=50%	19	15.57
50%<d<=75%	39	31.96
75%<d<=90%	25	20.49
90%<d<100%	9	7.37
d=100%	3	2.45
total	122	

TABLE 5.16

Estim. Tech.	OLS	FGLS	OLS	FGLS
Companies	233	233	233	233
Observations	1205	1205	1205	1205
CONSTANT	-0.301 (0.71)	-0.292 (0.63)	-0.361 (0.79)	-0.352 (0.71)
SALESGR	0.018 (5.97)	0.017 (5.59)	0.018 (5.88)	0.017 (5.52)
WAGEGR	-0.018 (2.42)	-0.017 (2.32)	-0.018 (2.44)	-0.017 (2.35)
PROFIT	8.199 (7.05)	7.960 (6.54)	8.425 (7.11)	8.170 (6.60)
EMPLOYMENT	-0.072 (0.10)	-0.063 (0.08)	-0.090 (0.13)	-0.080 (0.10)
DCLR	0.250 (1.29)	0.273 (1.29)	0.261 (1.33)	0.284 (1.33)
CLR	-0.921 (2.50)	-0.946 (2.45)	-0.947 (2.55)	-0.971 (2.49)
DDER	0.266 (1.57)	0.281 (1.51)	0.284 (1.66)	0.298 (1.59)
DER	0.115 (2.25)	0.118 (2.25)	0.111 (2.16)	0.114 (2.17)
PTYES	-0.083 (0.41)	-0.077 (0.35)	-0.047 (0.23)	-0.041 (0.19)
PTIM	0.026 (3.36)	0.025 (3.02)	0.024 (3.04)	0.024 (2.74)
SKILYES	-0.448 (1.52)	-0.461 (1.43)	-0.430 (1.45)	-0.443 (1.36)
SKIL	0.027 (5.82)	0.027 (5.33)	0.027 (5.80)	0.027 (5.32)
NMAN	-0.003 (0.84)	-0.003 (0.80)	-0.002 (0.72)	-0.002 (0.70)
FEM	0.010 (2.19)	0.010 (2.04)	0.009 (1.92)	0.009 (1.79)
DENSITY	-0.576 (2.27)	-0.589 (2.12)	-0.582 (2.13)	-0.597 (1.99)
sector dummies	no	no	yes	yes
R^2	0.154	0.154	0.158	0.158
rss	8673.0	8674.5	8636.0	8637.6

TABLE 5.17

Estim. Tech.	OLS	FGLS	OLS	FGLS
Companies	233	233	233	233
Observations	1205	1205	1205	1205
CONSTANT	-0.299 (0.70)	-0.284 (0.61)	-0.347 (0.75)	-0.327 (0.65)
SALESGR	0.017 (5.64)	0.016 (5.30)	0.018 (5.65)	0.017 (5.32)
WAGEGR	-0.019 (2.50)	-0.018 (2.40)	-0.019 (2.53)	-0.018 (2.43)
PROFIT	8.275 (7.11)	8.042 (6.61)	8.447 (7.14)	8.198 (6.63)
EMPLOYMENT	0.054 (0.80)	0.069 (0.09)	0.011 (0.01)	0.025 (0.03)
DCLR	0.235 (1.22)	0.258 (1.22)	0.244 (1.25)	0.266 (1.25)
CLR	-0.905 (2.46)	-0.932 (2.42)	-0.934 (2.52)	-0.960 (2.47)
DDER	0.291 (1.71)	0.305 (1.64)	0.302 (1.75)	0.314 (1.67)
DER	0.103 (2.02)	0.107 (2.04)	0.099 (1.94)	0.103 (1.96)
PTYES	-0.026 (0.13)	-0.021 (0.09)	0.007 (0.03)	0.013 (0.06)
PTIM	0.025 (3.23)	0.025 (2.90)	0.023 (2.85)	0.023 (2.57)
SKILYES	-0.419 (1.41)	-0.429 (1.32)	-0.431 (1.38)	-0.425 (1.29)
SKIL	0.026 (5.76)	0.026 (5.27)	0.027 (5.78)	0.027 (5.30)
NMAN	-0.003 (0.89)	-0.003 (0.88)	-0.003 (0.79)	-0.003 (0.78)
FEM	0.010 (2.20)	0.010 (2.05)	0.009 (1.93)	0.009 (1.80)
REC	-0.571 (2.95)	-0.590 (2.80)	-0.557 (2.65)	-0.579 (2.53)
UD>90	0.623 (1.64)	0.634 (1.52)	0.619 (1.62)	0.619 (1.50)
UD<25	0.598 (2.04)	0.625 (1.99)	0.672 (2.23)	0.706 (2.17)
sector dummies	no	no	yes	yes
R^2	0.158	0.158	0.162	0.162
rss	8631.9	8633.4	8595.2	8596.8

TABLE 5.18

Estim. Tech.	OLS	FGLS	OLS	FGLS
Companies	233	233	233	233
Observations	1205	1205	1205	1205
CONSTANT	-0.363 (0.85)	-0.355 (0.77)	-0.418 (0.91)	-0.408 (0.82)
SALESGR	0.018 (5.69)	0.017 (5.36)	0.018 (5.68)	0.017 (5.36)
WAGEGR	-0.019 (2.46)	-0.018 (2.36)	-0.019 (2.50)	-0.018 (2.40)
PROFIT	8.351 (7.18)	8.122 (6.68)	8.547 (7.22)	8.302 (6.73)
EMPLOYMENT	0.069 (0.10)	0.078 (0.10)	0.045 (0.06)	0.056 (0.07)
DCLR	0.253 (1.30)	0.275 (1.30)	0.269 (1.37)	0.291 (1.36)
CLR	-0.903 (2.45)	-0.930 (2.41)	-0.935 (2.52)	-0.959 (2.47)
DDER	0.300 (1.76)	0.314 (1.69)	0.309 (1.79)	0.323 (1.72)
DER	0.108 (2.12)	0.112 (2.14)	0.104 (2.03)	0.108 (2.06)
PTYES	-0.044 (0.22)	-0.038 (0.17)	-0.015 (0.07)	-0.009 (0.04)
PTIM	0.026 (3.35)	0.026 (3.03)	0.024 (2.95)	0.024 (2.68)
SKILYES	-0.423 (1.42)	-0.433 (1.33)	-0.415 (1.38)	-0.426 (1.30)
SKIL	0.027 (5.87)	0.027 (5.39)	0.028 (5.89)	0.028 (5.42)
NMAN	-0.002 (0.74)	-0.003 (0.72)	-0.002 (0.62)	-0.002 (0.61)
FEM	0.010 (2.21)	0.010 (2.06)	0.009 (1.94)	0.010 (1.82)
REC	-0.560 (2.78)	-0.572 (2.60)	-0.557 (2.54)	-0.571 (2.39)
UD>90	0.630 (1.64)	0.627 (1.51)	0.636 (1.66)	0.632 (1.52)
UD≤30	0.371 (1.46)	0.373 (1.34)	0.455 (1.73)	0.456 (1.58)
sector dummies	no	no	yes	yes
R^2	0.157	0.157	0.160	0.160
rss	8646.6	8648.0	8609.8	8611.3

TABLE 5.19

Estim. Tech.	OLS	FGLS	OLS	FGLS
Companies	233	233	233	233
Observations	1205	1205	1205	1205
CONSTANT	-0.312 (0.73)	-0.302 (0.65)	-0.378 (0.83)	-0.368 (0.75)
SALESGR	0.018 (5.81)	0.017 (5.48)	0.018 (5.74)	0.017 (5.42)
WAGEGR	-0.019 (2.52)	-0.018 (2.42)	-0.019 (2.55)	-0.018 (2.45)
PROFIT	8.207 (7.07)	7.985 (6.58)	8.448 (7.15)	8.213 (6.66)
EMPLOYMENT	0.058 (0.08)	0.065 (0.08)	0.016 (0.02)	0.023 (0.03)
DCLR	0.247 (1.27)	0.268 (1.27)	0.254 (1.29)	0.273 (1.28)
CLR	-0.899 (2.44)	-0.925 (2.40)	-0.923 (2.49)	-0.947 (2.44)
DDER	0.274 (1.61)	0.286 (1.54)	0.286 (1.67)	0.297 (1.59)
DER	0.102 (1.99)	0.106 (2.02)	0.098 (1.90)	0.102 (1.94)
PTYES	-0.052 (0.26)	-0.047 (0.22)	-0.017 (0.08)	-0.013 (0.06)
PTIM	0.024 (3.11)	0.024 (2.78)	0.022 (2.72)	0.022 (2.45)
SKILYES	-0.480 (1.63)	-0.495 (1.54)	-0.465 (1.56)	-0.481 (1.48)
SKIL	0.027 (5.96)	0.027 (5.48)	0.028 (5.94)	0.028 (5.48)
NMAN	-0.003 (0.86)	-0.003 (0.84)	-0.003 (0.79)	-0.003 (0.77)
FEM	0.010 (2.26)	0.010 (2.11)	0.010 (2.00)	0.010 (1.88)
DEN<25	2.104 (1.15)	2.339 (1.19)	2.423 (1.30)	2.631 (1.32)
25≤DEN≤90	-0.786 (2.82)	-0.793 (2.61)	-0.781 (2.61)	-0.789 (2.43)
DEN>90	0.121 (0.30)	0.109 (0.25)	0.128 (0.31)	0.116 (0.26)
sector dummies	no	no	yes	yes
R^2	0.160	0.160	0.164	0.163
rss	8619.2	8620.7	8578.1	8579.6

TABLE 5.20

Estim. Tech.	OLS	FGLS	OLS	FGLS
Companies	233	233	233	233
Observations	1205	1205	1205	1205
CONSTANT	0.349 (0.82)	-0.342 (0.74)	-0.411 (0.90)	-0.402 (0.81)
SALESGR	0.018 (5.73)	0.017 (5.41)	0.018 (5.70)	0.017 (5.38)
WAGEGR	-0.019 (2.49)	-0.018 (2.39)	-0.019 (2.52)	-0.018 (2.42)
PROFIT	8.271 (7.12)	8.050 (6.63)	8.489 (7.17)	8.250 (6.69)
EMPLOYMENT	0.045 (0.06)	0.051 (0.06)	0.019 (0.02)	0.026 (0.03)
DCLR	0.265 (1.37)	0.287 (1.36)	0.278 (1.42)	0.299 (1.41)
CLR	-0.909 (2.47)	-0.935 (2.43)	-0.938 (2.53)	-0.962 (2.48)
DDER	0.292 (1.72)	0.306 (1.65)	0.305 (1.77)	0.317 (1.70)
DER	0.107 (2.10)	0.111 (2.12)	0.103 (2.01)	0.107 (2.04)
PTYES	-0.041 (0.20)	-0.034 (0.15)	-0.011 (0.05)	-0.005 (0.02)
PTIM	0.026 (3.36)	0.026 (3.04)	0.024 (2.99)	0.024 (2.72)
SKILYES	-0.444 (1.50)	-0.455 (1.41)	-0.433 (1.45)	-0.444 (1.37)
SKIL	0.027 (5.92)	0.027 (5.44)	0.028 (5.95)	0.028 (5.48)
NMAN	-0.002 (0.77)	-0.003 (0.75)	-0.002 (0.66)	-0.002 (0.64)
FEM	0.010 (2.17)	0.010 (2.03)	0.009 (1.91)	0.009 (1.80)
DEN≤30	-0.652 (0.55)	-0.697 (0.55)	-0.357 (0.29)	-0.415 (0.31)
30<DEN≤90	-0.823 (2.95)	-0.834 (2.75)	-0.828 (2.76)	-0.842 (2.59)
DEN>90	0.091 (0.22)	0.075 (0.17)	0.093 (0.22)	0.075 (0.17)
sector dummies	no	no	yes	yes
R^2	0.158	0.158	0.161	0.161
rss	8638.3	8639.6	8600.0	8601.3

TABLE 5.21

DISTRIBUTION OF UNION DENSITY FOR COMPANIES WITH CLOSED SHOP SCHEMES

RANGE FOR DENSITY (d)	NUMBER OF COMPANIES
d<=10%	3
10%<d<=25%	6
25%<d<=50%	4
50%<d<=75%	6
75%<d<=90%	6
90%<d<100%	3
d=100%	1
total	29

TABLE 5.22

Estim. Tech.	OLS	FGLS	OLS	FGLS
Companies	242	242	242	242
Observations	1260	1260	1260	1260
CONSTANT	-0.368 (0.90)	-0.357 (0.80)	-0.490 (1.12)	-0.477 (1.00)
SALESGR	0.018 (5.95)	0.017 (5.57)	0.018 (5.94)	0.017 (5.55)
WAGEGR	-0.017 (2.39)	-0.016 (2.30)	-0.018 (2.42)	-0.017 (2.32)
PROFIT	8.295 (7.29)	8.048 (6.75)	8.447 (7.32)	8.179 (6.77)
EMPLOYMENT	0.060 (0.08)	0.076 (0.09)	0.055 (0.07)	0.070 (0.08)
DCLR	0.249 (1.33)	0.271 (1.33)	0.260 (1.34)	0.282 (1.36)
CLR	-0.927 (2.55)	-0.955 (2.50)	-0.931 (2.55)	-0.960 (2.50)
DDER	0.329 (2.02)	0.345 (1.93)	0.349 (2.12)	0.365 (2.01)
DER	0.068 (1.74)	0.072 (1.78)	0.065 (1.65)	0.069 (1.71)
PTYES	-0.079 (0.41)	-0.074 (0.35)	-0.062 (0.32)	-0.056 (0.26)
PTIM	0.027 (3.45)	0.027 (3.10)	0.025 (3.05)	0.025 (2.74)
SKILYES	-0.310 (1.10)	-0.319 (1.03)	-0.297 (1.05)	-0.306 (0.98)
SKIL	0.024 (5.35)	0.024 (4.88)	0.024 (5.29)	0.024 (4.82)
NMAN	-0.002 (0.82)	-0.003 (0.79)	-0.002 (0.73)	-0.003 (0.71)
FEM	0.010 (2.27)	0.010 (2.11)	0.010 (2.14)	0.010 (1.99)
REC	-0.492 (2.69)	-0.508 (2.55)	-0.433 (2.14)	-0.452 (2.04)
CLOSED	0.238 (0.97)	0.242 (0.89)	0.195 (0.77)	0.202 (0.72)
sector dummies	no	no	yes	yes
R^2	0.154	0.154	0.157	0.157
rss	8798.4	8800.2	8771.5	8773.3

TABLE 5.23

Estim. Tech.	OLS	OLS	OLS
Companies	226	226	226
Observations	1165	1165	1165
CONSTANT	-0.339 (0.78)	-0.34 (0.78)	-0.284 (0.65)
SALESGR	0.017 (5.58)	0.017 (5.58)	0.018 (5.68)
WAGEGR	-0.018 (2.37)	-0.018 (2.39)	-0.018 (2.33)
PROFIT	8.339 (7.04)	8.378 (7.07)	8.259 (6.97)
EMPLOYMENT	0.146 (0.19)	0.143 (0.19)	0.094 (0.12)
DCLR	0.277 (1.39)	0.271 (1.36)	0.277 (1.39)
CLR	-0.954 (2.52)	-0.955 (2.52)	-0.962 (2.53)
DDER	0.316 (1.81)	0.314 (1.80)	0.302 (1.73)
DER	0.11 (2.11)	0.11 (2.11)	0.114 (2.18)
PTYES	-0.081 (0.39)	-0.089 (0.43)	-0.109 (0.53)
PTIM	0.027 (3.28)	0.027 (3.30)	0.027 (3.25)
SKILYES	-0.43 (1.42)	-0.427 (1.41)	-0.426 (1.41)
SKIL	0.027 (5.73)	0.027 (5.76)	0.027 (5.63)
NMAN	-0.003 (0.91)	-0.003 (0.86)	-0.003 (1.03)
FEM	0.01 (2.24)	0.01 (2.21)	0.011 (2.25)
REC	-0.574 (2.77)	-0.573 (2.76)	-0.506 (2.48)
UD<30	0.422 (1.58)	0.422 (1.58)	0.36 (1.36)
UD>90	0.627 (1.61)	0.821 (1.69)	
CS>90		-0.487 (0.66)	0.249 (0.42)
sector dummies	no	no	yes
R^2	0.157	0.158	0.156
rss	8590.7	8587.4	8608.9

TABLE 5.24

Estim. Tech.	FGLS	FGLS	FGLS	FGLS
Period	1983-85	1983-85	1986-89	1986-89
Companies	186	186	236	236
Observations	507	507	769	769
CONSTANT	0.239 (0.33)	0.041 (0.05)	-0.660 (1.08)	-0.644 (0.99)
SALESGR	0.022 (4.26)	0.022 (4.14)	0.017 (4.41)	0.017 (4.50)
WAGEGR	0.001 (0.01)	0.000 (0.00)	-0.029 (3.10)	-0.029 (3.08)
PROFIT	6.448 (2.97)	6.662 (2.98)	8.601 (5.54)	8.706 (5.52)
EMPLOYMENT	0.353 (0.31)	0.356 (0.30)	-0.569 (0.57)	-0.682 (0.67)
DCLR	0.391 (1.22)	0.466 (1.40)	0.107 (0.38)	0.097 (0.34)
CLR	-0.972 (1.49)	-0.987 (1.49)	-1.073 (2.15)	-1.121 (2.21)
DDER	0.173 (0.62)	0.173 (0.60)	0.270 (1.09)	0.267 (1.05)
DER	0.003 (0.07)	-0.001 (0.02)	0.275 (3.45)	0.278 (3.47)
PTYES	-0.106 (0.32)	-0.090 (0.26)	-0.025 (0.08)	0.046 (0.15)
PTIM	0.019 (1.51)	0.014 (1.12)	0.032 (2.72)	0.032 (2.56)
SKILYES	-0.469 (0.92)	-0.430 (0.82)	-0.354 (0.83)	-0.378 (0.87)
SKIL	0.021 (2.87)	0.021 (2.79)	0.025 (3.90)	0.027 (4.04)
NMAN	-0.008 (1.44)	-0.008 (1.36)	0.001 (0.10)	0.001 (0.25)
FEM	0.008 (1.05)	0.008 (0.93)	0.013 (1.98)	0.012 (1.70)
REC	-0.711 (2.39)	-0.626 (1.92)	-0.240 (0.94)	-0.255 (0.90)
sector dummies	no	yes	no	yes
R^2	0.174	0.178	0.157	0.163
rss	3187.7	3172.2	5279.7	5241.9

TABLE 5.25

Estim. Tech.	OLS	FGLS	FGLS	FGLS
Period	1983-89	1983-89	1983-85	1986-89
Companies	138	138	138	138
Observations	883	883	391	492
CONSTANT	0.104 (0.19)	0.149 (0.22)	0.991 (1.15)	-0.452 (0.58)
SALESGR	0.021 (5.41)	0.018 (4.59)	0.017 (2.71)	0.021 (4.01)
WAGEGR	-0.033 (3.57)	-0.031 (3.44)	-0.023 (1.92)	-0.046 (3.32)
PROFIT	8.572 (5.45)	8.645 (4.85)	5.353 (2.11)	11.157 (4.97)
EMPLOYMENT	-0.357 (0.51)	-0.350 (0.39)	0.101 (0.08)	-1.040 (1.05)
DCLR	0.065 (0.30)	0.101 (0.37)	0.191 (0.54)	0.003 (0.01)
CLR	-0.926 (1.89)	-1.014 (1.88)	-0.452 (0.61)	-1.406 (1.95)
DDER	0.182 (0.94)	0.186 (0.76)	0.131 (0.40)	0.222 (0.79)
DER	0.232 (3.48)	0.244 (3.39)	0.027 (0.29)	0.464 (4.51)
PTYES	-0.137 (0.58)	-0.146 (0.49)	-0.145 (0.38)	-0.106 (0.30)
PTIM	0.031 (3.94)	0.031 (3.09)	0.020 (1.54)	0.037 (3.23)
SKILYES	-0.423 (1.11)	-0.445 (0.92)	-0.578 (0.93)	-0.295 (0.53)
SKIL	0.019 (3.99)	0.019 (3.19)	0.010 (1.29)	0.025 (3.60)
NMAN	-0.001 (0.35)	-0.001 (0.33)	-0.007 (1.13)	0.002 (0.35)
FEM	0.004 (0.95)	0.005 (0.75)	0.005 (0.60)	0.005 (0.77)
REC	-0.372 (1.84)	-0.398 (1.56)	-0.619 (1.79)	-0.338 (1.18)
sector dummies	no	no	no	no
R^2	0.147	0.146	0.109	0.204
rss	5545.9	5550.4	2267.8	3131.2

TABLE 5.26

Estim. Tech.	OLS	OLS	OLS	OLS	OLS
Sector	2	3	4	5	6
Companies	30	57	75	15	72
Observations	171	297	378	78	381
CONSTANT	-2.425 (2.83)	0.307 (0.36)	-1.594 (1.58)	5.535 (2.73)	0.092 (0.12)
SALESGR	0.016 (3.12)	0.017 (3.96)	0.024 (2.90)	0.003 (0.43)	0.016 (2.86)
WAGEGR	-0.027 (2.43)	-0.009 (0.71)	-0.015 (0.92)	-0.029 (1.76)	-0.015 (1.14)
PROFIT	0.982 (4.27)	0.518 (3.80)	0.936 (2.70)	0.91 (2.47)	1.157 (3.61)
EMPLOYMENT	-0.211 (0.45)	0.218 (0.06)	-0.001 (0.90)	-9.135 (0.40)	-0.289 (0.14)
DCLR	0.066 (0.18)	-0.011 (0.03)	-0.166 (0.40)	0.512 (0.95)	0.653 (1.73)
CLR	-0.235 (0.36)	-0.061 (0.10)	-0.633 (1.03)	-1.809 (1.17)	-2.585 (1.95)
DDER	0.283 (0.99)	0.238 (0.85)	0.113 (0.30)	-0.201 (0.39)	0.129 (0.37)
DER	0.048 (0.41)	0.076 (0.73)	0.62 (4.38)	-0.128 (0.56)	-0.012 (0.24)
PTYES	-0.748 (2.12)	0.265 (0.81)	-0.047 (0.11)	1.203 (1.70)	0.275 (0.61)
PTIM	-0.001 (0.01)	-0.013 (0.19)	0.077 (3.52)	-0.044 (0.85)	0.013 (1.01)
SKILYES	0.706 (1.08)	-0.262 (0.45)	-0.409 (0.65)	-4.918 (2.63)	-0.528 (1.03)
SKIL	0.021 (1.67)	0.013 (1.81)	0.015 (1.60)	-0.009 (0.64)	0.036 (3.80)
NMAN	0.01 (1.02)	-0.005 (0.79)	0.008 (0.93)	-0.041 (2.14)	-0.011 (1.72)
FEM	0.026 (1.96)	0.008 (0.74)	0.007 (0.90)	-0.023 (0.54)	0.008 (0.77)
REC	0.606 (1.52)	-0.912 (2.82)	0.725 (1.57)	1.33 (1.85)	-0.863 (2.35)
R^2	0.332	0.248	0.180	0.541	0.196
rss	278.8	1211.3	3433.1	127.9	3142.6

Note: see Appendix 4B for the definition of SIC sectors

TABLE 5.27

DISAGGREGATION OF COMPANIES ACCORDING TO THEIR UNION STATUS IN THE EIGHTIES

	ALL	%	ESTIMATION SAMPLE	%	SIC1	SIC2	SIC3	SIC4	SIC5	SIC6	SIC7
TOTAL	359		294		3	34	66	87	17	82	5
NO CHANGE	300	83.6	249	84.7	2	28	57	75	13	72	2
RECBEG	222	61.8	177	60.2	3	27	37	69	11	27	3
RECEND	219	61.0	176	59.9	3	27	36	68	11	29	2
LESSREC	40	11.1	29	9.9	1	5	6	7	3	5	2
DEREC	10	2.8	7	2.4	0	0	3	2	0	1	1
- 1980-84	4		2		0	0	1	1	0	0	0
- 1985-89	6		5		0	0	2	1	0	1	1
PARDEREC	30	8.4	22	7.5	1	5	3	5	3	4	1
- 1980-84	2		2		0	0	1	1	0	0	0
- 1985-89	25		17		1	4	2	4	2	3	1
- Both	3		3		0	1	0	0	1	1	0
MOREREC	19	5.3	16	5.4	0	1	3	5	1	5	1
- 1980-84	5		4		0	0	2	1	1	0	0
- 1985-89	11		9		0	1	1	3	0	3	1
- Both	3		3		0	0	0	1	0	2	0
NEWREC	7	1.9	6	2.0	0	0	2	1	0	3	0
- 1980-84	4		3		0	0	2	0	0	1	0
- 1985-89	3		3		0	0	0	1	0	2	0

TABLE 5.28

Estim. Tech.	OLS	FGLS	OLS	FGLS
Companies	294	294	294	294
Observations	1551	1551	1551	1551
CONSTANT	-0.320 (0.83)	-0.315 (0.73)	-0.339 (0.83)	-0.330 (0.72)
SALESGR	0.018 (6.36)	0.017 (5.92)	0.018 (6.44)	0.017 (5.98)
WAGEGR	-0.018 (2.61)	-0.017 (2.52)	-0.018 (2.61)	-0.017 (2.52)
PROFIT	9.667 (9.43)	9.322 (8.55)	9.782 (9.41)	9.417 (8.52)
EMPLOYMENT	-0.350 (0.83)	-0.334 (0.70)	-0.203 (0.46)	-0.193 (0.39)
DCLR	0.240 (1.40)	0.263 (1.36)	0.253 (1.46)	0.275 (1.42)
CLR	-0.947 (2.90)	-0.961 (2.77)	-0.981 (2.97)	-0.992 (2.83)
DDER	0.320 (2.11)	0.343 (2.02)	0.320 (2.10)	0.343 (2.00)
DER	0.079 (2.06)	0.082 (2.07)	0.076 (1.98)	0.080 (2.01)
PTYES	0.018 (0.10)	0.024 (0.12)	0.039 (0.22)	0.048 (0.22)
PTIM	0.038 (5.73)	0.038 (5.05)	0.037 (5.36)	0.036 (4.72)
SKILYES	-0.306 (1.13)	-0.314 (1.03)	-0.309 (1.13)	-0.318 (1.03)
SKIL	0.022 (5.36)	0.022 (4.79)	0.023 (5.46)	0.023 (4.87)
NMAN	-0.002 (0.90)	-0.002 (0.80)	-0.002 (0.77)	-0.002 (0.68)
FEM	0.004 (1.03)	0.004 (0.93)	0.003 (0.72)	0.003 (0.67)
RECBEG	-0.455 (2.77)	-0.464 (2.53)	-0.441 (2.50)	-0.453 (2.29)
LESSREC	0.262 (1.03)	0.228 (0.83)	0.338 (1.31)	0.297 (1.06)
MOREREC	0.365 (1.08)	0.398 (1.06)	0.377 (1.12)	0.411 (1.09)
sector dummies	no	no	yes	yes
R^2	0.163	0.162	0.165	0.165
rss	10992.9	10996.6	10960.6	10965.0

TABLE 5.29

Estim. Tech.	OLS	FGLS	OLS	FGLS
Companies	294	294	294	294
Observations	1551	1551	1551	1551
CONSTANT	-0.319 (0.83)	-0.314 (0.73)	-0.331 (0.81)	-0.322 (0.70)
SALESGR	0.018 (6.36)	0.017 (5.93)	0.018 (6.44)	0.017 (5.99)
WAGEGR	-0.018 (2.63)	-0.017 (2.53)	-0.018 (2.62)	-0.017 (2.52)
PROFIT	9.623 (9.40)	9.277 (8.52)	9.744 (9.38)	9.379 (8.50)
EMPLOYMENT	-0.381 (0.90)	-0.363 (0.77)	-0.263 (0.59)	-0.252 (0.51)
DCLR	0.237 (1.38)	0.260 (1.35)	0.249 (1.44)	0.270 (1.39)
CLR	-0.966 (2.96)	-0.976 (2.82)	-0.999 (3.03)	-1.005 (2.88)
DDER	0.321 (2.12)	0.344 (2.02)	0.321 (2.11)	0.343 (2.01)
DER	0.078 (2.03)	0.081 (2.05)	0.074 (1.94)	0.078 (1.97)
PTYES	0.008 (0.04)	0.014 (0.07)	0.029 (0.17)	0.034 (0.17)
PTIM	0.037 (5.63)	0.037 (4.97)	0.036 (5.30)	0.036 (4.69)
SKILYES	-0.298 (1.10)	-0.306 (1.10)	-0.308 (1.13)	-0.317 (1.03)
SKIL	0.022 (5.36)	0.022 (4.80)	0.023 (5.45)	0.023 (4.87)
NMAN	-0.002 (0.84)	-0.002 (0.75)	-0.002 (0.73)	-0.002 (0.65)
FEM	0.004 (1.05)	0.004 (0.95)	0.003 (0.73)	0.003 (0.68)
RECBEG	-0.451 (2.75)	-0.460 (2.51)	-0.431 (2.45)	-0.444 (2.25)
LESSREC	0.499 (1.77)	0.466 (1.52)	0.577 (2.01)	0.536 (1.73)
DEREC	-1.081 (1.94)	-1.072 (1.78)	-1.096 (1.93)	-1.086 (1.76)
MOREREC	0.377 (1.12)	0.409 (1.10)	0.384 (1.14)	0.418 (1.11)
sector dummies	no	no	yes	yes
R^2	0.165	0.164	0.167	0.167
rss	10965.8	10969.4	10933.9	10938.1

TABLE 5.30

Estim. Tech.	OLS	FGLS	OLS	FGLS
Companies	294	294	294	294
Observations	1551	1551	1551	1551
CONSTANT	-0.310 (0.81)	-0.305 (0.71)	-0.312 (0.78)	-0.312 (0.68)
SALESGR	0.018 (6.38)	0.017 (5.93)	0.018 (6.45)	0.017 (5.99)
WAGEGR	-0.018 (2.63)	-0.017 (2.53)	-0.018 (2.62)	-0.017 (2.52)
PROFIT	9.614 (9.39)	9.266 (8.51)	9.733 (9.37)	9.364 (8.48)
EMPLOYMENT	-0.333 (0.77)	-0.319 (0.66)	-0.224 (0.50)	-0.216 (0.43)
DCLR	0.233 (1.36)	0.256 (1.33)	0.245 (1.42)	0.267 (1.37)
CLR	-0.987 (3.01)	-0.994 (2.85)	-1.017 (3.07)	-1.020 (2.90)
DDER	0.316 (2.08)	0.339 (1.99)	0.316 (2.08)	0.339 (1.98)
DER	0.078 (2.03)	0.081 (2.05)	0.074 (1.94)	0.079 (1.98)
PTYES	0.011 (0.06)	0.017 (0.09)	0.032 (0.18)	0.037 (0.19)
PTIM	0.038 (5.66)	0.037 (4.99)	0.037 (5.32)	0.036 (4.70)
SKILYES	-0.312 (1.15)	-0.319 (1.04)	-0.320 (1.17)	-0.328 (1.06)
SKIL	0.022 (5.38)	0.022 (4.81)	0.023 (5.46)	0.023 (4.88)
NMAN	-0.002 (0.89)	-0.002 (0.79)	-0.002 (0.77)	-0.002 (0.68)
FEM	0.004 (1.05)	0.004 (0.95)	0.003 (0.73)	0.003 (0.67)
RECBEG	-0.433 (2.60)	-0.443 (2.38)	-0.417 (2.33)	-0.430 (2.14)
LESSREC	0.491 (1.74)	0.459 (1.50)	0.570 (1.98)	0.529 (1.70)
DEREC	-1.078 (1.94)	-1.069 (1.77)	-1.092 (1.92)	-1.082 (1.75)
MOREREC	0.214 (0.49)	0.261 (0.54)	0.244 (0.55)	0.289 (0.59)
NEWREC	0.394 (0.57)	0.368 (0.48)	0.341 (0.50)	0.319 (0.42)
sector dummies	no	no	yes	yes
R^2	0.165	0.165	0.167	0.167
rss	10963.4	10967.2	10932.1	10936.5

TABLE 5.31

Dependent Var.	WAGE	WAGE	WAGE	WAGE
Estim. Tech.	OLS	FGLS	OLS	FGLS
Companies	253	253	233	233
Observations	1322	1322	1205	1205
CONSTANT	9.430 (22.53)	9.455 (11.58)	9.220 (20.72)	9.511 (10.92)
SALES	0.188 (9.26)	0.279 (10.79)	0.191 (7.98)	0.282 (10.20)
PROFIT	3.684 (3.40)	2.865 (2.76)	3.703 (3.32)	2.430 (2.29)
EMPLOYMENT	-0.114 (7.32)	-0.175 (7.88)	-0.121 (6.71)	-0.180 (7.65)
PTYES	-0.711 (3.60)	-0.709 (1.81)	-0.671 (3.23)	-0.705 (1.71)
PTIM	-0.102 (12.36)	-0.101 (6.20)	-0.105 (12.57)	-0.104 (6.25)
SKILYES	-0.037 (0.12)	-0.074 (0.12)	0.017 (0.05)	0.037 (0.06)
SKIL	-0.003 (0.63)	-0.003 (0.32)	-0.006 (1.23)	-0.004 (0.47)
NMAN	0.053 (14.81)	0.052 (7.30)	0.055 (14.32)	0.052 (6.87)
FEM	-0.028 (5.79)	-0.025 (2.66)	-0.029 (5.79)	-0.027 (2.72)
REC	0.288 (1.50)	0.371 (0.98)		
DENSITY			0.891 (3.14)	0.494 (0.90)
sector dummies	yes	yes	yes	yes
R^2	0.421	0.401	0.437	0.411
rss	10204.0	10576.3	9460.1	9894.0

Note: see page 245.

TABLE 5.32

Estim. Tech.	OLS	FGLS	OLS	FGLS
Companies	253	253	233	233
Observations	1322	1322	1205	1205
CONSTANT	-0.316 (0.66)	-0.296 (0.56)	-0.309 (0.60)	-0.284 (0.50)
SALESGR	0.018 (6.15)	0.017 (5.73)	0.018 (5.91)	0.017 (5.52)
WAGE	-0.028 (1.13)	-0.027 (1.04)	-0.028 (1.04)	-0.028 (1.00)
PROFIT	8.641 (7.66)	8.335 (7.03)	8.531 (7.17)	8.270 (6.64)
EMPLOYMENT	-0.071 (0.10)	-0.058 (0.08)	-0.092 (0.13)	-0.083 (0.10)
DCLR	0.254 (1.40)	0.279 (1.39)	0.292 (1.49)	0.316 (1.46)
CLR	-0.867 (2.48)	-0.897 (2.43)	-0.941 (2.53)	-0.972 (2.48)
DDER	0.324 (2.04)	0.340 (1.93)	0.290 (1.68)	0.304 (1.61)
DER	0.069 (1.80)	0.073 (1.86)	0.119 (2.33)	0.123 (2.34)
PTYES	-0.060 (0.32)	-0.053 (0.25)	-0.057 (0.28)	-0.052 (0.23)
PTIM	0.023 (2.89)	0.023 (2.58)	0.022 (2.64)	0.022 (2.36)
SKILYES	-0.281 (1.02)	-0.292 (0.95)	-0.418 (1.40)	-0.433 (1.32)
SKIL	0.023 (5.57)	0.024 (5.04)	0.027 (5.74)	0.027 (5.24)
NMAN	-0.001 (0.08)	-0.001 (0.12)	-0.001 (0.25)	-0.001 (0.27)
FEM	0.008 (1.70)	0.008 (1.58)	0.008 (1.69)	0.008 (1.58)
REC	-0.420 (2.33)	-0.438 (2.19)		
DENSITY			-0.549 (2.00)	-0.566 (1.88)
sector dummies	yes	yes	yes	yes
R^2	0.151	0.151	0.154	0.154
rss	8900.3	8902.4	8671.7	8673.4

APPENDIX 5A

This appendix describes the model from which an estimated equation like (5.1) can be derived. The model is based on Denny and Nickell (1992)[1]. A firm facing a downward-sloping demand curve for its product is assumed to choose a stream of investment using intertemporal optimisation under adjustment costs. The firm's investment decision is taken in the knowledge that the wage will then be determined in each period as the result of bargaining between the firm and the union along the labour demand curve ("Right-to-Manage" model). Hence a two-stage structure is preserved as in the models presented in sections 1.3 to 1.5. Wage bargaining is described by the Generalised Nash Bargaining Solution. It is important to stress that the main purpose of this appendix is to set out a theoretical framework, based on Denny and Nickell (1992), for the definition of the estimated equations in the chapter rather than to provide specific predictions arising from the model.

Wage bargaining is analysed first. As described in section 1.2 the objective function for wage bargaining when the Generalised Nash Bargaining Solution is adopted can be written as[2]

---

[1]See also Urga (1991).

[2]The cooperative or axiomatic approach is here employed whereby disagreement pay-offs are represented by the outside options for the firm and the workers (no production and the alternative wage, respectively).

(5A.1) $$V = \left[U(w,L) - U(\overline{w})\right]^{\alpha} \cdot \left[p \cdot F(K,L) - w \cdot L\right]^{(1-\alpha)}$$

where

$U(\cdot)$ = union's objective function, $F(K,L)$ = production function,

α = union bargaining power ($0 \leq \alpha \leq 1$), w = wage, K = capital stock,

L = employment, $\overline{w}$ = alternative wage, p = output price

As a result the bargained level of the wage will depend on the quantity of capital, which is treated as fixed when wage bargaining takes place, the union bargaining power, and the alternative wage, i.e.

(5A.2) $$w = w(K,\alpha,\overline{w})$$

with L determined along the labour demand curve.

The production function is assumed to be

(5A.3) $$Y = F(K,L)$$

where Y = output.

Adjustment costs are given by

(5A.4) $$C\ (I,\ \alpha,\ p_K/\overline{p})$$

where

I = investment, $p_K/\overline{p}$ = price of investment (relative to the general price level).

Denny and Nickell (1992) assume that

(5A.5) $$\frac{\partial C}{\partial I} > 0,\ \frac{\partial^2 C}{\partial I^2} > 0,\ \frac{\partial C}{\partial \alpha} < 0,\ \frac{\partial C}{\partial(\frac{p_K}{\overline{p}})} \gtrless 0 \text{ if } I \gtrless 0$$

(5A.1) $$V = \left[U(w,L) - U(\overline{w})\right]^{\alpha} \cdot \left[p \cdot F(K,L) - w \cdot L\right]^{(1-\alpha)}$$

where

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with L determined along the labour demand curve.

The production function is assumed to be

(5A.3) $$Y = F(K,L)$$

where Y = output.

Adjustment costs are given by

(5A.4) $$C\,(I,\ \alpha,\ p_K/\overline{p})$$

where

I = investment, $p_K/\overline{p}$ = price of investment (relative to the general price level).

Denny and Nickell (1992) assume that

(5A.5) $$\frac{\partial C}{\partial I} > 0,\ \frac{\partial^2 C}{\partial I^2} > 0,\ \frac{\partial C}{\partial \alpha} < 0,\ \frac{\partial C}{\partial(\frac{p_K}{\overline{p}})} \gtrless 0 \text{ if } I \gtrless 0$$

It is worth noticing that in (5A.4) $C(\cdot)$ includes not only investment with the assumption of convexity of adjustment costs, but also the cost of capital, and, especially, union bargaining power. Hence unions are assumed to affect investment choices directly (and negatively in Denny and Nickell's approach) through their impact on adjustment costs (see the discussion in section 1.8).

The demand function is defined by

$$Y = (p/\overline{p})^{-\eta} \cdot \overline{Y} \tag{5A.6}$$

assuming $\eta = \eta(\overline{Y})$

where

η = elasticity of demand, $\overline{Y}$ = demand shift parameter.

The problem of the firm at time 0 is

$$\max_{I_t} \int_0^{+\infty} e^{-rt} \cdot [p \cdot F(K,L) - w \cdot L - C(I,\alpha,p_K/\overline{p})]dt \tag{5A.7}$$

subject to (5.A8) $\dot{K} \equiv \frac{dK}{dt} = I - \delta \cdot K$ and $w = w(K,\alpha,\overline{w})$

(for the sake of semplicity time indices are dropped)

where

δ = rate of capital depreciation, and r = discount rate (both are fixed parameters).

From (5A.3) and (5A.6)

$$p = F(K,L)^{-1/\eta} \cdot \overline{p} \cdot \overline{Y}^{1/\eta} \tag{5A.9}$$

It is worth noticing that in (5A.4) $C(\cdot)$ includes not only investment with the assumption of convexity of adjustment costs, but also the cost of capital, and, especially, union bargaining power. Hence unions are assumed to affect investment choices directly (and negatively in Denny and Nickell's approach) through their impact on adjustment costs (see the discussion in section 1.8).

The demand function is defined by

(5A.6) $$Y = (p/\overline{p})^{-\eta} \cdot \overline{Y}$$

assuming $\eta = \eta(\overline{Y})$

where

η = elasticity of demand, $\overline{Y}$ = demand shift parameter.

The problem of the firm at time 0 is

(5A.7) $$\max_{I_t} \int_0^{+\infty} e^{-rt} \cdot [p \cdot F(K,L) - w \cdot L - C(I,\alpha,p_K/\overline{p})] dt$$

subject to (5.A8) $\dot{K} \equiv \frac{dK}{dt} = I - \delta \cdot K$ and $w = w(K,\alpha,\overline{w})$

(for the sake of semplicity time indices are dropped)

where

δ = rate of capital depreciation, and r = discount rate (both are fixed parameters).

From (5A.3) and (5A.6)

(5A.9) $$p = F(K,L)^{-1/\eta} \cdot \overline{p} \cdot \overline{Y}^{1/\eta}$$

so that the objective function becomes

$$\max_{I_t} \int_0^{+\infty} e^{-rt} \cdot \left[\overline{p} \cdot F(K,L)^{\epsilon} \cdot \overline{Y}^{1/\eta} - w \cdot L - C(I,\alpha,p_K/\overline{p})\right] dt$$

where $\epsilon = 1 - 1/\eta$.

The labour demand curve is obtained by maximising the profit with respect to L. The FOC for this maximisation is given by

$$\text{(5A.10)} \qquad \overline{p} \cdot \epsilon \cdot F(K,L)^{-1/\eta} \cdot F_K(K,L) \cdot \overline{Y}^{1/\eta} = w$$

which using (5A.8) can be rewritten as

$$\text{(5A.11)} \qquad p \cdot \epsilon \cdot F_L(K,L) = w$$

The maximisation problem of the firm (5A.7) is a typical optimal control problem. Let the Hamiltonian be

$$\text{(5A.12)} \quad H = e^{-rt} \cdot \left[\overline{p} \cdot F(K,L)^{\epsilon} \cdot \overline{Y}^{1/\eta} - w \cdot L - C(I,\alpha,p_K/\overline{p})\right] + \lambda \cdot (I - \delta \cdot K)$$

(λ is the socalled costate variable)

Assuming perfect foresight the Hamiltonian conditions are given by

$$H_i = 0 \Rightarrow \qquad \text{(5A.13)} \qquad -e^{-rt} \cdot \frac{\partial C}{\partial I} + \lambda = 0$$

$H_k = -\dot{\lambda} \Rightarrow$

$$e^{-rt}\cdot\left\{\overline{p}\cdot\epsilon\cdot F(K,L)^{-1/\eta}\cdot F_K(K,L)\cdot\overline{Y}^{1/\eta}+\overline{p}\cdot\epsilon\cdot F(K,L)^{-1/\eta}\cdot F_L(K,L)\cdot\frac{\partial L}{\partial K}\cdot\overline{Y}^{1/\eta}+\right.$$

$$\left.-w\cdot\frac{\partial L}{\partial K}-\frac{\partial w}{\partial K}\cdot L\right\}-\lambda\cdot\delta = -\dot{\lambda} \qquad (5A.14)$$

reminding that $w = w(K,\alpha,\overline{w})$ and that employment is chosen along the labour demand curve.

Rearranging (5A.14) yields

$$e^{-rt}\cdot\left[\epsilon\cdot p\cdot F_K(K,L)+\frac{\partial L}{\partial K}\cdot\Big(p\cdot\epsilon\cdot F_L(K,L)-w\Big)-\frac{\partial w}{\partial K}\cdot L\right]-\lambda\cdot\delta = -\dot{\lambda}$$

but from (5A.11) $\quad p\cdot\epsilon\cdot F_L(K,L) = w \quad$ so that (5A.14) becomes

$$(5A.15) \qquad e^{-rt}\cdot\left[\epsilon\cdot p\cdot F_K(K,L)-\frac{\partial w}{\partial K}\cdot L\right]-\lambda\cdot\delta = -\dot{\lambda}$$

From (5A.13) $\lambda = e^{-rt}\cdot\frac{\partial C}{\partial I}$. Differentiating with respect to time and assuming that $\frac{\partial C}{\partial I}$ is independent on time yields

$$(5A.16) \qquad \dot{\lambda} = -r\cdot e^{-rt}\cdot\frac{\partial C}{\partial I}$$

Thus (5A.15) becomes

$$e^{-rt}\cdot\left[\epsilon\cdot p\cdot F_K(K,L) - \frac{\partial w}{\partial K}\cdot L\right] - e^{-rt}\cdot\delta\cdot\frac{\partial C}{\partial I} = r\cdot e^{-rt}\cdot\frac{\partial C}{\partial I}$$

i.e. (5A.17) $$(r+\delta)\cdot\frac{\partial C}{\partial I} = \epsilon\cdot p\cdot F_K(K,L) - \frac{\partial w}{\partial K}\cdot L$$

The outcome of wage bargaining, $w = w(K,\alpha,\overline{w})$, is assumed to obey

(5A.18) $$\frac{\partial \log w}{\partial \log K} = \gamma(\alpha,\overline{w})$$

(see Denny and Nickell (1992) for this assumption)

so that (5A.17) can be rearranged as follows

(5A.19) $$(r+\delta)\cdot\frac{\partial C}{\partial I} = \epsilon\cdot p\cdot F_K(K,L) - \left(\frac{\partial w}{\partial K}\cdot\frac{K}{w}\right)\cdot\frac{w}{K}\cdot L$$

and using (5A.18) and (5A.11)

(5A.20) $$(r+\delta)\cdot\frac{\partial C}{\partial I} = \epsilon\cdot p\cdot F_K(K,L) - \gamma(\alpha,\overline{w})\cdot p\cdot\epsilon\cdot F_L(K,L)\cdot\left(\frac{K}{L}\right)^{-1}$$

Hence

(5A.21) $$(r+\delta)\cdot\frac{\partial C}{\partial I} = \epsilon\cdot p\cdot\left[F_K(K,L) - \frac{\gamma(\alpha,\overline{w})\cdot F_l(K,L)}{(K/L)}\right]$$

Assuming that the expression in square brackets can be simplified as $\Phi\left(\frac{K}{L}, \alpha, \overline{w}\right)$ gives as final condition

$$(5A.22) \qquad (r+\delta)\cdot\frac{\partial C}{\partial I}(I,\alpha,p_K/\overline{p}) = \epsilon\cdot p\cdot\Phi\left(\frac{K}{L}, \alpha, \overline{w}\right)$$

Denny and Nickell (1992) parameterise $\frac{\partial C}{\partial I}(\cdot)$, ϵ, and $\Phi\left(\cdot\right)$ as follows

$$\frac{\partial C}{\partial I} = B_1\cdot I^{b_1}\cdot a^{b_2}\cdot(p_K/\overline{p})^{b_3}$$

$$\epsilon = B_2\cdot\overline{Y}^{b_4} \qquad (5A.23)$$

$$\Phi = B_3\cdot\left(\frac{K}{L}\right)^{b_5}\cdot a^{b_6}\cdot\overline{w}^{b_7}$$

Taking logs yields the empirical counterpart of equation (14). By solving for *log*I

$$log I = \frac{1}{b_1}\cdot\left(log B_2 + log B_3 - log(r+\delta) - log B_1\right) + \frac{b_6 - b_2}{b_1}\cdot log a + \frac{1}{b_1}\cdot log p +$$

$$(5A.24) \qquad - \frac{b_3}{b_1}\cdot log(p_K/\overline{p}) + \frac{b_4}{b_1}\cdot log\overline{Y} + \frac{b_5}{b_1}\cdot log\left(\frac{K}{L}\right) + \frac{b_7}{b_1}\cdot log\overline{w}$$

which represents Denny and Nickell's empirical model.

Alternatively, linear approximations of (5A.24) can be taken so as to give an equation like (5.1).

APPENDIX 5B

This appendix provides a brief description of the estimation techniques for panel data used in the chapter. In light of the presence of time invariant regressors at the company level (see, for instance, union recognition), Fixed Effects estimation is not feasible and Random Effects, together with pooled OLS, are mostly used. The main aim of this appendix is to detail, without proofs[1], how the Feasible GLS estimator for the Random Effect Model is computed. A mention is also given to an alternative estimator proposed by Hsiao for the case where some regressors are time invariant. This latter technique has been been used only when it has proved impossible to obtain FGLS estimates (see below for the negative estimated variance problem), although results based on it are not reported in the chapter.

The empirical model used throughout the chapter can be written as follows (see (5.2)[2])

(5B.1) $$Y_{it} = \alpha_i + X_{it} \cdot \beta + Z_i \cdot \gamma + \epsilon_{it} \qquad i = 1,..., N$$

where Y represents the investment measure, X is a vector of K_x time-varying (at the individual level) regressors, e.g. profitability, sales, employment, etc., and Z is a vector of K_z time invariant regressors, e.g union recognition, workforce

[1]For proofs and a detailed anaysis of the properties of panel data estimators see Hsiao (1986), Baltagi (1995), Judge et al. (1985, ch. 13), Greene (1991, 1993), Schmidt (1992), and Hausman and Taylor (1981).

[2]U_i, a separate regressor in equation (5.2) relating to union presence, is subsumed in Z_i in equation (5B.1).

characteristics, etc. Let $K_x + K_z = K$. The α's are individual fixed effects. Finally, ϵ_{it} is an indipendently and identically distributed random variable with mean 0 and variance σ_ϵ^2. N is the number of firms in the sample. The number of observations for each firm is T_i, i = 1, ... N, and it is not restricted to be the same across firms. Hence the panel is unbalanced.

1. If no regressor is time invariant ($K_z = 0$), i.e. if all regressors belong to X, then the Within, or Least Squares Dummy Variables estimator can be computed. It is easily shown that this amounts to the estimation of β from the following OLS regression

(5B.2) $$(Y_{it} - \overline{Y}_i) = (X_{it} - \overline{X}_i) \cdot \beta + \epsilon_{it}$$

where $\overline{Y}_i = \frac{1}{T_i} \cdot \sum_{t=1}^{T_i} Y_{it}$ and $\overline{X}_i = \frac{1}{T_i} \cdot \sum_{t=1}^{T_i} X_{it}$

Hence the Within estimator, $\hat{\beta}_w$ say, is obtained using the deviations from the group means in an OLS regression. The fixed effects, α_i, are then estimated as follows

(5B.3) $$\hat{\alpha}_i = \overline{Y}_i - \overline{X}_i \cdot \hat{\beta}_w \qquad i = 1,...N$$

If some regressors are time invariant ($K_z > 0$), i.e. if they are individual specific, so that $X_{it} = \overline{X}_i \ \forall t$, the Within estimator cannot be computed. Two routes can then be taken.

2. Hsiao Two-Step Estimator. Hsiao (1986, 50-52) suggests estimating a model like (5B.1) by firstly obtaining Within estimates for β as under 1, omitting the time invariant regressors, Z, from the regression. To estimate γ OLS can then be applied to

$$(5B.4) \qquad \overline{Y}_i - \overline{X}_i \cdot \hat{\beta}_w = Z_i \cdot \gamma + \overline{\epsilon}_i \qquad i = 1, \ldots N$$

The fixed effects are then estimated in a way analogous to (5B.3).

3. When individual specific regressors are included the Random Effects Model can still be used. Model (5B.1) can be reformulated as follows

$$(5B.5) \qquad Y_{it} = \mu + X_{it} \cdot \beta + Z_i \cdot \gamma + \alpha_i + \epsilon_{it}$$

assuming that

$$E(\epsilon_{it}) = E(\alpha_i) = 0 \quad E(\alpha_i) = \sigma_\alpha^2 \quad E(\epsilon_{it}) = \sigma_\epsilon^2$$

$$(5B.6) \qquad E(\epsilon_{it} \cdot \alpha_j) = 0 \quad \forall\, t, i, j \qquad E(\alpha_i \cdot \alpha_j) = 0 \quad \forall\, i \neq j$$

$$E(\epsilon_{it} \cdot \epsilon_{js}) = 0 \quad \forall\, t \neq s, i \neq j$$

It has been shown[3] that by appropriate transformation of (5B.5) GLS can be applied. This procedure amounts to estimating with OLS the following regression

$$[Y_{it} - (1 - \theta) \cdot \overline{Y}_i] = (1 - \theta) \cdot \mu + [X_{it} - (1 - \theta) \cdot \overline{X}_i)] \cdot \beta + \theta \cdot Z_i \cdot \gamma + \text{ error}$$

(5B.7)

[3]See any of the references in footnote 1.

where $$\theta = \sqrt{\frac{\sigma_\epsilon^2}{\sigma_\epsilon^2 + \left(\frac{1}{Q}\right)\cdot\sigma_\alpha^2}} \qquad (5B.8)$$

with σ_ϵ^2 and σ_α^2 as defined in (5B.6). The factor (1/Q) in (5B.8) refers to the size of the individual groups. This correction is needed given the unbalanced nature of the panel. Q is defined as (see Greene (1991, 312))

$$(5B.9) \qquad Q = \frac{1}{N}\cdot\sum_{i=1}^{N}\left(\frac{1}{T_i}\right)$$

If the panel is balanced, i.e. $T_i = T \ \forall i$, i = 1, ... N, $Q = \frac{1}{T}$.

The variances σ_ϵ^2 and σ_α^2, and thus θ, are not known and need to be estimated in order to carry out the estimation of (5B.7). This provides the Feasible GLS (FGLS) estimator. Estimates of σ_ϵ^2 and σ_α^2 are obtained as follows:

$$(5B.10) \qquad \hat{\sigma}_\epsilon^2 = \frac{\sum_{i=1}^{N}\sum_{t=1}^{T_i}[(Y_{it} - \overline{Y}_i) - \hat{\beta}_w\cdot(X_{it} - \overline{X}_i)]^2}{N^* - N - K_x}$$

$$(5B.11) \qquad \hat{\sigma}_\alpha^2 = \frac{\sum_{i=1}^{N}(\overline{Y}_i - \mu - \overline{X}_i\cdot\beta - Z_i\cdot\gamma)^2}{N - (K + 1)} - Q\cdot\hat{\sigma}_\epsilon^2$$

where $N^* = \sum_{i=1}^{N} T_i$ (the total number of available observations)

Hence $\hat{\sigma}_\epsilon^2$ is estimated using the within-group residuals from the regression that omits all the individual specific regressors Z, while the estimation of σ_α^2 is based on the sum of squared residuals from the between-group estimation, i.e the OLS regression with sample N carried out using the group means of each regressor (including the time invariant ones). Once $\hat{\sigma}_\epsilon^2$ and $\hat{\sigma}_\alpha^2$ have been obtained, θ can be estimated and the OLS regression in (5B.7) can be carried out. It is important to notice that the nature of the computation of $\hat{\sigma}_\alpha^2$ does not rule out a negative result. Although some techniques have been proposed to remedy the problem[4], a negative estimated variance component is interpreted as failure of the technique.

[4]For instance the negative estimate can be set equal to zero (see Judge et al. (1985. 525)).

APPENDIX 5C

LIST OF VARIABLES USED IN REGRESSION ANALYSIS

See Appendix 4A and sections 5.2 and 5.3 for additional information and sources.

All variables are defined at the company level. Superscript $*$ denotes a dummy (0 or 1) variable. Superscript $+$ denotes a time invariant regressor.

INV = Investment - Sales ratio (x100).

SALES = Current value of sales.

SALESGR = Annual percentage growth of sales.

EMPLOYMENT = Total employment.

WAGE = Per capita average wage (i.e. total labour costs over total employment).

WAGEGR = Annual percentage growth of per capita average wage.

PROFIT = Pre Tax Profit / Sales.

CLR = Cash - Liabilities ratio.

$DCLR^*$ = Positive cash-liabilities ratio (i.e. CLR $>$ 0).

DER = Debt - Equity ratio.

$DDER^*$ = Positive debt-equity ratio (i.e. DDER $>$ 0).

$PTIM^+$ = Percentage of part-time workers.

$PTYES^{*+}$ = Company employing some part-time workers (i.e. PTIM$>$0).

$SKIL^+$ = Percentage of skilled workers.

SKILYES^{*+} = Company employing some skilled workers (i.e. SKIL$>$0).

FEM^{+} = Percentage of female workers.

NMAN^{+} = Percentage of non-manual workers.

REC^{*+} = Union recognition in some or all establishments.

RECALL^{*+} = Union recognition in all establishments.

DENSITY = Union density (percentage).

UD$>$X* = Union density greater than X % (UD$<$X, UD $\leq$ X, and UD $\geq$ X are similarly defined).

DEN$>$X = UD$>$X $*$ DENSITY (DEN$<$X, DEN $\leq$ X, and DEN $\geq$ X are similarly defined).

CLOSED^{*+} = Existence of closed shop arrangements.

CS$>$X* = CLOSED $*$ UD$>$X.

FEWCO^{*+} = Company facing less than five competitors in the product market.

MONOP^{*+} = Company facing no competitors in the product market.

UKCOUP* = Increased domestic competition in the product market.

FCOUP* = Increased foreign competition in the product market.

RECBEG^{*+} = Union recognition at the beginning of the period (1980).

LESSREC* = Company experiencing derecognition (partial or complete).

DEREC* = Company experiencing complete derecognition (no establishment is currently unionised)

MOREREC* = Increase in the number of establishments recognising unions.

NEWREC* = Company recognising unions for the first time.

CONCLUSIONS

The aim of this thesis has been to provide some new results concerning the effect of unions on investment and innovation. The issue has been tackled on both the theoretical and the empirical level.

In the Introduction three channels through which unionisation can affect innovation and investment were mentioned. If the impact through work rules and restrictive practices is left aside, the effect of unions crucially depends on the relative importance of the "rent-seeking" mechanism stressed by Grout (1984) as opposed to the traditional "substitution effect" between capital and labour.

The theoretical model of innovation adoption in the presence of unions, wage bargaining and oligopolistic product markets developed in chapter 2 clearly shows the effectiveness of the "rent-seeking" argument. The main result is that an environment in which both unions are relatively strong (i.e. they have a high and similar union bargaining power as defined by the Generalised Nash Bargaining Solution) will, *ceteris paribus*, harm innovation in both firms. Conversely, the presence of relatively weak unions will be conducive to the adoption of new and more productive technologies. If instead there is enough spread between the two unions, in terms of their bargaining power, so that only one firm is able to innovate, it is always the firm faced with the weaker union which adopts the technology (provided the two unions have the same relative concern over employment and pay). Hence the "rent-seeking" effect, which works through higher wage demands stemming from the increased rents accruing from innovation, has a powerful effect on a firm's choice of technical change.

The results summarised above are based on the assumption that the perceived trade-off between wage and employment is the same across unions. If this is not the case, it is possible that the firm facing the more powerful union will be the only one to adopt the new technology. This outcome arises when the union facing the firm in question cares relatively more about employment than the "rival" union. This result shows that environments where unions value the defense of employment more than pay rises tend to favour innovation.

The theoretical results outlined above show that union strength is to some extent detrimental to innovation, but no policy conclusions should be rushed on this basis. This point is made particularly clear by noticing that there are cases where the innovation would not be adopted by any firm, *ceteris paribus*, under competitive (non-unionised) labour markets, but in which one firm would innovate in a unionised labour market.

The extensions of the analysis considered in chapter 3 corroborate the findings of the model. In particular, the presence of implicit collusion among firms in the product market tends to facilitate innovation, *ceteris paribus*, since bargained wages decline with the degree of collusion. Some attention has also been paid to the generalisation of the model so as to allow for the choice of the capital stock instead of the choice between innovating and sticking to the existing technology. The numerical results obtained in this case depend on the assumptions on the parameter values and claims of generality for these findings cannot be made. This caveat notwithstanding, the main prediction of the adoption model, i.e. the negative effect of union power on the capital level, is confirmed. At the same time no support is found for the interesting results put forward by Moene (1990) according to which increases in union power do not tend, as widely believed, to bias the choice of techniques in a capital-intensive direction.

The econometric analysis presented in chapter 5 appears to provide some evidence that union recognition involves *ceteris paribus* a lower propensity to invest for the sample of U.K. non-agricultural quoted companies over the period 1982-1989 used in this work. This result broadly confirms the findings of Denny and Nickell (1992), the most influential work available to date on the subject in the U.K., but based on industry data. A few qualifications, though, need to be made concerning this result.

The result appears to be robust to the consideration of product market conditions, i.e. the extent as well as the changes in the degree of competition, both domestic and foreign, over the period. On the other hand, the negative effect of recognition is more prominent during the first part of the period analysed and tends to die away at the end of the eighties. The effect of unions also seems likely to be rather non-homogeneous across industries. This sectoral disaggregation is worthy of additional analysis.

As is the case with other studies, no separate effect on investment can be linked with the presence of closed shop arrangements. A more intriguing issue is represented by the effect of union density conditional on recognition, for which annual data are available for a substantial number of unionised companies. Union density has a negative effect on investment. This work therefore reverses Denny and Nickell's findings. However, there is some evidence that this negative effect is mainly driven by companies with an intermediate range of unionisation. Firms where density is either very high (above 90 % approximately) or very low (below 25-30 %) have an investment performance which is not very different from similar non-union firms. More data and more work on the issue are certainly desirable.

A very topical issue in the analysis of the effects of unions during the eighties concerns the impact of changes in unions status, mostly derecognition, on firm performance. This thesis sheds some light on the matter by showing that there is some evidence (but definitely not overwhelming) that companies which decided to partially derecognise unions over the period have benefitted in terms of investment performance *ceteris paribus* over the short-run. This outcome does not characterise those companies which have completely derecognised: the very limited number of such cases, however, imposes caveats on the judgement of this result.

To conclude, the empirical analysis seems to support, with some qualifications, the predictions, cast in terms of the innovation adoption model, concerning the impact of union strength on innovation and investment. More data are needed in order to distinguish between "direct" and "indirect" union effects on investment. In general, further empirical work should concentrate on data which match more closely the construction of the theoretical model in order to establish the robustness of the results obtained in this thesis.

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