TECHNOLOGICAL AND FINANCIAL FACTORS IN MODELS OF WAGE DETERMINATION

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ABSTRACT

The present dissertation develops some theoretical models which analyze the impact on wages of the financial and technological choices operated by firms.

Chapter I considers the effects of technological change on efficiency-wages. We adopt Kremer's (1993) "O-Ring" production function, where technical progress can be represented through a change in the number of tasks to be performed in production. More complex production processes imply higher wage levels and higher general equilibrium unemployment. The model is extended to analyze within-group wage dispersion.

In Chapter II, we adopt an alternating-calls strategic bargaining model where the incentive to reach an early agreement does not rely on time-preferences, but on intrinsic decay in the cake's size. When outside options remain positive and constant over time and the interval between calls shrinks to zero, the solution to this game converges to the Nash-solution, where the outside options take the *status quo* positions. This result contrasts with Rubinstein (1982), where outside options can matter only as corner-solutions. The model is extended to consider the role of market factors on wage determination.

Chapter III considers the strategic role of debt in wage negotiations. Since debt provides a "credible threat" in bargaining, the entrepreneur can increase her profits by borrowing. Debt, thus, constitutes a (partial) remedy to Grout's (1984) under-investment problem.

Chapter IV extends the model developed in Chapter III to analyze the implications that strategic borrowing can have on technological sophistication. We show that debt may have positive effects not only on the quantity of investment, but also on the degree of sophistication of the chosen projects.

Chapter V (with G.Marini) analyses the role of foreign debt in promoting investment in Less Developed Countries that are subject to political risks. We show that, when default can trigger trade sanctions, foreign debt reduces the negative effects of political uncertainty on capital accumulation.

Chapter VI (with F.Bagliano) contrasts the explanation for mark-up

countercyclicality offered by the "price-war" model of Rotemberg and Saloner (1986) with the alternative explanation, based on "liquidity constraints", proposed by Chevalier and Scharfstein (1996).

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INTRODUCTION

The importance of issues such as technological change and capital budgeting is indicated by the attention of both professional economists and public opinion.

Although technological and financial factors invest a huge variety of economic aspects, here we will mainly be interested in their effects on a variable of particular relevance, the wage. To this purpose, the present dissertation will develop some theoretical models which analyse the impact on wages of the financial and technological choices operated by firms. As will be argued, the theoretical predictions obtained are broadly consistent with the existing empirical evidence.

The effects of technological change on labour market conditions have recently generated deep and broad concern. While there have been fears in the general public that technological progress may have a devastating impact on employment, academics have put greater emphasis on the effects of technical change on wage dispersion.

Chapter I develops an efficiency-wage model to investigate how technical change can affect wage levels and, in particular, wage inequality. Wage dispersion can be measured along different dimensions, since workers' observed characteristics differ in terms of education, age/experience, etc. During the Eighties, both the US and the UK have experienced increasing wage dispersion among workers of different observed quality (between-group wage inequality) as well as among workers of the *same* observed quality (within-group wage inequality). As Levy and Murnane (1992) note, changing characteristics in the quality of the labour supply, together with "skill-biased" shifts in labour demand, can satisfactorily explain the increasing between-group dispersion that has been reported. What remains to be better understood, however, is the part of inequality that was growing among workers of similar experience and schooling.

In the model we propose there are two main components, the efficiency wage principle and a characterisation of technology based on Kremer's (1993) "O-Ring" production function. The adoption of the efficiency-wage principle puts all the emphasis on the labour-demand side. On the other hand, the O-Ring theory of production conceives the production process as composed of several tasks, which can be mis-performed with positive probability. Mis-performance of even a single task leads to relevant losses in revenues or, at the extreme, to production failure. In the O-Ring approach, the number of tasks required by a production process can be interpreted as a measure of its technological sophistication. Since higher sophistication raises the risks of production failure for any given level of workers' effort, firms will have an incentive to pay higher wages, so to better motivate their employees and, thus, reduce the chances of an incorrect performance.

When we extend the model to analyse the behaviour of firms that adopt technologies of different sophistication and hire, at the same time, workers of homogeneous quality, between-firm within-group wage differentials arise in equilibrium. As a consequence, the wage a worker is paid can just be a matter of luck, depending on the firm which hired her. Other models, such as Bulow and Summers (1986) and Bertola and Ichino (1995), can also justify the existence of within-group inequality for reasons other than differences in the production technology. Those models, however, do not investigate the possible causes of the observed changes in wage dispersion. By contrast, our approach predicts that when the degree of technological sophistication among firms tends to diverge, wage inequality will rise. This conclusion seems quite consistent with several features of the evolution that has taken place in American industry during the Eighties.

* * *

The second part of the dissertation (from Chapter II to Chapter IV) is based on strategic bargaining theory, following the seminal work by Rubinstein (see Rubinstein (1982)).

Chapter II considers the issue of *outside options* in strategic bargaining theory. As emphasised by Binmore, Rubinstein and Wolinsky (1986), when one refers to a bargaining model *a la* Rubinstein (1982), where the driving force leading to an agreement depends on players' "impatience", outside options matter only as corner solutions to the game. Then, if the strategic foundations laid down by Rubinstein are strictly followed, the outside options levels cannot be interpreted as the *status quo* positions of the Nash-maximand, as commonly assumed in many labour economics applications.

In the strategic bargaining model we propose, agents still alternate in making proposals to each other. However, the driving force for an agreement is not (or, not only) constituted by time-discounting as in Rubinstein. We postulate that, if delay occurs, the cake's size itself intrinsically decays over time. In this perspective, the forces that govern the shrinking of the cake need not affect the external options available to the players. Our benchmark model, where the players' discount rate is zero and the outside options remain constant over time, generates two main results. The first is that the bargaining game has a finite horizon and always gives a unique Perfect Equilibrium solution, even for a number of players *greater than two*. This result can be better appreciated by recalling that, when the Rubinstein's model is applied to a game with more than two players, multiple solutions generally arise (see, e.g., Sutton (1986)). The second implication of our model is that, when the interval between two subsequent calls shrinks to zero, the game solution converges to the Nash solution where the *status quo*'s coincide with the outside options. This result, which is in neat contrast with the prescriptions that Binmore, Rubinstein and Wolinsky (1986) derive from Rubinstein (1982), provides thus a theoretical justification to the common practice of inserting the players' outside option levels in Nash-maximands.

In the concluding part of Chapter II, we apply the "decaying cake" model to wage negotiations to investigate *(i)* the effects of multi-union bargaining, *(ii)* the relation between bargained wages and efficiency-wages and, *(iii)* the influences that outside options have on investment in workforce's training.

After laying down the basic bargaining model, we consider the role of financial factors in wage negotiations (Chapter III to Chapter V). Extensive research has been devoted to investigate the determinants of corporate structure (see, e.g., Harris and Raviv (1991)). However, the effects of the financing choice on wages have only been explored in a small number of papers.

Chapter III analyses the wage bargaining process when an entrepreneur can choose whether to finance a project with debt or own-funds (or equity). An analogous problem is considered in Dasgupta and Sengupta (1993) and Perotti and Spier (1993), who find that debt reduces the amount of surplus that workers can appropriate. Similar results are also obtained in our framework. The innovation of the model we propose, however, is that we explicitly model the event of bankruptcy as a bargaining game. Our approach, thus, spells out the precise circumstances that make debt a "credible threat" for workers.

The core of the model is based on the idea that, when liquidation is dominated, default transfers the property rights of the firm's physical assets from the entrepreneur to lenders. Lenders, then, become entitled to negotiate over the surplus the firm can still produce. When both the entrepreneur and the workforce cannot be dispensed with in production, default generates a three-party bargaining game among lenders, workforce and the entrepreneur herself. By using a simple backward induction argument, we show that, in equilibrium, workers will have to bear a fraction of the repayments on the debt which has been raised and pocketed by the entrepreneur. In other words, firms can borrow to constrain workers' rent-seeking behaviour.

A relevant corollary to the main result is that the strategic use of debt raises the level of investment an entrepreneur is willing to implement. Thus, debt is a (partial) remedy to Grout's (1984) under-investment problem.

Chapter IV exploits the idea (developed in the previous Chapter) that debt can be used as a device to modify the distribution of surplus. The most relevant aspect of the model developed here, however, is the explicit analysis of the interactions between the entrepreneur's financing decisions and the degree of technological complexity chosen in equilibrium. In fact, in the spirit of Kremer (1993), production can be seen as a process where several complementary tasks must be performed.

When firms' surplus is shared through bargaining, increasing technological sophistication has advantages as well as costs. On the one hand, a more complex process can deliver goods that sell at higher prices. On the other hand, however, greater sophistication generally entails a larger number of tasks which have to be performed by additional agents. If these additional agents manage to gain some bargaining power over the surplus, there will be an "adverse distributive effect" that may cause under-sophistication in the technologies adopted. Indeed, an entrepreneur will generally have an incentive to undertake production processes that are *less* sophisticated than the socially optimal ones. We show however that, when the entrepreneur can borrow, the adverse distributive effect due to greater sophistication is smaller. In other words, debt can reduce both the Grout's under-investment problem (as we already know from the model in Chapter III) and the under-sophistication inefficiency we devise here.

This model has valuable implications from the viewpoint of the literature relating financial development to "growth". As emphasised by King and Levine (1993), financial development is a predictor of future growth. This observation is broadly consistent with our approach. In fact, since developed financial markets allow entrepreneurs to borrow more easily, our model predicts that the aggregate quantity of investment, as well as the quality of the projects implemented, are stimulated.

Chapter V contains joint work with Giancarlo Marini (University of Tor Vergata, Rome). Here, we focus on foreign debt as a possible incentive for investment in Less Developed Countries. Although the basic mechanism at work here is analogous to that of Chapter Three, the questions at stake are quite peculiar.

Workers' rent-seeking behaviour may discourage investment both in developed and less-developed countries. What is peculiar to LDCs, however, is that entrepreneurs are subject to political risks - such as risks of expropriation or very unfavourable taxation - in the event that a populist government comes into office. However, entrepreneurs can use *foreign* debt strategically, so to secure a larger share of investment's surplus. In fact, when foreign debt is implicitly backed by the threat of international sanctions (see Bulow and Rogoff (1989)), we show that an entrepreneur who borrows abroad can reduce the expected losses from adverse political changes.

This model provides a number of quite relevant implications. We conclude that foreign debt stimulates investment, that politically unstable countries may still be able to raise large amounts of debt from abroad, that foreign debt is more effective than Foreign Direct Investment to stimulate physical capital accumulation. Some of these predictions may seem *prima facie* counterfactual: for example, it has been commonly thought that large foreign debt had been detrimental for LDC investment (see, e.g., Sachs (1988)). However, some recent evidence reported in Warner (1993) supports the view that the large LDC debt had a *positive* effect on investment.

Finally, the approach we propose seems quite fruitful to explore some quite puzzling questions such as, why did the LDCs borrow so much from abroad in the past?

* * *

Chapter VI is joint work with Fabio Bagliano (University of Turin). In this Chapter, we abandon the analysis of wage determinants to deal with a different topic, the cyclicality of mark-ups in oligopolistic industries.

We build on Rotemberg and Saloner's (1986) analysis of implicit collusion between oligopolists over the business cycle. While monopoly pricing is likely to be sustainable in low-demand states, high-demand states provide greater incentives for an oligopolist to undercut rivals. As a consequence, mark-ups in oligopolistic sectors tend to move countercyclically.

Differently from Rotemberg and Saloner (1986), Chevalier and Scharfstein (1996) explain countercyclical mark-ups in a model with capital-market imperfections and customer's switching-costs. When firms need to raise debt, they may default. For this reason, firms have less incentive to build market share because they are not sure to receive the future benefits of the investment. Thus, since the probability of default is particularly high during recessions, capital-market imperfections tend to generate countercyclical mark-ups. Chevalier and Scharfstein also claim that the economic mechanism they devise is in contrast with the logic of "tacit collusion" exploited by Rotemberg and Saloner (1986): in fact, if "liquidity constraints" were introduced into the model of Rotemberg and Saloner, *procyclical* mark-ups would arise.

We tackle Chevalier and Scharfstein's claim explicitly, showing that it is not generally correct. The formal argument in Chevalier and Scharfstein (1996) boils down to the assumption that, for a firm, the probability of surviving a period of recession is strictly less than one. We adopt this characterisation in the context of Rotemberg and Saloner (1986) and find that, depending on the values of parameters, the modified model can generate *both* procyclical *and* anticyclical mark-ups. In the latter case, we also show that mark-ups are *more* anticyclical than the ones corresponding to the original Rotemberg and Saloner's model.

Chapter I

EFFICIENCY WAGES WITH O-RING PRODUCTION FUNCTIONS.
The Effects of Technological Change
on Unemployment and Within-Group Wage Inequality.

Introduction.

In the last few years, the labour market implications of technological change have captured both the public's and economists' attention. On the one side, non-academic press has put very much emphasis on the apocalyptic views expressed by Jeremy Rifkin's *End of Work*. According to Rifkin, the pervasive changes brought about by technological advancements (especially for what it concerns information technology) are going to destroy an unprecedented number of jobs. On the other side, labour economists have been concentrating more and more on the increase in wage dispersion observed during the eighties and the beginning of the nineties in the U.S. and the U.K. (see the OECD Employment Outlook (1996)). This topic has been another relevant argument of debate in the American press, since it is closely related to the so-called "deindustrialization" process and the much feared vanishing of middle-class jobs.

In this Chapter, we look at the effects of technical change on wage-levels, unemployment and wage-differentials by assuming that firms are competitive and set wages on the basis of efficiency considerations. The notion of technology we use is Kremer's (1993) "O-Ring" theory of production. Complex technologies require that several tasks are performed in the production process. However, the higher the number of tasks, the greater the probability that something goes wrong during production and output is destroyed. We modify the original Kremer's approach by assuming that the probability that each task is correctly performed depends, through effort, on the wage paid to the worker. We can thus look at technological change as a process that makes available new production technologies over time. Such new processes entail different degrees of complexity. In particular, when technical progress moves exogenously towards higher complexity in production, our model predicts that firms will have incentive to pay higher wages. Since complicated technologies are relatively more risky, higher wages elicit greater effort and, thus, increase the probability that each task will be performed successfully. Moreover, assuming that the worker's effort function is also increasing in the rate of unemployment, we show that the higher wage level involved by greater complexity in production causes higher unemployment in equilibrium. Similar results are obtained when the choice of technological complexity is endogeneised and progress affects, for example, the probability of success in production: even in this case, firms will have an incentive to adopt more sophisticated production process and pay higher wages over time. As a consequence, the unemployment rate will increase. Thus, if technological change were to be seen as a force that pushes only towards increasing complexity in production (for example, one may consider the *Challenger* spacecraft as a natural evolution of the aircraft industry), the fears of those who think that new technologies destroy jobs would be well grounded. However, historical experience stands against a positive correlation between technical change and unemployment. In contrast with Rifkin's view, it is also implausible to think that the present spread of information technology (computers, software and advanced telecommunication systems) is to be seen as a more pervasive and traumatic event than was the adoption of steam-engines in the nineteenth century or electric-powered machinery in the first two decades of this century.

Since technological change does not seem to imply necessarily higher unemployment[1], we turn our focus to a different question: is it possible to explain wage differentials among workers of the *same quality* through the relation between technology and wages that we devise? The question is a relevant one, both empirically and theoretically. As Levy and Murnane (1992) emphasise, there is much empirical evidence that stresses the relevance of what is known as *within-group inequality*: workers of the same observed quality in terms of gender, age/experience and education receive very different wages depending on the firm, or plant, that employs them (see, e.g., Davis and Haltiwanger (1991)). This deviation from what competitive wage theory predicts[2] has been theoretically justified by the two-sector efficiency wage model developed by Bulow and Summers (1986). In that paper, there is a primary sector (say, manufacturing) where production processes can only be imperfectly monitored. Primary sector wages, thus, must induce workers not to shirk. On the other hand, since workers in the secondary sector can be perfectly monitored on the workplace, they are paid the competitive wage. Thus, in Bulow and Summers' paper, between-sector wage differentials among workers of the same quality arise simply because of different abilities to monitor. Our approach provides a different story. Consider two firms (or sectors) characterised by different degrees of complexity in the technology they adopt. Even if the ability to monitor is the same in every production process, different wages will still be paid to workers of the *same* quality. In particular, firms adopting less sophisticated technologies will pay lower wages: in fact, less complexity ensures a reasonably high probability of success in production even when workers provide less effort. Also in our model, then, wages do not necessarily reward skills in equilibrium:

simply, some "lucky" workers get high wages, while other workers of the same ability are paid low wages.

Bertola and Ichino (1995) propose a different interpretation for the existing within-group wage dispersion in flexible labour markets, such as the American and the British ones. Even when workers have homogeneous skills, firms that are subject to idiosyncratic productivity shocks are willing to pay different wages. If workers face strictly positive costs in moving from "bad" to "good" firms, wage differentials will arise in equilibrium. Moreover, when firm-level productivity shocks become less persistent (a measure of increasing "turbulence"), wage differentials will become larger.

We believe that our technology-based approach[3] may have some advantages with respect to Bulow and Summers (1986) and Bertola and Ichino (1995). In reference to Bulow and Summers' paper, we explicitly focus on differences in production technologies, rather than different monitoring technologies among firms or sectors. On the other hand, it is quite hard to relate Bertola and Ichino's measure of shock persistence, which affects the stability of firms' labour demand curves, to a precise notion of technical change.

Technological change has been one of the main suspects for increased wage dispersion during the eighties. A large emphasis has been given, in particular, to the impact of "skill-biased technical change" on *between-group* wage dispersion[4]. However, by a theoretical point of view, the dynamic evolution of *within-group* wage inequality, ever growing from 1963 to 1989 in the U.S.[5], is hardly explained. We modify our basic model by supposing that the firms in the economy may have incentives to implement technologies that entail a diverging degree of sophistication. For instance, certain firms may tend to make their products more sophisticated (e.g., Ferrari's or Bentleys), while others may tend to simplify and standardise their product (e.g., Fiat or Ford). Under this hypothesis, we show that technological progress implies rising inter-firm wage differentials while it has ambiguous effects on the equilibrium unemployment rate. These predictions seem to be consistent with U.S. and British data.

In conclusion, we do not directly answer the important question raised by Levy and Murnane (1992):

> "..why do some firms respond to increasing competitive pressures by out-sourcing, speeding up production lines, and demanding wage and benefits givebacks from unions, while others invest in training and reorganising production so as to improve quality and manage costs?" (p.1374)

Our model, however, justifies formally the Levy and Murnane's conjecture on the consequences of these market transformations:

> "It may be that these different strategies reflect the organisation of the market. Some firms may choose to compete for larger shares of standardised products produced by low wage workers carrying out relatively simple tasks. Other firms may choose to taylor production to a high value-added, high quality product at the upper end of the same market. Both strategies may prove successful in generating profits, but with quite different consequences for workers' wages." (p.1374)

The Chapter is organised as follows. Section 1 develops the basic model, relating the wage level to the degree of technological complexity. Section 2 extends the basic model to analyse investment in monitoring intensity. Section 3 considers the degree of complexity in production as endogenous. Section 4 develops a model with heterogeneous firms, in order to analyse the issue of wage differentials. Section 5 extends the model in Sect.4 to consider the issue of minimum wages. We show that the introduction of a wage legislation, while artificially constraining wage dispersion, has a theoretically ambiguous impact on the unemployment rate. Section 6 concludes. In Appendices I-II-III we give the micro-foundations of the models analysed in Sect.1 and Sect.4 by following the asset-equation approach (see Shapiro and Stiglitz (1984)). In Appendix V we sketch a simple extension of the model where, for given workers' effort, some tasks have a better chance of success than others. When workers of higher quality perform the more difficult tasks, we obtain some interesting predictions about *between*-group wage inequality.

1. The Basic Model.

In the present model, we treat the worker's incentive problem by adopting a standard formulation for the "effort-function". A worker produces e units of effort depending on both the relative wage she receives, w/w_0, and the unemployment rate u. Thus:

$$e = e\left(\frac{w}{w_0}, u\right), \quad (e_w, e_u) > 0, \quad (e_{ww}, e_{uu}, e_{wu}) < 0 \tag{1}$$

where w is the real wage paid by the firm considered and w_0 is the average wage paid in the economy. Workers are willing to produce more effort when they are paid relatively better. Higher unemployment induces to work harder and it also reduces the wage-effect over effort.[6] Appendix I shows in detail that, by adopting an "asset-equation" approach of the kind of Shapiro and Stiglitz (1984), one can derive an effort equation which has the same characteristics as those postulated in (1) if, *(i)* the instantaneous utility function of the individual is multiplicative in wage and effort disutility (i.e., $U=w\cdot f(e)$, with $f(0)=1$ and $f'(e)<0$) and, *(ii)* the unemployment benefit is proportional to the average wage w_0, i.e., the benefit is equal to $\rho\cdot w_0$, with $\rho\in[0,1)$.

As far as technology is concerned, we adopt the "O-Ring Production Function", discussed in Kremer (1993). This technology characterises the production process through the number of tasks, n, that it entails. The parameter n can be interpreted as an index of the complexity of the technology adopted. We assume for simplicity that each task is performed by a single worker[7]. However, while Kremer's analysis is built on workers that are characterised by *different levels of skills*, here each worker has the *same ability*, and the probability that her performance is successful depends positively on the level of effort exerted. The probability that the worker's performance at a task i turns out to be successful is measured by $q_i\in(0,1)$. q_i can be seen as the expected fraction of product's maximum value that is retained when the worker executes the task. We thus have that $q_i=q_i(e)$, with $q_i'>0$ and $q_i''\leq 0$, where e is defined in (1). We abstract from capital. B denotes the output per worker if all the tasks are performed perfectly. Since a firm obtains nB with probability $\Pi_i q_i$, the (expected) level of revenues for given n is:

$$y = \left(\prod_{i=1}^{n} q_i(e)\right) nB \qquad (2)$$

Firms are risk-neutral and competitive.

In Kremer's problem, the firm chooses the degree of skill of the workers to be employed by referring to an (exogenously given) upward sloping wage-skill curve. By contrast, here the firm has to pick the wage to be paid to each worker, so to induce the optimal level of effort. The profit maximisation problem is then:

$$\max_{\{w_i\}} \left(\prod_{i=1}^{n} q_i[e(w_i/w_0;u)]\right) nB - \left(\sum_{i=1}^{n} w_i\right) \qquad (3)$$

By imposing symmetry ($w_i=w_j=w$ for all (i,j)) on the system of the first order conditions relative to problem (3), we obtain the following condition:

$$q^{n-1}\frac{q' e_w}{w_0} nB - 1 = 0 \qquad (4)$$

Combining equation (4) with the zero-profit condition $q^n nB=nw$ gives:

$$\frac{q' e_w}{q}\left(\frac{w}{w_0}\right) = \frac{1}{n} \qquad (5)$$

Condition (5) corresponds, in the present model, to the "Solow Condition" in efficiency wage theory and it implicitly defines the optimal level of the relative wage, w^*/w_0, for given n. Since (5) depends explicitly on n, it allows one to discuss the effects of "technical change" (seen as a change in the degree of complexity of the technology adopted) on the equilibrium level of wage. This feature is peculiar to our model. In fact, when "Hicks-neutral" or "Harrod-neutral" technological progress are considered, technical change does not affect the optimal level of wage as derived by the standard version of the Solow Condition[8].

By differentiation of (5), we obtain the following:

Result 1. For a given level of unemployment u, an increase in the degree of technological complexity increases the equilibrium efficiency-wage level, i.e. $dw^*/dn > 0$.

The intuition behind Result 1 is rather immediate. For any given level of performance q, a more complicated technology adds new tasks that decrease the expected fraction q^n of production's maximum value, nB. Thus, the firm finds it convenient to raise wages in order to induce higher performance.

Condition (5), which holds at *firm-level*, can also be used to give a *General Equilibrium* characterisation of the economy. Assuming[9] that in general equilibrium all firms set the same wage level, $w=w_0$, the equilibrium unemployment level u^* is implicitly defined by the following:

$$\frac{q'[e(1;u^*)]\cdot e_w(1;u^*)}{q[e(1;u^*)]} = \frac{1}{n} \qquad (6)$$

By differentiating (6) we obtain:

Result 2. The equilibrium unemployment level is increasing in the degree of technological complexity, i.e. $du^*/dn>0$.

Results 1 and 2 have neat implications. If Kremer's notion that industrial development can be characterised in terms of increasingly more complicated production processes, then the (exogenous) growth of n would entail higher wages for a decreasing number of employed workers. Many observers have indeed embraced such a pessimistic view on technological progress, with particular concern for the spreading of information technology. However, "despite a huge investment in computing and so on over the past decade, unemployment in the United States, at around 5.5%, is currently no higher than it was in the early 1960s" (*The Economist*, 11 February 1995). We will tackle this controversy in Sect.4.

We briefly discuss now the welfare implications of the private effort choice, as denoted by e^*. For simplicity, we take unemployment benefits to be equal to zero. The social planner maximises the representative individual's expected utility, EU, which is equal to $(1-u)\cdot w\cdot f(e)=(1-u)[q(e)^n\cdot B\cdot f(e)]$.

There are two possible notions of social optimum to investigate. Under the *First-Best* notion, we suppose that the planner can monitor the individual's effort choice perfectly and, hence, pick e^{FB} directly. By contrast, under the *Second-Best* notion (see Shapiro and Stiglitz (1984)), we assume that the planner can only monitor individuals imperfectly. Then, the second-best effort level e^{SB} will be determined by maximising EU with respect to the unemployment rate, subject to the effort function $e=e(1,u)$. The solution to this problem gives the "optimal rate of unemployment", u^{SB}.

As remarked by Shapiro and Stiglitz (1984), *the privately-chosen level of effort is generally inefficient.* By using the asset-equation approach developed in Appendix I, we show that private choices entail an inefficiently low level of effort, since it holds that $e^{*} < e^{SB} < e^{FB}$ (see Appendix II). However, as there is a positive relation between effort and unemployment, it also follows that the "natural rate" of unemployment (u^{*}) is lower than the optimal rate of unemployment (u^{SB}). This result is in contrast with the conclusion reached by Shapiro and Stiglitz (1984), where the natural rate of unemployment is inefficiently high. In Shapiro and Stiglitz (1984) firms require a fixed amount of effort, while here higher effort always raises expected returns. Nonetheless, each firm has rather limited incentives to pay higher wages, since part of the benefits from it would be captured by workers through a higher utility level[10]. Thus, as firms are satisfied with a relatively low level of effort, the "natural rate" of unemployment in the decentralised (symmetric) equilibrium is relatively low.

In the next section we test the robustness of the results obtained so far by allowing for endogenous monitoring.

2. Endogenously-determined Monitoring Intensity.

Our model can be easily extended to consider the firm's monitoring choice. There are two considerations that make monitoring relevant. First, monitoring, or more in general "supervision", is empirically relevant[11]. Second, the simple model developed above neglects the possibility that, when the degree of complexity in production increases, the firm may increase its monitoring intensity *instead of* raising the wage.

We assume that the firm can decide to monitor the worker appointed to the *i*th task with intensity m_i at a cost given by $M(m_i) > 0$, with $M' > 0$ and $M'' \geq 0$. Since more intense monitoring induces a worker to produce more effort, we now have that the *i*th-worker's effort function takes the form:

$$e_i = e\left(\frac{w_i}{w_0}, m_i; u\right), \quad (e_w, e_m) > 0, \quad (e_{ww}, e_{mm}) < 0 \tag{7}$$

For given n, the profit-maximisation problem becomes:

$$\max_{\{w_i\},\{m_i\}} \left(\prod_{i=1}^{n} q_i\left[e\left(w_i/w_0, m_i; u\right)\right]\right) nB - \left(\sum_{i=1}^{n} w_i + \sum_{i=1}^{n} M(m_i)\right) \tag{8}$$

Solving problem (8) and imposing symmetry ($w_i = w_j = w$ and $m_i = m_j = m$, for all $(i,j) = 1,..,n$) gives the optimal combination between w and m:

$$\frac{e_w}{e_m} = \frac{w_0}{M'(m)} \tag{9}$$

In order to make the argument more intuitive, we provide an example.

Example. Consider the following performance function: $q = [e-s]^{\phi}$, with $q \geq 0$ for $e \geq s$ and $q = 0$ otherwise; s is a strictly positive constant ensuring that the function q is concave only locally, while the parameter ϕ lies in the interval (0,1). The effort function is a Cobb-Douglas: $e = (w_i/w_0)^{\sigma}(m_i)^{1-\sigma}f(u)$, where $\sigma \in (0,1)$ and $f(u)$ is an increasing function of the unemployment rate u. The monitoring cost is taken to be linear in the monitoring intensity, $M(m_i) = \mu m_i$, $\mu > 0$. After solving for the optimum and imposing symmetry ($m_i = m$ and $w_i = w$ for all i), it turns out that the ratio between wage level and monitoring intensity is constant in equilibrium:

$$\frac{w}{m} = \frac{\mu \sigma}{1-\sigma} = const. \qquad (10)$$

Thus, an increase of n will have a positive effect both on w and m, so to leave their ratio unaltered.

Wage and monitoring are the "inputs" through which firms increase workers' performance. As shown by the example, the explicit consideration of monitoring does not generally eliminate wage increases when more sophisticated technologies are adopted (Result 1). For this reason, we will abstract from the monitoring investment choice in what follows.

3. Endogenous Choice of n.

The discussion above considered n, the degree of technological complexity, as exogenous. However, entrepreneurs may often choose among currently available production processes that have different sophistication. In this case, the maximum problem in (3) is to be solved also with respect to n.[12] We assume that the term B is increasing in n (see Kremer (1993,p.561)): in particular, $B=B(n)$, with $B'>0$ and $B''<0$. Exploiting symmetry, the maximand can be rewritten as follows:

$$\max_{w,n} \quad q\left[e\left(w/w_0;u\right)\right]^n \; n\,B(n) \quad - \quad n\,w \tag{11}$$

Since zero-profit implies $w=q^nB$, the first-order condition for n can be given the form:

$$\frac{B'(n)}{B(n)} = -\log q \tag{12}$$

As in Kremer (1993,p.562), equation (12) entails a positive relation between n and q. Hence, equation (12), like the efficiency-wage condition (5), implies that n is increasing in wage w. As shown in Figure 1, equation (5) is steeper than equation (12) at the equilibrium levels (w^*,n^*)[13,14].

We next try to investigate which are the exogenous forces that may lead to technological change.

3.1. What does drive Technological Change over Time?

According to (12), firms choose the optimal degree of technological complexity n^* from a given menu of possibilities defined in $[n_{min}, n_{MAX}]$. Thus, whenever n^* is an *internal* solution (i.e., $n_{min}<n^*<n_{MAX}$), what can modify the economic incentive to adopt technologies of different complexity over time?

By referring to equation (12), there are two possibilities for representing the role of time on the optimal choice of n. We can first suppose that the ratio $B'(n)/B(n)$ is a positive function of time. In this case, the incremental gains associated to more complex technologies increase relatively fast over time. This presumption might be justified in terms of tougher competition from Less Developed Countries[15]. Alternatively, we can suppose that the performance function $q(e)$ is increasing over time for any given level of effort. This would be the case when "experience" gives the firm greater chances to prevent mistakes in production.

By referring to Figure 1, consider first the case when the ratio $B'(n)/B(n)$ grows over time[16]: in this case, the curve representing equation (12) shifts upwards[17], while the curve relative to equation (5) does not move. As a consequence, an increasing (B'/B) ratio implies higher wage levels, higher technological complexity and, as we know from Result 2, a higher unemployment rate over time.

Consider now the case when q is increasing in time and the ratio q'/q in (5) is time-independent[18]. By increasing the level of q for any given wage level, the curve (12) will shift upwards over time. Again, wages, technological complexity and unemployment will rise over time.

Hence, by making plausible assumptions on the way time may affect technical progress, our model can justify the presence of a secular trend towards the adoption of processes that increase unemployment, as feared by modern "technophobics". Time becomes the driving force leading to changes in n^* and, hence, to changes in wage level and unemployment. The question, however, is: can technical change *only* be characterised through "increasing sophistication", as Kremer (1993) seems to hint? In many cases, change can also be seen as "increasing simplification" of production processes. For example, "Fordism" made car production a great deal easier than the craftsmanship methods of the twenties' automobile industry. From a more formal viewpoint, we can look at technical change by removing the assumption that optimal technologies can be characterised as *internal* solutions of equation (12). In what follows, we will consider what happens when different firms are constrained to adopt *corner* technologies. For instance, some firms' "ideal", but still unavailable, technology may be more complex than the currently adopted one (formally, it holds that $(B'/B) > -log(q)$). On the other hand, some firms' "ideal" technology may be simpler than the available one (for those firms, it holds that $(B'/B) < -log(q)$). As we are going to show in the next paragraph, this simple characterisation allows us to relate technical change (seen as a two-sided broadening of the boundaries of the currently available techniques, $[n_{min}, n_{MAX}]$) to wage-*differentials* and unemployment rate.

4. A Model with Heterogeneous Firms.

The model developed above can be extended to analyse within-group wage inequality. As we will show, between-firm differences in technologies generate within-group wage differentials in equilibrium. In what follows, we will mainly refer to heterogeneous firms in the same industry: such differences can be justified by "market segmentation" caused by vertical differentiation of the goods produced. The same model, however, can also be used to look at *between*-industry or *between*-sector differences (e.g., manufacturing vs. services sector)[19].

Assume that, for some reason[20], some firms (indexed by *h*) adopt technologies that are relatively sophisticated, while other firms (indexed by *l*) adopt technologies that are relatively simple. Formally, we have that $n^h > n^l$. Since the number of tasks is exogenously given, the economy can be simply described in terms of two efficiency-wage conditions relative to the types of firms (h,l) we consider. Thus, each *h*-type firm must respect the optimizing rule:

$$\frac{q^l \cdot e_w(w^h/w_0;u)}{q}\left(\frac{w^h}{w_0}\right) = \frac{1}{n^h} \tag{13}$$

while the corresponding rule for a *l*-type firm is:

$$\frac{q^l \cdot e_w(w^l/w_0;u)}{q}\left(\frac{w^l}{w_0}\right) = \frac{1}{n^l} \tag{14}$$

As before, the effort function is increasing in the wage w^h (w^l) paid by a *h*-firm (*l*-firm), relative to a measure of the average wages paid outside, w_0. Also, effort is increasing in the unemployment rate (Appendix III provides an asset-equation foundation of the model developed here). We postulate that:

$$w_0 = \beta w_0^h + (1-\beta) w_0^l \tag{15}$$

where w_0^h and w_0^l are, respectively, the wage levels paid on average by *h* and *l*-type firms. The parameter $\beta \in (0,1)$ represents the proportion of workers who are employed by "high-tech" firms.

Equations (13)-(14) hold at firm-level. In symmetric General Equilibrium, we impose that $w^h = w_0^h$ and $w^l = w_0^l$. The wage ratio w^h/w^l, measuring wage-dispersion, is defined as Δ. We can then rewrite (13) and (14) respectively as:

$$\frac{q^l e_w}{q} \cdot \left(\frac{\Delta}{\beta\Delta + (1-\beta)} \right) = \frac{1}{n^h} \qquad (16)$$

$$\frac{q^l e_w}{q} \cdot \left(\frac{1}{\beta\Delta + (1-\beta)} \right) = \frac{1}{n^l} \qquad (17)$$

For given technological parameters (n^h, n^l), the system (16)-(17) is composed of two equations in two unknowns: the equilibrium wage ratio Δ, and the equilibrium unemployment rate u. The following result holds:

Result 3. When $n^h \geq n^l$, $\Delta^* \geq 1$ holds: if firms adopt production process of different complexity, there are inter-firm wage differentials in equilibrium.[21]

As in the models of Bertola and Ichino (1995) and Bulow and Summers (1986), *similar* workers receive different wages in equilibrium, depending on the employer's type. Here, as well as in Bulow and Summer (1986), wages are set by firms on the basis of efficiency consideration. Indeed, high-tech firms will reject the bid of a worker who offers her labour services for less than the efficiency-wage level. Thus, even in the absence of productivity shocks of the kind advocated by Bertola and Ichino (1995), the amount a worker is paid may simply be a matter of "luck". Note also that, since n is likely to be correlated with plant-size, our model is consistent with the positive relation observed between plant-size and wages. Also, according to Davis and Haltiwanger (1991,p.173), plant-size accounted for 40% of the rise in between-plant wage dispersion for production workers between 1963 and 1980: as we are going to show, this observation is consistent with the present approach. In fact, our simple model can be immediately used to generate some results on the dynamics of the wage differential and the unemployment rate. The ensuing discussion on the forces that may lead to increasing wage dispersion is based on the following result:

Result 4. Suppose that $n^h \geq n^l$, so that $\Delta \geq 1$. When technological progress is represented through changes in the levels of n^h and n^l, the wage ratio Δ^* and the *unemployment rate* u^* *will vary as follows:* $d\Delta^*/dn^h > 0$, $d\Delta^*/dn^l < 0$, *and* $du^*/dn^h > 0$, $du^*/dn^l > 0$.[22]

The relevance of Result 4 can be better appreciated in the light of the following observations. Relative to the 1960s, the 1970s and the 1980s have been marked by deep changes in the characteristics of both the technologies adopted[23] and the product markets. As conjectured by Levy and Murnane (1992), "the variation in competitive strategies among firms in particular industries...may reflect a stable approach to an increasingly segmented product market" that turns out to produce "low wage strategies or high wage strategies" (p.1369). We do not try here to provide a theoretical justification as why markets have become increasingly segmented since the 1970s. We simply suppose that, in a given industry, greater market segmentation will push some firms (possibly those that target high-quality products) to adopt more sophisticated technologies, while other firms (possibly those that target lower-quality products) are seeking to adopt simpler technologies. Many examples can be found. While McDonald's in Oxford Street might be willing to adopt automatic devices to flip hamburgers, "San Lorenzo" restaurant in Knightsbridge (Lady Diana's favourite) might like to have more people preparing food in the kitchen, so to provide more variety in its menu. Similarly, while Airbus aircraft company might like to introduce more and more sophisticated automatic flight equipment (so to have a quality edge with respect to Boeing airplanes), tourist aircraft producer Cessna might like to produce cheaper and less sophisticated airplanes for amatorial pilots. Then, we can suppose that some firms would like to adopt processes which, if they were available at present, would imply more tasks than the ones performed under the current technology: in the notation used above, we may think of these firms as h-type ones. On the other side, other firms might like to adopt simpler processes, in terms of tasks, than the ones currently used: these firms can be thought of as l-type ones. In this perspective, (exogenous) technical change is a force that makes available over time both *more* and *less sophisticated* production processes. This view is consistent with Levy and Murnane's (1992,p.1369) observation about the trends of U.S. manufacturing in the last twenty-five years:

"Some manufacturing firms...have increased out-sourcing, thereby reducing the need for production workers, and have used electronic based technology to simplify jobs, and increase monitoring...These responses are consistent with low wage levels. Other firms have reorganised production and retrained workers to make greater use of workers' knowledge in increasing quality levels and lowering costs...These responses are consistent with high wage levels".

We can now appreciate the implications of Result 4. To fix ideas, consider the case when $n^h = n^l$, implying that the wage-ratio Δ is *initially* equal to one. According to our notion of technological change time makes available new technologies, some more and some less sophisticated than the existing ones[24]. In periods of increasing product market segmentation, certain firms will have an incentive to adopt processes that involve a *greater* number of tasks (n^h rises), while other firms will utilise processes involving a *smaller* number of tasks (n^l falls). From this viewpoint, Result 4 has two main consequences, which are consistent with the labour market developments that have been observed during the 1970s and the 1980s. First, our notion of technological progress can explain the *increasing wage dispersion* in equilibrium, due both to the increase in n^h and the decline in n^l. The second consequence is that technological progress has *ambiguous effects on the equilibrium unemployment rate*. While the increase in n^h pushes towards higher unemployment, the decrease in n^l has the opposite effect: as a consequence, the aggregate effect on u^* is *a priori* uncertain. Hence, the present model is consistent with the view that technical progress has not to entail, as many fear, an increasingly higher level of unemployment. At the same time, however, technological change may be the main force leading to rising wage differentials among workers who have the *same* characteristics in terms of age, education, etc.

The increasing technological heterogeneity among firms, as well as the high degree of market segmentation which have been observed since the 1970s are not necessarily, however, an irreversible trend. By an historical point of view for example, the U.S. experience of the 1960s was characterised by constant (if not decreasing) within-group wage dispersion (see, e.g., Katz and Murphy (1992)). In the same period many industries, such as the automobile business, were heading for mass-production methods that routinised several tasks of the production process. In general, when innovative technologies become mature over time, sophisticated firms will have the chance to adopt more standardised techniques that reduce aggregate riskiness in production: in our model, this implies that n^h may fall relative to n^l. It can thus be argued that some historical periods, such as the Industrial Revolution, are characterised by big technological innovations that increase the degree of heterogeneity among sectors, industries or firms (n^h/n^l rises). For these periods, our model unambiguously predicts increasing wage inequality. However, big technological changes tend to be followed by periods in which the new technologies are eventually automated or routinised. In these phases, the degree of technological heterogeneity among firms may decrease (n^h/n^l falls), so to reduce wage dispersion.

5. Minimum Wage Legislation.

We finally sketch the consequences of minimum wage legislation in our model. As emphasised by Bertola and Ichino (1995), labour markets in most developed countries can be divided into "flexible" and "rigid" ones. The U.S. and British labour markets belong to the first group: in those markets, the role of institutions (minimum wage regulations, job-security provisions, unions, etc.) is very limited. By contrast, European countries such as France have collective bargaining systems and minimum wage regulations (see Katz, Loveman and Blanchflower (1995)). In Italy, the mechanism of the *scala mobile* was such as to compress wage dispersion (see Erickson and Ichino (1995)). As commonly observed[25], "flexible" labour markets tend to generate high and increasing wage dispersion coupled with a relatively low unemployment rate. On the other side, "rigid" labour markets severely constrain wage-inequality at the cost of high unemployment.

Minimum wage regulations are generally considered a relevant source of "rigidity" in labour markets. However, the presumption that minimum wages have negative effects on employment is, both theoretically[26] and empirically, far from being uncontroversial. As Machin and Manning (1995,p.667) put it, "quite a lot of empirical evidence has been accumulated in recent years that fails to find any evidence of job loss associated to minimum wages". The model developed in Sect.4 can be easily used to address this issue. Figure 2 represents the Solow-conditions relative to high and low-tech firms (equations (16)-(17)): their intersection at (u^*,Δ^*) represents the equilibrium attained in the absence of wage regulations. Consider now the impact of a *minimum wage legislation* as an artificial compression of the wage differential, i.e., $\Delta_0<\Delta^*$. Assume, in particular, that low wages must not be smaller than a fraction $\alpha\in(0,1)$ of high wages, i.e., $min\{w^l\}=\alpha w^h$. When binding, such a legislation has two effects: it raises low wages (w^l/w_0) and it reduces high wages (w^h/w_0) with respect to their respective equilibrium levels[27]. Thus, it will hold that:

$$\frac{q^l e_w}{q}\cdot\left(\frac{1}{\beta+(1-\beta)\alpha}\right) > \frac{1}{n^h} \tag{18}$$

and

$$\frac{q^{l}e_w}{q}\cdot\left(\frac{\alpha}{\beta+(1-\beta)\alpha}\right) < \frac{1}{n^{l}} \tag{19}$$

Expression (18) implies that high-tech firms pay wages that are inadequately low, relatively to the complexity of the technology they currently adopt (n^h). Conversely, according to (19), low-tech firms pay wages that are too high with respect to the technology used (n^l). Thus, when wage differentials are artificially reduced to Δ_0, wage regulations are bound to have an impact on the equilibrium choice of technology itself. Consistently with the analysis of Sect.4, suppose that the technologies adopted by high-tech firms and low-tech firms are such that $B'(n^h)/B(n^h) \geq -log(q)$ and $B'(n^l)/B(n^l) \leq -log(q)$, respectively. An artificial reduction of wage differentials has opposite effects on the two types of firms. By decreasing q in the high-tech firms, a lower differential incentivates the choice of relatively *less* sophisticated technologies. By contrast, the higher level of q in low-tech firms makes simpler technologies less profitable. As a consequence, n^h tends to decrease, while n^l tends to rise in the new "minimum-wage" equilibrium. In terms of the Solow-conditions (16)-(17) represented in Figure 2, a decrease in n^h, together with an increase in n^l, imply a downward shift for both curves (see Figure 3), where Δ_0 marks the maximum level of wage dispersion that legislation can tolerate. In conclusion, *the final effect of a minimum wage legislation on unemployment is a priori ambiguous*[28], even if the model still predicts that countries with wage regulations will exhibit *less wage-inequality*. Note also that heterogeneous firms that are subject to wage regulation will tend to adopt technologies which are relatively more similar in terms of sophistication.

6. Concluding Remarks.

The simple model we developed builds upon two main components: Kremer's (1993) "O-Ring" production function and the efficiency-wage principle. We showed that when a firm adopts a more sophisticated technology, it will have an incentive to pay higher wages, to reduce the probability of workers' mis-performance. Elaborating on this basic result, we obtained predictions which are quite consistent with the empirical facts observed for the U.S. and British labour markets, especially for what it concerns within-group wage inequality. Within-group wage inequality and its dynamics over the last decades are both an extremely relevant empirical phenomenon and a theoretical problem in labour economics. Our model, as Bulow and Summers (1986) and Bertola and Ichino (1995), is able to provide a reason for the presence of *within-group* wage dispersion in equilibrium and gives some possible suggestions as far as the causes of increasing wage dispersion are concerned.

There is a very common critique to models of wage dispersion that are based on homogeneous workers. In fact, the supporters of competitive wage theory argue that, if two workers receive different wages, they must have different skills. In reality, those who are defined as "within-group" employees are a very composite aggregate of different workers that the existing data-sets, like the U.S. Current Population Survey, cannot appropriately sort out. As Murphy (1995) argues:

"..what we call within-group wage and employment variation is not variation in labor-market outcomes for identical workers. Rather, all of our observed groups are very heterogeneous collections of workers with various skills and talents" (p.57).

As a consequence, if workers' unmeasured attributes could be correctly accounted for, the residual variation captured by "within-group" dispersion would be drastically reduced. Such a line of argument obviously contains some validity and it may help understanding why within-group inequality has not received very much attention by labour economists. However, a better measurement of the workers' actual characteristics might still not be sufficient to settle the controversy in favour of the competitive wage theory. Consider the following example, based on the logic of our model. Suppose that, *ex-ante*, there are two perfectly identical workers in terms of skills and talents. One of them is lucky and is hired by a high-wage company which adopts very sophisticated production processes. The other is unlucky and is hired by a low-wage company that uses unsophisticated technologies. If those workers' skills were measured after some time that they have been employed, it would be quite unsurprising to discover that, *ex-post*, they have developed *different* abilities. It is quite plausible, in fact, that the lucky worker has learned quite a lot from being exposed to more sophisticated production methods requiring more intensive effort. On the other hand, the unlucky worker might have learned much less, or even forgot, since she was exposed to a much less demanding environment. Hence, finding that different skills are paid different wages may still not be conclusive evidence in favour of the competitive view on wage determination.

Finally, we believe that our model can be fruitfully exploited to analyse wage differentials among workers of *different* quality (*between*-group wage inequality). Appendix V sketches a simple extension of the model in this direction.

Appendix I

Asset-Equation foundation of the Effort-Function

The individual worker's instantaneous utility is taken to be multiplicative in wage and effort disutility $f(e)$, which is $U(w,e)=w \cdot f(e)$, where $f(0)=1$ and $f'(e)<0$. As in Shapiro and Stiglitz (1984), we denote by b and r, respectively, the exogenous turnover rate of workers per unit time and the discount rate. The probability of being caught and fired when shirking is π. We define V_E^s as the expected lifetime utility of an employed shirker, V_E^{ns} as the expected lifetime utility of a worker who does not shirk, and V_U as the expected lifetime utility of an unemployed.

For a shirker, we have that:

$$rV_E^s = w_i + (b+\pi)\left(V_U - V_E^s\right) \tag{A1.1}$$

while for a non-shirker it holds that:

$$rV_E^{ns} = w_i f(e_i) + b\left(V_U - V_E^{ns}\right) \tag{A1.2}$$

By imposing the *no-shirking condition (NSC)* $V_E^{ns} \geq V_E^s$, one obtains that the wage the firm has to pay in equilibrium is:

$$w_i = \frac{r\pi V_U}{f(e_i)(r+b+\pi)-(r+b)} \tag{A1.3}$$

Assuming that the unemployment benefit is a constant fraction $\rho \in [0,1)$ of the average wage paid in the economy, w_0, the asset equation for V_U is given by:

$$rV_U = \rho w_0 + a\left(V_E^0 - V_U\right) \tag{A1.4}$$

where a denotes the job acquisition rate. V_E^0 is the average expected utility of an employed worker when the average effort level and the average wage paid in equilibrium in the economy are, respectively, e_0 and w_0. Thus, similarly to (A1.2), we obtain that $V_E^0=[w_0 f(e_0)+bV_U]/(r+b)$. By substituting V_E^0 into (A1.4), and using the result to substitute for V_U in (A1.3), we obtain that:

$$\frac{w_i}{w_0} = \frac{\pi\left[\rho(r+b)+af(e_0)\right]}{(r+b+a)\left[f(e_i)(r+b+\pi)-(r+b)\right]} \tag{A1.5}$$

which yields an expression for the *relative* wage (w_i/w_0). From (A1.5) we can immediately derive the effort function:

$$e_i = f^{-1}\left[(r+b+\pi)^{-1}\left(\frac{w_0}{w_i} \cdot \frac{\pi\,[\rho(r+b)+af(e_0)]}{(r+b+a)} + (r+b)\right)\right] \qquad \text{(A1.6)}$$

where $f^{1}(.)$ denotes the inverse of function $f(.)$. By noting that in steady-state equilibrium it holds that $a=b[(1-u)/u]$, it can be readily checked that the effort function in (A1.6) satisfies to the conditions that we postulated for equation (1) in the text: in particular, effort is a function of the relative wage (w_i/w_0), and $\partial e_i/\partial w_i>0$, $\partial e_i/\partial u>0$, $\partial^2 e_i/\partial w_i^2<0$, $\partial^2 e_i/\partial u^2<0$, $\partial^2 e_i/(\partial w_i \partial u)<0$.

Appendix II

Inefficiency of the Private Effort Choice

The social efficiency of the private effort choice is analysed by exploiting the results found in Appendix I. For simplicity, we set the level of unemployment benefits to zero ($\rho=0$). When one re-considers the wage choice laid down in problem (3), subject to the effort equation (A1.6), private optimality implies the respect of the following first-order condition:

$$nB\left(\frac{1}{f'}\right)q'q^{n-1}\left(-\frac{w_0}{w^2}\cdot\frac{a\pi f(e_0)}{(r+b+\pi)(r+b+a)}\right) = 1 \qquad \text{(A2.1)}$$

Since $q^nB=w$ and, in general equilibrium, $w=w_0$ and $e=e_0$, the effort level induced by private choices (e^*) solves:

$$n\frac{q'}{q} = \left(\frac{-f'(e)}{f(e)}\right)\frac{(r+b+\pi)(r+b+a)}{a\pi} \qquad \text{(A2.2)}$$

One can assess the efficiency of the private effort choice by comparing it with the solution to the central planner's problem. We distinguish between two possible notions of efficiency: the *First-Best solution*, when the planner is able to pick effort directly, and the *Second-Best solution*, when the planner can only induce the desired level of effort through the choice of the optimal rate of unemployment.

First-Best Solution. When the benevolent social planner can monitor workers perfectly, he can pick the desired level of effort directly, and the first-best solution e^{FB} maximises the representative worker's expected utility:

$$\max_{e}\ (1-u)\left[q(e)^n\cdot B\cdot f(e)\right] \qquad \text{(A2.3)}$$

The first-order condition relative to (A2.3) can be rearranged to give:

$$n\frac{q'}{q} = \left(\frac{-f'(e)}{f(e)}\right) \qquad \text{(A2.4)}$$

Since the r.h.s. of (A2.4) is smaller than the r.h.s. of (A2.2) for any given level of e, the first-best effort level is greater than the privately optimal one, which is, $e^{FB}>e^*$.

Second-Best Solution (Optimal Rate of Unemployment). When even a central planner cannot perfectly monitor workers, the first-best effort level can not be enforced.

Suppose however that, as in Shapiro and Stiglitz (1984), the planner can choose the unemployment rate level so as to maximise the representative worker's expected utility. Under symmetry ($w=w_0, e=e_0$), effort incentives only depend on the unemployment rate through the steady-state flow condition $a=b[(1-u)/u]$. In particular, the effort function (A1.6) takes the following form:

$$e = f^{-1}\left(\frac{r+a+b}{r+a+b+\pi}\right) \tag{A2.5}$$

By solving problem (A2.3), subject to (A2.5), with respect to u, one obtains, after some manipulations:

$$n\frac{q'}{q} = \left(\frac{-f'(e)\cdot(r+b+a+\pi)^2\cdot b}{a\pi\,(a+b)}\right) + \left(\frac{-f'(e)}{f(e)}\right) \tag{A2.6}$$

Compare the r.h.s. of (A2.6) with the r.h.s. of (A2.2). After some trivial calculations, it can be shown that the second-best effort level e^{SB} is higher than the privately-optimal one, e^*. In particular, it holds that $e^* < e^{SB} < e^{FB}$. Moreover, since there is a positive relation between effort and unemployment, the socially optimal level of unemployment u^{SB} is higher than the "natural" rate u^*.

Appendix III

Asset-Equation Foundation of the Model with Heterogeneous Firms

The Shapiro and Stiglitz (1984) approach can be extended to the case where heterogeneous firms (*h*-type and *l*-type firms) pay efficiency wages. We assume that the monitoring ability (i.e., π) and the exogenous separation rate b are the same in every type of firm.

Workers (of the same quality) can be hired either by a *h*-firm, or by a *l*-firm. Consider a representative worker indexed by j. Once this worker takes the job, she can either shirk or work. In equilibrium, each firm in the economy will pay a wage that satisfies the no-shirking condition. Thus, for *h*-firms and *l*-firms respectively, it must hold that:

$$V_{Eh}^{ns} = \frac{w_j^h f(e_j^h) + bV_U}{r+b} \geq V_{Eh}^{s} = \frac{w_j^h + (b+\pi)V_U}{r+b+\pi} \tag{A3.1}$$

$$V_{El}^{ns} = \frac{w_j^l f(e_j^l) + bV_U}{r+b} \geq V_{El}^{s} = \frac{w_j^l + (b+\pi)V_U}{r+b+\pi} \tag{A3.2}$$

Hence, when worker j is hired by a *h*-firm, the wage she receives is:

$$w_j^h = \frac{r\pi V_U}{f(e_j^h)(r+b+\pi)-(r+b)} \tag{A3.3}$$

while the wage paid when the worker is hired by a *l*-firm is:

$$w_j^l = \frac{r\pi V_U}{f(e_j^l)(r+b+\pi)-(r+b)} \tag{A3.4}$$

Note that, when $e^h_j > e^l_j$, it holds that $w^h_j > w^l_j$, since $f' < 0$. Moreover, it is straightforward to derive from (A3.3)-(A3.4) that $w^h_j > w^l_j$ implies that the instantaneous utility of a worker hired by a *h*-firm, $U^h_j = w^h_j f(e^h_j)$, is greater than the utility that she obtains when hired by a *l*-firm, $U^l_j = w^l_j f(e^l_j)$. The last result also implies that the lifetime utility of a *h*-firm worker (V_{Eh}) is greater than the lifetime utility of a *l*-firm worker (V_{El}).

We now characterise the value of V_U (under the assumption that unemployment benefits are zero). By ruling out on-the-job search (an individual can search only if currently unemployed), we have that:

$$rV_U = a^h\left[V^0_{Eh} - V_U\right] + (1-a^h)a^l\left[V^0_{El} - V_U\right] \tag{A3.5}$$

where a^h and a^l are, respectively, the hiring rates of h and l-firms and V^0_{Eh} and V^0_{El} define, respectively, the average lifetime values of being employed in h-firms and l-firms:

$$V^0_{Eh} = \frac{w_0^h f(e_0^h) + bV_U}{r+b} \tag{A3.6}$$

$$V^0_{El} = \frac{w_0^l f(e_0^l) + bV_U}{r+b} \tag{A3.7}$$

where (w_0^h, e_0^h) and (w_0^l, e_0^l) are, respectively, the average wage and effort levels set by h and l-firms.

Expression (A3.5) needs some further explanation. When $w^{h0} > w^{l0}$, an individual will prefer to work in a h-firm, rather than in an l-firm: thus, an unemployed who is offered a job by a l-firm (prob.$=a^l$) will accept it only when she does not receive a better offer (prob.$=(1-a^h)$). The same individual will remain unemployed with probability $(1-a^l)(1-a^h)$. Note also that in (A3.5) we implicitly assumed that an unemployed will prefer to take up a job in a l-firm, rather than remaining unemployed (which is $V_{El}^0 > V_U$: this condition is satisfied when $[(r+b)+a^h]w_0^l f(e_0^l) > a^h w_0^h f(e_0^h)$).

By substituting expressions (A3.6)-(A3.7) into (A3.5), one obtains the following:

$$rV_U = \frac{a^h w_0^h f(e_0^h) + a^l(1-a^h)w_0^l f(e_0^l)}{(r+b) + a^h + a^l(1-a^h)} \tag{A3.8}$$

In steady-state equilibrium it holds that $b[1-z-u] = a^h u$ and $bz = a^l u$, where z represents the fraction of the labour force employed by l-firms. It can be easily shown that $dV_U/du < 0$ (the value of being unemployed is decreasing in the unemployment rate). Thus, once V_U is substituted away, expressions (A3.3)-(A3.4) implicitly define effort in h and l-firms as a function of the firm's wage, the average wages paid outside, and the unemployment rate u.

Appendix IV

Derivation of Result 4

Refer to the system given by eqs.(16)-(17). By differentiation, we obtain the following system in matrix form:

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} d\Delta \\ du \end{bmatrix} = \begin{bmatrix} \dfrac{-1}{(n^h)^2} \\ 0 \end{bmatrix} dn^h + \begin{bmatrix} 0 \\ \dfrac{-1}{(n^l)^2} \end{bmatrix} dn^l \qquad \text{(A4.1)}$$

where:

$A<0$ is given by the partial derivative of the l.h.s. of eq.(16) with respect to $(w_h/w_0)=[\Delta/(\beta\Delta+(1-\beta))]$ (which is negative by Second-Order conditions) multiplied by $d[\Delta/(\beta\Delta+(1-\beta))]/d\Delta>0$.

$B<0$ is given by the partial derivative of the l.h.s. of eq.(16) with respect to u (recall that $q'>0$, $q''<0$, $e_u>0$, $e_{wu}<0$).

$C>0$ is given by the partial derivative of the l.h.s. of eq.(17) with respect to $(w_l/w_0)=[1/(\beta\Delta+(1-\beta))]$ (which is negative by Second-Order conditions) multiplied by $d[1/(\beta\Delta+(1-\beta))]/d\Delta<0$.

$D<0$ is given by the partial derivative of the l.h.s. of eq.(17) with respect to u (again, $q'>0$, $q''<0$, $e_u>0$, $e_{wu}<0$).

Note that the determinant *(AD-CB)* is positive. The application of Cramer's Rule to system (A4.1) gives Result 4.

Appendix V

Tasks of different Difficulty and Between-Group Inequality

In the model developed above, we assumed, as in Kremer (1993), that all the tasks performed during the production process are *equally relevant* for the final success of the production process. However, when taken at face-value, this assumption may sound as hardly realistic. For instance, cleaning office blocks and taking crucial marketing decisions are two distinct tasks in the production process: there is little doubt, however, that sloppy decision-making may have much more dramatic consequences on the value of production. In what follows, we will show that a more general model does not alter the flavour of the results reached in the text.

Consider a production process that has two sets of tasks: there are m "easy" tasks, and $(n-m)$ "hard" tasks. Easy tasks are assumed to be perfectly monitorable (similarly to secondary sector jobs in Bulow and Summers (1986)) and succeed with probability one. For these tasks, employers do not need to pay efficiency wages, since mistakes (or shirking) can be immediately detected and remedied. By contrast, difficult tasks generally require greater discretion and can be imperfectly monitored. Moreover, mis-performance is likely to be very costly for the firm. Then, an employer will try to increase the probability $q \in (0,1)$ that a hard task is successfully performed by paying the efficiency wage.

We can give some additional meaning to the case we consider here by supposing that, within each firm, there is *skill-segregation* among workers of *different* observed ability (education, experience, etc.). Segregation may be motivated in several ways. For instance, workers who have low education (high-school education) are generally considered not eligible for delicate decision-making responsibilities. Low-skill workers, then, will only be hired to perform simple tasks and their labour market clears at the competitive wage W^C. Conversely, if highly educated workers (college educated) have a reservation wage greater than W^C, they will prefer to opt for unemployment and search for a good job, rather than accept a low-paid job. Under this assumption, there are two separate labour markets: one for the high-skilled and one for the low-skilled. High-skilled workers are assumed to have an effort function like the one in equation (1) (here, w_0 is the wage paid on average to the high-quality workers in the economy and u is the unemployment rate on the labour market for the skilled).

Under these assumptions, the profit-maximisation problem for a firm with both easy and difficult tasks becomes:

$$\max_{\{w_i\},\, n} \pi = n\,B(n) \prod_{i=m+1}^{n} q_i[e(w_i/w_0;u)] - m\,W^C - \sum_{i=m+1}^{n} w_i \qquad \text{(A5.1)}$$

By calculating the first-order condition relative to w_i and imposing symmetry in wages ($w_i=w$ for all i), one obtains:

$$nB(n)\,q^{n-m-1}q'e_w\frac{1}{w_0} = 1 \qquad \text{(A5.2)}$$

Using the zero-profit condition $nB(n)q^{n-m}=mW^C+(n-m)w$ and defining the ratio m/n as χ, the analog of Result 1 holds true: for given χ, an increase in n raises the equilibrium wage w paid by the firm. Under symmetric General Equilibrium ($w=w_0$), condition (A5.2) above becomes:

$$\frac{q'}{q}e_w\left[\chi\left(\frac{W^C}{w}\right)+(1-\chi)\right] = \frac{1}{n} \qquad \text{(A5.3)}$$

A greater n (given χ) tends to imply an increase in the wage-ratio w/W^C, due to the rise in w. Similarly, a higher ratio between hard and easy tasks (higher χ^{-1}, given n) raises the wage paid to the high-skilled: thus, the higher the proportion of high-skilled workers in the production process, the higher the wage-ratio w/W^C. This result is consistent with some of the evidence reported in Davis and Haltiwanger (1991) for U.S. manufacturing. The striking rise in the demand for college educated workers, relative to high-school educated ones, attributed to skill-biased technical change seems to have been a main cause of the increasing skill-differential in wages. In fact, a large part of the production activities that once were typically performed by the less educated workers have been transferred abroad, "leaving in the U.S. only the marketing and financial activities traditionally carried out by college educated workers" (Levy and Murnane (1992,p.1363)).

The present version of the model also provides the analog of the conclusions reached in Result 2. Consider the problem (A5.1) when there is symmetry in wages ($w=w_i$). The first-order condition with respect to n is then:

$$B(n)q^{n-m} + nB'(n)q^{n-m} + nB(n)q^{n-m}\log(q) - w = 0 \qquad \text{(A5.4)}$$

Under symmetric General Equilibrium ($w=w_i=w_0$), the success probability q depends only on u. When we can replace w in (A5.4) with the expression for w_0 derived from (A5.2), equation (A5.4) can be rewritten as:

$$B(n) + nB'(n) + nB(n)\log(q) - nB(n)\frac{q'}{q}e_w = 0 \qquad \text{(A5.5)}$$

Equation (A5.5) defines the equilibrium relation between u, the unemployment rate on the high-quality workers market, and n. By differentiation, one obtains that $du/dn > 0$. Then, if Kremer's notion is correct (i.e., if technological development entails the adoption of increasingly sophisticated production processes), this result can justify the fear that technical progress can destroy "middle-class" jobs.

Figure 1

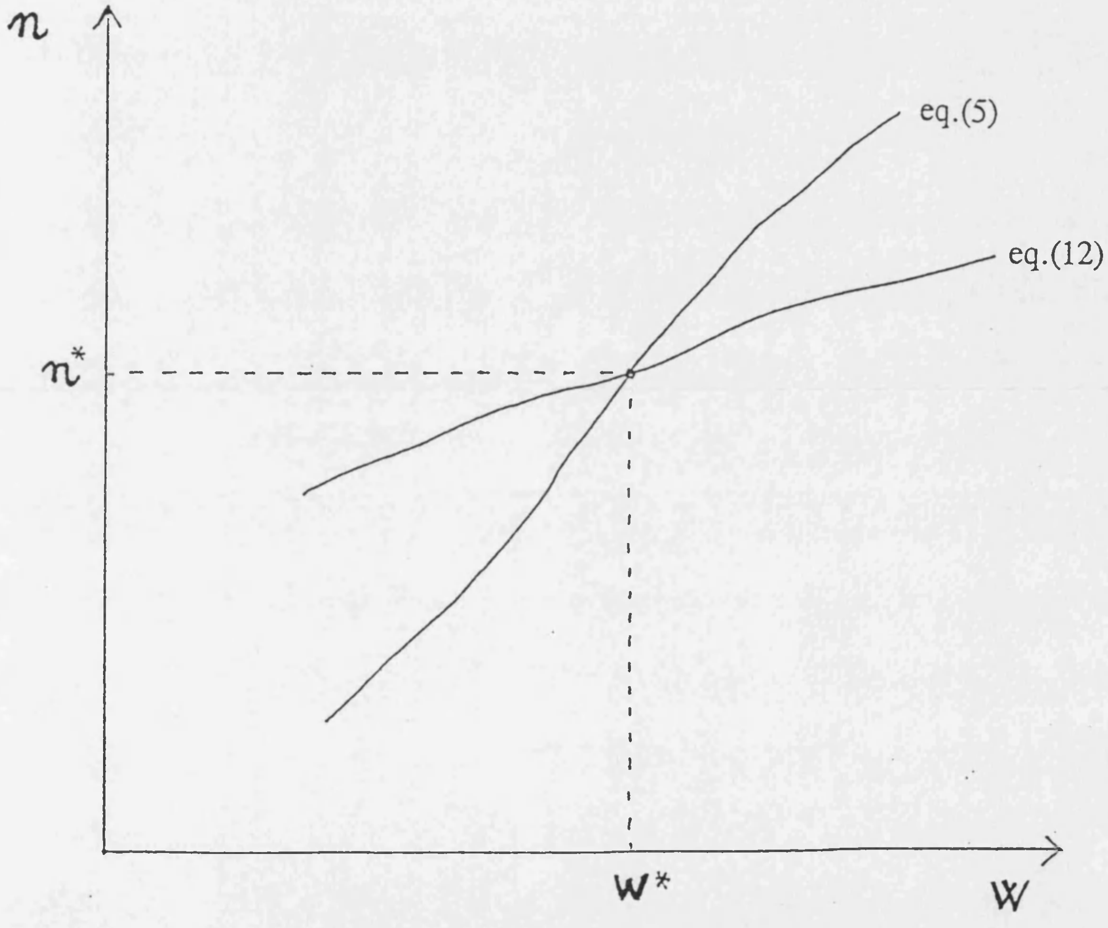


Figure 2

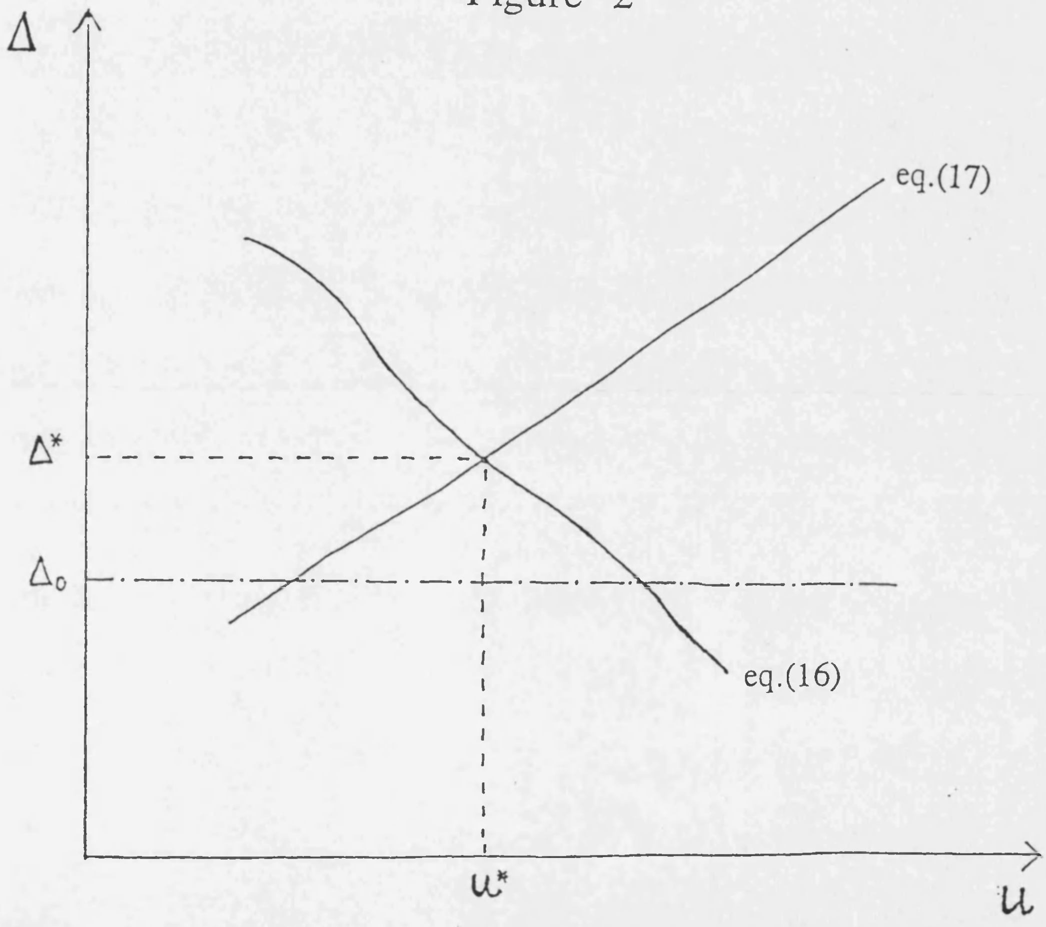
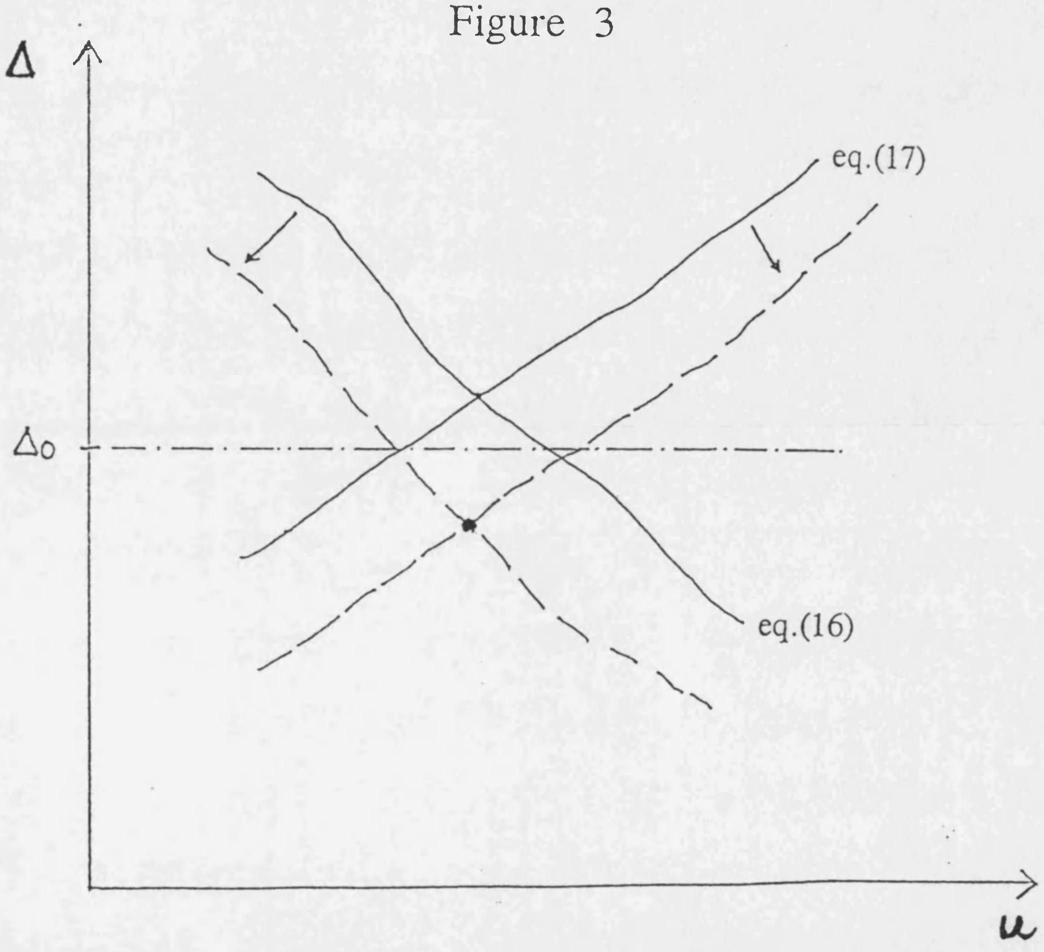


Figure 3



Notes

1. Mortensen and Pissarides (1995) consider a matching model where, due to technological progress, jobs are simultaneously destroyed and created. Firms that adopt old technologies are forced by external competition to pay higher wages over time: at a certain date, then, such firms become unprofitable and their jobs are destroyed. On the other hand, firms that adopt new technologies create new jobs because higher productivity raises their demand for labour. This model does not give clear-cut predictions about the effects of the (exogenous) rate of productivity growth on unemployment.

2. In principle, "compensating wage-differentials" for different working conditions might be the answer. This explanation, however, is quite implausible, since strong within-group wage inequality is observed among firms or plants in the *same* industry.

3. By assuming competitive wages, Kremer and Maskin (1996) develop an O-Ring production model to analyse the matching among workers of *different* quality inside plants. They find that changes in labour-supply characteristics can induce firms to hire either high-quality workers only, or low-quality workers only: thus, workers' segregation would also be responsible for the high level of wage inequality observed between plants. Although explanations based on changing labour-supply characteristics (such as educational attainments) are clearly relevant for the analysis of wage inequality, some observed facts (such as increasing within-group wage inequality) are driven by changes in labour-demand characteristics.

4. According to Katz and Murphy (1992), by favouring more experienced and more educated workers, "skill-biased technical change" has considerably increased overall wage inequality over the 1980s. Katz, Loveman and Blanchflower (1995) also document skill-driven labour demand shifts, both within and between industry, for the U.S., Britain and France. This notion is captured by the efficiency-wage model developed by Agènor and Aizenman (1997), where primary sector firms employ both skilled and unskilled workers and the relative productivity of the skilled grows over time. As Katz and Murphy (1992) note, however, factors that drive *between-group* wage inequality (such as skill-biased technological change) account for only a third of observed wage variability. Also, as noted by Davis and Haltiwanger (1991), *plant* characteristics seem to be more relevant than *worker* characteristics in explaining wage inequality.

5. See, for the U.S., Levy and Murnane (1992) and Katz, Loveman and Blanchflower (1995). As documented by Schmitt (1995) and, again, by Katz, Loveman and Blanchflower (1995), within-group wage inequality has been rising dramatically since 1979 also in the U.K.

6. Layard *et al.* (1991,p.151), Phelps (1992) and Hahn (1987) adopt similar effort functions. Although we do not denote it explicitly in equation (1), effort will also be a function of other variables, such as unemployment benefits, monitoring ability, turnover rate, etc., which we take as exogenous.

7. See Kremer (1993,p.553).

8. Define $x=eN$ as labour in efficiency units. It is immediate to verify that the standard Solow Condition, i.e. $e_w(w/w_0)=e$, is neither affected by the technological progress component $A(t)$ when $y=A(t)f(x)$ (Hicks-neutral), nor when $y=f[A(t)x]$ (Harrod-neutral). On this point, see also Layard *et al.* (1991,p.152).

9. See, e.g., Layard *et al.* (1991,p.151) and Manning (1995). Note also that the General Equilibrium wage level can still be derived by the zero-profit condition, which is, $w=Bq^n$.

10. As shown in Appendix III, when a firm obtains higher effort by raising the wage level (so to satisfy the no-shirking condition), the worker's lifetime utility level, V, increases.

11. As noted by Bulow and Summers (1986), a large fraction of the US employees is involved in supervision, rather than direct production of goods and services.

12. As in Kremer (1993), we abstract from integer constraints.

13. To show that equ.(5) is steeper than equ.(12) in the space (w,n) at the equilibrium point (w^*,n^*), we first define equ.(5) as $\pi_w(w,n)=0$ and equ.(12) as $\pi_n(w,n)=0$. The (positive) slopes of (5) and (12) are, respectively, $dn/dw|_{(5)}=-\pi_{ww}/\pi_{wn}$ and $dn/dw|_{(12)}=-\pi_{nw}/\pi_{nn}$. Since the Second-order conditions for a maximum associated to the system (5)-(12) require that the Hessian determinant $|H|=\pi_{ww}\pi_{nn}-\pi_{wn}\pi_{nw}$ be positive, it then follows that $dn/dw|_{(5)}>dn/dw|_{(12)}$.

14. When the social planner maximises individual welfare with respect to n, the efficient level of complexity in technology solves a condition that has the *same* form as (12), the private rule. Note also that equ.(12) defines a positive relation between n and q and, hence, between n and e. As a consequence, recalling that $e^*<e^{SB}<e^{FB}$ (see Sect.1 and Appendix II), it holds that also the private choice of n is inefficiently low: in particular, $n^*<n^{SB}<n^{FB}$, where n^{SB} and n^{FB} are the levels of complexity corresponding to the Second-Best and First-Best effort levels, respectively.

15. On the role of trade competition from the Third World, see Wood (1994).

16. This is the case when, by explicitly defining B as function of time, $B(n,t)=b(n)^t$. Notice instead that, if $B(n,t)=b(n)t^\theta$, time does not affect the ratio B'/B.

17. In reference to equation (12), note that, for any given level of n, an increase in (B'/B) forces a growth in $(-logq)$ and, hence, a smaller value of q (and w).

18. Consider, for example, the following specification: $q(e;t)=q(e)\cdot t^\theta$, $\theta<1$. When also the ratio q'/q is subject to changes over time, the position of curve (5) in Figure 1 is subject to shifts that, together with the movements of curve (12), generate ambiguous results on the equilibrium levels of (w^*,n^*).

19. As Levy and Murnane (1992,p.1347) recall, a relevant role for increasing wage inequality has often been attributed to "deindustrialization in which labor was forced to shift from manufacturing, with many middle class jobs, to the service sector, with a few

high paying jobs and many low paying jobs". As these authors note, however, firm-specificities appear to be even more important than sectoral differences to explain within-group wage inequality.

20. A theoretical example as why different firms can coexist in the same sector is given by Shaked and Sutton's (1983) model of vertical differentiation in product markets.

21. From (13)-(14) and Result 1 above it follows that, when $n^h > n^l$, it must hold that $(w^h/w_0) > (w^l/w_0)$. Hence, in symmetric General Equilibrium, it also holds that $\Delta > 1$.

22. The proof of Result 4 is given in Appendix IV.

23. Davis and Haltiwanger (1991,p.116) observe that since the late 1960s there have been "striking changes in the distribution of observable plant characteristics". Such changes were largely responsible for the increase of between-plant wage inequality.

24. In more formal terms, suppose that the old technology requires n_0 tasks and the new available technology requires n_1 tasks. It can either be that $n_0 < n_1$ (progress entails more sophistication), or that $n_0 > n_1$ (progress entails less sophistication). In either case, we assume that the loss from not adopting the new technology, $L = \pi(n_1) - \pi(n_0)$, is positive and greater than the adoption cost $k \geq 0$. Note that L can be approximated (through a Taylor's expansion around n_0) by $[n_0 B(n_0) q^{n0}] \{B'(n_0)/B(n_0) + \log q] \{n_1 - n_0]$. Hence, when $L > k$, each firm was adopting a technology, n_0, that was either "too much" sophisticated $(B'(n_0)/B(n_0) < -\log q \Leftrightarrow n_1 < n_0)$, or "too little" sophisticated $(B'(n_0)/B(n_0) > -\log q \Leftrightarrow n_1 > n_0)$, with respect to the new level, n_1.

25. See the OECD Employment Outlook (1996) and the references cited in Bertola and Ichino (1995). According to the OECD, wage inequality has continued to grow also during the nineties in those countries (Australia, Britain, New Zealand and the United States) where governments have been pursuing further labour market deregulation.

26. Manning (1995) develops two simple models, one based on efficiency wages, the other based on monopsonistic labour markets, where minimum wages may actually reduce unemployment.

27. Since binding minimum wages imply that $w^l = \alpha w^h$ (i.e., $\Delta_0 = 1/\alpha < \Delta^*$), then $(w^h/w_0) = 1/[\beta + (1-\beta)\alpha] < \Delta/[\beta\Delta + (1-\beta)]$ and $(w^l/w_0) = \alpha/[\beta + (1-\beta)\alpha] > 1/[\beta\Delta + (1-\beta)]$.

28. The net effect on the unemployment rate of the changes in (n^l, n^h) depends on $((du/dn^l) - (du/dn^h))$: for instance, it can be shown that when the fraction of workers employed in the low-tech sector $(1-\beta)$ is relatively high, the introduction of a minimum wage legislation is likely to increase the unemployment rate (through an increase in n^l).

Chapter II

OUTSIDE OPTIONS IN A BARGAINING MODEL WITH "INTRINSIC DECAY".

A Strategic Framework and some Implications for Wage Negotiations.

Introduction.

The determinants of bargaining power are still rather controversial. When one considers in particular the role of "outside options", the theoretical predictions are often at variance with what intuition and empirical observation would seem to suggest. These problems have a special relevance for the analysis of wage negotiations. In this Chapter, we address these and related issues by developing a simple strategic model of bargaining.

The main implications of the Nash's and Rubinstein's approaches to bargaining can be summarised as follows. Consider two agents who have to share a cake of size C. When the Nash-axiomatic approach is adopted, agent I and agent II face the following program:

Maximise $(S^1-s_1^0)(S^2-s_2^0)$ *with respect to* (S^1,S^2)*, subject to* $S^1+S^2\leq C$,

which yields the solution:

$$S^1 = \frac{1}{2}(C+s_1^0-s_2^0), \quad S^2 = \frac{1}{2}(C+s_2^0-s_1^0) \qquad \text{(N)}$$

where S^1 and S^2 represent, respectively, agent I's and agent II's shares of the cake C, while the parameters (s_1^0,s_2^0) define their *status-quo* points.

An agent's *status-quo* is a relevant measure of bargaining power: the higher agent I's *status-quo*, s_1^0, the higher her payoff S^1. Similarly, the higher s_2^0, the higher S^2. The interpretation of the *status-quo*'s is however quite ambiguous. As noted by Shaked and Sutton (1984b), the Nash-axiomatic approach is unable, *per se*, to give the *status-quo*'s a precise content unless the underlying game is specified.

In spite of this neat remark, it has often been common practice, especially in labour economics[1], to identify the *status-quo* points in the Nash solution *(N)* with the players' *outside options*, which we define here as s_1 and s_2: in this case, the modeller postulates that $(s_1^0,s_2^0)=(s_1,s_2)$.

A player's *outside option* (or *breakdown point*: see Binmore, Shaked and Sutton (1989)) is the level of utility that this player would obtain by leaving the negotiation table for good. Consider the example of wage negotiations, where an entrepreneur and his workforce have to share the firm's returns. The entrepreneur's outside option can be thought of as the liquidation value of the firm, or as the level of profits available by firing the current workforce and hiring a new one (in the latter case, his outside option will depend negatively on hiring and firing costs). On the other hand, the workers' outside option depends (positively) on the level of unemployment benefits and on the general conditions of the labour market: for example, a higher average wage and a lower unemployment rate will improve workers' outside alternatives. In the case of wage negotiations then, identifying the *status-quo* points with the outside options makes the firm-level wage determination depend directly on the *aggregate* conditions of the economy.

However, as emphasised by Binmore, Rubinstein and Wolinsky (1986), the common practice of interpreting the *status quo*'s as the outside option levels is theoretically *inconsistent* with the strategic representation of bargaining formulated in the seminal work of Rubinstein (see Rubinstein (1982)).

In the original Rubinstein (1982) model the players alternate in issuing proposals over the division of a cake *of given size* until an agreement is found. What drives the players to agree is their "impatience": future incomes are discounted at a positive rate (see also Sutton (1986)). The success of Rubinstein's model as a standard reference for applied bargaining problems is due to its property that, when the interval between two subsequent calls tends to zero, its unique Perfect Equilibrium solution converges to the Nash bargaining solution *(N)*.

In the context of the Rubinstein (1982) strategic model, Binmore, Rubinstein and Wolinsky (1986) show that the *status-quo* points in *(N)* coincide with the so-called *impasse points*, which we denote by (σ_1,σ_2). The pair (σ_1,σ_2) is defined as player I's and player II's utility levels during disagreement, that is, when bargaining continues *without an agreement being reached or negotiations being abandoned* (see Binmore Shaked and Sutton (1989, p.754)). Using again the example of wage negotiations that we mentioned above, a main determinant of the size of workforce's *impasse point* during the negotiation process is constituted by the availability of union strike-funds[2]. In what follows, we normalise the impasse points to zero, which is, $(\sigma_1,\sigma_2)=(0,0)$.

When there are mutual gains from an agreement (i.e., when the size of the cake is greater than what the players can obtain by taking their outside alternatives,

$C > s_1 + s_2$), the bargaining outcome predicted by the Rubinstein model with outside options is:

$$(S^1, S^2) = \begin{cases} (s_1, C - s_1), & \text{if } C/2 < s_1 \\ (C - s_2, s_2), & \text{if } C/2 < s_2 \\ (C/2, C/2), & \text{otherwise} \end{cases} \tag{R}$$

The *Outside Option Principle*[3] applies: *the outside option available to a player is relevant only when it is bigger than the half of the pie, C/2.*

Consider, for instance, the consequences of the Outside Option Principle for wage negotiation outcomes. In contrast to what is frequently assumed in several labour economics applications, Rubinstein (1982) implies that the wage bargained at firm level can *not* depend, at the same time, on "inside" factors, such as the firm's returns (here, C), as well as on own "external" factors, such as the labour market conditions (which determine the workers' outside option).

The Outside Option Principle has, however, an unattractive feature. Consider the following example: if $C/2 = 0.5 > s_1$, the equilibrium payoff for agent I will be $S^1 = 0.5$, regardless of whether her outside option is worth $s_1 = 0.49$ or $s_1 = 0.01$. In this case, the "external environment", determining the outside option levels, does not affect bargaining power at all. On the contrary, when $C/2 < s_1$, external conditions count even "too much", since $S^1 = s_1$.

The main aim of the present Chapter is to show that the Outside Option Principle is not robust to a simple modification of Rubinstein (1982) bargaining model. As emphasised by Sutton (1986), the Principle depends on the assumptions that *(i)* the agents have positive discount rates, and *(ii)* the size of the cake to be shared, as well as the sizes of the parties' outside options stay constant over time. The bargaining thus takes place in an infinite horizon, with a stationary structure (each player faces the same game when calling at different dates): if an agreement is not reached, the same cake of the same size will be available in the future. The only cost of disagreement is psychological, being due to "impatience".

However, if for some reason the cake decays "intrinsically" over time, delay in agreement will impose a further cost, beyond time-discounting. Our "intrinsic decay" hypothesis has a straightforward economic appeal[4]. In many situation of practical importance, it is indeed reasonable to posit a greater rate of shrinkage in the cake relative to outside options. In wage bargaining, for example, delays in production may involve a progressive physical decay of production opportunities over time (e.g., due to machinery depreciation in industrial firms for the lack of maintenance, or, in agricultural firms, due to delays in harvesting, with adverse consequences for the quantity and quality of products). Delays in production may also narrow the firm's market opportunities, if they impose waiting costs on customers who can switch to competitors. These factors tend to affect negatively the *firm*'s condition, while the parties outside options may remain unaffected.

In what follows, we analyze a simple modification to the basic Rubinstein's alternating calls bargaining game in which, due to some intrinsic (i.e., non-psychological) decaying factor, the cake shrinks faster than the outside options. As a consequence, the bargaining game is *non-stationary*: its time-horizon is finite[5], since there exists a point in time at which the amount to be shared equals the sum of the outside options (no net gains from an agreement can be obtained afterwards). By taking the discount rate equal to zero, we show the central results of the Chapter: in the game described, for a given order of calls, there is a unique Perfect Equilibrium solution; when the time interval between a call and the following one shrinks to zero, this solution coincides with the "split-the-difference" outcome (Sutton, 1986), which can be obtained from a simple Nash-maximand where the "status-quo" positions are shifted to the outside option levels (see Sect.1).

The results found in Sect.1 extend immediately to the case of three-party bargaining (see Sect.2): the Perfect Equilibrium solution is still unique and, when subsequent calls tend to be very close, the three-party version of the "split-the-difference" outcome is obtained. Our simple model thus avoids the problem emphasised by the "Shaked's example", showing that the application of the Rubinstein model to a game with $N>2$ players gives indeterminacy in the Perfect Equilibrium payoffs (see Sutton (1986) and Osborne and Rubinstein (1990)).

In Sect.3 we allow for strictly positive discount rates, together with intrinsic decay in the cake. Although the main results remain qualitatively unaltered, we show that the presence of discounting reduces the weight of the players' outside options in the bargaining outcome.

In Sect.4, we apply the models developed in Sects.1-2 to wage negotiations. Since our model gives a unique solution also for a number of players greater than two, we can obtain neat predictions about the consequences of multiple unionism on wage levels. Further, we analyse the relation between efficiency wages and bargaining by introducing "effort" and imperfect monitoring. Finally, by exploiting the result that outside options always matter, we consider the problems raised by bargaining for investment in workforce training.

The main results are summarised in Section 5.

1. The Basic Model.

In this Section, we analyse the simplest two-party problem without discounting.

At $t=0$, players I and II face the problem of sharing a cake of size C; their outside options are (s_1,s_2), respectively, and such that $(s_1,s_2)\geq 0$ and $s_1+s_2<C$ (i.e., mutual gains from agreement are available). As in Rubinstein (1982), offers alternate. We consider an extensive form of the game in which a player can opt out *only after rejecting the other's proposal* (analogously to the game in Osborne and Rubinstein (1990,par.3.12.1)). We assume however that *(i)* both players have a discount rate equal to zero, *(ii)* the cake size "decays" over time by a factor $\beta\in(0,1)$, so that the cake size at t is $\beta^t\cdot C$, and *(iii)* the size of the outside options stays constant over time. The second assumption provides the incentive to an early agreement which is an alternative to Rubinstein's time preferences mechanism, ruled out by *(i)*. The role of assumption *(iii)* is that of simplifying the argument, provided that in the more general case the cake still shrinks faster than the outside opportunities available to the parties.

The modifications introduced above imply a non-stationary bargaining framework: the constancy over time of the sum of the outside options limits the horizon in which mutual gains from an agreement can be obtained to a certain date, $t=T^*$. This date is defined as function of the parameters (C,β,s_1,s_2) by

$$T^*:\quad \beta^{T^*}C=s_1+s_2 \tag{1}$$

Defining $\Delta>0$ as the time passing between each offer and the subsequent one, the last call will take place at $t=T$, where $T\leq T^*$ and $T^*-T<\Delta$. Thus we have that:

$$\beta^T C = s_1+s_2+\epsilon\,,\quad \textit{with}\ \epsilon=\epsilon(\Delta)\geq 0, \tag{2}$$

$$\textit{such that}\quad \beta^{T+\Delta}C<s_1+s_2$$

Note that the ratio T/Δ is the maximum positive integer in $(0,T^*/\Delta]$.

In order to obtain the main result, contained in Proposition 1, we show the following:

Lemma 1. For any given order of calls (player I first/not first caller and last/not last caller), there is a unique Perfect Equilibrium solution to the agents' payoff.

The result is proved for the case in which player I is both last (at $t=T$) and first (at $t=0$) caller. The computation of agent I's (unique) payoffs in the three remaining cases is quite straightforward and will be omitted. Uniqueness is shown by construction.

Proof. Let $S_{(\tau)}$ denote the payoff of the agent who is making the offer at $t=\tau$.

At $t=T$, when player I is calling, the size of the cake is $\beta^T C=\beta^{T^*}C+\epsilon$. In case of refusal of I's offer, player II can get at most s_2. Then, s_2 is the minimum acceptable offer player I has to make, and constitutes her unique optimal offer to player II (as usual, we assume that when an agent is indifferent between accepting or not, she accepts). It follows that the unique Perfect Equilibrium (P.E.) payoff obtained by player I at $t=T$ is

$$S_{(T)} = \beta^T C - s_2$$

Player II calls at $t=T\text{-}\Delta$, when the cake size is $\beta^{T-\Delta}C$. To make his proposal accepted, II must offer at least $S_{(T)}$ to player I; again, $S_{(T)}$ is the unique optimal offer for the caller (player II) at this stage. Player II's unique P.E. payoff at $t=T\text{-}\Delta$ is then

$$S_{(T-\Delta)} = \beta^{T-\Delta} C - S_{(T)}$$

Applying the same argument, at $t=T\text{-}2\Delta$, player I obtains

$$S_{(T-2\Delta)} = \beta^{T-2\Delta} C - S_{(T-\Delta)} = \beta^{T-2\Delta}(1-\beta^{\Delta}+\beta^{2\Delta})C - s_2$$

In general, player I calls at each $t=T\text{-}2k\Delta$, with $k=0,1,..,k^*$; k^* defines player I's call closest to $t=0$ (either at $t=0$ or $t=\Delta$: since we assume here that I calls at $t=0$, k^* solves $T\text{-}2k^*\Delta=0$). Player I obtains

$$S_{(T-2k\Delta)} = \beta^{T-2k\Delta}(1-\beta^{\Delta}+..+\beta^{2k\Delta})C - s_2 = \beta^{T-2k\Delta}\frac{1+\beta^{(2k+1)\Delta}}{1+\beta^{\Delta}}C - s_2 \qquad (3)$$

Recalling that at each stage of the game the caller's optimal offer is unique and equal to the unique P.E. payoff the other can obtain when calling in the following stage, expression (3) describes the unique P.E. payoff that can be obtained by player I at *each* stage of the game. ■

Noting that $S_{(T-2k\Delta)}$ is increasing in k, an early agreement (at $t=0$) will be reached. Since player I was assumed to be calling at $t=0$, her unique Perfect Equilibrium payoff for the game described is $S_{(0)}$, obtained by setting $T\text{-}2k\Delta=0$ in (3)[6]:

$$S_{(0)} = \frac{1+\beta^{T+\Delta}}{1+\beta^{\Delta}} C - s_2 \tag{4}$$

The P.E. payoff of player II is $C\text{-}S_{(0)}$. (The pair of strategies supporting this solution are described in Shaked and Sutton (1984a)).

Note also that player I's payoff in expression (4) can be rewritten (taking, without loss in generality, $\epsilon=0$) as:

$$S_{(0)} = C(1-\beta^{\Delta})(1+\beta^{2\Delta}+\beta^{4\Delta}+...+\beta^{T-2\Delta}) + s_1$$

which is the sum of the shrinkages occurring after player I's calls up to $t=T\text{-}2\Delta$ *plus* I's outside option s_1. This representation underlines a key feature of the result: the game ends with each player taking up the outside option.

Remark 1. In the game above, we assumed that a player can opt out only after rejecting the other's proposal. Consider now an extensive form of the game in which a player can opt out *only when his own offer is rejected* (refer to the game in Osborne and Rubinstein (1990, par.3.12.2)): in infinite horizon bargaining games, multiplicity problems would arise. In our model, however, the present modification to the opting out procedure will still deliver the unique Perfect Equilibrium solution $(S_{(0)}, C\text{-}S_{(0)})$ found above[7].

We are now ready to state the following:

Proposition 1. When the time interval between two subsequent shrinks to zero ($\Delta \to 0^+$), the unique Perfect Equilibrium solution to the bargaining games considered in Lemma 1 collapses in the same limit payoff vector[8], regardless the order of the calls. This limit payoff vector is the "split-the-difference" outcome.

Proof. Taking the limit of expression (4), we obtain

$$\lim_{\Delta \to 0^+} S_{(0)} = \frac{1}{2}C + \frac{1}{2}(s_1 - s_2) \tag{5}$$

by noticing that, for $\Delta \to 0^+$, $T \to T^*$ ($\epsilon(\Delta) \to 0$) and using (1). ■

As well known, player I's "split-the-difference" payoff given by (5) can be obtained as solution to the following problem, where S^1 and S^2 are I's and II's payoffs:

$$\max_{(S^1, S^2)} (S^1 - s_1)(S^2 - s_2), \quad s.t. \quad S^1 + S^2 \leq C \tag{6}$$

i.e., a Nash-maximand in which the *status-quo* positions are shifted to the outside options levels. This clearcut result partly derives from assumption *(i)*: here, the discount rate is equal to zero. The case with a strictly positive discount rate is analysed in Sect.3.

In the next Section we extend the main results to the case of three-party bargaining.

2. Three-Party Bargaining with Intrinsic Decay.

When the Rubinstein (1982) bargaining model is extended to the problem of sharing a cake of given size among $N>2$ players, the perfectness argument is, in general, not sufficient to ensure uniqueness. This conclusion holds true for games in which the structure of the replies to a given proposal is either *sequential* (as in the original "Shaked's example"), or *simultaneous* (see Haller (1986)). Hence, unless very particular game structures are examined (see, e.g., in Chae and Yang (1988)) or restrictions on strategies are assumed, *any* partition of the cake can be supported as a Perfect Equilibrium (see, e.g., Herrero (1985), Sutton (1986), Osborne and Rubinstein (1990)).

Consider the extension of the model developed in Sect.1 to a three-party bargaining game. Again, $\beta\in(0,1)$ and players' common discount rate is zero. Suppose that, at $t=0$, agent I proposes a partition of the cake, say $(\sigma^1, \sigma^2, \sigma^3)$, such that $\sigma^i\geq 0$ and $\Sigma_i\sigma^i=C$: agents II and III reply (either in turn or simultaneously: the conclusion does not change); if both II and III agree, the game ends. If either (or both) disagrees, agent II makes a proposal at $t=\Delta$, etc. The game continues with I, II, III making offers in turn until: either an agreement is reached at some $t\leq T$ $(T\leq T^*)$, or the parties separate and take up their outside options (respectively, s_1, s_2, s_3). Analogously to the two-party model developed in Sect.1, given $(C,\beta,s_1,s_2,s_3,\Delta)$, we define

$$T^*: \quad \beta^{T^*}C = s_1 + s_2 + s_3 \tag{7}$$

and

$$T: \quad \beta^T C = s_1 + s_2 + s_3 + \epsilon, \quad \textit{with}\ \epsilon = \epsilon(\Delta)\geq 0$$
$$\textit{such that} \quad \beta^{T+\Delta}C < s_1 + s_2 + s_3 \tag{8}$$

Under these assumptions, we state the following:

Lemma 2. For any given order of calls, there is a unique Perfect Equilibrium solution to the agents' payoff triple.

Proof. See Appendix I.

Since an agreement will be reached at $t=0$, we state the following Proposition:

Proposition 2. When the interval between two subsequent calls shrinks to zero ($\Delta \rightarrow 0^+$), the unique Perfect Equilibrium solution to the three-party bargaining game collapses into the same limit partition, regardless of the order of the calls. This limit partition can be obtained as solution to the Nash problem

$$\max_{(S^1, S^2, S^3)} \Omega = \prod_{i=1}^{3} (S^i - s_i), \quad s.t. \sum_{i=1}^{3} S^i \leq C$$

where (S^1, S^2, S^3) are respectively agent I's, II's, III's shares of the cake C.

Proof. See Appendix I.

In contrast with Rubinstein (1982), the results found for the two-party game extend immediately to a $N > 2$ party game without any further qualification.

3. Strictly Positive Discount Rates.

In what follows, we extend the two-party model developed in Sect.1 to analyse the case when the players have strictly positive (and common) discount rates. Similarly to Rubinstein (1982), player I and II have utility $U(x,t)=\delta^t x$, where x denotes income and $\delta<1$ is the discount factor.

Let the upper limit to the bargaining horizon be given by T, as defined by $C\beta^T=s_1+s_2$. Suppose that player I issues a proposal at each date $T-(2k+1)\Delta$, while player II calls at each $t=T-2k\Delta$ ($k=0,1,2,..$). Assuming that $max\{\delta^\Delta S_{(T-2k\Delta)},s_2\}$ is equal to $\delta^\Delta S_{(T-2k\Delta)}$, player I will have to offer player II the amount $\delta^\Delta S_{(T-2k\Delta)}$ at $t=(T-2k\Delta)-\Delta$. Player I's payoff is thus given by:

$$S_{(T-(2k+1)\Delta)} = C\beta^{T-(2k+1)\Delta}\{1-\delta^\Delta\beta^\Delta+..+(\delta^\Delta\beta^\Delta)^{2k}\} - \delta^{2k\Delta}s_2 = \\ = C\beta^{T-(2k+1)\Delta}\left\{\frac{1+(\delta^\Delta\beta^\Delta)^{2k+1}}{1+\delta^\Delta\beta^\Delta}\right\} - \delta^{2k\Delta}s_2 \tag{9}$$

Similarly, if $max\{\delta^\Delta S_{(T-(2k+1)\Delta)},s_1\}=\delta^\Delta S_{(T-(2k+1)\Delta)}$, player II will have to offer $\delta^\Delta S_{(T-(2k+1)\Delta)}$ when calling at $t=T-(2k+1)\Delta-\Delta$, obtaining:

$$S_{(T-2k\Delta)} = C\beta^{T-2k\Delta}\{1-\delta^\Delta\beta^\Delta+..-(\delta^\Delta\beta^\Delta)^{2k-1}\} + \delta^{(2k-1)\Delta}s_2 = \\ = C\beta^{T-2k\Delta}\left\{\frac{1-(\delta^\Delta\beta^\Delta)^{2k}}{1+\delta^\Delta\beta^\Delta}\right\} + \delta^{(2k-1)\Delta}s_2 \tag{10}$$

Suppose that player I calls at $t=0$. By setting $T-(2k+1)\Delta=0$ and using expression (9), we obtain

$$S_{(0)} = C\frac{1+\beta^T\delta^T}{1+\beta^\Delta\delta^\Delta} - \delta^{T-\Delta}s_2 \tag{11}$$

and, consequently, player II's payoff is

$$C - S_{(0)} = \delta^\Delta S_{(\Delta)} \tag{12}$$

Note that $(\beta^\Delta,\delta^\Delta)\to(1,1)$ for $\Delta\to 0$. By making use of $C\beta^T=s_1+s_2$, one obtains that:

$$S^1 \equiv \lim_{\Delta\to 0} S_{(0)} = \frac{C}{2} + \frac{\delta^T}{2}(s_1-s_2) \tag{13}$$

$$S^2 \equiv \lim_{\Delta \to 0}(R - S_{(0)}) = \frac{C}{2} + \frac{\delta^T}{2}(s_2 - s_1) \tag{14}$$

The Perfect Equilibrium payoffs (S^1, S^2) in (13)-(14) solve the following Nash-problem:

$$\max_{\{S^1, S^2\}} (S^1 - \delta^T s_1)(S^2 - \delta^T s_2), \quad s.t. \; S^1 + S^2 \leq C \tag{15}$$

Furthermore, when the discount rate approaches zero, the discount factor δ tends to one and the equilibrium payoffs converge to the payoffs obtained from problem (6).

The main conclusion drawn in Sect.1 still remains valid: the outside option levels of player I and II *always* enter the Perfect Equilibrium solution to the game described. However, time-preferences imply that the outside alternatives are weighted by δ^T, which is decreasing in T. The closer β is to one, the higher is T: thus, when the forces leading to "intrinsic decay" are relatively weak, the role of the outside options in determining the partition of the cake tends to be less relevant.

4. Applications to Wage-Bargaining.

We can apply the model developed in Sect. 1 to the following bilateral bargaining situation[9]: a firm and its labour force (of given size, say 1) have to find an agreement on the sharing of the returns R obtainable from a production process taking place at $t=0$. We denote the worker's and firm's payoffs and outside options, respectively, as (W,Π) and (W^*,Π^*). According to the "intrinsic decay" hypothesis, disagreement will imply a decay (by a factor β) of the returns R to be shared over time.

Proposition 1 suggests that the parties will agree at $t=0$, yielding the worker a payoff

$$W = \frac{1}{2}R + \frac{1}{2}(W^* - \Pi^*) \tag{16}$$

The worker's payoff W can then be obtained by solving the following Nash-problem:

$$\underset{(W)}{Max}\ \Omega = (R - W - \Pi^*)(W - W^*) \tag{17}$$

A feature of the present model, which is necessary to the result, is that the sum of the outside options exceeds, after some date, the value of the firm. In other words, we are assuming a context in which delays in bargaining will eventually lead to the dissolution of the firm as the parties take up their outside options. In such an environment, equation (16) gives a formal justification for the "shifting of the *status-quo* points" to the outside option levels. This observation reduces the destructive impact of the criticism about the mistreatment of the outside options in labour economics, where an improper use of Rubinstein's model is often justified on empirical grounds[10] (see Binmore, Shaked and Sutton (1989) and, in particular, Binmore, Rubinstein and Wolinsky (1986)). Although fully justified within the basic Rubinstein (1982) framework, this criticism does not survive in the kind of context suggested here.

The actual relevance of outside options in *firm*-level wage equations is, however, an empirical issue. Indeed, the theoretical predictions of the bargaining models that we contrasted depend on the structure of the underlying game that one assumes. Scaramozzino (1991) provides a noticeable attempt to test the Outside Option Principle in reference to wage bargaining. There, the Principle generates the following empirical prediction: for those firms where outside options do not "bite" as corner solutions, all the variables that characterise the external labour market conditions must *not* be significant in the wage equation. The Principle is only partially supported by the evidence: while the "outside" (industry) average wage level is not significant, the change in the industry unemployment level (measuring labour market "tightness") is strongly significant.

In the following paragraphs, we exploit the properties of our model to investigate three issues: the effects of multi-unionism on wage determination, the role of effort with imperfect monitoring, and investment in workforce's training.

4.1. Multi-Unionism and Wage Bargaining.

The presence of multiple unions, competing over the sharing of the firm's revenues, has been considered by the theoretical models in Horn and Wolinsky (1988) and Jun (1989). Horn and Wolinsky (1988) show that when workers are substitutable, they are better off by negotiating through a single union. By contrast, when the firm's workers are complementary, they are better off by creating separate unions which act as single bargaining units. In the latter case, a *N*-party bargaining game arises. As mentioned in Sect.2 however, a $N>2$ game suffers indeterminacy unless stringent assumptions (such as stationarity in strategies) are made (see, e.g., Sutton (1986)).

The problem with multiple unions can be easily dealt with here. We suppose that there are two unions and that *each* union can halt the production process in case of disagreement. The wage negotiation process can be represented as a three-party bargaining game among the entrepreneur, union 1 and union 2. The triple (Π^*, W_1^*, W_2^*) defines the players' outside options. Intrinsic decay implies the existence of a terminal date, say T', defined by $R\beta^{T'}=\Pi^*+W_1^*+W_2^*$. For $\Delta \to 0$ the equilibrium payoffs converge to:

$$(\Pi,\ W_1,\ W_2) = \\ = \left(\frac{R}{3}+\frac{1}{3}(2\Pi^*-W_1^*-W_2^*),\ \frac{R}{3}+\frac{1}{3}(2W_1^*-\Pi^*-W_2^*),\ \frac{R}{3}+\frac{1}{3}(2W_2^*-\Pi^*-W_1^*)\right) \tag{18}$$

Then, when multiple unions participate in the bargaining process, the firm has to concede a larger wage bill than in the single union case: in fact, W_1+W_2 is greater than W, as defined in (16). This prediction is empirically supported by Machin, Stewart and Van Reenen (1993), who find that the participation in wage negotiations of multiple recognised unions as separate bargaining units actually leads to higher wages[11].

It must be recalled, however, that the presence of active trade unions is not necessary to justify the plausibility of a bargaining approach[12]. Indeed, bargaining models do provide a natural solution to any bilateral-monopoly situation between worker and firm due, e.g., to matching problems as in Pissarides' (1987) search model.

4.2. The Role of Effort.

We now consider a simple model with "effort", in order to investigate the relation between bargaining and efficiency-wage theory. According to the argument that we are going to develop, it emerges that the borderline between models of wage determination based on bilateral-monopoly power and models based on effort and incentive problems may be more blurred than what common wisdom may suggest.

We assume, after Shapiro and Stiglitz (1984)[13], that the firm's revenue function $R(e;t)$ is a discontinuous function of "effort", e:

$$R(e;t) = \begin{cases} R\beta^t, & \text{if } e \geq e^* \\ 0, & \text{if } e < e^* \end{cases} \tag{19}$$

Thus, if the effort level is below e^*, returns drop to zero. The worker has utility $U(W,e)=W-e$ and her outside option is worth $U^\circ>0$. If the worker shirks, she has a probability $q>0$ of being caught and fired without pay. The minimum wage level consistent with no shirking W^e must be such that the worker's utility when working hard ($e=e^*$) is not smaller than her expected utility when shirking ($e=0$), which is, $W-e^* \geq (1-q)W+qU^\circ$. Hence, the *minimum* level of wage the firm has to pay in order to guarantee positive returns is:

$$W^e = \frac{e^*}{q} + U^\circ > U^\circ \tag{20}$$

The bargaining horizon of the worker-entrepreneur wage game is limited by the firm's ability to pay *at least* W^e. As already mentioned, when $W<W^e$, returns drop to zero: in this case, the parties are better off by separating and taking up their outside alternatives. The final date of the bargaining game, say T°, is thus implicitly defined

by $R\beta^{T^\circ}$-$\Pi^*=W^e$. By backward induction, we obtain that the Perfect Equilibrium wage level is given by:

$$W = \frac{1}{2}(R-\Pi^*+W^e) = \frac{1}{2}(R-\Pi^*+\frac{e^*}{q}+U^\circ) \tag{21}$$

Wage equation (21) encompasses different approaches to wage determination. Hence, it may not be surprising to find that the merits of competing wage theories are difficult to assess empirically. According to (21), inter-firm wage differentials are explained by, *(i)* the set of variables affecting "efficiency" (e.g., the effectiveness of monitoring), *(ii)* the firm's "ability to pay" R, and *(iii)* the parties' outside options, U° and Π^*.

By an empirical point of view, Leonard's (1987) test raises some doubts about efficiency-wage theories based on monitoring and turnover. However, technological factors seem to be relevant in explaining the observed wage structures. According to Layard, Nickell and Jackman (1991,p.167), this fact is mostly consistent with efficiency-wage theories (see also Chapter I). On the other hand, firms' "ability to pay" (R, here) has wide empirical support as determinant of wage differentials, both at firm and industry level (see, e.g., Dickens and Katz (1987) and Krueger and Summers (1987)). This finding is fully consistent with the wage-bargaining model, as well as with efficiency-wage theories such as Akerlof's (1982) "gift exchange" principle.

4.3. Under-Investment in Workforce Training.

We abstract here from effort considerations and analyse a firm which can increase its revenues by investing in workforce's training, H. The revenue function is given by $R(H;t)=R(H)\beta^t$, with $R_H>0$ and $R_{HH}<0$.

Although training at firm's level tends to be mainly firm-specific (think, for example, of the "Mc Donald's University"), it may also have some positive spill-over on the worker's human capital. In general, the worker's value on the external labour market will be a positive function of the amount of training received. In our model, then, the worker's outside option is increasing in H: $W^*=W^*(H)$, $W^{*\prime}(H)>0$.

As we are going to show, our approach generates a new mechanism leading to sub-optimal investment in training, beyond the mechanism emphasised by the seminal paper of Grout (1984). Grout (1984) concentrates on the physical investment. When the workforce can bargain over returns once the investment cost has been sunk, under-investment arises in equilibrium (this issue will be extensively examined in Chapter III). However, if investment in training H is considered, the degree of inefficiency will be even more severe than in Grout's model.

Denote the unit cost of training as $\tau>0$. Efficient investment in workforce's training would require that $R_H=\tau$. However, as in Grout (1984), the workforce cannot commit not to bargain over wages once the training cost $H\tau$ has been sunk. Then, since the entrepreneur's share is given by $\frac{1}{2}(R-W^*+\Pi^*)$ and $W^{*\prime}(H)>0$, the privately optimal choice of H will solve the first order condition $\frac{1}{2}(R_H-W^{*\prime}(H))=\tau$, implying that $R_H=W^{*\prime}(H)+2\tau>\tau$. Being $R_{HH}<0$, private investment in training will be lower than the socially efficient level.

There are two forces leading to sub-optimality. The first one corresponds to the traditional Grout-effect: when bargaining occurs *ex-post*, the entrepreneur will only be able to appropriate *half* of the marginal benefit (R_H) from his investment. In our model, however, there is also a second effect contributing to under-investment. Whenever training increases the worker's value outside the firm ($W^{*\prime}(H)>0$), the entrepreneur will be in a weaker position when negotiating over the surplus: in other words, the entrepreneur's investment also contributes to strengthen his counterpart's bargaining power. This effect is peculiar to our model, since the "intrinsic decay" hypothesis implies that outside options always constitute a determinant of bargaining power. These observations give a new motivation for the desirability of policy interventions aimed at supporting training programs. Layard, Nickell and Jackman (1991) advocate public training schemes in order to reduce the degree of mis-match in labour markets. In the perspective of the present model, public intervention can also reduce the distortions deriving from rent-seeking behaviour. Publicly supported training could be implemented by incentivating firms to train their own employees under specific programs (through subsidies or tax bonuses), or by directly providing schemes that enhance the skills of the unemployed, so to reduce the costs of hiring.

5. Conclusions.

We have analysed a simple Rubinstein-type bargaining model in which the cake to be shared decays over time at a positive rate. As a consequence, outside options enter players' unique Perfect Equilibrium payoffs. Further, when the interval between two subsequent calls shrinks to zero, the payoffs take the "split-the-difference" form. These results generalise to the case of three-party bargaining. Our model can thus justify the common practice of deriving wage-equation expressions from Nash-maximands where the *status-quo* points are identified with the outside option levels.

With regard to wage-bargaining, we used our basic model to consider the distributive implications of multiple unionism. We also analysed workers' effort choice, so to investigate the relation between wage bargaining and efficiency wages. Finally, we examined the issue of workers' training, showing that entrepreneurs' choice may be severely inefficient.

In the next Chapter, we utilise the results from the strategic bargaining model developed here to analyse the role of financial decisions on the distribution of surplus between entrepreneurs and workers.

Appendix I

Proofs of Lemma 2 and Proposition 2.

Proof of Lemma 2. Refer to expressions (7) and (8) in the text (Sect.2). Let $S_{(\tau)}$ be the payoff of the agent calling at $t=\tau$. Consider the case in which $(C,\beta,s_1,s_2,s_3,\Delta)$ are such that agent I calls at $t=T$, when the size of the cake is $\beta^T C$. If the partition proposed by I at this stage is vetoed, II and III can get at most (s_2,s_3), respectively. Then, (s_2,s_3) are the minimum acceptable offers for II and III, and it is I's unique optimal offer to II and III. The unique Perfect Equilibrium partition at $t=T$ is then $(S_{(T)},s_2,s_3)$ where

$$S_{(T)} = \beta^T C - s_2 - s_3$$

Notice that the Perfect Equilibrium partition is the same with sequentiality in replies (II replies first: if he does not accept, the agents will take up their respective outside options; if he accepts, it is II's turn to reply: if he accepts, the proposed partition is enforced) or simultaneity in replies.

Agent III calls at $t=T\text{-}\Delta$, the size of the cake being $\beta^{T-\Delta}C$. To make his proposal accepted, he must offer I and II at least $(S_{(T)},s_2)$, respectively; again, $(S_{(T)},s_2)$ are the unique optimal offers for the caller at this stage. The unique P.E. partition at $t=T\text{-}\Delta$ is then $(S_{(T)},s_2,S_{(T-\Delta)})$, where

$$S_{(T-\Delta)} = \beta^{T-\Delta} C - S_{(T)} - s_2$$

Analogous argument holds for II's call at $t=T\text{-}2\Delta$. The P.E. partition at this stage is $(S_{(T)},S_{(T-2\Delta)},S_{(T-\Delta)})$, where

$$S_{(T-2\Delta)} = \beta^{T-2\Delta} C - S_{(T-\Delta)} - S_{(T)}$$

In general, agent II calls at each $t=T\text{-}(2+3h)\Delta$, $h=0,1,..,h^*$, obtaining

$$S_{(T-(2+3h)\Delta)} = (1-\beta^{\Delta})\,\beta^{T-(2+3h)\Delta}(1+\beta^{3\Delta}+\beta^{6\Delta}+..+\beta^{3h\Delta})\,C+s_2 =$$

$$= \beta^{T-(2+3h)\Delta}\frac{1-\beta^{3(h+1)\Delta}}{1+\beta^{\Delta}+\beta^{2\Delta}}C+s_2 \tag{A1.1}$$

Recalling that what agent II can receive at $t=T\text{-}(2+3h)\Delta$ in P.E. is equal to what he will be offered by I and III when they call at $t=T\text{-}(2+3h)\Delta\text{-}\Delta$ and $t=T\text{-}(2+3h)\Delta\text{-}2\Delta$

respectively ($t \geq 0$), expression (A1.1) characterizes the unique P.E. payoff obtained by II at *each* stage of the game. Analogous conclusions hold for III, calling at each $t=T-(1+3h)\Delta$, $h=0,1,..,h^*$, and receiving

$$S_{(T-(1+3h)\Delta)} = \beta^{T-(1+3h)\Delta}\frac{1-\beta^{3(h+1)\Delta}}{1+\beta^{\Delta}+\beta^{2\Delta}}C+s_3 \tag{A1.2}$$

Note that the result claimed in Lemma 2 holds either with simultaneity or with sequentiality in the reply structure of the calls and it is independent of changes in the order of calls. ■

An agreement will be reached at $t=0$. Refer to expression (A1.1). Given the order of calls we assumed, II calls at $t=\Delta$: h^* solves $T-(2+3h^*)\Delta=\Delta$ and II's unique P.E. payoff at $t=0$ is

$$S_{(\Delta)} = \beta^{\Delta}\frac{1-\beta^{T}}{1+\beta^{\Delta}+\beta^{2\Delta}}C+s_2 \tag{A1.3}$$

Since III calls at $t=2\Delta$, his unique P.E. payoff at $t=0$ is

$$S_{(2\Delta)} = \beta^{2\Delta}\frac{1-\beta^{T}}{1+\beta^{\Delta}+\beta^{2\Delta}}C+s_3 \tag{A1.4}$$

The unique P.E. partition at $t=0$ is then $(S_{(0)}=C-S_{(\Delta)}-S_{(2\Delta)},\ S_{(\Delta)},\ S_{(2\Delta)})$. We can now give the following:

Proof of Proposition 2. (We omit the proof of the proposition for different orders of calls). Let $(\sigma^1, \sigma^2, \sigma^3) \equiv (S_{(0)}, S_{(\Delta)}, S_{(2\Delta)})$, where $(S_{(\Delta)}, S_{(2\Delta)})$ are defined by (A1.3) and (A1.4). Taking the limit of $(\sigma^1, \sigma^2, \sigma^3)$ for $\Delta \to 0^+$, using (8) in the text, and noticing that $\epsilon \to 0$ and $(\beta^{\Delta}, \beta^{2\Delta}) \to (1,1)$,

$$\lim_{\Delta \to 0^+} \sigma^i = \frac{1}{3}C + \frac{2}{3}s_i - \frac{1}{3}\sum_{\substack{j=1 \\ (j\neq i)}}^{3} s_j, \quad i=1,2,3$$

Therefore, $lim_{\Delta\to 0+}(\sigma^1, \sigma^2, \sigma^3)=(S^1, S^2, S^3)$, where the triple (S^1, S^2, S^3) solves the Nash problem written in Proposition 2. ■

Notes

1. See, among many others, McDonald and Solow (1981), Grout (1984), Pissarides (1987), Nickell and Wadhwani (1990) and Layard, Nickell and Jackman (1991).

2. See, e.g., Barth (1992).

3. See also Shaked and Sutton (1984), Sutton (1986) and Binmore, Shaked and Sutton (1989).

4. Hart (1989) provides similar arguments to justify decay. His paper, however, abstracts from outside options.

5. Finiteness in alternating calls models is, *per se*, nothing new: it has been considered in Binmore (1987) to provide an alternative proof for uniqueness and was used in Ståhl's pioneering work on bargaining (see Ståhl (1972),(1988)).

6. Notice that if we assumed I calling at $t=\Delta$, then $S_{(\Delta)}$, obtained imposing $T\text{-}2k\Delta=\Delta$ in (3), would be the unique Perfect Equilibrium payoff for I at $t=0$.

7. While uniqueness is generated by the finiteness in the horizon of the game, the reason for the coincidence of payoffs in both game structures is the absence of discounting.

8. We omit the proof of this result for each of the three possible cases remaining; notice however that, having I calling both at $t=0$ and $t=T$, we gave her the greatest advantage possible: this advantage is shown to disappear for $\Delta \to 0$, a standard result in Rubinstein bargaining theory (see Sutton(1986), Binmore, Rubinstein and Wolinsky (1984)).

9.In what follows, we simplify the argument by taking $\delta=1$ (no discounting).

10. The significance of the coefficients of the outside option characterisations in empirical wage-equations estimated on *aggregate* data does *not* serve to discriminate between the "Outside Option Principle" and the "shift in the *status-quo*" since, even under the former, the fact that some firms will be "close to" the constraint implies that the outside options *will* affect the outcome in the aggregate (for a theoretical example, see Shaked and Sutton (1984b)).

11. The respect of inequality $W_1+W_2>W$ implies that $R>\Pi^*+W^*$, which is always true (we take $W_1^*+W_2^*=W^*$). Let (L,L_1,L_2) denote respectively the firm's employees, the firm's employees who are members of union 1, and the firm's employees who are members of union 2. Since $L_1+L_2=L$, the per-capita wage workers obtain under separate unions, $(W_1+W_2)/(L_1+L_2)$, is greater than the per-capita wage obtained under a single union, W/L.

12. Gosling and Machin (1993) find evidence that the reduction in union coverage in UK establishments during the 1980s has worsened the relative position of semi-skilled workers, relative to skilled workers: this supports the view that unions mostly increase

the bargaining power of weaker workers.

13. Similar implications would be obtained using the "morale" or "fairness" efficiency-wage principle (see, e.g., Akerlof and Yellen (1990)).

Chapter III

THE ROLE OF DEBT IN WAGE NEGOTIATIONS: A STRATEGIC BARGAINING MODEL WITH BANKRUPTCY.

Introduction.

As Grout (1984) has asserted, the inability of labour unions to make wage commitments creates an under-investment problem. When wages can be negotiated after investment has been sunk, workers are able to bargain over the gross returns the project can generate. Then, the entrepreneur will correctly anticipate that, after paying the full cost of investment, he will appropriate only a *fraction* of the surplus. As a consequence, the privately optimal choice turns out to be inefficiently low by a social point of view.

This Chapter reconsiders Grout's under-investment problem by concentrating on the role of debt in wage bargaining when long-term labour contracts cannot be written[1]. The impossibility of writing long-term complete contracts can be justified in terms of "transaction costs" (due to contingencies that are either unforeseeable or hard to describe, costly legal enforcement of contracts, etc.) after Williamson (1975). As we show through an explicit analysis of the "threat" of bankruptcy, the extent of under-investment depends on whether leverage can influence the distribution of surplus between wages and profits.

We analyse the relation between debt and wages in a strategic bargaining framework, assuming that delays in agreement will reduce the surplus to be shared (see Chapter II). We further assume that the workers and the entrepreneur are indispensable in production due to their specific skills. We show that if the parties fail to reach an agreement for a sufficiently long time, the firm will default on its debt obligations. In this model debt allocates the control rights over the firm *ex-post*. A similar approach has been taken by Aghion and Bolton (1992) and Hart and Moore (1994). When bankruptcy occurs, ownership is transferred to lenders, who can decide whether to liquidate or maintain the firm as a "going concern". Similarly to Hart and Moore (1994), we assume that in the event of bankruptcy lenders will come to bargain over the surplus the firm can still generate (under the assumptions made, it turns out that liquidation is never profitable). What is peculiar to our model is that bankruptcy will trigger a *three*-party bargaining game among the lenders, the workers and the entrepreneur in order to split the available surplus. While the workforce and the entrepreneur are assumed to be indispensable in production, lenders derive their bargaining power from the newly-acquired control of physical capital[2].

Bankruptcy never occurs in equilibrium in the present non-stochastic context.

However, the "threat" of bankruptcy reduces the workers' bargaining power in the bilateral bargaining game with the entrepreneur. By issuing £1 of debt on a competitive financial market, the entrepreneur can cash this amount today and reduce, by the same amount, the available surplus to be shared tomorrow with the workers. As a consequence, the entrepreneur always wants to issue as much debt as possible and, in some cases the amount of funds raised even exceeds the sheer cost of investment (*over-borrowing*).

The way debt financing works explains why the "hold-up" problem can be reduced, although not eliminated. By borrowing, the entrepreneur obtains a higher share of surplus which enhances his investment incentives. The amount of funds that the entrepreneur can raise in equilibrium is limited, however, since he is unable to precommit not to repudiate the debt contract whenever he finds it convenient. This observation has two main consequences. First, even if debt is a powerful instrument to constrain wages, workers still remain able to share part of the firm's surplus. Second, the limit imposed on the firm's debt capacity may imply that wealth-constrained entrepreneurs cannot borrow enough money to fund profitable projects.

Other papers have analysed the role of debt on wage negotiations[3], without providing an explicit analysis of bankruptcy. Dasgupta and Sengupta (1993) adopt a Nash-bargaining approach and find a negative wage-debt relation by making the extreme assumption that disagreement in wage bargaining leads to liquidation[4]. However, our view that financial distress is more likely to be dealt with by negotiations is supported by the observation that, for the US "financial distress is often resolved through private workouts or legal reorganisation under Chapter 11 of the U.S. Bankruptcy Code. Only much more rarely are distressed firms liquidated under Chapter 7 of the Code" (Wruck, 1990, p.425).

Bronars and Deere's (1991) Nash-bargaining model with exogenous bankruptcy costs generates very similar results. Their results hinge on the assumption that bankruptcy costs are increasing in the size of debt. Higher debt tends to increase the number of creditors, raising the cost of "resolving competing claims" in case of default[5]. Such costs, however, are more likely to hit creditors (due, e.g., to legal expenses), rather than workers (on this issue, see Webb (1987)).

Perotti and Spier (1993) analyse investment and financial choices as means to elicit wage reductions. In their model, shareholders may credibly threaten not to undertake new investment unless workers make concessions on the existing wage contracts. There are, however, some main differences between that model and ours. First, since they implicitly assume that workers cannot bargain over wages *after* that investment is sunk, they reach the conclusion that the investment level is *always* the efficient one, independently of the choice of leverage. Our reconsideration of Grout's problem leads to different conclusions, suggesting that under-investment cannot be eliminated, even if debt may improve efficiency (a similar result is also obtained by Dasgupta and Sengupta (1993)). Moreover, while Perotti and Spier argue that shareholders may extract the *whole* surplus through strategic debt issues, in our model workers are still able to appropriate part of the rents generated by investment. Finally, the conclusion that financial decisions "are a crucial factor in the *ex-post* allocation of the firm value" (Perotti and Spier, 1993, p.1132) depends crucially in our model on the indispensability of the entrepreneur in production. As we demonstrate, when the entrepreneur can be replaced costlessly, debt does not affect the wage level. This result distinguishes our model from the rest of the literature on debt and wages.

The Chapter is organised as follows. In Section 1, we describe the model, analyse the bankruptcy process and derive the wage as a function of debt. Section 2 illustrates the optimal choice of debt, discusses the theoretical implications, and examines the empirical predictions of the model. The efficiency implications of the model are discussed in Section 3. In Section 4, we explore the case when the firm is able to issue equity contracts. Section 5 concludes.

1. The Model.

We present a simple deterministic[6] model in which all agents have symmetric information and utility $U(x)=x$, where x is income. We assume that the parties cannot write long-term contracts. The investment project considered costs $I_0>0$ and generates a return equal to $R>I_0$. Both the workers and the entrepreneur have bargaining power over R: neither of them can be replaced, due to their indispensability in production. The workers' outside option, $W_0>0$, is what they can obtain by leaving the negotiation table for good. $L_0\geq 0$ is the liquidation value of the project. As in the bargaining model developed in Chapter II, we assume that delays in production cause decay of returns over time: $R(t)=\beta^t R$, with $\beta\in(0,1)$, for any $t\geq 0$. Thus, $R(t)$ is the total return that can be obtained if production takes place at date t. There are net gains from production until the terminal date $t=\tau>0$, defined by $R(\tau)=W_0+L_0$. After τ, the parties find it mutually convenient to abandon the project (that is liquidated) and to take up their outside options, rather than to produce. Similarly to Chapter II, the assumption of decaying returns can be justified as follows. A strike, by causing delays in production, is likely to worsen the *firm*'s position (due to lost market opportunities, physical decay of machinery, etc.). By contrast, disagreement is unlikely to affect the parties' outside options, which mainly depend on *market* conditions.

The amount borrowed by the entrepreneur from a competitive financial market (the net interest rate is, for simplicity, zero) is denoted by $D\geq 0$.

The model is structured in two subsequent games (see Figure 1):

- *Workforce-Entrepreneur bargaining.* At $t=0$, the debt contract is written and the investment cost, I_0, is sunk. A bargaining game with alternating calls starts between the workers and the entrepreneur. If an agreement is reached immediately, production takes place, returns are shared, and debt is repaid. On the other hand, if disagreement persists (and neither player leaves the negotiation table) workers and entrepreneur go on issuing proposals, *unless bankruptcy occurs at date*[7] $t=T$.

Bankruptcy can be triggered by either party. As in Hart and Moore (1994), the entrepreneur always has the possibility of repudiating debt. On the other side, workers may drive the firm into default through a strike which, by preventing production, precludes debt repayment.

- *Bankruptcy game*. If bankruptcy occurs, the unfulfilled debt contract, requiring D as repayment, is cancelled. Lenders receive the property rights over the firm's physical assets and decide whether to liquidate (which gives L_0) or not. If they do *not* liquidate, a three-party bargaining over the residual return, $R(t)$ with $t \in [T,\tau]$, starts. The workers and the entrepreneur take part in negotiations, since they are indispensable in production, while lenders derive bargaining power from their ability to foreclose the use of firm's capital.

The bargaining framework adopted is based on the model developed in Sections 1-2 of Chapter II. When *(i)* the firm's returns decay over time at a given rate, *(ii)* the sum of the agents' outside options is positive and constant, *(iii)* the discount rate is zero and, *(iv)* the calls alternate at intervals shrinking to zero, a dynamic game with $N \geq 2$ agents, starting at date t, yields the following *unique* Perfect Equilibrium payoffs[8]

$$S^i = \frac{1}{N}\left\{ Z(t) + (N-1)s_i - \sum_{j=1, i \neq j}^{N} s_j \right\}, \quad \forall\, i = 1,2,...,N \tag{1}$$

where S^i and s_i are, respectively, agent i's share of the pie, $Z(t)$, and i's outside option. Mutual gains from an agreement require that $Z(t) > \Sigma^N_{i=1} s_i > 0$.

The model is solved by *backward induction*. We first solve the bargaining problem under bankruptcy and then specify the conditions which may lead to bankruptcy, analysing the implications for the entrepreneur-workforce game.

1.1 Distribution under Bankruptcy.

When at date $t=T$ bankruptcy occurs, lenders come to control the firm's physical assets and trilateral negotiations start, unless the firm is liquidated. Since liquidation remains available, L_0 is the lenders' outside option. The entrepreneur's outside option is zero.

In equilibrium, using (1) for $N=3$, $Z(t)=R(t)$ and $t=T$, the payoffs on which workers, entrepreneur and lenders agree are, respectively:

$$W^d_{(T)} = \frac{1}{3}\left(R(T) - L_0 + 2W_0\right) \tag{2}$$

$$\Pi^d_{(T)} = \frac{1}{3}\left(R(T) - L_0 - W_0\right) \tag{3}$$

$$L^d_{(T)} = \frac{1}{3}\left(R(T) - W_0 + 2L_0\right) \tag{4}$$

The players' payoffs, $(W^d_{(T)}, \Pi^d_{(T)}, L^d_{(T)})$, are not smaller than the corresponding outside alternatives, $(W_0, 0, L_0)$, if and only if $R(T) \geq R(\tau)$, that is, if and only if $T \leq \tau$. The condition $T \leq \tau$ must hold in equilibrium, otherwise it would be mutually convenient to liquidate the firm before reaching date T. Hence, when bankruptcy occurs at T, *liquidation is dominated* (since $T \leq \tau$ implies that $L^d_{(T)} \geq L_0$, lenders will prefer to find an agreement over $R(T)$, rather than liquidate).

Using equations (2)-(4), we can evaluate what the entrepreneur and the workforce would obtain in bankruptcy[9]. We derive next the backward-induction solution to the workforce-entrepreneur bargaining game, as a function of $(W^d_{(T)}, \Pi^d_{(T)})$ and debt repayment D.

1.2 The Workers-Entrepreneur Bargaining Game.

At $t=0$, the loan is granted and investment is implemented. Competitive lenders are willing to finance (or re-finance) the firm as long as they expect to break-even on the debt contract they offer. As in Hart and Moore (1994), creditors must take into account that the entrepreneur can deliberately default on debt whenever she finds it convenient.

In order to analyse the role of debt on wage bargaining, we distinguish between the cases of $D > L_0$ and $D \leq L_0$.

- Consider first the case when the level of debt repayment, D, is greater than the firm's liquidation value, L_0. If, at $t=0$, the entrepreneur and the workers find an agreement over the sharing of R-D, production takes place and debt is repaid. If there is disagreement, however, production does not occur and debt cannot be repaid. In this case, bankruptcy can only be avoided by rolling over debt from the current to the next period, provided that lenders are willing to do so. If lenders refuse to roll over debt, the firm is declared bankrupt.

The following Lemma gives the conditions under which debt roll-over is feasible:

Lemma 1. Suppose that $D > L_0$. Define T as the date which solves $L^d_{(T)} = D$. If workers and entrepreneur disagree during wage bargaining, lenders are willing to roll over debt until date T is reached, but not beyond.

Proof. Recall that the lenders' bankruptcy payoff, $L^d_{(t)} = \frac{1}{3}[R(t) - W_0 + 2L_0]$, is monotonically decreasing over time: lenders do not make losses when rolling over debt up to a date $t \leq T$, since $L^d_{(t)} \geq D$ (should bankruptcy occur at date t, lenders would obtain *at least* D, the amount lent).

Moreover, debt is never rolled over beyond T. When $t > T$, $L^d_{(t)} < D$: the entrepreneur would rather repudiate her debt, forcing lenders to accept $L^d_{(t)}$, than repay D (by doing this, the entrepreneur would be able to share $D - L^d_{(t)}$, the lenders' loss, with the workers). ■

Hence, before T is reached, disagreement in wage bargaining need not imply bankruptcy. Moreover, the entrepreneur *will* roll over debt up to any $t < T$, in case of disagreement with the workers[10].

Since $L^d_{(T)}$ is monotonically decreasing in $T \in (0, \tau]$, the maximum level of credit available to the firm, D^*, is given by $L^d_{(0)}$, where $L^d_{(0)}$ denotes $L^d_{(T)}$ calculated for T arbitrarily close to zero. Hence:

Lemma 2. The firm's debt capacity is:

$$D^* = \frac{1}{3}\left(R - W_0 + 2L_0\right) \qquad (5)$$

Notice that $D^* > L_0$, since $R - W_0 - L_0 > 0$. When D^* is chosen, disagreement between the workers and the entrepreneur forces *immediately* the firm into bankruptcy negotiations.

It is now possible to characterise the Perfect Equilibrium payoffs of this bargaining game, defined for $t \in [0,T)$ over $R(t)-D$, when $D > L_0$.

Since $W^d_{(T)} \geq W_0$ and $\Pi^d_{(T)} \geq 0$, neither party will ever quit the firm before date T is reached. The workers' and the entrepreneur's bankruptcy payoffs become the economically relevant alternatives to an earlier agreement on $R(t)-D$. Thus, evaluating (1) for $N=2$, $Z(t)=R(t)-D$ and $t=0$, we obtain the following result:

Lemma 3. Suppose that $D \in (L_0, D^*]$. In equilibrium, the workforce's and the entrepreneur's payoffs are given by, respectively

$$W|_{D>L_0} = \frac{1}{2}\left(R - D + W^d_{(T)} - \Pi^d_{(T)}\right) = \frac{1}{2}\left(R - D + W_0\right) \tag{6}$$

$$\Pi|_{D>L_0} = \frac{1}{2}\left(R - D - W^d_{(T)} + \Pi^d_{(T)}\right) = \frac{1}{2}\left(R - D - W_0\right) \tag{7}$$

while the payoff of the lenders is D (the amount lent).

Both the entrepreneur's and the workers' shares bear the burden of debt repayment. With $D > L_0$, should disagreement last long enough to cause bankruptcy, the entrepreneur would lose control over the firm. Bankruptcy involves the cancellation of debt D but triggers, at the same time, the participation of lenders in negotiations. Thus, the workforce and the entrepreneur are unable to eschew their part of debt repayments, since in equilibrium it holds that $D = L^d_{(T)}$.

- We analyse now the case for $L_0 \geq D$. When the liquidation value of the firm is not smaller than the contractual debt repayment, rolling over D is never a problem since, in bankruptcy, lenders can obtain their money back just by liquidating the firm. The bargaining process between the workers and the entrepreneur, whose outside option is now $L_0 - D \geq 0$, takes place in $t \in [0,\tau]$ over $R(t)-D$. Evaluating (1) for $Z(t)=R(t)-D$ and $t=0$, we obtain the following result:

Lemma 4. Suppose that $L_0 \geq D$. In equilibrium, the payoffs of the workers and the entrepreneur are, respectively:

$$W|_{D\leq L_0} = \frac{1}{2}\left(R - D + W_0 - (L_0 - D)\right) = \frac{1}{2}\left(R - L_0 + W_0\right) \tag{8}$$

$$\Pi|_{D\leq L_0} = \frac{1}{2}\left(R - D - W_0 + (L_0 - D)\right) = \frac{1}{2}\left(R + L_0 - W_0\right) - D \tag{9}$$

while the payoff of the lenders is D.

The whole burden of debt is borne by the entrepreneur's share. With $L_0 \geq D$, the entrepreneur always finds it convenient to repay debt, in order to keep control over the firm's physical assets: using (3) and (9), it is immediate to verify that, over the bargaining horizon $t \in [0,\tau]$, entrepreneur's voluntary repudiation is sub-optimal. In fact, repudiation at t would be convenient if $(1/2)[R(t)-W_0+L_0]-D < (1/3)[R(t)-W_0-L_0]$, which *never* holds, since $L_0 \geq D$ and $R(t)-W_0-L_0 \geq 0$.

Since the possibility of bankruptcy is ruled out when $L_0 \geq D$, lenders will never come to compete with workers over the sharing of the rents.

Notice finally that *bankruptcy never occurs in equilibrium*: forward-looking agents can infer the consequences of financial distress without provoking it.

2. The Optimal Choice of Debt and its Implications.

The strategic financial choice of an entrepreneur who is indispensable in production can now be analysed. We assume that the cost of the investment project, I_0, is greater than its liquidation value, L_0. A level of debt D greater than I_0 is also possible: the entrepreneur may use borrowed funds for activities which are *unrelated* to the production process, such as perquisites consumption, acquisition of assets, etc.

The level of debt, D, is chosen to maximise the profit expression

$$M = R - W - I_0 \tag{10}$$

The following statement characterises the entrepreneur's optimal choice:

Proposition 1. The entrepreneur's optimal choice of debt in $[0,D^*]$ is D^*: the entrepreneur borrows up to the firm's debt capacity, defined in (5).

Proof. For $D \leq L_0$, the wage is defined by $W|_{D \leq Lo}$ in (8): since this wage level is unaffected by debt, profits are independent of D. For $D > L_0$, the wage is $W|_{D>Lo}$, as defined in (6): since profits, calculated for $W = W|_{D>Lo}$, are monotonically increasing in D, M is maximised for $D = D^*$, as defined in (5). It remains to be shown that $R\text{-}W|_{D \leq Lo}\text{-}I_0 = (1/2)(R+L_0\text{-}W_0)\text{-}I_0$ is smaller than the corresponding expression calculated for $D = D^*$, i.e., $R\text{-}W|_{D>Lo}\text{-}I_0 = (1/2)(R+D^*\text{-}W_0)\text{-}I_0$: this is always true, since $D^* > L_0$. ■

For $D = D^*$, the wage and the profit levels are, respectively

$$W(D^*) = \frac{1}{2}\left(R - D^* + W_0\right) = \frac{1}{3}\left(R - L_0 + 2W_0\right) \tag{11}$$

$$M(D^*) = \frac{2}{3}R - \frac{2}{3}W_0 + \frac{1}{3}L_0 - I_0 \tag{12}$$

The wage expression (11) is explained as follows. When D^* is chosen, the workforce is indifferent between: *(i)* disagreeing and trigger a bankruptcy process with three party bargaining over $R(T)$, which is arbitrarily close to $R(0)$ (T is arbitrarily close to zero, when $D=D^*$), and *(ii)* accepting a deal over R-D^*, according to the rules in (6)-(7). Since "conflict" brings no gain to the workers, an agreement over R-D^* is immediately found. On the other side, the entrepreneur cashes the entire amount D^*, while the repayment of D^* itself is *equally* borne by $W|_{D>Lo}$ *and* $\Pi|_{D>Lo}$, defined by (6)-(7). Borrowed funds can thus be strategically used to divert part of the rents away from the workforce. However, a noticeable feature of the present model is that, since the entrepreneur's ability to manipulate the firm's capital structure is limited by the debt capacity D^*, workers are still able to share part of firm's surplus. In other words, wage $W(D^*)$ is greater than W_0, its "market" alternative[11].

Another relevant implication of the model is that the strategic use of debt can also generate *over-borrowing:*

Corollary. When $D^*>I_0$, *the firm borrows* D^* *and uses the amount* D^*-I_0 *to finance activities not related to the production process.*

Even if unrelated to production needs, this use of financial resources is not *per se* wasteful, being just a side-effect of the distributional role of debt.

Notice that the results we have obtained so far are crucially based on the assumption that the entrepreneur is indispensable in production. Under the extreme assumption that the entrepreneur can be costlessly replaced, bargaining in bankruptcy will reduce to a two-party game between lenders and workers. In fact, an entrepreneur who is not indispensable in production derives his bargaining power only from physical assets' ownership, which is lost in case of bankruptcy. Also, the firm's credit capacity is equal to $(1/2)[R+L_0-W_0]$ and is greater than D^*, defined in (5): should bankruptcy occur, lenders could exclude the entrepreneur, bargain only with the workforce and obtain a larger share of returns. In this case however, as shown by the following Proposition, debt cannot be used to affect the workers' bargaining position.

Proposition 2. If the entrepreneur is dispensable and can be replaced costlessly in production, debt can not affect the wage level.

Proof. Take $D>L_0$. If the entrepreneur is dispensable for production, the bankruptcy payoffs are $\Pi^d_{(T)}=0$, $W^d_{(T)}=(1/2)[R(T)+W_0-L_0]$ and $L^d_{(T)}=(1/2)[R(T)-W_0+L_0]$. Since $D=L^d_{(T)}$, bilateral bargaining between entrepreneur and workers over $R(t)-D$ in $t\in[0,T)$ gives them, respectively, $\Pi=(1/2)[(R-D)-W^d_{(T)}]=(1/2)[R-W_0+L_0]-D$ and $W=(1/2)[(R-D)+W^d_{(T)}]=(1/2)[R+W_0-L_0]$. Notice also that W and Π coincide with (8)-(9). ■

The results obtained in Proposition 1 and 2 are encompassed by a model where the entrepreneur turns out to be indispensable with probability $\alpha\in[0,1]$, should bankruptcy occur. In Appendix I we show that the entrepreneur will still choose to borrow up to full debt capacity as far as $\alpha>0$.

Our results have some empirical implications. In general[12], firms with a specialised, or unionised, workforce will tend to exhibit higher leverage than firms with non-specialised (or non-unionised) workers. This prediction is consistent with the findings of Bronars and Deere (1991) and Machin and Scaramozzino (1993). Bronars and Deere (1991) find a positive and significant relation between unionisation and leverage for a sample of U.S. firms. This finding is not directly confirmed by Machin and Scaramozzino (1993) for a panel of U.K. firms. They find, however, a positive and significant relation between the proportion of skilled workers in the firm and the debt-equity ratio. Their interpretation is that the proportion of skilled workers is likely to measure bargaining power over the firm's rents: high debt would then be a device to constrain wages.

Moreover, the result that firms tend to raise more debt than required by investment costs (as predicted by the Corollary) seems to be empirically supported. As reported by Hart and Moore (1994,p.864-5), "there is some evidence that firms borrow more than they strictly need to cover the cost of their investment project"[13].

Further, our wage equations such as expression (11) predict that inter-firm wage differentials depend on the returns generated by each firm, as commonly observed[14]. On the contrary, if debt could transfer the whole surplus to the profit share as hinted by Perotti and Spier (1993), wages should be *unrelated* to the firm's returns.

3. Implications for Efficiency.

The *social optimality condition for investment* prescribes that the returns generated by the project are not smaller than labour's and capital's opportunity costs: $R \geq W_0 + I_0$. We can rewrite this condition as

$$R - W_0 - L_0 \geq I_0 - L_0 \qquad (13)$$

When projects which satisfy (13) are not realised, "under-investment" occurs. We separate the deviations from (13) into two classes: "Grout-type" and "Hart-Moore-type" inefficiencies.

- *Grout-type Inefficiency*. As in Grout (1984), this type of inefficiency derives from the ability of the workforce to bargain over wages once the cost I_0 has been sunk. A project of cost I_0 will be undertaken if, and only if, $M(D^*) \geq 0$ holds. Using (12), this condition is equivalent to:

$$R - W_0 - L_0 \geq \frac{3}{2}(I_0 - L_0) \qquad (14)$$

Inequality (14) is more restrictive than (13), therefore the entrepreneur will be willing to undertake a set of projects *smaller* than the socially desirable set. If however debt had no power to constrain wages (as it happens under Proposition 2) the condition for investing would be $R - L_0 - W_0 \geq 2(I_0 - L_0)$, which is even *more* restrictive than (14). By redistributing surplus to the entrepreneur, debt allows for the realisation of investment projects which would have otherwise been unprofitable. Our argument provides a possible reason why developed and competitive credit markets may favour the investment process[15].

The conclusion that high leverage enhances efficiency holds, however, *provided that* workers do *not* have to make any specific and costly investment as well[16]. Indeed, as pointed out by Dasgupta and Sengupta (1993), if *workers* had to make some costly firm-specific investment *ex-ante*, strategic debt could reduce efficiency. To illustrate briefly this point, assume that the workers' investment level, ϵ, generates disutility $g(\epsilon)$ ($g' > 0$, $g'' \geq 0$). Returns are given by $R(\epsilon)$ ($R' > 0$, $R'' < 0$) and the workers' utility is equal to $W - g(\epsilon)$. With $D = D^*$, workers choose ϵ_*, solving $\frac{1}{3}R'(\epsilon)$-

$g'(\epsilon)=0$. On the other hand, if $D=0$, workers will choose ϵ_0, solving $\frac{1}{2}R'(\epsilon)-g'(\epsilon)=0$. Since $\epsilon_0>\epsilon_*$, the strategic use of debt drives the workers' investment decision *further away* from its efficient level (defined by $R'(\epsilon)-g'(\epsilon)=0$). We will consider this issue in greater detail in Chapter IV.

- *Hart-Moore-type Inefficiency*. When the entrepreneur is unable to precommit not to default on her debt, wealth-constraints may prevent the realisation of profitable projects, even when Grout-type inefficiencies are not at work ($M(D^*)\geq 0$). If debt does not cover the full cost of the project ($D^*<I_0$), investment is unfeasible whenever the entrepreneur's wealth, Φ_0, is such that $\Phi_0<I_0-D^*$. This is the same mechanism that generates under-investment in Hart and Moore (1994): profitable investment projects may be foregone due to the firm's insufficient financing capacity[17].

As made clearer by the following numerical examples, the Hart-Moore-type inefficiency and the Grout-type inefficiency need not imply each other. For $R-W_0=8$, $L_0=0$, $I_0=4$, $\Phi_0=0$, only the Hart-Moore-type inefficiency is at work. For $R-W_0=8$, $L_0=0$, $I_0=6$, $\Phi_0=4$, only the Grout-type inefficiency operates.

These results can be summarised in the following proposition:

Proposition 3. An entrepreneur will not undertake a socially efficient investment project (such that $R>W_0+I_0$) when:

(i) either $M(D^*)<0$: Even if the entrepreneur takes up as much debt as she can, her final payoff will still be negative since workers capture "too much" of the surplus generated by investment (Grout-type inefficiency),

(ii) or $\Phi_0+D^*<I_0$: The entrepreneur is unable to finance the project because of wealth-constrains and cannot commit not to repudiate her debt (Hart-Moore inefficiency).

However, the use of debt allows for the realisation of efficient investment project which otherwise would have been unprofitable.

The problem relative to the Hart-Moore effect raised by Proposition 3 can be much less dramatic if firms can issue *equity contracts*. This issue is discussed in the next Section.

The inefficiencies we considered only arise if the parties cannot write long-term contracts before investment is sunk[18]. Legislation against strikes that violate previous agreements might perhaps provide a "commitment technology" for the workers, as Grout (1984,p.450) argues on the basis of the comparison between the US and UK laws on industrial disputes. Although the presence of no-strike provisions in labour contracts can be relevant, it is unlikely that the under-investment problem can be fully eliminated. As Hart (1995) recalls, the inability to precommit not to renegotiate the contract conditions at a future date exposes the party who invested to the other party's opportunistic behaviour[19]. Moreover, opportunism may also explain why a party can be unwilling to enter self-restraining commitments, when the other can take actions difficult to contract *ex-ante*, such as the choice of leverage. As Perotti and Spier's (1993) analysis suggests, workers who accept to "tie their hands" by committing not to strike expose themselves to the adverse consequences of debt manipulations.

4. Equity Contracts

We define an equity contract as a contract specifying that a positive fraction $\sigma \in [0,1)$ of the entrepreneurial share (7) will be paid out to shareholders who bought shares of value E. Thus, with competitive capital markets and net interest rate equal to zero, the dividend flow must equate E:

$$\sigma\left[\frac{1}{2}(R-D-W_0)\right] = E \tag{15}$$

In contrast with debt repayments (which impose a constraint on the flow of returns generated by the firm), dividends are paid out of the entrepreneur's share *residually*. This fact has two consequences. First, equity is not an effective tool in reducing wages and, thus, the entrepreneur will still maximise profit by choosing $D=D^*$. As a consequence, *debt-financing dominates equity-financing (as well as own-financing)*[20]. Moreover, an entrepreneur will issue equity only[21] when debt (D^*) is insufficient to cover the cost of investment (I_0): in this case, $E=I_0-D^*>0$. Hence, *when feasible, equity-issues can wipe out the under-investment inefficiency generated by wealth constrains* (the Hart-Moore effect). These results are consistent with the finding that, in contrast with debt, equity issues tend to be associated with relatively low profitability (see, e.g., Harris and Raviv (1991)). Here, highly profitable firms not only have no need to issue stock to cover the cost of investment, but they will also be able to over-borrow.

The possibility of equity-issues in the present context remains, however, quite questionable. In general, debt repayments are much easier to enforce than dividend payments. As it happens in the present model, debtors who are not repaid can appeal to a court and get the control over the firm. As emphasised by Shleifer and Vishny (1995), shareholders are generally in a weak bargaining position, especially when they own minority stakes. For example, when firm's profitability is not easily verifiable by a court, the entrepreneur may successfully divert funds and pay out a smaller amount of dividends. Hence, the potential conflict of interest between entrepreneur and equity-holders makes it difficult for many firms to access stock markets[22]. This will be true, in particular, for countries (like Italy or Korea) where the legal protection offered to shareholders is rather limited[23].

5. Conclusions.

In this Chapter, we examined how the capital structure of the firm can be used to affect the division of the surplus between an entrepreneur and his workforce.

The idea that debt can constrain wages has been already explored in the literature, beginning with Bronars and Deere (1991). The present approach, however, has the advantage of using an explicit bargaining game to model the bankruptcy process. Our procedure allows us to identify better the conditions which make debt an effective strategic tool. We considered what the workforce and the entrepreneur can obtain by "disagreeing". If disagreement in bilateral wage bargaining lasts long enough, the firm is led to bankruptcy. Lenders obtain the control over the firm's assets and, if the entrepreneur is indispensable in production, there will be a three-party bargaining over the available surplus. Therefore, a relevant aspect of the model we presented is that failure to meet the requirements specified by the contract has a direct impact on the structure of the bargaining game to be played by forward-looking agents.

From the point of view of welfare, different sources of inefficiency coexist in this model. With regard to Grout's "hold-up" problem we showed that, by increasing the profit share, debt can reduce under-investment. A second source of inefficiency is generated by the limit to the debt capacity of the firm. A wealth-constrained entrepreneur may not be able to raise enough money to fund a profitable investment project.

The results obtained above apply immediately to any context that concerns bargaining between the firm and input suppliers other than the workers.

The themes we treated here are partly re-considered in Chapter IV, where we analyse the role of debt not only for what it concerns the level of investment, but also with regard to the degree of sophistication of the projects chosen.

Appendix I

The Optimal Choice of Debt when the Entrepreneur can be replaced with Probability $1-\alpha \in [0,1]$.

The motivation for considering the case when the incumbent entrepreneur can be replaced with some positive probability in case of bankruptcy comes from the empirical observation that the level of turnover of directors and managers in financially distressed firms is significantly higher than the corresponding one in firm which do not experiment financial troubles. This is the case even when distressed firm are expected to remain in business (see Gilson (1989,1990)).

The only relevant case in which entrepreneur's substitutability matters is the one in which $D > L_0$ (for $D \leq L_0$, Lemma 4 applies). Consider the case when, if bankruptcy occurs, lenders have probability $1-\alpha \in [0,1]$ of finding a new management which has the same ability of the incumbent one to run the firm. The incumbent entrepreneur will then maintain his bargaining power in bankruptcy only with probability α. When the incumbent entrepreneur can be actually substituted, there will be a bilateral bankruptcy game between the workforce and the lender. Otherwise, the entrepreneur will keep his position and there will be again a three-party bargaining game. Thus, the expected workforce's payoff in bankruptcy (at time, say, t') is

$$EW^d_{(t')} = (1-\alpha)\left[\frac{1}{2}(R(t') - L_0 + W_0)\right] + \alpha\left[\frac{1}{3}(R(t') - L_0 + 2W_0)\right]$$

while management's expected payoff becomes $E\Pi^d_{(t')} = \alpha(1/3)(R(t')-W_0-L_0)$.

The terminal date $t=T'$ in the management-workforce bargaining game is defined by:

$$T': \ R(T') - D = EW^d_{(T')} + E\Pi^d_{(T')} \tag{A1.1}$$

which we can rearrange into the following

$$R(T') - W_0 - L_0 = (D - L_0)\frac{6}{3-\alpha} \tag{A1.2}$$

By using (A1.2) we have that the management P.E. payoff is

$$\Pi' = \frac{1}{2}(R-D) + \frac{1}{2}(E\Pi_{(T')} - EW^{d}_{(T')}) =$$

$$= \frac{1}{2}(R-W_0) + \frac{3(1-\alpha)}{2(3-\alpha)}L_0 - \frac{3-2\alpha}{3-\alpha}D \qquad \text{(A1.3)}$$

The wage expression ($W'=R$-D-Π') takes the form:

$$W' = \frac{1}{2}(R+W_0) - \frac{3(1-\alpha)}{2(3-\alpha)}L_0 - \frac{\alpha}{3-\alpha}D \qquad \text{(A1.4)}$$

Thus, when $D>L^*$, profits are given by

$$\mathrm{M}(D;\alpha) = R - W' - I_0 =$$

$$= \frac{1}{2}(R-W_0) + \frac{3(1-\alpha)}{2(3-\alpha)}L_0 + \frac{\alpha}{3-\alpha}D - I_0 \qquad \text{(A1.5)}$$

which is monotonically increasing in D, provided that $\alpha>0$. The level of D will be therefore set to its upper bound, D^{**}, where

$$D^{**} = L^{d}_{(0)} = (1-\alpha)\frac{1}{2}(R+L_0-W_0) + \alpha\frac{1}{3}(R+2L_0-W_0) =$$

$$= \frac{1}{2}(R+L_0-W_0) - \alpha\frac{1}{6}(R-L_0-W_0) > L_0 \qquad \text{(A1.6)}$$

(recall that $D^{**}>L_0$ is implied by $I_0>L_0$).

After having shown that the optimal level of D is D^{**} (if $\alpha>0$ and $D>L_0$), we want to check that $M(\alpha,D^{**})\geq M(D|D<L_0)$ for any $\alpha\in[0,1]$, where $M(D|D<L_0)$ is the profit level R-W-I_0 calculated for the wage level (8). This inequality implies that:

$$\frac{1}{2}(R-W_0) + \frac{3(1-\alpha)}{2(3-\alpha)}L_0 + \frac{\alpha}{3-\alpha}D^{**} - I_0 \geq \frac{1}{2}(R-W_0+L_0) - I_0$$

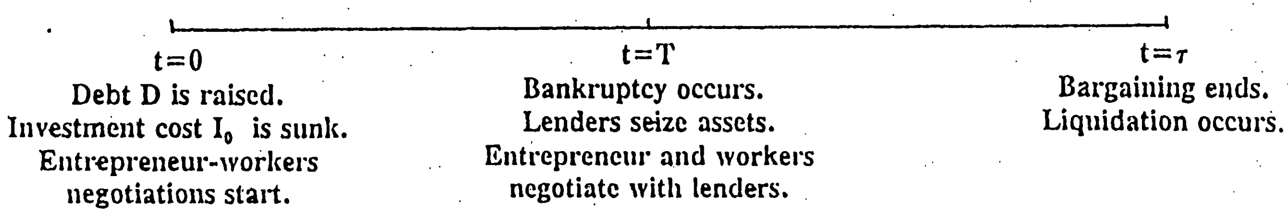
$$\Rightarrow D^{**}\frac{\alpha}{3-\alpha} \geq L_0\frac{\alpha}{3-\alpha}$$

which holds strictly for any $\alpha\in(0,1]$, since $D^{**}>L_0$.

The explanation of this result is quite immediate: if managers can be replaced with probability one in a bankruptcy state ($\alpha=0$), they lose any bargaining power in the bankruptcy state (the argument here is quite similar to what generates the "walrasian case" of Shaked and Sutton (1984a)). It follows that the level of debt repayments they contract, D, cannot constrain the wage level: as a consequence, the management will be indifferent to the financial source to use to finance the project. This indifference is broken when the management has a positive probability of not being replaced ($\alpha>0$), making the maximum level of sustainable debt (here, D^{**}) the optimal choice. (Notice that $D^{**}=D^{*}$, as defined by Lemma 2, for $\alpha=1$).

FIGURE 1

TIMING



Notes

1. With "contract incompleteness" under-investment arises in a variety of economic contexts (see Hart (1995) for a comprehensive and detailed discussion). We return to these issues in Sect.IV.

2. Hart and Moore (1994) also assume that the entrepreneur has special skills in production. However, they use the bargaining outcome between the lender and the defaulted borrower to define the *set* of the viable debt contracts, i.e., those contracts which do not induce the entrepreneur to default voluntarily (see also Moore (1992)).

3. The strategic role of debt has been analysed in other contexts than wage negotiations: for example, Brander and Lewis (1986) consider the strategic choice of leverage in a model of oligopolistic competition.

4. On this point, see also Gilson *et al.* (1990).

5. Bronars and Deere (1991,Note 4,p.234)

6. The extension of the model to the case of stochastic returns is quite straightforward.

7. Date T will be shown to depend on the level of D.

8. As discussed in Chapter II, the payoffs' uniqueness, *holding also for a number of players greater than two*, follows from the finiteness of the time-horizon ($\tau < \infty$). By contrast, we recall that the extension of Rubinstein (1982) to three (or more) players generates indeterminacy, unless stringent restrictions on strategies are imposed (see, e.g., Osborne and Rubinstein (1990)).

9. If strategies were assumed to be stationary, the application of the Rubinstein's (1982) model to trilateral bankruptcy negotiations would also generate a unique solution (see note 7). In that context, however, the players' outside alternatives would matter, at most, as corner solutions ("Outside Options Principle").

10. Lenders would benefit from a bankruptcy process starting at a date $t<T$, since $L^d_{(t)} \geq D$. As a consequence, the entrepreneur and the workers would get bankruptcy payoffs which are smaller than those obtainable by agreeing and repaying D.

11. Note that the basic result in Proposition 1 holds even if R is taken to be stochastic, provided that the firm is economically viable ($R \geq L_0 + W_0$). Similarly to Perotti and Spier (1993), the debt level can be suitably adjusted *ex-post*, so to provide a "bargaining tool" in wage negotiations.

12. See Appendix I.

13. In contrast with our explanation, Hart and Moore (1994) argue that firms over-borrow "to provide themselves with a 'financial cushion'".

14. See, e.g., Nickell and Wadhwani (1990).

15. The positive relation between credit market development and physical capital accumulation is strongly supported by King and Levine (1993).

16. In contrast with our result that debt improves efficiency, Perotti and Spier (1993) find that issuing debt may reduce efficiency because it exposes (risk-averse) workers to more risk.

17. Notice that when $D^* \geq I_0$ (the over-borrowing case discussed in Sect.III) it holds that $R-L_0-W_0 \geq 3(I_0-L_0)$: hence, condition (14) is satisfied. Investment is always feasible (no Hart-Moore inefficiency) and profitable (no Grout inefficiency).

18. See for example Dasgupta and Sengupta (1993,p.215).

19. Post-contractual opportunism is what drives Hart and Moore's (1994) results, since the entrepreneur "can always threaten to repudiate the contract by withdrawing his human capital" (p.841).

20. Note that, with $E \geq 0$ and $D=D^*$, the entrepreneur's profit, net of dividend payment, is still given by $M(D^*)$ as defined in (12). This fact can be shown by maximising (10) as in Sect.2, noticing that $E>0$ (i.e., $\sigma>0$) has no impact on the wage level.

21. As implied by (15), equity-issue *per se* bring no net gain to the entrepreneur.

22. The problem of the conflict of interest between manager and shareholders (see the literature surveyed in Harris and Raviv (1991)) is not considered in Perotti and Spier (1993). These authors in fact assume that managers operate financial choices in the interest of shareholders.

23. In countries like the U.S.A. or the U.K., the courts have fully accepted "the idea of managers' duty of loyalty to shareholders" (Shleifer and Vishny (1995,p.22)).

Chapter IV

STRATEGIC EXTERNAL FINANCING AND SOPHISTICATION OF THE PRODUCTION PROCESS.

Introduction.

In their 1991 survey on capital structure, Harris and Raviv noted that the interactions between financing decisions and product/input markets were quite underexplored (see Harris and Raviv (1991)). Since then, research on this topic has mainly developed in two directions. The first one has further investigated the role of leverage as a commitment device in oligopolistic competition, after the seminal work of Brander and Lewis (1986) (see Zechner (1996)). The second direction of research has concentrated on inputs, analyzing the role of debt as a "bargaining tool" in wage negotiations when labour has specific skills in production and labour contracts are not binding (see the literature quoted in Chapter III). Notably, Titman (1984) has offered another possible route for research by trying to relate the capital structure with certain attributes of output (in his model, production of durable and/or specific goods tends to be associated with low leverage). In the present Chapter we focus on the effects of debt on the features of production abstracting from the impact of leverage on inter-firm competition. In particular, we ask how the strategic use of debt in negotiations that we analysed in Chapter III can influence the characteristics of the production process chosen in equilibrium. The main result we obtain is that leverage may strongly affect the entrepreneur's decision about the degree of technological complexity adopted in production.

The notion of technological complexity used here exploits the underlying idea of several works in the economic literature, which range from theories of economic development, such as Kremer (1993), to the theory of the firm (see, e.g., Hart and Moore (1990)): the adoption of sophisticated production processes requires the performance of several tasks, the use of multiple assets, and the hiring of groups of specialised workers. For example, successful car companies need a mix of tasks such as design, engineering, marketing and assistance. Our model hinges on the distributive conflict that arises within the firm when each corporate unit assigned to a task acquires specific skills in production. If such a production unit, constituted by a group of employees, is indispensable, it will gain some bargaining power over the surplus.

Consider an entrepreneur who has access to a set of projects requiring a different number of tasks (for example, the entrepreneur can decide whether to produce simple goods, such as bicycles, or complex products, such as jet planes). In this perspective, when an entrepreneur decides whether to invest, and which type of project to adopt, two kinds of social inefficiencies may arise. The first inefficiency is the same as the one analysed in Chapter III, after Grout's (1984) hold-up problem: the level of investment tends to be too low. The second kind of inefficiency, which mainly characterises the present Chapter, is what we denote as "under-sophistication": given a set of alternative and profitable investment projects, the degree of technological sophistication chosen by the entrepreneur tends to be too low.

Under-sophistication originates from the fact that, in our model, the intensity of the struggle over surplus distribution is increasing in the measure of technological complexity we adopt. Indeed, the adoption of more sophisticated processes has two main consequences. On the one hand, a more complex production tends to generate higher revenues but, on the other hand, a larger number of tasks has to be carried out. Since such tasks are to be performed by groups of employees who form a bargaining unit, greater sophistication ends up generating tougher competition over the division of the surplus. Thus, from the entrepreneur's perspective, the benefits from more complex productions are likely to be overweighed by the cost implicit in the participation of additional players in negotiations. As a consequence, even when it would be socially efficient to adopt more complex processes (producing, say, airplanes), the entrepreneur will generally choose simpler production technologies (e.g., motorbikes).

A central result of the Chapter is that the extent of under-sophistication is reduced when the entrepreneur can borrow from a financial market. Following the "control rights" approach to corporate borrowing put forward by Hart and Moore (1994), we know from Chapter III that debt can effectively modify the agents' bargaining position by imposing additional and credible claims on surplus. When a firm fails to meet its contractual obligations, lenders are entitled to take control over physical assets and, for this reason, are enabled to bargain over the returns that the project can generate. Thus, when liquidation is dominated, defaulting on contractual repayments triggers lenders' participation in bankruptcy negotiations.

In the present model, debt works through two different mechanisms.

First, as already shown in Chapter III, a high level of debt raises the entrepreneur's profit: when debt is sold to competitive lenders, the entrepreneur can pocket money today against a future repayment that will have to be borne by all those who take part in the project.

However, debt also works through a second effect, which neatly characterises the present model. This new mechanism is a side-effect of the strategic use of debt in surplus negotiations: as we show, debt stimulates the choice of more complex projects because it reduces the adverse distributive effect brought in by highly sophisticated processes. In this perspective, leverage tends to lessen both under-investment (see Chapter III) and under-sophistication. As we will demonstrate, debt may also encourage the adoption of more complex production methods when financial markets are non-competitive and the positive effect that debt has on the profit *level* is destroyed.

The main contribution of this Chapter may then be summed-up as follows: our model links, through the analysis of strategic debt in negotiations, leverage considerations together with production characteristics. For this reason, the present approach gives a new direction of research in the field that was first explored by Titman (1984).

The results that we obtain have several implications. Since technological complexity (in terms of tasks, assets, corporate divisions) is likely to be related to the company's dimension, our model is consistent with one of the most robust empirical findings in corporate finance, the positive correlation between size and leverage (see Rajan and Zingales (1995), and the references quoted in Harris and Raviv (1991)). Also, if technical progress can be seen, at least in part[1], as a process that generates increasingly complicated production processes, our model might help explaining why an historical trend towards increasing leverage has been observed (see Taggart (1985) and Masulis (1988)). Moreover, the availability of a skilled labour force may not be sufficient, in contrast with Kremer's (1993) suggestion, for the implementation of highly sophisticated productions: when employees can exercise some bargaining power over surplus, developed financial markets may also be necessary. This observation is quite consistent with the empirical results found in a series of papers by King and Levine (see King and Levine (1993a,b,c)). According to these authors, the degree of a country's financial development is an important predictor of later growth and investment. Indeed, cross-country differences in the rates of physical capital accumulation seem to be positively linked to two main factors: the size of the financial sector, and its propensity to finance private entrepreneurship. Thus, our paper may help explaining why "rich" countries, which also happen to have highly developed financial sectors, specialise in complicated production processes[2], while "poor" countries concentrate on primary productions[3].

As already mentioned in Chapter III, the strategic use of debt[4] as a credible threat has been studied in many papers. In particular, Perotti and Spier (1993) examine debt-for-equity swaps as a tool to renegotiate wages. Similarly, Dasgupta and Sengupta (1993) find a negative wage-debt relation in the context of a firm-union bargaining model. However, even if the models developed in Dasgupta and Sengupta (1993) and in Chapter III conclude that debt may encourage the accumulation of physical capital, neither of them analyses the implications of leverage on the characteristics of the production process. Two important papers, which abstract from financing issues, analyse the relation between bargaining and technological decisions: when labour contracts are non-binding, Stole and Zwiebel (1996a,b) show that employees' bargaining power tends to distort the technology choice of the entrepreneur. The crucial assumption of these authors is that the entrepreneur bargains "pairwise" with *each* of the employees who are assigned to a certain task. Stole and Zwiebel find that an entrepreneur has an incentive to over-employ: in fact, excess-employment allows the firm to "play a workers against the other" during negotiations and, as a consequence, equilibrium wages turn out to be equal to the competitive level. Although some implications of Stole and Zwiebel's model have sound economic appeal, their "pairwise bargaining" approach has an important limit. As shown by Horn and Wolinsky's (1988) paper on unionisation patterns, workers that are substitutable in production have an incentive to form a "coalition" (e.g., a union), so to constitute a single bargaining unit that avoids between-worker competition during negotiations. Horn and Wolinsky's argument eliminates Stole and Zwiebel's over-employment result and it justifies the one-to-one correspondence we assume between tasks (performed each by a certain number of employees) and bargaining units.

The Chapter is organised as follows. Section 1 presents the basic model and discusses, in the absence of capital markets, the inefficiencies generated by the distribution process. Section 2 introduces capital markets and Section 3 considers the implications of debt over the entrepreneur's selection of the project. Section 4 analyses the case of multiple lenders and evaluates the consequences of public debt versus private debt. The presence of a monopolistic lender is considered in Section 5: we find that a monopolistic lending institution may even outperform a competitive market in reducing under-sophistication inefficiencies. Section 6 extends the basic model to consider employees' effort choice. When employees' effort is relevant, the positive effects of high leverage can be overturned: indeed, the negative effect that debt has on each employee's share can drastically reduce effort investment. For this reason, it can be in the entrepreneur's interest to commit not to use leverage strategically. This observation might contribute to explain why companies which undertake large R&D expenditures have relatively low leverage (see Harris and Raviv (1991)). In fact, researchers' effort in R&D is likely to be crucial for the firm's (expected) returns. Section 7 concludes.

1. The Basic Framework.

We consider an entrepreneur (agent 1) who has the ability of starting-up a firm and has access to a set of N alternative investment projects, which involve different levels of sophistication. A project of type n, with $n=1,2,..,N$, yields a return equal to $Y(n)>0$ and costs $I(n)\geq 0$. The degree of technological sophistication of the project is indexed by n, which is equal to the number of complementary tasks that must be performed in order to produce $Y(n)$. Each individual who does not take part in multi-task productions can implement an *autarkic* production ($n=1$) and obtain $Y(1)-I(1)\equiv y\geq 0$. Further, the opportunity of undertaking the autarkic production is foregone when an agent decides to take part in a project such that $n>1$. Thus, participation in "sophisticated" productions and "autarkic" activities (such as craftsmanship or farming) are mutually exclusive[5].

The characteristics of the technology available are such that investment is irreversible. Once the cost $I(n)$ has been sunk, the investment made can only be used for a n-type production. In other words, we suppose that the cost of converting, say, a truck factory into a bicycle or shoe factory is too high to be economically viable. Further, a n-type project yields $Y(n)$ with certainty, provided that all the n tasks are carried out: however, if even one of the task fails to be performed, returns drop to zero[6].

For simplicity, we assume that each task is performed by a single employee: in this way, a bargaining unit is composed of just one worker. There are at least $H\geq N$ available agents who are sufficiently skilled to execute a task. Also, we assume that each individual who participates in a certain project acquires special skills and can be replaced only at very high cost. When agents gain project-specific knowledge and binding contracts are unfeasible (due, for example, to the inability to precommit not to renegotiate *ex-post*, as in the typical Grout's problem discussed in Chapter III[7]), each employee acquires bargaining power over the surplus generated by the project.

The *timing* of the model is the following:

In the first stage ($t=1$), the entrepreneur decides whether to invest. If she invests, she also decides the degree of sophistication, n, to be adopted in the production process.

In the second stage ($t=2$), the entrepreneur decides about the quantity of external funds to be raised (*if* the firm has access to a financial market).

In the third stage (t=3), investment is implemented and the n agents start bargaining over returns. If an agreement is found, production is carried over and surplus is shared.

We solve the model by *backward induction.* Although the functions we consider are intrinsically defined only for discrete values of n, it will be sometimes useful to treat n as a continuous variable over the interval [2,N], abstracting away from integer constraints.

1.1. The Sharing Rule.

Each task gives some monopoly power to the agent who performs it for two reasons. First, each of the n tasks is necessary in the production of $Y(n)$ and, further, agents' replacement is very costly, due to the acquisition of special skills. As mentioned, since each task is performed by a single agent, we have a one-to-one correspondence between bargaining parties (equal to the number of the complementary tasks) and employees.

Under the conditions exposed in Chapter II, it can be shown that when n agents alternate in making proposals over a pie of value R, agent i's perfect equilibrium payoff is (i=1,2,..,n):

$$S^i = \frac{1}{n}\left\{R + (n-1)s_i - \sum_{z=1,z\neq i}^{n} s_z\right\} \tag{1}$$

where s_i is i's outside option.

By setting $R=Y(n)$, we can consider the sharing of the returns from an n-type project. In what follows, we assume that the outside option available to each agent other than the entrepreneur is negligible after entering the project[8]. During negotiations, instead, the entrepreneur maintains the possibility of liquidating the project, obtaining as alternative payoff the liquidation value $L(n)\geq 0$, where $L(n)\leq I(n)$. Thus, the entrepreneur's and the employees' (i=2,..,n;$i\neq 1$) payoffs are, respectively:

$$S^1 = \frac{Y(n) + (n-1)L(n)}{n} \quad and \; S^i = \frac{Y(n) - L(n)}{n} \tag{2}$$

Having characterised the distribution rule, we can illustrate the two main sources of inefficiency arising from the model. In order to do this, we abstract momentarily from the presence of capital markets: projects have to be entirely funded by the entrepreneur herself.

1.2. The Sources of Inefficiency with No Capital Markets.

- *Under-investment (Grout-inefficiency)*. Some under-investment generally arises when the surplus generated by an agent's investment can partly be appropriated by others. As emphasised by Grout (1984) in the context of bilateral firm-workforce negotiations, the equilibrium level of investment is inefficiently low whenever workers cannot make credible wage commitments before the investment cost is sunk by the entrepreneur (refer to Chapter III). By the same token, consider a project of a *given* degree of sophistication, *n*. When the entrepreneur is not wealth constrained, the project can be undertaken even in the absence of capital markets. However, anticipating the outcome of the bargaining process over *Y(n)* defined in (2), the entrepreneur will invest if and only if

$$S^1 - I(n) = \frac{Y(n)+(n-1)L(n)}{n} - I(n) \geq y \equiv Y(1) - I(1), \tag{3}$$

$$or, \quad Y(n) \geq ny + I(n) + (n-1)(I(n) - L(n))$$

In contrast, a project is *socially efficient* when the following inequality holds:

$$Y(n) \geq ny + I(n) \tag{4}$$

The extent of inefficiency amounts to[9] $(n-1)(I(n)-L(n)) \geq 0$. As shown in Chapter III, projects which are socially desirable will not be implemented because, once the entrepreneur has sunk the investment cost, the remaining *(n-1)* agents can appropriate part of the surplus that is generated. Note finally that the choice of the optimal sophistication level, analysed in what follows, is constrained to the set of projects which satisfy condition (3).

- *Under-Sophistication.* Suppose that all the available investment projects are profitable, which is, that condition (3) is satisfied for any $n \in \{2,N\}$. Even when all the alternative investment projects are profitable, a new source of inefficiency comes about when the choice of n is considered. Without financial markets, the entrepreneur's choice of n solves the problem:

$$\max_{\{n\}} \ M^1(n) = \max_{\{n\}} \frac{1}{n} Y(n) - I(n) \tag{5}$$

Suppose that the maximand can be represented as a continuous *concave* function[10] over [2,N]. Let us also take sufficiently small values of y, so that choosing $n=2$ always dominates "autarky" ($n=1$). When condition (3) is satisfied for any type of project, the entrepreneur selects a degree of sophistication n, rather than $(n-1)$, if[11]:

$$\frac{Y(n)+(n-1)L(n)}{n} - I(n) \geq \frac{Y(n-1)+(n-2)L(n-1)}{n-1} - I(n-1), \quad (n>2) \tag{6}$$

$$i.e., \quad Y(n) \geq \frac{n}{n-1} Y(n-1) + n[I(n)-I(n-1)] - \Lambda$$

where $\Lambda \equiv [(n-1)L(n)-n(n-2)L(n-1)/(n-1)]$. The level of sophistication n is an interior maximum (i.e., $n<N$), if it holds that $M^1(n+1)<M^1(n)$.

Turning to welfare considerations, suppose that $Y(n)-I(n)$ is a positive and monotonically increasing function of n. Then, *social efficiency* requires that n is preferred to $(n-1)$ whenever:

$$Y(n) - I(n) \geq [Y(n-1) - I(n-1)] + y, \quad (n \geq 2) \tag{7}$$

$$i.e., \quad Y(n) \geq Y(n-1) + [I(n) - I(n-1)] + y$$

If the level of y is sufficiently small, the social optimum corresponds to N.[12] In what follows, we normalise y to zero.

The extent of the under-sophistication inefficiency turns out to be equal to[13]

$$\xi_0 = \frac{Y(n-1)}{n-1} + (n-1)[I(n) - I(n-1)] - \Lambda, \qquad n \geq 2 \tag{8}$$

The inefficiency level in expression (8) can be broken into two components. Let us first abstract from the project's cost by setting $I(n) = I(n\text{-}1) = I(1) = 0$ and, hence, $\Lambda = 0$. For any $n > 2$, the inefficiency measure ξ_0 is a positive quantity[14]. Under the conditions we set, the private choice of more sophisticated projects increases social efficiency. However, since $\xi_0 > 0$, highly sophisticated projects that are socially desirable may *not* be implemented. Under-sophistication is caused by surplus sharing: in fact, the higher the number of tasks required in production, the larger the number of agents who acquire bargaining power over the surplus. This kind of inefficiency arises whenever the positive effect that higher sophistication has on returns is outweighed by the negative effect induced by tougher competition over the division of returns. A similar adverse effect on the coalition's size is discussed by Chatterjee, Dutta, Ray and Sengupta (1993), in the context of a multi-party bargaining model with stationarity in strategies derived from Rubinstein (1982).

The extent of under-sophistication, as measured by (8), tends to be even larger when increasing investment costs are considered. When the liquidation values contained in the term Λ are relatively small, the additional cost that the entrepreneur has to bear for a more sophisticated project, $\Delta I(n) > 0$, produces an "incremental" version of the Grout-inefficiency that we discussed above. The conclusions we obtained can be summarised by the following:

Result 1. (Inefficiency of private choice): (I) Since the agents who take part in a project are able to bargain ex-post over its surplus, the level of investment tends to be inefficiently low (Under-investment inefficiency). Further, (II) even assuming that the available projects are all profitable (no under-investment inefficiency), the degree of technological sophistication selected by the entrepreneur tends to be inefficiently low in equilibrium (Under-sophistication inefficiency).

Result 1 implies that when the acquisition of special skills in production creates bargaining power, individuals' skills will generally be under-utilised. In particular, the entrepreneur might have undertaken more complicated productions than the one actually chosen in equilibrium. As a consequence, capable agents are forced to take up autarkic productions when it is socially efficient to hire them in sophisticated projects. Differently from Kremer's (1993) suggestion, then, bargaining implies that the availability of skilled workers and capable entrepreneurs may be insufficient to incentivate the adoption of advanced production processes.

2. The Presence of Capital Markets.

As we showed in Chapter III, the strategic choice of leverage can effectively modify the distribution of surplus. In what follows, we also show that debt has relevant implications for the type of projects that an entrepreneur is willing to implement.

Consider a firm which issued some debt. Exploiting again the control rights' perspective suggested in Hart and Moore (1994), default on debt obligations shifts the property of the firm from the current owner (the entrepreneur) to the lender. Under default, then, the lender comes to control the firm's physical assets and, for this reason, gains the ability to bargain over the rents that can still be produced (see Chapter III).

The *debt capacity* of a project is defined as the maximum amount of repayments that a debt contract can require without triggering voluntary default[15]. Let D define the level of contractual debt repayments. When a technology with n agents has been implemented, the bargained payoffs depend on whether debt is repaid or not. In case that debt is repaid, each of the n agents gets $(Y(n)-D)/n$, the n-th fraction of returns *net* of debt repayments. However, each agent has the power to halt production and, by preventing the repayment of D, force the firm into bankruptcy. In this case, the lender gets control and bargains over $Y(n)$ whenever liquidation, yielding $L(n)$, is unprofitable. When the entrepreneur cannot be dispensed with in production, bankruptcy will trigger a $(n+1)$-party bargaining game in which the lender gets $[Y(n)+nL(n)]/(n+1)$, and each other agent receives a payoff equal to $[Y(n)-L(n)]/(n+1)$. Note also that liquidation is always dominated in equilibrium, since $Y(n)>I(n)>L(n)$ implies that $[Y(n)+nL(n)]/(n+1) > L(n)$.

The maximum level of D such to make repudiation not convenient solves the inequality $(Y(n)-D)/n \geq [Y(n)+nL(n)]/(n+1)$, and gives the project's debt capacity, D':

$$D' = \frac{Y(n)+nL(n)}{n+1} \tag{9}$$

Note that D' is independent of the competitive regime which prevails in the financial market. Similarly to the approach originally followed by Bulow and Rogoff (1989a) (see Chapter V), D' represents the maximum amount of repayments that a lender can be credibly paid back. Also notice that, as empirically observed (see, e.g., Harris and Raviv (1991)), debt capacity is increasing the project's liquidation value, $L(n)$.

3. Competitive Financial Markets.

Consider a competitive capital market in which, for simplicity, the net interest rate is zero ($r_0=0$). When the level of repayments specified by the debt contract is such that $D \leq D'$, the share of net surplus $Y(n)-D$ that *each* agent obtains is $(Y(n)-D)/n$. The payoffs of the entrepreneur (agent 1) and of each agent i, $i \neq 1$, are equal to, respectively:

$$M^1(D;n) = Y(n) - (n-1)\frac{Y(n)-D}{n} - (1+r_0)I(n) = \frac{Y(n)}{n} + \frac{n-1}{n}D - I(n) \tag{10}$$

and

$$M^i(D;n) = \frac{Y(n)-D}{n}, \quad i=2,3,..,n \tag{11}$$

Since profit $M^1(D;n)$ is monotonically increasing in D, agent 1 will always set D to its maximum available level[16], D'. When $D=D'$, *each* of the n agents in the game is made indifferent between accepting the repayment of debt and triggering default. Since bankruptcy does not bring any benefit, we assume that debt is repaid. The payoffs (10)-(11) calculated for $D=D'$ become, respectively:

$$M^1(D';n) = \frac{2Y(n)+(n-1)L(n)}{n+1} - I(n) > M^1(0;n) \tag{12}$$

and

$$M^i(D';n) = \frac{Y(n)-L(n)}{n+1}, \quad i=2,3,...,n \tag{13}$$

In equilibrium, the lender's payoff is D', the amount lent: a competitive lender breaks even on the debt contract he offers.

The reason why the entrepreneur prefers debt to self-financing is the same we described in Chapter III. Debt creates an *additional* and credible claim on surplus while keeping intact, at the same time, the entrepreneur's bargaining power (she is indispensable in production). Since debt is sold to competitive lenders, the entrepreneur can pocket money today against a future repayment, which will have to be borne by *all* the n agents who take part in the production process.

3.1. Reconsidering Inefficiency with Competitive Financial Markets.

- *Under-investment (Grout).* We assumed that every agent who chooses to participate in a sophisticated project ($n>1$) foregoes the possibility of implementing the autarkic project. Hence, when there are competitive capital markets, the entrepreneur is willing to implement a n-type project whenever it holds that $M^1(D'(n);n)=2Y(n)/(n+1)-I(n)\geq y$: this condition is less stringent than the corresponding condition (3) discussed in Sect.1.2. Since debt raises the profit that an entrepreneur can obtain from any given project, the strategic use of debt increases the set of efficient projects that the entrepreneur is willing to implement. As we noted in Chapter III, this result is consistent with the empirical results reported in King and Levine (1993a,c), according to which both the presence of developed financial markets and their propensity to finance private entrepreneurship favour physical capital accumulation. Our conclusions are also consistent with the results found by Rajan and Zingales (1996) on the base of an international comparison among industrial sectors. These authors find that industries that are more dependent on external financing grow relatively faster in countries that have more developed financial markets and institutions. In particular, they observe that investment in such industries is "disproportionately higher" in countries with a better developed financial sector.

A *caveat* is, however, in order. Better profitability may be necessary, but not sufficient, for project's implementation when y, the payoff from autarkic production, is not negligible. Indeed, the $(n-1)$ agents other the entrepreneur are willing to participate in a n-type project when it holds that $M^i(D'(n);n)=Y(n)/(n+1)\geq y$, $i=1,2,..,N$: when this condition is violated, the entrepreneur's ability to manipulate the project's leverage generates *debt-induced inefficiencies* (if *ex-ante* side-payments cannot be made to agents $2,3,..,n$). In other words, debt improves entrepreneurial incentives but, when y is relatively large, it may discourage others' participation in the project. In what follows, we will suppose that y is sufficiently small to ensure participation in a project.

- *Under-Sophistication.* In order to concentrate on the under-sophistication issue, suppose that any n-type project, $n\in\{2,N\}$, is profitable. Since $D'(n)$ is the amount of debt chosen in equilibrium, the entrepreneur selects the level of n solving the following problem:

$$\max_{\{n\}} \; M^1(D'(n),n) \;=\; \max_{\{n\}} \frac{2Y(n)+(n-1)L(n)}{n+1} - I(n) \tag{14}$$

As for (5), we assume that $M^1(D'(n),n)$ in (14) can be represented as a concave function over [2,N].

The entrepreneur will prefer a n-type project to a less sophisticated $(n\text{-}1)$-type project when it holds that $M(D'(n),n) \geq M(D'(n\text{-}1),n\text{-}1)$, which is:

$$\frac{2Y(n)+(n-1)L(n)}{n+1} - I(n) \;\geq\; \frac{2Y(n-1)+(n-2)L(n-1)}{n} - I(n-1) \tag{15}$$

$$or \quad Y(n) \;\geq\; \frac{n+1}{n}Y(n-1) + \frac{n+1}{2}[I(n)-I(n-1)] \;-\; \Lambda'$$

where $\Lambda' \equiv \frac{1}{2}[(n\text{-}1)L(n)\text{-}(n\text{-}2)(n+1)L(n\text{-}1)/n]$. The level of n satisfying (15) is an interior maximum in {2,N} if it holds that $M^1(D'(n+1);n+1) < M^1(D'(n);n)$, where $n+1 \leq N$.

Compare condition (15), calculated for $D=D'$, with condition (6), holding for $D=0$. The use of debt tends to favour the implementation of relatively more sophisticated projects in two ways. First, note that the coefficient associated with the term $[I(n)\text{-}I(n\text{-}1)] \equiv \Delta I(n)$ is relatively smaller in (15): by spreading the burden of greater investment costs also on other agents, strategic debt favours the adoption of more sophisticated (and more expensive) technologies. For this reason, debt reduces the impact of the Grout-type inefficiency in its "incremental" version (see Sect.1). This result is also consistent with the empirical evidence documenting a positive correlation between leverage and expenditure in fixed assets (see Harris and Raviv (1991), Rajan and Zingales (1995)): in the perspective of the model, relatively complex productions which require a large number of physical assets may be scarcely profitable when the entrepreneur cannot borrow.

The (positive) effect exerted by debt on the investment cost differential is partially compensated by positive liquidation values. Indeed, Λ' in (15) is generally smaller than Λ in (6). A sufficient condition for the negativity of $\Lambda'\text{-}\Lambda = \text{-}L(n\text{-}1)/[n(n\text{-}1)]\text{-}(n\text{-}1)[L(n)\text{-}L(n\text{-}1)]/2$ is that $\Delta L(n) \equiv [L(n)\text{-}L(n\text{-}1)] \geq 0$. However, the possibility that the liquidation value decreases in the level of sophistication of the project ($\Delta L(n) < 0$)

has some plausibility. According to Williamson (1988), the more an investment project is specialised, the lower is assets' redeployability and, hence, the lower the liquidation value of physical capital.

Even abstracting from investment costs, condition (15) is easier to satisfy than (6), since $(n+1)/n > n/(n-1)$. The greater incentive to choose sophisticated projects, here, is not *directly* generated by the re-distributive properties of debt. Here, the lender implicitly becomes an additional player in the bargaining game: either he is repaid, or he will bargain over the surplus in bankruptcy. Thus, the lender's presence dilutes the share of $Y(n)$ that each agent can appropriate *ex-post*. As a side-effect, hence, debt weakens the adverse distributive effect brought in by the adoption of more sophisticated projects. Then, while debt does not affect the gains from a more complicated technology (i.e., $\Delta Y(n) \equiv Y(n)-Y(n-1)$), it diminishes the distributive cost implicit in the need of additional employees for more sophisticated processes[17].

In conclusion, competitive debt financing both raises the profit level M^1 and shifts its peak rightward. Analogous conclusions are reached when the maximands are treated as continuous functions of n.[18]

We now provide an example which illustrates the role played by debt on the technological choice for different forms of the function $Y(n)$.

Example. For simplicity we assume here that the liquidation value of a project, $L(n)$, is zero. Consider the following specification for the revenue function: $Y(n)=n^{\beta}-(1-\alpha)$, where $\beta>0$. The investment cost is linear in n: $I(n)=\alpha n$, with $\alpha<1$ (notice that $Y(1)-I(n) \equiv y=0$, here). Figure 1 illustrates the social net returns from investment, $Y(n)-I(n)$, when $\alpha=0.2$ and β takes the values $\{0.8,1,1.2\}$.

Problem (5), the choice of n when debt financing is not available, specialises to the maximisation of $[n^{\beta}-(1-\alpha)]/n-\alpha n$. On the other side, the maximand in (14) becomes $2[n^{\beta}-(1-\alpha)]/(n+1)-\alpha n$. The shapes of the profit functions (5) and (14), calculated for $\alpha=0.2$, when $\beta=\{0.8,1,1.2\}$ are represented in Figure 2, 3 and 4, respectively. The effect of debt on the optimal level of sophistication is particularly evident when the function $Y(n)$ is convex. Indeed, when $\beta=1$, debt shifts the optimal level of sophistication from 2 to $n=3$ (see Figure 3). When $\beta=1.2$, debt financing raises the optimal n from 3 to 5 "tasks" (see Figure 4).

Our results are consistent with evidence on the role of financial markets. The finding of Rajan and Zingales (1996) that "the scale of firms is related to the development of financial markets" (p.18) is of particular interest here. Since complexity in production is likely to be correlated with firm's size, our model in fact suggests that large firms are relatively more profitable only when external finance is available[19].

Our results also match the observation (see Kremer (1993,p.563)) that "rich" countries - which also happen to have the more developed and private-sector oriented financial systems - tend to specialise in complicated products. This remark is consistent with the observation of Rajan and Zingales (1996) that developed financial markets are a source of "competitive advantage" for industries that are more dependent on external finance (p.30-31).

In conclusion, the working of debt financing on surplus distribution emphasised here appears to be complementary, rather than alternative, to explanations based on non-financial factors. For example, in Kremer (1993) economic advancement is based on the matching of high-quality workers in sophisticated productions. As we showed, the availability of skilled workers and capable entrepreneurs is a necessary, but generally not sufficient, condition to start a process of sustained economic progress.

Finally, it may be argued that the present model is biased towards debt financing, rather than equity financing. As a matter of facts, however, Bolton and Scharfstein (1996,p.1-2) report that firms raise external funds mainly in the form of debt, which accounts for 85 percent of all external financing. Furthermore, Rajan and Zingales (1996) find that "a dollar of market capitalization is not the same as a dollar of credit; it has only 40% of the effect on the growth of financially dependent firms" (p.18).

We reconsider now the issue of *efficiency*. Debt financing increases sophistication, even if it is generally insufficient to fully eliminate welfare losses (for instance, in the *Example* given above, the maximum sophistication level N is the socially efficient choice, since it holds that $Y(n)-I(n)=(1-\alpha)(n-1)$). We can claim the following[20]:

Result 2. Since an entrepreneur tends to choose projects of higher degree of sophistication under debt financing ($D=D'$), rather than under self-financing ($D=0$), *the strategic use of leverage tends to reduce the extent of under-sophistication.*

The measure of inefficiency is now:

$$\xi_{D'} = \frac{Y(n-1)}{n} + \frac{n-1}{2}[I(n)-I(n-1)] - \Lambda' \tag{16}$$

which is a quantity smaller than (8), provided that Λ-Λ' is not too large.

Another implication of the model is related to *aggregate* productivity:

Corollary. By encouraging the implementation of more sophisticated and more efficient projects, debt increases the agents' average per-capita productivity.

When debt allows for the implementation of a n-task project, the n agents involved have an average per-capita productivity equal to $Y(n)/n$. On the other hand, if a $(n-1)$-task project had been implemented, the average productivity of same n agents would have been only $[Y(n-1)+y]/n$, which is equal to $[Y(n-1)]/n$ when $y=0$. The finding that an active financial system favours higher productivity is consistent with the empirical results reported by King and Levine (1993a,c). Moreover, by favouring participation in non-autarkic productions, debt allows "low income" individuals (i.e., agents who would have otherwise got y) to share the surplus generated by sophisticated projects.

In what follows, we will consider three extensions to the simple model discussed above: (i) the presence of multiple creditors, (ii) the presence of a monopolistic credit market and, finally (iii) the role of effort choice.

4. Multiple Lenders.

In Sect.3, we analysed the case when the entrepreneur borrows from a *single* (competitive) lender. Assume now that the entrepreneur borrows from $X>1$ lenders who, in case of bankruptcy, have the right to impose the liquidation of the project[21]: in case of default then, *each* lender gains bargaining power over the returns the project can generate and a $(n+X)$-party bargaining game over $Y(n)$ takes place. If we take for simplicity the liquidation value of the project to be equal to zero, each agent gets a payoff equal to $Y(n)/(n+X)$ in bankruptcy. In equilibrium, then, the maximum amount that *each* lender is willing to concede is $D_\lambda{}^* = Y(n)/(n+X)$ (with $\lambda=1,2,..,X$) and the firm's debt capacity is equal to $XD_\lambda{}^*$. Given X, the expected profit of the entrepreneur is $Y(n)-(n-1)[(Y(n)-\Sigma_\lambda D_\lambda)/n]-I(n)$, which is maximised for $D_\lambda=D_\lambda{}^*$ ($\lambda=1,2,..,X$). Thus:

$$M^1(D_\lambda^*;n) = Y(n)\left[\frac{1+X}{n+X}\right] - I(n) \tag{17}$$

Profit is increasing in X. At the extreme, when the number of credit relations is arbitrarily large, the entrepreneur is able to cash the *whole* surplus from the project:

$$\lim_{X\to\infty} M^1(D_\lambda^*;n) = Y(n) - I(n) \tag{18}$$

Consider now the effect of $X>1$ on project sophistication, when (17) is maximised with respect to n. The analog of condition (15), which was calculated for $X=1$, is now[22]:

$$Y(n) \geq \frac{n+L}{(n-1)+L}Y(n-1) + \frac{n+L}{1+L}[I(n)-I(n-1)] \tag{19}$$

It immediately follows that:

Result 3. The larger the number of credit relationships, X, the higher the degree of sophistication chosen in equilibrium.

This result is consistent with the observation that large and complex corporations (where multiple tasks are performed) tend to exhibit multiple credit relationships. Indeed, according to our model, the creation of several credit links brings a reduction of the adverse distributive effect due to higher sophistication. However, when we interpret X as the number of "banks" which lend to the entrepreneur, such a number is likely to be relatively small[23]. Note also that, up to now, lenders were supposed to be able to start immediately a negotiation process with the firm in case of financial distress. This feature seems to be typical of lending institutions such as banks. Empirical observation, however, supports the view that negotiations are more likely to fail with dispersed debtholders (see Gilson, John and Lang (1990)). As Rajan (1992) puts it: "bank debt is easily renegotiated, because the bank is a monolithic, readily accessible creditor. However, a typical arm's-length creditor like the bondholder receives only public information. It is hard to contact these dispersed holders and any renegotiation suffers from information and free-rider problems" (p.1369). The risks of inefficient liquidation created by dispersed creditors have been first emphasised by Bulow and Shoven (1978). Gertner and Scharfstein (1991) consider the possibility that troubled firms renegotiate with public debtholders: there, the firm can offer a package of new securities and cash against the original public debt. However, a free-rider problem arises, since debtholders with small stakes have an incentive to "hold out". A similar argument is put forward by Detragiache and Garella (1996) in a model with privately-informed creditors. Bolton and Scharfstein (1996) also show that a higher number of creditors makes asset liquidation more costly to stop. For this reason, dispersed debtholders seem to be particularly effective in discouraging *voluntary* default (the kind of default we consider here, after Hart and Moore (1994)).

Notwithstanding the possibility of inefficient liquidation created by the presence of many dispersed creditors, however, a large number of firms place relevant parts of their debt directly on the financial market. Our framework can offer a strategic explanation as why such a kind of debt is issued. Suppose that the entrepreneur can issue public debt and assume, for simplicity, that the presence of dispersed debt-holders always[24] leads to (inefficient) liquidation in case of default. Since liquidation implies that the n agents involved in production obtain a payoff equal to zero, voluntary default will be avoided as far as $[Y(n)-D]/n \geq 0$. Consequently, the maximum amount that a firm can raise through public debt issues is equal to $D''=Y(n)$. Hence, an entrepreneur who issues public debt is able to appropriate the whole surplus from the project since:

$$M^1(D'';n) = Y(n) - (n-1)\frac{Y(n)-D''}{n} - I(n) = Y(n) - I(n) \qquad (20)$$

As the entrepreneur's maximand in (20) coincides with socially-efficient one, public debt issues may fully eliminate both the under-investment and the under-sophistication inefficiencies we discussed above. In particular, the privately optimal degree of sophistication will also be socially efficient. This conclusion can be restated as follows:

Result 4. When default causes the liquidation of the project, an entrepreneur who issues public debt will choose a degree of sophistication which is socially efficient.

The strong implication we draw from Result 4, however, remains valid if, and only if, employees have not to make effort choices. As we argue in Sect.6, the potential relevance of effort choices can severely modify some of the conclusions about debt reached so far.

5. Monopolistic Lender.

We now abandon the assumption that the financial market is competitive to analyse the opposite case: the working of debt when the lender is a *monopolistic price setter*. The attention to such an extreme case helps understanding whether the effects of debt we described so far only depend on the assumption that the credit market is competitive.

The sequence of events is as follows. The entrepreneur first decides whether to invest and, subsequently, chooses the degree of sophistication, n, of the project. She then decides whether to borrow from the monopolistic lender or not (provided that she is not wealth-constrained). Finally, investment is implemented and, after reaching an agreement over the sharing of returns, production occurs. To simplify, we assume that liquidation values are negligible.

Whatever the amount lent, a monopolistic lender is able to set the contractual amount to be repaid, D_m. We have now to determine which is the maximum value of D_m that the monopolist can be credibly paid back and the maximum interest rate, r_m, he can set when lending.

By applying the same argument used in Sect.3, the maximum level of debt repayments that the contract can prescribe is (again) equal to $D_m = Y(n)/(n+1)$. Thus, a monopolistic lender can only appropriate a part of the surplus from the project.

When the lender finances a fraction $\phi \in (0,1]$ of the investment cost $I(n)$, against a future repayment optimally set to $D_m = Y(n)/(n+1)$, the entrepreneur ends up obtaining:

$$M^1(D_m;n) = Y(n) - (n-1)\frac{Y(n)-D_m}{n} - \phi(1+r_m)I(n) - (1-\phi)I(n) \tag{21}$$

$$= \frac{Y(n)}{n+1} - (1-\phi)I(n)$$

where $r_m \equiv \{[Y(n)/(n+1)] - \phi I(n)\}/\phi I(n)$ is the monopolistic lending rate. We can now analyse inefficiency when credit is non-competitively priced.

- *Under-investment.* When the interest rate on alternative assets is normalised to zero, the monopolistic lender will lend as far as $Y(n)/(n+1) \geq \phi I(n)$: if this condition holds only for $\phi < 1$, an entrepreneur who is not wealth-constrained will be willing to invest only if $Y(n)/(n+1) \geq (1-\phi)I(n)$. An interesting implication of the present case is that an entrepreneur will prefer to borrow from a monopolistic lender (instead of financing the project with own funds) whenever it holds that $\phi I(n) > Y(n)/[n(n+1)]$, i.e., when $D_m < n\phi I(n)$: in this case, even if very costly, debt maintains the property of spreading the investment cost $I(n)$ over *all* the agents involved in the project. Then:

Result 5. Even monopolistic credit markets may allow for the implementation of investment projects that would otherwise be unprofitable under self-financing.

- *Under-sophistication Inefficiency*. When the entrepreneur borrows from a monopolistic lender, n is chosen in order to maximise (21). Then, a n-type project will be preferred to a project of type $(n-1)$ whenever:

$$\frac{Y(n)}{n+1} - (1-\phi)I(n) \geq \frac{Y(n-1)}{n} - (1-\phi)I(n-1), \tag{22}$$

$$i.e., \quad Y(n) \geq \frac{n+1}{n}Y(n-1) + (n+1)(1-\phi)[I(n)-I(n-1)]$$

Such a n is an interior solution to the maximum problem if it holds that $M^1(D_m(n);n) > M^1(D_m(n+1);n+1)$, with $n+1 \leq N$.

A case of particular interest is the one in which the investment cost is entirely covered by debt, which is, when $\phi = 1$. Recalling that we assumed above that liquidation values are negligible, the following holds:

Result 6. When an entrepreneur finances the full investment cost by borrowing from a monopolistic lender ($\phi = 1$), the condition for implementing a more sophisticated project given by (22) is:

(I) less restrictive than the corresponding condition under self-financing (condition (6)) and, moreover,

(II) less restrictive than the corresponding condition under competitive debt financing (condition (15)), whenever $I(n)-I(n-1) > 0$.

Result 6(I) states that even monopolistic financial markets preserve the property of promoting sophisticated production processes. Further, and quite surprisingly, Result

6(II) asserts that a monopolistic capital market may outperform a competitive market when the incentives to adopt sophisticated processes are considered (algebraically, when $\phi=1$, monopolistic lending "eliminates" the term in $I(n)-I(n-1)$). In other words, also monopolistic debt financing spreads the incremental cost of investment on the share of *each* agent participating in the project.

A remark, however, is in order. The conclusion that monopolistic lending *always* favours sophistication in production may fail to hold. Suppose that, being $I(n)$ sufficiently small, the inequality $D_m \geq nI(n)$ is verified (we take $\phi=1$): then, an entrepreneur who is not wealth-constrained will prefer to finance the project with her own funds, since she manages to obtain a profit higher than that available by borrowing from the monopolist. As a consequence, the high cost of credit can create under-sophistication "traps". This remark is consistent with the argument put forward by Rajan and Zingales (1996). According to them, financial development - which tends to increase competition in capital markets - affects investment through lower costs of external finance. In the perspective of our model, an under-developed and non-competitive financial market generates high interest rates for borrowers and it reduces the effectiveness of debt as a tool for redistributing surplus.

6. Effort Choice.

As briefly observed in Chapter III, when effort decisions are considered, the conclusions about the efficiency-enhancing properties of debt may end up being deeply modified. A very simple example can effectively introduce the argument.

Suppose that a project requires, on behalf of the n agents, a specific effort investment equal at least to e^* in order to generate positive returns, $Y(n,e^*)$. If the entrepreneur does not use debt financing, the level e^* can be attained as long as the inequality $Y(n,e^*)/n \geq c(e^*)$ holds, $c(e^*)$ denoting the level of effort disutility. However, the condition for exerting effort e^* may *not* hold when the entrepreneur borrows. In fact, effort e^* requires that a more restrictive condition, $Y(n,e^*)/(n+1) \geq c(e^*)$, be respected. It may then happen that, if the entrepreneur is unable to precommit not to borrow, the project can fail to be implemented. This pessimistic conclusion is reinforced in the case (discussed in Sect.4) that default implies liquidation. Since the whole surplus is captured by the entrepreneur, none of the agents participating in production has any incentive to exert costly effort.

In conclusion, there may be cases in which effort is particularly relevant, and the possibility of borrowing destroys efficient investment opportunities. In such cases, then, the entrepreneur would like to commit not to use debt strategically. This observation may offer some hints as why innovative firms, which spend much in R&D and rely heavily on their researchers' effort, tend to exhibit low leverage (see Harris and Raviv (1991)).

In what follows, we provide a more general treatment of this issue. Suppose that the n agents involved in production have to make some effort investment which is specific to the project: a higher level of effort e_i chosen by agent i (i=1,2,..,n) increases returns while leaving unaltered the agents' productivity *outside* the project.

We consider the following timing of events. In the first stage, the entrepreneur decides whether to invest, the degree of sophistication n, and the amount of debt to raise. In the second stage, given n, each of the agents chooses the optimal level of effort e_i on the base of the bargaining outcome she anticipates. In the third stage bargaining occurs: if an agreement is reached, production occurs and the surplus is shared[25].

The revenue function takes the form $Y=Y(e_1,e_2,..,e_n;n)$, with $\partial Y/\partial e_i \equiv Y_i > 0$,

$\partial Y/\partial n \equiv Y_v > 0$, and $\partial^2 Y/\partial e_i^2 \equiv Y_{ii} \leq 0$. Effort e_i entails disutility equal to $c(e_i)$, with $c' > 0$ and $c'' \geq 0$.

We can now analyse the consequences of effort on both: (i) the set of projects which an entrepreneur is willing to implement and, (ii) the optimal degree of complexity in production.

Assume first that $D=0$. This is equivalent to prevent the entrepreneur from resorting to financial markets. Once n is fixed, each agent i ($i=1,2,..,n$) correctly anticipates that her share of Y will be Y/n. For given e_{-i}, which denotes the effort chosen by the remaining $(n-1)$ agents, the optimal level of e_i solves the following problem:

$$\max_{\{e_i\}} \frac{Y(e_i;e_{-i},n)}{n} - c(e_i) \tag{23}$$

Hence, the Nash-equilibrium choice of e_i^0 is defined by

$$Y_i(e_i^0;e_{-i},n) = n\,c'(e_i^0) \tag{24}$$

where $\sigma_i^0 \equiv Y_{ii} - nc'' < 0$.

In a Symmetric Nash Equilibrium (S.N.E.), it holds that $e_i^0 = e_{-i}^0 = e^0$. Thus, the S.N.E. equilibrium level e^0, holding for $D=0$ is implicitly given by[26]:

$$Y_i(e^0;e^0,n) = n\,c'(e^0) \tag{25}$$

Let us now consider an entrepreneur who has the possibility to raise debt. Note that, once the entrepreneur has pocketed the funds raised through debt, she gets a share of surplus which is identical to the shares obtained by the remaining $(n-1)$ agents: for this reason, she has the same incentives to invest in effort as the others.

When $D=D'$ (no matter if the financial market is competitive or monopolistic), agent i's effort choice solves, for given n and e_{-i}:

$$\max_{\{e_i\}} \frac{Y(e_i;e_{-i},n)}{n+1} - c(e_i) \tag{26}$$

with $i=1,2,..,n$. The Nash-equilibrium level e_i' solves the condition $Y_i(e_i';e_{-i},n)=(n+1)c'(e_i')$ (with $\sigma_i'\equiv Y_{ii}-(n+1)c''<0$).

With $D=D'$, then, the S.N.E. effort level e' solves:

$$Y_i(e';e',n) = (n+1)\,c'(e') \tag{27}$$

Since debt dilutes each agent's share of surplus, it also reduces the incentive to invest in effort, given the others' choice: as a consequence, the S.N.E. effort choices, defined respectively by (25) for $D=0$, and by (27) for $D=D'$, are such that[27] $e^0>e'$. The adverse effect of debt on effort is magnified when there are "strategic complementarities", i.e., when $\partial^2Y/\partial e_i\partial e_j\equiv Y_{ij}>0$, and reduced with "strategic substitutability", i.e., $Y_{ij}<0$ (see Cooper and John (1988))[28]. Independently of the kind of strategic interaction among agents' effort choice, the following holds:

Result 7. Given n, the use of debt reduces the level of returns a project generates by lowering the employees' effort choice.

From the point of view of social optimality, Result 7 implies that *the strategic use of debt makes the private effort choice even less efficient*: in fact, the socially efficient level of e_i solves $Y_i(e_i;e_{-i},n)=c'(e_i)$.

Result 7 has another relevant implication. Since $Y(e',n)<Y(e^0,n)$, the entrepreneur would like to commit not to raise any debt whenever $Y(e^0,n)/n-I(n)>2Y(e',n)/(n+1)-I(n)$. Such a commitment, however, cannot credible if the entrepreneur can access the capital market and borrow *after* that effort levels have already been chosen. This conclusion is reinforced when the entrepreneur can sell debt to dispersed debt-holders, so that default is likely to be associated with liquidation (see Sect.4): in this case, no agent has any incentive to invest in effort.

Since the redistributive power of debt may have a devastating impact on project implementation when effort is relevant, we ask whether there are some arrangements which can work as a "commitment technology" for the entrepreneur's financial choices. The answer is positive: a "partnership" may avoid such problems. In other words, the entrepreneur can fragment the project's control (including control on financing decisions) among those who participate in production. In this way, project participants become equity-holders with equal rights over the use of funds raised through debt-issues. This device prevents *de facto* any redistributive role for debt (debt could be used at most to overcome wealth-constraints). Our model thus predicts that control over relevant decisions, such as financing, will be dispersed among the "partners" when returns are highly sensitive to effort investment. This conclusion, reached from a financial point of view, has a flavour similar to the main result in Hart and Moore (1990), according to which the property of assets should go to those agents who make crucial firm-specific investment.

We now consider how the optimal choice of n is modified by effort investment. As shown in Appendix (I.a), it holds that:

$$\frac{de^0}{dn} = \frac{-(Y_{i\nu} - c')}{\sigma^0 + (n-1)Y_{ij}} \qquad (28)$$

where $Y_{i\nu} \equiv \partial Y_i / \partial n > 0$ and, for S.N.E. stability, it must hold that $|\sigma^0| > (n-1)|Y_{ij}|$, where $i \neq j$ (see Note 26). Then, it follows that $sgn(de^0/dn) = sgn(Y_{i\nu} - c')$. Analogously, when one considers e', as implicitly defined in (27), it holds that $de'/dn = -(Y_{i\nu} - c')/(\sigma' + (n-1)Y_{ij})$.

We assume that there is no financial market (so that $D=0$), and treat n as a continuous variable for mere convenience. Maximising $Y(e^0(n);n)/n - I(n)$ with respect to n gives the following first-order condition:

$$\left[\frac{1}{n}\left(\frac{\partial Y(e^0)}{\partial n} - \frac{Y(e^0)}{n}\right) - I'(n)\right] + \frac{1}{n}\sum_{i=1}^{n} Y_i(e^0) \cdot \frac{de_i^0}{dn} = 0 \qquad (29)$$

With respect to the case without effort decisions, we now have the additional term $(1/n)\Sigma_i Y_i \cdot (de_i^0/dn) = Y_i \cdot (de^0/dn)$, whose sign coincides with the sign of $(Y_{i\nu} - c')$. Hence, with $D=0$, effort investment tends to raise (lower) sophistication when $Y_{i\nu} > c'$ ($Y_{i\nu} < c'$). When $Y_{i\nu} > c'$, a higher n increases the marginal benefit from effort, Y_i, relatively more than its cost.

Note that the condition $Y_{i\nu}>c'$ takes a very simple form when the term in effort is multiplicative in the revenue function, which is, when $Y(e_1,e_2,..,e_n;n)=H(e_1,e_2,..,e_n)\cdot y(n)$. Since expression (24) implies that $y(n)\cdot H_i=n\cdot c'$, it also holds that $Y_{i\nu}=y'(n)\cdot H_i=y'(n)\cdot n\cdot c'/y(n)$. Then, the condition $Y_{i\nu}>c'$ can be written as $y'(n)>y(n)/n$: in order to obtain that $de^0/dn>0$, the function $y(n)$ must be convex.

Similar considerations hold for $D=D'$. Maximising $2Y(e;n)/(n+1)-I(n)$ with respect to n gives:

$$\left[\frac{2}{n+1}\left(\frac{\partial Y(e')}{\partial n}-\frac{Y(e')}{n+1}\right)-I'(n)\right]+\frac{1}{n+1}\sum_{i=1}^{n}Y_i(e')\frac{de_i'}{dn}=0 \tag{30}$$

As for expression (29), effort choice adds the term $[1/(n+1)]\Sigma_i Y_i\cdot(de_i'/dn)=[n/(n+1)]Y_i\cdot(de'/dn)$. Again, if $Y_{i\nu}>c'$, effort investment tends to raise sophistication with respect to the case when effort does not matter (see Sect.3).

We can finally compare privately-optimal sophistication under internal financing (D=0) and external financing ($D=D'$). Define n^0 and n' the internal solutions to equations (29) and (30), respectively.

We claim the following:

Result 8. When the condition $(\partial Y(e^0;n^0)/\partial n)-(n^0-1)Y(e^0;n^0)/[n^0(n^0+1)]>I'(n^0)$ *is satisfied, then* $n'>n^0$*: the presence of effort investment favours a higher level of sophistication in production.*

We leave to Appendix (I.b) the proof of this result and further details.

7. Conclusions.

Consistently with empirical observation, the model we presented supports the view that financial markets can be very relevant in promoting both physical capital accumulation and the adoption of sophisticated production processes.

The approach we follow provides a novel explanation as to why developed financial markets may stimulate economic advancement. More traditional approaches, such as Rajan and Zingales (1996), argue that the financial sector has real effects because it reduces the transaction costs associated to saving and investment, and it lowers the cost of external finance. In our model, the cost of finance is relevant, but not necessarily pivotal: here, financial markets are mainly a device to redistribute surplus. As shown, the use of debt can effectively modify the distribution of returns between the entrepreneur and the employees participating in production. By borrowing, the entrepreneur cashes money today against a (credible) promise of future repayments, which are going to be born by *all* the agents taking part in production. Hence, debt encourages physical capital accumulation by shifting part of the investment cost onto agents other than the entrepreneur. However, as we noted in the case of monopolistic credit markets, the relation between debt and sophistication does not work only through surplus redistribution (which is, through the *profit level*). As we emphasised, debt stimulates the implementation of sophisticated projects by lessening the adverse distributional effect generated by multi-task productions. In general, financial development may have deep effects on the structure of the economy, since it makes it possible to abandon "autarkic" sectors, such as agriculture or craftsmanship, for more complex productions.

With regard to policy implications, the main conclusion we draw here is that the presence of capable entrepreneurs and skilled workers may not be sufficient to start up a faster process of economic advancement, even in the absence of wealth constraints. Much attention, in fact, has also to be paid both to the development of the financial system and to its propensity to finance private entrepreneurship. This observation may be particularly relevant for the transition process of the Eastern European economies.

Appendix I.a

Derivation of expression (28).

Consider the case for $D=0$. Let us differentiate i's first order condition (24) with respect to e_i ($i=1,2,..,n$), e_{-i} (the subscript $-i$ refers to any other agent j, with $j \neq i$) and the degree of project sophistication, n. In symmetric equilibrium, we obtain the following system:

$$\begin{bmatrix} \sigma^0 & k & k & .. & k \\ k & \sigma^0 & k & .. & k \\ . & . & . & & \\ k & k & k & .. & \sigma^0 \end{bmatrix} \begin{bmatrix} de_1 \\ de_2 \\ . \\ de_n \end{bmatrix} = - \begin{bmatrix} x \\ x \\ . \\ x \end{bmatrix} dn \qquad \text{(A1.1)}$$

where $\sigma^0 = Y_{ii} - nc'' = Y_{jj} - nc'' = ..$, $k = Y_{ij}$ and $x = Y_{i\nu} - c' = Y_{j\nu} - c' = ..$ for all i and j, $i \neq j$. By applying Cramer's rule, it can be verified that de_i/dn can be written as the ratio between $-x \cdot (\sigma^0 - k)^{n-1}$ (the numerator) and the hessian, $(\sigma^0 - k)^{n-1} \cdot [\sigma^0 + (n-1)k]$ (the denominator). Expression (28) follows immediately.

Appendix I.b

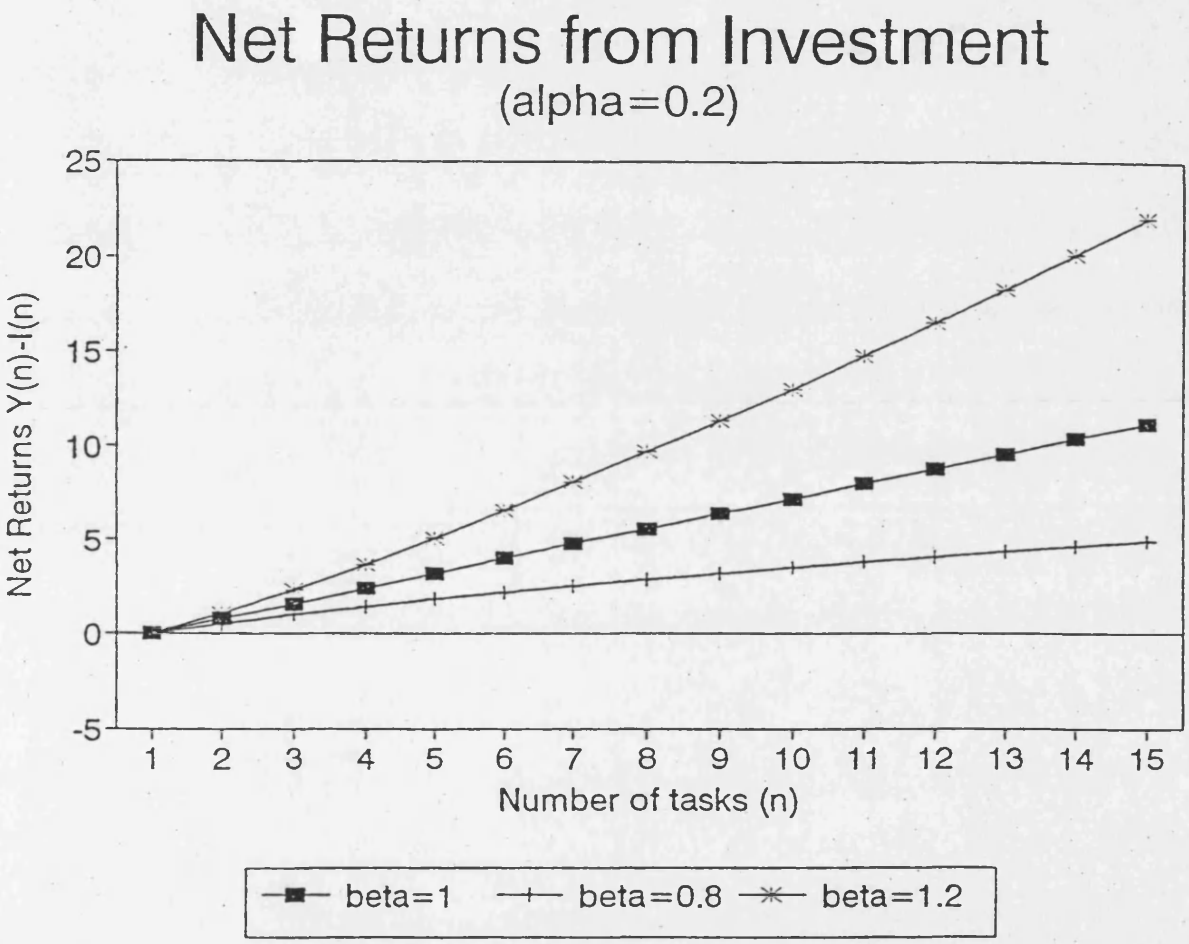
Proof of Result 8.

Call $h'(n)$ the left-hand-side of f.o.c. (30). By definition, the sophistication degree n^0 solves (29), holding for $D=0$. Calculate $h'(n)$ for n^0 and multiply the result by (n^0+1). Finally, subtract the left-hand-side of (29), which is equal to zero in n^0, from $h'(n^0)(n^0+1)$:

$$h'(n^0) \times (n^0+1) - zero = \qquad \text{(A1.2)}$$
$$= \left(\frac{\partial Y(e(n^0),n^0)}{\partial n} \right) - \left(\frac{(n^0-1)}{n^0(n^0+1)} \right) Y(e(n^0),n^0) - I'(n^0)$$

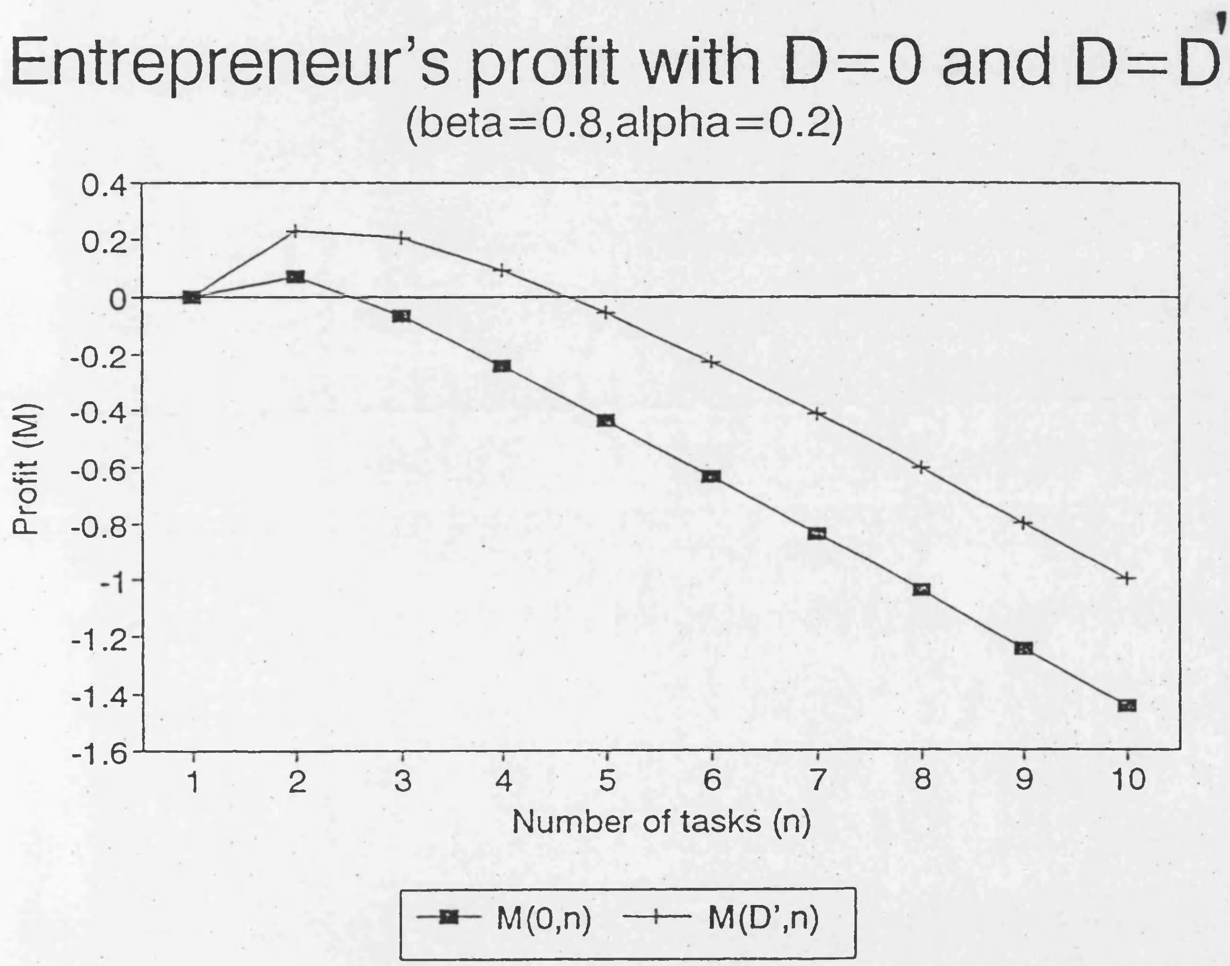
Since n' is such that $h'(n')=0$, it follows that $n' > n^0$ whenever $h'(n^0) > 0$: this is the case when $(\partial Y/\partial n) - (n^0-1)Y/[n^0(n^0+1)] > I'(n^0)$ holds, as claimed in Result 8.

Figure 1



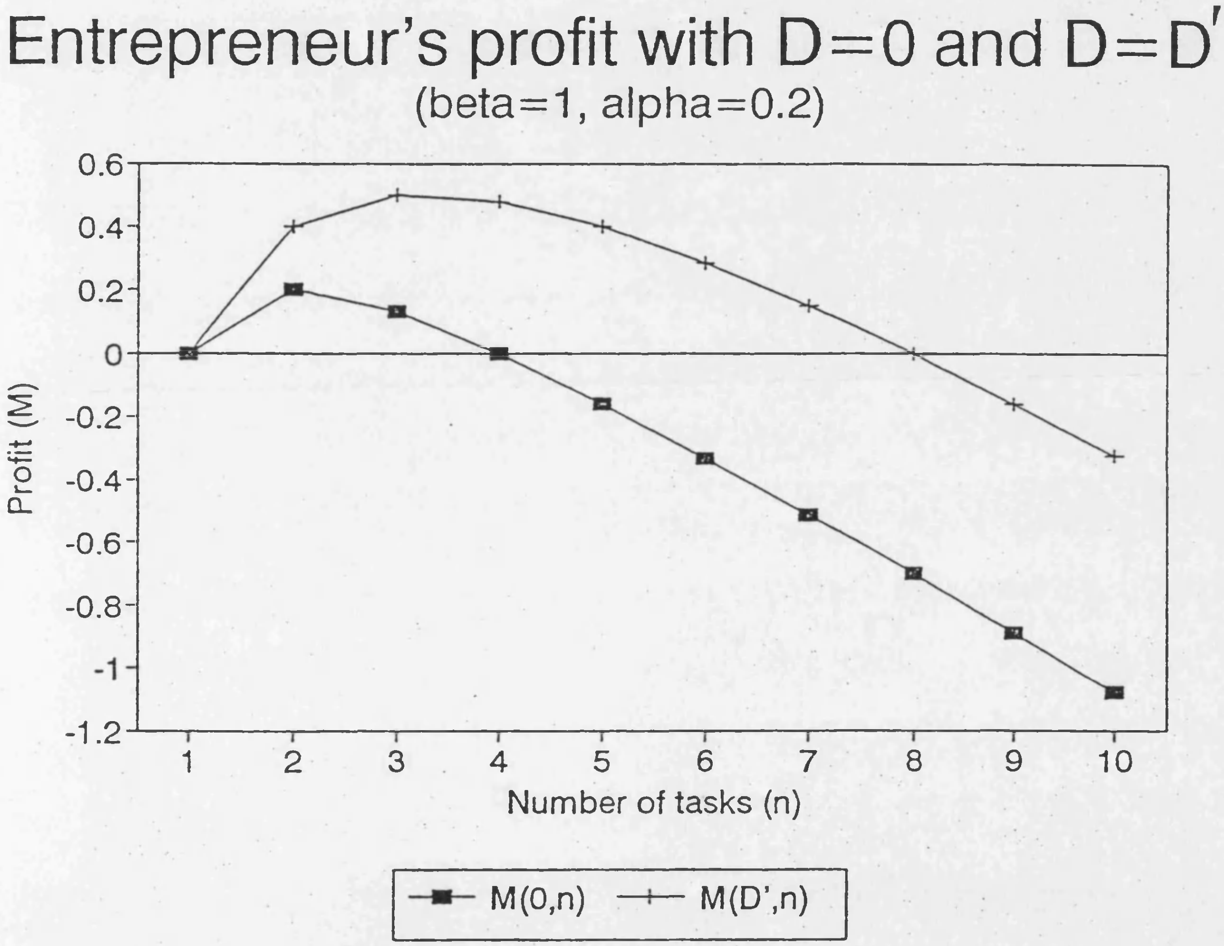
Net Returns from Investment
(alpha=0.2)
25
20
15
10
5
0
-5
Net Returns Y(n)-I(n)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Number of tasks (n)
beta=1
beta=0.8
beta=1.2

Figure 2



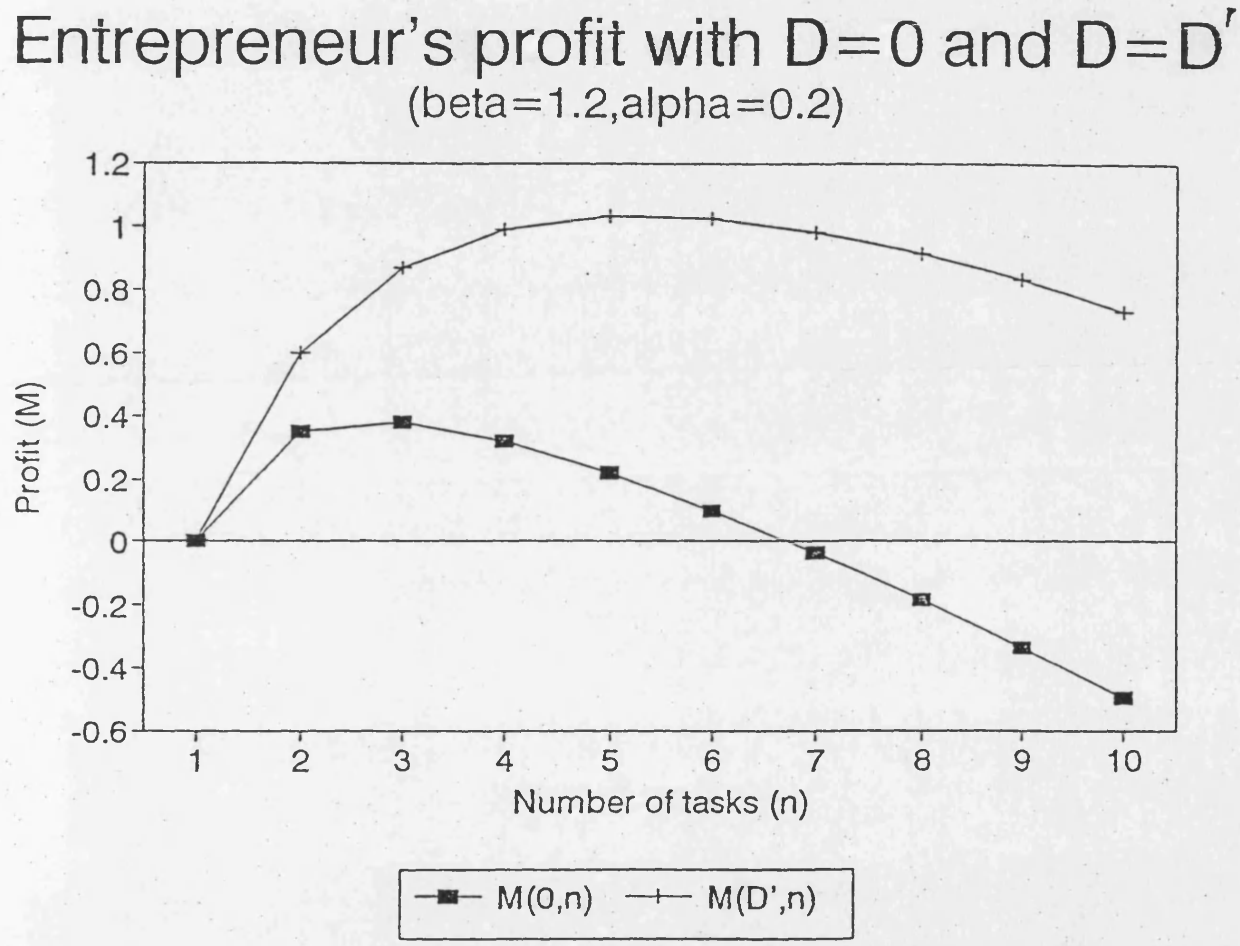
Entrepreneur's profit with D=0 and D=D'
(beta=0.8,alpha=0.2)
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
-1.6
Profit (M)
1
2
3
4
5
6
7
8
9
10
Number of tasks (n)
M(0,n)
M(D',n)

Figure 3



Entrepreneur's profit with D=0 and D=D'
(beta=1, alpha=0.2)
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
Profit (M)
1
2
3
4
5
6
7
8
9
10
Number of tasks (n)
M(0,n)
M(D',n)

Figure 4



Entrepreneur's profit with D=0 and D=D'
(beta=1.2,alpha=0.2)
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
Profit (M)
1
2
3
4
5
6
7
8
9
10
Number of tasks (n)
M(0,n)
M(D',n)

Notes

1. See the discussion in Chapter I.

2. See Kremer (1993).

3. Our emphasis on the effects that financial decisions have on surplus distribution neatly distinguishes our model from the (macroeconomic) literature on financial markets, capital accumulation and growth. Those models mainly focus, in fact, on the role that the financial sector has in channelling savings to firms, improving the allocation of funds, alleviating information problems, etc. For an overview of the literature, see Pagano (1993).

4. The approach we adopt has a bias towards debt financing, especially when financial markets are competitive. Our model abstracts from certain issues (such as project's monitoring, management's incentives, etc.) that may complement the present analysis and provide a rationale for the merits of internal financing under certain circumstances (see, for example, the theoretical analysis in Gertner, Scharfstein and Stein (1994)).

5. This assumption, made just to make the basic results neater, implies that the autarkic production, once forsaken, cannot be a credible outside option in bargaining (see Sect.2.1).

6. This assumption has a flavour similar to Kremer's (1993) model. There, tasks that are inadequately performed in a complex production process may cause project's failure. Our model, in fact, follows Kremer's notion of tasks' complementarity in sophisticated technologies.

7. See also the discussion in Stole and Zwiebel (1996a).

8. Our assumptions ensure that, once the investment cost is sunk, any project of type m $(m \neq n)$, which was *ex-ante* alternative to the currently adopted one, cannot be undertaken anymore: as a consequence, when agents are bargaining over $Y(n)$, we cannot consider $y = Y(1)-I(1)$ as a credible outside alternative.

9. Inefficiency is calculated from $[Y(n)-ny-I(n)]-[Y(n)-ny-I(n)-(n-1)(I(n)-L(n))]$.

10. If the maximand were convex over [2,N], the optimal choice of n would obviously be either $n=2$ or $n=N$.

11. Notice that condition (6) is more restrictive than condition (3), once (as assumed) condition (3) holds and $L(n)$ is not too large.

12. This social optimality criterion hinges on the assumption that only the entrepreneur can undertake projects such that $n>1$. In fact, if agents other than 1 could simultaneously implement projects of sophistication equal to, say, *2* and $(n-2)$, it might occur that $Y(n)-I(n) < Y(n-2)-I(n-2)+Y(2)-I(2)$, even when (7) holds: in such a case, the project n would be socially dominated.

13. The extent of inefficiency is obtained from the following difference: $\{[Y(n)-Y(n-1)]-[I(n)-I(n-1)]\}-\{[Y(n)-nY(n-1)/(n-1)]-n[I(n)-I(n-1)]+\Lambda\}$.

14. Should $y>Y(n-1)/(n-1)$ hold, condition (3), calculated for a $(n-1)$-type project would be violated against our assumption.

15. In the present non-stochastic context, involuntary default cannot take place.

16. As noted in Chapter III, when $D'>I(n)$, the investment cost is not greater than debt capacity and the entrepreneur borrows more than what is actually needed to implement the project. In this case, the extra amount of money borrowed can be used for financing activities not directly related to production, such as perquisite consumption, etc. (over-borrowing). On the other hand, when $D'<I(n)$ (borrowing does not cover the whole investment cost), project's implementation requires the contribution of the entrepreneur's own wealth: whenever the entrepreneur's wealth is less than $I(n)-D'>0$, under-investment can arise also because of wealth constraints, as in Hart and Moore (1994).

17. Notice also that the condition $M^1(0;n+1)<M^1(0;n)$ for an internal maximum ($n<$N) in the absence of debt is *easier* to satisfy than the corresponding condition $M^1(D'(n+1);n+1)<M^1(D'(n);n)$, calculated under debt financing. Hence, debt makes high sophistication levels more likely to be attained.

18. Define by $n_{D=0}$ the level of n solving the first order condition of problem (5), $dM^1(0,n)/dn=0$. By referring to (14), it is immediate to show that $dM^1(D'(n),n)/dn$, calculated for $n=n_{D=0}$, is a positive quantity: then, since $dM^1(D'(n),n)/dn$ is decreasing in n, the value $n_{D=D'}$ that solves problem (14) is larger than (or equal to, due to integer constraints) $n_{D=0}$.

19. Also, a strong and (almost) universal empirical finding reported in Rajan and Zingales (1995,p.1452-1454)) asserts that firm's size and leverage are positively correlated. In our model, leverage is an instrument to reduce the adverse distributive impact implied by multiple bargaining units.

20. We take y equal to zero.

21. As assumed in Bolton and Scharfstein (1996), one may think that debt is secured to $X>1$ complementary parts of the firm's physical assets, which can be liquidated by each of the X lenders in case of default.

22. In the present case, the condition for an interior maximum is given by $Y(n)>[(n+X)/(n+1+X)]Y(n+1)-[(n+X)/(1+X)][I(n+1)-I(n)]$, with $n+1\leq$N, and is less easy to satisfy than the corresponding one calculated for $X=1$.

23. This can be due, for example, to the presence of "restrictive covenants" on debt contracts: see Brealey and Myers (1991,p.601-602).

24. The main argument would remain valid if, when default on public debt occurs, the firm is liquidated with probability less than one.

25. The timing relative to the financing decision is not crucial here. Even if the entrepreneur raises no debt in the first stage, she always maintains the possibility to come back on the financial market *after* that effort decisions have been made, so to condition the bargaining outcome (a similar argument is made in Perotti and Spier (1993)). Then, when choosing effort, each agent anticipates the redistribute effects of debt independently of the *current* level of leverage.

26. As in Cooper and John (1988), the *stability* of such a S.N.E. requires that, in $e=e^0$, $|\sigma_i| > (n-1)Y_{ij}$.

27. In order to show formally that $e' < e^0$, one can refer to Appendix (I.a) (which gives the explicit expression for de_i/dn) and note that, since debt financing implicitly adds a player to the sharing of the returns from a n-agent project, the use of debt financing (instead of own-financing) implies that $Y_{i\nu}-c'=-c'$.

28. As emphasised by Cooper and John (1988), the presence of strategic complementarities can lead to *multiple S.N.E.'s*: in what follows, we will abstract from this possibility.

Chapter V

FOREIGN DEBT, SANCTIONS AND INVESTMENT: IMPLICATIONS FOR LDCs.

with

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Introduction.

The external debt of less developed countries (LDCs) has been widely debated in recent years[1]. As stressed by Cohen (1994), however, it is still not entirely clear why LDCs borrow and to what extent foreign debt may contribute to investment and growth. These issues are central in order to assess whether the industrialisation process in LDCs and Eastern Europe countries can be speeded up by foreign direct investment of transnational companies or externally financed domestic investment.

The predominant view on the LDCs' experience during the Eighties is that high foreign debt caused low investment. Krugman (1988) and Sachs (1988), for example, argue that debt-overhang enables foreign creditors to appropriate almost entirely the additional output generated by capital accumulation[2]. This negative view on the effects of debt is questioned by Bulow and Rogoff (1990,p.36): "During the 1960-73 era, before the debt buildup began in earnest, Latin American investment averaged roughly 20 percent of GDP. The ratio for 1987 was roughly two points lower, at 18.2 percent. But the investment ratio for industrialized countries has fallen even more sharply, from over 24 percent in 1960-73 to 20.7 in 1987. It is only relative to the peaks of the late 1970s that Latin American investment today looks so low". Furthermore, the empirical evidence reported by Warner (1992) for a panel of heavily indebted LDCs suggests a quite optimistic interpretation for the role of debt: debt in fact exerts a *positive* (and significant) effect on investment[3]. The aim of the present paper is that of providing a theoretical rationale capable to explain why it is that foreign debt may stimulate investment.

We consider countries where property rights are under threat. Adverse attitudes towards private investment (from outright expropriation, down to high tax-rates on capital income) seem more likely to emerge in countries characterised by high inequality in income and wealth, a major cause of social discontent[4]. In such environments, investors face the risk that an adverse government will come into office and take measures that, *de facto*, deplete their capital incomes[5]. Investment in LDCs may thus be much lower than the socially efficient level: in fact, "political risks" may seriously exacerbate the under-investment problem that arises when workers can bargain *ex-post* on investment's surplus (see Grout (1984)). International trade relations can, however, reduce the problems arising from political uncertainty. In particular, the violations of international agreements, such as the expropriation of foreign investment, can provide the case for the application of trade sanctions. In case of expropriation, thus, the threat of costly sanctions may force the domestic government to find a deal with foreign investors. As a consequence, sanctions help to preserve the capital share and make foreign direct investment more appealing than (self-financed) domestic investment. A similar argument applies when foreign debt contracts are repudiated. As in Bulow and Rogoff (1988,1989a), the credible threat of sanctions implies that debt repudiation will lead to a bargaining process between domestic borrowers and foreign lenders. Foreign debt has a particular role in our model. We show that, by borrowing abroad from a competitive financial market, a domestic capitalist can obtain a share of surplus that is not only *higher* than the share she would obtain under self-financing, but *also higher* than the share foreign investors can appropriate. Hence, foreign debt may dominate foreign direct investment and be the best financing device in order to stimulate investment in developing countries. The economic rationale for our result is that external debt gives lenders the right to negotiate over the surplus, in case of repudiation. The capitalist, who captures the (competitive) lender's share, can thus effectively constrain the behaviour of hostile governments.

Wealth constraints, or consumption smoothing, have typically been advocated to rationalise the extensive use of LDCs' foreign borrowing (see, e.g., Eaton (1993)). However, many highly-indebted LDCs are *net creditors* towards the rest of the world. Our hypothesis provides a new interpretation to the role of foreign debt, seen as a strategic tool to condition surplus distribution. The present approach has some similarities to models, such as Perotti and Spier (1993), Dasgupta and Sengupta (1993) and ours (see Chapter III), that find a negative relation between corporate debt and wages. Those models, however, are conceived for economic set-ups where there is certainty about the legal rules that apply in case of breach of the contractual conditions. By contrast, as Eaton and Fernandez (1995) emphasise, sovereign entities can generally offer little as collateral to guarantee a loan. Moreover, a court's ability to force a sovereign government to comply with its resolutions is rather limited. Thus, the respect of contracts between foreign parties can often be obtained only through indirect devices, such as sanctions (see also Eaton *et al.* (1986,p.484)). Furthermore, our analysis of investment in LDCs emphasises problems, such as political risks, that give an additional role to the strategic use of debt. Other predictions are that foreign debt repayments are always renegotiated in equilibrium and investment projects more vulnerable to sanctions are likely to be selected. The co-existence of capital flight and high levels of foreign debt is also consistent with our approach.

The scheme of the Chapter is as follows. Section 1 presents the basic structure of the model. Section 2 illustrates the under-investment problem for economies characterised by political uncertainty. Section 3 analyses foreign direct investment (FDI). The strategic role of foreign debt and its implications are analysed in Section 4. Section 5 concludes.

1. A Simple Model.

We consider a small country with two groups of agents, "workers" and "capitalists". Without loss of generality, we assume that there is only one worker, indexed by w, and a capitalist, indexed by c. In order to emphasise the links between international trade and international financial relations for LDCs, we assume that the agents in the economy produce an export good and consume a good imported from abroad (see, e.g., Bulow and Rogoff (1988)). Both the worker and the entrepreneur have utility function:

$$U(C_i) = C_i, \qquad i = (w, c) \tag{1}$$

where C_i, is agent i's consumption of the imported good. The capitalist has access to a technology that costs $K>0$, requires the labour services of the worker and generates y units of the export good. Once the decision to invest is taken, the capitalist sinks the amount K, that could have alternatively been spent on foreign consumption goods. Each unit of the export good can be traded for P units of the import good, so that the aggregate level of consumption is equal to $C=Py$. The capitalistic technology is socially efficient, that is C-$K>0$. We assume that, once the investment cost K is sunk, the worker acquires specific skills and becomes indispensable for production. As a consequence, the worker always retains some bargaining power over the surplus that the project can generate[6].

We now specify in detail the distribution of surplus, the country's political environment, the working of sanctions and the timing of the model.

- *Distribution.* We normalise the worker's and the capitalist's outside options to zero: should either agent abandon the project, her payoff would be zero. The outcome of the distribution process over C (the total amount of consumption that is derived by producing and shipping abroad the export good) is the N-party Nash bargaining solution: $S_i=C/N$, where S_i is agent i's share of C.[7]

- *Political Environment.* The capitalist is subject to the risk that a "populist" government (type-w government) comes into office once the investment cost has been sunk. Such a kind of political risk is likely to be more pronounced in less developed countries, characterised by high levels of inequality in income and wealth (see, e.g., Alesina and Perotti (1996)). Once in office, the type-w government will aim at maximising the worker's consumption level, C_w. Such an adverse attitude towards the capital share can take several forms: an hostile government can opt for outright expropriation of the capitalist's assets, or it can impose rules which strongly limit the capitalist's "right to manage" her assets. The income from capital can also be heavily taxed, so to redistribute surplus in favour of workers[8]. Here, under a type-w government, the capitalist is *de facto* excluded from the bargaining process over the returns generated by her investment. As in Alesina and Tabellini (1989), we assume that, once the project has been implemented, there is an exogenous probability $(1-\rho)$ that a populist government will win the elections (or it will overthrow a type-c government, more keen on the capitalist's interests).

- *Sanctions*. We assume that foreign partners can impose sanctions whenever the country considered violates some international agreement. Similarly to Bulow and Rogoff (1988), sanctions prevent the country from trading the export good against an import good and, hence, from consuming[9]. When the country's trade is halted by sanctions, the export good is stored until an agreement is found and sanctions are lifted[10].

- *Timing*. We consider the following sequence of events: at time $t=0$, the decision of whether to invest or not is taken. When investment is undertaken, the cost K is sunk. At time $t=1$, political uncertainty is solved. A type-c government is in office with probability ρ. At time $t=2$ production takes place and trade occurs, provided that actions leading to sanctions have not been taken (see Figure 1).

Eaton and Fernandez (1995,p.2045-2046) criticise the "bargaining with sanctions" approach followed by Bulow and Rogoff (1988,1989a) on two grounds. First, the creditor is assumed to have considerable power[11], since it can impose severe costs on the country's trade. Moreover, the results crucially depend on the exact specification of the bargaining game. The limits emphasised by this criticism are obviously also relevant for the results of our model.

2. The Under-Investment Problem.

Suppose that, at $t=0$, the domestic capitalist sinks the investment cost K by using own funds (K might have been otherwise spent to purchase consumption goods abroad). Depending on the political outcome at $t=1$, the capitalist will either remain in control of her assets (with prob. ρ) or, will be excluded from the division of the surplus C (with prob. $1-\rho$). In the first case, the capitalist retains the power to foreclose the worker from the access to physical capital. Since both parties must find an agreement in order to produce at date $t=2$ (the worker is indispensable for production), there is a bilateral bargaining over C that generates equilibrium payoffs equal to $S_w=S_c=\frac{1}{2}C$. By contrast, if an adverse government comes into office and the capitalist is expropriated (or fully taxed on capital income), her payoff is zero while the worker obtains the whole surplus C. Under risk-neutrality and common knowledge of ρ, the worker's and the entrepreneur's expected shares (at $t=0$) are, respectively:

$$ES_w^I = \frac{\rho}{2}C + (1-\rho)C = (1-\frac{\rho}{2})C \tag{2}$$

and

$$ES_c^I = \frac{\rho}{2}C \tag{3}$$

Hence, the capitalist's *ex-ante* expected consumption, net of investment costs, is:

$$EC_c^I = C - ES_w^I - K = \frac{\rho}{2}C - K \tag{4}$$

The implementation of a project of cost K requires that $EC_c' \geq 0$. This condition, compared with the less restrictive "social optimum" rule for investment, $C-K \geq 0$, implies that the country's physical capital accumulation is generally "too low". As emphasised by Grout (1984), under-investment is a standard result when a party can capture *ex-post* part of the rents generated by other parties' investment. However, the under-investment problem arising in the present context is a rather more serious matter, since the bargaining power of capitalists in less-developed countries is likely to be inherently reduced by political uncertainty ($\rho < 1$). In particular, a sufficiently high probability of type-w governments coming into office, $1-\rho$, implies that no investment is ever implemented, even when considerable gains from industrialisation are possible.

In this case, private wealth is also likely to flee abroad.

In the next section, we examine in detail the case of transnational corporations, that is, the case of *foreign* capitalists who invest under the shelter of sanctions.

3. Foreign Direct Investment.

Foreign firms can directly undertake the investment project and face, however, the risk that an hostile government will come into office. If there is no legal case for the application of sanctions, then, the analysis of FDI is equivalent to that of domestic investment. On the contrary, should the unfavourable treatment of a foreign company qualify as violation of international agreements, the transnational company can demand the application of trade sanctions against the breaching country[12].

When sanctions can be imposed, the expected worker's and foreign company's shares are, respectively:

$$S_w^{FDI} = \frac{1}{2}C, \quad and \quad S_c^{FDI} = \frac{1}{2}C \tag{5}$$

The result in (5) can be explained as follows. If type-*c* government comes into office (prob.$=\rho$), the worker and the company will agree on a partition giving each of them half of *C*. On the other hand, when a type-*w* government expropriates the foreign company (pr.$1-\rho$), the application of sanctions enables foreign investors to block the country's international trade and, thus, to bargain over *C* with the domestic government (acting in the worker's interest). When an agreement is reached, foreign investors lift sanctions and trade occurs. In equilibrium, the bargaining outcome is, again, $(½C,½C)$. The coverage of sanctions always guarantees foreign investors half of the surplus. The net payoff in consumption units generated by foreign direct investment, $C_c^{FDI}=½C-K$, is greater than the net payoff EC_c' defined in (4). Consequently, under FDI, the sanctions' threat eliminates the portion of under-investment that is entirely due to political uncertainty, $(1-\rho)½C$ (the reduction in the extent of inefficiency is calculated from the difference $(½C-K)-(\rho½C-K)$).

4. The Strategic Use of Foreign Debt.

In Sect.2, we considered a capitalist who self-funded her own investment. However, domestic capitalists may often borrow abroad to finance investment projects. In this case, the repudiation of the outstanding debt obligations makes the country's export liable to the application of sanctions[13]. As a consequence, foreign creditors gain bargaining power over the surplus C, since the embargo will be lifted only when an agreement between foreign lenders and domestic debtors is reached. We denote the amount borrowed abroad and the repayment prescribed by the debt contract by X and D, respectively.

At $t=0$, the investment is implemented and debt is contracted with a foreign (competitive) lender. At $t=1$, political uncertainty is solved. As before, the capitalist remains in full control of the investment project with probability ρ. Instead, should a type-w government come into office (prob. $1-\rho$), the capitalist would be excluded from the bargaining process over C. At $t=2$ production and trade are ready to take place. At this stage, the party who has the "right to manage" may decide to default on foreign debt. When the capitalist retains control, she may decide to repudiate to maximise her share, S_c^D. When the capitalist loses control, the populist government may default to maximise the worker's share, S_w^D. The definition of the surplus on which the parties bargain depends on the repudiation decision. When repudiation does not occur, the parties will bargain over C-D and the lender will be paid D back. If repudiation occurs, the application of sanctions will enable the lender to participate in the bargaining game over C. Once an agreement is eventually reached among the parties, trade and consumption will take place.

The number of agents taking part in negotiations when foreign debt is repudiated depends on the political outcome at $t=1$. Since the worker is indispensable for producing the export good, repudiation implies that there will be a two-party game over C (between foreign lender and domestic government) whenever a type-w government is in office. Under a type-c government, instead, repudiation entails a three-party game[14] among the capitalist, the worker and the lender.

4.1. Strategic Debt Repudiation.

For any given level of contractual repayments, $D \geq 0$, the debt-repudiation decision is taken to maximise the share of whoever will be in control of the project at

t=2 (be the capitalist or the populist government). Default on foreign debt is conditional to the resolution of political uncertainty at t=1.

Lemma 1. If a type-c government prevails, voluntary default on foreign debt will occur for any $D > \frac{1}{3}C$. If a type-w government prevails, voluntary default will occur for any $D \geq \frac{1}{2}C$.

Proof. The optimal debt-repudiation strategy for the capitalist, as well as for the w-type government, depends on the level of D. Consider two cases. Case (I): suppose that a type-c government, keen on the capitalist's interest, prevailed at t=1 (an event with prob.$=\rho$). At t=2, the decision whether to repudiate is taken by the capitalist, who controls the project. If the contractual amount D is paid back, the capitalist, the worker and the lender obtain, respectively, $({}^{nr}S_c, {}^{nr}S_w, {}^{nr}S_l) = (\frac{1}{2}(C\text{-}D), \frac{1}{2}(C\text{-}D), D)$. If the capitalist chooses repudiation, the lender can apply sanctions: a three-party bargaining over C occurs, with equilibrium payoffs equal to $({}^{r}S_c, {}^{r}S_w, {}^{r}S_l) = (\frac{1}{3}C, \frac{1}{3}C, \frac{1}{3}C)$. Then, the capitalist will default on foreign debt whenever ${}^{nr}S_c < {}^{r}S_c$, i.e., when $D > \frac{1}{3}C$. Consider now case (II): at t=2, a type-w government, that prevailed at t=1, decides in the worker's interest whether to repudiate foreign debt. If debt is repaid, the capitalist, the worker and the lender obtain, respectively, $({}^{nr}S_c, {}^{nr}S_w, {}^{nr}S_l) = (0, C\text{-}D, D)$. In case of repudiation, sanctions will force the type-w government to bargain with the foreign lender. In equilibrium, the following payoffs are offered and accepted: $({}^{r}S_c, {}^{r}S_w, {}^{r}S_l) = (0, \frac{1}{2}C, \frac{1}{2}C)$. Repudiation occurs whenever ${}^{nr}S_w \leq {}^{r}S_w$, i.e., when $D \geq \frac{1}{2}C$. ■

As a consequence of the Lemma 1, the expected worker's share at t=0 is equal to:

$$ES_w^D = \rho \max\left\{\frac{1}{2}(C-D),\ \frac{1}{3}C\right\} + (1-\rho)\max\left\{(C-D),\ \frac{1}{2}C\right\} \tag{6}$$

Expression (6) can be rewritten as function of the contractual debt repayment D:

$$ES_w^D(D) = \begin{cases} \frac{\rho}{2}(C-D) + (1-\rho)(C-D), & \text{if } D \le \frac{1}{3}C \\ \rho\frac{1}{3}C + (1-\rho)(C-D), & \text{if } D \in \left(\frac{1}{3}C, \frac{1}{2}C\right) \\ \frac{\rho}{3}C + \frac{(1-\rho)}{2}C, & \text{if } D \ge \frac{1}{2}C \end{cases} \tag{7}$$

The function $E_w{}^D(D)$ is decreasing in the contractual repayment D, as illustrated in Figure 2.

4.2. The Country's Debt Capacity.

From the analysis of the repudiation decision, the expected lender's share at $t=0$ is increasing in D (see Figure 3):

$$ES_l^D(D) = \rho \cdot \min\left\{D, \frac{1}{3}C\right\} + (1-\rho) \cdot \min\left\{D, \frac{1}{2}C\right\} \tag{8}$$

Assume that the *international capital market is competitive* and, for simplicity, that the net interest rate is zero. Risk-neutral lenders break even *ex-ante* when their expected payoff ES_l^D is equal to the amount lent, X. The country's debt capacity, i.e., the maximum amount that a foreign lender is willing to concede, is defined as follows:

Lemma 2. The country's debt capacity is equal to:

$$X^* = \left(\frac{1}{2} - \frac{\rho}{6}\right) C \tag{9}$$

Proof[15]. Notice from (8) that for any $D \ge ½C$, the contractual debt repayment will be repudiated. When repudiation always occurs, the lender's expected payoff is equal to $(1/2-\rho/6)C$, which is also the maximum share of C that a lender can expect to obtain at $t=0$ (see Figure 2). Hence, $(1/2-\rho/6)C$ is the maximum amount that a foreign lender can concede at $t=0$ while still making non-negative expected profits. ■

Note that assuming a positive net interest rate would leave the main result unchanged. Denote the gross interest rate by $R \ge 1$. The lenders' break-even condition now becomes $ES_t^D = RX$. The country's debt capacity (as defined in Lemma 2) would thus be $X^{*\prime} = R^{-1}X^*$, where X^* is defined by (9).

The country's foreign debt capacity is based on the lender's ability to impose effective trade sanctions in case of debt repudiation. This is consistent with the observation that "syndicated bank loans generally involve banks from all the borrower's major trading partners" (Bulow and Rogoff (1989a,p.175)). The view that countries with a high degree of openness to foreign trade have better access to external debt is also supported in a recent study by the IMF[16]. The explanation here, as in Bulow and Rogoff, lies in the superior ability of a relevant trading partner to inflict harmful sanctions in case of debt repudiation[17]. However, in case of default, foreign lenders do *not* need to implement sanctions to reach an agreement with forward-looking debtors.

The model has another relevant implication. Since X^* is decreasing in ρ, equation (9) predicts that foreign lenders are willing to lend greater amounts of funds to countries that are more likely to have populist governments. In fact, Lemma 1 implies that foreign lenders are in a stronger position when bargaining with governments that aim at increasing workers' consumption. This implication is not at odds with the experience of some Latin American countries during the Seventies. As reported by Berg and Sachs (1988, p.283-284), the governments of Mexico, Argentina and Brazil undertook overtly populist policies during the period 1970-1982, in order to reduce income inequality and contain social unrest. At the same time, these three countries were able to raise, over the *same* period, huge quantities of new debt from abroad. Indeed, the foreign debt of Argentina, Mexico and Brazil grew at a much higher rate than that of Chile[18], a country that after 1973 was ruled by a military government with strong anti-populist attitudes (see, e.g., Sachs (1989)). Further, the case of Nicaragua offers some evidence that foreign lenders may have advantages when negotiating with governments which are more prone to endorse populist issues. After taking power in 1979, the Sandinista government decided not to repudiate the foreign debt that had been raised under the Somoza's regime. According to Basu (1991), "Nicaragua's decision to repay its debt illustrates well the effectiveness of the threat of punitive action" (p.11). Further anecdotal evidence that foreign lenders may do better when dealing with governments that are more prone to endorse populist issues comes from the comparison between the different management of the Latin America debt crises of the Twenties and of the Eighties. In contrast with the Latin American dictatorships of the Twenties-Thirties, the democratic regimes of the Eighties reacted to the crisis by continuing to service their debts, at least partially: "They did so even though those debt obligations loomed much larger -absolutely and relatively- than during the previous Great Depression" (Drake, 1989, p.52). According to Roett (1989, p.70), both the historical and more recent experience on debt crises has generated the perception that U.S. institutions' interests are better protected when lending to democratic regimes, even if such regimes may have stronger incentives to undertake populist policies.

Note finally that the political process of our model can be simply re-interpreted to generate a positive correlation between amount of debt and *political instability*. Suppose that at t=0, when the investment decision is taken, a type-*c* government is in office. The probability ρ can thus be considered as the *conditional* probability that the type-*c* government will remain in office at t=1, *once in office at t=0*. In this case, then, ρ may be seen as a measure of "political stability": the higher ρ, the higher the expectation that the incumbent government will remain in power. Since the algebra we laid down still goes through, equation (9) now predicts that larger levels of debt are likely to be observed for more "unstable" countries. This prediction is supported by the evidence that Özler and Tabellini (1991) report for the period 1972-1981.

A simple correlation analysis also supports the positive linkage between debt and political instability. We calculated the correlation coefficient between the country's measure of political instability provided in Alesina and Perotti (1993) and the 1980-94 average ratio between foreign debt and GDP (Source: World Debt Tables, *World Bank*). The correlation coefficient for the ten major Latin American countries (Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Mexico, Peru, Uruguay, Venezuela) is equal to 0.684. If Argentina is excluded from the sample, the correlation coefficient rises to 0.836.

4.3. Strategic Financial Choice.

We can now show how the strategic choice of foreign debt twists income distribution in favour of domestic entrepreneurs, even in political environments which are likely to be adverse to capital. Define D^* as $D=\frac{1}{2}C$: when the face-value repayments prescribed by the debt contract are greater than D^*, repudiation will *always* occurs. Also, it holds that $X^* \leq D^* \equiv ½C$. Since the expected worker's share $ES_w^D(D)$ is monotonically decreasing in D, the capitalist's expected consumption, $EC_c^D(D) = C - ES_w^D - K$, is *increasing* in D. The capitalist's payoff in terms of consumption units is thus maximised for *any* $D \geq D^* = ½C$. When the capitalist borrows from a foreign competitive financial market, the amount X that can be obtained against a debt contract that requires a repayment greater than D^* coincides with the country's credit capacity itself, X^*. Hence:

Result 1. The domestic capitalist always borrows from abroad up to full debt capacity, X^*.

The equilibrium financial choice of the domestic capitalist has an immediate implication with regard to the secondary market for foreign debt. Notice first that, even with a zero net interest rate on the international capital market, the contractual repayment D would coincide with the principal X *only when* $D < ⅓C < D^*$. Hence, when debt is optimally chosen, the contractual repayment, D^*, is larger than the amount that is lent and it is expected to be paid back, X^*:

Corollary. Since the debt face-value is systematically larger than its actual market value, X^*, *the foreign debt of countries subject to political uncertainty trades at a discount in equilibrium.*

The contract conditions chosen in equilibrium will always be repudiated, since $D \geq D^*$. The actual repayment received by the lender is negotiated at date 2, under the credible threat of sanctions[19]. This feature of our model makes foreign debt similar to *junk bonds*: rational lenders anticipate that the face-value of the debt contract, specifying a very high level of interest, will be renegotiated *ex-post*. According to the measure used by Cohen (1992), in fact, "all major debtors (except Brazil) delivered a market return to the commercial banks" (p.65)[20].

Result 1 is consistent with the fact that LDC residents have been inclined to accumulate large amounts of foreign debt in the Seventies[21]. High levels of debt can also be justified by the model of Alesina and Tabellini (1989): there, by borrowing from abroad, the incumbent government insures its supporters against the possibility of adverse political changes in the future. Here, differently, foreign debt modifies the agents' ability to negotiate over the surplus. In fact, foreign borrowing constrains workers' bargaining power[22]: in equilibrium, the worker expects to receive $(1/2-\rho/6)C$, the lowest available payoff (see Figure 1). The capitalist's expected consumption is, instead,

$$EC_c(D^*) = C - ES_w(D^*) - K = \left(\frac{1}{2} + \frac{\rho}{6}\right)C - K \tag{10}$$

When contracting a repayment greater than D^* at date 0, the capitalist cashes X^* against the right for the lender to participate in negotiations over C at date $t=2$. Hence, even when political risks are very high ($\rho \approx 0$), the capitalist still manages to appropriate a share of surplus equal to X^*. Foreign debt encourages capital accumulation, since it redistributes part of the surplus to the capitalist's share. This conclusion is consistent with the empirical findings of Warner (1992), showing a positive and significant debt effect on investment for a panel of highly indebted countries. It must be recalled, however, that there are alternative and more obviuos explanations for Warner's (1992) results: one, for example, is that a high return on capital in a country can lead both to high investment and high debt to finance it.

The following result also holds:

Result 2. Both the strategic use of foreign debt and foreign direct investment yield a net capital share greater than the one generated by domestic capitalist's self-financing (i.e., EC_c' in (4)).

This result is consistent with the strong correlation found between foreign debt and FDI, on the one side, and LDCs' growth on the other (see Claessens (1993,p.95)). In particular, our model suggests that foreign debt and FDI tend to cause investment and growth.

Comparing the net capital share $EC_c(D^*)$ from (10) with the net share that a transnational company obtains through foreign investment, $C_c^{FDI} = ½C - K$, it can be noted that:

Result 3. The strategic use of foreign debt dominates foreign direct investment.

This result is due to the structure of the bargaining game to be played under FDI and external debt, respectively. Under FDI, our assumptions always generate a two-party bargaining game between the foreign company and its domestic counterpart (independently of the political outcome). Consider, for simplicity, the implications of foreign debt in the extreme case that $\rho=1$. When a domestic capitalist borrows abroad and contractual repayments are renegotiated, the bargaining game over C is to be played by three parties, since the lender can credibly impose sanctions. If the international loan market is competitive, the lender's expected share, X^*, is fully captured by the local capitalist. Foreign debt can thus be considered as a "poison pill" (see Brealey and Myers (1991;p.839)): in our model, in fact, debt works as a "shark-repellent" against the aggressive behaviour of the workers (or their political representatives). Result 3 is also consistent with the observation that the volumes of foreign direct investment have been lower than debt stocks in developing countries. As reported by Claessens (1993,p.94), "in 1988 FDI stocks for all developing countries were equivalent to only about 11 percent of total debt claims. The average ratio of FDI stocks to gross national product (GNP) was 10 percent, while the ratio of debt to GNP was 83 percent."

In the absence of a credible commitment to "tie the hands" of a populist government, external debt may incentivate the implementation of socially efficient projects which, otherwise, would not have been undertaken. The strategic use of foreign debt may thus be an effective device to reduce under-investment and promote the capitalistic development.

Foreign debt, however, is not a panacea for LDCs. For example, sanctions that apply to international trade are ineffective on projects that produce goods for domestic use: such productions may thus be abandoned in favour of *socially sub-optimal productions*. Consider for example two mutually exclusive investment projects, (a,b). Project-a costs K^a and produces and export good that can be exchanged for C^a units of an import good. Project-b costs K^b and produces C^b units of a good that can be directly consumed domestically (here, we take utility to be $U(C^a,C^b)=C^a+C^b$). Suppose, also, that project-b socially dominates project-a: C^a-$K^a<C^b$-K^b. However, since project-b is not liable to foreign-trade sanctions, project-a will be preferred whenever $(1/2+\rho/6)C^a$-

$K^a > \frac{1}{2}\rho C^b - K^b$.[23] Furthermore, the preference for projects that produce exportable goods may excessively expose LDCs' economies to international price-variability, a major cause of the Eighties' debt crisis (see, among others, Diaz-Alejandro (1984), Eaton (1990), Warner (1992)).

A final implication that is implicit in our model is that *the domestic capitalist's wealth (when subject to the risk of expropriation) is likely to be held abroad and strategically "re-imported" through the international financial system, which relies on the threat of trade sanctions*. Eaton (1990) notes that "for many of the major debtors, private claims abroad equal around half of national indebtness. At the extreme, estimates for Venezuela show it to be a net creditor" (p.44). Further evidence on the co-existence of capital flight with high debt is in Bulow and Rogoff (1990). Our simple framework, thus, provides also a strong rationale for the simultaneous presence of high levels of foreign debt and capital flight[24].

5. Conclusions.

The present paper has focused on the incentives to invest in LDCs. In particular, we provided an hypothesis for the possible relevance of foreign debt in countries where the absence of secure property rights typically results in low investment and growth. Although the role of foreign finance in speeding up growth is still debated, Cohen (1992,p.99) concludes that foreign debt may play a relevant part especially for countries that are "relatively well endowed in human capital and relatively poor in physical capital". Cohen's observation is consistent with our assumption that there are domestic entrepreneurs capable of implementing projects, but they may be discouraged by political uncertainty.

Our framework abstracts from many aspects related to such a complex issue as foreign debt (e.g., the role of public lending institutions such as the IMF, the issue of seniority when there are multiple creditors, etc.). However, this simple model generates some new implications on the possible role of foreign finance. For instance, we showed that both external debt financing and foreign direct investment twist the distribution of the surplus, via the sanctions' threat, towards the capital share. External debt financing, however, can be more effective than FDI in reducing under-investment in less developed countries. These conclusion are compatible with the existing empirical evidence. According to Warner (1992), foreign debt had positive effects on capital accumulation. Also, the implication that foreign debt provides greater incentives to invest may contribute to explain why the observed FDI stocks are much lower than total debt claims. Other predictions of our model in accord with empirical observation are that LDCs' debt trades at a discount, and capital flights coexist with large foreign debts. Moreover, as the Latin American experience has shown, populism and political instability do not deter foreign institutions from lending large amounts of funds, whilst the advantages of borrowing abroad push LDCs towards high openness to international trade.

Although further investigation is in order, our hypothesis on foreign debt receives some preliminary support from the existing evidence. Hence, we conclude that the design of external debt contracts supported by credible sanctions may be quite relevant to promote and speed up the industrialisation process in countries (such as many Eastern European ones) that are characterised by insecure property rights, under-investment and under-development.

Figure 1

TIMING

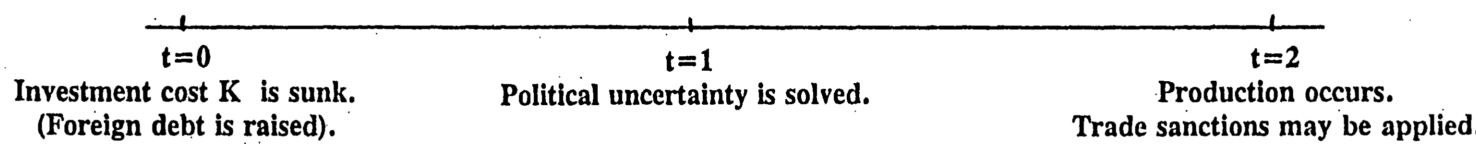


Figure 2

Worker's Expected Share

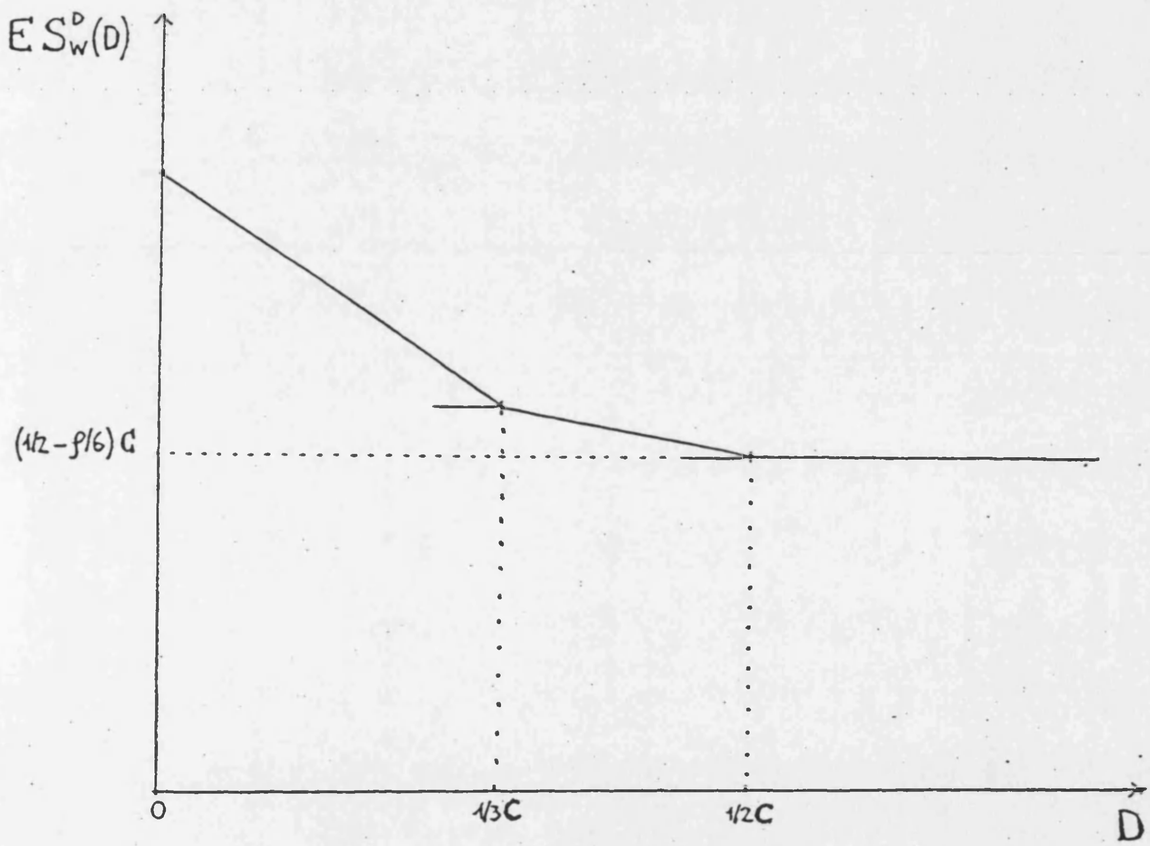
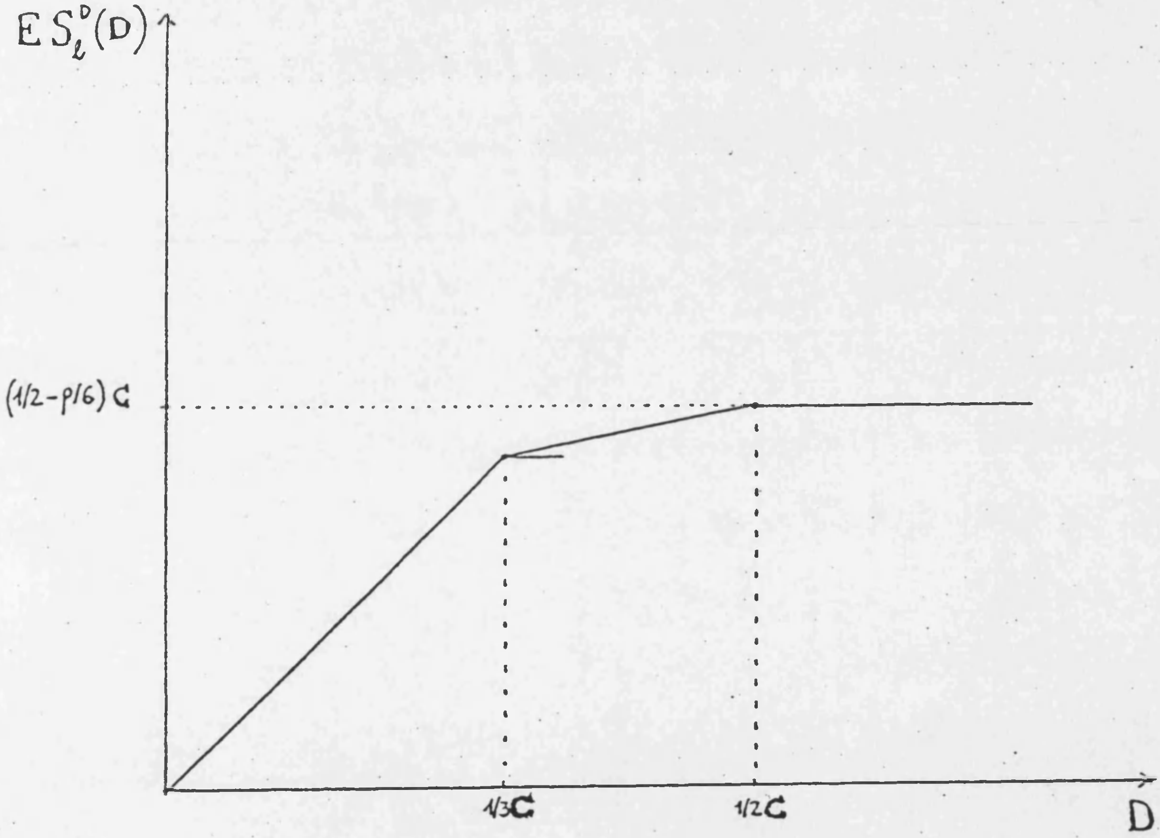


Figure 3

Lender's Expected Share



Notes

1. See, among others, Cohen (1994), Eaton (1993) and Kletzer (1994).

2. Similar arguments are put forward by Helpman (1988).

3. The overall decrease in LDCs' investment has to be attributed to the worsening of these countries' terms of trade. Cohen (1993) also finds that large external debt was not an investment deterrent in the Eighties, although forced debt service payments had a negative and significant, albeit small, effect. Furthermore, by analysing a sample of 20 highly-indebted countries during the 1980s, Cohen (1992) finds that the stock of debt has a positive, although not statistically significant, effect on growth.

4. The relation between inequality and under-investment, leading to underdevelopment, is empirically investigated by Alesina and Perotti (1996).

5. See, e.g., Clague *et al.* (1996).

6. When a worker acquires specific skills in production, she might only be replaced at a very high cost. This feature drives Grout's (1984) under-investment result and, more in general, the so-called "hold-up" problem (see Hart (1995) for an extensive discussion of this issue).

7. The payoff S_i, i=1,..,N, is the (unique) solution to the following generalised Nash problem: *maximise* $(S_1)\cdot(S_2)..\cdot(S_N)$ *with respect to* $\{S_1, S_2, .., S_N\}$, *subject to* $S_1+S_2+..+S_N \leq C$. The Nash-solution for $N \geq 2$ players can also be obtained as unique solution in explicitly strategic contexts, as when the Rubinstein's (1992) model is extended to more than two players under the assumption of stationarity in strategies. As shown in Chapter II, the Nash solution also holds in an alternating calls bargaining model where the size of the cake decays over time and the parties retain strictly positive (even if possibly very small) outside options.

8. In Alesina and Tabellini (1989), a type-*w* government imposes a tax rate on capital income equal to 100%. There several forms of hostile behaviour: as Claessens (1993,p.108) puts it, "creeping expropriation of the earnings of a foreign investment - through taxes, union activities, or domestic ownership requirements- is hard to detect, making it difficult to measure expropriation properly".

9. The assumption that sanctions can forestall the country's *whole* shipment is quite extreme; however, Bulow and Rogoff (1989a) show that similar results apply also when foreigners can block a *fraction* of the country's trade.

10. Bulow and Rogoff (1988,1989a) assume that stored goods decay at a given rate. Such assumption, which is similar to the "decaying cake" hypothesis in Chapter II, provides the main driving force leading to an early agreement in the strategic bargaining game they adopt.

11. By adopting a model where the parties can take actions which strategically determine their relative strength, Fernandez and Rosenthal (1990) show that creditors still have an advantage in renegotiations.

12. Transnational companies (which traditionally seem to have been highly exposed to expropriation risks) have means other than trade sanctions to react to a host country's aggressive behaviour. For instance, a foreign company may repatriate its managers and technicians, so to inflict serious losses in production (see, for example, Eaton and Gersovitz (1984) and Thomas and Worrall (1994)).

13. Foreign debt repudiation can be costly due to *loss of reputation*, preventing the country's future access to international capital markets (see, e.g., Eaton and Gersovitz (1981) and Cohen and Sachs (1986)). Such approaches are criticised by Bulow and Rogoff (1989b) on theoretical grounds. Alternatively, Rowlands (1993) considers the *cost of a country's constitution change*, due to exogenous breakdown costs implied by debt repudiation. Our analysis, following Bulow and Rogoff (1989a), is centred on the presence of sanctions as the main cost of repudiation.

14. As mentioned, Bulow and Rogoff (1989a) have been the first authors to treat debt repudiation as an event leading to bargaining between lenders and debtors. This notion has been adopted also in Hart and Moore (1994). Bulow and Rogoff (1988) consider, in a different context, a three-party bargaining game (foreign government, foreign lenders and domestic debtor) following the event of debt repudiation.

15. The argument here is similar to the one in Bulow and Rogoff (1989a).

16. See International Monetary Fund (Ch.3,1991). The vulnerability to sanctions can also be due to high technological dependence from abroad. Warner (1992) documents the strong technological dependence of highly-indebted countries from abroad.

17. Recall that, here, sanctions can halt foreign trade with probability equal to one. It can also be considered the case when sanctions are effective only with a probability less than one. In that case, the debt capacity would be increasing in the likelihood that sanctions are effective.

18. See, e.g., Bulow and Rogoff (1990).

19. The result in the Corollary arises from the possibility of voluntary default. Debt, however, will trade at a discount also when involuntary default may occur (due, e.g., to adverse shocks in the country's terms of trade). The extent of discount on LDCs' foreign debt is documented is Bulow and Rogoff (1990).

20. The conclusion reached by Cohen (1992) on debt returns is however questioned by Bulow (1992), who accounts also for currency differentials.

21. As in the model developed in Chapter III, the strategic use of debt can generate *over-borrowing*, which is, $X^* > K$. On the contrary, when $X^* < K$ and the capitalist's wealth is sufficiently low, under-investment may also be generated by wealth constraints.

22. A strong concentration of foreign debt in the large industrial groups of Mexico, Argentina and Brazil is reported in Maxfield (1989). Large companies generally have, indeed, organised and skilled workforces.

23. Similar distortionary effects in the choice of technology are examined in Eaton and Gersovitz's (1984) expropriation model.

24. In their two-period model, Alesina and Tabellini (1989) motivate the simultaneous presence of high debt and capital flight in terms of "insurance" against the risk of future taxation.

Chapter VI

CAPITAL MARKET IMPERFECTIONS AND COUNTER-CYCLICAL MARKUPS.

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Introduction.

The evidence of pro-cyclical movements in factor prices relative to output prices has long been viewed as a potentially serious problem for theories of the business cycle based on aggregate demand fluctuations and perfect competition in product markets. However, as shown first by Rotemberg and Saloner (1986) and then by Rotemberg and Woodford (1991,1992), dynamic models of imperfectly competitive product markets may generate counter-cyclical markups.

In particular, when firms compete in an oligopolistic market, Rotemberg and Saloner (1986) show that the incentive to collude is stronger during periods of relatively low demand, whereas (implicit) collusion is harder to maintain when demand is high. On the one side, a high-demand state entails the following "temptation": by lowering its own output price, a deviating firm can obtain a substantial increase in current profits at the expense of rival firms. On the other side, the ensuing punishment for deviations (which is, the reversion to competitive pricing over the whole future horizon) brings to zero the stream of future expected profits. Then, if the rate at which firms discount future profits is sufficiently high, implicit collusion over monopolistic pricing cannot be sustained during high demand periods: in this case, booms generate "price wars" that lead to a counter-cyclical pattern in markup determination[1].

More recently, an alternative explanation of counter-cyclical markups has been offered by Chevalier and Scharfstein (1995,1996), based on the effect of capital market imperfections on the pricing decisions of firms which operate in an oligopolistic market. These authors start from the consideration that, in models of intertemporal price competition where prices may be set below the short-run profit-maximising level, the presence of liquidity constraints forces firms to raise prices in order to increase current profits and cash-flows. Since financial constraints are more likely to arise during recessions, markups tend to display a counter-cyclical behaviour.

Following Klemperer (1995), Chevalier and Scharfstein (1996) construct an intertemporal model that incorporates "switching costs" for consumers. Firms use a policy of moderate prices in order to attract customers and build market share to be exploited in the future. However, when external funds are needed, firms end up bearing a risk of default (and liquidation) which is particularly high during recessions. Thus, since firms are less likely to overcome slowdowns, investment in market share becomes less valuable and prices are raised, following a short-run profit-maximisation criterion.

Chevalier and Scharfstein (1996) also claim that, if capital market imperfections are relevant, the Rotemberg-Saloner implicit collusion model cannot rationalise counter-cyclical markups. As they put it:

"[Our] results are inconsistent with the tacit collusion model proposed by Rotemberg and Saloner (1986) and Rotemberg and Woodford (1991,1992). ..these models predict that in booms there is a greater temptation to deviate from the collusive outcome by cutting prices in an attempt to increase short-run profits. However, adding liquidity constraints to their model tends to reverse the prediction of countercyclical markups. If firms are more liquidity constrained in recessions, then they will be *more* tempted to cheat on a collusive agreement because they need to increase short-run profits. Thus, their model predicts that prices should fall *more* in busts when firms are most cash constrained. By contrast, we find that prices fall *less*". (p.705)

In this Chapter we show that this claim on the Rotemberg-Saloner model does not hold in general, but only under the rather extreme assumptions made by Chevalier and Scharfstein. In fact, the model adopted in Chevalier and Scharfstein (1996) is based on the implicit assumption that a firm has *zero* probability of surviving a recession. By using the Rotemberg-Saloner setup, we assume that oligopolistic firms survive recessions with positive probability: under such a milder (but perhaps more realistic) assumption, we show that the "implicit collusion" model is still capable of generating counter-cyclical markups for non-negligible ranges of the relevant parameters. Furthermore, when markups are counter-cyclical, the introduction of "capital market imperfections" increases the degree of counter-cyclicality relative to the benchmark Rotemberg-Saloner model.

Section 1 presents the model and gives the main results. Section 2 concludes.

1. The model.

We consider a simple extension of the basic Rotemberg-Saloner (1986) setup, as presented in Tirole (1988), where two firms, producing an homogeneous good, compete in a market with stochastic demand. In every period, the demand can be either "high" or "low", with equal probability. Demand shocks are identically and independently distributed over time. In each period, the two firms learn the current state of demand before choosing their price simultaneously. Each firm chooses prices so as to maximize the discounted value of profits over the entire future infinite horizon, earning profits Π_H (Π_L) if a good (bad) realization of demand occurs. In what follows, we solve for a pair of prices $\{p_L,p_H\}$ such that: (i) both firms set the same price p_s when the state of demand is s, (ii) the pair $\{p_L,p_H\}$ is sustainable as an equilibrium (i.e., deviating from p_s in state s is not privately optimal), and, (iii) the expected present discounted value of each firm's profit, calculated for $\{p_L,p_H\}$, is not dominated by any other pair of prices which satisfy (i) and (ii) (i.e., in case there are other pairs of prices sustainable as equilibria, both firms prefer the pair $\{p_L,p_H\}$ considered)[2].

In the model of Chevalier and Scharfstein (1996), liquidity constraints due to capital market imperfections lead to liquidation when low demand states occur: thus, a liquidity-constrained firm *never* survives a recession. These authors justify this assumption by arguing that, when the firm has some debt to repay, the only way to induce the manager to pay out cash flow is to threaten him to liquidate the firm's assets in case of default[3]. Thus, when debt is sufficiently high, a recession implies that the manager does not have enough cash to make repayments and avoid liquidation.

In the Rotemberg-Saloner framework, the assumption that recessions imply firm's liquidation rules out *counter-cyclical* mark-ups. Nevertheless, although recessions are likely to exacerbate financial difficulties, firms may sometimes avoid liquidation by raising fresh external funds. In this perspective, we assume that when a bad realization of demand occurs, each firm has a probability $0 \leq \rho \leq 1$ of surviving to the next period and, conversely, a probability $1-\rho$ of being liquidated and cease operations. In so doing, we encompass the polar cases of Rotemberg-Saloner ($\rho=1$) and Chevalier-Scharfstein ($\rho=0$). Therefore, for a firm in period 0, the probability of being operative in period t is $[(1+\rho)/2]^{t-1}$ if in period 0 demand is high, and $\rho[(1+\rho)/2]^{t-1}$ if demand is currently low[4].

Given the probabilities above, we have the following expressions for each firm's profit stream, discounted by a factor $0 \leq \delta \leq 1$, expected at time 0:

$$V_H = \Pi_H + \sum_{t=1}^{\infty} \delta^t \left(\frac{1+\rho}{2}\right)^{t-1} \left(\frac{\Pi_H}{2} + \frac{\Pi_L}{2}\right)$$
$$= \Pi_H + \frac{2\delta}{2 - \delta(1+\rho)} \left(\frac{\Pi_H}{2} + \frac{\Pi_L}{2}\right) \quad (1)$$

when demand is currently high, and

$$V_L = \Pi_L + \sum_{t=1}^{\infty} \delta^t \rho \left(\frac{1+\rho}{2}\right)^{t-1} \left(\frac{\Pi_H}{2} + \frac{\Pi_L}{2}\right)$$
$$= \Pi_L + \frac{2\rho\delta}{2 - \delta(1+\rho)} \left(\frac{\Pi_H}{2} + \frac{\Pi_L}{2}\right) \quad (2)$$

when demand is currently low. Note that the "survival probability" ρ is such that future expected profits have smaller weight in the computation of the value of the firm.

If firms adopt a fully-collusive behaviour, prices are set at the monopoly level corresponding to each state of demand, p_H^m and p_L^m, yielding profits Π_H^m and Π_L^m in the good and bad state respectively. For the collusive outcome to be sustainable, the future losses when deviating from monopoly pricing must be larger than the (current) gains accruing to the deviating firm. Suppose that rival firms adopt a trigger-strategy behaviour such that the deviation from collusive (monopoly) pricing in one period determines the reversion to the competitive (zero-profit) pricing in all future periods ("maximal-punishment principle"). Thus, the gains from deviation amount to either Π_H^m or Π_L^m, whereas the losses are given by the second term in the right-hand-side of either (1) or (2).

Therefore, for collusion to be sustainable in periods of high current demand we must have:

$$\Pi_H^m \leq \frac{\delta}{2 - \delta(1+\rho)} \left(\Pi_H^m + \Pi_L^m\right) \quad (3)$$

yielding the following condition on the discount factor δ:

$$\delta \geq \delta_H \equiv \frac{2}{K^m + (2 + \rho)} \tag{4}$$

where $K^m \equiv \Pi_L{}^m/\Pi_H{}^m$ is the ratio between the level of monopoly profits in the low and high demand states, proxying for the amplitude of cyclical fluctuations ($0 \leq K^m \leq 1$). In periods of low demand collusion is sustainable if:

$$\Pi_L^m \leq \frac{\rho\,\delta}{2 - \delta(1 + \rho)} \left(\Pi_H^m + \Pi_L^m\right) \tag{5}$$

implying the following condition on δ:

$$\delta \geq \delta_L \equiv \frac{2K^m}{(1 + 2\rho)K^m + \rho} \tag{6}$$

From (4) and (6) we see that a lower probability of avoiding liquidation in periods of low demand raises the critical values δ_H and δ_L necessary to sustain collusion: in both cases the future loss to the deviating firm is reduced by a lower ρ. Thus, a higher discounting factor δ would be needed to compensate for the resulting greater incentive to deviate.

The case for $\rho = 1$ (certain survival in low demand states) yields the original Rotemberg-Saloner result: for $\delta_L < \delta < \delta_H$ collusion is sustainable only in low-demand states and mark-ups display counter-cyclical behaviour. As shown in Figure 1(a), the range of values for the discount factor yielding counter-cyclical mark-ups (the shaded area in the figure) is wider the lower is K^m: when the amplitude of cyclical fluctuations is large (K^m tends to 0), current profits are high in favourable states, yielding a greater incentive to deviate, whereas profits are low in bad states, making collusion more likely. Indeed, when the firm incurs no liquidation risk in either state, it becomes easier to enforce monopoly prices in recessions, when the gain from deviation is relatively low. Note also that, if there are no cyclical fluctuations ($K^m = 1$) collusion is sustainable in both high and low demand states if $\delta \geq 1/2$, as in Friedman (1971).

In the above setting, the assumptions in Chevalier and Scharfstein (1996) - based on management's moral-hazard problems - lead to the termination of the firms with certainty if a low demand state occurs, corresponding to $\rho = 0$. In this case, δ_L is always greater than δ_H, which rules out the possibility of counter-cyclical mark-ups. Hence, under the extreme Chevalier-Scharfstein assumptions, the Rotemberg-Saloner setup is unable to rationalize counter-cyclical markups; instead, it may even generate pro-cyclical mark-ups if $\delta_H < \delta < \delta_L$, as shown in Figure 1(d).

We now come to the central contribution of the present Chapter. In the less extreme case of a positive survival probability for firms in low demand states ($0<\rho<1$), mark-ups may display counter- or pro-cyclicality according to the magnitudes of ρ (capturing the relevance of financial constraints) and K^m (the amplitude of fluctuations). The following proposition summarizes the main results:

Proposition 1. With $\rho \in (0,1)$, mark-ups are counter-cyclical whenever $\delta_L < \delta < \delta_H$ holds, and pro-cyclical if $\delta_H < \delta < \delta_L$.

The proof goes as follows. From (4) and (6), the direction of the inequality between δ_L and δ_H depends, for any given ρ, on the value of K^m. Denoting by K^* the (admissible) value of K^m which solves the equation $\delta_L = \delta_H$, it turns out that $K^* = \rho$. Then, if $K < K^*$, $\delta_L < \delta_H$: as in the Rotemberg-Saloner's original model, if $\delta_L < \delta < \delta_H$ collusion at monopoly prices is sustained only in low demand states, whereas in high demand states the price is $p_H{}^*$, lower than the corresponding monopoly level $p_H{}^m$, so that the following condition is satisfied:

$$\delta = \frac{2}{\dfrac{\Pi_L^m(p_L^m)}{\Pi_H^*(p_H^*)} + (2 + \rho)} \tag{7}$$

On the other hand, if $K > K^*$, $\delta_L > \delta_H$: thus, when $\delta_H < \delta < \delta_L$, collusion occurs only in high demand states ($p_H = p_H{}^m$), whereas in low demand states the price is $p_L{}^*$, lower than the corresponding monopoly level $p_L{}^m$, such that:

$$\delta = \frac{2\,\dfrac{\Pi_L^*(p_L^*)}{\Pi_H^m(p_H^m)}}{(1+2\rho)\dfrac{\Pi_L^*(p_L^*)}{\Pi_H^m(p_H^m)} + \rho} \tag{8}$$

Figure 1(b) and 1(c) illustrate examples with $\rho<1$, showing the ranges of δ implying counter and pro-cyclicality of mark-ups. (Recall also that, if $\delta>(\delta_L,\delta_H)$, firm always collude on monopoly prices $(p_L{}^m,p_H{}^m)$. On the contrary, when $\delta<(\delta_L,\delta_H)$, firms collude in neither state of demand.)

The relevant implication of Proposition 1 is that, in contrast with the argument put forward by Chevalier and Scharfstein (1996), the introduction of a "survival probability" in the Rotemberg-Saloner set-up does not destroy in general the possibility that mark-ups remain counter-cyclical. As the graphs show, the possibility of counter-cyclical markups is crucially related to the magnitude of the survival probability ρ, which measures the rate at which oligopolistic firms escape liquidation during recessions. One may also argue that, since oligopolistic firms are in general relatively big, their liquidation risk is rather small: in this perspective, the Rotemberg-Saloner explanation to markup counter-cyclicality may look more appealing than the liquidity-constraint explanation put forward by Chevalier and Scharfstein (1996).

Interestingly, "survival probabilities" may play a specific role also in the implicit-collusion model. Rather surprisingly, one can also show that, when counter-cyclical behaviour occurs, the degree of mark-up counter-cyclicality is even *magnified* with respect to the standard Rotemberg-Saloner case, holding for $\rho=1$. The following proposition holds:

Proposition 2. Consider the case with counter-cyclical mark-ups $(\delta_L<\delta<\delta_H)$. *It holds that: (i) The price set in low demand states is equal to* $p_L{}^m$ *(the monopoly price), independently of* ρ. *(ii) Denoting as* $p_H{}^*$ *the price set in a high demand state when* $\rho<1$, *and* $p_H{}^{*\prime}$ *as the price set when* $\rho=1$ *(the standard Rotemberg-Saloner case), it follows that* $p_H{}^*<p_H{}^{*\prime}$.

The proof of part (i) of Proposition 2 is rather immediate, since p_L^m maximises current profits in low demand states (recall that the current period profit function is independent of ρ). As for part (ii), the argument goes as follows. In a high demand state, expression (7) must hold: thus, the lower ρ, the higher the ratio Π_L^m/Π_H^*. As a consequence, given Π_L^m, a ρ smaller than one implies a lower Π_H^* and, hence, a p_H^* lower than $p_H^{*\prime}$ (the positive relation between p_H and Π_H is ensured by the fact that prices higher than the monopoly level, p_H^m, would always make undercutting profitable: see Tirole (1988, note 17, p.249)).

The rationale for this result can be found by recalling that, according to (3), uncertain survival decreases the potential future loss for the deviating firm, enhancing the incentive to deviate in high demand states. Therefore, prices must be relatively lower in equilibrium.

Proposition 2 has an empirically relevant implication. Since liquidation risks can offer a specific contribution to the extent of counter-cyclicality in markups *also* in the Rotemberg-Saloner model, it becomes quite difficult to sort out the implicit-collusion approach from the Chevalier-Scharfstein approach on the base of regressions that test for the mere significance of liquidity-constraint variables on pricing behaviour.

2. Conclusions.

In the present Chapter, we considered the basic ingredient leading to countercyclical markups in Chevalier and Scharfstein (1996) (which is, firms incur very high liquidation risks during recessions), and used it in Rotemberg-Saloner's "implicit collusion" framework. We found that the results obtained by Rotemberg-Saloner are quite robust to such a modification and, furthermore, liquidation risks may even strengthen the degree of counter-cyclicality in markups.

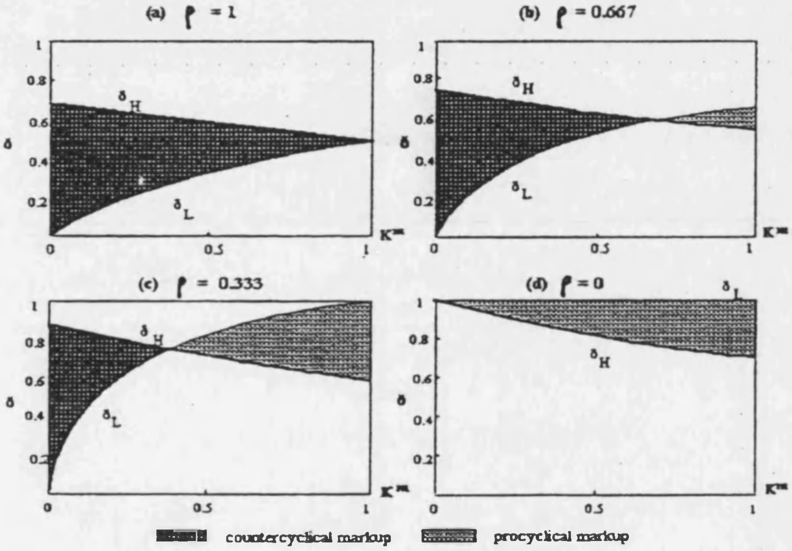

Figure 1: Combinations of δ and K^m yielding counter- and procyclical markups for different values of ρ.

Notes

1. A relevant assumption in the Rotemberg-Saloner setup is that output demand is driven by i.i.d. shocks. Extensions of this framework to serially correlated demand disturbances are provided by Haltiwanger and Harrington (1991) and Kandori (1991).

2. See Tirole (1988,p.248).

3. See Hart and Moore (1989).

4. The calculation of these probabilities is rather trivial. Suppose, for example, that at $t=0$, the demand-state is good. The firm will survive to period $t=1$ with prob.=1. Either a bad or a good state can occur at $t=1$, each with prob.=½: in the former case, the firm will survive to $t=2$ with prob.=ρ. In the latter case (good state at $t=1$), the firm will survive to $t=2$ with prob.=1, etc. Hence, the probability of "being around" at $t=2$, conditionally to a good state realised at $t=0$, is equal to $[(1+\rho)/2]$.

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DECLARATION

I hereby certify that the following chapter of the thesis

Technological and Financial Factors in Models of Wage Determination

by

Alberto Dalmazzo

describes conjoint work with the undersigned:

Chapter 5 *Foreign Debt, Sanctions and Investment: implications for LDC's.*

The contribution of Alberto Dalmazzo to the above chapter has been at least 50%.

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describes conjoint work with the undersigned:

Chapter 6: Capital market imperfections and countercyclical markups.

The contribution of Alberto Dalmazzo to the above chapter has been at least 50%.

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