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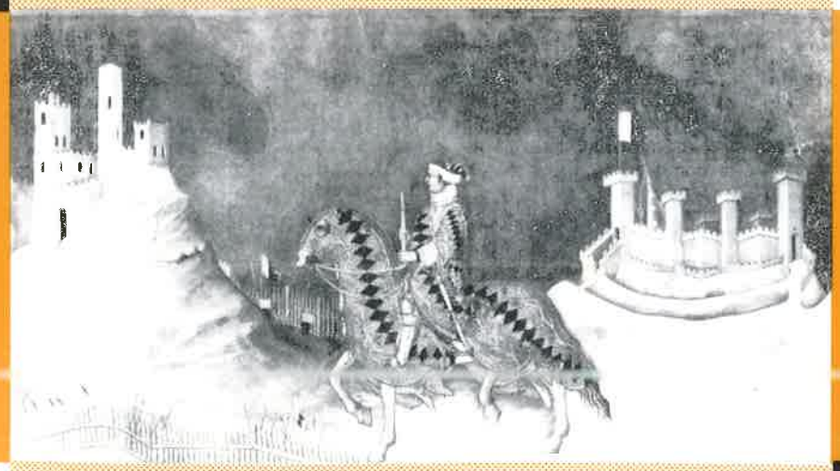
QUADERNI DEL DIPARTIMENTO
DI ECONOMIA POLITICA

ALBERTO DALMAZZO

STRATEGIC EXTERNAL FINANCING AND SOPHISTICATION OF THE PRODUCTION PROCESS



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Alberto Dalmazzo

STRATEGIC EXTERNAL FINANCING AND SOPHISTICATION OF THE PRODUCTION PROCESS

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Abstract. We analyse a model where an entrepreneur has to decide, when investing, the degree of sophistication of the production process. When a higher degree of sophistication is chosen, new tasks have to be performed by additional agents, who gain bargaining power over the surplus. Under such a distributive conflict, the chosen level of sophistication will generally be inefficiently low. We show that the entrepreneur's use of debt can reduce both under-investment and under-sophistication inefficiencies.
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1. Introduction.

The traditional view considered financial markets as merely ancillary to industry. However, some recent empirical literature has argued that the degree of a country's financial development is an important predictor of later growth, as measured by GDP, investment and productivity. In particular, cross-country differences in the rates of physical capital accumulation, as well as in the efficiency of the use of capital itself, seem to be positively linked to two main factors: first, the size of the financial sector and, second, its propensity to finance private entrepreneurship (see King and Levine (1993a,b,c)). In what follows, we consider such broad issues by analysing the role of external finance on the investment process and on the degree of sophistication of the production processes chosen. The reason why we give particular attention to the issue of product sophistication is that, as recalled by Kremer (1993) in the context of his workers' quality matching model, "rich" countries (which are also more financially developed) specialise in complicated production processes, while "poor" countries concentrate on primary productions.

We consider a model where an entrepreneur has access to a set of investment projects. Once the cost of capital is sunk, the agents taking part in production acquire bargaining power over returns, similarly to Grout (1984). When investing is convenient, the entrepreneur chooses the degree of sophistication of the production process. A more complex production generates higher revenues but requires a larger number of tasks to be carried out. Since these tasks are performed by additional agents who gain bargaining power over the surplus, greater sophistication entails a more acute distributive conflict. As a consequence, the processes selected in equilibrium can be inefficiently under-sophisticated.

A central result of the paper is that the extent of this inefficiency is reduced when the

entrepreneur can rely on external sources of finance. In fact, by imposing additional and credible claims on returns, "debt" modifies the agents' bargaining positions. The impact of the financial choices on distribution distinguishes our model from others addressing the relation between financial markets and capital accumulation (for some basic references, see Pagano (1993)).

Here, debt works through two different mechanisms. First, in equilibrium, its strategic use allows the entrepreneur to obtain higher profit for any given type of project. Second, debt stimulates the choice of more sophisticated projects by lessening the adverse distributive effect implied by sophistication. As we will see in detail, this latter mechanism still works in the context of non-competitive financial markets, where the positive effect of debt on the *level* of profits is generally destroyed.

The role of debt as a credible threat has been analysed in an oligopoly model by Brander and Lewis (1986) and, in a wage renegotiation model, by Perotti and Spier (1993). Following Dalmazzo (1992b), the present paper considers the working of debt by concentrating on what happens under bankruptcy. We will assume that, when the firm fails to repay its contractual obligations, lenders take the control of the project and bargain over the returns that can still be generated, whenever liquidation does not occur.

Section 2 presents the basic model and discusses the sources of inefficiency in the absence of capital markets. Section 3 introduces capital markets and Section 4 considers the presence of a competitive lending market and its implications over project selection. The case for multiple lenders is analysed in Section 5. A monopolistic capital market is analysed in Section 6: in order to reduce under-sophistication inefficiencies, we find that a monopolistic capital market may in some cases outperform a competitive market. Section 7 concludes. In

Appendix 2 we extend the model to the case when several agents can form a joint-venture of "peers".

2. The Basic Framework.

Consider an entrepreneur, say agent 1, who has access to a set of N investment projects. A project of type n, with $n=1,2,..,N$, has return $Y(n)>0$ ($Y(0)=0$) and costs $I(n)\geq 0$. Also, n indexes the degree of technological sophistication of the project undertaken, since a number of n different and *complementary* tasks must be performed in order to obtain $Y(n)$. Should even one of such tasks fail to be carried out, returns from the project would be zero. For simplicity, we assume that each task is performed by a single agent. We also assume that:

(*a.i*) Only agent 1 has access to projects which are more sophisticated than the *autarkic* one ($n=1$), giving $Y(1)-I(1)\equiv y>0$. Instead, the autarkic project can always be implemented by each agent in the economy.

(*a.ii*) (*Irreversibility*) Once the cost $I(n)$ has been sunk, the investment can only be used to produce $Y(n)$.

(*a.iii*) Once an agent has decided to take part in a project such that $n>1$, the opportunity of implementing the autarkic project is foregone.

(*a.iv*) When an agent participates in a project, he acquires special skills in production and can be replaced only at very high cost.

Assume that $Y(n)-I(n)$ is a positive and monotonically increasing function of n (see Figure 1). The choice of projects of higher technological sophistication will enhance social efficiency whenever the condition $Y(n)-I(n)\geq Y(n-1)-I(n-1)+y$ holds. As a consequence, provided that y is sufficiently small, the social optimum is reached for $n=N$.

This social optimality criterion hinges on assumption (*a.i*), i.e., only agent 1 can access 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 $Y(n)-I(n) < Y(n-2)-I(n-2)+Y(2)-I(2)$: in this case, the project n would be socially dominated.

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

The *timing* of the model is the following.

In the first stage, an entrepreneur decides whether to invest. If she invests, she also decides which degree of complexity, n, to adopt in the production process.

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

In the third stage, investment is implemented and the n agents start bargaining over returns. If an agreement is found, production is carried over.

We solve the model by backward induction.

2.1. The Sharing Rule.

Each task gives some monopoly power to the agents performing it, both because each of the n tasks is indispensable in the production of $Y(n)$ and because agents' replacement is very costly (assumption *a.iv*). Since each task is performed by a single agent[1], we have a one-to-one correspondence between bargaining units, equal to the number of the complementary tasks, and agents themselves.

It can be shown under certain conditions[2] that, when n agents alternate in making

proposals over a pie of value R, agent i's perfect equilibrium payoff is ($i=1,2,..,n$):

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

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. If the outside option available to each agent is negligible after entering the project[3], the payoff of agent i ($i=1,2,..,n$) reduces to:

$$S^i = \frac{Y(n)}{n} \qquad (2)$$

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 must be self-funded by the entrepreneur.

2.2. The Grout-Inefficiency with No Capital Markets.

The inefficiency due to under-investment closely follows the logic of Grout (1984). Consider a project of a *given* degree of sophistication, n. When agent 1, 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), agent 1 invests if and only if

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

$$or, \quad Y(n) \geq ny + nI(n)$$

while *social optimality* requires that

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

As a consequence, the extent of inefficiency amounts to[4] $(n-1)I(n) \geq 0$. 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 rents generated by the project.

2.3. The Under-Sophistication Inefficiency with No Capital Markets.

A second major source of inefficiency comes about when the choice of n is considered. In the absence of capital markets, the entrepreneur's problem is:

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

We assume that the maximand can be represented as a continuous *concave* function[5] over [2,N]. Figure 2 illustrates the three possible cases for $M^1(n)$. In what follows, we consider "small" values of y, so that choosing $n=2$ always dominates "autarky" ($n=1$).

When choosing the degree of sophistication, the entrepreneur selects n, instead of $(n-1)$, if:

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

Such a level of sophistication is also an interior maximum (i.e., $n<N$), if the following condition holds:

$$\frac{1}{n+1}Y(n+1) - I(n+1) < \frac{1}{n}Y(n) - I(n), \quad with\ n+1 \leq N$$
$$i.e., \quad Y(n) > \frac{n}{n+1}Y(n+1) - n(I(n+1) - I(n)) \tag{7}$$

Notice that the higher the level of autarkic surplus an agent can generate, the lower the sophistication level likely to be chosen in equilibrium. In other words, an higher y makes condition (6) more difficult to meet, as it is apparent when $Y(n)$ is re-defined as $y+v(n)$, $v(1)=0$.

By the point of view of efficiency, *social optimality* requires that the entrepreneur choose n whenever[6]:

$$Y(n) - I(n) \geq (Y(n-1) - I(n-1)) + y, \quad (n \geq 2)$$
$$i.e., \quad Y(n) \geq Y(n-1) + (I(n) - I(n-1)) + y \tag{8}$$

Using (6) and (8), the extent of the under-sophistication inefficiency turns out to be equal to[7]

$$\xi_0 = \frac{Y(n-1)}{n-1} - y + n[I(n) - I(n-1)], \qquad n \geq 2 \tag{9}$$

Abstract, for the moment, from the project's cost by setting $I(n)=I(n-1)=I(1)=0$ (In this case, condition (6) coincides with the social optimality condition (8) when $n=2$, since $y=Y(1)$). For any $n>2$, the inefficiency measure, ξ_0, is a positive quantity: in fact, when $y > Y(n-1)/(n-1)$ holds, no agent will *ex-ante* participate in a $(n-1)$-type project giving less than

the autarky payoff. Hence, when a more sophisticated project is preferred by the entrepreneur, it will also be socially preferred. However, $\xi_0>0$ implies that certain sophisticated projects, which are also socially desirable, will *not* be implemented. The reason is that the positive effect that higher sophistication has on returns can be outweighed by the negative effect due to the necessity of additional agents in production, who acquire bargaining power over the *whole* return *Y(n)*. In other words, whenever the adverse distributional effect prevails, under-sophistication occurs[8].

When increasing investment costs are considered in (9), the degree of efficient sophistication tends to be even more distant from the degree of sophistication actually chosen in equilibrium. In fact, the additional cost born by the entrepreneur for a more sophisticated project, $\Delta I(n)>0$, produces a Grout effect in project cost's "increments".

3. The Presence of Capital Markets.

In our bargaining perspective, financial instruments like debt may condition rents' distribution. Similarly to Dalmazzo (1992b), we consider how debt can be strategically used, so to condition the distribution process. As will be shown, the re-distributive role of debt has relevant implications for the set of projects that an entrepreneur is willing to implement.

Consider a firm which issued debt. As in Hart and Moore (1994), we assume that failure to repay debt 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 same reason, gains the ability to bargain over the rents the firm can still produce[9].

We first characterise the *debt capacity* of a firm, which is, the maximum amount of repayments that a debt contract can require without triggering *voluntary* default[10]. Let D

define the level of debt repayments due back to the lender. When a technology with n agents has been implemented, the bargaining process is as follows.

If debt is repaid, each of the n agents gets $(Y(n)-D)/n$, i.e., the n^{th} fraction of *net* returns. However, each of the n agents can halt production and prevent the repayment of D, so to force the firm into bankruptcy. In bankruptcy, the lender takes over and enters a bargaining process over $Y(n)$ with the n agents: then, in equilibrium, each party will receive $Y(n)/(n+1)$.

The maximum level of D consistent with non-repudiation solves the inequality $(Y(n)-D)/n \geq Y(n)/(n+1)$, and defines the project's debt capacity, D', as:

$$D' = \frac{Y(n)}{n+1} \tag{10}$$

Notice that D' is defined independently of the capital market's competitive regime. Independently of the way in which the interest rate on loans is determined, D' represent the maximum amount of repayments that a lender can credibly obtain back.

4. Competitive Capital Markets.

We consider a competitive capital market in which, also, the net interest rate is zero ($r_0=0$). As shown, when the level of debt repayments is such that $D \leq D'$, the payoff of *each* agent in the bargaining game over $Y(n)-D$ is equal to $(Y(n)-D)/n$. Then, the payoffs of agent 1 (the entrepreneur) and of each agent i, $i \neq 1$, are respectively

$$M^1(D;n) = Y(n) - (n-1)\frac{Y(n)-D}{n} - (1+r_0)I(n) = \frac{Y(n)}{n} + \frac{n-1}{n}D - I(n) \tag{11}$$

and

$$M^i(D;n) = \frac{Y(n) - D}{n}, \quad i = 2,3,..,n \tag{12}$$

Since expression (11) is monotonically increasing in D, agent 1 sets D to its maximum available level[11], D'. When $D=D'$, *each* of the n agents in the game is made indifferent between debt repayment and default (since bankruptcy does not bring any benefit, we assume that debt is repaid). The payoffs of agent 1 and agents i's when $D=D'$ become, respectively:

$$M^1(D';n) = \frac{2Y(n)}{n+1} - I(n) > M^1(0;n) \tag{13}$$

and

$$M^i(D';n) = \frac{Y(n)}{n+1}, \quad i = 2,3,...,n \tag{14}$$

The reason why the entrepreneur prefers debt to self-financing is the following. Debt creates an *additional* and credible claim on returns keeping intact, at the same time, the entrepreneur's bargaining power (she can never be replaced in production). Since debt is sold to competitive lenders, the entrepreneur can thus pocket money today against a future repayment, which will have to be borne by *all* the n participants in the production process.

4.1. Participation Constraints and Grout-Inefficiency with Competitive Capital Markets.

As a consequence of assumption (*a.iii*), by taking the decision of participating in a project such that $n>1$, an agent foregoes the possibility of implementing the autarkic project, which would have given y. Hence, by choosing debt optimally, the entrepreneur is willing to implement a given n-type project whenever:

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

Since the financial choice of agent 1 is correctly anticipated, the remaining $(n-1)$ agents are willing to participate in the project when

$$\frac{Y(n)}{n+1} \geq y \tag{16}$$

The violation of either participation constraints (15)-(16) implies that the project will not be undertaken[12].

For what it concerns under-investment induced by the Grout effects (see Sect.2.2), we can conclude that, by raising the level of entrepreneur's profit:

Result 1. *The strategic use of debt increases the set of efficient projects that the entrepreneur is willing to implement.*

Condition (15) is less stringent than condition (3), which holds in the absence of external financing. This result is consistent with the empirical observations in King and Levine (1993a,c). Both the presence of developed financial markets and their high propensity to finance private entrepreneurship favour physical capital accumulation.

As (16) is violated, however, the possibility to manipulate the project's leverage generates *debt-induced inefficiencies* (if ex-ante payment cannot be made to agents 2,3,..,n). As a consequence, in some circumstances debt helps the entrepreneur to invest but, in others, it may halt the project by discouraging some agents from participating[13].

4.2. Under-Sophistication with Competitive Capital Markets.

Assume that the participation constraints (15)-(16) hold for any feasible project. Since the maximum available level of debt is chosen in equilibrium, the entrepreneur selects the level of n solving the following:

$$\max_{\{n\}} \; M^1(D'(n),n) \;=\; \max_{\{n\}} \frac{2}{n+1}Y(n) - I(n) \qquad (17)$$

As for (5), we assume that also the maximand in (17) is concave over [2,N].

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

$$\frac{2Y(n)}{n+1} - I(n) \geq \frac{2Y(n-1)}{n} - I(n-1) \qquad (18)$$

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

A n satisfying (18) is an interior maximum in {2,N} if the following holds:

$$\frac{2}{n+1}Y(n) - I(n) > \frac{2}{n+2}Y(n+1) - I(n+1), \qquad (19)$$

$$i.e., \quad Y(n) > \frac{n+1}{n+2}Y(n+1) - \frac{n+1}{2}(I(n+1) - I(n))$$

where $n+1 \leq N$.

Compare condition (18) to (6), calculated for D=0. Notice first that the coefficient associated to the term $[I(n)-I(n-1)] \equiv \Delta I(n)$ is now relatively smaller. Hence, debt financing lessens the impact of increasing investment costs due to more sophisticated technologies. Strategic debt thus diminishes the Grout effect also in its "incremental" version (see Sect.2.3), by spreading the additional investment costs also on the other agents.

However, even when abstracting away from investment costs, condition (18) is more easily met than (6), since $(n+1)/n > n/(n-1)$. The greater incentive to sophistication does not derive from debt's ability to transfer rents among the parties (as it happens, instead, with the Grout-inefficiency, both in "levels" and in "increments"). Here, debt works by introducing, implicitly, an additional player in the bargaining game: the lender. By diluting the share of $Y(n)$ that any agent can appropriate, debt also reduces the negative distributive effect generated by the participation of new agents. So, while debt leaves the gains from a more complicated technology (i.e., $\Delta Y(n) \equiv Y(n)-Y(n-1)$) unaffected, it diminishes the distributive cost of sophistication[14].

Analogous conclusions are reached when the maximands are treated as continuous functions of n. Writing the first order condition of problem (5) as $dM^1(0,n)/dn=0$, the corresponding condition for problem (17) is $dM^1(D'(n),n)/dn = dM^1(0,n)/dn + \phi(n) = 0$. Since $\phi(n)$ is a positive quantity and $dM^1(D'(n),n)/dn$ is decreasing in n, the sophistication level solving (17) is larger than (or equal to, due to integer constraints) the one solving (5). In other terms, as illustrated by Figure 3, debt both raises the maximand level and shifts its peak rightward[15].

Example. Consider the following specification: $Y(n)=n-(1-\alpha)$ and $I(n)=\alpha n$, with $\alpha < 1$ (notice that $y=0$, in this case). Problem (5) specialises in the maximisation of $[n-(1-\alpha)]/n-\alpha n$, yielding $n_{D=0}=((1-\alpha)/\alpha)^{1/2}$. The maximand of (17) becomes $2[n-(1-\alpha)]/(n+1)-\alpha n$, giving $n_{D=D'}=((4-2\alpha)/\alpha)^{1/2}-1 > n_{D=0}$. In particular, for $\alpha=0.2$, $n_{D=0}=2$ and $n_{D=D'}=3.24$.

These results can be summarised as follows:

Result 2. *The conditions for implementing a project of a higher degree of sophistication are less restrictive under debt financing (D=D') than under self-financing (D=0).*

Our conclusion matches the observation, reported in Kremer (1993,p.563), that "rich" countries, which also have the more developed and private-sector oriented financial systems, tend to be specialised in complicated products[16]. Thus, the presence of well-functioning capital markets can drive an economy to more sophisticated productions and, if n is correlated with size, to larger firms.

From the perspective of *efficiency*, by stimulating the adoption of more sophisticated technologies, we have that:

Result 2.1. *The strategic use of leverage permits the implementation of a larger set of socially desirable projects.*

The measure of inefficiency is now:

$$\xi_{D'} = \frac{Y(n-1)}{n} - y + \frac{n-1}{2}[I(n)-I(n-1)] \qquad (20)$$

which is a quantity smaller than (9)[17].

Another implication is related to productivity:

Result 2.2. *By incentivating the implementation of more sophisticated projects, debt increases the agents' average per-capita productivity.*

When debt allows for the implementation of a n-task project, the agents' average per-

capita productivity is $Y(n)/n$. On the other hand, if a $(n-1)$-task project had been realised, the average productivity of the n agents considered would have been only[18] $[Y(n-1)+y]/n$. The finding that an active financial system favours higher productivity is consistent with the empirical results reported by King and Levine (1993a,c).

Notice also that inequality on the lower end of *income distribution* is reduced. By stimulating the inclusion of additional agents in the project, debt allows potentially "low income" individuals (i.e., agents who would have otherwise got y) to share the rents of a sophisticated project.

In Appendix 1, we deal with the surrender of the firm's control as an alternative financial strategy to the use of debt. Appendix 2 gives some preliminary results on "partnerships", where also other agents share the investment cost.

5. Multiple Lenders.

In the section above we concentrated on the case when the entrepreneur borrows from a *single* lender. Assume now that the project's physical capital can be subdivided into $L>1$ *complementary* parts[19] (which can be replaced only at high cost). When there are multilateral lending relations, thus, each lender can be given a first claim on one of the L mortgaged portions and gain bargaining power in the event of bankruptcy. Hence, default will entail a $(n+L)$-party bargaining game over $Y(n)$, in which each agent obtains $Y(n)/(n+L)$. Thus, the maximum amount that *each* lender is willing to concede is equal to $D_\lambda^*=Y(n)/(n+L)$ (with $\lambda=1,2,..,L$) and the firm's debt capacity is equal to LD_λ^*. Given L, the expected profit of the entrepreneur is equal to $Y(n)-(n-1)[(Y(n)-\Sigma_\lambda D_\lambda)/n]-I(n)$. The entrepreneur, when maximising profit with respect to D_λ ($\lambda=1,2,..,L$) will choose D_λ^* and

obtain:

$$M^1(D_\lambda^*;n) = Y(n)\left[\frac{1+L}{n+L}\right] - I(n) \tag{21}$$

Profit is increasing in L. This might give a rationale as why many firms (especially large ones) have multiple lending relations. In particular:

$$\lim_{L\to\infty} M^1(D_\lambda^*;n) = Y(n) - I(n) \tag{22}$$

If the number of the lending relations were very large, the entrepreneur would cash the *whole* surplus from the project.

Consider now the effect of $L>1$ on project sophistication, when (21) is maximised with respect to n. The analog of condition (18), which was calculated for $L=1$, is here[20]:

$$Y(n) \geq \frac{n+L}{(n-1)+L}Y(n-1) + \frac{n+L}{1+L}[I(n)-I(n-1)] \tag{23}$$

Hence:

Result 3. *The larger L, the higher the degree of sophistication of the projects chosen.*

This result is consistent with the observation that large corporations exhibit multiple credit relationships.

Notice that, for $L\to\infty$, the right-hand-side of (23) goes to $Y(n-1)-\Delta I(n)$: in this case, condition (23) is *less* restrictive than condition (8) and high levels of sophistication tend to be chosen. However, a large L also implies that agents other than the entrepreneur would receive a very low payoff, $Y(n)/(n+L)$, even when a strictly positive autarkic payoff, y, was ex-ante available. In other words, when debt is "too effective" in redistributing surplus to the entrepreneur, the incentives to participate are likely to be destroyed, so that the project can

not implemented. There are, however, several reasons to restrain our analysis to the case in which L is a relatively small number[21].

6. Monopolistic Capital Market.

In this section we analyse the working of debt when the (unique) lender is a *monopolistic price setter*. The analysis of such extreme case is aimed at testing whether the debt effects found in the previous sections entirely depend on the assumption of competitive lenders.

The entrepreneur first decides whether to invest and, subsequently, chooses the degree of complexity, n, of the project. She then decides whether to borrow or not (provided that she is not wealth-constrained) from the monopolistic lender. Finally investment is implemented and, after reaching an agreement over the division of returns, production occurs.

Whatever the amount lent, a monopolistic lender is able to set unilaterally 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, i.e., which is the maximum interest rate, $r_m \equiv (D_m-I(n))/I(n)$, he can set when lending $I(n)$. From the discussion in Sect.3 we already assessed that, once the debt contract is written, the entrepreneur has the option of repudiating, so to trigger bankruptcy and obtain $Y(n)/(n+1)$. On the other hand, if debt is paid back, each of the n agents receives $(Y(n)-D_m)/n$. Once again, then, the maximum level of debt repayments that the lender can credibly impose is equal to $Y(n)/(n+1)$. The monopolistic lender can only appropriate a part of the surplus from the project.

When the lender finances the whole cost of the investment[22], $I(n)$, against a future repayment optimally set to $D_m=Y(n)/(n+1)$, the entrepreneur receives:

$$M(D_m;n) = Y(n) - (n-1)\frac{Y(n)-D_m}{n} - (1+r_m)I(n) = \frac{Y(n)}{n+1} \qquad (24)$$

where $r_m \equiv \{[Y(n)/(n+1)]-I(n)\}/I(n)$.

An 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 $D_m < nI(n)$, i.e., $I(n) > Y(n)/(n(n+1))$. Even if at the cost of high interest rates, debt still helps spreading the investment cost, $I(n)$, over *all* the participants in the project. Hence:

Result 4. *If the project cost is sufficiently high, investment can be more profitable under a monopolistic lending regime than under self-financing.*

In some cases, then, even non-competitive financial markets can improve the entrepreneur's profit level.

6.1. Participation Conditions.

The discussion on the level of r_m purposely over-looked the issue of agents' participation. However, under monopolistic lending, each of the agents (including agent 1) participates in a project if and only if $(Y(n)-D_m)/n \geq y$, which is, $D_m \leq Y(n)-ny$. It must then hold that $max(D_m) = min\{Y(n)/(n+1), Y(n)-ny\}$. In other words, the monopolistic lender can always set the level of debt repayments so to respect the participation constraint[23]. For this reason, the interest-rate setting decision is such that *a monopolistic credit market always avoids "participation inefficiencies"*.

In what follows, however, we will exclusively concentrate on the case in which $max(D_m) = Y(n)/(n+1)$, holding when $Y(n) > (n+1)y$.

6.2. The Entrepreneur's Optimal Choice of n.

When credit market regime is monopolistic and the entrepreneur borrows, n will be chosen in order to maximise (24). In this case, a n-type project will be preferred to a project of type $(n-1)$ whenever:

$$\frac{Y(n)}{n+1} \geq \frac{Y(n-1)}{n}, \quad i.e., \quad Y(n) \geq \frac{n+1}{n}Y(n-1) \qquad (25)$$

Such a n is an interior solution whether, for $n+1 \leq N$, it holds that:

$$Y(n) > \frac{n+1}{n+2}Y(n+1) \qquad (26)$$

Hence, the following holds[24]:

Result 5. *When an entrepreneur borrows from a monopolistic lenders, the condition for implementing a more sophisticated project is:*

(i) always less restrictive than the corresponding condition under self-financing (condition (6)), and

(ii) less restrictive than the corresponding condition (18), holding for competitive capital markets, whenever $I(n)-I(n-1) > 0$.

Because of (i), a capital market maintains the property of promoting sophisticated production processes even when it is monopolistic. Further, and more surprisingly, a monopolistic capital market provides stronger incentives to sophistication than a competitive market[25]. The reason is that monopolistic lending "eliminates" the term in $I(n)-I(n-1)$, since the incremental cost of investment is spread over all the participants in the project[26].

It must be emphasised, however, that the conclusion that monopolistic lending favours sophistication in production may fail to hold. This occurs when $I(n)$ is sufficiently small (i.e., when $D_m \geq nI(n)$ is verified) and the entrepreneur is not wealth-constrained. In this case, self-financing will be preferred, since it yields a *level* of profit higher than that obtained by borrowing. As a consequence, "under-sophistication traps" can arise again (see Sect.2).

8. Conclusions.

Consistently with empirically observed facts, the model we presented supports the view that financial markets can have great relevance to promote capital accumulation and the adoption of sophisticated production processes.

In our model, the use of external funds effectively modifies the distribution of surplus between an entrepreneur and the agents participating in production. In particular, debt enables the entrepreneur to cash money today against a (credible) promise of future repayments, which will be shared among *all* the participants. This mechanism, operating through the profit level, incentivates investment by spreading its cost on agents other than the entrepreneur. However, as we emphasised in the case of monopolistic credit markets, the relation between debt and sophistication does not work (only) through redistributions of surplus. Debt, in fact, encourages the implementation of more sophisticated projects by lessening the adverse distributional effect attached to a larger number of tasks in production.

The framework we presented has a bias towards external finance, especially when financial markets are competitive. However, issues such as project's monitoring, management's incentives, etc. (considered, for example, by Gertner, Scharfstein and Stein (1994)), might complement our analysis and provide some rationale for the advantages related to the use of internal finance.

With regard to policy implications, the present paper supports the view that skilled and wealthy entrepreneurs alone may not be sufficient to start a process of economic development, if scarce attention is paid, first, to the development of the financial system and, second, to its propensity to private sector financing. This observation is, of course, particularly relevant for the transition process of the Eastern European countries.

Appendix 1. ***Control Surrender as an Alternative to Debt Financing.***

Borrowing may not be the only financial strategy able to guarantee agent 1 a larger share of surplus. Assume first that the capital market is competitive and consider the case when agent 1 surrenders directly the firm's ownership to a $(n+1)^{th}$ party through an equity issue. When corporate debt is zero and the project's control is surrendered, ownership is transferred to an additional agent, as it would happen with debt *when bankruptcy occurs*: in this way, the majority shareholder gains bargaining power, since he can deny the use of capital to the other n parties, and obtains $Y(n)/(n+1)$ in equilibrium. As a consequence, when agent 1 invests and surrenders control to an external agent, she gets $Y(n)/(n+1)-I(n)$ *plus* $P=Y(n)/(n+1)$, where P is the maximum price a buyer is ever willing to pay to gain control. Hence:

Result 6. *In a competitive financial market, with perfect substitutability between debt and equity issues, agent 1 obtains the same level of profits either by surrendering control over the firm (with $D=0$), or by borrowing up to full debt capacity ($D=D'$)*[27].

The analysis is immediately generalised to the case for $D\geq 0$ (this case is relevant, since the majority shareholder himself might try to manipulate the firm's capital structure for his own benefit). However, *once control has been surrendered to an agent who has no specific role in the production of Y(n), debt becomes neutral with respect to the distribution of rents.*

With $D\geq 0$, it can be easily proved that the majority shareholder gets $Y(n)/(n+1)-D$ in equilibrium: debt is entirely borne on the shareholder's share. In fact, the occurrence of bankruptcy would simply replace the current ownership (the shareholder) with a new one (the incumbent lender) who, as the former, derives its bargaining power *uniquely* from the control

of physical capital[28]. The market price of a firm with a positive level of debt becomes $P=Y(n)/(n+1)-D$, which is equal to zero for $D=D'$. Then:

Result 7. *Using both debt and control surrender, agent 1 can do no better than using either pure debt or pure equity issues*[29].

Appendix 2. ***Joint-Ventures vs. Integration.***

In the previous sections we analysed the case of a project which is implemented by *just one agent*, the entrepreneur. The entrepreneur bears the investment cost and has full control over the financing decisions: we will define such a case as "integration". The object of the present section is to analyse the possibility of "partnerships", or *joint-ventures*: in this case, when a given n-type project is realised, other agents than agent 1 contribute to its total cost $I(n)$ and acquire the right to make financing choices[30]. We assume that the investment cost $I(n)$ is equally shared among the θ partners.

Both agent 1 and those agents who entered the partnership have command over production for two reasons. Like the rest of the n agents, they have special skills. Secondly, each of them controls a fraction of physical capital.

In what follows, we try to endogenously explain the formation of a partnership of size $\theta\in[1,n]$, and analyse its implications for the sophistication choice of the project.

Consider the following sequence of events. At stage 1, the size of the partnership, θ, is determined. At stage 2, the partners decide the optimal degree of complexity, n, as a function of $\theta\leq n$. Then, at stage 3, the financing decisions are taken and investment is implemented. At stage 4, production takes place and $Y(n)$ is shared among the n agents participating in the project.

We solve by backward induction starting from the sharing of $Y(n)$. Define D^j as the level of debt chosen at stage 3 by an agent j belonging to the partnership Θ. By postulating *symmetry* among the θ members of the partnership, each of them receives a payoff equal to:

$$S^j = Y(n) - (\theta-1)S^{j'} - (n-\theta)\frac{Y(n) - \sum_{h=1}^{\theta} D^h}{n}, \quad (j,j')=1,2,..,\theta, \quad j \neq j' \tag{27}$$

since we set $S^j = S^{j'}$ and $D^j = D^{j'}$. Hence:

$$S^j = \frac{Y(n)}{n} + (n-\theta)\frac{D^j}{n} \tag{28}$$

At stage 3, each agent j ($j \in \Theta$) chooses D^j so to maximise expression (28). Since (28) is monotonically increasing in D^j, agent j will choose the maximum amount of debt that lenders are willing to concede, which is[31]:

$$D^{j*} = \frac{Y(n)}{n+\theta} \tag{29}$$

Calculating (28) for $D^j = D^{j*}$ yields:

$$S^j(D^{j*}) = \frac{2Y(n)}{n+\theta}, \quad j=1,2,..,\theta \tag{30}$$

At stage 2, given θ, n is chosen so to maximise j's profits:

$$M^j(n) = \frac{2Y(n)}{n+\theta} - \frac{I(n)}{\theta}, \quad j \in \Theta \tag{31}$$

When $\theta \geq 1$, the condition for selecting a project of complexity n, instead of a project of complexity $(n\text{-}1)$, is that:

$$\frac{2Y(n)}{n+\theta} - \frac{I(n)}{\theta} \geq \frac{2Y(n-1)}{n+\theta-1} - \frac{I(n-1)}{\theta} \tag{32}$$

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

Noticing that, for $\theta > 1$, condition (32) is less restrictive than the corresponding condition (18), we can state that:

Result 8. *The larger the partnership's size θ, the higher the incentive to implement complex projects.*

Since the possibility of partnerships favours more complex projects, fiscal benefits to joint-ventures (or legal bans to vertical integration, such as anti-trust policies) can artificially promote sophistication.

Let us now determine under which conditions a partnership of size $\theta > 1$ will be formed (Stage 1). An agent z who does not belong to the partnership ($z \notin \Theta$) will be willing to join it whenever the following inequality is satisfied (*join-condition*):

$$\frac{2Y(n)}{n+\theta} - \frac{I(n)}{\theta} > \frac{Y(n)}{n+\theta-1}, \quad or$$

$$\frac{Y(n)}{I(n)} > \frac{(n+\theta)(n+\theta-1)}{\theta(n+\theta-2)} \equiv A, \quad \theta \in [2,n] \tag{33}$$

where $n = n(\theta)$.

Each agent j belonging to a partnership of size $\theta \geq 1$ will allow z to join whenever the following holds (*let in-condition*):

$$\frac{2Y(n)}{n+\theta} - \frac{I(n)}{\theta} > \frac{2Y(n)}{n+\theta-1} - \frac{I(n)}{\theta-1}, \quad or \tag{34}$$

$$\frac{Y(n)}{I(n)} < \frac{(n+\theta-1)(n+\theta)}{2\theta(\theta-1)} \equiv B, \qquad \theta \in [2,n]$$

Since for $\theta=n$ it holds that A=B, the maximum size a partnership can possibly reach is $(n-1)$. In fact, when $\theta<n$ is true, it is also true that A<B.

It holds that[32]:

Result 9. *(i) If $Y(n)/I(n) \leq A$ or $Y(n)/I(n) \geq B$, then either no other agents want to join agent 1 in the partnership, or agent 1 will not allow others' participation: in both cases, $\theta=1$. (ii) Otherwise, θ will be the maximum integer in $\{1,2,..,n-1\}$ such that $Y(n)/I(n) \in (A,B)$.*

With regard to point (i), when the profitability of the project is sufficiently low ($Y(n)/I(n)<$A), the join-condition (33) is not respected: the project cost, $I(n)$, is too high to induce other agents to share it. Integration is forced on the entrepreneur. On the contrary, when the profitability of the project is relatively high ($Y(n)/I(n)>$B), the let in-condition (34) is not met: by excluding partners who would have liked to join, the entrepreneur preserves the whole redistributive power related to debt's control. In conclusion, only projects which have "median" profitability can be associated with joint-ventures ($\theta>1$). In this case, the existing partners allow another agent to access the benefits of debt, in order to spread the incidence of the investment cost more widely.

Coming finally to the issue of *participation*, partnerships can also be a device to

induce an agent to enter a project by eliminating, for instance, debt-induced distortions (see Sect.4.1). When debt is used, all the agents excluded by the partnership get a payoff equal to $Y(n)/(n+\theta)$. In order to induce participation when $Y(n)/(n+\theta)<y$, it is sufficient to offer a partnership to *all* the agents, so that each of them can obtain[33] $(Y(n)-I(n))/n$. In other words, a partnership of full size ($\theta=n$) is an effective commitment to void debt of its redistributive properties.

The participation question becomes more problematic when, by bearing the whole cost of investment, agent 1 would obtain a payoff, $2Y(n)/(n+1)-I(n)$, which is smaller than y. In that case, the project is implemented if also other agents contribute to its cost[34]. However, *(inefficient) non-implementation can be a Nash Equilibrium*[35].

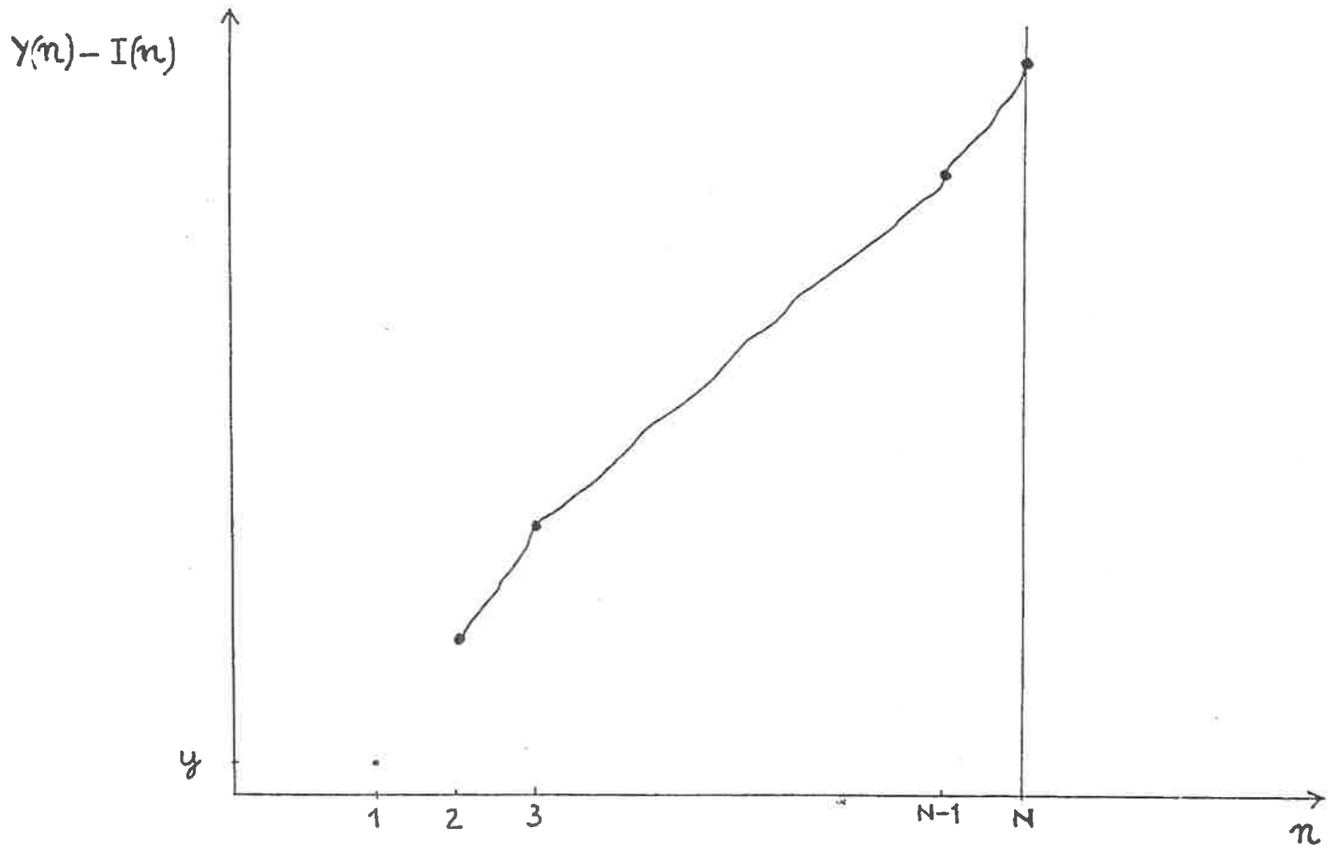

Figure 1

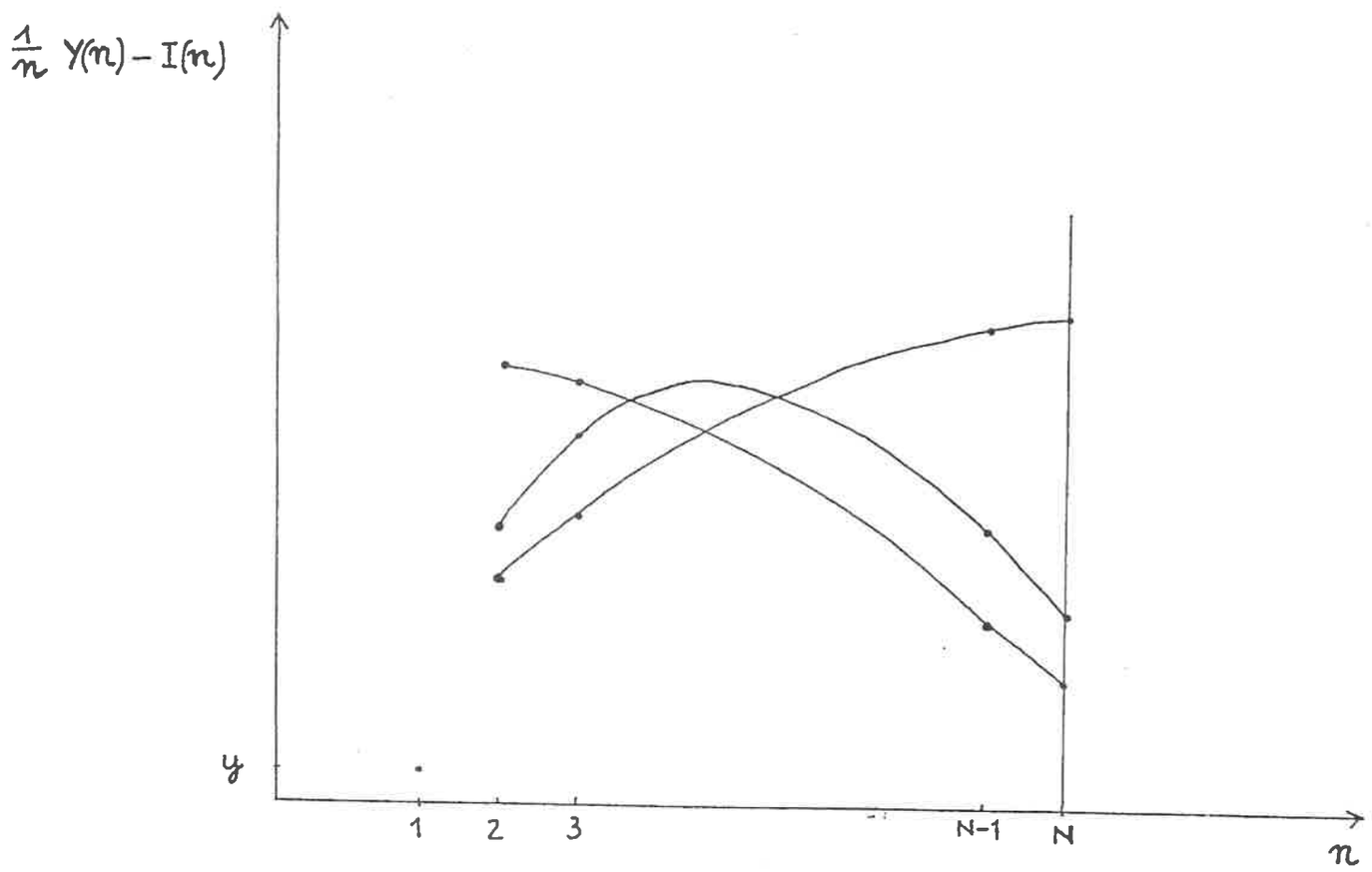

Figure 2

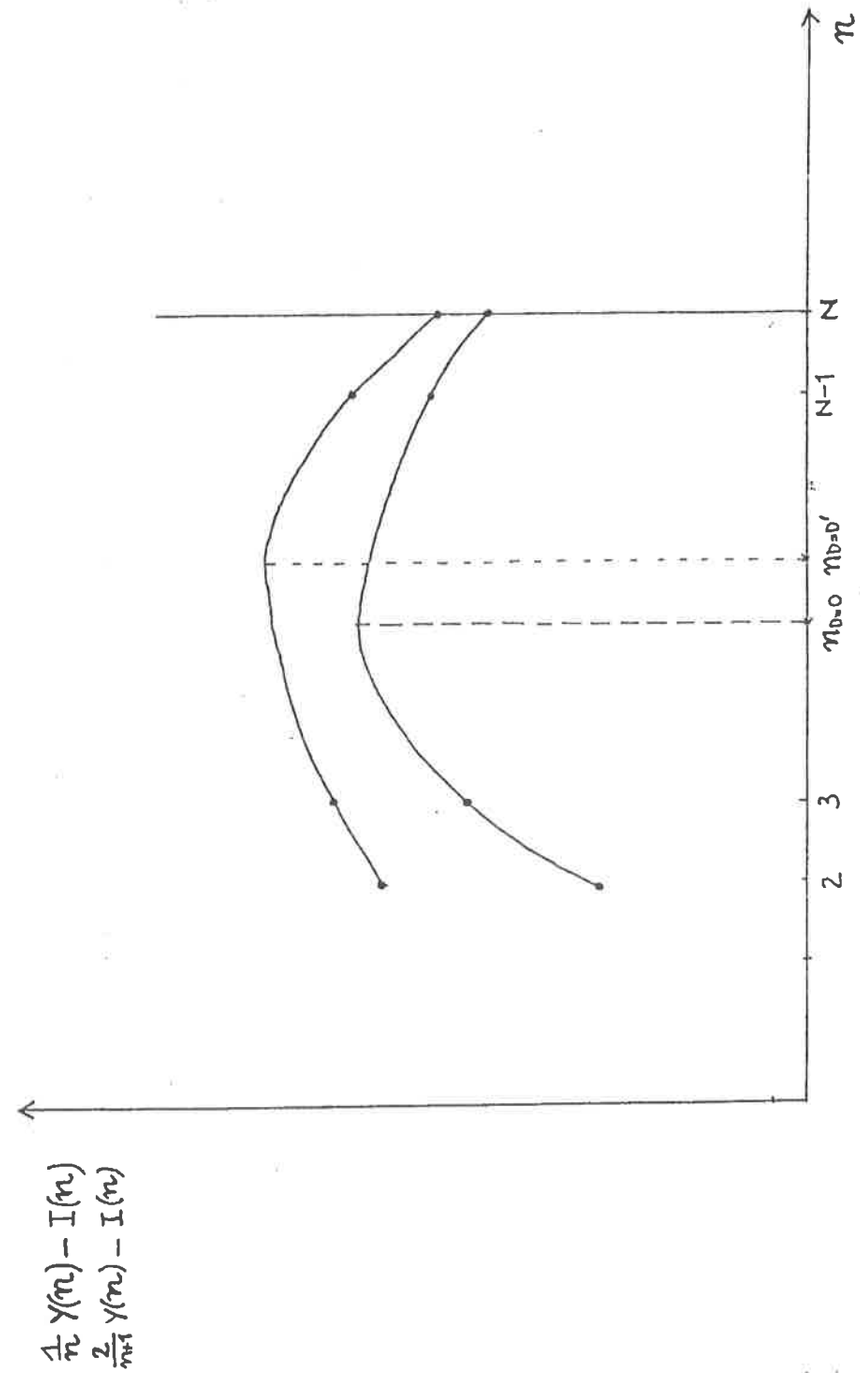

Figure 3

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Notes

1. A natural objection to our assumptions on the distribution process might be that the entrepreneur has an incentive to hire two workers for the *same* task, train them, and "play one against the other" in the bargaining process, so to make their salary equal to their outside wage. This is, indeed, the approach Stole and Zwiebel (1993) follow in their "pairwise bargaining" model. However, in the light of Horn and Wolinsky (1988), Stole and Zwiebel's treatment has an important limit: when workers are substitutable in the task they perform, they have a strong incentive to form a "coalition" (e.g., a union), so to constitute a single bargaining unit: in this way, they avoid to compete with each other during negotiations.

2. See Dalmazzo (1992a).

3. Our assumptions ensure that, once the investment cost is sunk, any project of type m ($m \neq n$) which ex-ante was alternative to the current one cannot be undertaken anymore: as a consequence, ex-post, we cannot consider, e.g., $y=Y(1)-I(1)$ as a credible alternative to an agreement over $Y(n)$.

4. Inefficiency is calculated as $[Y(n)-ny-I(n)]-[Y(n)-ny-nI(n)]$.

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

6. Recall that, whenever $Y(n)-I(n)-ny$ is monotonically increasing in n, social optimality requires that the maximum available degree of sophistication be chosen, which is, $n=N$.

7. This measure is obtained from the following difference: $\{[Y(n)-Y(n-1)-y]-[I(n)-I(n-1)]\}-\{[Y(n)-nY(n-1)/(n-1)]-n[I(n)-I(n-1)]\}$.

8. 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 derived from Rubinstein (1982).

9. This is the case if the firm is not liquidated. In what follows, we simply take the liquidation value of the firm to be zero, i.e., physical capital does not have any value outside the firm. For an analysis with positive liquidation values, see Dalmazzo (1992b).

10. Notice that, in this non-stochastic context, involuntary default cannot take place.

11. When $D'>I(n)$, being the investment cost not greater than debt capacity, the entrepreneur borrows more than what actually needed for implementing the project. On the other hand, when $D'<I(n)$ (borrowing cannot cover the whole investment cost), investment implementation needs the contribution of the entrepreneur's own wealth: in this case, as in Hart and Moore (1994), under-investment can arise also because of wealth constraints.

12. Notice that the violation of condition (16) is due to agent 1's inability to pre-commit to a sufficiently low level of debt.

13. The relative importance of the Grout under-investment is larger whenever $Y(n)/n-I(n)<Y(n)/(n+1)$,i.e., when $Y(n)<n(n+1)I(n)$, holding for sufficiently high values of $I(n)$.

14. Analogously, condition (7) for an internal maximum ($n<N$) is *easier* to satisfy than the corresponding condition (19). Hence, debt makes the social optimum level N more likely to be attained.

15. The argument can be extended to the case when the project has a positive liquidation value, $\Lambda(n)$. When the entrepreneur does not borrow, profit is equal to $Y(n)/n+[(n-1)/n]\Lambda(n)-I(n)$, since the entrepreneur can use project's liquidation as a valuable outside option in negotiations (see equation (1)). In contrast, when the entrepreneur borrows, the project's debt capacity is equal to $[Y(n)+n\Lambda(n)]/(n+1)$, which is, the share that lenders would obtain in case of default: since lenders come to control the project's physical assets in default, they can exploit $\Lambda(n)$ as outside option in the bargaining process. As a consequence, when the entrepreneur borrows (optimally) up to the full debt capacity of the project, profit is equal to $2Y(n)/(n+1)+[(n-1)/(n+1)]\Lambda(n)-I(n)$. By treating n as a continuous variable, it can be shown that, under debt financing, the liquidation value induces a further positive effect on the choice of n (with respect to the case of no debt financing) provided that the inequality $(n^2-2n-1)\Lambda(n)+n(n^2-1)\Lambda'(n)>0$ holds: a sufficient condition for this (with $n\geq 3$) is that $\Lambda'(n)\geq 0$. The possibility that the liquidation value decreases in the level of sophistication of the project ($\Lambda'(n)<0$) has, however, some plausibility. According to Williamson (1988), the more investment is specialised, the lower is assets' redeployability and, hence, the lower the liquidation value of physical capital.

16. Kremer (1993), however, explains this empirical observation through a matching model of workers' skills.

17. If Y(n)-I(n) started decreasing after some n', the choice of a $n>n'$ would surely not be socially optimal. In this were the case, *over-sophistication* (due to the working of debt) could not be ruled out. Notice that, when $\Delta I(n)=0$ and $y>Y(n-1)/n$, the inefficiency measure (20) would be *negative*, generating *over-sophistication*. In this case, (18) would hold true when (8) does not hold.

18. Notice that $[Y(n-1)+y]/n$ is surely smaller than $Y(n)/n$ when the choice of n is efficient, which is, when (8) holds.

19. The fragmentation of the firm's physical capital, so to back up debt issues, may take place in two ways: (i) debt can be secured to a particular asset, and (ii) each lender can be given the same priority over a fraction of physical capital value. This latter way, however, imposes that each lender acquires veto powers, making majority rules insufficient.

20. The analog of (19), the condition for an interior maximum, is in this case given by $Y(n)>[(n+L)/(n+1+L)]Y(n+1)-[(n+L)/(1+L)][I(n+1)-I(n)]$, with $n+1\leq N$, and is less easy to satisfy than (19).

21. Since additional lenders would dilute the bargaining power of the existing ones in case of bankruptcy negotiations, the number of lending relations has to be limited, if a market for debt exists. For instance, these limitations are actually present in reality as "restrictive covenants" on debt contracts (see Brealey and Myers (1991), p.601-602). Moreover, it is unlikely that many lenders can each be given a first claim on a *indispensable* piece of equipment. In general, a large number of lenders is likely to make the organisation of bankruptcy negotiations more difficult: when negotiations become difficult to arrange, liquidation will tend to be more frequent and the strategic power of debt will be destroyed.

22. Here, we constrain the analysis to the case for $D_m\geq I(n)$: the amount borrowed, which cannot exceed the maximum level of repayments D_m, can fully cover the investment cost.

23. Obviously, if $D_m=Y(n)-ny$, the entrepreneur will never default on debt, since $Y(n)-ny<Y(n)/(n+1)$.

24. Similar conclusions are immediately reached when n is treated as a continuous variable. The first order condition for n relative to (24) is $Y'(n)-Y(n)/(n+1)=0$, and determines a level of n greater than the ones solving both the self-financing and the competitive capital markets cases.

25. Following the *example* given in sect.4.2, maximum sophistication N would be optimally chosen by the entrepreneur.

26. Notice that when $D'>I(n)$ holds, the entrepreneur's profit *level* is strictly higher under the competitive regime than under monopolistic lending.

27. Since a public offer of equity is an effective device to twist the distribution of rents in favour of the investor, this argument can contribute to explain the decision to "go public", i.e., to float the firm on the stock market.

28. Notice that the n agents involved the production of $Y(n)$ are indifferent as to whom is the actual owner. Whoever is in control, in equilibrium, their share of returns remains equal to $Y(n)/(n+1)$.

29. The equivalence result obtained for debt and control surrender in competitive capital markets does not fully hold, however, under a monopolistic market regime, at least as far as participation constraints are concerned. We showed how, in a monopolistic credit market, debt contracts' design is flexible enough to always ensure participation in a project. In contrast, if control is surrendered (to a monopolistic buyer), the participation constraints may be violated: a majority shareholder cannot commit himself not to use his bargaining power, once the project is implemented. (An analogous problem arises when, e.g., suppliers have to acquire firm-specific skills. Also in this case, stock-market floatation can be dominated by bank-oriented relationships: see Allen (1993,p.86) and references quoted there).

30. Suppose that the investment is undertaken by two partners, agent 1 and agent 2, who contribute to its cost. The project can thus be seen as the joint-venture between two separate "firms", led respectively by agent 1 and agent 2.

31. Debt must be such that agent j does not find it convenient to repudiate over D^j. In other words, D^j must satisfy the condition $[Y(n)-D^j-(\theta-1)D^{j'}]/n \geq [Y(n)-(\theta-1)D^{j'}]/(n+1)$, with $j \neq j'$, which defines, with equality sign, agent j's credit capacity.

32. Recall that n is function of θ itself.

33. $(Y(n)-I(n))/n$ has to be greater than y for the project to be economically meaningful.

34. Notice that there must exist a partnership of size $\theta_0 \leq n$, such that each member gets $2Y(n)/(n+\theta_0)-I(n)/\theta_0 > y$, while the $(n-\theta_0)$ non-members get $Y(n)/(n+\theta_0)$ (*Proof*: set $\theta_0=n$).

35. Consider the case when $2Y(n)/(n+1)-I(n) < y$ holds and, in case of implementation, no additional agent would be willing to join the partnership. It follows that agent 1, by investing, would receive $2Y(n)/(n+1)-I(n)$ since, at the same time, nobody among the $(n-1)$ remaining agents would have any advantage in joining her (condition (33) does not hold). But when no other agent is willing to join in case of implementation, agent 1's best choice is autarkic production, y.

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