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Shareholders and Stakeholders: Human Capital and Industry Equilibrium*

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Abstract

Producing high technology output and supplying sophisticated services often involves costly investment in industry specific skills. But the threat of poaching means that it is the individual "stakeholder", not the firm, who must bear the cost. We investigate various mechanisms for funding human capital investment in an industry equilibrium framework where capital market imperfections would (in the absence of intervention) result in underinvestment. The main result is that government provision of loan guarantees (conditional on no-bankruptcy) leads to wage hikes which (by forcing exit of some firms thus increasing monopoly power) raise profits in a socailly inefficient manner: income contingent loans and levy subsidy schemes, meanwhile, can result in a socially efficient outcome.

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Recent analysis of investment under uncertainty has stressed the irreversible commitment that this may involve — and the value of waiting before committing or withdrawing resources, Dixit and Pindyck (1994). The investment considered is usually in physical capital — oil rigs, for example — and the decision makers are the shareholders who own equity capital, or their delegates. But in many high technology and service industries investments of a less tangible nature are also required — those in human skills. If they are costly to acquire and are not transferable outside the industry, then this will also involve irreversible decisions under uncertainty.

The focus of this paper is on these complementary investments, in particular in *industry specific* skills where the costs are borne not by the shareholders but by other "stakeholders". If the required skills were specific to the firm, then the firm might well be willing to pay. But this is unlikely for industry specific skills, where there is a serious "free rider" problem facing firms who bear the costs of training. Commercially valuable skill — human capital— differs fundamentally from physical capital in that "property rights over physical assets can be traded whereas human capital is inalienable", Moore (1991); and the right of skilled employees to quit means that firms that are willing to bear the costs of industrial training face the threat of "poaching" by firms that are not. So the costs of acquiring skills will generally be shifted onto the employees; and it is their investment in these skills that makes them "stakeholders" in the industry.

Issues which immediately arise are: how will these stakeholders finance their investments in human capital? Will the outcome be socially efficient if it is the shareholders who control the firm? If not, are there mechanisms to enhance efficiency? In the US and the UK there has been a growing awareness that the provision of skills faces poaching and credit constraints that call for some kind of market correction. It has been observed that the poaching problem seems to be avoided in Japan on the account of the "lifetime employment system" which binds employer and employee together and in Germany through organisation of industry-wide training schemes. Some economists, John Kay in particular, advocate the adoption of the stakeholder approach to managerial behaviour which views managers not as delegates who maximise profits for the shareholder but as trustees who must balance the interest of the various constituencies in the business — including employees and customers as well as the shareholders, see Kay (1996) and Plender (1997, pp16–17). (In much the same way it has been argued that bankruptcy courts should take account of suppliers and customers as well as the creditors, see Frank and Nyborg, 1993).

Our procedure in this paper is to adopt a specific model of competitive industry equilibrium which is known to be socially efficient, that of Leahy (1993), and to modify it by introducing industry specific human capital as an input to production. This can lead to several forms of market failure — in the market for risk, for example, see Dixit and Pindyck (1994, Chapter 9). Here, however, we assume risk neutrality and focus on the problems of poaching and credit rationing associated with the inalienability of human capital, and we examine how different arrangements do or do not achieve socially efficient outcomes. (We have assumed a competitive labour market; but we note that current thinking about general/specific human capital embraces insights from the literature on monopsonistic labour markets, see for example the model of "poaching externalities" of Stevens (1996). This provides an alternative justification for government intervention in the market for training.)

We begin in Section I with the case where shareholder and stakeholder are one and the same. As the decision maker takes both tangible and intangible investments into account on entry and exit, the price triggers for an industry composed of many such firms will be socially efficient. This may not be too plausible as a realistic equilibrium, but it does provide us with a useful benchmark for assessing other outcomes.

But what happens when stakeholders are not shareholders? The approach we adopt here is to take control by shareholders as given, but to use the device of profit-sharing as a mechanism to determine the price triggers for enter and exit. This is essentially the "agency" approach of Ross (1974), with the shareholder as agent. In this instance, it can deliver the outcome sought by those advocating the trusteeship approach as we find that the socially efficient price triggers emerge from industry equilibrium so long as profits are divided appropriately between the two.

This profit sharing equilibrium may be socially efficient, but is it feasible? Even if it is, will it dominate other more traditional payment structures — such as high wages for skilled employees (without any profit sharing)? Firms can raise money to buy physical capital by issuing shares, but equity style finance (or loans with income-contingent repayment) is not generally feasible for individuals: and the inalienability of human capital makes it impossible to use skills as the security for a conventional fixed-interest loan. In short, the profit sharing solution to poaching falls afoul of the capital market constraints facing those who seek to acquire skills.

If the market failure lies in credit markets then, as Booth and Snower (1996, p2) argue, "the government could ... provide loan guarantees in order to make the market for loans function more smoothly". In Section II, we examine an equilibrium where the government's guarantees enables agents to borrow on the security of human capital, and find that the outcome is very much like the case where the firms are levered. It may be persons who borrow, not firms; but the high wages employees need to cover the interest payments on these loans raise the firm's fixed costs just the same.

The surprising result is that this high wage equilibrium generates higher returns for shareholders than does the socially efficient, profit sharing equilibrium. (This is confirmed by numerical simulations which show that entry will take place earlier with the "traditional" high wages than with profit-sharing.) The reason for this is that when the price lies below the entry trigger, firms are in a monopoly position, and the high wages (which precipitate early exit of some firms) reduce the output, raise product prices and increase average profits in the industry. This result is analogous to that reported in Fries *et al* (1997) — for the Leahy model without human capital but with corporate debt — where they find that an industry-wide increase in leverage would raise profits and lower the entry trigger below that for unlevered firms.[2]

Two further ways of dealing with market imperfections are considered by Booth and Snower (1996, pp334–335), namely government provision of loans for training and education (financed by taxes on subsequent earnings) and a levy system "whereby firms in each selected industry are required to pay levies into a central fund that is then used to finance training programmes in that industry". In our framework we find in Section III that both of these can in principle help to solve the credit constraint and poaching problems.[3]

A summary of the issues addressed is presented in Table 1. The off diagonal entries describe arrangements which satisfy only one of the criteria necessary for the viability of a high tech industry. In the top right is the right case where firms have the financial resources to provide training needed by their employees, but the poaching problem removes the incentive to do so. On the bottom left is the profit-sharing scheme which avoids the poaching problem

[2]For corporate debt, they note that the high debt/high profit equilibrium tends to "unravel" as each firm tries to free ride by reducing its own leverage below the industry average — so as to ensure that it is not the one to pay the costs of bankruptcy. But in the high wage/high profit equilibrium in this paper, the very market imperfections which force individuals into debt to acquire human capital also prevent the unravelling. (Individuals are not free to switch from debt to equity so as to lower the wage and avoid bankruptcy.)

[3]Some of the issues discussed here also arise in the financing of general higher education. Thus the income contingent loan scheme proposed by Booth and Snower (1996) is not unlike the student loan scheme advocated by Barr and Crawford (1996) in their evidence to the Dearing Committee, where they recommend that repayments be charged as a supplement to National Insurance Contributions; see also the graduate tax proposal described in Juffras and Sawhill (1991, p344). General higher education is of course a type of human capital but it differs in two significant ways from the vocational skills being discussed in this paper. First because it more clearly possesses the characteristics of a public good and second because it is much more widely transferable. (The first implies that outright subsidies are more appropriate, the second that poaching problems will be more pervasive.)

Table 1: Satisfying the no-poaching and credit constraints.

		Credit Constraint	
		Binding	*Not Binding*
No-Poaching	*Violated*		Low wage with training supplied by firms
Constraint	*Satisfied*		Low wage with Industry Training Levies
		Profit sharing	Profit sharing with Income Contingent Loans
			High wage with Government Loan Guarantees

but falls a foul of credit constraints on employees. The three arrangements discussed above are designed to satisfy both criteria and are listed in the table (bottom right). First is the traditional high wage equilibrium, where employees pay for their own training financed by government guaranteed loans — a solution which is attractive to shareholders but not to consumers (who have to pay for excessive "churning" of human and physical capital). The other arrangements shown try to achieve social efficiency by remedying the defects of simple profit-sharing or firm training. The provision of income contingent loans for employees can ease the credit constraints associated with the former; and the poaching problem can be avoided if firms providing training are subsidied by industry-wide levies charged on profits. We conclude that institutional arrangements to alleviate these constraints may be crucial in the global competition for supplying high tech goods and services.

I Human Capital in Leahy's Model of Industry Equilibrium

Assume that there is a large number of risk-neutral competitive firms in the industry, each producing one unit of the product per period. Production requires inputs of two units of unskilled labour per period, and the services of one unit of physical capital and one unit of human capital. Both of the latter are industry-specific — and, except for those fortunate enough to be naturally "endowed" with the relevant skill, acquiring them involves irreversible investment. Assume that the labour market is competitive with homogenous skilled and unskilled individuals. Let the unskilled wage be w and the lump sum cost of the complementary factors be K and H respectively. Note that, as in Leahy (1993), we assume fixed coefficients of production with no factor substitution. While K is the price of a machine, one could think of H as the cost of industry specific training — in biotechnology, for example or astrophysics.

The inverse demand curve for industry output q is

$$p = xD(q), \tag{1}$$

where p is the product price and x is an industry-wide demand shock, assumed to follow a geometric Brownian motion process with parameters μ and σ.

$$dx = \mu x dt + \sigma x dz, \tag{2}$$

where z is a standard Brownian motion. In the interval of time when no entry and exit take place, q is fixed and p is proportional to q, so

$$dp = \mu p dt + \sigma p dz. \tag{3}$$

I.1 The socially efficient solution

To find the socially efficient solution we will assume that the shareholder and the stakeholder are one and the same. So the firm can start producing on making an investment of K plus H, K to buy the machine and H to acquire the skill. It loses K plus H if ever it stops producing — but not before; i.e., these investments are both irreversible and non-depreciating. On these assumptions the competitive industry equilibrium will be that described in Leahy (1993) or Dixit and Pindyck (1994), except that the entry price is higher, $K + H$ instead of K. And it will have the same efficiency properties associated with it, namely that of maximising the sum of consumer and producer surplus — as discussed in Dixit and Pindyck (Chapter 9, 1994). These socially efficient triggers can be derived from the value function as follows.

Since the future price path depends on the current price level p, the expected present value of the firm's future profits is a function of p, which we denote by $V(p)$. Then in the absence of new entry and exit, the value of the firm $V(p)$ must satisfy the following arbitrage condition

$$\frac{E_t dV(p)}{dt} + p - 2w = rV(p) \tag{4}$$

where r is the real rate of interest. The first term on the left hand side indicates the capital gain, $p - 2w$ is the profit per unit time and right hand side represents a normal return on holding the asset $V(p)$. (It is assumed that the skilled worker also supplies one unit of unskilled labour, so the wage bill $2w$ includes wages for unskilled work by both skilled and unskilled workers.)

Using (3) and applying Ito's lemma to (4) yield

$$\frac{1}{2}\sigma^2 p^2 V''(p) + \mu p V'(p) + p - 2w = rV(p). \tag{5}$$

The above ordinary differential equation has the following general solution

$$V(p) = \frac{p}{r-\mu} - \frac{2w}{r} + A_+ p^{\xi_+} + A_- p^{\xi_-} \tag{6}$$

where A_+ and A_- are two arbitrary constants to be determined and ξ_+ and ξ_- are positive and negative roots of the quadratic equation

$$\frac{1}{2}\sigma^2 \xi(\xi - 1) + \mu\xi = r. \tag{7}$$

It can be shown that $\xi_+ > 1$ and $\xi_- < 0$.

The first term in (6) is the the present value of profits assuming prices follow an unregulated Brownian motion, while the second and third terms measure the effects on profits of upper and lower price bounds. The weights on these terms, and the price bounds characterising the industry equilibrium, are determined by the following boundary conditions. Let p_e and p_b be the price triggers for new entry and bankruptcy respectively. When prices hit p_e, new entry occurs, prices are reflected downwards. So the boundary conditions characterising new entry are given by

$$V(p_e) = K + H, \tag{8}$$

$$V'(p_e) = 0. \tag{9}$$

Equation (8) implies that new entry occurs only if the value of the firm can cover capital investment $K + H$, and the "smooth pasting" condition (9) is simply the consequence of the reflecting barrier. If exit does not involve any cost, then the boundary conditions for bankruptcy are given similarly by

$$V(p_b) = 0, \tag{10}$$

$$V'(p_b) = 0. \tag{11}$$

These four conditions will be sufficient to determine the parameters $A_\pm$ together with entry and bankruptcy price triggers.

The conditions for industry equilibrium can be seen in Figure 1 where V, the value of the representative firm, is shown as a function of the product price p. The first term in the value function is given by the line XX, drawn with slope $1/r$, passing through the point p_b^M on the horizontal axis and crossing the line labelled $K + H$ at the point M. The latter defines the so-called Marshallian trigger for entry, where $p_e^M = 2w(r-\mu)/r + r(K+H)$, while the former, where $p_b^M = 2w(r-\mu)/r$, defines the Marshallian quit-point. These price bounds are far narrower than those characterising stochastic industry equilibrium shown at p_e and p_b where the value function is tangent to the line $K+H$ and the horizontal axis respectively.

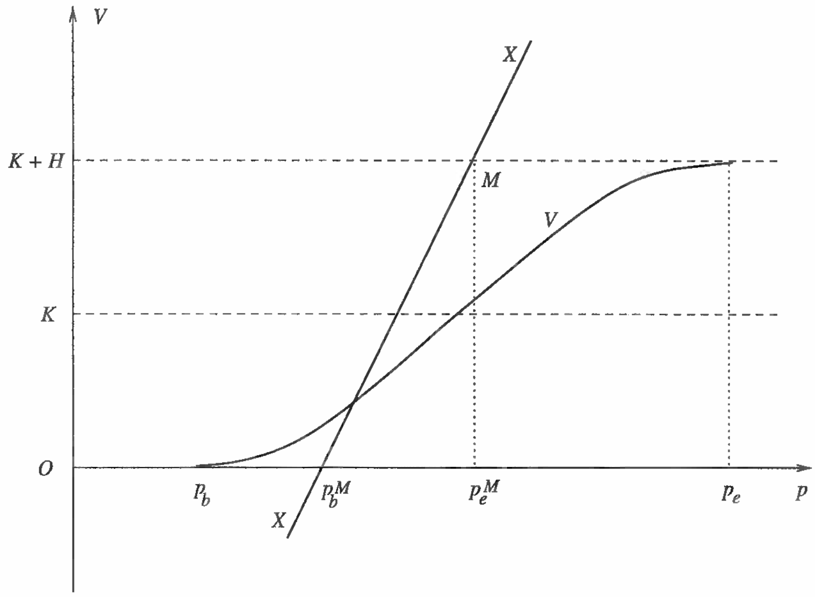

Figure 1: Socially efficient trigger prices.

The S-shape described by V itself is in turn due to the effect of the price bounds on expected profits. To the right the threat of new entry at p_e pulls the value function downwards. To the left the option of cutting losses by liquidating at p_b keeps the value function from falling below zero. The key feature of this solution is that the trigger prices correctly reflect the scale of the resources being irreversibly committed.

By construction, the effect of adding H has been to widen the bands in the same way that raising K would have done. The social efficiency of the equilibrium rests upon the fact that resources are not committed until the value of extra output to society covers the option value of waiting as well as the resource cost of $K+H$ used in expanding production, Dixit and Pindyck (1994, p287). Likewise the lower trigger, at which resources are withdrawn from production, takes account of the loss of both human and physical capital involved when a firm is liquidated and the social value of delaying exit. (It is assumed that unskilled labour can earn the same wage elsewhere, but that skills and machines are irreparably junked. One could modify the results by allowing for transfer earnings and second hand prices: these would narrow the price band but leave the analysis intact as long as there is some significant loss of value on exit.)

The numerical illustration appearing in the first line of Table 1 shows how dramatically wider the socially efficient trigger points can be relative to their Marshallian counterparts. For a wage of 1 and a cost of capital of 3% on a total of $K + H = 5$, the Marshallian entry price is 1.15 and exit price is 1. But with a price volatility of 0.2 (i.e., a standard deviation of 20% a year) — the central value used in Dixit and Pindyck (1994, p264) in their simulations of industry equilibrium — p_e is closer to 2 and p_b about 2/3, giving a price band about eight times as wide. (Numerical results for different variability in product prices and combination of physical and human capital are given in Appendix C.) As Dixit and Pindyck emphasise, this means that society should be a lot more cautious about committing and withdrawing resources from production than the Marshallian triggers imply.

Table 2: Numerical results: the base case.

	p_b	p_r	p_e	Loan Risk-premium	$V_P(p_e) - K$
Socially optimal solution	0.643	–	1.904	–	–
Liquidation-only	0.789	–	1.796	0.021	–
Restructuring	0.633	0.894	1.974	0.076	0.353

However convenient it may be to treat human and physical capital alike to find the right trigger points, this neglects the fundamental fact that human capital is inalienable (Moore, 1991). While purchasing a machine gives the firm the right to use its services until it chooses to sell, the money spent on training a skilled worker confers no such right. As long as skilled workers retain the option of quitting the firm, their commitment to supply skilled services to the current firm is limited. If they can be induced by a slightly higher wage to transfer their skills to another firm, this inability to precommit can entirely remove the incentive for firms to supply general (non-firm specific) training, so costs of training will be shifted onto the worker. Nevertheless, if workers are not credit constrained, a system of profit sharing can replicate the socially efficient outcome. This is what we examine in the next section, before turning to the consequences of credit constraints.

I.2 Profit Sharing

Assume that decisions to enter and exit the industry are made by — or on behalf of — the shareholder who owns the physical capital and has residual rights to the profits made by the firm. Following the agency approach of Ross (1974), one could ask whether these residual rights be defined in such a way that the decisions of shareholders who are concerned only with profits also take into account the interest in other stakeholders, in particular those workers whose skills will be wasted when the firm leaves the industry. This may well be a difficult problem in general, but here there is an easy answer in the affirmative. Let the stream of profits be divided in proportion to the initial investments, then it turns out that the trigger prices will be socially optimal.

Proposition 1 *Let $\alpha = K/(K+H)$ be the fraction of the operating profits retained by the shareholders, leaving a profit share of $1-\alpha$ for skilled workers, then the prices at entry and bankruptcy will replicate the socially optimal triggers.*

PROOF: Let $V_K(p)$ be the value of the firm entitled by shareholders and $V_H(p)$ be the value of human capital, and α be the fraction of profits shared by the shareholders, then $V_K(p)$ and $V_H(p)$ must satisfy the following arbitrage conditions

$$\frac{1}{2}\sigma^2 p^2 V_K''(p) + \mu p V_K'(p) + \alpha(p-2w) = rV_K(p), \tag{12}$$
$$\frac{1}{2}\sigma^2 p^2 V_H''(p) + \mu p V_H'(p) + (1-\alpha)(p-2w) = rV_H(p)$$

The value matching conditions at the entry trigger are

$$V_K(p_e) = K,$$
$$V_H(p_e) = H.$$

The boundary conditions for $V_K(p)$ and $V_H(p)$ at the exit trigger are exactly the same as in (9)–(11). If $\alpha = K/(K+H)$, then $V(p) = V_K(p)/\alpha = V_H(p)/(1-\alpha)$. Therefore, the entry and bankruptcy triggers for $V_K(p)$ and $V_H(p)$ are identical to those of $V(p)$. QED

The reason why this rule for profit sharing is socially optimal can be explained intuitively as follows. In comparison with the problem posed above the shareholder now has to make much less of a commitment — only K instead of K plus H — and this will tend to promote early entry. Profit sharing will on the other hand reduce the value of the investment and so delay entry. Choosing a profit share of $K/(K+H)$ ensures the two effects cancel out, leaving the trigger points unchanged. (Note that with these profit shares skilled workers would choose the same entry and exit triggers if the decisions are delegated to them.)

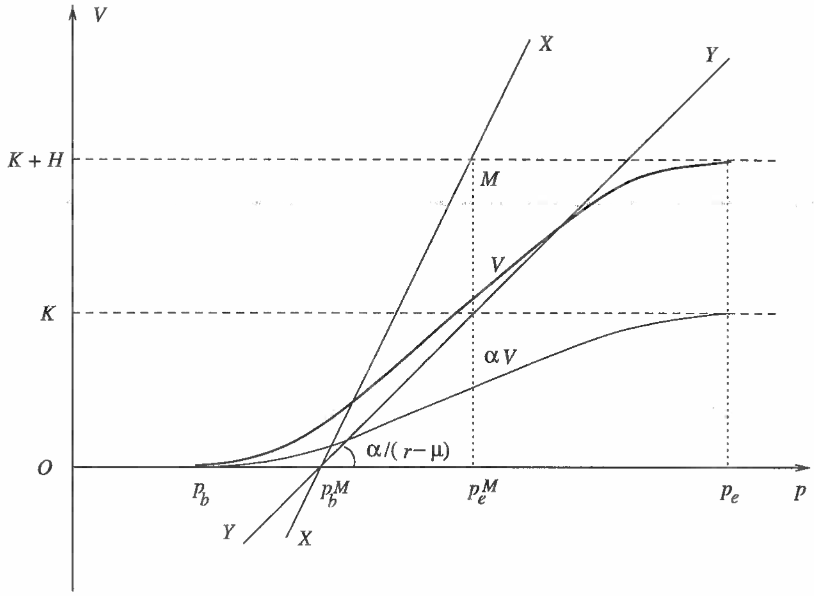

Figure 2: Social efficiency of profit sharing.

This can be seen graphically in Figure 2 where slope of YY relative to XX indicates the share of profits going to equity holders who pay the low base wage of w and splitting the profits with skilled workers. When the value of waiting is deducted from YY and the value of the option of quitting is added, one obtains the schedule labelled αV which has the same socially efficient triggers as in Figure 1.

In reality, the share of profit going to skilled workers will be determined by bargaining between firms and employees which need not result in social effciency. If, for example, α is higher than $K/(K + H)$, then skilled workers will need to be compensated with higher wages. In next section we discuss the polar case where $\alpha = 1$.

II LIQUIDATION-ONLY BANKRUPTCY

If human capital is inalienable, then it cannot be used as the security for a loan. Of course banks will be willing to lend on the basis of other security — property for example. (See Kiyotaki and Moore (1997) for an interesting model where loans for developing human capital are secured on land.) If all those who needed to train had sufficient property to secure the loan, then the cost of skilled labour would be $s = rH + w$ where w is the unskilled wage and r the riskless rate and H is the sum borrowed.

But the assumption that all who need to borrow have sufficient equity to do so at the riskless rate is obviously untenable. Since skilled workers are likely to face credit constraints Snower (1993) and Booth and Snower (1996, p344) advocate government loan guarantees as a way of tackling the failure of capital markets in this case. Let us assume specifically that loans are unsecured, but backed with conditional loan guarantees whereby the government ensures repayment except in the case where the firm goes bankrupt. This is of course a strong assumption, for it is "as if" loans can be secured on human capital, and workers can borrow on the same terms as firms in the industry, namely, the riskless rate plus a risk premium to cover the probability of bankruptcy. So there is no capital constraint, just a risk premium varying with economic conditions.

The pricing of corporate debt subject to bankruptcy risk in Leahy's model of industry equilibrium is examined in Fries, Miller and Perraudin (1997), where it is found to depend on the product price elasticity of demand facing the industry. (Technically, the relevant boundary condition applying to loans at the point of bankruptcy is that the elasticity of the value of the loan with respect to the product price should match the product price elasticity: this ensures that the downside risk of the loan being written off if the price falls is just matched by the recovery of the loan value if the price goes up.) Here there is no corporate debt, it is those that acquire skills who borrow H; however, if the wage paid to skilled labour is increased to cover the cost of servicing the loan, costs of production rise "as if" the firm had taken on leverage. So we may apply analogous boundary conditions to obtain industry equilibrium as follows.

Denote $V_B(p)$ and $L_B(p)$ the equity and loan value under liquidation-only case, and let the interest payment of the skilled worker to the bank be h (so the wage for the skilled labour becomes $s = h + w$), then the arbitrage conditions for $V_B(p)$ and $L_B(p)$ are given by the following equations

$$\frac{1}{2}\sigma^2 p^2 V_B''(p) + \mu p V_B'(p) + p - h - 2w = rV_B(p), \tag{13}$$

$$\frac{1}{2}\sigma^2 p^2 L_B''(p) + \mu p L_B'(p) + h = rL_B(p). \tag{14}$$

Since the equity holder determines the entry and liquidation, the boundary conditions for V_B are the same as those in (9)–(11), with the value matching condition at the entry trigger replaced by

$$V_B(p_e) = K. \tag{15}$$

For given entry and bankruptcy triggers, banks will determine the appropriate risk premium, h, which the skilled worker will then charge the shareholder. So the loan value at the entry trigger are the following value matching and smooth pasting conditions

$$L_B(p_e) = H, \tag{16}$$

$$L_B'(p_e) = 0. \tag{17}$$

As discussed above, at the bankruptcy trigger, the loan value is given by the following elasticity condition

$$L_B'(p_b)p_b / L_B(p_b) = \eta, \tag{18}$$

where η is the price elasticity of demand, which is assumed to be a constant. These boundary conditions will be sufficient to solve for the unique equity and loan values. (See Appendix A for a formal derivation.)

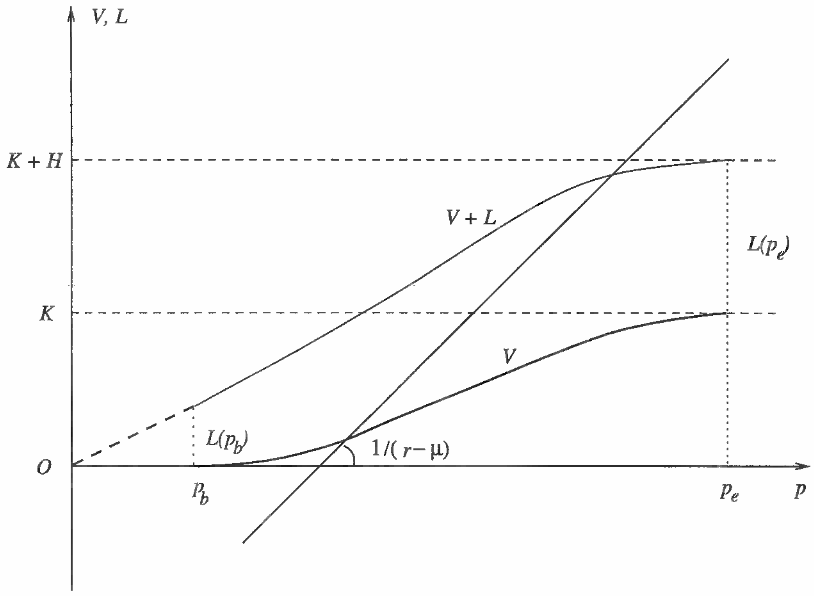

Figure 3: Liquidation only with personal bankruptcy ($\eta = 1$).

These solutions are briefly illustrated in Figure 3. The value of equity which is reflected at entry and exit barriers is shown as the schedule V which is tangent to the horizontal lines at p_e and p_b. When the price elasticity of demand $\eta = 1$, the total value of the firm, shown by the sum of values of the loan and equity $(V + L)$, will smooth paste the horizontal line only at the entry trigger p_e. At the exit trigger p_b, as the elasticity condition applies to the loan function, the total value of the firm smooth pastes the 45^o line starting from the origin.

Assuming a unitary product price elasticity of demand, simulation results for the base case are shown in the second line of Table 1. The price band is narrower than before, with a higher bankruptcy trigger of about 0.8 and a lower entry trigger of 1.8. The risk premium, measured as the excess of the loan rate over the riskless rate, i.e. $b/L(P_e) - r$, turns out to be 2% — which we assume is added into the cost of hiring skilled labour.

That exit should occur earlier than is socially efficient when firms face higher fixed wages is not surprising. What is remarkable is that these early bankruptcies raise profits in the industry and reduce the entry trigger. So high wage payments and earlier liquidation will dominate profit sharing!

The intuitive explanation for this is that while Leahy's model is one of competitive equilibrium, nevertheless monopoly profits (or quasi rents) may be made by existing firms if they can restrict output and raise prices (so long as the price is below the entry trigger). And this is precisely what early liquidation achieves. It may be costly, but these costs are more than covered by the quasi-rents. (See Fries, Miller and Perraudin (1997) for a similar result when firms take on leverage.)

When firms go bankrupt, liquidation is not the only option. As an alternative, the financial and management structure can be reorganised, as when a firm files for bankruptcy under Chapter 11 (in the US) or goes into administration (in the UK), see Hart (1995, Chapter 7). One might suppose that earlier liquidation could be avoided by these means. But this is not at all clear. In Appendix B, for example, we show how imaginative procedures for debt relief for individuals can fall afoul of the "no poaching constraint" on firms. This must cast some doubt on the notion that the problem of providing skills can be solved simply by financial engineering under bankruptcy law.

III Training Loans and Levies

The robustness of the socially inefficient high wage/high profit equilibrium and the seemingly inability of private financial restructuring to unravel this equilibrium imply that the government may have to tackle the problems of poaching and/or credit constraints directly. In this section we briefly examine two schemes discussed by Booth and Snower (1996) to see how they might change the industry equilibrium. First is the provision of *personal loans for training and education* to be repaid by taxes on subsequent earnings. Such a scheme can dramatically ease credit constraints as employees effectively borrow on the basis of skills they are to acquire: and the fact that firms need no longer to bear training costs reduces the problem of poaching. This should promote more efficient use of human resources, as is summarised in the following proposition.

Proposition 2 *Suppose that the government provides loans with income contingent repayment for training and education; then, if firms adopt profit sharing and the repayments match the profit share $H/(H+K)$ accruing to the skilled workers, the prices at entry and bankruptcy will replicate the socially efficient triggers.*

Note that for these loans to promote social efficiency it is necessary that firms adopt profit sharing: but the widespread availability of such loans would in principle give firms the incentive to do this, as those that do not will tend to go bankrupt before those that do. So as a result, the high wage/high profit equilibrium will tend to "unravel".

The second scheme is an *industrial training levy* which is designed to encourage firms to provide training by penalising free riders. Those who take on skilled workers without training have to pay a tax which is effectively transferred to those who have supplied the training. But if the poaching problem is resolved in this way, there is no imperative for firms to shift the burden of financing training onto their employees. So, in our framework, it turns out that the training levy is consistent with social efficiency as long as it is charged as a tax on profits, which are split between the shareholder and contributions to the the training scheme with refunds given for training supplied. This may be summarised as follows.

Proposition 3 *Let the government implement an Industrial Training Levy which is refunded for those providing training. If the training levy is charged at the rate of $H/(K+H)$ percent of operating profits, then the the price at entry and exit will replicate the socially efficient triggers.*

Because the share of profits accruing to them is the same as for profit sharing, shareholders should make socially efficient decisions; and the profit share accruing to the training scheme will, on average, be sufficient to cover the cost. Two points are worth making about this outcome. First, individuals no longer have to pay for training so they get no share of profits (and on the margin, the wage provided by the firm will make them indifferent between training and taking on unskilled job). Second that the training levy needs to be charged as a percentage of profits and not fixed mark-up on wage costs if the high wage/high profit equilibrium is to be avoided. (Note, however, that were firms free to choose *ex ante* the kind of fee to be paid they would have an incentive to "collude" on the socially inefficient levy as it promises to be more profitable.) It is interesting to see that the "pay or play" system proposed by Clinton in 1992, before he was elected president for the first term, seemed likely to add to wage costs as it required that "all firms with more than 20 employees invest 1.5% of payroll for training." It was not subsequently implemented, however.

IV Summary and Conclusions

A straightforward market solution to the acquisition of skills is bedevilled by poaching problems and credit constraints, attributable in part to the inalienability of human capital. Following Ross's agency approach, we have explored these issues in a model of investment under uncertainty and we conclude first that in the absence of credit constraints profit sharing could provide the right incentives for shareholders/managers to take due account of investments in industry specific human capital by other stakeholders. Taking into account the credit constraints faced by would-be skilled workers we find that government loan guarantees enabling individuals to borrow on the same terms as firms in the industry are no guarantee of social efficiency: the high fixed interest charges for workers act like increased leverage for firms and sustain an equilibrium where quasi rents are increased by "churning" capital — assets are scrapped earlier and replaced more quickly than is socially desirable.

Government provision of income contingent loans, on the other hand, would enable employees to use a form of equity finance and allow more flexibility in the reward paid to the skilled workers; this will tend to unravel the high wage/high profit equilibrium and attain social efficiency. (By analogy it has been argued that the income contingent loan scheme proposed by Barr and Crawford (1996) for funding higher education will allow for more flexibility in graduate employment allowing them to take jobs which do not guarantee high salaries.)

Another mechanism we consider is that of industrial levies. These tackle the problem at source by punishing poaching; whether or not levies are consistent with socially efficient triggers depends *inter alia* on whether the levy is imposed as a fixed charge or in a form of profit tax. (Only in the latter case does it allow for social efficiency; but firms may be tempted to collude on fixed charges so as to raise industry profits.)

In practice in areas like law and accounting it is not uncommon for employees to acquire human capital by extended periods of training at low wages. We have not examined this kind of solution to the poaching and credit market constraints partly because the distribution of consumption over time on the part of the workers seems clearly suboptimal. But the prevalence of such arrangements suggests that this would be a useful extension. (It might also be useful to compare various mechanisms proposed for funding the acquisition of industry skills with those being proposed for the funding of general higher education.)

To simplify the analysis we have assumed fixed coefficients of production and risk neutrality for all agents. If workers are risk averse and insurance markets fail there may be additional reasons for subsidising training to be considered, Dixit and Pindyck (1994, Chapter 9 and references therein). How allowing for factor substitution would affect our conclusions is also worth investigating.

When markets fail institutions can play a significant role, as Acemoglu (1996, p55) has pointed out in the context of economic growth. The successful performance of Japan and Germany in manufacturing industry may serve as examples. In the global competition to supply high-tech goods and sophisticated services, institutional arrangements for acquiring and rewarding human skills are likely to prove no less important.

Appendices

A Entry and exit under liquidation-only bankruptcy

Here we derive the entry and exit triggers p_e and p_b together with the coupon rate h charged by the bank. Let $x = p_b/p_e$. Using the boundary conditions at p_e yields

$$\frac{p_e}{r-\mu}\left[1-\frac{x^{\xi_-}-x}{\xi_+(x^{\xi_-}-x^{\xi_+})}-\frac{x-x^{\xi_+}}{\xi_-(x^{\xi_-}-x^{\xi_+})}\right]=K+\frac{2w+h}{r}. \tag{A1}$$

Using the boundary conditions at p_b yields

$$\frac{p_e}{r-\mu}\left[x-\frac{(x^{\xi_-}-x)x^{\xi_+}}{\xi_+(x^{\xi_-}-x^{\xi_+})}-\frac{(x-x^{\xi_+})x^{\xi_-}}{\xi_-(x^{\xi_-}-x^{\xi_+})}\right]=\frac{2w+h}{r}. \tag{A2}$$

Conditions for the loan function imply

$$\frac{h}{r}=\frac{H[\xi_+\xi_-(x^{\xi_-}-x^{\xi_+})-\eta(\xi_+x^{\xi_-}-\xi_-x^{\xi_+})]}{\xi_+-\xi_-+\xi_+\xi_-(x^{\xi_-}-x^{\xi_+})-\eta(\xi_+x^{\xi_-}-\xi_-x^{\xi_+})}. \tag{A3}$$

Solving (A1)–(A3) yields the solutions for p_e, h and x, while $p_b = xp_e$ determines the exit trigger.

B Debt Relief and Restructuring

The easiest way to solve for industry equilibrium with debt relief is to assume that all personal debt is written off when the economic value of the firms in the industry falls to zero, and that this writedown is fully reflected in the loan rate but not in the share price. (So, to get a recursive solution, we effectively assume that shareholders are "myopic" and do not anticipate the benefits of the writedown; a more reasonable assumption would be that the bank chooses the latest possible time for debt relief so as to avoid moral hazard problem, see Hayri (1996).) In this case we can first determine the entry trigger and the (Chapter 11) bankruptcy point just as in the liquidation only model discussed in section II. Then the liquidation point for the restructured firms can be found recursively.

Note that we assume the profit sharing is irreversible once adopted, and that it is not available to new entrants (until they go into administration, their employees gain debt relief and they can then reorganise). The industry will thus consist of a mix of high-wage new entrants and profit sharing firms which have been reorganised.

Formally the equilibrium is as follows. Let $V(p)$ and $L(p)$ be the value of equity and loan before restructuring, then $V(p)$ and $L(p)$ satisfy arbitrage conditions (13) and (14) respectively. The boundary conditions for $V(p)$ at the entry trigger p_e are given by (15) and (9), and those at the restructuring trigger p_r are

$$V(p_r) = 0, \tag{B4}$$

$$V'(p_r) = 0. \tag{B5}$$

The boundary conditions for $L(p)$ at p_e are the same as in (16) and (17), while that at p_r is given by

$$L(p_r) = 0. \tag{B6}$$

The reason that (B6) replaces the elasticity condition (18) at p_r is that when the product price reaches p_r, it keeps falling because of restructuring. This unravels the liquidation-only equilibrium.

Denote post-restructuring value of equity by $V_P(p)$, then it must satisfy (12) with boundary conditions

$$V_P'(p_e) = 0, \tag{B7}$$

$$V_P(p_r) = 0, \tag{B8}$$

$$V_P'(p_r) = 0. \tag{B9}$$

These conditions will uniquely determine V, L, V_P, p_b, p_r, p_e and h. Specifically, let $x = p_b/p_e$ and $y = p_r/p_e$. Using boundary conditions for the pre-restructuring value of equity yields similar equations to (A1) and (A2), namely

$$\frac{p_e}{r-\mu}\left[1 - \frac{y^{\xi_-} - y}{\xi_+(y^{\xi_-} - y^{\xi_+})} - \frac{y - y^{\xi_+}}{\xi_-(y^{\xi_-} - y^{\xi_+})}\right] = K + \frac{2w+h}{r}, \tag{B10}$$

$$\frac{p_e}{r-\mu}\left[y - \frac{(y^{\xi_-} - y)y^{\xi_+}}{\xi_+(y^{\xi_-} - y^{\xi_+})} - \frac{(y - y^{\xi_+})y^{\xi_-}}{\xi_-(y^{\xi_-} - y^{\xi_+})}\right] = \frac{2w+h}{r}. \tag{B11}$$

Using boundary conditions for the loan function implies

$$\frac{h}{r} = \frac{H(\xi_+ y^{\xi_-} - \xi_- y^{\xi_+})}{\xi_+ y^{\xi_-} - \xi_- y^{\xi_+} - (\xi_+ - \xi_-)}. \tag{B12}$$

These three equations can be used to solve for y, p_e and h (and of course p_r).

Applying boundary conditions to the post-restructuring value of equity yields

$$\frac{p_e}{r-\mu}\left[x - \frac{(x^{\xi_-} - x)x^{\xi_+}}{\xi_+(x^{\xi_-} - x^{\xi_+})} - \frac{(x - x^{\xi_+})x^{\xi_-}}{\xi_-(x^{\xi_-} - x^{\xi_+})}\right] = \frac{2w}{r}. \tag{B13}$$

Conditional on p_e obtained above, (B13) can be used to solve for x and so the liquidation trigger p_b.

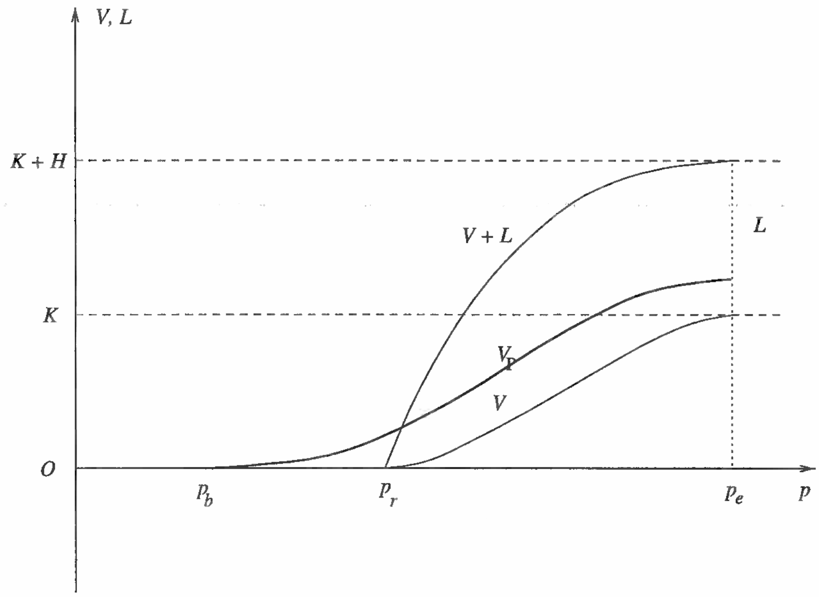

Figure 4: Debt relief with restructuring — myopic case.

The trigger points determining industry equilibrium are illustrated in Figure 4. Trigger p_e shows the price at which new entry takes place by firms with wages fixed high enough to cover interest on loans with excusable default provisions attached. These loans will be written off when firms file for bankruptcy at the price p_r, at which point profit related pay is introduced. The value of high wage firms, who proximately determine the entry trigger, is shown as V. The value of firms with profit-sharing is labelled V_P. If prices were to fall as low as p_b there would be liquidations — enough to stop the price falling any lower.

The simulation results in Table 2 show, as one might expect, that restructuring avoids early liquidation, and the trigger for restructuring of 0.89 is well above the liquidation-only exit point of 0.79. Will the possibility of restructuring unravel the high wage/high profit equilibrium and move the entry and exit triggers closer to their socially efficient levels? To answer this question note from the last column of Table 2 that $V_P(p_e) > K$. This means that the equilibrium described fails to satisfy the no-poaching condition (NPC) that the value of the restructured firms should not exceed the value of the new entrants at p_e. Hence new entrants could supply physical capital K and poach the skilled workers from the restructured firms with the offer of profit sharing and a slightly higher fixed wage, thus undermining the equilibrium.

Our simulation results lead us to doubt that financial restructuring will unravel the high wage/high profit equilibrium. (Nor does reducing the moral hazard problem along the lines suggested by Hayri (1996) change this conclusion as all simulations violated NPC.)

C Numerical Results

Table 1 in the text shows the numerical results for the base case where the parameters are chosen as follows: $r = 3\%$, $K = H = 2.5$, $w = 0.5$, $\eta = 1$, $\mu = 0$ and $\sigma = 0.2$. As a check on the robustness of these findings we have varied two key parameters — the standard deviation of prices and the ratio of human to physical capital — with results reported in Tables 2 to 5. So in the high noise case, we change σ to 0.4; in the low noise case, $\sigma = 0.1$. The high human capital case is characterised by $H/K = 4$, where $H = 4$ and $K = 1$ so the total capital is unchanged. In the low human capital case, we select $H = 1$ and $K = 4$. All the results are summarised in the following tables.

Table 3: High noise case.

	p_b	p_r	p_e	Loan Risk-premium	$V_P(p_e) - K$
Socially optimal solution	0.509	–	2.682	–	–
Liquidation-only	0.715	–	2.481	0.060	–
Restructuring	0.495	0.885	2.852	0.160	0.439

Table 4: Low noise case.

	p_b	p_r	p_e	Loan Risk-premium	$V_P(p_e) - K$
Socially optimal solution	0.759	–	1.547	–	–
Liquidation-only	0.871	–	1.490	0.007	–
Restructuring	0.754	0.935	1.580	0.038	0.272

Table 5: High human capital case.

	p_b	p_r	p_e	Loan Risk-premium	$V_P(p_e) - K$
Socially optimal solution	0.643	–	1.904	–	–
Liquidation-only	0.955	–	1.711	0.032	–
Restructuring	0.593	1.428	2.386	0.173	1.067

Table 6: Low human capital case.

	p_b	p_r	p_e	Loan Risk-premium	$V_P(p_e) - K$
Socially optimal solution	0.643	–	1.904	–	–
Liquidation-only	0.692	–	1.865	0.017	–
Restructuring	0.642	0.717	1.911	0.050	0.054

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