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No. 743

**PRIVATIZATION, RISK-TAKING, AND  
THE COMMUNIST FIRM**

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## ABSTRACT

### Privatization, Risk-taking, and the Communist Firm\*

This paper studies alternative methods of privatizing a formerly communist firm in the presence of imperfect risk markets. The methods include cash sales, a give-away scheme, and a participation contract where the government retains a sleeping fractional ownership in the firm. It is shown that with competitive bidding, the participation contract dominates cash sales because it generates both more private restructuring investment and a higher expected present value of revenue for the government. Under weak conditions the participation contract will induce more investment than the giveaway scheme, and it may even share the cash sales' virtue of incentive compatibility.

JEL classification: D44, P13

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## NON-TECHNICAL SUMMARY

There are many ways of privatizing the communist firm. Voucher schemes, cash sales and participation models are among the methods used or discussed. Voucher schemes spread ownership widely but lead to a diffusion of responsibilities and therefore represent only a very indirect way of bringing in the new management necessary for adapting the firm to market conditions. Many economists therefore advocate plain cash sales to competent entrepreneurs. They argue that such competitive cash sales will maximize the incentive to invest in restructuring and provide the best way to foster economic recovery.

Cash sales are not without problems, however; they absorb funds that credit-constrained investors would otherwise have borrowed for restructuring purposes, and raise the market rate of interest when the government uses the sales revenue for the purchase of goods and services rather than for reinvesting in the capital market. An alternative to cash sales is a 'participation' contract, where the government, instead of receiving a cash payment, retains a sleeping fractional ownership in the firm which entitles it to receive a certain percentage of all future profit distributions. The participation contract in effect obliges the government to use its cash-sales revenue to provide the firm with an equity endowment in exchange for ownership shares. The equity endowment frees investors' funds for the purpose of restructuring. The ownership shares can be distributed to the workers and the general population to compensate them for the loss of state-owned assets which they had previously owned in common.

This paper examines another aspect of the participation model: its risk sharing properties. Restructuring the communist firm is a very risky, but potentially lucrative enterprise. Many potential investors may hesitate to participate in the risky cash-sales programme and if so, they may take up only moderate stakes. The participation model may help overcome their risk aversion, because the government shares the risk of failure by reducing or giving up its claim to receive the sales price. Private risk markets, in principle, could also do the job, but they do not exist or are underdeveloped in the countries concerned. The government is the only risk consolidating mechanism available.

We develop a risk-theoretic competitive auction model that makes it possible to compare cash-sales and participation contracts. Instead of making cash bids, the bidders are allowed to offer participation contracts which specify the percentage sleeping ownership ceded to the government and the volume of reorganization investment. The bid that promises the highest expected present value of the cash flow accruing to the government is selected.

We analyse this question using a model of a risk neutral trust agency that seeks to sell a firm to identical risk averse investors. Under the cash-sales method,

investors specify their offer price, and under the participation method they specify their own required ownership fraction, which we denote the 'participation rate', and the amount of reorganization investment that they promise to finance with an equity injection. We assume that the government can monitor reorganization investment and enforce the promise, but has no voting rights. We initially also assume that all parties have identical beliefs about the cash flow distribution that will result for this investment level. One way of interpreting this assumption is that investors must give any information they have to the government and that the latter can verify its truth without cost.

The two crucial policy questions in the privatization debate have been: which privatization method generates most revenue and which induces the highest volume of reorganization investment? For didactic purposes, we begin our analysis by comparing the expected revenue for the government generated by the two contract types, when investment is kept constant at a given level. When we compare the maximum expected return generated by both contracts, intuition suggests that the participation mechanism should perform better, because the government absorbs some of the risks and earns a risk premium. This intuition is indeed correct: given the volume of reorganization investment, the participation contract yields a higher expected revenue for the government than the cash-sales contract.

Although the maximization of the government's privatization revenue is a significant goal, many politicians have argued that the stimulation of private investment is of overriding importance. In fact, in the German debate it has frequently been recommended that the Treuhandanstalt should simply give its properties away in order to maximize the volume of private reorganization investment, and this is what the agency often does. We also discuss the validity of this recommendation. For this purpose we neglect the revenue goal and compare the cash-sales, giveaway and participation schemes solely with regard to the level of reorganization investment they will induce.

In the present model, the view that giveaways generate more investment than cash sales can be rationalized by the well-founded assumption that the preferences of investors exhibit decreasing absolute risk aversion. A positive cash price reduces the wealth of the investor which increases his local aversion. This, in turn, leads him to reduce the level of investment. We find, however, that when preferences of the investor exhibit constant or increasing relative risk aversion and the optimal investment, under the giveaway policy, is less than the wealth of the investor, the participation contract yields more investment than giving the firm away.

The main reason for the investment stimulus is that the introduction of the participation contract reduces the investor's local marginal risk aversion. The negative wealth effect of paying dividends to the government increases the local

marginal risk aversion, but the risk reduction resulting from the participation contract reduces the local marginal risk aversion even more. The assumptions underlying this result are plausible, but there are others that would change the sign of the net effect of the two forces. If, for example, the optimal investment under the giveaway policy is larger than the investor's wealth, the participation contract yields less investment than giving the firm away.

When the level of investment is given, the participation contract is a better revenue raiser than cash sales, and when revenue does not matter the participation contract may generate even more investment than giving the firm away. This suggests that the participation contract dominates the cash-sales contract. We prove that this is indeed the case under fairly weak assumptions. Provided only that the investors are risk averse while the government is risk neutral, the participation contract generates both higher expected revenue and a higher level of reorganization investment than the cash-sales contract does.

There are two sections in the paper that check the robustness of its results with regard to adverse selection and moral hazard problems. We prove that the participation bidding process can be designed such that the investors have a full incentive to reveal their true knowledge of the firm's profitability, and we argue that the participation contract will continue to outperform the cash-sales contract despite a potential moral hazard problem resulting from the sharing in the returns between the Treuhand and the private investor.

We conclude by examining the relevance of these results for Germany. Germany's case is less obvious because there are capital and risk markets which, in principle, make the cash-sales strategy worth considering. There are a number of reasons, however, why we believe the participation contract to be superior even there.

First, the poverty of the East Germans makes it difficult for them to borrow. Banks impose credit constraints which are a certain multiple of the available equity capital, but if someone has no equity they receive no credit. The poverty is not the result of the inefficiency of community production, but an implication of the currency exchange programme.

Second, the poverty of the East Germans creates excessive risk aversion. Even the most lucrative investment opportunities are unable to make them risk substantial commitments. Small wonder that, thus far, only 5% of Treuhand sales have involved East German buyers.

Third, the West German stock market is chronically underdeveloped and unable to diversify Treuhand risks. There are excessively high legal entry barriers that have effectively prevented Treuhand firms from being sold via this market. The



Treuhandanstalt has sold or given away thousands of firms, but only in one case has it been able to sell a firm in the stock market.

At first sight it might be tempting to believe that the difficulties in selling the East German firms directly on the stock market could be overcome by selling them indirectly in this market via West German partner firms. The West German firms could buy the East German firms and issue new shares on the stock market to spread the financial risks over many shoulders. The West German firms that are supposed to buy the Treuhand properties are, however, mostly entrepreneurial firms or partnerships with no more than a handful of owners. There are only about 600 publicly-traded stock companies in Germany and no more than one-tenth of these has a diversified ownership (in the sense that there is no single majority owner). West Germany is not comparable with the United Kingdom, let alone the United States. Developed risk markets that could absorb the Treuhand risks are simply not available. The unexpected flood of entrepreneurial risks that came with unification has overwhelmed the risk bearing capacity of the existing financial system.

Originally, the German Treuhandanstalt had forecast that it would be able to earn a revenue of about DM 600b. Now, after seeing the revenue it is actually collecting, even the more optimistic forecasts do not place the total revenue at more than DM 60b, one tenth of the original value. Given this huge discrepancy, there is every reason to consider alternative privatization procedures.

### *1. Introduction*

The collapse of communism is the most important historic event since the second world war, and the privatization of the formerly communist firms is the most important and most difficult economic problem in the subsequent transition to a market economy. The enormous transition cost in terms of output losses, distributional upheavals and the resulting social unrest makes it essential for privatization to be socially balanced and to activate the market forces as quickly and strongly as possible.

The typical communist firm was internally inefficient, was adapted to a wrong price vector, and had learned to react to institutions that were unlike those which constitute a market economy. It has few survival chances, if it continues to operate in its usual fashion. It will only be possible for the former state owned companies to prosper in the strong gale of international competition, if privatization succeeds in stimulating energetic entrepreneurial activities and large scale reorganization investment, and only then can a quick recovery of the ex-communist economies be expected.

There are many ways of privatizing the communist firm. Natural restitution, voucher schemes, cash sales, and participation models are among the methods used or discussed. Natural restitution is time consuming and prohibitively complicated, if not impossible. Voucher schemes lead to a widespread ownership and a diffusion of responsibilities; they are a very indirect way of bringing in the new management necessary for adapting the firm to market conditions. Many economists therefore prefer plain cash sales to competent entrepreneurs. They argue that competitive cash sales maximize the incentive to carry out reorganization investment and are thus the best way to foster economic recovery.

However the cash sales method is not without problems. It absorbs funds that credit constrained investors otherwise would have borrowed for restructuring purposes and it raises the market rate of interest when the government uses the sales revenue for the purchase of goods and services rather than for reinvesting in the capital market. Both micro and macroeconomic credit constraints imply serious stock-flow mismatches which

impede private investment and which can only be mitigated by selling at giveaway prices or by slowing down the privatization process.

An alternative to cash sales is a participation contract where the government, instead of receiving a cash payment, retains a sleeping fractional ownership in the firm which entitles it to receive a certain percentage of all future profit distributions. This model was discussed in earlier publications (Sinn 1991a, 1991b; Sinn and Sinn 1991), found considerable political attention in Germany, and was further developed in a number of papers including those of Bös (1991) and Bolton and Roland (1992). In effect, applying the participation contract is the same as the government using its cash sales revenue to provide the firm with an equity endowment in exchange for ownership shares. The equity endowment frees the investors' funds for the purpose of reorganization investment and loosens the micro and macroeconomic credit constraints. The ownership shares can be distributed to the workers and the general population to compensate them for the loss of state owned assets which they had previously owned in common.

An important additional aspect of the participation model is its risk sharing property, and this is the theme of this paper.<sup>1</sup> Restructuring the communist firm is a very risky, but potentially lucrative enterprise. It encounters thousands of unprecedented and unknown difficulties, but it promises huge pioneer profits. Many potential investors may hesitate to become engaged in the risky cash sales program and if so, they may chance only moderate stakes. The participation model may help overcome their risk aversion, because the government shares the risk of failure by reducing or giving up its claim to receive the sales price. Private risk markets, in principle, could also do the job, but for reasons that will be discussed in section 8, they do not exist or are underdeveloped in the countries concerned. The government is the only risk consolidating mechanism available.

We develop a risk theoretic competitive auction model that makes it possible

<sup>1</sup>A discussion of the risk sharing properties of the participation model can also be found in Sinn and Sinn (1991). However these authors concentrate on the stock-flow mismatches and do not derive a formal risk-theoretic model as is done here.

to compare cash-sale and participation contracts. Instead of making cash bids, the bidders are allowed to offer participation contracts which specify the percentage sleeping ownership ceded to the government and the volume of reorganization investment. The bid that promises the highest expected present value of the cash flow accruing to the government is selected. To focus on risk problems, this paper abstracts from imperfections in credit markets. Incorporating such imperfections would strengthen our basic conclusions (see Sinn and Sinn 1991).

The paper was motivated by controversial discussions about the two privatization contracts in the Scientific Advisory Committee of the German Ministry of Economics (Wissenschaftlicher Beirat beim Bundesministerium für Wirtschaft 1991). A minority of the Committee advocated the participation contract, but the majority supported the government's choice of cash sales, arguing that participation cannot increase the government revenue but will reduce the incentive for reorganization investment and slow down economic recovery. We hope that our model makes it possible to discuss the issue in a more transparent way than has been possible thus far. Our main questions are which of the two contract types will generate more revenue and which will induce more private reorganization investment.

An additional issue addressed in the paper is the rationale of a simple giveaway policy where competent investors receive the firm as a gift. The give away policy has occasionally been advocated by economic advisors, and it is in many cases carried out by the German Treuhand, the central privatization agency for East Germany, where East German firms are sold to West German investors for a single symbolic deutschmark. The paper will discuss the question of whether the Treuhand's hope of maximizing the volume of reorganization investment by using this policy is justified.

The following Section 3 sets up the formal model, and Sections 3-5 compare the alternative privatization approaches. Sections 6 and 7 consider informational asymmetries, and Section 8 concludes the paper by discussing the assumption of missing risk markets.

## 2. The Model

We consider the problem of a risk neutral trust agency which attempts to sell a firm to some identical risk averse investors, whose preferences satisfy the von Neumann Morgenstern axioms. There may be additional investors who are different, but we assume that there are sufficiently many clones of the investor who makes the highest bid to satisfy the assumption of competitive bidding. Under the cash-sales method the investor specifies his offer price  $P$ , under the participation method he specifies his own required ownership fraction  $q$ , which we denote the "participation rate", and the amount of reorganization investment  $I$  that he promises to finance with an equity injection. We assume that the government can monitor  $I$  and enforce the promise, but has no voting rights. For the time being we also assume that all parties have identical beliefs about the cash flow distribution that will result from  $I$ . One way of interpreting this assumption is that the investor has to give any information he has to the government and that the latter can verify its truth without cost. The assumption will be relaxed in section 6. Unless otherwise stated the government selects the offers so as to maximize its own expected revenue.

We like to think of the participation contract as a dividend tax of the Meade Committee's (1978) S-base type whose rate,  $1-q$ , can be chosen by the investor together with the initial equity endowment  $I$  which he contributes. The endogeneity of the tax rate makes our problem theoretically interesting while the cash-flow character of the dividend tax promises the administrative and allocative advantages that have been derived in other model frameworks.<sup>2</sup> Unlike in the Committee's proposal, expensing of the initial equity injection is not allowed. Future investment is assumed to be financed from retained earnings and will thus be treated as the Committee suggested.<sup>3</sup>

<sup>2</sup>The tax interpretation also points to similarities with the public finance literature on taxation and risk taking (see e.g. Ahsan 1974). Other similarities concern the literature on sharecropping (e.g. Stiglitz 1974) and that on mixed enterprises (see section 8 below). Despite the similarities, the propositions of this paper have, to the best of our knowledge, not yet been derived.

<sup>3</sup>Cf. section 7 below.

The present value of the dividends resulting from the reorganization investment takes the form  $\theta f(I)$  where  $f$  is a strictly increasing and concave function and  $\theta$  is an arbitrarily distributed random variable with expected value  $\mu(\theta) > 0$  and standard deviation  $\sigma(\theta) > 0$ .<sup>4</sup> For simplicity we assume that  $f(0) = 0$ . Algebraically, we allow for simultaneous cash and non-cash bids. When the contract parameters  $q$ ,  $I$ , and  $P$  are specified, the investor's post-contract wealth is

$$Y = q \theta f(I) - I - P + K$$

where  $K$  is his initial wealth.

Without loss in generality, we specify the model as a  $(\mu, \sigma)$  approach. Let  $\mu(Y)$ ,  $\sigma(Y)$ , and  $Z(Y)$  denote respectively the expected value, the standard deviation, and the standardized distribution of the random variable  $Y$ :

$$\mu(Y) = q \mu(\theta) f(I) - I - P + K \quad (1)$$

$$\sigma(Y) = q \sigma(\theta) f(I) \quad (2)$$

$$Z(Y) = \frac{Y - \mu(Y)}{\sigma(Y)} \quad (3)$$

Substituting  $Y$ ,  $\mu(Y)$ , and  $\sigma(Y)$  into equation (3) shows that the standardized distribution of  $Y$  is independent of the policy parameters  $P$ ,  $q$ , and  $I$ .

<sup>4</sup>Since we place no particular restrictions of the shape of  $\theta$ 's probability distribution, this formulation is equivalent to the form  $g(\theta)f(I)$  where  $g$  is an arbitrary function and  $\theta$  the state of the world. See e.g. Stiglitz (1974). Nevertheless, of course, the specification is not perfectly general. Analyzing more general kinds of randomness may be desirable, but will certainly imply substantial complications.

$$Z = \frac{\theta - \mu(\theta)}{\sigma(\theta)}$$

The independence implies that all attainable probability distributions of the firm's net cash flow belong to a unique linear class for which the investor's von Neumann Morgenstern utility function can exactly be represented by the utility function  $u[\mu(Y), \sigma(Y)]$  without assuming normal distributions or quadratic utility. Let  $s(\mu, \sigma)$  denote the slope of the indifference curve at the combination  $(\mu, \sigma)$  which measures the *local marginal risk aversion*.<sup>5</sup> As discussed by Mayer (1987, 1989) and Sinn (1983, 1989), the slope of any indifference curve is zero along the  $\mu$ -axis:  $s(\mu, 0) = 0$ , and risk aversion implies that the indifference map is convex:  $ds(\mu, \sigma)/d\sigma|_{\mu} > 0$ . Moreover, the Pratt-Arrow measures of absolute and relative risk aversion have plausible implications for  $s(\mu, \sigma)$ . For example, if the preferences of an agent exhibit decreasing absolute risk aversion, an increase of  $\mu$  holding  $\sigma$  constant, will decrease the local marginal risk aversion. More generally, for  $\sigma > 0$ :

$$\frac{\partial s(\mu, \sigma)}{\partial \mu} \begin{cases} (\geq) \\ (\leq) \end{cases} 0 \Leftrightarrow \begin{cases} \text{increasing} \\ \text{constant} \\ \text{decreasing} \end{cases} \text{ absolute risk aversion}$$

and

$$\left. \frac{ds(\mu, \sigma)}{d\mu} \right|_{\mu/\sigma = \text{const.}} \begin{cases} (\geq) \\ (\leq) \end{cases} 0 \Leftrightarrow \begin{cases} \text{increasing} \\ \text{constant} \\ \text{decreasing} \end{cases} \text{ relative risk aversion.}$$

These properties will be needed in the analysis to follow.

<sup>5</sup>It is assumed that  $\mu = \mu(Y)$  and  $\sigma = \sigma(Y)$  unless it is explicitly defined to which random variable the two moments refer.

### 3. Revenue Comparison with Given Reorganization Investment

The two crucial policy questions in the privatization debate have been: which privatization method generates most revenue and which induces the highest volume of reorganization investment? For didactic purposes, we begin our analysis by comparing the expected revenue for the government generated by the two contract types, when investment is kept constant at a given level  $I$ . First, we consider a standard cash sales contract:  $P > 0, q = 0$ . With this contract, the expected revenue for the government is simply the cash price  $P$ . Second, we consider a "pure" participation contract:  $P = 0, q < 1$ . Now the expected revenue for the government is equal to its portion of the cash flow  $(1-q)\mu(\theta)f(I)$ . We assume that competitive bidding guarantees that the government can extract the entire rent. Specifically, for either contract,  $[\mu(Y), \sigma(Y)]$  is assumed to satisfy the requirement:

$$u[\mu(Y), \sigma(Y)] = u(K, 0).$$

When we compare the maximum expected return generated by both contracts, intuition suggests that the participation mechanism should do better, because the government absorbs some of the risks and earns a risk premium. Proposition 1 proves that this intuition is, indeed, correct.

**Proposition 1:** *Given the volume of reorganization investment, the participation contract yields a higher expected revenue for the government than the cash-sales contract.*

**Proof:** To prove this proposition (and to introduce the reader into the model) we first consider the participation contract. Holding  $I$  constant and varying  $q$  yields a linear relationship between  $\mu(Y)$  and  $\sigma(Y)$ , which we refer to as the *participation line*. The

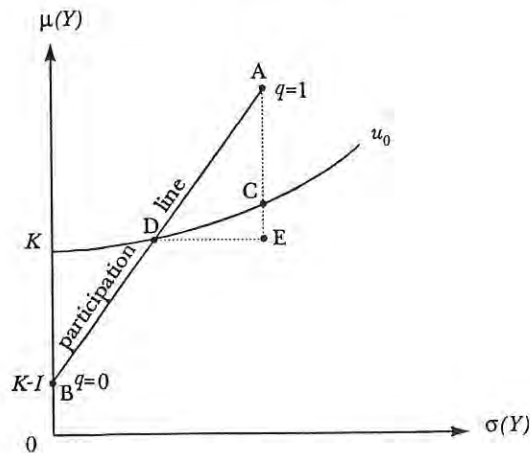


moments  $\mu(Y)$  and  $\sigma(Y)$  follow from equations (1) and (2) by setting  $P = 0$ . Eliminating  $q$  yields the participation line:

$$\mu(Y) = \frac{\mu(\theta)}{\sigma(\theta)} \sigma(Y) + K - I \quad (4)$$

The participation line is illustrated in figure 1. Point A is characterized by  $q = 1$ , point B by  $q = 0$ . Point A gives the  $(\mu, \sigma)$  combination when the government gives the firm away to the investor at zero price. Point B represents the other extreme case where the investor gives the reorganization investment away. As  $q$  varies between 0 and 1,  $[\mu(Y), \sigma(Y)]$  moves along the line segment AB. Equation (4) implies that the slope of the participation line is  $\mu(\theta)/\sigma(\theta)$ .

Figure 1: Revenues with Given Investment



The indifference curve  $u_0 = u(K, 0)$  represents the minimum level of utility which the investor is willing to accept. Thus, D characterizes the minimum value of  $q$

which does not violate the individual rationality constraint of the investor, the value being given by  $q = BD/BA$ . Since the total expected return on the investment is given, the expected return to the government equals the vertical distance between points A and E.

To conclude the proof, we compare AE to the maximum cash price of the firm. A positive cash price reduces the expected return on the investment but leaves the standard deviation unaffected. Again, point A characterizes a price of zero. As the price increases, the point  $[\mu(Y), \sigma(Y)]$  moves along a vertical line down from point A. The maximum price, where the agency extracts the entire rent, is therefore characterized by the distance AC. As can be seen from the figure, the convexity of the indifference curve guarantees that  $AE > AC$ . QED

#### 4. Giving the Firm Away

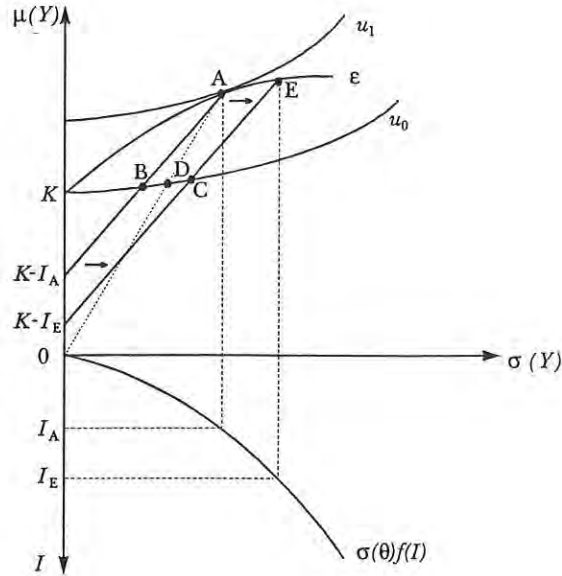
Although the maximization of the government's privatization revenue is a significant goal, many politicians have argued that the stimulation of private investment is of overriding importance. In fact, in the German debate it has frequently been recommended that the Treuhand should simply give its properties away in order to maximize the volume of private reorganization investment, and this is what the agency often does. This section discusses the validity of this recommendation. It neglects the revenue goal and compares the cash sales, giveaway, and participation schemes solely with regard to the level of reorganization investment they will induce.

The main tool needed for this analysis is the efficiency curve  $\epsilon$  which is depicted in figure 2. The efficiency curve is defined as the relationship between expected wealth and standard deviation when the agency gives the firm away and the investor varies  $I$ . It follows from (1) and (2) that the efficiency curve starts from the coordinate at  $\mu(Y) = K$  and has a maximum where  $\mu(\theta)f'(I) = 1$ . The two properties suggest that  $\epsilon$  is concave. Appendix 1 proves analytically that this is indeed the case, and even in a strict



**Proposition 3:** *When the preferences of the investor exhibit constant or increasing relative risk aversion and the optimal investment, under the giveaway policy, is less than the wealth of the investor, then the participation contract yields more investment than giving the firm away.*

Figure 3: Giveaway vs. Participation Contract



**Proof:** Using figure 3, we start the argument at point A, which characterizes the optimal investment plan when the agency gives the firm away. In A, the efficiency curve  $\epsilon$  and the indifference curve  $u_1$  are just tangent. By assumption  $K - I_A > 0$ , therefore, the participation line is above a ray from the origin through the point A. We define point B as the intersection between  $u_0$  and the participation line for investment  $I_A$ , and D as the intersection between  $u_0$  and the ray from the origin through A. Since the preferences

exhibit constant or increasing relative risk aversion, we know that

$$s(\mu_A, \sigma_A) \geq s(\mu_D, \sigma_D), \quad (5)$$

and, because of the strict convexity of the indifference curve,

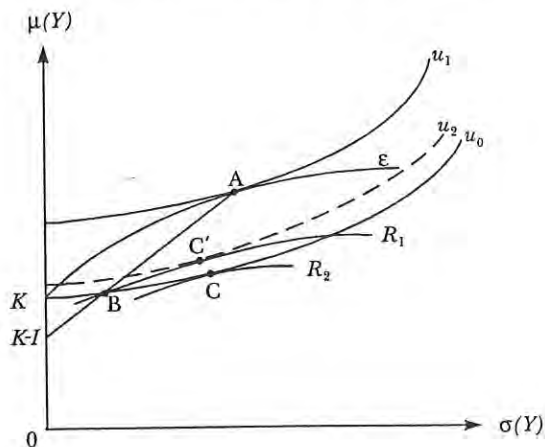
$$s(\mu_D, \sigma_D) > s(\mu_B, \sigma_B). \quad (6)$$

In appendix 2, we prove analytically the geometric intuition from figure 3, that if the government wants to maximize its expected revenue using the participation contract, it is necessary for the slope of the indifference and the efficiency curves to be equal along the participation line. Since (5) and (6) imply that  $s(\mu_B, \sigma_B) < s(\mu_A, \sigma_A)$ , this can only happen to the right of points A and B. Notice from equation (4), that an increase in  $I$  shifts the participation line parallel to the right. In conclusion, if the government offers the optimal participation contract, it will induce more investment than by giving the firm away. In figure 3, the optimal contract is characterized by points E and C, and induces the level of investment  $I_E > I_A$ . QED

At first, Proposition 3 might appear counter-intuitive because it is not to be expected that reducing the profit of the investor could induce him to increase  $I$ . By introducing the government's iso-revenue curves figure 4 offers, perhaps, a more intuitive explanation of the proposition than the proof does. An iso-revenue curve is the locus in  $(\mu, \sigma)$  space where alternative combinations of the level of investment  $I$  and the investor's rate of participation  $q$  generate the same expected revenue for the government. We prove in appendix 3 that the iso-revenue curves have equal slopes along a participation line. Since the efficiency curve  $\epsilon$  is the iso-revenue curve for a revenue of zero, this means that the iso-revenue curves can be constructed by parallel shifts from the efficiency curve in a south-west direction, along the participation lines. The vertical distance covered by such a shift measures the government's revenue. Let  $i(\mu, \sigma)$  be the slope of an iso-revenue curve at

the combination  $(\mu, \sigma)$ .

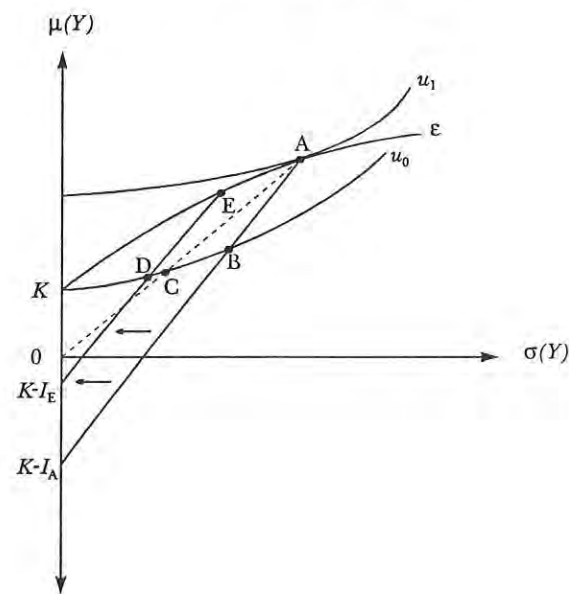
Figure 4: *Competitive Bidding and Iso-revenue Curves*



Suppose that the government offers an investor the contract characterized by point B. Since B and A are on the same participation curves, it follows that  $s(\mu_A, \sigma_A) = i(\mu_B, \sigma_B)$  and obviously (5) and (6) imply that an iso-revenue curve,  $R_1$  in figure 4, intersects the indifference curve  $u_0$  from below at point B:  $i(\mu_B, \sigma_B) > s(\mu_B, \sigma_B)$ . We conclude that the investor can make a credible offer,  $C'$  in figure 4, where he receives a higher participation rate  $q$ , invests more, obtains a higher level of utility, and keeps the expected revenue of the government constant. However,  $C'$  is not an equilibrium. Competitive bidding will guarantee that contracts with lower participation rates for the investor and higher revenues for the government are offered. At the optimal contract C, the iso-revenue curve  $R_2$  is tangent to the indifference curve  $u_0$ . There is no other contract which would make the investor better off without reducing the revenue of the government. Since C is below the original participation line, it implies a higher level of investment than A.

As is obvious from the above discussion, the main reason for the investment stimulus is that the introduction of the participation contract reduces the investor's local marginal risk aversion. The negative wealth effect of paying dividends to the government increases the local marginal risk aversion, but the risk reduction resulting from the participation contract reduces the local marginal risk aversion even more. While we believe that the assumptions underlying this constellation are plausible, there are others that would change the sign of the net effect of the two forces. The next proposition clarifies this.

Figure 5: *Cash Gifts Can Dominate*



**Proposition 4:** *When the preferences of the investor exhibit constant or decreasing relative risk aversion and the optimal investment under the giveaway policy is larger than the investor's wealth then the participation contract yields less investment than giving the firm away.*



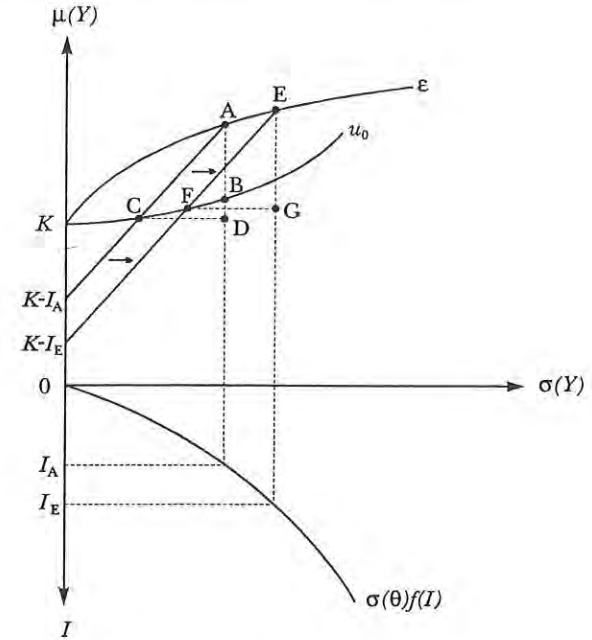
**Proof:** The present proof parallels the proof of Proposition 3. Again, point A characterizes the optimal plan of the investor, when the agency gives the firm away. By assumption  $K - I_A < 0$ , and, therefore, point B is to the right of C. From the convexity of  $u_0$ , we know that:  $s(\mu_B, \sigma_B) > s(\mu_C, \sigma_C)$ . Also, the preferences exhibit constant or decreasing relative risk aversion, thus:  $s(\mu_C, \sigma_C) \geq s(\mu_A, \sigma_A)$ . Obviously, the slope of the efficiency curve at the point A is flatter than the slope along  $u_0$ , at the point B:  $s(\mu_B, \sigma_B) > s(\mu_A, \sigma_A)$ . The curvatures of the efficiency curve and of  $u_0$  guarantee that a reduction in investment, which shifts the participation curve to the left, will increase the expected revenue of the agency. QED

5. The Optimal Contract

Proposition 1 showed that the participation contract is a good revenue raiser when the level of investment is given, and Propositions 2 and 3 showed that this contract may generate more investment than the cash-sales contract or even a giveaway scheme. This suggests that the participation contract dominates the cash-sales contract. However, as shown by Proposition 4, this implication rests on special assumptions. Moreover, of course, it is unclear whether the revenue comparison of Proposition 1 generalizes to the case of endogenous investment. In this section, we use a different argument to prove that, under the assumptions of our model, in all cases the participation contract dominates the cash-sales contract.

**Proposition 5:** *In the case where the investors are risk averse and the government is risk neutral, the participation contract dominates the cash-sales contract. It generates both higher expected revenue and a higher level of reorganization investment.*

Figure 6: Cash-Sales vs. Participation Contract



**Proof:** Consider figure 6. Point A characterizes the optimal cash sales contract. Thus, the slope of the efficiency curve in A and the slope of the indifference curve in B are equal. Suppose we keep the level of investment constant at  $I_A$ . From Proposition 1, we know that the associated participation contract yields a higher expected revenue and is characterized by the point C. The convexity of  $u_0$  implies:

$$s(\mu_C, \sigma_C) < s(\mu_B, \sigma_B) = e(\mu_A, \sigma_A)$$

where  $e(\mu, \sigma)$  denotes the slope of the efficiency curve. Therefore, from appendix 2, we know that the government can further increase its expected revenue. The curvatures of the

efficiency curve and  $u_0$  imply that the optimal level of investment is larger than  $I_A$ . In the figure, the optimal contract is characterized by the level of investment  $I_E$ , because this level implies that the efficiency curve and the indifference curve have the same slope along a participation line:  $e(\mu_E, \sigma_E) = s(\mu_F, \sigma_F)$ . The government's expected cash flow now is EG. Obviously,  $EG > AD > AB$ , where AD is the government's revenue from the participation contract with constant investment, and AB is the government's revenue from the cash-sales contract. QED

Proposition 5 shows that, from a pure revenue perspective, the participation contract dominates the cash-sales contract for two reasons. First, because the government provides a partial insurance and earns a risk premium (Proposition 1). Second, because competitive bidding with the participation contract induces a higher level of investment and a higher value of the aggregate cash flow available to both parties. This result stands the opinion of the Scientific Advisory Committee to the German Ministry of Economics, which was cited in the introduction, on its head, and it supports the minority's recommendation of the participation model.

### 6. Incentive Compatibility

In the next two sections, we discuss generalizations by introducing asymmetric information between the potential investors and the government. In this section, we model the idea that investors have more accurate information than the agency does about the state of the firm – meaning its ability to generate profit. Specifically, we assume that the functional form  $f(I, z)$  is common knowledge, but that  $z$ , which parameterizes the profitability of the firm, is observable by the investor only. The investor may convey his information to the government, but the government cannot verify its truth. We impose the restrictions  $f_z, f_{Iz} > 0$ . Thus, a larger  $z$  denotes a more profitable firm and higher marginal rate of return to

investment.<sup>7</sup> Geometrically, these assumptions guarantee that an increase in  $z$  shifts the efficiency curve upward and that for every  $I$  the slope of the efficiency curve increases.<sup>8</sup> Examples of what we have in mind are patents, land sites, know how, or teams of workers whose use requires complementary capital investment. The government does not know whether, or to what extent, such investment makes sense, and it has to rely on the estimates given by the buyers.

In the remainder of this section, we show that, irrespective of the information asymmetry, the optimal solution described in sections 4 and 5 remains attainable. Initially, disregarding the information asymmetry, we denote the optimal participation bidding mechanism  $M$ , described by an investment function and a participation function  $M = \{\bar{I}(z), \bar{q}(z)\}$ . We will prove that  $M$  is incentive compatible. If a buyer reveals  $z$ , the government calculates and imposes the corresponding values of the participation rate  $q$  and the amount of investment  $I$  which extract the investor's rent as described in the previous section. The government then calculates the resulting cash-flow distribution and assigns the property to the bidder who reveals the highest  $z$  and whose information therefore promises the highest expected revenue for the government. The bidders can lie about  $z$  and try to manipulate the conditions of the contract, but we will show that it is in their interest not to do so. Revealing a false value of  $z$  will either result in a  $(q, I)$  contract that is unattractive to the investor or brings the risk that other investors will make higher bids.

Before proving this result, we note that our complementarity assumption  $f_{Iz} > 0$  implies that the optimal level of investment  $I$ , as derived in the previous section, is a strictly increasing function of  $z$ . In figure 7,  $\varepsilon(z)$  denotes the efficiency curve when the

<sup>7</sup>The second inequality is a single crossing requirement. This type of assumption is very common in asymmetric information problems.

<sup>8</sup>This result follows immediately by differentiating (A.1) from appendix 1:

$$\frac{d}{dz} e(\mu_I, \sigma_I) = \frac{d}{dz} \left[ \frac{\mu(\theta) f_I(I, z) - 1}{\sigma(\theta) f_I(I, z)} \right] = \frac{\sigma(\theta) f_{Iz}(I, z)}{[\sigma(\theta) f_I(I, z)]^2} > 0$$

level of profitability is  $z$ . We consider the case of two alternative profitability levels  $z_1$  and  $z_0$ , where  $z_1 > z_0$ . Point A characterizes the optimal participation contract for  $z = z_0$ . Thus, the slopes at points A and B are equal. Consider now state  $z_1$ . If investment is kept constant at the level  $I_B$ , it will generate the point C along the efficiency curve  $\varepsilon(z_1)$ . Point C is on the same participation line as B, because, from (4), the position of this curve is independent of  $f(I, z)$ . By assumption, the slope of the efficiency curve is steeper at C than at B. The curvatures imply that equalizing the slopes between the indifference curve  $u_0$  and  $\varepsilon(z_1)$  will require the participation line to shift to the right towards points E and D, thereby increasing investment from  $I_B$  to  $I_E$ .

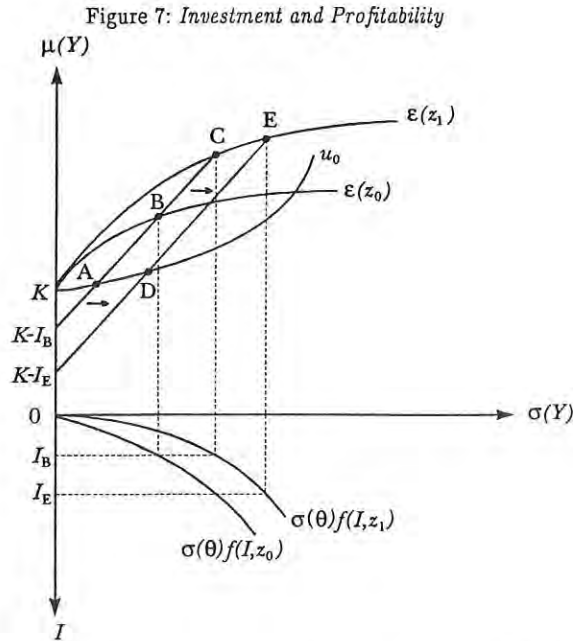


Figure 7: Investment and Profitability

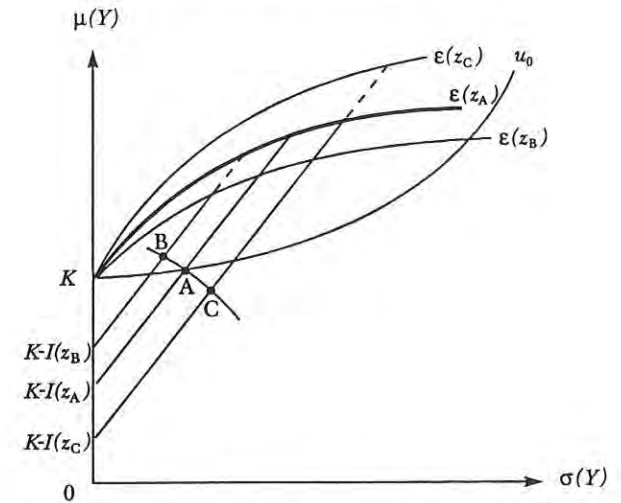
Since the level of investment,  $I$ , is strictly monotonic in  $z$ , there exists an equivalent bidding mechanism to  $M$ ,  $M^* = \{q^*(I)\}$ , where

$$q^*(I) = \bar{q}[\bar{I}^{-1}(I)]$$

This suggests, as a solution to the information asymmetry, letting the investors bid in  $I$ , giving the firm to the investor who offers the highest level of investment at the participation rate  $q^*(I)$ . The next proposition shows that this procedure, indeed, overcomes the information asymmetry between investors and the agency.

**Proposition 6:** *Bidding in  $I$  according to the mechanism  $M^*$  will implement the participation mechanism as in the foregoing section despite the information asymmetry.*

Figure 8: Truthful Revelation



**Proof:** For the sake of argument assume that, initially, the agency randomly selects one investor as owner of the firm, offers the contract type  $M^*$ , and asks the investor to make an investment offer. Using figure 8, it is easy to show that the randomly selected investor will *not* bid optimally.

Assume the true profitability is  $z_A$ . If the investor bids  $I = \bar{I}(z_A)$ , he will reach point A. Suppose the investor wants to suggest that  $z_B$  is true and bids  $I = \bar{I}(z_B)$  instead, with  $z_B < z_A$ . The participation rate,  $q = q^*[\bar{I}(z_B)]$ , has been calculated in such a way that, when the investor tells the truth, his utility is reduced to  $u_0$ . Since the investor understates the profitability of the firm, he must attain a better position, like point B. The curve AB yields the  $(\mu, \sigma)$  combinations where the investor understates the profitability of the firm by alternative degrees and, therefore, underinvests.

Understating the profitability makes sense when the investor has no rivals, but not when he participates in a competitive bidding process. In a competitive bidding process a point like B in figure 8 is not attainable, since there are other investors who are willing to offer higher investment volumes, those that fit the true efficiency curve better. Ultimately the investors will bid the entire rent away, offer  $I = \bar{I}(z_A)$ , and attain the level of utility  $u_0$ .

Overstating the profitability is not attractive either. Suppose the investor bids  $I = \bar{I}(z_C)$  with  $z_C > z_A$ , knowing that the government requires  $q = q^*[\bar{I}(z_C)]$  to extract the rent that would be available if  $z_C$  were true. This reduces the investor to a point like C which is below his initial utility level  $u_0$ . QED

Obviously, there is no incentive to cheat. Since the bidding mechanisms  $M$  and  $M^*$  are equivalent, this immediately gives another result.

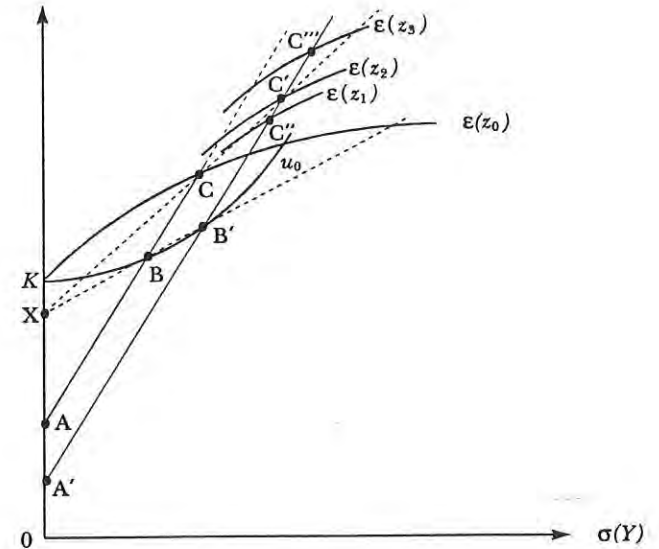
**Proposition 7:** *Investors will truthfully reveal their knowledge of the firm's profitability  $z$  when a competitive participation mechanism is applied.*

To conclude this section we note that, under our assumptions, it is not in general possible to design a bidding mechanism which is based on the participation rate  $q$  rather than the investment level  $I$ . At first glance,  $q$  and  $I$  seem to have symmetrical roles such that it is possible to replace the mechanism  $M = \{\bar{I}(z), \bar{q}(z)\}$  with  $M^{**} = \{I^{**}(q)\}$  where

$$I^{**}(q) = \bar{I}[\bar{q}^{-1}(q)]$$

and then assign the firm to the bidder who accepts the lowest participation rate. It is easy to show, however, that  $q$  cannot reveal the investor's information because the inverse of the participation function  $\bar{q}$  does not in general exist. This implies the following statement.

Figure 9: *Ambiguity in the Value of  $q$*



**Proposition 8:** *Bidding in  $q$  according to the mechanism  $M^{**}$  will not, in general, be able to implement the participation mechanism  $M$ .*

**Proof:** It is sufficient to prove that, under the assumptions made,  $q$  may be rising or falling with  $z$ . In figure 9,  $z_0$  yields the participation line ABC and  $\bar{q}(z_0)$  is given by the ratio



AB/AC. Suppose, the profitability increases to  $z_2$  so that the efficiency curve shifts to  $\varepsilon(z_2)$ . The condition that there be equal slopes of the efficiency and utility curves now defines the new participation line  $A'B'C'$  such that  $\bar{q}(z_2) = A'B'/A'C'$ . By construction C and C', B and B', A and A' are all on rays through a point X on the ordinate. Thus  $\bar{q}(z_0) = \bar{q}(z_2)$ . The efficiency curve  $\varepsilon(z_2)$  is the borderline case between an increase and a decline of  $q$  as a reaction to an increase of  $z$ . Obviously  $\bar{q}(z_3) = A'B'/A'C'' < \bar{q}(z_0)$  and  $\bar{q}(z_1) = A'B'/A'C' > \bar{q}(z_0)$ . Since  $\varepsilon(z_1)$ ,  $\varepsilon(z_2)$ , and  $\varepsilon(z_3)$  are all compatible with the assumption that, given  $I$ , the slope of the efficiency curve increases with  $z$ ,  $q$  cannot reveal the underlying value of  $z$ , and thus cannot be used for a bidding process. QED

The last proposition may serve as a warning to those who believe that the government's participation (or tax) rate  $1 - q$  can be used in an auction in a way that parallels the cash price in a standard auction. Proposition 6 makes it clear that the planned and promised level of reorganization investment is much better suited for that purpose.

### 7. Moral Hazard

A criticism frequently raised in the German debate on the participation model was that it might reduce the private investment incentive, because, it was maintained, the government participates in the investor's returns but not in his expenses. It has been shown above that the basic fear behind this argument is unwarranted. The simultaneity in the choice of revenue maximizing values of  $q$  and  $I$  creates a stronger investment incentive than revenue maximization does with the cash-sales method. Nevertheless the argument points to three possible incentive problems that are worth discussing in more detail.

The first concerns the incentives for *future* investment. Such incentives are created in the participation model in three possible ways, depending on whether retained earnings or new capital injections are the source of equity finance. When, as is normally the case in private firms, retained earnings are the source of finance, the government fully

shares the cost of investment to a degree given by its own participation or tax rate  $1 - q$ . When the rare case occurs that the investor plans additional equity injections, the government can choose between two options. One is contributing its fair share  $1 - q$  by also injecting more funds. The other is not contributing at all and accepting an increase in the investor's participation rate  $q$  instead. In the present, atemporal, model these constellations have not been formalized explicitly. However, the first two of them are implicitly captured by defining  $\theta f(I)$  as the present value of the net cash flow generated by the firm, and it is obvious that the third constellation will preserve the investment incentives in the future.

The second, more serious, incentive problem concerns *unobservable and non-contractable* resource transfers from the investor to the firm. It is true that the investor has every reason to document and prove such transfers carefully because he wants his bid to win, or to receive the government's fair equity contribution, or to increase his participation rate. However, there are some resources that cannot easily be documented. Specifically, it will be very difficult to measure the real cost associated with the transfer of managerial know-how. Suppose an investor reallocates one of his managers to the new firm. The real cost of this transfer depends on the manager's alternative occupation, information which, in general, will not be available to the government.

For the sake of argument, we assume that the investor's post-contract wealth takes the following form:

$$Y = q \theta f(I_1, I_2) - I_1 - I_2 - P - K$$

where the variables  $I_1$  and  $I_2$  denote contractable and non-contractable investments respectively. That is, in  $I_2$  we sum up all the non-contractable decision variables. We analyze optimal blends between the participation and cash sales contracts defined by  $I_1$ ,  $q$ , and  $P$  and start by discussing two extreme cases.

First, consider the case where all the investments are contractable; i.e.,

$f_2 = 0$ . In this case, the participation model is fully applicable. In fact, it is easy to see from figure 1 that, in this case, the participation model is so attractive for the investors that a revenue maximizing and rent extracting government should set the investor's participation rate equal to zero,  $q = 0$ , and "charge" a negative cash price equal to the volume of reorganization investment:  $P = -I_1$ . The government would thereby effectively abandon privatization and earn a full-insurance risk premium. Of course, this solution would violate a number of incentive requirements and political constraints outside the model, but it is a theoretical extreme which highlights an important potential for welfare gains from the participation contract.

The second extreme case is where none of the investments are contractable, i.e.,  $f_1 = 0$ . In this instance,  $P > 0$  and the optimal participation rate of the investor will be close to one, because the moral hazard problem reduces the possibility of insuring the investor. Note, however, that even in this case optimal risk sharing will require some participation of the government:<sup>9</sup>  $q < 1$ . The intuition is straightforward. For  $q = 1$  investments are first-best, the derivative of utility with respect to investment is zero. Thus small changes in  $I$  will only lead to second order changes in utility. On the other hand, changes in  $q$  will have first order effects.

In the intermediate case, the optimal participation rate will be in between the two extremes. A policy which sets  $P = 0$  and requires potential investors to bid in  $q$  and in the level of contractable investment  $I_1$  might be a justifiable approximation.

The third incentive problem is the possibility of asset stripping. In order to make the participation contracts attractive for private investors it is necessary that the government's participation does not imply voting rights. However the absence of voting rights makes the government vulnerable to a fraudulent erosion of the firm's equity base by selling assets to other firms controlled by the investor at below market prices. This problem is the same as with any company tax system, and its only solution is to give the

<sup>9</sup>For a related discussion see Shoven (1979).

government extensive rights to monitor the behavior of the firm and punish asset sales that do not satisfy the arm's length principle. Fortunately, the marginal costs of establishing such a monitoring system would be low, since it would have to be established anyway if a corporate tax system is to be introduced.

### 8. Conclusions: Privatization with Incomplete Risk Markets

Privatizing the communist firm is not the same as privatizing British Telecom. It is true, in a well functioning market economy with developed capital and risk markets there is a good case for privatization via cash auctions. If the firm to be privatized is profitable, bidders can easily raise the cash needed to pay the government and they can also find insurance in the risk markets. For example, they can raise the funds needed and load the risks involved on many people's shoulders by reselling all or part of the privatized firm in the stock market. It is well known from the work of Mintz (1982) and others that, with well functioning stock markets, mixed enterprises cannot improve the allocation of risk bearing.<sup>10</sup> How could it then be expected that the establishment of such corporations via participation auctions would be an efficient way of privatizing the communist firm.

This statement may even be true, when information asymmetries create adverse selection problems and make the capital and risk markets incomplete. When the government has no superior knowledge there may be very little it can do to improve the privatization procedure by trying to replace the missing market contracts.<sup>11</sup>

The situation is very different, though, with the actual privatization problems faced by the former communist countries of the East. These countries have no

<sup>10</sup>Cf. also Bulow and Summers (1984) or Gordon (1985).

<sup>11</sup>This view is expressed by Konrad (1991) who considers risk markets with interior, partial coverage insurance solutions. Discussions of the virtue of government risk sharing under less ideal conditions can be found in Mintz (1979) or Boardman, Eckel and Vining (1982).

credit markets and no risk markets, and yet they have to privatize their firms as quickly as they can. Establishing risk and credit markets before privatization is simply not an option. Creating the legal framework for these markets takes years, and even if the laws could be put in place quickly, private market agents first had to learn how they function. But how can they learn *before* privatization takes place? Surely, privatization has to precede the creation of the markets.

Communist dictatorship was not an adverse selection problem, and the state is the only financial and risk-consolidating agency available. There can be little doubt that, under these circumstances, the plain cash sales contract loses many of its virtues and that the participation contract is an attractive alternative. The participation contract mitigates the problem of missing capital markets because it allows the investor to pay later, and it mitigates the problem of missing risk markets because it allows the investor to pay only if, and to the extent that, distributable profits become available. The latter aspect has been studied in this paper. We have shown that, with a competitive bidding process, the participation contract will generate more revenue for the government than cash sales and, what is more, that it will also induce more private investment. Under plausible conditions the participation contract can be expected to generate even more investment than giving the firms away would, and its virtues are likely to remain if there are asymmetric information problems.

Compared to the countries of the East, Germany's case is less obvious because there are capital and risk markets which, in principle, make the cash sales strategy worth considering. However, there are a number of reasons why we believe the participation contract to be superior even there.

First, the poverty of the East Germans makes it difficult for them to borrow. Banks impose credit constraints which are a certain multiple of the available equity capital, but if someone has no equity he receives no credit. The poverty is not the result of the inefficiency of communist production, but an implication of the currency exchange program. East Germans received exactly the amount of transactions cash necessary to

match the West German velocity ratio, but they were not given the financial wealth which, in a market economy, would have backed the existing stock of real assets. East Germans are therefore unable to buy this stock from the Treuhand.

Second, the poverty of the East Germans creates excessive risk aversion. Even the most lucrative investment chances are unable to make them risk substantial commitments. Small wonder that, thus far, only 5 % of the Treuhand sales have involved East German buyers.

Third, the West German stock market is chronically underdeveloped, unable to diversify the Treuhand risks. There are excessively high legal entry barriers that have effectively prevented Treuhand firms from being sold via this market. The Treuhand has sold or given away thousands of firms, but only in one case has it been able to sell a firm in the stock market. Of course, it would have been possible for Germany to establish a new "junk bond" market tailored to the special needs of the East German firms, but this was never considered as a serious political option. The German stock market's inability to support the privatization of the East German economy is an extreme case of policy failure.

At first sight it might be tempting to believe that the difficulties of selling the East German firms directly in the stock market could be overcome by selling them indirectly in this market via West German partner firms. The West German firms could buy the East German firms and issue new shares in the stock market to spread the financial risks over many shoulders. However, the West German firms that are supposed to buy the Treuhand properties are mostly entrepreneurial firms or partnerships with no more than a handful of owners. There are only about 600 publicly traded stock companies in Germany, and no more than one tenth of these has a diversified ownership (in the sense that there is no single majority owner). West Germany is not comparable with the UK, let alone the US. Developed risk markets that could absorb the Treuhand risks are simply not available. The peculiar German way of organizing the financial markets may have had advantages under the steady and stable conditions of the past. However, the unexpected flood of entrepreneurial risks that came with unification has overexhausted the risk bearing

capacity of the existing financial system. Under these circumstances the cash and give away privatization strategies of the Treuhand are not beyond doubt.

Originally, the German Treuhand had forecast that it would be able to earn a revenue of about DM 600 b. Now, after seeing the revenue it is actually collecting, even the more optimistic forecasts do not place the total revenue at more than DM 60 b., one tenth of the original value. Given this huge discrepancy, there is every reason to think about alternative privatization procedures. This paper discussed one.

## A 1

*Appendix 1:* In this section, we prove analytically that the efficiency curve is concave. The efficiency curve,  $\varepsilon$ , is defined as the total  $(\mu, \sigma)$  relationship generated by different levels of investment when  $P=0$  and  $q=1$ . The  $(\mu, \sigma)$  combination follows from the level of investment, specifically:

$$\mu_I = \mu(\theta)f(I) - I + K$$

$$\sigma_I = \sigma(\theta)f(I)$$

Let  $e(\mu, \sigma)$  denote the slope of the efficiency curve at the combination  $(\mu, \sigma)$ . Obviously,

$$e(\mu_I, \sigma_I) = \frac{\partial \mu_I / \partial I}{\partial \sigma_I / \partial I} = \frac{\mu(\theta)f'(I) - 1}{\sigma(\theta)f'(I)} \quad (\text{A.1})$$

Further differentiating the above expression with respect to investment, yields:

$$\frac{d}{dI} e(\mu_I, \sigma_I) = \frac{\sigma(\theta)f''(I)}{[\sigma(\theta)f'(I)]^2} < 0 \quad (\text{A.2})$$

that is, the slope of the efficiency curve decreases as investment goes up. Since  $\sigma_I$  is increasing,

$$\frac{d\sigma}{dI} = \sigma(\theta)f'(I) > 0,$$

(A.2) also proves that the efficiency curve is concave. QED

## A 2

*Appendix 2:* In this section, we prove the geometrical claim discussed in Proposition 3, that the optimal participation contract requires that the indifference and the efficiency curve have equal slopes. The optimal government's participation contract solves the following problem:

$$\begin{aligned} & \text{Max}_{q, I} (1-q)\mu(\theta)f(I) \\ & \text{s.t. } u[q\mu(\theta)f(I) - I - P + K, q\sigma(\theta)f(I)] \geq u_0. \end{aligned}$$

Differentiating the appropriate Lagrangian with  $q$  and  $I$  respectively, yields two first-order conditions:

$$-\mu(\theta)f'(I) + \lambda[u_\mu \mu(\theta)f'(I) + u_\sigma \sigma(\theta)f'(I)] = 0, \quad (\text{A.3})$$

$$(1-q)\mu(\theta)f'(I) + \lambda\{u_\mu[q\mu(\theta)f'(I) - 1] + u_\sigma q\sigma(\theta)f'(I)\} = 0. \quad (\text{A.4})$$

where  $\lambda$  is the Lagrange multiplier. From (A.3) we see that  $\lambda$  is non-zero, that is, the constraint is always binding and the agency extracts the entire rent from the investor. Dividing (A.3) by  $f'(I)$  yields the equality:

$$\mu(\theta) = \lambda[u_\mu \mu(\theta) + u_\sigma \sigma(\theta)]. \quad (\text{A.5})$$

Substituting this expression into (A.4), further yields:

$$\mu(\theta)f'(I) = \lambda u_\mu.$$

Finally, using (A.5) to eliminate  $\lambda$ , we obtain:

$$f'(I) = \frac{u_\mu}{u_\mu \mu(\theta) + u_\sigma \sigma(\theta)}.$$

This equality can easily be transformed to the necessary condition:

$$-\frac{u_\sigma}{u_\mu} = \frac{\mu(\theta)f'(I) - 1}{\sigma(\theta)f'(I)}.$$

This concludes the proof: the left hand side of the above equation is the slope of the indifference curve and, from (A.1), the right hand side is the slope of the efficiency curve. QED



*Appendix 3:* In this appendix we prove that, along the participation line (4), the government's iso-revenue curve has the same slope, regardless of the revenue level  $R$ . With the participation contract ( $P = 0, q \geq 0$ ) the iso-revenue condition is:

$$R \equiv (1-q) \mu(\theta) f(I) = \text{const.}$$

Solving for the parameter  $q$  and substituting into the definitions of the expected value and the standard deviation of  $Y$ , (1) and (2), yields:

$$\mu(Y) = \mu(\theta) f(I) - R - I + K \quad (\text{A.6})$$

$$\sigma(Y) = \sigma(\theta) f(I) - R \frac{\sigma(\theta)}{\mu(\theta)} \quad (\text{A.7})$$

Equations (A.6) and (A.7) define the iso-revenue curve in  $(\mu, \sigma)$  space for alternative levels of revenue  $R$ . Differentiating the two equations for  $I$  gives the slope of an iso-revenue curve:

$$i[\mu(Y), \sigma(Y)] = \frac{\partial \mu(Y) / \partial I}{\partial \sigma(Y) / \partial I} = \frac{\mu(\theta) f'(I) - 1}{\sigma(\theta) f'(I)} .$$

The slope is a function of  $I$ , which is constant along a participation curve, but not a function of  $R$ , and obviously it is the same as the slope of the efficiency curve as given by (A.1). QED

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