DISCUSSION PAPER SERIES

No. 7056

PUBLIC VERSUS PRIVATE OWNERSHIP: QUANTITY CONTRACTS AND THE ALLOCATION OF INVESTMENT TASKS

Eva I. Hoppe and Patrick W. Schmitz

INDUSTRIAL ORGANIZATION

Centre for Economic Policy Research

www.cepr.org

Available online at: **www.cepr.org/pubs/dps/DP7056.asp**

ISSN 0265-8003

PUBLIC VERSUS PRIVATE OWNERSHIP: QUANTITY CONTRACTS AND THE ALLOCATION OF INVESTMENT TASKS

Eva I. Hoppe, University of Cologne
Patrick W. Schmitz, University of Cologne and CEPR

Discussion Paper No. 7056
November 2008

Centre for Economic Policy Research
53–56 Gt Sutton St, London EC1V 0DG, UK
Tel: (44 20) 7183 8801, Fax: (44 20) 7183 8820
Email: cepr@cepr.org, Website: www.cepr.org

CEPR Discussion Paper No. 7056

November 2008

ABSTRACT

Public Versus Private Ownership: Quantity Contracts and the Allocation of Investment Tasks*

The government wants a certain good or service to be provided. Should the required assets be publicly or privately owned or should a partnership be formed? Building on the incomplete contracting approach, we argue that the initially specified quantity of an ex ante describable basic good can have important effects on investment incentives, which has been neglected in the literature so far. We also study how the tasks of investing in quality improvements and cost reductions should be assigned. We show how the optimal contracts and governance structures depend on the exogenous parameters of the model such as the nature of the investments and the parties' bargaining powers.

JEL Classification: D23, D86, H11 and L33
Keywords: contractible control, incomplete contracts and privatization

Eva I. Hoppe
University of Cologne
Albertus-Magnus-Platz
D-50923 Cologne
GERMANY
Email: eva.hoppe@uni-koeln.de

For further Discussion Papers by this author see:
www.cepr.org/pubs/new-dps/dplist.asp?authorid=169078

Patrick W. Schmitz
University of Cologne
Albertus-Magnus-Platz
D-50923 Cologne
GERMANY
Email: patrick.schmitz@uni-koeln.de

For further Discussion Papers by this author see:
www.cepr.org/pubs/new-dps/dplist.asp?authorid=149900

* We would like to thank Andrea Leuermann, Andreas Roider, Dirk Sliwka, Achim Wambach, and seminar participants in Heidelberg and Cologne for helpful comments and discussions. Moreover, we are grateful to David Kusterer and Florian Gössl for excellent research assistance.

Submitted 11 November 2008

1 Introduction

This paper offers a new perspective on the boundaries between public and private firms. Suppose the government wants a certain good or service to be provided. Who should be the owner of the essential assets that are required to provide the good? According to the property rights approach to the theory of the firm, ownership structures (i.e., the allocation of control rights over non-human assets) matter when only incomplete contracts can be written. In the present paper, we study how the assignment of investment tasks and simple contracts that specify a quantity of a basic good to be provided interact with the ownership structure to induce investments in innovations.

Specifically, we consider the following framework which is in the spirit of Hart, Shleifer, and Vishny's (1997) seminal work on incomplete contracts and privatization. Society, represented by the government G, writes a contract with a manager M who is supposed to provide a good or service. After the contract which specifies the characteristics of a basic version of the good has been written, two kinds of observable but unverifiable investments can be made. First, it is possible to invest in the development of a quality innovation which (if implemented) increases the government's benefit from the good. Yet, the quality innovation also has the side effect of increasing the costs of provision. Second, it is possible to invest in a cost innovation which (if implemented) reduces the manager's costs, but also lowers the quality of the provided good. Hence, the implementation of an innovation leads to an (ex ante non-contractible) modification of the good actually provided. Both kinds of innovations are efficient; i.e., their desired effects outweigh their negative side effects. However, the implementation of innovations requires access to the essential assets. Under public ownership, the government controls the assets, so that it has the right to approve or veto the implementation of innovations, while under private ownership the manager can decide whether or not innovations are implemented.

Our model differs from Hart, Shleifer, and Vishny's (1997) analysis in three important ways. First, we follow their assumption that "G and M are able to write a long term contract specifying some aspects of the good or service to be provided" (p. 1132). Yet, while they assume that the quantity specified in the contract is always at its first-best level, we show that ex ante the parties may actually prefer to agree on an ex post inefficient quantity, which will later be renegotiated to its first-best level.[1]

[1] The fact that for strategic reasons parties might deliberately agree on ex post inefficient clauses in an initial contract that will be renegotiated later has also been pointed out by Huberman and

Second, we depart from the standard property rights approach by assuming that the investment tasks are "contractible control actions" in the sense of Aghion, Dewatripont, and Rey (2002, 2004); i.e., while the investment levels are non-contractible, it is possible to contractually specify who is in charge of which task. In contrast, Hart, Shleifer, and Vishny (1997) assume that the manager is always in charge of both tasks.

Third, in addition to public and private ownership, we consider two kinds of partnerships where the parties are in symmetric positions. In particular, either both parties can veto the implementation of innovations, or they have no veto power at all; i.e., if one party wants to implement an innovation, it is free to do so.[2]

As we combine four different ownership structures with four possible task assignments, there are altogether 16 governance structures which we analyze. It will turn out that only five governance structures can actually be optimal.

Under private ownership, the manager should always be in charge of the investment in cost innovation, while it depends on the parties' relative bargaining powers who will be responsible for the quality investment. Similarly, under public ownership the government should be in charge of the investment in quality innovation, while the responsibility for the cost investment depends on the bargaining powers. Finally, if the parties agree on a partnership, then no one will have veto power and they assign the cost investment to the manager and the quality investment to the government.

Different allocations of ownership rights imply markedly different patterns of investments. In particular, under private ownership the investment in cost reduction is at its first-best level, while there is underinvestment in the development of quality improvements. Hart, Shleifer, and Vishny (1997) argue that private ownership leads to overinvestment in cost reduction, because the manager disregards the side effect of the cost innovation (as she has the right to implement the innovation without having to compensate the government for the reduced quality). Yet, the overinvestment result crucially relies on their implicit assumption that the ex ante specified quantity of the basic good is the ex post efficient one. In general, the manager's investment in cost reduction is an increasing function of the quantity specified in the

Kahn (1988) in a different context.

[2] Shared authority and joint ownership with bilateral veto power have recently also been considered by Francesconi and Muthoo (2006) in the framework of Besley and Ghatak (2001), where a nongovernmental organization directly benefits from the provision of a public good. See also Bös and De Fraja (2002), Hart (2003), Bennett and Iossa (2006a,b), and Martimort and Pouyet (2008), who discuss other aspects of private-public partnerships from an incomplete contracts perspective.

initial contract. If the ex ante specified quantity is small, then the investment yields only a small return in the absence of renegotiation. When the parties renegotiate, the manager will get only a fraction of the additional total return (cost savings net of benefit reduction) generated by her investment. Hence, if the parties initially specify a sufficiently small quantity, there is underinvestment, while a suitably chosen intermediate quantity leads to the first-best investment level. In contrast, the quality investment is independent of the ex ante specified quantity, because under private ownership the manager would not implement the quality innovation in the absence of renegotiation. This means that the quality investment is carried out only because successful renegotiation of the implementation decision is anticipated (and as a consequence, the incentives to invest in quality depend on the parties' bargaining powers in the renegotiations).

Similarly, under public ownership first-best investments in quality improvement are attainable by specifying the appropriate quantity of the basic good in the initial contract, while there is always underinvestment in cost reduction.

In a partnership where no party has veto power, both kinds of innovations are implemented even in the absence of renegotiations, because the manager chooses to implement the cost innovation and the government implements the quality innovation. Hence, renegotiation will occur only with regard to the quantity. The manager's incentives to invest in cost reduction are the same as under private ownership, while the government's incentives to invest in quality are the same as under public ownership. This means that now both investments depend on the ex ante specified quantity. However, in general the quantity that induces first-best cost investments will be different from the one that induces first-best quality investments. In other words, there are two goals that the parties must try to attain with only one instrument. It will turn out that the parties then agree on a quantity which induces overinvestment with regard to one task and underinvestment with regard to the other task.

Which governance structure is the optimal one depends on the importance of the cost innovation, its adverse effect on quality, the importance of the quality innovation, its cost-increasing side effect, and the parties' bargaining powers. Roughly speaking, if one party has a sufficiently large bargaining power, then the extent of the underinvestment in one task (which is the only disadvantage of ownership by a single party) becomes arbitrarily small, so that a partnership cannot be optimal. In contrast, if the parties' bargaining powers are almost equal, then the underinvestment problem under single ownership will turn out to be most severe, which makes ownership by a single party less attractive. Whether private or public ownership will be preferred depends on the relative strengths of the side effects caused by the innovations. If the side effect of the cost (quality) innovation becomes very large, so that inducing cost (quality) investment is relatively unimportant, then public (private) ownership is optimal (because then the first-best investment in the important innovation is induced). In contrast, if the side effects of both innovations almost disappear, then a partnership with no veto power must be optimal, because overinvestment (which is the partnership's drawback compared to single ownership) is no longer a problem.

Our paper brings together different strands of literature. First, there is by now a huge literature on the pros and cons of privatization. For surveys, see e.g. Vickers and Yarrow (1988), Bös (1991), Shleifer (1998), and Martimort (2006). Second, our paper contributes to the growing literature on the property rights approach to the theory of the firm based on incomplete contracting as pioneered by Grossman and Hart (1986) and Hart and Moore (1990); see Hart (1995) for a comprehensive survey.[3] While several authors have investigated the issue of privatization from an incomplete contracts perspective, many of these papers rely on informational asymmetries (e.g., Shapiro and Willig, 1990, Laffont and Tirole, 1991, Schmidt, 1996a, 1996b). In contrast, following Hart, Shleifer, and Vishny (1997), we assume throughout that there is symmetric information between the government and the manager. Third, to the best of our knowledge, the present paper is the first one that analyzes an incomplete contracting model in the tradition of Grossman and Hart (1986) when the investments are "contractible control actions" in the sense of Aghion, Dewatripont, and Rey (2002, 2004). In standard models of the property rights approach, only ownership rights (i.e., the control over ex post decisions) can be allocated ex ante, while in addition we consider how the investment tasks should be assigned to the parties.[4]

The remainder of the paper is organized as follows. In the following section, the model is introduced. In section 3, we analyze the investment incentives for all assign-

[3]For discussions of the foundations of incomplete contracting, see Hart and Moore (1988, 1999), Che and Hausch (1999), Maskin and Tirole (1999), and Tirole (1999). See also Roider (2004), who studies the interaction of organizational form and quantity contracts in this framework.

[4]Aghion, Dewatripont, and Rey (2002) argue that in traditional moral hazard models, actions are pre-assigned. In contrast, in their "partial contracting" approach they consider contractible control actions which have the property that while their level is non-contractible, it is possible to contractually specify who is in control of such an action. Note that their approach is closely related to the literature on multi-task principal-agent analyses and job design in the tradition of Holmström and Milgrom (1991).

ments of the investment tasks and for all ownership structures, taking into account that quantity contracts are feasible. In section 4, we characterize circumstances under which different governance structures are optimal. Concluding remarks follow in section 5.

2 The model

Consider the following simple model of the public or private provision of a good (or service). At date 0, the government (G) and a manager (M) write a contract which specifies a quantity $q \in [0, 1]$ of a basic good (whose characteristics can be described ex ante) and a payment P_0 from the government to the manager.[5] When the manager provides the basic good, she incurs costs qC_0, while the government's benefit is given by qB_0, where $B_0 > C_0$. The parties also agree on an ownership structure and on an investment task assignment.

Specifically, the ownership structure $o \in \{M, G, J, N\}$ determines who is in control of the essential assets that are needed to provide the good. Under private ownership ($o = M$), the manager has the right to modify the assets in order to implement innovations that may improve quality or reduce her provision costs (and thus may influence the ex ante non-contractible characteristics of the actually provided good). Under public ownership ($o = G$), the government controls the essential assets. Moreover, we consider two kinds of partnerships where both parties are in a symmetric position. Under $o = J$, both parties have veto power, so that no one can implement any innovations without the partner's consent, while under $o = N$ each party has the right to modify the assets to implement innovations.[6]

The task assignment $A \in \{M, G, MG, GM\}$ determines who is in charge of the two types of non-contractible investments that can be made at date 1. The investments

[5] In order to focus on the relationship between G and M, we follow Hart, Shleifer, and Vishny (1997) in assuming that there are no agency problems between the government representative G and society (excluding M). Similarly, agency problems between the manager and the owners of the private firm are also not considered.

[6] Note that $o = J$ corresponds to the standard definition of joint ownership in the property rights theory (see Hart, 1995). In these models, sole ownership gives a party the right to leave the relationship with the assets owned if renegotiations fail (while joint ownership must mean that both parties have veto power, as they cannot simultaneously use the assets for their own purpose). In contrast, in the present context it is reasonable to also consider a partnership with no veto power ($o = N$), because even if renegotiations fail, the assets must be used to provide the basic good and the right to implement innovations may well be given to both parties simultaneously.

are denoted by e and i and they are measured by their costs. The investment $e \in [0, \bar{e})$ aims at developing an innovation to reduce the costs of providing the good. If implemented, such an innovation reduces the manager's costs per unit by $c(e)$, but at the same time it also lowers the quality and thus reduces the government's benefit per unit by $b(e)$. The investment $i \in [0, \bar{i})$ results in an innovation that can improve the good's quality, so that the government's benefit per unit is increased by $\beta(i)$, but at the same time the manager's costs per unit are increased by $\gamma(i)$. The assignment $A = M$ (respectively, $A = G$) means that the manager (respectively, the government) is in charge of both investments. The assignment $A = MG$ (respectively, $A = GM$) means that the manager (respectively, the government) is in charge of investment task e and the government (respectively, the manager) is responsible for investment task i.[7]

Finally, at date 2 the parties may renegotiate the quantity of the good to be provided, the decisions whether or not to implement the innovations, and the payment. Following the standard incomplete contracting approach, the negotiations are modelled using the Nash bargaining solution. The time structure of the model is illustrated in Figure 1.

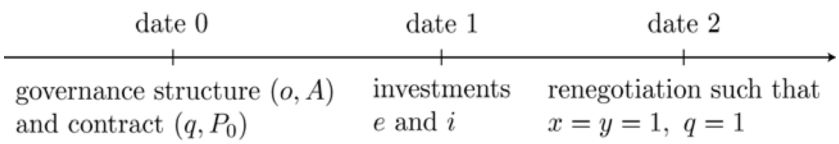

Figure 1. The sequence of events.

The manager's per unit costs of providing the good are given by

$$C(x, y) = C_0 - xc(e) + y\gamma(i),$$

where $x \in \{0, 1\}$ (respectively, $y \in \{0, 1\}$) denotes the decision whether or not the cost innovation (respectively, the quality innovation) is implemented. Similarly, the government's per unit benefit from provision of the good is given by

$$B(x, y) = B_0 + y\beta(i) - xb(e).$$

[7] Following Aghion and Tirole's (1994) work on the management of innovation, we assume throughout that an innovation once made becomes known to both parties. Hence, a party that has the right to implement an innovation can do so regardless of who developed it.

Following Hart, Shleifer, and Vishny (1997), we assume throughout that it is ex post efficient to implement both kinds of innovations. Formally, we make the following assumption for all investment levels $e > 0$ and $i > 0$.

Assumption 1. $c(e) > b(e)$ and $\beta(i) > \gamma(i)$.

For simplicity, let all functions be twice differentiable and let the following technical assumptions be satisfied.

Assumption 2. $c(0) = 0$, $\lim_{e\to 0} c'(e) = \infty$, $c'(\bar{e}) = 0$, $c''(e) < 0$, $b(0) = 0$, $0 < b'(e) < c'(e)$, $b''(e) \geq c''(e)$.

Assumption 3. $\beta(0) = 0$, $\lim_{i\to 0} \beta'(i) = \infty$, $\beta'(\bar{i}) = 0$, $\beta''(i) < 0$, $\gamma(0) = 0$, $0 < \gamma'(i) < \beta'(i)$, $\gamma''(i) \geq \beta''(i)$.

The first-best benchmark. As a benchmark, consider for a moment a first-best world in which every decision were contractible. Then the parties would always implement both, cost and quality innovations ($x^{FB} = y^{FB} = 1$). They would agree on the efficient quantity $q^{FB} = 1$ and they would choose the investment levels e^{FB} and i^{FB} that are given by

$$\begin{aligned} c'(e^{FB}) - b'(e^{FB}) &= 1, \\ \beta'(i^{FB}) - \gamma'(i^{FB}) &= 1. \end{aligned}$$

In the remainder of the paper, we return to the second-best world in which the class of feasible contracts is restricted as described above.

Ex post bargaining. As the parties are symmetrically informed, in accordance with the Coase Theorem they will always agree on the ex post efficient quantity and implementation decisions. Assuming that the negotiations at date 2 lead to the Nash bargaining solution, each party gets its default payoff (i.e., what it would get in the absence of renegotiation) plus a fraction of the renegotiation surplus (i.e., the additional surplus generated by the ex post efficient decisions). In the absence of renegotiation, quantity q is provided and the characteristics of the good depend on the ownership structure as the owner can decide which innovations are implemented. Specifically, let x^o and y^o denote the decisions whether or not the cost and quality innovations are implemented in the absence of renegotiation. Hence, the manager's date-2 payoff is

$$U_M^o(e, i) = P_0 - qC(x^o, y^o) + \alpha\Delta,$$

and the government's date-2 payoff is

$$U_G^o(e,i) = qB(x^o,y^o) - P_0 + (1-\alpha)\Delta,$$

where $\Delta = [B(1,1) - C(1,1)] - q\,[B(x^o,y^o) - C(x^o,y^o)]$ is the renegotiation surplus and $\alpha \in (0,1)$ denotes the manager's bargaining power.

Consider $o = M$. In the absence of renegotiation, the manager will implement the cost innovation ($x^M = 1$), which improves her default payoff $P_0 - qC(x^M,y^M) = P_0 - q[C_0 - x^M c(e) + y^M\gamma(i)]$, while she will not implement the quality innovation ($y^M = 0$), because she would suffer from the cost increase without profiting from the improved quality. Analogously, if $o = G$, then in the case of disagreement the government would implement the quality innovation only ($x^G = 0$, $y^G = 1$). Next, consider $o = J$, so that each party has veto power. In this case, the manager would veto the implementation of the quality innovation, while the government would not approve the implementation of the cost innovation ($x^J = y^J = 0$). Finally, under $o = N$, where each party is free to implement any innovation, the manager would implement the cost innovation and the government would implement the quality innovation ($x^N = y^N = 1$).

Given a governance structure (i.e., an ownership structure o and a task assignment A), we can now characterize the equilibrium investment levels e_A^o and i_A^o, which may depend on the contractually specified quantity q of the basic good.

Since the parties are symmetrically informed, at date 0 they agree on a governance structure (o,A) and a quantity q which maximizes the total surplus

$$S_A^o = B_0 + \beta(i_A^o) - b(e_A^o) - [C_0 - c(e_A^o) + \gamma(i_A^o)] - i_A^o - e_A^o,$$

where successful renegotiation is anticipated. Note that the parties can divide the total surplus according to their initial bargaining powers by choosing a suitable lump sum payment P_0.

3 Quantity contracts and investments

3.1 Only the manager has investment tasks

Suppose first that it is exogenously given that the manager is responsible for both investment tasks, $A = M$. Then the date-1 investment levels under ownership structure o are characterized by

$$(e_M^o, i_M^o) = \arg\max_{(e,i)} U_M^o(e,i) - e - i.$$

Consider first the case of privatization ($o = M$), where $x^M = 1$ and $y^M = 0$. In this case, the manager's date-2 payoff reads

$$U_M^M(e,i) = P_0 - qC_0 + qc(e) + \alpha\left[\beta(i) - \gamma(i) + (1-q)(B_0 - C_0 + c(e) - b(e))\right].$$

Hence, at date 1 the manager chooses e_M^M and i_M^M to maximize $U_M^M(e,i) - e - i$, so that under our assumptions the investment levels can be characterized by the first-order conditions

$$\begin{aligned} qc'(e_M^M) + \alpha(1-q)[c'(e_M^M) - b'(e_M^M)] &= 1, \\ \alpha\left[\beta'(i_M^M) - \gamma'(i_M^M)\right] &= 1. \end{aligned}$$

Note that the investment i_M^M in the development of a quality innovation is always below its first-best level i^{FB}, because the manager can obtain a fraction α of the marginal return of this investment only through renegotiations. In contrast, observe that the manger's investment e_M^M in the development of a cost innovation is a function of the contractually specified quantity q.[8]

In particular, when q is increased, then the manager gets a larger fraction of the marginal return generated by her investment in cost innovation, $q[(1-\alpha)c'(e_M^M) + \alpha b'(e_M^M)] + \alpha[c'(e_M^M) - b'(e_M^M)]$. For this reason, the manager has increased incentives to invest when q becomes larger. Observe that if q were zero, then there would be underinvestment compared to the first-best. In this case, the investment would generate no returns in the absence of renegotiation, and the manager will get only the fraction α of the returns when the quantity is renegotiated to its efficient level. In contrast, if the parties agreed on the efficient quantity $q = 1$ at date 0 already, then there would be overinvestment. In this case, the manager would ignore the negative side effect that the cost innovation has on the benefit of the government. It follows that there is an intermediate quantity $\bar{q}$ such that the manager will invest e^{FB}.

Lemma 1 *(i) The investment level $e_M^M(q)$ is increasing in q.*

(ii) There exists a quantity $\bar{q} \in (0,1)$ such that $e_M^M(\bar{q}) = e^{FB}$, which is given by

$$\bar{q} = \frac{1-\alpha}{c'(e^{FB}) - \alpha}.$$

Proof. (i) By the implicit function theorem,

$$\frac{de_M^M}{dq} = -\frac{(1-\alpha)c'(e_M^M) + \alpha b'(e_M^M)}{qc''(e_M^M) + \alpha(1-q)[c''(e_M^M) - b''(e_M^M)]} > 0.$$

[8] To simplify the notation, we suppress the dependence of the investments on q whenever appropriate.

(ii) Inspection of the first-order conditions reveals that if $q = 0$, then $e_M^M < e^{FB}$. Moreover, if $q = 1$, then $e_M^M > e^{FB}$. Since $e_M^M(q)$ is continuous and strictly increasing, a simple intermediate value argument implies that there exists a unique $\bar{q} \in (0, 1)$ such that $e_M^M(\bar{q}) = e^{FB}$. The conjecture then follows from the first-order conditions for e_M^M and e^{FB}. ■

It is straightforward to see that the investment level $e_M^M(q)$ is increasing in α for any given q. In particular, if the manager's bargaining power α is relatively large, then the investment is only slightly below the first-best level even for $q = 0$. Hence, specifying a small quantity q ex ante is sufficient to generate the additional investment incentives such that the manager invests e^{FB}. Therefore, the larger is α, the smaller will be the optimal date-0 quantity $\bar{q}$.

Moreover, it is intuitively clear that if the marginal side effect of the cost innovation becomes larger, then the first-best investment level e^{FB} decreases. However, the manager does not take into account the full change of the marginal side effect and hence does not reduce her investment e_M^M sufficiently when the quantity level is not adjusted. For this reason, the optimal quantity must go down when $b'(e)$ becomes larger.

Remark 1. *(i) The quantity $\bar{q}$ is decreasing in the manager's bargaining power α.*

(ii) The quantity $\bar{q}$ goes down if the marginal side effect of the cost innovation, $b'(e)$, increases.

Proof. (i) Part (i) follows immediately from inspection of the first derivative

$$\frac{d\bar{q}}{d\alpha} = \frac{1 - c'(e^{FB})}{[c'(e^{FB}) - \alpha]^2} < 0,$$

where the inequality holds because $c'(e^{FB}) = 1 + b'(e^{FB}) > 1$.

(ii) Suppose that initially $b'(e) = b_0'(e)$, so that the first-best level of the cost innovation is characterized by $c'(e_0^{FB}) - b_0'(e_0^{FB}) = 1$. Consider now an increase of the marginal side effect, $b'(e) = b_1'(e) > b_0'(e)\ \forall e$. Now $c'(e_1^{FB}) - b_1'(e_1^{FB}) = 1$. By the definition of $\bar{q}$ in Lemma 1 (ii), we have to show that $c'(e_1^{FB}) > c'(e_0^{FB})$. The latter inequality follows from $e_1^{FB} < e_0^{FB}$, which is implied by the concavity of $c(e) - b(e)$. ■

Consider next public ownership, $o = G$. In this case the default decisions are $x^G = 0$ and $y^G = 1$, so that the manager's date-2 payoff is

$$U_M^G(e, i) = P_0 - qC_0 - q\gamma(i) + \alpha\,[c(e) - b(e) + (1 - q)(B_0 - C_0 + \beta(i) - \gamma(i))]\,.$$

Hence, at date 1 the manager chooses the investment levels e_M^G and i_M^G that maximize $U_M^G(e,i) - e - i$. Both kinds of investments are always below their first-best levels. In particular, the cost investment is implicitly defined by the first-order condition

$$\alpha \left[c'(e_M^G) - b'(e_M^G) \right] = 1.$$

The quality investment i_M^G now depends on the contractually specified quantity.

Lemma 2 *Under public ownership, $i_M^G(q) < i_M^M$ for all $q > 0$ and $i_M^G(0) = i_M^M$.*

Proof. The first derivative of the manager's date-1 payoff $U_M^G(e,i) - e - i$ with respect to i is given by $-q\gamma'(i) + \alpha(1-q)[\beta'(i) - \gamma'(i)] - 1$. Hence, if $q = 0$, then $i_M^G(0) = i_M^M$, which is implicitly defined by $\alpha \left[\beta'(i_M^M) - \gamma'(i_M^M) \right] - 1 = 0$. Now consider $q > 0$. Note that the derivative of the manager's payoff can be rewritten as $-\alpha q \beta'(i) - (1 - \alpha) q \gamma'(i) + \alpha[\beta'(i) - \gamma'(i)] - 1$. Since $\beta''(i) - \gamma''(i) \leq 0$ and $-\alpha q \beta'(i) - (1-\alpha) q \gamma'(i) < 0$, the manager's payoff is strictly decreasing for all $i \geq i_M^M$, so that she will invest strictly less than i_M^M. ■

Note that if the parties agreed on the efficient quantity $q = 1$ at date 0, then the manager would not invest at all, because she would have to suffer from the negative side effect of the investment in quality improvement (i.e., she would have to incur larger costs) without profiting from the enhanced benefit of the government. In contrast, if q is zero, then the investment yields no returns without renegotiation, and the manager gets the fraction α of the returns when the quantity is renegotiated. As there is always underinvestment and the total surplus $B(1,1) - C(1,1) - i - e$ is concave in i, the parties will ex ante specify the quantity $q = 0$, because $i_M^G(0)$ is the largest level of quality investment that can be induced under $o = G$.[9]

Next, consider $o = J$, where $x^J = y^J = 0$. The manager's date-2 payoff then is

$$U_M^J(e,i) = P_0 - qC_0 + \alpha \left[\beta(i) - \gamma(i) + c(e) - b(e) + (1-q)(B_0 - C_0) \right].$$

Under this ownership regime, the manager chooses

$$\left(e_M^J, i_M^J \right) = \arg\max_{(e,i)} U_M^J(e,i) - e - i.$$

Inspection of the first-order conditions immediately reveals that now both investment levels are independent of the quantity q. In the absence of renegotiation, the manager

[9] Notice that this result is in the spirit of Maskin and Moore (1999) and Che and Hausch (1999), who show that it may be optimal to write no contract at all if a party's investment can improve the bargaining position of the other party only.

does not get any returns from her investments. The manager thus gets only a fraction α of the returns through renegotiation. In particular, $e_M^J = e_M^G$ and $i_M^J = i_M^M = i_M^G(0)$. Hence, $o = J$ leads to the same investment levels as $o = G$ when under G-ownership the quantity is optimally chosen.

Finally, consider $o = N$ so that renegotiations occur only with regard to the quantity (as $x^N = y^N = 1$). Then the manager's date-2 payoff reads

$$U_M^N(e,i) = P_0 - qC_0 + qc(e) - q\gamma(i) + \alpha(1-q)\left[B_0 - C_0 + \beta(i) - \gamma(i) + c(e) - b(e)\right].$$

At date 1, the manager chooses

$$\left(e_M^N, i_M^N\right) = \arg\max_{(e,i)} U_M^N(e,i) - e - i.$$

Now both investment levels depend on the contractually specified quantity q, because both kinds of innovations are implemented without renegotiation. Thus, $e_M^N(q) = e_M^M(q)$ and $i_M^N(q) = i_M^G(q)$. Recall that $e_M^M(q)$ is increasing in q, whereas $i_M^G(q)$ is at its largest attainable level for $q = 0$. But this means that creating efficient investment incentives by choosing the optimal quantity for one investment task will have adverse effects on the other task.

Proposition 1 *If quantity contracts are taken into account and the manager is in charge of both investment tasks, then $o = M$ is always optimal.*

Proof. At date 1 the parties agree on the ownership structure that maximizes the total surplus S_M^o, which is concave in e and in i. The ownership structure $o = M$ is better than $o = G$ because $e_M^G < e_M^M(\bar{q}) = e^{FB}$ and $i_M^G(0) = i_M^M$. Similarly, $o = M$ is better than $o = J$ because $e_M^J < e_M^M(\bar{q}) = e^{FB}$ and $i_M^J = i_M^M$. Finally, in order to see that $o = M$ is better than $o = N$, recall that $i_M^N(q) < i_M^M$ for $q > 0$ and $i_M^N(0) = i_M^M$. In other words, under N-ownership the quality investment is smaller than under M-ownership except for $q = 0$. But for $q = 0$, the cost innovation given $o = N$ is smaller than the cost innovation when the manager is the owner, $e_M^N(0) < e_M^M(\bar{q}) = e^{FB}$. ■

Note that this result is in stark contrast to Hart, Shleifer, and Vishny (1997). In their model, the parties do not explicitly specify a quantity in the initial contract. They implicitly assume that the date-0 contract is based on the ex post efficient quantity $q^{FB} = 1$, so that under M-ownership there is always overinvestment in cost innovation (while there is underinvestment in quality innovation). The overinvestment effect can be so strong that G-ownership (which leads to underinvestment in both tasks) may be superior even when the manager is in charge of both, cost and quality investments. In contrast, we argue that if it is possible to write a contract on the provision of a basic good as assumed by Hart, Shleifer, and Vishny (1997), then it is also reasonable to specify in this contract the quantity that is optimal from an ex ante perspective. By choosing a suitably small quantity (which will be renegotiated ex post), the parties can ensure that the manager has just the right incentives to invest in cost reduction.[10] As a consequence, G-ownership can be optimal only if the government has to make an investment decision itself, as we will see in the next subsections.

3.2 Only the government has investment tasks

Suppose now that the government is responsible for both investment tasks, $A = G$. Then, the investment levels under ownership structure o are characterized by

$$(e^o_G, i^o_G) = \arg\max_{(e,i)} U^o_G(e, i) - e - i.$$

Consider first public ownership ($o = G$), so that $x^G = 0$ and $y^G = 1$. In this case, the government's date-2 payoff reads

$$U^G_G(e, i) = qB_0 - P_0 + q\beta(i) + (1 - \alpha)\left[c(e) - b(e) + (1 - q)(B_0 - C_0 + \beta(i) - \gamma(i))\right].$$

Hence, at date 1 the government chooses the investments e^G_G and i^G_G that maximize $U^G_G(e, i) - e - i$. The investment levels are implicitly defined by the first-order conditions

$$(1 - \alpha)\left[c'(e^G_G) - b'(e^G_G)\right] = 1,$$

$$q\beta'(i^G_G) + (1 - \alpha)(1 - q)[\beta'(i^G_G) - \gamma'(i^G_G)] = 1.$$

Note that the present case is similar to M-ownership when the manager is in charge of both investments. Yet, in contrast to that case, now there is always underinvestment regarding e, while it is the investment i in quality innovations that is increasing in q and for which the first-best level can be implemented by specifying a suitable quantity ex ante.[11]

[10] Note that Hart, Shleifer, and Vishny's (1997) model also differs from the present one in that they assume that under public ownership a fraction of the gains from innovations can be realized by hiring another manager from a competitive market, while we assume that the parties are locked in; i.e., their relationship has undergone Williamson's (1985) "fundamental transformation." However, it is straightforward to show that also in their original model private ownership is always optimal when the suitable quantity of the basic good is contractually specified.

[11] The proofs of all claims in section 3.2 are analogous to the proofs in section 3.1 and are therefore omitted.

Lemma 3 *(i) The investment level $i_G^G(q)$ is increasing in q.*

(ii) There exists a quantity $\tilde{q} \in (0,1)$ such that $i_G^G(\tilde{q}) = i^{FB}$. Specifically,

$$\tilde{q} = \frac{\alpha}{\beta'(i^{FB}) + \alpha - 1}.$$

The comparative statics properties of the critical quantity $\tilde{q}$ are analogous to the properties of $\bar{q}$. In particular, when the government's bargaining power or the marginal side effect of the quality innovation become small, then the quantity $\tilde{q}$ must increase.

Remark 2. *(i) The quantity $\tilde{q}$ is increasing in the manager's bargaining power α.*

(ii) The quantity $\tilde{q}$ goes down if the marginal side effect of the quality innovation, $\gamma'(i)$, increases.

Consider next the case of privatization, $o = M$. The government's date-2 payoff is then given by

$$U_G^M(e,i) = qB_0 - P_0 - qb(e) + (1-\alpha)\left[\beta(i) - \gamma(i) + (1-q)(B_0 - C_0 + c(e) - b(e))\right].$$

Hence, at date 1 the government chooses the investment levels $\left(e_G^M, i_G^M\right) = \arg\max_{(e,i)} U_G^M(e,i) - e - i$. There is always underinvestment. The quality investment is given by the first-order condition

$$(1-\alpha)\left[\beta'(i_G^M) - \gamma'(i_G^M)\right] = 1,$$

while the cost investment e_G^M depends on the contractually specified quantity.

Lemma 4 *Under private ownership, $e_G^M(q) < e_G^G$ for all $q > 0$. Moreover, $e_G^M(0) = e_G^G$.*

Hence, given M-ownership, the parties will ex ante specify the quantity $q = 0$. Note that this case is analogous to the case of public ownership when the manager is in charge of both investments.

Next, consider $o = J$, so that the government's date-2 payoff is

$$U_G^J(e,i) = qB_0 - P_0 + (1-\alpha)\left[\beta(i) - \gamma(i) + c(e) - b(e) + (1-q)(B_0 - C_0)\right].$$

The government then chooses $\left(e_G^J, i_G^J\right) = \arg\max_{(e,i)} U_G^J(e,i) - e - i$. As is clear from the first-order conditions, the investment levels satisfy $e_G^J = e_G^G = e_G^M(0)$ and $i_G^J = i_G^M$. Hence, $o = J$ leads to the same investments as $o = M$ when under M-ownership the quantity zero is specified.

Finally, consider $o = N$, where the government's date-2 payoff is given by

$$U_G^N(e,i) = qB_0 - P_0 + q\beta(i) - qb(e) + (1-\alpha)(1-q)\left[B_0 - C_0 + \beta(i) - \gamma(i) + c(e) - b(e)\right].$$

The government chooses the investments $\left(e_G^N, i_G^N\right) = \arg\max_{(e,i)} U_G^N(e,i) - e - i$. Thus, $e_G^N(q) = e_G^M(q)$ and $i_G^N(q) = i_G^G(q)$. In analogy to Proposition 1, we can thus state the following result.

Proposition 2 *If quantity contracts are taken into account and the government is in charge of both investment tasks, then $o = G$ is always optimal.*

3.3 Both parties have investment tasks

Suppose first that the government is responsible for the investment in cost reduction and the manager is in charge of the investment in quality improvement ($A = GM$). In this case, the investment levels under ownership structure o are characterized by

$$\begin{aligned} e_{GM}^o &= \arg\max_e U_G^o(e,i) - e, \\ i_{GM}^o &= \arg\max_i U_M^o(e,i) - i. \end{aligned}$$

As the payoffs are additively separable, the government's investment in cost innovation does not depend on the level of the investment in quality improvements. This means that different task assignments concerning the investment in quality innovation do not affect the government's choice of the investment in cost reductions. Hence, for any given quantity, $e_{GM}^o = e_G^o$ must hold. Similar arguments apply to the manager's investment in quality improvement, so that $i_{GM}^o = i_M^o$ must hold for any given level of quantity q.

Proposition 3 *The task assignment $A = GM$ (the government is in charge of the cost investment and the manager is in charge of the quality investment) is never optimal.*

Proof. For any ownership structure the task assignment $A = GM$ is dominated by allocating both tasks to the manager and letting her be the owner ($A = M$, $o = M$). In the latter case, the investment levels are $e_M^M(\bar{q}) = e^{FB}$ and i_M^M.

Now consider $A = GM$. If $o = M$, the investment levels are $e_G^M(q) < e^{FB}$ and i_M^M. Similarly, if $o = G$, the investment levels are $e_G^G < e^{FB}$ and $i_M^G(q) \leq i_M^M$. If $o = J$, the investment levels are $e_G^J < e^{FB}$ and $i_M^J = i_M^M$. Finally, if $o = N$, the investments are $e_G^N(q) < e^{FB}$ and $i_M^N(q) \leq i_M^M$. ■

The task assignment $A = GM$ is always inferior, because it means that a party can never improve its bargaining position by investing. In the absence of renegotiation, the government would never invest in cost reduction (which could only reduce its benefit), while the manager would never invest in quality improvements (which could only increase her costs). The best that the parties can do is either to agree on $o = J$ or to specify a quantity of zero, so that their disagreement payoffs are independent of the investments. The parties will then invest only because they get a fraction of the returns through renegotiation, so that there is always underinvestment. In contrast, as we have seen above, if one party is the single owner and responsible for both investments, then this party can improve its bargaining position by investing and it will even choose a first-best investment level for one task if the appropriate quantity is specified ex ante.

Suppose next that the manager is in charge of the cost investment and the government is in charge of the quality investment ($A = MG$). The investment levels under ownership structure o are then given by

$$\begin{aligned} e^o_{MG} &= \arg\max_e U^o_M(e,i) - e, \\ i^o_{MG} &= \arg\max_i U^o_G(e,i) - i. \end{aligned}$$

Because of additive separability, it is immediately clear that $e^o_{MG} = e^o_M$ and $i^o_{MG} = i^o_G$ must hold for any given quantity q.

If $o = M$ and $A = MG$, then $e^M_{MG}(q) = e^M_M(q)$ and $i^M_{MG} = i^M_G$. Since the latter investment does not depend on q, it is straightforward to see that it is optimal for the parties to specify $q = \bar{q}$, because then the investment in cost reduction is at its first-best level. Similarly, under G-ownership, it is optimal to set $q = \tilde{q}$.

Proposition 4 *If the manager is responsible for the cost investment and the government is in charge of the quality investment ($A = MG$), then $o = J$ cannot be optimal.*

Proof. The ownership structure $o = M$ is better than $o = J$, because $e^M_M(\bar{q}) = e^{FB} > e^J_M$ and $i^J_G = i^M_G$. ■

Finally, consider $o = N$ and $A = MG$. In this case, setting $q = \bar{q}$ induces first-best investment in cost reduction, while $q = \tilde{q}$ leads to first-best investment in quality improvement. Hence, in the special case where $\bar{q} = \tilde{q}$, the first-best outcome can be attained. Now consider the case $q = \bar{q} < \tilde{q}$, so that $e = e^{FB}$ and $i < i^{FB}$. Increasing

q slightly above $\bar{q}$ leads only to a second-order loss regarding e, but it implies a first-order gain with regard to i. Therefore, the optimal quantity $q = \hat{q}$ must lie strictly between $\bar{q}$ and $\tilde{q}$. A similar argument holds if $\bar{q} > \tilde{q}$.

Lemma 5 *Consider the case $A = MG$, such that the manager chooses e and the government chooses i.*

(i) Consider the case $\bar{q} = \tilde{q}$. Then the parties agree on $o = N$ and they specify the quantity $\hat{q} = \bar{q} = \tilde{q}$, so that the first-best outcome is achieved.

(ii) Consider the case $\bar{q} \neq \tilde{q}$. If the parties choose the ownership structure $o = N$, then they specify the quantity $\hat{q}$, where $\min\{\bar{q}, \tilde{q}\} < \hat{q} < \max\{\bar{q}, \tilde{q}\}$.

Proof. (i) If $\hat{q} = \bar{q} = \tilde{q}$, then $e^N_{MG}(\hat{q}) = e^M_M(\bar{q}) = e^{FB}$ and $i^N_{MG}(\hat{q}) = i^G_G(\tilde{q}) = i^{FB}$.

(ii) The parties choose q in order to maximize the total surplus. Note that

$$\frac{dS^N_{MG}}{dq} = \left[\beta'(i^G_G(q)) - \gamma'(i^G_G(q)) - 1\right] \frac{di^G_G}{dq} + \left[c'(e^M_M(q)) - b'(e^M_M(q)) - 1\right] \frac{de^M_M}{dq}.$$

Without loss of generality, let $\bar{q} > \tilde{q}$. If $\hat{q} \geq \bar{q}$, then $e \geq e^{FB}$ and $i > i^{FB}$, so that $\frac{dS^N_{MG}}{dq} < 0$; i.e., decreasing $\hat{q}$ increases the total surplus. If $\hat{q} \leq \tilde{q}$, then $e < e^{FB}$ and $i \leq i^{FB}$, so that $\frac{dS^N_{MG}}{dq} > 0$; i.e., increasing $\hat{q}$ increases the total surplus. ■

Lemma 5 implies that if $\bar{q} \neq \tilde{q}$, then one of the two investments is above and the other investment is below the first-best level when the parties agree on the optimal quantity $\hat{q}$. In particular, the following result holds.

Remark 3. *There is a critical level of the manager's bargaining power,*

$$\hat{\alpha} = \frac{\beta'(i^{FB}) - 1}{c'(e^{FB}) + \beta'(i^{FB}) - 2} \in (0, 1),$$

such that $\tilde{q} = \bar{q}$.

(i) If $\alpha < \hat{\alpha}$, then $\hat{q} \in (\tilde{q}, \bar{q})$, so that $e^N_{MG}(\hat{q}) < e^{FB}$ and $i^N_{MG}(\hat{q}) > i^{FB}$.

(ii) If $\alpha > \hat{\alpha}$, then $\hat{q} \in (\bar{q}, \tilde{q})$, so that $e^N_{MG}(\hat{q}) > e^{FB}$ and $i^N_{MG}(\hat{q}) < i^{FB}$.

Proof. From the definition of $\bar{q}$ and from Remark 1, we know that $\bar{q}$ is continuous, bounded from above, strictly decreasing in α, and it is equal to zero at $\alpha = 1$. Analogously, $\tilde{q}$ is equal to zero at $\alpha = 0$ and it is continuous, bounded from above, and strictly increasing. Hence, there exists a unique $\hat{\alpha} \in (0, 1)$ such that $\bar{q} = \tilde{q}$. The expression for $\hat{\alpha}$ is obtained from solving this equality. The remainder of the Remark follows immediately from Lemma 5. ■

To conclude, under $o = N$ and $A = MG$, there is exactly one bargaining power for which the first-best outcome can be achieved. Otherwise, consider the case in which the manager's bargaining power α is small, so that the quantity $\tilde{q}$ that is required to induce first-best quality investments is smaller than the quantity $\bar{q}$ that is required to induce first-best cost investments. In this case, if the optimal quantity $\hat{q} \in (\tilde{q}, \bar{q})$ is chosen, then there is underinvestment in cost innovation and overinvestment in quality innovation.

Figure 2 shows how the quantities $\bar{q}$ and $\tilde{q}$ behave as functions of the manager's bargaining power α. Note that $\hat{q}$ must always lie between these two curves, as is illustrated in the displayed example.[12] Notice that the critical bargaining power $\hat{\alpha}$ will go up if the marginal side effect of the quality investment increases (which makes $\tilde{q}$ smaller according to Remark 2, while $\bar{q}$ remains unchanged). Similarly, an increase in the marginal side effect of the cost investment decreases $\hat{\alpha}$.

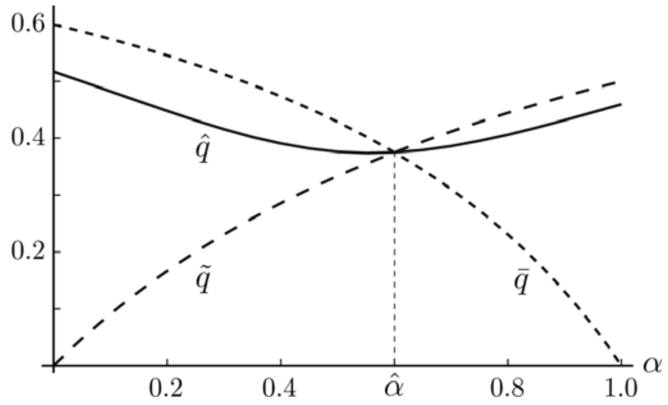

Figure 2. Optimal quantities.

To summarize the analysis so far, consider Table 1, which illustrates the optimal quantities for all potentially optimal governance structures. Note that a priori there are 16 governance structures resulting from all conceivable combinations of the four ownership structures and the four different task assignments. The preceding analysis implies that only five governance structures can potentially be optimal.

Specifically, $A = GM$ can never be optimal according to Proposition 3. Propositions 1 and 2 show that if both tasks are assigned to one party, then this party should be the owner. Proposition 4 then implies that $o = J$ can never be optimal.[13]

[12] In all examples that we illustrate in the subsequent figures, we assume that $c(e) = 2e^{1/2} - e$ and $\beta(i) = 2i^{1/2} - i$, where $\bar{e} = \bar{i} = 1$. In Figure 2 and in Figure 3, we depict the case $b(e) = 0.4c(e)$ and $\gamma(i) = 0.5\beta(i)$, so that $\hat{\alpha} = 0.6$.

[13] Note that this result is in accordance with Hart's (1995) standard property rights model, where $o = J$ can never be optimal. Yet, it has been demonstrated in Schmitz (2000) that $o = J$ could

It also follows that $o = N$ can be optimal only if the government chooses the quality investment and the manager chooses the cost investment.

	$o = M$	$o = G$	$o = J$	$o = N$
$A = M$	$\bar{q}$			
$A = G$		$\tilde{q}$		
$A = GM$				
$A = MG$	$\bar{q}$	$\tilde{q}$		$\hat{q}$

Table 1. Five governance structures can be optimal.

All of the remaining five governance structures can turn out to be optimal. We further characterize the specific circumstances favouring each of these governance structures in the following section.

The investment levels associated with the five remaining governance structures are illustrated in Figure 3.

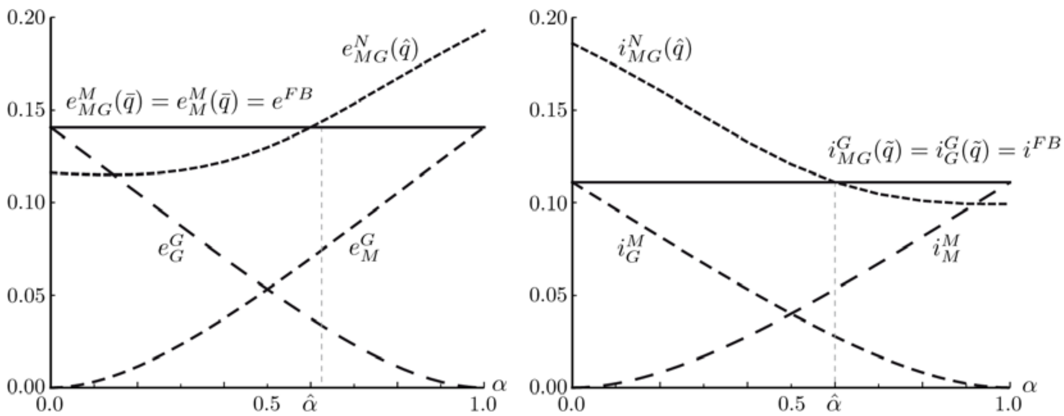

Figure 3. Investments in cost and quality innovations.

For instance, consider the investment in cost reduction, which is displayed in the left panel of Figure 3. Under $o = M$, the parties specify the quantity $\bar{q}$ at date 0, so that the investment is always at its first-best level, regardless of whether the manager or the government is in charge of the quality investment, $e^M_{MG}(\bar{q}) = e^M_M(\bar{q}) = e^{FB}$. Under $o = G$, if the manager (respectively, the government) is responsible for

actually be optimal in the privatization context if the quantity were exogenously fixed as in Hart, Shleifer, and Vishny (1997), where private ownership may induce overinvestment in cost reduction.

the cost investment, then it is increasing (respectively, decreasing) in the manager's bargaining power α. Moreover, note that under $o = N$ the manager has always stronger incentives to invest in cost reduction than she would have under $o = G$. In accordance with Remark 3, if the quantity $\hat{q}$ is specified, then she overinvests relative to the first-best level whenever her bargaining power α is larger than $\hat{\alpha}$.

4 Optimal governance structures

It is easy to see that if the parties have different bargaining powers, then only three of the five remaining governance structures have to be considered. Specifically, under sole ownership by one party the optimal investment task assignment depends on who has the larger bargaining power, as is stated in the following proposition.

Proposition 5 *(i) Consider $o = M$. If $\alpha > 1/2$, then both investment tasks should be assigned to the manager ($A = M$). If $\alpha < 1/2$, then the manager should be responsible for the cost investment and the government should be in charge of the quality investment ($A = MG$).*

(ii) Consider $o = G$. If $\alpha > 1/2$, then the manager should be responsible for the cost investment and the government should be in charge of the quality investment ($A = MG$). If $\alpha < 1/2$, then both investment tasks should be assigned to the government ($A = G$).

Proof. (i) According to Table 1, under M-ownership we have to consider the task assignments $A = M$ and $A = MG$ only. The investment in cost reduction is always at its first-best level, $e_M^M(\bar{q}) = e_{MG}^M(\bar{q}) = e^{FB}$. If $\alpha > 1/2$, the first-order conditions for the quality investments immediately show that $i_{MG}^M < i_M^M < i^{FB}$. Hence, $A = M$ is optimal. If $\alpha < 1/2$, then $i_M^M < i_{MG}^M < i^{FB}$, so that $A = MG$ is optimal.

(ii) The proof is analogous to part (i). ■

Note that if both parties happen to have the same bargaining power, then $e_{MG}^G = e_G^G$ and $i_{MG}^M = i_M^M$, so that the parties are indifferent between the task allocations mentioned in Proposition 5.

A partnership with no veto power can be optimal only if the parties' bargaining strengths do not become too asymmetric. When one party's bargaining power becomes large, then the difference between the quantities $\bar{q}$ and $\tilde{q}$ increases, which aggravates the problem under $o = N$ to find an intermediate quantity $\hat{q}$ that balances the incentives for making both types of investments.

Proposition 6 *If $\alpha \to 0$ or $\alpha \to 1$, then $o = N$ cannot be optimal.*

Proof. Consider $o = M$, so that the parties agree on the quantity $\bar{q}$ which implies $e_M^M(\bar{q}) = e^{FB}$. If $\alpha > \frac{1}{2}$, then according to Proposition 5 the parties assign both investment tasks to the manager, so that the quality investment is characterized by $\alpha\left[\beta'(i_M^M) - \gamma'(i_M^M)\right] = 1$. Note that $i_M^M \to i^{FB}$ when $\alpha \to 1$. If $\alpha < \frac{1}{2}$, then they assign the cost investment to the manager and the quality investment to the government, so that the latter investment is implicitly given by $(1-\alpha)\left[\beta'(i_G^M) - \gamma'(i_G^M)\right] = 1$. Hence, $i_G^M \to i^{FB}$ when $\alpha \to 0$.

Similarly, if $o = G$, then $i_G^G(\tilde{q}) = i^{FB}$. If $\alpha > \frac{1}{2}$, then the cost investment is assigned to the manager and $e_M^G \to e^{FB}$ when $\alpha \to 1$. If $\alpha < \frac{1}{2}$, then e is assigned to the government and $e_G^G \to e^{FB}$ when $\alpha \to 0$.

Finally, consider $o = N$, so that the manager is in control of the cost investment and the government is in charge of the quality investment. In this case, if $\alpha \to 1$, in the limit the equilibrium investment levels are characterized by $qc'(e_M^N) + (1 - q)[c'(e_M^N) - b'(e_M^N)] = 1$ and $q\beta'(i_G^N) = 1$. Note that q must be close to 0 for e_M^N to be close to e^{FB}, but as q approaches zero, i_G^N becomes arbitrarily small. A similar argument holds for $\alpha \to 0$. ■

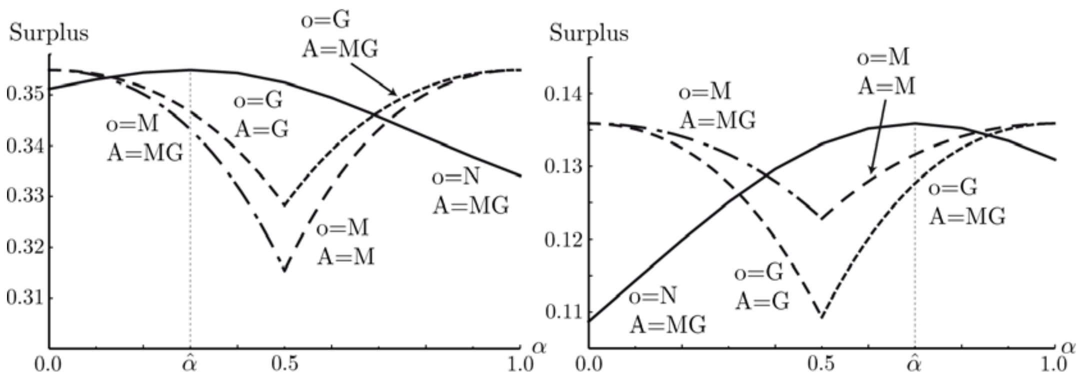

Figure 4. The total surplus.

Figure 4 illustrates the two preceding propositions. Consider the V-shaped curve which depicts the total surplus under $o = M$. Recall that under $o = M$, the investment e in cost innovation is always at its first-best level, regardless of the manager's bargaining power α. The investment i in quality innovation (and hence the surplus) is decreasing in α when this investment task is assigned to the government (i.e., if $\alpha < 1/2$) and it is increasing in α otherwise. Similarly, the other V-shaped curve shows the total surplus under G-ownership. Under $o = N$, the total surplus (depicted by the solid curve) attains its maximum at $\alpha = \hat{\alpha} \in (0, 1)$, where the first-best outcome is achieved. In contrast, sole ownership by one party is optimal for sufficiently small or sufficiently large values of the manager's bargaining power. The relative importance of cost and quality innovations determines whether $o = M$ or $o = G$ leads to a larger surplus.[14]

In particular, whether M-ownership or G-ownership can be optimal depends on the strength of the side effects that accompany the cost and quality innovations. Specifically, $o = G$ cannot be optimal if the deterioration to quality from cost innovations vanishes, provided that the manager's bargaining power is not too small. Recall that under $o = N$ it is always possible to induce first-best quality investments (just as under $o = G$) by specifying the quantity $\tilde{q}$, but in general this may lead to over- or underinvestment in cost innovation. Yet, overinvestment cannot occur when cost innovations have no negative side effects. Moreover, investment in cost innovation is larger under $o = N$ than under $o = G$ provided that the manager's bargaining power is sufficiently large.

Similarly, $o = M$ cannot be optimal if the negative side effect of quality innovation disappears, provided that the manager's bargaining power is sufficiently small. In this case, $o = N$ is superior, because it allows to induce first-best cost investment just as $o = M$, but it leads to larger quality investment (where overinvestment is not a problem anymore). As a consequence, when the side effects of both kinds of innovations go to zero, then N-ownership must always be optimal.

Proposition 7 *(i) Consider $\alpha > \frac{1-\tilde{q}}{2-\tilde{q}}$. Suppose that $b(e) \equiv \theta \check{b}(e)$, where $\theta > 0$. Then for θ sufficiently small, $o = N$ is better than $o = G$.*

(ii) Consider $\alpha < \frac{1}{2-\tilde{q}}$. Suppose that $\gamma(i) \equiv \psi \check{\gamma}(i)$, where $\psi > 0$. Then for ψ sufficiently small, $o = N$ is better than $o = M$.

(iii) Suppose that $b(e) \equiv \theta \check{b}(e)$ and $\gamma(i) \equiv \psi \check{\gamma}(i)$, where $\theta > 0$ and $\psi > 0$. Then for θ and ψ sufficiently small, $o = N$ is better than both $o = M$ and $o = G$.

Proof. (i) Assume that under $o = N$ the parties would specify the quantity $\tilde{q}$, so that $i_G^N = i_G^G = i^{FB}$. If $\theta \to 0$, then in the limit $\tilde{q}c'(e_M^N) + \alpha(1 - \tilde{q})c'(e_M^N) = 1$ when $o = N$. Under G-ownership, in the limit we have $\alpha c'(e_M^G) = 1$ if $\alpha \geq 1/2$ and

[14] In Figure 4, $B_0 = 2$, $C_0 = 1.1$, and $b(e) = 0.5c(e)$. In the left panel, $\gamma(i) = 0.3\beta(i)$ while in the right panel, $\gamma(i) = 0.7\beta(i)$. Note that when the side effect of the quality innovation becomes stronger, then $\hat{\alpha}$ increases (from 0.3 to 0.7) and public ownership becomes less attractive.

$(1-\alpha)c'(e_G^G) = 1$ if $\alpha < 1/2$. Note that the cost investment is in both cases smaller than the first-best, but it is larger under N-ownership than under G-ownership if $\tilde{q} + \alpha(1-\tilde{q}) > \max\{\alpha, 1-\alpha\}$, which holds when $\alpha > \frac{1-\tilde{q}}{2-\tilde{q}}$. Note that the surplus under $o = N$ were even larger if instead of $\tilde{q}$ the quantity $\hat{q}$ would be chosen.

(ii) Suppose that under N-ownership the parties would specify $\bar{q}$, so that $e_M^N = e_M^M = e^{FB}$. If $\psi \to 0$, then in the limit $\bar{q}\beta'(i_G^N) + (1-\alpha)(1-\bar{q})\beta'(i_G^N) = 1$ when $o = N$. Under $o = M$, in the limit we have $\alpha\beta'(i_M^M) = 1$ if $\alpha \geq 1/2$ and $(1-\alpha)\beta'(i_G^M) = 1$ if $\alpha < 1/2$. Note that the quality investment is in both cases smaller than the first-best, but it is larger under $o = N$ than under $o = M$ if $\bar{q} + (1-\alpha)(1-\bar{q}) > \max\{\alpha, 1-\alpha\}$, which holds when $\alpha < \frac{1}{2-\bar{q}}$.

(iii) When both θ and ψ go to zero, then the first best is approached under $o = N$ with $\hat{q} = 1$. In contrast, if $o = M$ there remains to be underinvestment with regard to i, while under G-ownership there is still underinvestment with regard to e. ■

Finally, let us investigate what happens if the negative side effect of an innovation becomes as large as its desired effect. If the reduction of the government's benefit associated with a cost innovation approaches the extent of the cost reduction, then the first-best investment in cost innovation becomes negligibly small. Recall that under $o = G$ the investment in cost innovation is always below its first-best level, while the quality innovation is at its first-best level if the parties specify the quantity $\tilde{q}$ in their date-0 contract. Hence, under $o = G$ the first-best outcome is approached when the side effect of the cost innovation tends to offset its desired effect. In contrast, under $o = M$ the investment in quality innovation is always below its first-best level. Moreover, $o = G$ is also better than $o = N$. Under $o = N$, the first-best investment in quality innovation could be achieved by specifying the quantity $\tilde{q} > 0$. But this would create incentives for the manager to invest in cost reduction, which is undesirable when the total return of the cost investment vanishes.

Similar arguments explain why $o = M$ is always optimal if the cost increase that is caused by a quality innovation becomes as large as the additional benefit of the government generated by the quality innovation.

Proposition 8 *(i) Suppose that $b(e) \equiv \theta c(e) + (1-\theta)\breve{b}(e)$, where $\theta \in (0,1)$. Then for $\theta \to 1$, the ownership structure $o = G$ is better than $o = M$ and $o = N$.*

(ii) Suppose that $\gamma(i) \equiv \psi\beta(i) + (1-\psi)\breve{\gamma}(i)$, where $\psi \in (0,1)$. Then for $\psi \to 1$, the ownership structure $o = M$ is better than $o = G$ and $o = N$.

Proof. (i) If $\theta \to 1$, then $e^{FB} \to 0$, so that under G-ownership (where $i_G^G(\tilde{q}) = i^{FB}$) the first-best outcome is approached. In contrast, under $o = M$ there is still underinvestment with regard to i. Under $o = N$, the parties must set $\hat{q} = \tilde{q} > 0$ if they want to implement i^{FB}. But then $\tilde{q}c'(e_M^N) + \alpha(1-\tilde{q})(1-\theta)[c'(e_M^N) - \breve{b}'(e)] = 1$, so that there is overinvestment with regard to e when $\theta \to 1$.

(ii) If $\psi \to 1$, then $i^{FB} \to 0$, so that under M-ownership (where $e_M^M(\bar{q}) = e^{FB}$) the first best is approached. In contrast, under $o = G$ there is still underinvestment with regard to e. Under $o = N$, the parties must set $\hat{q} = \bar{q}$ if they want to implement e^{FB}. But then there is overinvestment with regard to i when $\psi \to 1$. ■

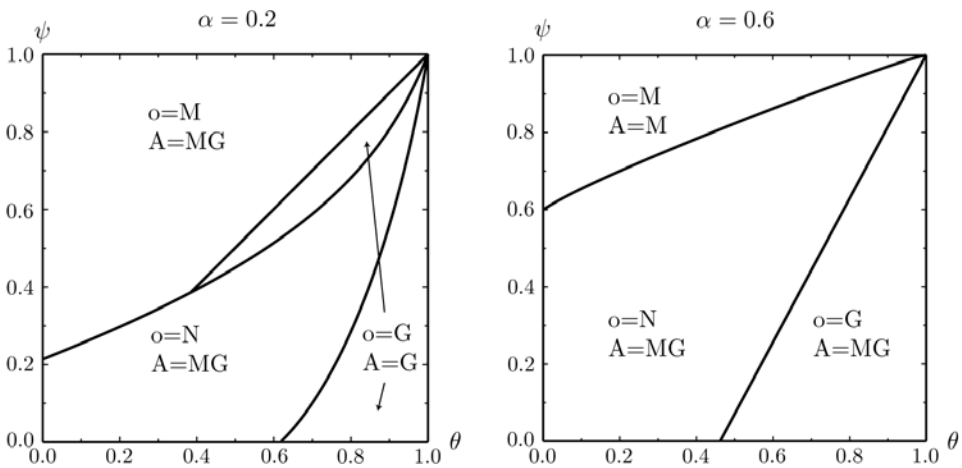

Figure 5. Optimal governance structures.

As an illustration, suppose that the side effects of the investments are given by fractions of their desired effects, $b(e) = \theta c(e)$ and $\gamma(i) = \psi\beta(i)$.[15] Consider Figure 5, which shows (for given values of α) how the optimal governance structures depend on the strengths θ and ψ of the side effects caused by the cost and quality innovations, respectively.

Observe that if θ goes to 1, so that the side effect of the cost investment offsets its benefit, then $o = G$ (which leads to first-best quality investments) must become optimal. Similarly, for sufficiently large values of ψ, the ownership structure $o = M$ (which leads to first-best cost investments) must be optimal. In contrast, if both side effects become small, then the parties prefer $o = N$, which implies more balanced

[15] Hence, $\breve{b}(e) = c(e)$, $\breve{\gamma}(i) = \beta(i)$ in Proposition 7 and $\breve{b}(e) = \breve{\gamma}(i) = 0$ in Proposition 8.

incentives for both types of investments. Specifically, due to symmetry, in the example displayed in the figure, $o = M$ is better than $o = G$ whenever $\psi > \theta$. As illustrated for the case $\alpha = 0.6$, the parameter range for which $o = N$ is optimal can be so large that a small change of the side effects will never induce the parties to directly jump from public to private ownership (or vice versa). In contrast, when the parties' bargaining powers become more extreme (cf. the case $\alpha = 0.2$), there must be more parameter constellations for which ownership by a single party is better than $o = N$, so that a small change of θ or ψ can make a direct transition between public and private ownership optimal.

5 Concluding remarks

The remarkable shift away from public to private firms in the last two decades has evoked a vital and controversial discussion concerning the issue of privatization. At the same time, the property rights approach to the theory of the firm based on incomplete contracting has been developed and is now widely accepted as a standard model to analyze the effects of ownership rights.

Williamson (2000) criticizes that the standard incomplete contracting approach "is a property rights and property rights only construction" (p. 606) which tends to neglect important elements of governance structures such as the organization of work. He emphasizes that a wider range of contracts and hybrid modes of governance may well be relevant.[16] This criticism also seems to be applicable to the leading incomplete contracts model on privatization developed by Hart, Shleifer, and Vishny (1997). Thus, while we follow their assumption that a contract describing a basic good to be provided can be written, we argue that it is then also reasonable for the parties to contractually specify a suitable quantity of this good.[17] Moreover, we consider partnerships as hybrid forms of private-public ownership and we allow the parties to organize their relationship by assigning investment tasks.

The consideration of such a richer set of contractual arrangements can have important implications. For instance, in Hart, Shleifer, and Vishny's (1997) model giving a

[16] See also Holmström and Milgrom (1994) and Holmström and Roberts (1998), who have stressed that ownership is not the only means by which incentives can be affected.

[17] Hart (2003, p. C71) points out already that the possibility to write a long-term contract is a major difference between Hart, Shleifer, and Vishny's (1997) framework and the standard property rights model. Yet, the crucial role played by the contract is seriously underestimated when the specification of an appropriate quantity is not taken into account.

non-investing party ownership rights can be optimal, since ownership by the investing party may cause heavy overinvestment. This result can be refuted if it is possible to write quantity contracts with regard to the basic good.[18] Overinvestment then is a concern only in partnerships where both parties may implement innovations. It also turned out that allocating control over investment tasks can have important effects on the parties' incentives to invest when the investment levels themselves are non-contractible. Finally, we have shown that the optimal governance structure critically depends on the parties' bargaining powers. Note that the manager's bargaining power might be related to the degree of competition. Hence, integrating a property rights model of privatization into a model of competition seems to be a promising avenue for future research.

[18] Note, however, that giving a non-investing party ownership rights might turn out to be optimal if there were asymmetric information ex post; cf. Schmitz (2006), who introduces private information into Hart's (1995) standard incomplete contracting model.

References

Aghion, P. and J. Tirole, "The Management of Innovation," *Quarterly Journal of Economics* 109 (1994), 1185–1209.

Aghion, P., M. Dewatripont, and P. Rey, "On Partial Contracting," *European Economic Review* 46 (2002), 745–753.

Aghion, P., M. Dewatripont, and P. Rey, "Transferable Control," *Journal of the European Economic Association* 2 (2004), 115–138.

Bennett, J. and E. Iossa, "Building and Managing Facilities for Public Services," *Journal of Public Economics* 90 (2006a), 2143–2160.

Bennett, J. and E. Iossa, "Delegation of Contracting in the Private Provision of Public Services," *Review of Industrial Organization* 29 (2006b), 75–92.

Besley, T. and M. Ghatak, "Government versus Private Ownership of Public Goods," *Quarterly Journal of Economics* 116 (2001), 1343–1372.

Bös, D., *Privatization: A Theoretical Treatment* (Oxford, 1991).

Bös, D. and G. De Fraja, "Quality and Outside Capacity in the Provision of Health Services," *Journal of Public Economics* 84 (2002), 199–218.

Che, Y.-K. and D.B. Hausch, "Cooperative Investments and the Value of Contracting," *American Economic Review* 89 (1999), 125–147.

Francesconi, M. and A. Muthoo, "Control Rights in Public-Private Partnerships," Discussion Paper (2006).

Grossman, S.J. and O.D. Hart, "The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration," *Journal of Political Economy* 94 (1986), 691–719.

Hart, O.D., *Firms, Contracts and Financial Structure* (Oxford, 1995).

Hart, O., "Incomplete Contracts and Public Ownership: Remarks, and an Application to Public-Private Partnerships," *Economic Journal* 113 (2003), C69–C76.

Hart, O. and J. Moore, "Incomplete Contracts and Renegotiation," *Econometrica* 56 (1988), 755–785.

Hart, O.D. and J. Moore, "Property Rights and the Nature of the Firm," *Journal of Political Economy* 98 (1990), 1119–1158.

Hart, O. and J. Moore, "Foundations of Incomplete Contracts," *Review of Economic Studies* 66 (1999), 115–138.

Hart, O., A. Shleifer, and R.W. Vishny, "The Proper Scope of Government: Theory and Application to Prisons," *Quarterly Journal of Economics* 112 (1997), 1127–1161.

Holmström, B. and P. Milgrom, "Multitask Principal-Agent Analyses: Incentive Contracts, Asset Ownership, and Job Design," *Journal of Law, Economics, and Organization* 7 (1991), 24–52.

Holmström, B. and P. Milgrom, "The Firm as an Incentive System," *American Economic Review* 84 (1994), 972–991.

Holmström, B. and J. Roberts, "The Boundaries of the Firm Revisited," *Journal of Economic Perspectives* 12 (1998), 73–94.

Huberman, G. and C. Kahn, "Limited Contract Enforcement and Strategic Renegotiation," *American Economic Review* 78 (1988), 471–484.

Laffont, J.-J. and J. Tirole, "Privatization and Incentives," *Journal of Law, Economics, and Organization* 7 (1991), 84–105.

Martimort, D., "An Agency Perspective on the Costs and Benefits of Privatization," *Journal of Regulatory Economics* 30 (2006), 5–44.

Martimort, D. and J. Pouyet, "To Build or not to Build: Normative and Positive Theories of Public-Private Partnerships," *International Journal of Industrial Organization* 26 (2008), 393–411.

Maskin, E. and J. Moore, "Implementation and Renegotiation," *Review of Economic Studies* 66 (1999), 39–56.

Maskin, E. and J. Tirole, "Unforeseen Contingencies, Property Rights, and Incomplete Contracts," *Review of Economic Studies* 66 (1999), 83–114.

Roider, A., "Asset Ownership and Contractibility of Interaction," *RAND Journal of Economics* 35 (2004), 787–802.

Schmidt, K.M., "The Costs and Benefits of Privatization: An Incomplete Contracts Approach," *Journal of Law, Economics, and Organization* 12 (1996a), 1–24.

Schmidt, K.M., "Incomplete Contracts and Privatization," *European Economic Review* 40 (1996b), 569–579.

Schmitz, P.W., "Partial Privatization and Incomplete Contracts: The Proper Scope of Government Reconsidered," *FinanzArchiv* 57 (2000), 394–411.

Schmitz, P.W., "Information Gathering, Transaction Costs, and the Property Rights Approach," *American Economic Review* 96 (2006), 422–434.

Shapiro, C. and R. Willig , "Economic Rationales for the Scope of Privatization," in: E.N. Suleiman and J. Waterbury, eds., *The Political Economy of Private Sector Reform and Privatization* (Boulder, 1990).

Shleifer, A., "State versus Private Ownership," *Journal of Economic Perspectives* 12 (1998), 133–150.

Tirole, J., "Incomplete Contracts: Where Do We Stand?," *Econometrica* 67 (1999), 741–781.

Vickers, J. and G. Yarrow, *Privatization: An Economic Analysis* (Cambridge, 1988).

Williamson, O.E., *The Economic Institutions of Capitalism* (New York, 1985).

Williamson, O.E., "The New Institutional Economics: Taking Stock, Looking Ahead," *Journal of Economic Literature* 38 (2000), 595–613.