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01–5

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Private or Public? A Taxonomy of Optimal Ownership and Management Regimes*

Stephen King† Rohan Pitchford‡

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Abstract

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*Special thanks to Luigi Zingales for his insightful comments as a discussant at the AEA meetings. We would also like to thank Russell Cooper, Dhammika Darmapala, Joshua Gans, Oliver Hart, Philippe Jehiel, Marco Ottavianni, participants at the AEA meetings in Chicago and the Australasian econometrics society meetings, economics theory workshop participants at the Australian National University, and seminar participants at University College London,The University of Melbourne, Monash University and The University of Western Sydney for their feedback on various manifestations of this paper.

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1 Introduction

> "...the Government proposals are a massive betrayal of our National Interest against which the activities of [cold war spies] Burgess, Maclean, Philby and Blunt are very minor matters."[1]

Fierce passions are aroused by debate over public versus private ownership. Supporters of privatization argue that private ownership improves efficiency through increased profitability, while opponents claim that public ownership better serves the wider social interest. To help reconcile these contrasting views, this paper develops a model that identifies some of the basic characteristics that distinguish public and private ownership.

The model we develop uses an incomplete contracting framework to explore systematically the relationship between ownership, incentives, and the public goods characteristics of firm production. Governments are limited in their ability to perfectly regulate the operations of either public or private firms. As a result, public managers tend to face relatively flat commercial incentives compared with private managers. Flat incentives can be socially desirable when commercially productive activities generate large social harms relative to profit, but are undesirable when these activities are either benign or create external social benefits. From this basic insight we develop a taxonomy of optimal ownership regimes and apply it to a variety of real world examples.

The basic model considers managerial control of a single, indivisible asset. This is extended to the ownership and management of multiple assets. We consider mixed or separate public and private ownership, and joint or separate management – regimes that have widespread practical applicability. To the best of our knowledge, these possibilities have not been explored in previous literature.

The starting point of our analysis is the literature on incomplete contracts, beginning with Grossman and Hart (1986) and Hart and Moore (1990). These papers were the first to present a formal model that explains which agents should have ownership of an asset, when private firms should merge and when they should stay separate. More recently, Schmidt (1996); Hart, Shleifer and Vishny (1997); and Bolton and Xu

[1] The Right Honourable Mr. Tony Benn, in the British parliamentary debate over the sale of the British National Oil Corporation, Parliamentary Debates, Sixth Series, Volume 2, House of Commons, Official Report Session 1981-82, page 500.

(1997b), and Laffont and Tirole (1993) have extended the reasoning of these early pieces to the choice between public and private ownership.[2]

A crucial assumption in Grossman and Hart (1986); Hart and Moore (1990); Hart, Shleifer and Vishny (1997); and Bolton and Xu (1997b) is ex-post verifiability and bargaining. The parties with an interest in the firm bargain and contract over production variables that are chosen after some subset of them has made a specific investment. However, while the early ownership literature assumed that parties were private individuals, these papers extend the power of ex-post observability to government, or at least to a socially-minded government representative.

In contrast, we assume that government can commit to a set of coarse rules restricting the actions managers can take that enable them to divert value. Examination of the legislation governing public firms provides plentiful evidence of these coarse restrictions. For example, the Federal Aviation Administration "did not control its budget and was forced to overcome burdensome procurement regulations for every major purchase".[3] Managers of the government owned British Steel Corporation needed the consent of the Secretary of State to undertake substantial changes in activities.[4,5] Examples of the kinds of coarse rules that we have in mind in our model, include rules intended to prevent public managers from diverting funds to themselves or to their pet projects, rules governing disposal of assets, and rules that restrict the types of inputs that can be purchased.

We model private firms where incentives are well approximated by the behavior of a single owner-manager. That is, we do not consider agency problems that might exist between management and shareholders. This assumption is standard in the

[2]The literature on outside ownership, for example Rajan and Zingales (1998), and DeMeza and Lockwood (1998), can also be applied to the choice between public and private ownership, if one interprets the outside owner in their setting as government.

[3]Aman, 1996, p35

[4]Statutes in Force, Official Revised Edition, Iron and Steel Act 1982, Chapter 25, Part I, 2-(2), 4-(2) and (3), 5-(1) and (3).

[5]Other examples abound. Managers of the government owned Trans-Australian Airlines were unable to acquire rights or property, sell rights or property, or enter into a contract for construction, without prior approval of the minister, if the amount involved exceeded $250,000 (Australian National Airlines Act 1945, Division 1, section 22). Similar controls were also placed on the ability to lease or purchase land. Managers of Amtrak, the TVA and when publicly owned, British Telecom, as well as numerous smaller state-owned firms face restrictions on their ability to dispose of or purchase assets (e.g. Part 1, section 6 of the British Telecommunications Act 1981). As an extreme example, managers of Telecom Australia, at one stage, were required to ask for ministerial approval for standard business activities such as the routine purchase of cable.

emerging literature on the theory of private vs. public ownership. The assumption is a reasonable approximation in some cases and not others. Limited partnerships, small firms, and of course owner-managed firms fit this category. Examples might include emergency services, prisons, waste disposal, small scale utilities, and small scale research and development. Our model is not intended to represent large publicly listed corporations with disparate shareholding, except to the extent that these firms have solved agency problems.[6]

We model public and private ownership as distinct sets of rules that limit potential value-diverting activities that the manager is able to undertake. With pure private ownership there are *no* rules to limit value diversion. In effect, value is not diverted, but goes to the owner\manager as it is intended. In contrast, public ownership is consistent with greater restrictions on potential value-diversion than private ownership. This is not costless. For example, a rule that stipulates an extensive committee-based process for the sale of assets can entail a substantial resource cost. While abuses can be prevented, time and resources are expended in such processes. We assume that the extent of public ownership is synonymous with a list of procedures – or bans on activities – contingent on specific states of nature that may be realized (e.g., if sale of an asset is needed, if inputs must be purchased, or if a personnel problem must be solved). Such bans reduce the fraction of asset value managers are able to extract, but entail a bureaucracy cost. The government commits to this ex-post inefficiency to improve the ex-ante incentives of public managers.

A cost of banning value diversion is that the public manager is given flatter incentives for commercial activities. As mentioned this can be socially desirable if commercial activities are in conflict with external effects. Thus the Government faces a trade-off between value diversion, commercial incentives and external effects in its choice between public and private ownership. While this trade-off bears some similarity to informal conventional wisdom concerning privatization, we are not aware of any literature that formally models these phenomena from the perspective of the incomplete contracts approach to asset ownership. As well as examining ownership, our model is sufficiently flexible to enable us to represent the Government's choice of a regulatory system. For the sake of brevity, this extension of the basic model

[6]Laffont and Tirole (1991) is the only theoretical analysis of which we are aware, that includes the multiple agency introduced by shareholders. The rest of the literature cited here essentially assumes firms are run by a single owner manager.

is presented in the appendix. Among other things, we show that if it is optimal to privatize a firm, but the firm is kept in public ownership, then intervention by government (regulation) of the public firm will optimally be heavier.

The ownership framework we develop extends the incomplete contracts privatization literature (Hart, Shleifer and Vishny (1997); Bolton and Xu (1997b); and Rajan and Zingales (1998), and DeMeza and Lockwood (1998) – as applied to private ownership). In each of these papers, differences between private and public ownership emerge because government accounts for consumer surplus but not producer profits ex-post. If producer profits are also included in ex-post welfare, then the literature predicts that there is no difference between private and public ownership. A contribution of the present paper to the literature, is to explain differences between private and public ownership in a model where the government maximizes total social surplus including producer profits, ex-ante and ex-post.

The basic model in section 2 has one asset and one manager. We formally model the choice of ownership in this section. A mapping is derived between the commercial characteristics of the core activity associated with the asset, the external effects generated by the activity, and optimal ownership. In the appendix, we show how private and public ownership can be derived endogenously, as either a blanket ban, or tacit acceptance of potentially value-diverting activities, and we discuss interior solutions (where some potentially value diverting actions are banned and others are allowed). After presenting basic results, we show how our model can explain some of the key results in Hart, Shleifer and Vishny (1997) and Schmidt (1996).

The model is extended in section 3 to allow for two assets and two potential managers.[7] This leads to a considerably richer set of results compared with the one asset - one manager model. Having two assets introduces the possibility of spillovers between asset values in the two firms, and allows us to examine issues of joint and separate ownership that have not been formally explored by other authors. For example, we address the following questions: When privatizing related assets, should they be sold together or sold as separate firms? If it is desirable to separate assets, when does it make sense for one to be publicly owned and the other private?

A general pattern emerges from our framework. While the case for private own-

[7] The ownership and regulation of multiple assets is important in practice. For example, the breakup of the Bell group in the US (see Brennan 1987), gas privatization in the UK (see Armstrong, Cowan and Vickers 1995 and Vickers and Yarrow 1988) and rail and telecommunications reform in Japan (see Takeuchi, Imahashi and Yamauchi 1997).

ership can sometimes be made on the basis of qualitative characteristics (that is, the direction of the external, commercial and spill-over effects) public ownership requires quantitative analysis. From a policy maker's perspective, this means that the case for public ownership is more difficult to establish. Moreover, the set of potentially optimal regimes expands whenever private and social effects move in different directions. For example, we show that when the core activities improve asset value and generate spill-overs – but cause external harm – any ownership or management regime can be optimal. When there are conflicts between effects, measurement is required to determine the best regime.

A central objective of this paper is to provide policy makers with an organizing framework and a method to determine optimal ownership and management. To aid this process, the paper includes applications that we feel are relevant. Among other things, the model is able to explain why in some cases disposal of toxic waste might best be dealt with by a public agency, and why some kinds of innovative activity are best kept in the private sector. We discuss applications to emergency service provision, retail product innovation, airport ownership, and spill-overs in vertical production chains.

2 The single asset case

2.1 The Model

There are two players in the model – a government G and a manager M. G chooses the ownership regime $z \in \{0, 1\}$. The mechanics of this regime are explained in section 2.1.1 below.[8] Once the ownership structure is determined, M is hired from a homogenous pool of managers to run the firm. After the firm has been established, M chooses a production variable or effort $e \in \mathbb{R}_+$ at personal cost $\psi(e)$, which determines an external benefit (or cost) $b(e)$, and the value of the firm's asset $a(e)$.

Technical assumptions and terminology relating to e, a, ψ, and b are as follows:

Asset Value $a(e)$ is twice continuously differentiable and concave.

Managerial Effort e is

[8] The full version of diversion foundations, and an extension of this basic model to regulation are presented in the appendix.

(i) *commercially productive* if $a'(e) > 0 \ \forall \ e$, and $\lim_{e \to 0} a'(e) = \infty$; and

(ii) *commercially unproductive* if $a'(e) < 0 \ \forall \ e$.

We allow a to be either increasing or decreasing in e in order to allow for a variety of practical applications. For example, if the production variable e is research and development then this could be embodied in higher asset value. Alternatively if higher e leads to a fall in a, e can be interpreted as an action that 'wears down' the firm's capital. In emergency service provision, for example, assets consist of vehicles, medical and rescue supplies. Greater emergency service activity wears these assets down.

Effort Cost $\psi(e)$:

(i) is twice continuously differentiable and convex; and

(ii) has $\psi(0) = 0$, $\psi'(0)$ finite and $\psi'(e) > 0$ for e sufficiently large.

When $\psi > 0$, this reflects the standard cost of managerial activity. We allow the possibility that $\psi < 0$, and interpret this as the manager either enjoying the activity or increasing her human capital through 'on the job training'. For example, in emergency services, $\psi < 0$ could correspond to M obtaining transferable skills from being a rescue service manager.

External benefit $b(e, s)$ is

(i) a *positive externality* whenever $b_e(e) \geq 0$ for all e;

(ii) a *negative externality* if $b_e(e) < 0$ for all e;

(iii) twice continuously differentiable and concave;

An example of a negative externality is any kind of pollution. Increased community safety from increased emergency service activity is an example of a positive externality. We do not limit the interpretation of b to the impact on a group of consumers of the activity. The function b captures any benefit external to the firm that the planner cares about. From a positive political economy perspective, for example, it could be interpreted as any effect of the manager's action on re-election chances.

Following the literature on incomplete contracts, we assume that each of e, ψ, a, and b are non-verifiable. This is a stark assumption, and we relax the assumption that

these variables are always non-verifiable in the appendix. The flavor of results is not substantially changed by this modification, and some additional results on regulation are obtained.

2.1.1 Ownership

After output has been produced at date 1, the manager can take actions at date 2 which we think of as financial management actions, rather than directly productive actions. Ownership consists of a set of rules that restrict the types of actions M can take. For example, a rule could stipulate the procedures that M must follow when she sells assets, or when she pays creditors or otherwise disperses revenue. In some situations, restrictions – for example on asset sales procedures – will prevent M from disposing of an asset that delivers her some value (e.g., under-selling in return for perks or flavors). However, the rule can also have a side-effect that the sale process is bound up in red-tape, which entails a loss in efficiency. Rules may also determine the kinds of perquisites that the manager can generate, e.g. restrictions on travel, meal and office expenses. Again, these rules will prevent abuse, but will also entail some cost, for example if a business trip is important in resolving a costly personnel problem. There are many other examples where restrictions can have the dual effect of preventing value diversion, but also of preventing some efficiency from being realized. For example, rules on selection of future projects might prevent the manager from selecting a pet project, or one that gives her monetary benefits. However, it will also reduce the efficiency with which good projects are selected. The manager may also be restricted in the type of the office equipment she can purchase. Again this is good for preventing wasteful expenditure, but bad if the best equipment cannot therefore be bought.

All of these examples are situations where the manager is prevented from obtaining some positive asset value. If the firm makes a loss, rules can be instituted that prevent the manager from transferring these losses to the government. For example, rules could determine the type of expenses that are paid by government, and those which are not. Determining expenses that will not be paid by government entails costly investigation.[9]

The evidence we have gathered on public firms supports then notion that they are

[9] A very straightforward example where losses can be transferred to the government, is if they are the holders of the firm's worn down assets when output has been produced.

encumbered with more rules that restrict managers' behavior than private firms. This is especially true for the private firms in our model, since they are modeled as owner managed: our private firms do not suffer from agency problems, such as those which might exist between disparate shareholders and managers. We argue therefore that with public firms, governments place substantial restrictions on value diversion by the manager which means that they are worse at realizing practical efficiencies than private firms. Pure private firms are run by owner\managers, and do not need to set rules to prevent diversion, since all value ends up in the hands of the owner\manager regardless.[10]

In the appendix section 4.1.1, we exposit the value diversion foundations of our model, and extend the model to situations involving regulation and ownership. We have included only the discussion on pure public and pure private ownership in the main body of the paper for the sake of clarity. Thus, we define a pure private firm as one where there are no rules restricting value diversion, so that the private owner\manager legally receives a fraction $z = 1$ of asset value a. A public firm is owned by the government, and any activities that might allow the manager to divert value are banned. Thus, the manager receives a fraction $z = 0$ of asset value a. We assume this process is costs an amount l. We derive the solutions $z = 0, 1$ endogenously in section 4.1.1 of the appendix.

Solving the game Timing in the game is represented in figure 1. First, $z \in \{0, 1\}$ is chosen. At the time M chooses e, she anticipates being able to divert $z \in \{0, 1\}$ of asset value. Thus, she chooses e as follows:

$$e^z = \arg\max \{za(e) - \psi(e)\} \tag{1}$$

The manager of a pure public firm will choose $e = e^0$, the value that minimizes $\psi(e)$. If the activity is commercially productive then e^z is increasing in z. In particular, the manager of a purely private firm chooses effort $e^1 > e^0$. When e is commercially unproductive e^z is decreasing in z and $e^1 < e^0$ if $e^0 > 0$. Note that we assume both public and private managers have the same cost of effort. This eliminates any bias towards one for of ownership or the other.[11]

[10] Pure private ownership is *defined* as the government having no rules on diversion.

[11] We could assume, for example that public managers are more adept at correcting externalities. Alternatively, we could simply assume that public managers care about externalties per-se. Both of these assumptions would bias the starting point in comparing ownership regimes, so we make a more neutral assumption.

Subject to M's choice e^z, G chooses z to maximize the expected value of a utilitarian social welfare function:[12]

$$EW = b(e^z) + a(e^z) - \psi(e^z) - (1-z)l \tag{2}$$

The first three elements of EW are external benefit, asset value and effort cost evaluated at e^z chosen by M. The last term $(1-z)\,l$ is the loss from imposing bans on $M's$ potentially value diverting actions: we normalize $l = 0$ for simplicity, since positive values of l only serve to push the optimal regime towards private ownership in all cases.

Here, we concentrate on comparisons between pure public and pure private ownership. These options are might be the only practical alternatives if it is only possible to establish very coarse rules on potential value diverting activities – i.e. a ban ($z = 0$) or allowing the actions ($z = 1$).[13] As mentioned, the appendix section 4.1.1, considers situations where pure public or pure private ownership remains optimal even if mixed ownership is feasible (i.e. $z \in [0, 1]$).

2.2 Results

2.2.1 Trade-offs between pure private and pure public ownership

In the following discussion, define $\pi^z = a(e^z) - \psi\,(e^z)$ and $b^z = b(e^z)$ as firm profits and external benefits under regime z. Note that profits are always at least as high under pure private ownership as they are under pure public ownership, i.e. $\pi^1 \geq \pi^0$. Thus G's decision to privatize in the case where z is only either zero or unity, depends whether the increase in firm profits $\pi^1 - \pi^0$ plus the efficiency gain l exceeds the loss in external benefit $b^0 - b^1$. Private ownership is preferred to public ownership iff

$$\pi^1 - \pi^0 + l > b^0 - b^1$$

[12] This represents a utilitarian government that weighs the dollar value of external harm and firm profits equally. We could make a variety of alternative assumptions about G's objective function. Denote W as the welfare function excluding efficiency costs. Then $W = b$ represents a planner who may be captured by the constituency that faces the external benefit. If $W = a - \psi$, then G could be considered revenue maximizing, since G is unconcerned about external benefits that cannot be monetized and can capture all profits under either ownership regime. With $W = b + (1-\delta)\pi$, the planner is concerned about the constituency that faces the external benefit, but has an empire-building preference for public ownership.

[13] A trite, but telling example comes from peoples committments to stop smoking. It is easy to tell that someone has been smoking, but difficult to tell how many cigarettes they have had. Thus a ban on smoking is easy to enforce, compared to an explicit limit on the number of cigarettes consumed.

A taxonomy of possible cases is presented in Table 1. When the activity is commercially productive and causes a positive externality, (cell (III)), private ownership is optimal. In this case, $e^1 > e^0$. The marginal commercial gain from the activity is positive, so a private manager chooses a higher level of the activity. Since the externality is positive, external benefits are also higher under private ownership. For commercially unproductive activities that generate negative externalities (cell (IV)), private ownership is also optimal. A private manager has a commercial incentive to cut back the activity so that $e^1 < e^0$. Since e also generates an external harm, private ownership is unambiguously preferred.

Retail product innovation is a leading example of a commercially productive activity that generates positive externalities. An innovation that is privately profitable can provide spill-over benefits to other businesses. A public sector firm faces no commercial incentive to innovate. The lack of product innovation in the former Soviet Union and other centrally planned economies is illustrative of this case. For commercially unproductive activities that generate negative externalities, one example might be personal bias. Suppose a manager has preferences that are biased against a particular group of people on grounds of race, religion or personality.[14] A public manager faces no commercial incentive to refrain from discriminatory behavior, whereas a private manager may find it a money losing strategy. Private ownership will therefore be preferred.

Cells (III) and (IV) present situations where qualitative information on the nature of the asset is sufficient to determine the optimality of private ownership. The remaining cells in Table 1 involve ambiguous cases where relative magnitudes must be compared. Consider cells (I) and (II) where a commercially productive activity generates a negative externality. Since $e^1 > e^0$, private ownership creates a larger external harm than public ownership. Clearly, benefit functions $b(\cdot)$ exist where the increment in harm is larger than the gain in profits, and there are others where this increment is smaller. The former could be called relatively strong negative externalities, and the latter, relatively weak negative externalities.[15] An example in this

[14] It may be difficult for the government to prevent such discrimination. Rules favoring minorities when candidates are of 'equal ability' are difficult to enforce when the public manager judges candidate ability. Also, discrimination may operate over many dimensions and rules cannot prevent discrimination if the government does not know exactly which groups the manager is biased against.

[15] For example, suppose $b(e) \equiv \beta B(e)$, for $B_e > 0$, $B(0) = 0$. There exist negative β such that $\beta\left(B^1 - B^0\right) < \pi^1 - \pi^0 + l$, and also there exists positive β such that the reverse is true.

category is disposal of toxic waste, where effort is time spent thinking about cheaper methods of containment or dumping. Suppose the effects of poor waste disposal will not be felt until far in the future, so it is not possible to hold a manager personally liable.[16] A public manager is unconcerned about the costs of disposal. However, a private owner will have an incentive to cut corners and keep costs low. With waste of slight toxicity, savings from cheaper disposal could outweigh expected environmental costs, shifting the balance in favor of private ownership. However, if the waste is extremely toxic, public ownership will be preferred.

Cells (V) and (VI) represent optimal ownership when there is a commercially unproductive activity that generates a positive externality. Since $e^1 \leq e^0$, public ownership leads to at least as great external benefit as private ownership. As before, this gain must be weighed against the loss in profits. When the positive externality is relatively strong, public ownership is preferred, otherwise private ownership is better. Emergency services, such as fire, ambulance and rescue are good examples of this trade-off. While a public spirited manager might prefer to attend all calls, a private ambulance or fire service faces a financial disincentive when the customer cannot provide evidence of ability to pay. The choice between ownership structures depends on whether the cost of attending false emergencies outweighs the cost of unattended emergencies. Ambulance services are private in many parts of the United States, and public in the United Kingdom and Australia.[17]

Our analysis with a single asset and $z = 1$ or $z = 0$ suggests that qualitative information is sufficient to establish the dominance of private ownership in two cases. In contrast, quantitative information is *always* needed to establish the dominance of public ownership. Since estimation of external benefits for normative purposes is typically difficult, our model suggests that *the case for public ownership will generally be more difficult to establish.* Nevertheless, the 'privatization index', $p \equiv \frac{b^1 - b^0}{\pi^1 - \pi^0 + l} + 1$,

[16] The doctrine of successor liability, where subsequent owners of the assets are held liable for future environmental costs associated with the asset, will alleviate the problem in some, but not all circumstances. A successor is only held liable if the contamination is detected, and this may occur well after the firm has ceased operations. Parties may also use bankruptcy to become judgement proof and avoid facing the full costs of the contamination. Pitchford (1995) demonstrates that the potential for judgement-proofness ensures that an irreducible external social cost remains.

[17] The disincentive created by ownership in this example is similar in spirit to Rajan and Zingales (1998). In their model, ownership may reduce (socially desirable) investment by undermining an agent's *ex post* bargaining position. In our model, private ownership may reduce socially desirable activities when they directly generate private costs. We are grateful to Luigi Zingales for pointing out this analogy.

might be a useful cost benefit ratio to estimate when optimal ownership is ambiguous. $p > 0$ indicates private ownership is optimal and $p < 0$ means public ownership is optimal. The index is also useful as a summary of qualitative factors that favor privatization. When $p > 1$, external benefits and profit are higher under privatization. For other values of p, the magnitudes of private and external benefits need to be measured and compared.[18]

We extend the model to the case of regulation in the appendix. The basic flavor of results in proposition 1 are maintained in proposition 3 in the appendix. We show that with costless regulation, there is no difference between ownership regimes; conversely, some cost of regulation is needed for ownership to matter. We demonstrate that if a firm is kept in one form of ownership when the other is optimal (e.g. public when private is optimal), then the original (e.g. public) firm will optimally be more tightly regulated.

2.3 Comparisons with Current Literature

To the best of our knowledge, Schmidt (1991; 1996) was the first paper to distinguish between public and private ownership in an incomplete contracts model where the government has social welfare as its objective.[19] The manager of the firm in his model is assumed to make a non-contractible private investment e at date 0 that increases the probability that costs will be low when production takes place at date 1. Under public ownership, the government can observe costs at date 1, and chooses a production plan that is ex-post efficient. This, however, reduces the manager's incentive to invest at date 0. Under private ownership, the government induces more efficient investment *ex ante*, but at the cost of distortionary *ex post* regulation. Thus, Schmidt (1991; 1996) explains why public firms can suffer from X-inefficiency, where private firms suffer from distortionary regulation. The optimal regime is found by comparing these effects.

The basic assumption in Schmidt's model, is that the owner – be it a private

[18] Different objective functions for G alter the results somewhat. When G is captured by the constituency facing the external benefit ($W = b$), optimal ownership is straightforward to predict. Cells (I), (II), (V) and (VI) have public ownership as optimal. Private ownership is optimal in cells (III) and (IV). With $W = b + (1 - z)\pi$, assuming $\pi^0 > 0$, public ownership is preferred in cells (I), (II), (V) and (VI), and may be preferred in (III) and (V) if π^0 outweighs the loss $b^1 - b^0$.

[19] There are also a number of papers that analyze privatization in a positive political economy framework. For example, Boyco, Shleifer and Vishny (1996). See also Lopez-de-Silanes, Shleifer and Vishny (1997).

owner or a government – is able to observe the same variables as the manager.[20] Our model can be used to explain similar outcomes in situations where G has no informational advantage under public ownership. Consider table 1 when the activity is commercially productive. Under public ownership, M chooses a lower level of effort than an equivalent private manager because she is lacking a commercial incentive. This is analogous to the x-inefficiency of the public firm in Schmidt. The inefficient regulation aspect of Schmidt's results can also be captured. Under private ownership, effort is higher due to the commercial incentive, but may be inefficiently high if production generates a negative externality. This can be interpreted as an inability to perfectly regulate to account for the external effect.

Hart, Shleifer and Vishny (1998) emphasize the fact that different incentives to implement cost and quality innovations have been central to the privatization debate in the informal literature. They develop a model, with *ex post* renegotiation between the government and the public or private manager. One of their key results is that relative to public ownership, private ownership can give stronger (and socially excessive) incentives to lower costs at the expense of quality. But overall, quality under private ownership can be higher or lower than under public ownership.

While Hart, *et al*'s analysis involves two distinct activities, similar results can be derived in the one-asset version of our model. Consider table 1 when the manager can engage in an activity that is commercially productive but generates a negative externality. For example, the activity reduces production costs but also reduces product quality. If the private manager cannot be made to bear the full social costs of the quality reduction — for example in a prison where the quality of rehabilitation is hard to observe — then the activity will generate a negative externality.[21] From our results above, a private owner will choose a higher level of this activity than a public manager. Optimal ownership depends on the relative size of both the cost reduction and the deterioration in quality (cells I and II in table 1). If there is relatively little reduction in quality but a substantial cost saving from the activity then private ownership will be desirable. Conversely, where cost savings are outweighed by the negative effects of quality deterioration, public ownership will be preferred.

[20] We make a more conservative assumption, because the premise that ownership confers an ability to observe raises a number of theoretical questions. First, if ownership is conducted at arms length, why is monitoring possible? If arms length monitoring is possible, then why is this not separable from ownership? See Hart (1991,1995) for details.

[21] Such an activity is equivalent to the investment e in Hart, *et. al.*

Our model can also be used to explain how private ownership can yield higher levels of quality and lower *net* costs. In the table, consider an activity that is commercially productive and generates a positive externality. For example, the manager may be able to raise product quality. If the manager can (imperfectly) capture the benefits of any quality improvement through increased revenues, then raising quality will generate both increased asset value and external social benefits.[22] A private manager will choose a higher level of the activity than a public manager. Private ownership raises quality and asset value, and is unambiguously desirable.

Our framework can capture the flavor of the cost versus quality trade-off in Hart, *et al*, and extends their results to more general government objective functions. Hart, *et al* assume that the government's utility function at the time of ex-post bargaining is given by the welfare of society *excluding* the utility of the manager. This can be justified in terms of a voting model where the manager has insignificant power to elect the government. However, if a purely normative approach is taken, G's utility at the time of *ex post* bargaining will be identified with *ex post* social welfare. As Hart, *et. al* note,[23] if the government seeks to maximize total *ex post* social welfare, the first best can be achieved. In this case, public and private ownership are identical. This result occurs elsewhere in the ownership literature. If the government (a) has the ability to observe and negotiate over *ex post* variables, and (b) has a purely normative objective of maximizing social welfare both *ex post* and ex-ante, then the first best can be achieved.[24] The reason is that with social welfare as an objective, G gains utility with the manager on a one-for-one basis. Therefore, G will be willing to give M all the surplus in any bargain, with the result that M faces the full marginal social incentive to invest.

In our model, G can commit to a set of rules that sometimes restrict the actions M can take to divert value $a(e)$. Without commitment to this bureaucratic structure, G would have an incentive to renegotiate after e is chosen, and allow M to divert all value so that the efficiency gain l is realized. However, a public manager would anticipate this and choose the private production level $e = e^1$. Commitment to bureaucratic waste is the method that G uses in order that public managers be given appropriate ex-ante incentives. Such commitment generates the key difference between public and

[22] This is equivalent to the investment i in Hart, *et. al.*

[23] Hart, Shleifer and Vishny (1997) page 9, footnote 6.

[24] See for example, the outside ownership analyses of Rajan and Zingales (1998), and DeMeza and Lockwood (1998) – re-interpreted and applied to the issue of private versus public ownership.

private ownership that distinguishes our model from the literature.

One might argue that in our framework, the government could mimic public incentives under private ownership if it required that the firm was owned by a private party whose role was to enforce the rules that inhibit value diversion. Such a party would receive asset value and would only be responsible for making sure that the manager does not undertake potentially value diverting actions. Under this interpretation, our model would apply to any arms-length ownership rather than government ownership – and so might not be considered a theory of public ownership. The flaw in this argument is that such a private owner does not care about $b(\cdot)$ and therefore has an incentive to collude with the manger to enable her to capture a higher net return, for example by allowing value-diverting actions in return for a side-payment. G would then need to monitor the private owner to ensure that rules are followed, and so making this structure equivalent to the original public firm. The distinguishing feature of a purely private firm is that G does not need to make any rules, and so has no need to monitor M at all.

3 The two asset case

Extending the model to two assets, two productive efforts, and two potential managers, allows us to analyze optimal ownership when actions taken by one firm affect the profitability of the other. Ownership and management regimes are significantly more complex in the two asset case. Specifically, we can examine the determinants of when assets should be jointly or separately owned under either private or public ownership. For example, when considering a railway system, should the tracks and rolling stock be private or public? If private, should they be jointly owned or separated? Rather than examine the general case, this section will focus on two examples that illustrate the trade-offs in the general case.[25]

We denote the managers by A and B and index the assets by $j \in \{1, 2\}$. Other than their label, the managers are identical. To avoid excessive notation and to make the analysis tractable, we confine attention pure public or private ownership and assume $l = 0$.[26] Denoting z_j as the ownership regime for asset j, we therefore make the restriction $z_j \in \{0, 1\}$ for $j = 1, 2$.

[25] A complete analysis of the two-asset case is available in King and Pitchford 1998.

[26] Positive l biases the optimal regime towards privatization.

Initially, G decides whether each individual asset will be publicly or privately owned and assigns manager $M \in \{A, B\}$ to assets. G may choose either a single manager for both assets or different managers for each asset. Management can be either 'unified' or 'separate' depending on whether G appoints one manager for both assets or different managers for each asset respectively. Ownership is 'public' or 'private' if $z_1 = z_2 = 0$ or $z_1 = z_2 = 1$ respectively. If one asset is private while the other is public we refer to ownership as 'mixed'. Thus, overall, six ownership and management regimes are available to the government.

After the regime is selected, managers choose their activities. The manager of asset j chooses effort $e_j \in \mathbb{R}_+$. This effort affects the value of asset j through the asset value function $a_j(e_j)+\alpha_j(e_k)$, $k \neq j$. As in the single asset case, $a_j(e_j)$ represents the direct effect of the managerial activity on asset value. In addition, $\alpha_j(e_k)$ is a spill-over effect from the effort associated with the other asset. Let $a_j(e_j) = e_j$ and $\alpha_j(e_k) = I_j \alpha_j e_k$ where $\alpha_j \in (0, 1)$ and $I_j \in \{-1, +1\}$, $k \neq j$. Managerial activities are commercially productive in this example (that is, $a_j' > 0$). The activities have positive spill-overs if $I_1 = I_2 = +1$ and negative spill-overs if $I_1 = I_2 = -1$. In each case, we assume $\alpha_j < 1$, so that spill-over effects are 'weaker' than direct effects on asset value.

Activities generate externalities through the external benefit function $b(e_1, e_2) = \beta_1 e_1 + \beta_2 e_2$. Activity e_j generates a negative externality if $\beta_j < 0$ and a positive externality if $\beta_j > 0$. The relative strength of an externality is measured by the size of the coefficient β_j.

Activity e_j creates dis-utility $\psi(e_j) = \frac{1}{2}e_j^2$ for the manager of asset j. If A manages both assets, then total dis-utility is $\psi\frac{1}{2}e_1^2 + \frac{1}{2}e_2^2$.[27]

First consider the case of positive spill-overs ($I_1 = I_2 = +1$). Figure 3 illustrates the socially optimal ownership regimes for various levels of externalities β_1 and β_2.[28] The quadrant with $\beta_1, \beta_2 > 0$ leads to unified private ownership. If commercially productive activities involve positive externalities and positive inter-asset spill-overs, then unified private ownership will encourage the socially desirable activities. This is analogous to the single asset case where if all private and social incentives are aligned (unified) private ownership is optimal. There is one major difference with

[27] We assume additive separability of effort cost because this eliminates any technical bias towards separate or joint management.

[28] The social welfare comparisons used to generate figure one are given in the appendix.

the single asset case: We will show below that the fact that spill-overs are positive is crucial. Note also that, analogous to the single asset case, G only needs to have qualitative information about externalities and spill-overs to determine that unified private ownership is optimal.

Airport management provides an example of this situation. Good administration improves the return at a given airport, but also has a positive spill-over to other airports. If a plane's departure is delayed due to poor management at an originating airport, then its arrival is also delayed, making operation of the terminating airport more difficult.[29] This suggests that the unified sale of the British Airports Authority in 1987 was appropriate. The Federal Government of Australia recently privatized the airports in all major cities except Sydney. However, contrary to our model, it chose separate private ownership.[30]

Consider the quadrant in figure 3 with $\beta_1 > 0$ and $\beta_2 < 0$. On the dotted line beginning at $\beta_1 = \tilde{\beta}_1$, if β_2 is close to zero, the benefits of encouraging e_1 outweigh the costs of encouraging e_2 and unified private ownership is optimal. As β_2 falls, separate private ownership of asset 2 becomes optimal. This regime reduces the managers' incentive to undertake e_2 and e_1, as spill-overs are not internalized. As β_2 decreases further, asset 2 should be publicly owned in order to further decrease e_2. However, because of the weak spill-over of e_2 on asset 1's value, it is worthwhile having the owner of asset 1 also manage asset 2. That is, unified mixed ownership with asset 1 private is optimal. (Effort e_2 is too low if the other manager is in charge of asset 2.) Finally, with β_2 sufficiently negative, the strongest possible incentive to discourage e_2 needs to be given and separate public ownership of asset 2 is optimal.

[29] It is difficult to write contracts to allocate liability for delays, because other factors such as weather, or delays at other airports can be blamed.

[30] Vickers and Yarrow (1988) discuss the privatization of the BAA. See 1997 and 1998 issues of *Public Utility Regulators Forum*, published by the Australian Competition and Consumer Commission, for details on the sale and regulation of Australian airports. In both cases, parties argued for separate private ownership to improve competition. This argument is quite weak in the Australian case. Most flights are domestic, each major city has only one major airport and distance precludes competition by combining air and ground transport. There is likely to be some competition between airports representing their regions as tourist destinations. However, the margins seem too small for many tourists to alter their decisions based on the facilities and prices charged by an airport. Separate privatization of airports in the same city is another matter. In this case, a competition argument is stronger, since the airports do in fact compete with each other. A competition based conclusion could be made in large countries or regions that have competing hubs. For example, in the UK, competition between British airports must be placed in the context of wider European airport competition.

The remaining quadrant is $\beta_1, \beta_2 < 0$, which illustrates a situation where any regime may be optimal. Consider the dotted line in this region. At low levels of β_1 and β_2, contributory spill-overs outweigh the externalities and unified private ownership is optimal. Moving down the line, the externalities become more negative and outweigh the positive effect of inter-asset spill-overs. Separate private ownership is preferred. As β_1 and β_2 continue to fall, it is desirable to have public ownership of the asset with the more severe externality. Moving further, separate mixed ownership with 2 public is optimal, as this regime more effectively discourages e_2 than unified mixed ownership. Eventually if both activities generate sufficiently strong negative externalities, public ownership of both assets is optimal.

Anti-competitive activity, such as deterring or blockading entry, is captured by the movement along the line with β_1 and β_2 negative. This activity benefits other incumbent firms but makes consumers worse off. The choice between unified and independent private ownership depends on the severity of the effect on consumers. If the negative effects of these anti-competitive activities are sufficiently severe, then public ownership might be considered.

Alternative trade-offs are illustrated when $I_1 = I_2 = -1$ so that there are negative spill-overs between firms. Figure 4 illustrates the socially optimal ownership regimes for various levels of externalities β_1 and β_2 when $\alpha \in (\frac{1}{2}, 1)$.[31] If externalities are relatively small, then unified private ownership is optimal. If β_1 and β_2 both increase, however, then separate private ownership is preferred to encourage the activities. This is in contrast with the positive spill-overs case, where unified private ownership was always optimal when $\beta_1, \beta_2 > 0$. When spill-overs are negative and positive externalities are large, separate ownership means the spill-overs are not internalized, so encouraging higher effort, and taking advantage of the positive effect on outside parties.

If β_1 and β_2 are sufficiently negative then public ownership is preferred to retard the commercial activities. This case is relevant for spill-overs in vertical production. Suppose there are two assets, water supply and water distribution. Negative spill-overs between asset values are generated by reductions in water quality. While this reduces costs and is commercially productive, it has a negative external effect on consumers. Because of the spill-over effect between the upstream and downstream producers, separate private ownership is always socially dominated by unified private

[31] The social welfare comparisons used to generate figure two are given in the appendix.

ownership. If the reduction in water quality at both production stages is sufficiently harmful, as measured by β_1 and β_2, then public ownership can dominate any form of private ownership. Similar issues arise in rail privatization and the separation of track and train companies in the UK has led to considerable concern about vertical spill-overs and industry performance.

4 Conclusion

In this paper we have developed a framework for comparing public and private ownership. The key feature underlying our model that differentiates it from the literature is that government can commit to a set of rules that control the managers ability to divert value. The simple model that results from this hypothesis is applicable to a wide variety of situations involving single and multiple assets. While our results have considerable intuitive appeal, the complexity of interactions between ownership, inter-asset spill-overs and social externalities shows the need for careful formal analysis.

Our model is aimed at providing an organizing framework for policy makers. We show that the optimality of private ownership (with integrated management where relevant) may be judged purely on qualitative factors. In contrast, the optimality of all other ownership and management regimes will depend on specific quantitative information. In the case of a single asset, this makes the case for public ownership intrinsically more complex than that for private ownership. Similarly, for multiple assets, regimes involving public ownership or separate management must be based on stronger evidence than is sometimes necessary to show optimal integrated private ownership.

Our analysis makes clear the type of information that needs to be gathered to establish which regimes are preferable. Practitioners must consider how a shift in ownership interacts with managerial incentives. In some cases, it may be desirable to consider 'non-standard' combinations of ownership and management, for example where a private owner also manages a public firm.

A key implication of our model is the benefit of considering privatization on a case-by-case basis. While it may be easier to make the case for private ownership rather than public ownership, policy makers still face the burden of proving their case. If the government's aim is to maximize social welfare, then a general ownership

policy is unlikely to be adequate.

Appendix

4.1 Extensions and Foundations

4.1.1 Foundations: A Model of Diversion

Timing in the game is as follows: G hires M, the ownership regime $z \in [0,1]$ is determined, M chooses productive effort e, and then nature reveals the type of actions M can take to divert value. See Figure 2.

Let the random variable $\zeta \in [0,1]$ determine the nature of actions the manager can take to divert value. We assume that ζ is uniformly distributed without loss of generality. Ownership is modeled as follows: At the beginning of the game, G can commit to rules that ban potentially value diverting actions in states $\zeta \geq z$. Thus z determines a partition between states where the actions are allowed, and where they are not allowed. Note that a 'ban' on an action is equivalent to setting up a process (e.g. a committee, or some other kind of scrutiny) that prevents some action from being taken. This process is assumed to cost l. This cost can be thought of as a direct cost of scrutiny, or a foregone efficiency from that results from banning actions.[32] If $z = 1$, then G does not ban actions in any state. M receives all of a, and we describe this as a pure private firm. If $z = 0$, then G decides to ban actions in all states – this is our definition of a pure public firm. M receives none of asset value a. We allow the possibility of hybrid regimes where $0 < z < 1$, where M receives fraction za of asset value. However, it is very important to note that in practice it may be difficult to finely describe actions in each state, so that only more coarse ownership structures may be feasible in practice. We consider such a case in the main body of the paper (e.g. only $z \in \{0,1\}$ is feasible.)[33]

We assume that if an action is not banned (i.e. $\zeta < z$), then M is able to divert some fraction of asset value a to her own use. This is assumed to be 100% for ease of notation – the qualitative nature of our results is unchanged if we assume that a positive but non-zero fraction is diverted. If an action is banned (i.e. when $\zeta \geq z$), then no diversion occurs, but a loss l is suffered.[34]

Figure 2 summarizes the basic structure of timing in the diversion game. First the ownership structure z is chosen, and G hires M. Then M chooses e at cost ψ

[32] Note that when the activity is commercially unproductive and $a < 0$, we interpret z as follows: G must scrutinize actions that M takes that seek to transfer assets out of the firm.(such as through the transfer back to G of worn down assets, or the depletion of stocks of other inputs). For states $\zeta \geq z$, M will receive authorization for such transfers at cost l. For states $\zeta < z$, authorization will not be given, so M must bear the loss. Just as in the case $a > 0$, it is important that the value or loss M realizes is non-verifiable.

[33] Note that M has the residual right to divert value in all those circumstances where diversion is not prevented. This precisely fits the definition of ownership as given in Grossman and Hart (1986). When z can only be chosen from a coarse partition, e.g. $z \in \{0,1\}$, $z = 1$ gives M the residual right to keep value in *all* states of nature. If $z = 0$, then M has no ownership rights as we have defined them. In this case, G is considered to be the owner.

[34] Thus, G is chooses to describe the set $\zeta \geq z$ in legislation as activities that are not allowed. This is also technically equivalent to a random ban on diversionary activity with probability $1 - z$, though the interpretation in the text is more practical.

which determines a and b. After this, ζ is realized and M diverts value if possible.

Below we present results for the optimal choice of $z \in [0,1]$. We derive conditions under which pure public or pure private ownership remain optimal even though the government can finely control diversionary activities (ie choose z as any fraction between 0 and 1). For ease of exposition, we assume $l = 0$. Larger values of l – the efficiency gain from not banning value-diverting actions – increases the set of cases where private ownership is optimal.

Proposition 1 *Suppose ownership can be finely controlled* ($z \in [0,1]$) *and define* $g(z) = b_e(e^z) + a_e(e^z)$

(1) *Private ownership* ($z = 1$) *is optimal if* $b_e \cdot a_e > 0$ *for all* s, e.

(2) *Public ownership* ($z = 0$) *is optimal if*

- **(i)** *e is commercially unproductive, has a positive externality and* $g(0) > 0$, *or*
- **(ii)** *e is commercially productive, has a negative externality and* $g(0) < 0$.

(3) *Hybrid ownership* ($z \in (0,1)$) *is optimal if*

- **(i)** *e is commercially unproductive, has a positive externality and* $g(0) < 0$, *or*
- **(ii)** *e is commercially productive, has a negative externality and* $g(0) > 0$.

Proof. This is a special case of proposition 3 below. ■

The intuition for each of these results is very similar to the intuition for the discrete case $z = 1$ or 0. For (1) $b_e \cdot a_e > 0$ means that commercial and external effects are in the same direction. Private ownership and social incentives coincide and a corner solution $z = 1$ must be optimal, since allowing value diversion provides the strongest possible available incentive. For (2) and (3) the externality and the commercial effect are in different directions. Consider part (ii) for each of (2) and (3), with $b_e < 0$, $a_e > 0$. This is the leading case for a trade-off between private and public ownership, since there is a negative externality associated with a commercially productive activity. The function $g(0)$ is the sum of the expected marginal externality $b_e(e^0)$ and the marginal commercial effect $a_e(e^0)$ under pure public ownership. Note that it must be true that $e^0 < e^z$ for all $z > 0$ by continuity of the manager's objective and our assumptions on managerial effort and effort cost. Since $b_{ee} < 0$, the marginal negative externality becomes stronger if $e > e^0$. However, since $a_{ee} < 0$, the (positive) marginal commercial effect becomes weaker if $e > e^0$. Consider (2)(ii). Public ownership is optimal if $g(0) < 0$, since any increase in the managerial activity leads to greater marginal external harm than marginal commercial gain. However, in (3)(ii) where $g(0) > 0$, it is desirable to set $z > 0$ to provide some private incentives. Loosely speaking, the optimal level of z will tend to fall as the negative externality becomes 'stronger'. The reasoning for part (i) of cases 2 and 3 is analogous. Clearly, the intuition that we gain from the case where $z \in \{0,1\}$ and only pure regimes are possible, carries over strongly to the case where more finely tuned regimes are possible.

4.1.2 Extension: The Model with Regulation and Ownership

The one asset model is modified by introducing a regulatory state of nature $s \in [0,1]$, distributed according to a CDF, $F(s)$. Realization of this variable determines the exact type of externality that is generated in conjunction with the firm's production. Consider the timing diagram figure 3. The regulatory regime is modeled as follows: We assume that by virtue of her day to day running of the firm, M is always able to observe the regulatory state of nature s at date $1/2$. Therefore, M can determine the effect that e will have on external benefits $b(e,s)$ at date 1. G is not able to costlessly observe s and e. Instead, G sets up a regulatory regime $\sigma \in [0,1]$ at cost $c(\sigma)$ at date 0 that enables her to monitor M's choice of e in all states of nature $s \leq \sigma$ at date $1/2$. The cost $c(\cdot)$ is increasing and convex. Thus, higher states are harder to monitor and hence regulate, but in states $s \leq \sigma$, G will require that M choose the first-best level of e at date 1.

The first point to note is that if regulation is costless, then ownership is irrelevant:

Remark 2 *If $c(\sigma) \equiv 0$, then the first best is obtained, and expected social welfare does not depend on ownership. In particular, there is no difference between pure public and pure private ownership.*

Proof. G can verify e for all $s \leq \sigma$, and since σ is costless, she will choose $\sigma = 1$. Thus, G sets $e = e^*(s)$, the first best level, for all s. ■

However, if regulation is costly, private and public ownership will differ in their impact on social welfare: With regulation, proposition 1 is modified as follows:

Proposition 3 *Suppose diversion can be finely described ($z \in [0,1]$) and define $g(z,\sigma) = \int_\sigma^1 b_e(e(z),s)dF(s) + a_e(e(z))[1 - F(\sigma)]$*

(1) *Private ownership ($z = 1$) is optimal if $b_e \cdot a_e > 0$ for all s, e.*

(2) *Public ownership ($z = 0$) is optimal if*

- **(i)** *e is commercially unproductive but has a positive externality and $g(0,\sigma) > 0$ for all $\sigma \in [0,1]$, or*
- **(ii)** *e is commercially productive, has a negative externality and $g(0,\sigma) < 0$ for all $\sigma \in [0,1]$*

(3) *Hybrid ownership ($z \in (0,1)$) is optimal if*

- **(i)** *e is commercially unproductive but has a positive externality and $g(0,\sigma) < 0$ for all $\sigma \in [0,1]$, or if*
- **(ii)** *e is commercially productive, has a negative externality and $g(0,\sigma) > 0$ for all $\sigma \in [0,1]$.*

These results parallel the case without regulation.

Proof of Proposition 3. At date 1, the manager's problem for states of nature above σ is

$$\max_e za(e) - \psi(e)$$

which yields the solution $e(z)$ satisfying

$$e'(z) = \frac{-a'}{za'' - \psi''}$$

so that

$$sgn\left(e'(z)\right) = sgn\left(a'(e)\right). \tag{3}$$

$G's$ problem (with $l = 0$ for simplicity) is to select z and σ to solve

$$\max_{z,\sigma}\left[EV = \int_{-\infty}^{\sigma} w^*(s;\beta)dF(s) + \int_{\sigma}^{\infty} w\left(e(z), s;\beta\right)dF(s) - c\left(\sigma\right)\right]. \tag{4}$$

Where

$$\begin{aligned} w^*(s;\beta) &= \beta b(e^*, s) + a(e^*) - \psi(e^*) \\ e^* &= \arg\max_e\{\beta b(e, s) + a(e^*) - \psi(e^*)\} \end{aligned}$$

and

$$w(e\left(z\right), s;\beta) = \beta b\left(e(z), s\right) + a(e\left(z\right)) - \psi(e(z)).$$

We interpret $\beta \in \mathbb{R}_+$ as the strength of the externality. Using the envelope theorem from the manager's problem, the first-order-condition with respect to z for this program is

$$\frac{\partial EV}{\partial z} = \left\{\int_{\sigma}^{\infty} \beta b_e\left(e(z), s\right)dF(s) + \left(1 - z\right)a_e\left(e\left(z\right)\right)\left[1 - F(\sigma)\right]\right\}e'(z) = 0 \tag{5}$$

Consider the following term in (5):

$$\gamma(\sigma, z) = \int_{\sigma}^{\infty} \beta b_e\left(e(z), s\right)dF(s) + \left(1 - z\right)a_e\left(e\left(z\right)\right)\left[1 - F(\sigma)\right].$$

Since $e' \neq 0$, the properties of γ will determine the optimal ownership structure. In particular, note that

$$\gamma_z(\sigma, z) = \left\{\int_{\sigma}^{\infty} \beta b_{ee}dF(s) + \left(1 - z\right)a_{ee}\left[1 - F(\sigma)\right]\right\}e' - a_e\left[1 - F(\sigma)\right].$$

Since by (3) $sgn\left(e'\right) = sgn\left(a'\right)$, we must have $\gamma_z\left(\sigma, z\right) > 0$ in the case (2)(i) since $\alpha_e < 0$, and $b_{ee} < 0$, $a_{ee} < 0$. However, (2)(i) specifies $b_e > 0$, and $g\left(\sigma\right) = \gamma\left(\sigma, 0\right) > 0$ for all σ, so that from (5), $\frac{\partial EV}{\partial z} = \gamma e' < 0$ for all σ, so $z = 0$ must be optimal. Case (2)(ii), $b_e < 0$, $\alpha_e > 0$ with $g\left(\sigma\right) < 0$ for all $\sigma \in [0, 1]$ has an analogous proof. Consider (3)(i) in which hybrid ownership ($z \in (0, 1)$) is optimal if $b_e > 0$, $\alpha_e < 0$, and $g\left(\sigma\right) < 0$ for all σ. From (2)(i), we had the same conditions except that $g\left(\sigma\right) > 0$. With γ an increasing function of δ, the condition $g\left(\sigma\right) = \gamma\left(\sigma, 0\right) < 0$, and the fact that $\gamma\left(\sigma, 1\right) = \int_{\sigma}^{\infty} \beta b_e\left(e(z), s\right)dF(s) > 0$, means that the continuous function $\gamma(\sigma, z)$ equals zero for some $z \in (0, 1)$. The proofs for the first part of (3)(ii) are analogous. Finally, note that there are reasonable circumstances under which

$g(\sigma)$ can be positive or negative, for example, suppose b is independent of s. Then $g(\sigma) = \gamma(\sigma, z) = [\beta b_e(e^0, s) + a_e(e^0)][1 - F(\sigma)]$. ■

In addition to confirming that the structure of results is maintained with regulation, we can make statements about the interaction between regulation and ownership. For simplicity, assume that $F(s)$ is continuously differentiable with an associated probability density function $f(s)$. Further, $f(s)$ has a finite upper bound. Then, if $\lim_{\sigma \to 1} c(\sigma) = \infty$, it will never be optimal to fully regulate either a public or a private firm (i.e. set $\sigma = 1$). Assume that $EV(\sigma, z)$ is strictly concave in σ for any z. First consider the binary case $z \in \{0, 1\}$. Optimal ownership regimes for a given level of regulation σ by the government parallel the case where regulation is not possible: we simply consider the residual unregulated choices by M under different ownership regimes. Clearly, if one regime dominates for all possible choices of σ, then it will dominate under any choice of regulation. However, the choice of optimal regulation provides some additional insights. Consider the expression for EV in (4), and differentiate with respect to σ to solve for critical points σ, which we shall denote as σ^z:

$$\frac{dEV(\sigma^z, z)}{d\sigma} = [w^*(\sigma^z) - w^z(\sigma^z)] f(\sigma^z) - c'(\sigma^z) = 0 \tag{6}$$

To interpret this equation, suppose for example, that private ownership dominates in all regulatory states of nature, so that $w^1(\sigma) > w^0(\sigma)$ for all σ. This occurs, for example, when $b_e a_e > 0$ for all s, e. Then from (6), it must be that $\sigma^0 > \sigma^1$, i.e.. a firm that remains public will be more heavily controlled than the privatized firm. The intuition is that the welfare is lower in any given state in the public firm, so that it is worth controlling the firm more tightly and gaining w^* in a greater proportion of states, i.e., if we suppose $w^z(\sigma) > w^{z'}(\sigma)$ for all σ, and $z \neq z'$, then $\sigma^z > \sigma^{z'}$.

Derivation of diagrams:

Let $W^{Rz_1z_2}$ refer to social welfare under regime Rz_1z_2. Figure 1 is derived from the following 21 relationships.

$SW^{U11} - SW^{I11} = \alpha + \beta_1 + \beta_2$
$SW^{U11} - SW^{I10} = \alpha\beta_1 + (1+\alpha)\beta_2 + \frac{1}{2} + \alpha(1+\alpha)$
$SW^{U11} - SW^{I01} = \alpha\beta_2 + (1+\alpha)\beta_1 + \frac{1}{2} + \alpha(1+\alpha)$
$SW^{U11} - SW^{U10} = \alpha\beta_1 + \beta_2 + \frac{1}{2} + \frac{1}{2}\alpha^2$
$SW^{U11} - SW^{U01} = \alpha\beta_2 + \beta_1 + \frac{1}{2} + \frac{1}{2}\alpha^2$
$SW^{U11} - SW^{U00} = \beta_1 + \beta_2 + 1 + \alpha$
$SW^{I11} - SW^{I10} = \beta_2 + \frac{1}{2} + \alpha$
$SW^{I11} - SW^{I01} = \beta_1 + \frac{1}{2} + \alpha$
$SW^{I11} - SW^{U10} = \beta_2 + \frac{1}{2}\alpha + \frac{1}{2}$
$SW^{I11} - SW^{U01} = \beta_1 + \frac{1}{2}\alpha + \frac{1}{2}$
$SW^{I11} - SW^{U00} = \beta_1 + \beta_2 + 1 + 2\alpha$
$SW^{I10} - SW^{I01} = SW^{U10} - SW^{U01} = \beta_1 - \beta_2$
$SW^{I10} - SW^{U10} = -\beta_2 - 1 - \frac{1}{2}\alpha$
$SW^{I10} - SW^{U01} = \beta_1(1-\alpha) - \beta_2 - \alpha - \frac{1}{2}\alpha^2$

$SW^{I10} - SW^{U00} = \beta_1 + \frac{1}{2} + \alpha$
$SW^{I01} - SW^{U10} = \beta_2(1-\alpha) - \beta_1 - \alpha - \frac{1}{2}\alpha^2$
$SW^{I01} - SW^{U01} = -\beta_1 - 1 - \frac{1}{2}\alpha$
$SW^{I01} - SW^{U00} = \beta_2 + \frac{1}{2} + \alpha$
$SW^{U10} - SW^{U00} = \beta_1 + \alpha\beta_2 + \frac{1}{2} + 2\alpha + \frac{1}{2}\alpha^2$
$SW^{U01} - SW^{U00} = \beta_2 + \alpha\beta_1 + \frac{1}{2} + 2\alpha + \frac{1}{2}\alpha^2$

Figure 2 is derived from the following 21 relationships.

$SW^{I10} = SW^{U10}$
$SW^{I01} = SW^{U01}$
$SW^{U11} - SW^{I11} = \alpha - \beta_1 - \beta_2$
$SW^{U11} - SW^{I10} = SW^{U11} - SW^{U10} = \beta_2(1-\alpha) - \alpha\beta_1 + \frac{1}{2} - \alpha(1-\alpha)$
$SW^{U11} - SW^{I01} = SW^{U11} - SW^{U01} = \beta_1(1-\alpha) - \alpha\beta_2 + \frac{1}{2} - \alpha(1-\alpha)$
$SW^{U11} - SW^{U00} = (1-\alpha) + \beta_1 + \beta_2$
$SW^{I11} - SW^{I10} = SW^{I11} - SW^{U10} = \frac{1}{2} - \alpha + \beta_2$
$SW^{I11} - SW^{I01} = SW^{I11} - SW^{U01} = \frac{1}{2} - \alpha + \beta_1$
$SW^{I11} - SW^{U11} = \beta_1 + \beta_2 + 1 - 2\alpha$
$SW^{I10} - SW^{I01} = SW^{I10} - SW^{U01} = SW^{U10} - SW^{I10} = SW^{U10} - SW^{U01} = \beta_1 - \beta_2$
$SW^{I10} - SW^{U11} = SW^{U10} - SW^{U11} = \frac{1}{2} - \alpha + \beta_1$
$SW^{I01} - SW^{U00} = SW^{U01} - SW^{U11} = \frac{1}{2} - \alpha + \beta_2$

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