Public Ownership as a Redistribution Device

PRELIMINARY DRAFT

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Abstract

Raising government revenue for redistribution is commonly realized via taxing the private sector in various ways. In most countries, however, governments dispose of an additional channel through which revenue is raised. From Norway to Venezuela state ownership of firms and redistribution of dividends plays an important role for state budgets. This paper provides an analytical contribution to an old but highly relevant debate by exploring the distributional aspects of capital ownership in a simple mechanism design framework. By means of a theoretical model I compare the distortions occurring in an economy with public ownership to the distortions in a world with taxation of privately owned capital. It is shown that the optimal choice of ownership, hence the government's redistribution device, depends on two parameters: the external revenue requirement of the government and the agents' entrepreneurial skill.

1 Introduction

Raising government revenue for redistribution is commonly realized via taxing the private sector in various ways. In most countries, however, governments dispose of an additional channel through which revenue is raised. From Norway to Venezuela state ownership of firms and redistribution of dividends plays an important role for state budgets. In the past decades, public finance literature has largely neglected this channel. Private ownership has economically and historically proven to be the most efficient institution as it maximizes an economy's output and hence the potential for redistribution. In the 1990s a wave of privatizations occurred around the globe and the persistence of the remaining public firms was either explained by natural monopolies or political concerns. Public finance studies therefore focused on private sector taxation and literature on ownership mainly focused on efficiency concerns and commitment devices without taking into account distributional consequences.

Policy changes in Latin America and the recent crisis-specific semi-nationalizations in developed countries have put this almost antique topic of state ownership and redistribution back on the (political) agenda. This paper provides an economic and analytical contribution to an old but highly relevant debate by exploring the distributional aspects of capital ownership in a simple mechanism design framework. I consider the problem of a government in finding the optimal way to raise funds: taxing capital income or owning capital and collecting dividends. By means of a theoretical model I compare the distortions occurring in an economy with public ownership to the distortions in a world with taxation of privately owned capital. It is shown that the optimal choice of ownership, hence the government's redistribution device, depends on two parameters: the external revenue requirement of the government and the heterogeneity of the agents' entrepreneurial skill.

The analysis therefore links two major strands of literature. First, the paper builds on the literature of privatization (Boycko1996, Shleifer1998, and Schmidt1996) and ownership (Laffont and Tirole 1993 and Llfesman 2007) by acknowledging the deficiencies of the public sector in running a firm. The second strand, the public finance literature, serves as a basis for modeling the inefficiencies associated with the use of distortionary tax instruments. For the analysis, I consider a government which must meet an external revenue requirement. The requirement can be understood as the government's objective to redistribute to those who neither possess entrepreneurial skill nor own capital. The government faces a trade off in collecting funds. Owning the company and receiving rents decreases the company's efficiency as many empirical and theoretical studies have shown, see Megginson and Netter (2001) for a survey. Alternatively, by taxing private capital income the government causes distortions in private investment decisions - a well know result in public finance.

In each ownership setting, there exists a number N of entrepreneurs which differ with respect to their skills. Entrepreneurial skill captures the sophistication of a company or industry. Each entrepreneur has an optimal choice of capital and technology for her project depending on the skill parameter. If ownership is private, entrepreneurs realize their project taking into account the tax rate on capital income set by the government. The distortions from taxation are modeled such that (a) the level of investment depends negatively on the tax rate (quantitative distortion) and (b) taxation affects the technology choice of the firm (qualitative distortion). The second distortion is similar to the idea of "gambling for resurrection". In a one-period-game, taxes only have to be paid in the case of success. For an appropriate choice of the skill parameter's support, a positive tax rate can lead to a biased choice of technology.

Concerning the second regime, the public ownership economy, the market outcome is now replicated with the government as mechanism designer (and thus capital owner) facing a classical principle-agent problem with hidden information. Entrepreneurial skill, the quality of the project, is only known to the entrepreneur herself. The entrepreneur has an incentive to under-state her skill level to reduce the transfer payments to the government. To determine the optimal level of capital investment granted to a project and thus to induce truth telling about the skill level the government is willing to pay information rents to its manager-entrepreneurs. The main results can be summarized accordingly. From the private ownership regime, we know that a larger revenue requirement implies a higher tax rate. Furthermore, the higher the tax rate, the larger the distortions in the private ownership setting. The public ownership case tells us that the larger the support of entrepreneurial skill parameter, the more information rents the government has to pay. In order to reduce rents the government will choose an inefficiently low capital investment leading to efficiency losses.

Several policy implications can be derived from the theoretical results. First, a government facing a strong desire to redistribute, due to large inequality la Meltzer and Richard (1981) for instance, and an industry with a relatively homogenous skill pattern will choose to raise revenue via public ownership. Second, an industry with greatly heterogeneous entrepreneurial skill, IT or biotech projects for instance, is more efficient when taxed by the state rather than owned by the state. Furthermore, qualitative statements on the impact of the ownership structure on redistribution can be made. Taxing capital leads to a different pattern of redistribution than in the public ownership case. No distortion at the top - a typical property in screening problems - implies that, if there are only "high skilled entrepreneurs", the transfers to these agents under public ownership would be larger than their rents under private ownership. Moreover, if there is variance in the skill parameter, in the public ownership setting, wealth is shifted from low skilled to high skilled entrepreneurs by the allocation of rents. In conclusion, the paper provides additional input to the existing public finance literature by including the largely neglected channel of revenue creation.

Section 1 provides the analysis in the private ownership case under taxation, section 2 considers the public ownership case and Section 3 compares welfare under both settings.

2 Capital Taxation and Private Ownership

This section uses basic set-up which is well-know in the public finance literature to represent distortions created by capital taxation.

2.1 Model

The economy consists of N entrepreneurs with initial wealth. Each entrepreneur has a project idea θ_i and finances her project by own capital endowments. Hence there is no borrowing or lending for the moment. (We will relax this constraint later on). Capital is the only input and there is no labor in the economy. After production, the entrepreneurs collect their dividends. In order to meet an external revenue requirement T, the government determines a tax rate τ on capital income.

2.1.1 Entrepreneurs

Entrepreneurs are assumed to differ by an ability parameter denoted by θ_i, which reflects skill level and project quality. θ_i is private information to the entrepreneur and independently distributed over $\Theta = \left[\underline{\theta}, \overline{\theta}\right] \subseteq R^+$ with a continuous and strictly positive density $g(\theta)$ and (common knowledge) cdf $G(\theta)$ on Θ for all i. The larger θ_i, the more able the entrepreneur and the larger must be the project return. Consequently, the optimal capital investment K_i, chosen by entrepreneur i, is variable. Capital income is achieved via the production function $F(K_i)$, with $F' > 0 > F''$. While the production technology is the same for all entrepreneurs (which will be altered later on), the actual return of the project is stochastic and the success of production depends positively on θ_i.

The entrepreneur's expected utility from running a project of type θ_i is

$$U_i(\theta_i, K_i) = (1 - \tau) \cdot \overline{p}(\theta_i) F(K_i) - rK_i, \tag{1}$$

where

$$\overline{p}(\theta_i) = \int_0^1 p \cdot d\Phi(p|\theta = \theta_i). \tag{2}$$

$\Phi(p|\theta = \theta_i)$ denotes the cumulative distribution of success $p \in [0, 1] = P$ given the entrepreneur has project idea θ_i. To reflect the impact of the project's quality on expected return, let $\Phi(p|\theta = \theta') < \Phi(p|\theta = \theta'')$ if $\theta' > \theta''$. Thus, a better project θ' first order stochastically dominates lower quality project θ''. In other words the expected success of the project increases with θ and $\overline{p}(\theta) > 0$ and $\overline{p}'(\theta) > 0$. This can best be thought of as θ and p being two random variables with joint density $phi(\theta, p)$ and conditional density $\phi(p|\theta = \theta_i)$. The marginal density $\phi_\phi(p) = \int_P \phi(\theta, p)dp$ is then the above stated density over Θ, $g(\theta)$.

There is no limited liability and agents fully bear entrepreneurial risk. As $\overline{p}(\underline{\theta}) \geq 0$, entrepreneurs always have an incentive to realize their idea and invest their capital. The opportunity costs of capital r are the same for all entrepreneurs and are not tax deductible. $\tau \in [0, 1)$ denotes the share of capital income to be transferred to the government.

2.1.2 Government

I consider a benevolent government which aims at maximizing social welfare while facing an external revenue requirement T. T is exogenously given and will serve as a parameter to compare the welfare under both ownership structures in section 3. The revenue requirement can be understood as the government's objective to redistribute to those who neither possess entrepreneurial skill nor own capital, for instance. One can also interpret T as infrastructure investment that enables the entrepreneurs to come up with their ideas at the very beginning. Social welfare is determined by the sum over the N entrepreneurs' individual utilities. I normalize welfare weights to one in this section. The external revenue requirement is included in social welfare. T can be dropped without loss of generality and I report welfare including T and net of T. The government faces the following ex ante budget constraint:

$$N \cdot \int_{\underline{\theta}}^{\overline{\theta}} \tau \cdot \overline{p}(\theta_i) \cdot F(K_i(\theta_i, \tau)) dG(\theta_i) \geq T. \tag{3}$$

Note that, in the current setting, it is not necessary for the government to know the entrepreneurs' types. The government can determine the optimal tax rate τ ex ante by calculating the expected aggregate tax revenue given the types' distribution.

For the tax system to work, however, the realized ex post returns must be observable. I will maintain this assumption throughout the paper. The current set-up comes closest to real world capital taxation where governments raise a flat tax on realized capital income ex ante, commonly ranging between 20% and 30%, and monitor actual earnings ex post.

2.1.3 Information Structure

Nature draws θ and the entrepreneurs learn the quality of their project. Distribution and support of θ is common knowledge and the government decides on τ such that social welfare is maximized given external revenue requirement T. Taking into account τ, each entrepreneur chooses the optimal level of capital $K_i(\theta_i, \tau)$ for her project. Production takes place and entrepreneurs pay taxes.

2.2 Equilibrium

An equilibrium is characterized by the outcome $(\mathbf{K}_i, \tau)$ consisting of profiles of capital allocations $\mathbf{K}_i = (K_1, ..., K_N) \in R^N$ for each individual and the tax rate on capital income. By backward induction, I first solve the entrepreneurs' optimization problem and then determine the optimal taxation by the government.

2.2.1 Optimal Capital Investment

Taking the derivative of an entrepreneur i's expected profits 1 with respect to capital gives the optimal project investment given θ_i and τ.

$$F'(K_i^*(\theta_i, \tau)) = \frac{r}{(1-\tau)\overline{p}(\theta_i)} \tag{4}$$

The production function is strictly concave for all K_i and $K_i^*(.)$ yields the maximum utility for entrepreneur i at a given tax rate τ. Regarding individual utility, the first best allocation of capital is achieved in case of no taxation, $\tau = 0$. Any positive tax rate lowers marginal return, which equals constant marginal costs r. Thus, K_i^* is strictly decreasing in τ:

$$\frac{\partial K_i^*(.)}{\partial \tau} = \frac{r}{F''(K_i^*(.)) \cdot \overline{p}(\theta_i)(1-\tau)^2} < 0, \forall \tau, \theta_i \tag{5}$$

Higher quality and thus more successful projects imply larger capital investments.

2.2.2 Optimal Taxation

Individual utility U_i is strictly decreasing in τ, including and net of tax payments. A (gross or net) welfare maximizing government will choose the smallest τ which meets its budget constraint. Ex ante $\tau^*(T)$ is implicitly defined by

$$\tau^* \cdot N \cdot \int_{\underline{\theta}}^{\overline{\theta}} \overline{p}(\theta_i) \cdot F(K^*(\tau^*, \theta_i))dG(\theta_i) = T \tag{6}$$

Government revenue is strictly concave for all $\tau \in [0, 1)$ and peaks at τ^{max}. We can see this by taking the first and second derivative of the lhs of equation (3) with respect to τ.

$$\frac{\partial}{\partial \tau} = N \cdot \int_{\underline{\theta}}^{\overline{\theta}} \overline{p}(\theta_i)F(K^*(.))dG(\theta_i) + \tau N \cdot \int_{\underline{\theta}}^{\overline{\theta}} \overline{p}(\theta_i)F'_K(.)K'^*_\tau(.)dG(\theta_i) = 0 \tag{7}$$

The first summand is positive, but strictly decreasing in τ. The second summand is negative and increasing. Thus, the derivative of B with respect to τ is positive as long as production is larger than τ multiplied by the marginal change of production with respect to τ. Both equalize at τ^{max}.

$$\frac{\partial^2}{\partial\tau^2} = N \cdot \int_{\underline{\theta}}^{\overline{\theta}} \overline{p}(\theta_i)[2 \cdot F'_K(.)K'^*_\tau(.) + \tau F''_K(.)(K'^*_\tau(.))^2 + \tau F'_K(.)K'^*_\tau(.)K''^*_\tau(.)]dG(\theta_i) < 0 \tag{8}$$

Denote the maximum level of external revenue requirement $T^{max} = B(\tau^{max})$. Any tax rate $\tau > \tau^{max}$ reduces aggregate utility *and* government revenue. A welfare maximizing government is therefore neither interested in taxing beyond the top of the Laffer curve [1] nor able to extract enough revenue to meet an requirement $T > T^{max}$. Therefore, the domain of T will be restricted to $T \in [0, T^{max}]$. As a consequence, we have a continuous, strictly increasing function of T which can be inverted. We can state the following Lemma about the relationship between T and τ.

Lemma 2.1. *Let $T < T^{max}$. The larger the external revenue requirement, the higher the tax rate τ.*

2.3 Welfare under Private Ownership and Taxation

Ex ante maximized welfare, as defined above, can be written as

$$W^{priv*} = N \cdot \int_{\underline{\theta}}^{\overline{\theta}} [\overline{p}(\theta_i) \cdot F(K_i^*(\theta_i, \tau^*)) - rK_i^*(\theta_i, \tau^*)]dG(\theta_i). \tag{9}$$

It is straightforward to describe welfare under private ownership with regard to the external revenue requirement and the distribution of types. Taking the derivative

[1] There exists a bunch of literature explaining the phenomenon of governments "'killing the golden goose"' (cite). I abstract from this discussion which is beyond the scope of this paper.

with respect to T and applying the implicit function theorem, we see that welfare is decreasing in T, $T \in [0, T^{max}]$.

$$\frac{\partial W}{\partial T} = (\overline{p}(\theta_i) \cdot F'_K(.) - r) \cdot K'^{*}_{\tau}(.) \tau'^{*}_{T}(.) - 1 < 0 \tag{10}$$

Given the concavity of F(.), capital investment $K(., \tau) \leq K^{opt}(.)$ for any $\tau \geq 0$. Thus, the marginal return of a project is always greater than or equal to the marginal cost. That is, the term $\overline{p}(\theta_i) \cdot F'_K(.) - r$ is non-negative for $\tau \in [0, 1)$.

Proposition 2.2. *If $T \leq T^{max}$, aggregate welfare under private ownership decreases in the external revenue requirement T. The efficient capital investment is independent of the support of θ.*

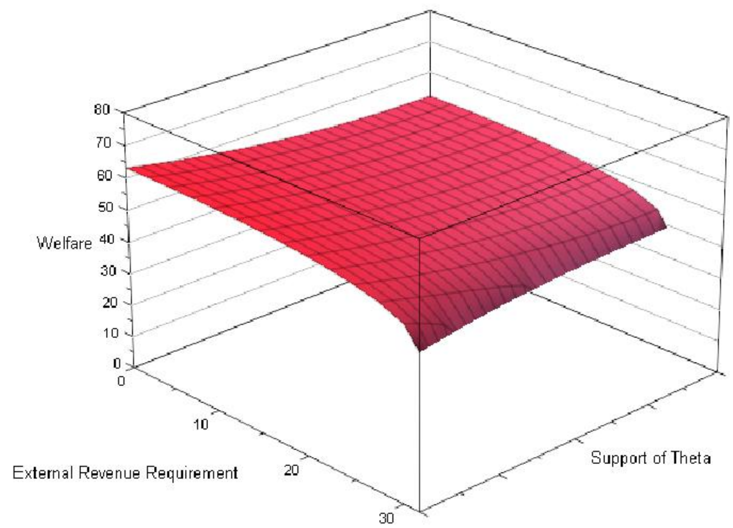
For values $T > T^{max}$, welfare is set to zero. Expanding the support of θ_i for all i, for instance by preserving the mean and increasing the upper limit and decreasing the lower limit by the same amount, triggers a slight increase in aggregate welfare [2]. This is due to the convexity of individual utility with respect to θ. Overall, welfare under private ownership depends negatively on the external revenue requirement and capital taxation is only possible up to a threshold revenue requirement. The actual size of T^{max} depends on the concavity of the production function, the number of entrepreneurs in the economy, and the average quality of their projects.

An example Consider a Cobb Douglas production technology with $\alpha = 1/2$. For simplicity, assume that $\Theta \subset P$ and $\overline{p}(\theta_i) = \theta$. Plugging this into the above equations gives the following results: The maximum tax rate $\tau^{max} = 1/2$ and $W^{priv}(\tau^{max}) =$

[2] $\Theta \subseteq R^+$

$3/2 \cdot T^{max}$. The lowest level of welfare is attained at T^{max} and is still three quarters of the benchmark welfare with zero taxation.

Figure 1: Welfare under Private Ownership and Capital Taxation.



The graph depicts the concave hull of social welfare's Pareto frontier. It is decreasing in T and slightly increasing in mean-preserving $\Delta\theta$, where $\Delta\theta = \overline{\theta} - \underline{\theta}$.

3 Public Ownership of Capital

In this section, I replicate the market-taxation game above by a mechanism in which the government acts as mechanism designer, allocates capital and chooses dividends - the same outcome tuple as before. In less abstract terms, the government faces the same population of N entrepreneurs and considers now to provide capital by its own. Hence, instead of taxing the entrepreneurs, the government acts like an investor and collects dividends to pay for the external revenue requirement. One could compare the two settings by claiming the former to be similar to debt finance versus the latter equity finance. The difference to the actual corporate finance literature is that, first, we face a welfare, not profit or revenue maximizing principle. Second, this principle chooses - ex ante - between debt financing and tax collection on the one hand and equity financing by himself on the other.

3.1 Model

The ingredients of the economy are the same with some minor changes in the utility of the entrepreneurs and the budget constraint of the government. The main difference to the market-taxation game is that the government must know the type ex ante to determine the level of capital it grants to the entrepreneur. To induce truth telling by the entrepreneurs, the government designs the dividend payments accordingly.

3.1.1 Entrepreneurs-Managers

To be precise, the former entrepreneurs indeed become managers in this setting. They present their idea to the government in order to get funding for their project and will be paid according to the quality of their idea. To work with a quasi-linear environment, I will modify the agents' individual utility at this stage and denote $t_i(\theta_i)$ the dividend payment of the entrepreneur-manager. In section **??**, a class of incentive compatible and feasible transfers will be specified which satisfy a similar structure as under taxation, where the entrepreneur-manager transfers a share of output to the government. So far, her interim expected utility given that she is type

θ_i and that all other agents report truthfully is as follows:

$$U_i(.) = \int_{\underline{\theta}}^{\overline{\theta}} [\overline{p}(\theta_i)F(K_i(\theta_i)) - t_i(\theta_i)]dG(\theta|\theta_i) \tag{11}$$

The assumptions on support, density and distribution of θ and p remain valid.

3.1.2 Government

The government's objective function is aggregate utility, as before. The budget consists of revenue from dividend collection on the income side and opportunity costs of capital plus the external revenue requirement on the expenses side. Note that the riskless interest rate capturing capital opportunity costs is the same for private entrepreneurs and for the government. This is certainly a critical assumption but will be maintained for the sake of comparability. The budget constraint can be written as

$$N \cdot \int_{\underline{\theta}}^{\overline{\theta}} t_i(\theta_i)dG(\theta_i) \geq T + N \cdot \int_{\underline{\theta}}^{\overline{\theta}} rK_i(\theta_i)dG(\theta_i) \tag{12}$$

3.1.3 Information Structure

Nature draws θ and agents learn their types. The entrepreneurs-managers present their idea $\hat{\theta}$ to the government and ask for the appropriate capital investment to run their project. The government can not observe the quality of the project and must rely on an incentive compatible mechanism which induces truth telling. It therefore offers a dividend payment $t(\theta)$ dependent on the announced type to be paid by the entrepreneur after production took place. The government is able to observe the actual return ex post. However, it is not able to infer the type, as a particular realization of p is stochastic and all types have the same support of their success p.

3

3.2 Equilibrium

The equilibrium concept used in solving this model is perfect Bayesian equilibrium. A feasible direct mechanism is a function $\eta : \Theta \to Z$, where Z is the subset of $\mathbf{K} \times R^N$ such that transfers cover the costs of $\mathbf{K}$ and T. Also, the feasible outcome pair $(K, t) \in Z$.

3.2.1 Implementation

Denote interim individual utility by

$$U_i(\theta_i, \hat{\theta}_i) = \overline{p}(\theta_i)\overline{F}(K_i(\hat{\theta}_i)) - \bar{t}_i(\hat{\theta}_i), \tag{13}$$

where the reduced form expressions represent the expected value of that type's allocation under the mechanism, when all types report truthfully $\overline{F}(K_i(\theta_i)) = \int_{\underline{\theta}}^{\overline{\theta}} F(K_i(\theta_i))dG(\theta|\theta_i)$ and $\overline{t_i}(\theta_i) = \int_{\underline{\theta}}^{\overline{\theta}} t_i(\theta_i)dG(\theta|\theta_i)$. An incentive compatible allocation must satisfy $U(\eta, \theta, \theta) \geq U(\eta, \theta, \hat{\theta})$. Differentiablitiy of $F(.)$, $K(.)$ and $t(.)$ with respect to θ allows for the envelope condition to reduce to $\overline{\theta_i}\frac{\partial \overline{F}}{\partial \theta_i} = \frac{\partial \overline{t_i}}{\partial \theta_i}$ [4] and therefore

$$\overline{p}(\theta_i)\overline{F}'(K_i(\theta_i)) \cdot K_i'(\theta_i) = \bar{t}_i'(\theta_i). \tag{14}$$

Integrating by parts and rearranging gives the well known result:

[3] Theoretically it is possible to condition the equity contracts on realized return by ex post monitoring all projects. This, however, does not necessarily imply truth telling and will lead to overinvestment, for instance, as shown by Boadway and Keen, 2006. Conditioning the transfers on the return that "'should"' arise ex post comes closer to public companies' structures.

[4] See Ledyard and Palfrey 2007, for instance, for a description of interim efficient mechanisms

Lemma 3.1. *A direct mechanism η is incentive compatible iff, for all i, $\theta_i \in \Theta$,*

$$U_i(\theta_i) = U_i(\underline{\theta}) + \int_{\underline{\theta}}^{\theta} \overline{p}'(s) F(K_i(s)) ds \tag{15}$$

and $\overline{F}'(K_i(\theta_i))$ is non-decreasing in θ.

3.2.2 Feasibility and Individual Rationality

Plugging equation (13) into (15) and solving equation for $\bar{t}_i(\theta_i)$, taking expectations and integrating by parts gives

$$\int_{\underline{\theta}}^{\overline{\theta}} t_i(\theta_i) dG(\theta_i) = \int_{\underline{\theta}}^{\overline{\theta}} [t_i(\underline{\theta}_i) - \overline{p}(\underline{\theta}_i) F(K_i(\underline{\theta}_i)) + \overline{p}(\theta_i) F(K_i(\theta_i)) - \overline{p}'(\theta_i) F(K_i(\theta_i)) \frac{1 - G(\theta_i)}{g(\theta_i)}] dG(\theta_i). \tag{16}$$

Plugging equation (16) into (12), the budget constraint of the government, yields

$$N \cdot \int_{\underline{\theta}}^{\overline{\theta}} [F(K_i(\theta_i)) \cdot (\overline{p}(\theta_i) - \overline{p}'(\theta_i) \frac{1 - G(\theta_i)}{g(\theta_i)}) - rK_i(\theta_i) + t_i(\underline{\theta}_i) - \overline{p}(\underline{\theta}_i) F(K_i(\underline{\theta}))] dG(\theta_i) \geq T. \tag{17}$$

Finally, individual rationality is specified such that entrepreneurs receive at least their outside option when taking part in the mechanism. The outside option is normalized to zero. Given that $\overline{F}(K_i(\theta)_i) \geq 0$, the IR constraint reduces to the classical specification

$$\overline{p}(\underline{\theta}) \overline{F}(K_i(\underline{\theta})) - \bar{t}_i(\underline{\theta}) \geq 0. \tag{18}$$

3.2.3 Allocation

The government faces the following Kuhn-Tucker optimization problem to achieve ex ante efficient allocations of capital:

$$\overset{max}{\{K_i(\theta_i)\}}\ N \cdot \int_{\underline{\theta}}^{\overline{\theta}} [\overline{p}'(\theta_i)F(K_i(\theta_i))\frac{1-G(\theta_i)}{g(\theta_i)} - t_i(\underline{\theta}) + \overline{p}(\underline{\theta})F(K_i(\underline{\theta}))]dG(\theta_i) + T \quad (19)$$

subject to

$$N \cdot \int_{\underline{\theta}}^{\overline{\theta}} [F(K_i(\theta_i)) \cdot (\overline{p}(\theta_i) - \overline{p}'(\theta_i)\frac{1-G(\theta_i)}{g(\theta_i)}) - rK_i(\theta_i) + t_i(\underline{\theta}) - \overline{p}(\underline{\theta})F(K_i(\underline{\theta}))]dG(\theta_i) \geq T$$

$$\overline{p}(\underline{\theta})\overline{F}(K_i(\underline{\theta})) - \overline{t}_i(\underline{\theta}) \geq 0$$

$$\overline{p}(\theta_i)\overline{F}(K_i(\theta_i)) \text{ non-decreasing in } \theta$$

Define δ and ρ_i the Lagrange multipliers of the budget constraint and individual rationality constraint respectively. The maximization of aggregate welfare with respect to $K_i(.)$ requires that the terms under the intervals be maximized with respect to $K_i(\theta_i)$ for all θ_i and i. Ignoring the monotonicity constraint ant taking the derivatives with respect to $K_i(\theta_i)$ and $t_i(\underline{\theta})$, the necessary and sufficient conditions for a maximum are

$$F'(K_i^*(\theta_i, \delta)) = \frac{r}{\overline{p}(\theta_i) - \overline{p}'(\theta_i)\frac{1-G(\theta_i)}{g(\theta_i)}\frac{\delta-1}{\delta}} \quad (20)$$

$$\delta = \rho_i + 1 \quad (21)$$

Primal and dual feasibility apply, $BC \geq 0, IR \geq 0, \delta \geq 0, \rho_i \geq 0$, as well as the complementary slackness conditions $\delta \cdot BC(K^*(.)) = 0, \rho_i \cdot IR_i(K^*(.)) = 0$.

Denote the denominator of equation (20) the virtual valuation $v(\theta_i)$ and assume that $v'(\theta_i) > 0$ [5]. The optimal solution satisfies the monotonicity constraint of the constraint set above if v(.) is increasing in θ_i. The first best capital allocation is given by $F'(K_i^{opt}(\theta_i)) = \frac{r}{\overline{p}(\theta_i)}$. From equation (21) and from the dual feasibility conditions for the Lagrange multipliers we know that $\delta \geq 1$. Therefore, virtual valuations are equal to or lower than actual valuations and the efficient choice of K is equal to or lower than the benchmark capital investment for all $\theta_i < \overline{\theta}$. Hence, allocative efficiency crucially depends on the parameter δ.

Lemma 3.2. *There exists a threshold function $\overline{T}(\Delta\theta) \geq 0$, with $\Delta\theta = \overline{\theta} - \underline{\theta}$, such that for all $T \in [0, \overline{T}(\Delta\theta)]$, individual rationality is not binding ($\rho_i = 0$ and $\delta = 1$), the efficient allocation of capital under the mechanism equals the fist best allocation, $F'(K_i^*(\theta_i, \delta = 1)) = \frac{r}{\overline{p}(\theta_i)} = F'(K_i^{opt}(\theta_i))$, and*

$$N \cdot \int_{\underline{\theta}}^{\overline{\theta}} [F(K_i^{opt}(\theta_i)) \cdot (\overline{p}(\theta_i) - \overline{p}'(\theta_i)\frac{1 - G(\theta_i)}{g(\theta_i)}) - rK_i^{opt}(\theta_i)]dG(\theta_i) - T \geq 0. \quad (22)$$

Proof. Denote the difference between the expected aggregate production with first-best capital investment $N \cdot \int_{\underline{\theta}}^{\overline{\theta}} \overline{p}(\theta_i)F(K_i^{opt}(\theta_i))dG(\theta_i)$ and the expected capital costs $N \cdot \int_{\underline{\theta}}^{\overline{\theta}} rK_i^{opt}(\theta_i)dG(\theta_i)$ the expected surplus S in the economy. For any support of θ, $\left[\underline{\theta}, \overline{\theta}\right] \subseteq R^{0+}$ and $\overline{\theta} > 0$, S is strictly positive. Assume there exists a function $\tilde{v}(\theta_i) = \overline{p}(\theta_i) - \overline{p}'(\theta_i)\frac{1-G(\theta_i)}{g(\theta_i)} < \overline{p}(\theta_i)$ with given support $\left[\underline{\tilde{\theta}}, \overline{\tilde{\theta}}\right]$ such that with first best capital investment as above, we have $\tilde{S}_v = N \cdot \int_{\underline{\theta}}^{\overline{\theta}} [\tilde{v}(\theta_i)F(K_i^{opt}(\theta_i)) - rK_i^{opt}(\theta_i)]dG(\theta_i) = 0$. Decreasing $\Delta\theta$ by ϵ increases the density of θ_i and thus $\tilde{v}(.)$. Accordingly, $\tilde{S}_v > 0$.

[5] This is a common assumption in this environment and satisfied when the marginal distribution of θ is uniform and the conditional distributions for p are normal, for instance

Without welfare losses, $\tilde{S}_v$ can be used for government spending and determines $\overline{T}(\Delta\theta)$. For $\bar{\tilde{\theta}} = \underline{\tilde{\theta}}$, $\tilde{S} = T^{max} = \overline{T}(\Delta\theta = 0)$. □

For $T > \overline{T}(\Delta\theta)$, the individual rationality constraint is binding ($\rho_i > 0$ and $\delta > 1$) and we face a downward distortion of capital for all types but the highest. In this case, however, the government is not always able to design the mechanism such that all types can realize their project. If the virtual valuation becomes negative for entrepreneur-manager i, i.e. if $\overline{p}(\underline{\theta}) \cdot g(\underline{\theta}) < \overline{p}'(\underline{\theta})$, the government is forced to set the appropriate level of capital to zero. Let θ_δ^0 be the boundary type separating those who are assigned a positive level of capital from those with zero capital and solving $\overline{p}(\theta_\delta^0) - \overline{p}'(\theta_\delta^0)\frac{1-G(\theta_\delta^0)}{g(\theta_\delta^0)}\frac{\delta-1}{\delta} = 0$. Furthermore, the weight of the budget constraint, δ is determined such that

$$N \cdot \int_{\underline{\theta_\delta^0}}^{\overline{\theta}} [F(K_i^*(\theta_i, \delta)) \cdot (\overline{p}(\theta_i) - \overline{p}'(\theta_i)\frac{1-G(\theta_i)}{g(\theta_i)}) - rK_i^*(\theta_i, \delta)]dG(\theta_i) - T \geq 0. \quad (23)$$

Lemma 3.3. *If there exists an allocation $\eta = (K, t)$ which is interim efficient and individually rational for any $T^{max}(\Delta\theta) > \overline{T}(\Delta\theta) \geq 0$, then there exists a positive and monotonic relation between the external revenue requirement and the Lagrange multiplier of the budget constraint δ for all $T \in [\overline{T}(\Delta\theta), T^{max}(\Delta\theta)]$.*

Proof. The virtual valuation $v(\theta_i)$ as defined above is always greater than $\tilde{v}(\theta_i) = \overline{p}(\theta_i) - \overline{p}'(\theta_i)\frac{1-G(\theta_i)}{g(\theta_i)}$ for finite values of δ. Put differently, the lhs of equation (23) is characterized by "'virtual overinvestment"'. Increasing δ reduces $K_i^*(\theta_i, \delta)$ and increases the "'virtual surplus"'. The expression within the integral is therefore monotonically increasing in δ. The integral itself, however, is affected by δ in the opposite way. The larger δ, the fewer types are paying the bill. (Those who are assigned zero capital pay, by IR, no dividends). At $T^{max}(\Delta\theta)$, the two effects equalize. $\square$

Note that, if too many types drop out relative to the efficiency gains from capital reduction after an increase of δ, there is no public ownership mechanism which allows for a revenue requirement $T^{max}(\Delta\theta) > \overline{T}(\Delta\theta)$. Whether this is the case depends on the distribution of θ.

3.3 Welfare under Public Ownership

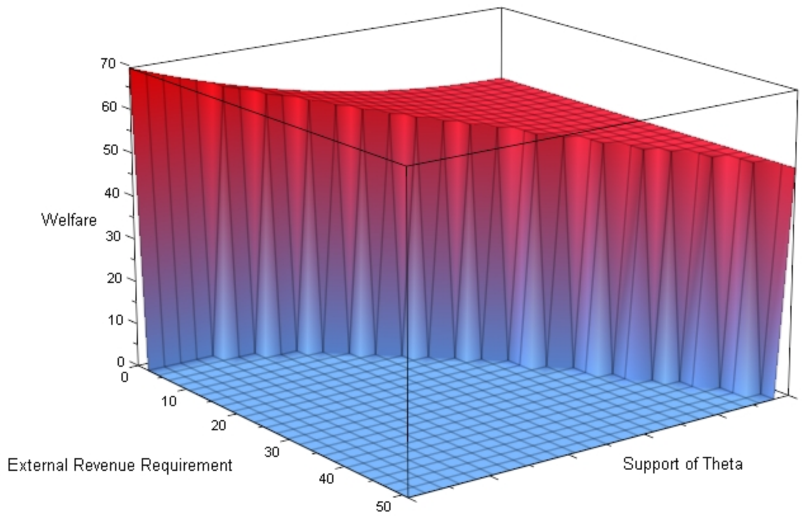
Welfare under public ownership depends strongly on the support of θ. The larger the support, the more information rents the government has to pay to induce truth telling. Similar to the private case, ex ante maximized welfare can be written as

$$W^{pub*} = N \cdot \int_{\underline{\theta_\delta^0}}^{\overline{\theta}} [\overline{p}(\theta_i) \cdot F(K_i^*(\theta_i, \delta)) - rK_i^*(\theta_i, \delta)] dG(\theta_i). \tag{24}$$

If $T \in [0, \overline{T}(\Delta\theta)]$, $\delta = 1$. For gross welfare, it is irrelevant which value of the interval T realizes, the surplus is shifted from entrepreneurs-managers to T without efficiency loss. That is, aggregate welfare achieves first best, irrelevant of T. This can nicely be seen in figure 2 based on a Cobb Douglas production function with $\alpha = 1/2$, where the efficient Pareto frontier is characterized by a horizontal plane which is slightly increasing in the support of θ and delimited by the cutoff values given by $\overline{T}(\Delta\theta)$. As under private welfare, the former effect is due to taking expectations over a convex function.

If $\overline{T}(\Delta\theta) < T \leq T^{max}(\Delta\theta)$, individual rationality is binding and $\delta > 1$. Capital investment $K_\delta^*(.)$ has to be corrected downwards and is inefficiently low for all

Figure 2: Welfare under Public Ownership and Slack Individual Rationality.



$\theta < \overline{\theta}$. As a consequence, welfare is strictly lower than in the $\delta = 1$ case and strictly decreasing in T. Moreover, the set of producing entrepreneurs decreases via the virtual value condition in T, $\frac{\partial \theta_\delta^0}{\partial T} = \frac{\partial \theta_\delta^0}{\partial \delta} \cdot \frac{\partial \delta}{\partial T} < 0$, and in the support of θ, $\frac{1-G(\theta_i)}{g(\theta_i)}$ increases in $\Delta\theta$. This effect, in addition to allocative changes, reduces overall welfare. We can summarize the results in the following proposition.

Proposition 3.4. *Welfare under public ownership without welfare weights is characterized by two regimes. If $T \in [0, \overline{T}(\Delta\theta)]$, first best allocation of capital and thus first best aggregate welfare is achieved. If $T \in (\overline{T}(\Delta\theta), T^{max}(\Delta\theta)]$, welfare is strictly decreasing in T and in $\Delta\theta$.*

3.3.1 Ex Post Limited Liability**UNDER CONSTRUCTION

Lemma 3.5. *There exists a subclass of transfers* $t(\theta, p) = \alpha p F(K^*(\theta))$ *such that ex post limited liability is satisfied.*

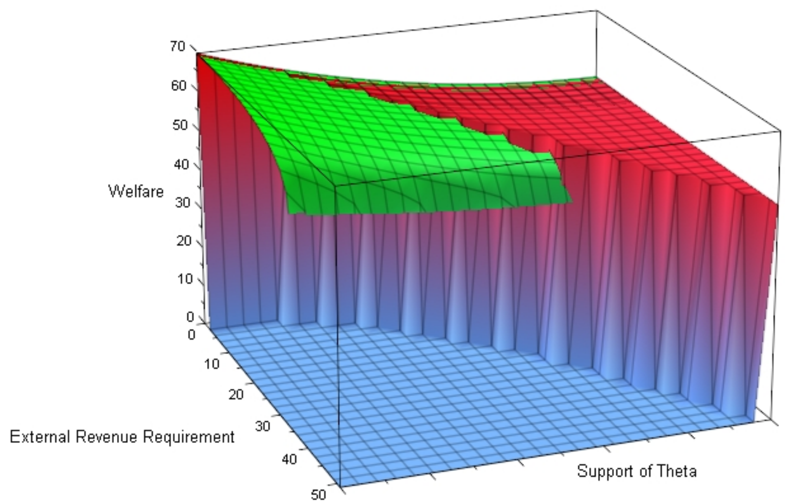
4 Making Both Worlds Compatible: Welfare, Capital Allocations and Distortions

From the previous analysis it is straight forward to see that for $T \in [0, \overline{T}(\Delta\theta)]$ public ownership achieves first best and thus generates higher aggregate utility than private ownership - except for $T = 0$ and $\Delta\theta = 0$, where both settings deliver first best solutions. With increasing heterogeneity of project quality, however, the first best efficient frontier of public welfare is getting "'thinner"'. In the private ownership setting, on the contrary, individual welfare is not adversely affected by an increase of heterogeneity.

Proposition 4.1. $W^{priv}(T^{max}_{priv}) < W^{pub}(T^{max}_{priv})$

Proof. under construction □

Figure 3: Welfare under Both Settings.



5 Extensions

5.1 Welfare Weights

5.2 Qualitative Investment Distortion

6 Policy Implications and Conclusions

Real world decisions over public ownership of companies are largely driven by political reasons and, in particular, ideology, which can be seen in recent developments in Latin America, for instance. Nevertheless, this paper shows that economic reasoning does play a role in finding the right ownership structure by grasping *economic* incentives accompanying these decision. Bridging the gap to empirics, one might put forward that the inefficiencies in public companies stem from distorted treatment of labor input rather than from capital input. This is certainly a valid argument. The analysis captures this claim to a certain extent as the payment of the entrepreneur is made dependent on her ex ante announcement. Overall we can derive a number of policy implications. First, a government facing a strong desire to spend large T and an industry with a relatively homogeneous skill pattern will choose to raise revenue from this industry via public ownership. Second, an industry with greatly heterogeneous entrepreneurial skill, IT or biotech projects for instance, is more efficient when taxed by the state rather than owned by the state.

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