Cost of Capital and Valuation in the Public and Private Sectors: Tax, Risk, and Debt Capacity

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Abstract

Cost of capital and valuation differ in the private and public sectors, because taxes are a cost to the private sector but are only a transfer to the private sector. We show how to transform the after-tax private sector cost of capital into its pre-tax equivalent, for comparison with the public sector cost of capital. We establish the existence of a tax induced wedge between these two costs of capital. The wedge introduces a preference on the part of the private sector for assets with rapid tax depreciation, high debt capacity, and low risk. We show that, in circumstances where an asset has identical public and private sector valuation in the absence of taxes, the tax induced difference in valuation is identical to the change in government tax receipts that results from having the asset owned by the private rather than the public sector. We provide some examples of distortions that result from failure to adjust for changes in tax revenues, and show how to effect such adjustment.

Keywords: public sector, private sector, cost of capital, valuation, tax, risk, debt capacity, depreciation, privatization, outsourcing, regulation

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1. Introduction

Numerous assets and activities lie at the boundary between the private and public sectors; whether these should belong to or be undertaken by a private sector firm or the government involves the comparison of the value of these assets or activities under private and public sector ownership or provision. For example, decisions regarding the privatization of public assets, the private financing of public infrastructure, the contracting out of government services, the granting of government guarantees, and the forward purchase of goods and services by the government all involve the computation of the present value of the associated cash flows under public and private ownership or provision. They therefore require the determination of public and private sector valuation procedures and costs of capital.

These differ in the presence of taxes, even for the same asset or activity: taxes are a cost to the private sector but are only a transfer to the public sector. We use a novel approach based on quasi-arbitrage to derive the discount rates and determine the valuation procedures that should be used by the private and public sectors in the presence of corporate and personal taxes. We show how to transform the after-tax private sector cost of capital into its pre-tax equivalent for comparison with the public sector cost of capital. We establish the existence of a tax induced wedge between these two costs of capital. We show that, in circumstances where an asset has identical public and private sector valuation in the absence of taxes, the tax induced difference in valuation is identical to the change in government tax receipts that results from having the asset owned by the private rather than the public sector: a higher private sector valuation is at the expense of the government, which sees its tax revenues decrease as compared to the case in which the government owns the asset; conversely, a lower private sector valuation benefits the government, which enjoys an increase in tax revenues.

Taxes are a cost to private sector investors, who individually receive, in the form of government benefits, only a very small fraction of the incremental tax payments that they make following investment in a given project.[1] The private sector therefore adjusts for tax both in the cash flows that it receives from the project and in the discount rate which reflects the opportunity cost of investing in that project. In contrast, taxes incurred as part of public investment are but a

[1] Alternatively, private sector investors may enjoy reduced tax payments; recall the discussion in the preceding paragraph and see the formal analysis below.

transfer within the public sector, for example from the public sector corporation that has undertaken a given project to the general government budget.

The quasi-arbitrage approach we use is similar to that used by Modigliani and Miller (1958, 1963). Investment in a project sees both shareholders and citizens/taxpayers rebalance their portfolios away from equity and towards debt to hedge the risk of the investment. The requirement that there be no arbitrage equates the return on the hedged investment to the risk free return; returns are expressed on an after-tax basis for shareholders and on a before-tax basis for citizens/taxpayers. The resulting equilibrium conditions deliver the valuation procedures and the cost of capitals for the private and public sectors. Transforming the private sector equilibrium condition from after- to pre-tax obtains the pre-tax equivalent of the after-tax private sector cost of capital. Comparison with the public sector cost of capital reveals the existence of a wedge between the private and public sector costs of capital, due to the different taxation of debt and equity and of real and financial investment.

The wedge implies that a project will appear to have different values depending on whether it is undertaken by the public or the private sector. Under conditions that characterize most tax systems, taxes induce a systematic preference by the private sector for assets with rapid tax depreciation, high debt capacity, and low systematic risk. Yet, such difference is illusory, as a difference in valuation that is due entirely to tax considerations amounts only to a wealth transfer between the public and the private sectors. Indeed, we show that the difference in valuation corresponds to the change in tax payments that result from the transfer of the asset from the public to the private sector.

The apparent difference in valuation has possibly misleading implications for whether a project should be undertaken by the public or the private sector. We analyse these implications for the choice between public and private ownership, transactions between the public and the private sector, and regulation. We show how to evaluate such decisions correctly.

For our analysis to matter, governments must use present value techniques for the purpose of evaluating projects. Is that the case? The guidelines for investment of the Asian Development Bank (Asian Development Bank, 2017), the European Investment Bank (European Investment Bank, 2013), France’s Inspection des Finances (Charpin, Ruat, and Freppel, 2016), the United Kingdom’s Treasury (HM Treasury, 2018), the United States’ Office of Management and Budget (Office and Management and Budget, 2018), and the World Bank (Independent

Evaluation Group, 2010), all suggest such is indeed the case, for central governments and supranational investment banks at least.[2]

Our analysis makes a number of assumptions. To concentrate on the effect of tax, we abstract from other important considerations. Specifically, we abstract from differences in risk-bearing ability by assuming that both sectors have access to the same perfectly elastic capital market. We also abstract from differences in agency by assuming that both sectors generate the same pre-tax cash flow.

The paper proceeds as follows. Section 2 reviews the literature. Section 3 presents the basic assumptions. Section 4 analyses the benchmark case with no taxes. Section 5 introduces corporate and personal taxes and derives the costs of capital with taxes. Section 6 examines the distortions introduced by tax and discusses the adjustments to valuation procedures that these distortions make necessary. Section 7 illustrates the effects of the distortions through a number of examples. Section 8 concludes.

2. Literature review

The central role of taxes in our analysis naturally relates our work to the very extensive body of work, surveyed by Auerbach (2002) and Graham (2013), on the effect of taxes on considerations as varied as capital structure, organizational form, payout and compensation policies, risk and earnings management, and financial innovation. Benninga and Sarig (2003) and Cooper and Nyborg (2008) examine the effect of taxes on the private sector costs of debt and equity. Our concern is with the effect of taxes in introducing a wedge between public and private sector costs of capital and valuations.

Our work is closest to that of Huizinga and Nielsen (2001), who compare under certainty the importance of tax and efficiency considerations to privatization decisions. They conclude that tax effects can be of the same order of magnitude as efficiency effects; indeed, 'taxation of capital income forms an intervention which, other things equal, renders public production more attractive' (Huizinga and Nielsen, 2001, p. 411). Our work differs from Huizinga and Nielsen's in considering risk, in introducing a capital market in which risk is priced, in distinguishing between a risky claim, equity, and a risk-free claim, debt, and in abstracting from efficiency

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[2] The case of local government may be different; we thank the anonymous referee for alerting us to that difference.

considerations. Whereas Huizinga and Nielsen seek to identify the tax system that achieves the best trade-off between tax and efficiency considerations, we aim to analyse the distortions induced by taxes even if there should be no difference in efficiency whatsoever.

We do not deny the importance of efficiency considerations but wish to limit the difference between the public and the private sector to a single consideration, the tax system; we therefore assume equality of private and public sector pre-tax cash flows. As an example of taxes' importance, consider Baumol's (1968, p. 790) observation that, in the presence of a 50% corporate tax rate, a required rate of return of r for the private sector implies a corresponding rate of $2r$ for the public sector. We formalize and considerably extend Baumol's (1968) observation.

The importance of efficiency, information, and contractibility in determining the choice between public or private ownership, financing, or service provision is reflected in the extensive literature that analyses such issues. To take but very few examples, Schmidt (1996) and Hart, Shleifer, and Vishny (1997) examine the desirability of privatization and Bentz, Grout, and Halonen (2005), Engel, Fischer, and Galetovic (2013), and Iossa and Martimort (2015) that of public–private partnerships used to finance public infrastructure privately and to contract out government services.[3] As just noted, we abstract from efficiency and similar considerations to focus on taxes.

It is for this reason that we assume that the investment to be made by either the public or the private sector is not so large as to affect interest rates and risk premia. This distinguishes our work from that which determines the discount rate applicable to government investment in the presence of taxes when the size of government investment alters the interest rates. The studies by Harberger (1968), Sandmo and Drèze (1971), and Marchand and Pestiau (1984) are examples of such work in the absence of risk and Bailey and Jensen (1972) in its presence.

Another consideration that we abstract from is the public sector's greater or lesser ability to diversify risk and, consequently, its lower or higher risk premium, respectively. This is an important issue, which receives much attention but which, like investment size, does not arise in the infinitely elastic global capital market setting in which we conduct our analysis. Arrow (1965), Hirshleifer (1966), Diamond (1967), Arrow and Lind (1970), Bailey and Jensen (1972), and Stapleton and Subrahmanyam (1978) lay the basis for the formal analysis of the

[3] Lucas and McDonald (2010) discuss the pricing of government guarantees, a topic that, perhaps surprisingly, appears to have received relatively little attention.

government's capacity for risk bearing; their results are used by Bazelon and Smetters (1999), Spackman (2004), and Lucas and Phaup (2010), among others, to compare the public and private sector costs of capital in the presence of risk.

The last consideration that we abstract from is that stemming from the presence of externalities, such as those imposed by the present generation on future generations with whom no trade is possible. Marglin (1963), Baumol (1968), Dasgupta, Mäler, and Barrett (1999), Caplin and Leahy (2004), and Dasgupta (2008) are among those who derive the social discount rate to be used in such circumstances. In short, in our setting, there should be no difference whatsoever between public and private sector discount rates and valuations in the absence of taxes.

3. Assumptions

We consider an economy with two dates, 0 and 1. We focus on a single country. The country has a citizenry, a government (the public sector), and private firms (the private sector). Both government and firms can invest in real projects, but only firms can issue both debt and equity to fund these projects; the government can issue only debt.[4] We make the following assumptions:

Assumption 1. No difference in efficiency between the public and the private sectors;

Assumption 2. No externalities;

Assumption 3. Full information;

Assumption 4. Free access to the global capital market, which is perfect and infinitely elastic; projects are therefore 'small' in that they affect neither the equilibrium interest rate nor the price of risk; citizens, the government, and firms can all borrow and lend at the risk-free rate;

Assumption 5. The capital market is in the equilibrium described by the global capital asset pricing model (CAPM); non-spanned risk is idiosyncratic; there is neither inflation uncertainty nor real exchange rate uncertainty.[5]

Assumptions 1 and 2 together imply the equality of public and private sector pre-tax cash flows. Assumption 3 provides citizens and shareholders with the information necessary for

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[4] We do not allow the government to issue direct equity claims on the project as this would amount to privatization.

[5] See Grauer, Litzenberger, and Stehle (1976) for an analysis of the global CAPM. The assumption that there is neither inflation uncertainty nor real exchange rate uncertainty is made for simplicity only: the presence of either type of uncertainty would leave our results unchanged under the assumption of infinitely elastic capital markets.

portfolio rebalancing to hedge investment risk.[6] Assumptions 2 and 4 ensure that citizens and shareholders have access to identical hedging opportunities on terms left unchanged by investment.[7] Assumption 5 has these terms set by the global CAPM.

Assumptions 1 to 5 will be shown in Section 4 to imply the equality of public and private sector discount rates and valuations in the absence of taxes. We note that, even if the pre-tax cash flows were in fact to differ because Assumption 1 were not to hold, the valuation *procedures* that we derive would remain valid under Assumptions 2 to 5, which define the environment in which investment risk is hedged.

Valuation proceeds by imposing the condition that a risky project whose systematic risk has been hedged must have the same payoff as a safe project with identical initial investment. Failure of the condition to hold would imply the existence of a quasi-arbitrage opportunity, where the qualifier 'quasi' is due to idiosyncratic risk. In the absence of taxes, the condition results in the same cost of capital and valuation as for the private sector (compare Propositions 1 and 2). In the presence of taxes, the condition makes possible the identification of the relevant tax effects (compare Propositions 3 and 4).

4. The benchmark case: no taxes

To highlight better the central role of taxes in our analysis, we initially consider a benchmark case with no taxes. We show that the public and private sector discount rates and valuations are identical under Assumptions 1 to 5.

Consider a project that can be undertaken either by the government or by a private firm. The project requires an investment of 1 at date 0 and has a random payoff of C at date 1. The cash flows from the project are identical for both the government and the firm because of Assumptions 1 and 2. The division of project cash flows among the citizens of the country, or between the citizens of the country and foreign citizens, may nonetheless differ in the two cases in which the government or the firm undertakes the project: in the absence of portfolio rebalancing, the project's costs and benefits would be limited to the firm's shareholders in the latter case, and they would extend to all the country's citizens in the former case.

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[6] See the formal analysis in Sections 4 and 5.

[7] Assumption 2 is necessary because externalities may introduce a difference between citizens' social and shareholders' market discount rates; recall the discussion in the literature review.

We define R_F as the global risk-free rate, R_M as the return on the global market portfolio, β as the beta of the project's cash flow C with respect to the global market portfolio, and P as the global market risk premium. Letting $E[.]$ denote expectation, we have:

$$\beta \equiv \frac{\operatorname{cov}[C, R_M]}{\operatorname{var}[R_M]} \tag{1}$$

and:

$$P \equiv E[R_M] - R_F. \tag{2}$$

Our first result considers valuation by the private firm.

Proposition 1: If the project is undertaken by the private sector, it has required return $R_F + \beta P$ and net present value (NPV):

$$NPV(private) = -1 + \frac{E[C]}{1 + R_F + \beta P}. \tag{3}$$

Proof: Hamada (1969).

We now turn to the valuation procedure to be used by the government. We start with an equilibrium situation in which the citizens of the country hold their optimal portfolio allocations. The government must decide whether to undertake the project. This and subsequent decisions are evaluated incrementally to the initial equilibrium.

Should the government decide to undertake the project, it would fund it entirely with debt borrowed at the rate R_F.[8] The government can borrow at the risk-free rate to fund even a risky project, because it is assumed to have an independent source of revenue that would cover any shortfall in the cash flows from the project; state-owned corporations are an example.[9] The

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[8] Recall from Footnote 2 that the government does not issue equity in the project.

[9] This assumption is made necessary in this part of the analysis by the assumed absence of taxes, which precludes the taxation of the citizens to honor the government's obligations. An alternative assumption would be that of lump sum taxes. These have no effect at the margin, in contrast to the proportional taxes considered later.

government's decision to undertake the project implies that citizens will owe the risk-free cash flow $1+R_F$ at date 1 and receive the risky cash flow C at that date. We show in Appendix 1 that:

Proposition 2: If the project is undertaken by the public sector, it has required return $R_F+\beta P$ and net present value:

$$NPV\left(public\right)=-1+\frac{E\left[C\right]}{1+R_F+\beta P}. \tag{4}$$

Propositions 1 and 2 establish the result that, in the absence of taxes and under Assumptions 1 to 5, the required return and NPV of the project are the same for the public and private sectors. This enables us to focus our analysis below solely on the effect of taxes.

The proof of Proposition 2 uses a quasi-arbitrage argument.[10] A consensus citizen hedges the market risk of the risky cash flow to re-establish his initial, optimal portfolio allocation. He does so by decreasing his holding of the global market portfolio and increasing his holding of the risk-free asset. Assumption 3 ensures that he has the cash flow and rate of return information necessary for rebalancing. Assumptions 4 and 5 set the terms on which rebalancing occurs; these are determined by the global CAPM. They are identical to those available to a shareholder of the private firm, who is confronted with the same hedging problem as the citizen: the shareholder too will receive C and owe $1+R_F$; Assumptions 1 and 2 ensure that C is the same for both the citizen and the shareholder, Assumption 4 that R_F is the same. Citizen and shareholder therefore use the same discount rate to discount the same cash flows; they naturally obtain the same NPV. This establishes the result that the public and private sectors should use the same discount rate to obtain the same NPV when evaluating the same project. This result bears some similarity to Modigliani and Miller's (1958) capital structure irrelevance theorem: debt or equity financing in their case and public or private sector ownership in our case have no effect on firm or project discount rates and valuations in the absence of taxes.

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[10] See Modigliani and Miller (1958, 1963).

The project should be undertaken if it has positive NPV. While the total wealth increases as a result, it is not necessarily the case that all the citizens of the country benefit directly from the project. The benefits of the project may accrue primarily to some citizens, and the costs may be borne primarily by other citizens. Nonetheless, the value created by the project should make possible the compensation of the citizens who are adversely affected by the project. Thus, if the allocation of wealth was deemed to be socially optimal prior to the undertaking of the project, the government could redistribute wealth to re-establish the desired allocation (Kaldor, 1939; Hicks, 1940). There will be no risk-sharing consequences of the way in which the project is financed, as citizens can trade market risk back to their optimal allocations and other risks can be diversified. This justifies the undertaking of the project as well as the reliance on a consensus citizen to determine the public sector cost of capital.

5. Public and private discount rates with taxes

We now introduce taxes, which are the main focus of our analysis. We define T_{PD} and T_{PE} as the investor tax rates on debt and equity, respectively.[11] We denote by T_C^R the corporate tax rate on real investment and by T_C the corporate tax rate on financial investment: the tax rules are such that T_C^R and T_C will generally differ. We focus on the role of depreciation in lowering T_C^R below T_C, specifically on the role of the difference between economic and tax depreciation. The former will be recalled to be the loss in asset value through utilization.

To see why $T_C^R < T_C$, consider real investment and debt financing, the latter being the 'mirror image' of financial investment. Both give rise to a tax shield, the depreciation tax shield for real investment and the interest tax shield for debt financing. Yet, whereas tax deduction and interest expense are identical in the case of the interest tax shield, tax deduction and loss in asset value are not in the case of the depreciation tax shield: depreciation allowances are generally higher than actual economic depreciation in the early years of the life of an asset, those that loom largest in present value terms. This lowers the effective tax rate on real investment below the

[11] Note that in general not all investors – whether shareholders or citizens – will have tax rates T_{PD} and T_{PE}. The conditions for a well-defined equilibrium with multiple tax brackets and debt and equity finance are given by Miller (1977) and Schaefer (1982). An important condition is that investors are subject to short-selling constraints, because tax arbitrage among investors in different tax brackets would otherwise be possible (Schaefer, 1982).

statutory rate, the latter being the tax rate on financial investment. Briefly, denoting INC income before depreciation, interest, and tax, ED economic depreciation, TD tax depreciation, INT interest payments, and T_C the statutory tax rate, the effective tax rate is $T_C\left(INC-TD\right)/\left(INC-ED\right)\equiv T_C^R$ for real investment, $T_C\left(INC-INT\right)/\left(INC-INT\right)=T_C$ for debt financing. Clearly, if $TD>ED$, then the first ratio, the tax rate on real investment T_C^R, is lower than the second ratio, the statutory rate T_C which is also the tax rate on financial investment.[12,13]

In accordance with conventional notation, we let R_M now denote the post-corporate-tax return on the global market portfolio and $P\equiv E\left[R_M\right]-R_F$ the post-corporate-tax global market risk premium. We define:

$$\beta'\equiv\frac{\operatorname{cov}\left[\left(1-T_C^R\right)C,R_M\right]}{\operatorname{var}\left[R_M\right]}=\left(1-T_C^R\right)\beta \tag{5}$$

as the post-corporate-tax beta corresponding to the pre-corporate-tax beta β in (1). We derive the discount rate for the public sector followed by that for the private sector.

5.1 The public sector discount rate

The derivation of the public sector discount rate with taxes is similar to that in Section 4 above without taxes. As in Section 4, the consensus citizen, now taxpayer, will receive the net cash flow $C-\left(1+R_F\right)$ from the government at date 1. This cash flow has a beta equal to β. The taxpayer will hedge the market risk of that cash flow, because his prior allocation of risk was optimal and he wishes to re-establish it. He will do so by reducing his holding of the market portfolio and lending the amount thus obtained. Although the former transaction entails foregoing after-tax return $\left(1-T_{PE}\right)R_M$ and the latter has after-tax return $\left(1-T_{PD}\right)R_F$ to the taxpayer, the government, in making its decision regarding whether to undertake the project,

[12] A similar result would hold if real investment were encouraged by way of an investment tax credit larger than the tax shield provided by economic depreciation, $ITC>T_C ED$: $T_C^R\equiv\left(T_C INC-ITC\right)/\left(INC-ED\right)<T_C$ in such case.

[13] See Gordon, Kalambokidis, and Slemrod (2003) for an extensive analysis of the difference between the statutory and the effective tax rate on investment. Gordon et al.'s u is our T_C and their m our T_C^R.

considers the pre-tax returns, as it recognizes that the ensuing change in government tax receipts will, in the final analysis, accrue to the taxpayers themselves.

A direct analogy to Proposition 2 implies that the public sector discount rate and valuation are the same as in the no-tax case:

Proposition 3: The public sector has required return on the project $R_{PU} \equiv R_F + \beta P$. It is used to discount the pre-tax expected cash flow from the project $E[C]$.

Note that both the taxpayer and the government use the post- rather than the pre-corporate-tax global market risk premium, computed using the post-corporate-tax expected return E[R_M] on the global market portfolio as the relevant benchmark. That is the pre-investor-tax expected return on risky assets that is available in the capital market. Further note that the government pays no corporate tax: the cash inflow from the project is C not $\left(1-T_C^R\right)C$.

The required return given by Proposition 3 differs from the results of Harberger (1968), Sandmo and Drèze (1971), Bailey and Jensen (1972), and Marchand and Pestieau (1984) in that these authors' assumption of inelastic capital markets makes the public sector discount rate an average of households' and firms' discount rates. These are not the same, because a wedge is introduced between households' marginal rate of time preference and firms' marginal productivity of capital by the presence of taxes. Households' and firms' discount rates are weighted by the derivatives of consumption and investment with respect to public sector borrowing to account for the displacement of consumption and investment by public sector projects. No such displacement occurs under Assumption 4's infinitely elastic capital market.

5.2 The private sector discount rate

We now derive the private sector discount rate. It differs from the public sector discount rate because, unlike the government acting on behalf of taxpayers in Section 5.1, shareholders do not account for the benefits derived from any change in government tax receipts that may result from the undertaking of the project. Only a very small fraction of any such change would accrue to or be borne by the shareholders of the firm undertaking the investment. Shareholders therefore consider after- rather than before-tax returns on the transactions that they too will enter into to hedge the market risk of the project. These returns are $\left(1-T_{PD}\right)R_F$ on the risk-free asset and $\left(1-T_{PE}\right)R_M$ on the market portfolio. Note that, like the taxpayers in Section 5.1, shareholders use the post- rather than the pre-corporate-tax global market risk premium, computed using the post-corporate-tax return R_M on the global market portfolio.

The shareholders of a private firm need not all reside in the same country, which need not be the country in which the firm undertakes the project. The investor tax rates T_{PD} and T_{PE} are therefore those of the consensus shareholder and the corporate tax rates T_C and T_C^R those of the country in which the investment is made. In Section 6 below, we briefly discuss how the incidence of taxes by country should affect the government's analysis of private sector valuations. We assume that a fraction $1-L$ of the project is financed by equity and the remaining fraction L is financed by risk-free debt; L is chosen fully to exploit the project's debt capacity, subject to debt remaining risk-free.[14] The project has an after-corporate-tax beta equal to β' in (5). We show in Appendix 2 that the private sector evaluates the project as follows:

Proposition 4: The after-tax required return on equity is:

$$(1-T_{PD})R_F+\frac{\beta'}{1-L}\left[\left(1-T_{PE}\right)E\left[R_M\right]-(1-T_{PD})R_F\right]; \tag{6}$$

it is used to discount the expected after-tax cash flow to equity:

$$(1-T_{PE})\left((1-T_C^R)E\left[C-1\right]-(1-T_C)LR_F\right)+(1-L). \tag{7}$$

The after-tax required return on the project is:

$$(1-L)\left(\left(1-T_{PD}\right)R_F+\frac{\beta'}{1-L}\left[(1-T_{PE})E\left[R_M\right]-(1-T_{PD})R_F\right]\right)+L(1-T_{PE})(1-T_C)R_F; \tag{8}$$

it is used to discount the expected after-tax cash flow from the project:

$$(1-T_{PE})(1-T_C^R)E\left[C-1\right]+1. \tag{9}$$

The after-tax required return on the project has the pre-tax equivalent:

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[14] We acknowledge a limitation of our analysis in that such choice of L need not be optimal.

$$R_{PR} \equiv R_F + \beta P + L\left[\frac{T_C^R - T_C}{1-T_C^R}\right]R_F + \beta\left[\frac{T_{PD} - T_{PE}}{1-T_{PE}}\right]R_F$$
$$+(1-L)\left[\frac{(1-T_{PD})-(1-T_{PE})(1-T_C^R)}{(1-T_{PE})(1-T_C^R)}\right]R_F; \tag{10}$$

it is used to discount the expected pre-tax cash flow from the project $E[C]$.

The first two parts of Proposition 4 establish the result that the private sector will discount after-tax cash flows at after-tax discount rates. This is true for the cash flow to equity, (7), discounted at the cost of equity, (6), as well as for the cash flow from the project, (9), discounted at the cost of capital, (8). It is in contrast to the public sector, which was shown in Proposition 3 to discount pre-tax cash flows at the pre-tax cost of capital. Such a contrast is not surprising, for the public sector does not pay taxes whereas the private sector does. The last part of Proposition 4 expresses the private sector after-tax cost of capital on a pre-tax basis; it makes the comparison of the private and public sector costs of capital possible.

Note from (7) and (9) that corporate tax is levied at the rate T_C^R on cash flow C net of economic depreciation 1, as represented by the term $\left(1-T_C^R\right)E[C-1]$. As depreciation is not in fact a cash flow, it does appear as the last term in the numerators, $1-L$ for the equity cash flow in (7) (L serving to repay the debt), and 1 for the entity cash flow in (9). In contrast, the interest payment provides a tax shield at the rate T_C, as represented by the term $\left(1-T_C\right)LR_F$ in (7). There is no corresponding term in (9) because the benefit of the interest tax shield is incorporated in the discount rate (8) through the term $L\left(1-T_{PE}\right)\left(1-T_C\right)R_F$; again, the tax shield is at the rate T_C.

That the cost of debt $\left(1-T_{PE}\right)\left(1-T_C\right)R_F$ in (8) does not depend on T_{PD} may be surprising at first. It reflects the fact that those who ultimately make the interest payment are the shareholders of the firm, not its debtholders. That the after-tax cost of the interest payment is $\left(1-T_{PE}\right)\left(1-T_C\right)LR_F$ can perhaps best be understood by recalling that the tax system makes the government a 'partner' of the firm and its owners, with whom the government shares costs and benefits in proportion to the tax rate. Interest payments LR_F are a cost; they are first shared by the firm with the government in the proportions $1-T_C$ and T_C; the net interest payment made by the firm, $(1-T_C)LR_F$, is then shared by shareholders with the government in the proportions $1-T_{PE}$ and T_{PE}.

5.3 The difference between the public and the private sector discount rates

We examine the difference between the public and the private sector pre-tax discount rates. We subtract the public sector discount rate, R_{PU}, defined in Proposition 3, from the private sector discount rate, R_{PR}, defined in Proposition 4. We call the resulting difference, either as such or divided by the risk-free rate, the 'tax wedge'. We denote the tax wedge's second variant τ; it consists of three components, $\tau = \tau_1 + \tau_2 + \tau_3$:

$$\tau_1 \equiv L\left[\frac{T_C^R - T_C}{1-T_C^R}\right], \tag{11}$$

$$\tau_2 \equiv \beta\left[\frac{T_{PD} - T_{PE}}{1-T_{PE}}\right], \tag{12}$$

and:

$$\tau_3 \equiv (1-L)\left[\frac{(1-T_{PD})-(1-T_{PE})(1-T_C^R)}{(1-T_{PE})(1-T_C^R)}\right]. \tag{13}$$

Observe that (1) the sign of each component depends only on the tax rates, (2) the magnitudes of τ_1 and τ_3 depend on the debt capacity, measured by leverage L, and (3) the magnitude of τ_2 depends on the project pre-corporate-tax beta β.

We now consider the three components in turn. The first component, τ_1, in (11) represents the combined effect of the interest and depreciation tax shields. The tax rate on financial investment T_C is the rate at which the interest tax shield is granted; the tax rate on real investment T_C^R reflects the benefits of the depreciation tax shield. Where depreciation lowers the tax rate on real investment below that on financial investment, $T_C^R < T_C$, depreciation causes profit to be taxed at a lower rate (T_C^R) than is shielded by leverage (T_C). This is of benefit to the private sector, the pre-tax discount rate of which is lowered below its public sector counterpart, $\tau_1 < 0$. It is the more so the higher is the debt capacity of the project L. The private sector therefore favours assets with high debt capacity and rapid tax depreciation; all else being equal, the private sector does so the more the larger is the tax rate on financial investment T_C at which the interest tax shield is granted.

The preceding conclusion about τ_1 assumes that the tax system allows a tax loss generated by the combined effect of the depreciation and interest tax shields to be used to protect other taxable income. For that to be the case, the high debt capacity and low tax assets that give rise to the tax loss have to be pooled for tax purposes with other assets that generate taxable profit.[15] We return to this issue in Section 5.6 below.

The second component, τ_2, represents the effect of the difference in investor tax on the risk premium received by investors. To take on the incremental risk of a project, investors rebalance the remainder of their portfolios away from equity and towards debt. If the investor tax rate on debt is higher than that on equity, $T_{PD} > T_{PE}$, as is the case in most tax systems, this rebalancing is costly to investors. The private sector pre-tax discount rate is therefore raised above its private sector counterpart, $\tau_2 > 0$, because the public sector does not suffer this tax penalty when it rebalances risk. The larger the beta of the project and the more extensive the rebalancing required, the larger this effect. Thus, if tax is the only factor, high beta assets will be valued less by the private sector than by the public sector. The private sector will therefore be reluctant to take risky assets away from the public sector.

The third component, τ_3, recalls Miller's (1977) net tax discrimination term between debt and equity, $(1-T_{PD})-(1-T_{PE})(1-T_C)$, from which τ_3's numerator differs in including the tax rate on real (T_C^R) rather than financial (T_C) investment. It represents the possible tax benefit (if negative) or cost (if positive) to choosing equity over debt financing. While it is zero in a Miller (1977) equilibrium, the net tax discrimination term is positive in most tax systems, implying that equity financing is costlier than debt financing.[16] This raises the private sector cost of capital above its public sector counterpart, $\tau_3 > 0$. The greater the reliance on equity financing $1-L$,

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[15] An example is the UK privatized water companies, which are funded with large amounts of debt and are generally held in combination with other assets rather than as stand-alone firms (see *Financial Times*, 23 January 2018, page 9).

[16] That the net tax discrimination term is zero in a Miller equilibrium (1977) will be recalled from the discussion at the end of the previous section.

the larger is the effect. Assets that need to be financed heavily with equity will therefore be valued less by the private sector than by the public sector. This reinforces the preference of the private sector for assets that can be funded heavily with debt.[17]

Our analysis can be viewed as complementing Miller's (1977) in that it accounts for both the combined effect of the interest and depreciation tax shields (τ_1) and the effect of the difference in investor tax on the risk premium (τ_2) in addition to the differential tax effect of equity and debt financing (τ_3) analysed by Miller (1977). That taxes affect the private sector pre-tax cost of capital R_{PR} but not the public sector cost of capital R_{PU} is, as previously noted, a consequence of the fact that taxes are a transfer to taxpayers but a cost to shareholders.[18]

5.4 The relation between the private sector discount rate and the public sector cash flow

We now turn our attention from the wedge introduced by taxes to the private sector discount rate, $R_{PR} = R_{PU} + \tau R_F$, to the corresponding change in public sector tax revenues: taxes paid by a private sector firm are taxes received by the government, and taxes saved by the firm are foregone by the government. We show in Appendix 3:

Proposition 5: The value to the government of the change in tax revenues at date 1 resulting from a private sector project with zero NPV is given by $\Delta TAX = \tau R_F$.

An immediate corollary to Proposition 5 is:

Corollary 1: The wedge between the private and the public sector costs of capital equals the value of the change in tax revenues: $R_{PR} = R_{PU} + \Delta TAX$.

To understand the intuition for these results, consider a zero-NPV project.[19] Using (8) and (9), we have:

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[17] Recall the discussion of τ_1 above.

[18] Compare the discussion at the beginning of Sections 5.1 (public sector) and 5.2 (private sector).

[19] We consider a zero-NPV project because we wish to keep the beta constant: when a private sector project has non-zero NPV, the undertaking of the project changes the beta because it changes the value of the tax shield relative

$$-1+\frac{(1-T_{PE})(1-T_C^R)E\left[C-1\right]+1}{\left\{\begin{array}{c}1+(1-L)\left((1-T_{PD})R_F+\dfrac{\beta'}{1-L}\left[(1-T_{PE})E\left[R_M\right]-(1-T_{PD})R_F\right]\right)\\ +L(1-T_{PE})(1-T_C)R_F\end{array}\right\}}=0 \tag{14}$$

$$\Leftrightarrow E\left[C\right]=1+\left(1-L\right)\left[\frac{1-T_{PD}}{\left(1-T_{PE}\right)\left(1-T_C^R\right)}\right]R_F+\beta\left[E\left[R_M\right]-\left[\frac{1-T_{PD}}{1-T_{PE}}\right]R_F\right]+L\left[\frac{1-T_C}{1-T_C^R}\right] \tag{15}$$

$$\Leftrightarrow E\left[C\right]=1+R_F+\beta P+\tau R_F\,, \tag{16}$$

where we have used (11)–(13). The effect of taxes is to change the cash flow required for the project to have zero NPV from $E\left[C\right]=1+R_F+\beta P$ in the absence of taxes to (16) in their presence. The difference between these two cash flows, the tax wedge τR_F, is the tax paid by the firm and received by the government if positive or the tax saved by the firm and foregone by the government if negative. In the present case of unit initial investment, the cash flow required to have zero NPV equals the cost of capital.

The change in tax revenues also equals the date 1 difference in valuation if the project were undertaken by the government rather than the firm. To see this, note that if the project with cash flow $E\left[C\right]$ in (16) were undertaken by the government, it would have net present value at date 0:

$$-1+\frac{E\left[C\right]}{1+R_{PU}}=-1+\frac{1+R_F+\beta P+\tau R_F}{1+R_F+\beta P}=\frac{\tau R_F}{1+R_F+\beta P}.$$

The corresponding value at date 1 is $\tau R_F=\Delta TAX$.

The result in Proposition 5 is obtained by having the government hedge the incremental cash flows associated with the changes in tax payments resulting from the project: recall the observation in Section 5.2 that the tax system makes the government a ‘partner’ of the firm in sharing both the rewards and the risks of the project. Thus, like shareholders who hedge the after-tax cash flows from the project (recall Proposition 4), the government acting on behalf of taxpayers hedges the tax cash flows from the project. Unlike shareholders who hedge on an

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to the operating cash flow. Although it is possible to derive a formula for the NPV that accounts for the change in the beta, this complicates the analysis without adding much insight.

after-tax basis, the government hedges on a pre-tax basis.[20] This difference makes the equality between the tax wedge and the change in tax revenues non-trivial, albeit intuitive.

Proposition 5 and Corollary 1 imply that, in any transaction between the public and the private sector that is materially affected by tax considerations, the impact of tax on the private sector's discount rate and valuation is, in the present case of unit initial investment, identical to its impact on the public sector's tax revenue.[21] We discuss the implications of this result for the analysis of transactions between the public and the private sector in Section 6.

5.5 Public and private sector discount rates and asset preferences

We now examine the combined effect of all three components of the tax wedge, $\tau = \tau_1 + \tau_2 + \tau_3$. As indicated by (11)–(13), the wedge depends on the tax rates, debt capacity L, and asset beta β. In line with our discussion of tax rates in Section 5.4, we make the following assumption, which holds for most standard tax systems:

Assumption 6. $T_C^R < T_C$, $T_{PD} > T_{PE}$ and $(1-T_{PD}) - (1-T_{PE})(1-T_C^R) > 0$.

The first part of the assumption states that depreciation lowers the corporate tax rate on real investment below that on financial investment. The second part states that the investor tax rate on debt is greater than that on equity. The third part asserts that the combination of the effective corporate tax rate and the investor tax rate on equity exceeds the investor tax rate on debt.

Given Assumption 6, we show that taxes induce a private sector preference for projects with a low asset beta and high debt capacity. Formally, the tax wedge τ has partial derivatives:

$$\frac{\partial \tau}{\partial \beta} = \frac{T_{PD} - T_{PE}}{1 - T_{PE}} > 0$$

and

$$\frac{\partial \tau}{\partial L} = \frac{(1-T_{PE})(1-T_C) - (1-T_{PD})}{(1-T_{PE})(1-T_C^R)} < 0.$$

Thus, based on taxes alone and compared with the public sector, the private sector shows a greater preference for projects or cash flows that have low risk and a high debt capacity.

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[20] Compare the proofs of propositions 4 and 5.

[21] If the initial investment were K, then the change in tax revenues and the difference in valuation would be $\tau R_F K$; the wedge between the discount rates would, however, remain τR_F.

In some cases, this preference will result in an advantage for private sector ownership, as Table 1 illustrates. Panel A considers high debt capacity projects, $L = 0.8$. For projects that combine a high debt capacity with a low asset beta, the tax wedge τ is negative, indicating that the private sector has a tax-induced advantage over the public sector in undertaking these projects. Panel B shows that projects with low debt capacity always have a tax disadvantage for the private sector, regardless of their asset beta. This is because the tax wedge τ is always positive, increasing the private sector's discount rate above that of the public sector. The table also illustrates that the tax advantage of the private sector stems only from τ_1, the component of the tax wedge due to the difference between the effective and the statutory corporate tax rates.

The private sector is therefore in a position to offer the public sector high prices for assets with rapid tax depreciation schedules and high debt capacity. Since only low beta assets have high debt capacity and given that high leverage naturally implies low equity, the disadvantage from the positive τ_2 and τ_3 does not eliminate the advantage from the negative τ_1. We discuss in Section 6 whether such tax-induced high prices constitute a valid reason for the public sector to transfer assets to the private sector.

Figure 1 generalizes Table 1 in that it shows, for a range of values for debt capacity L and asset beta β, the areas in which there is a tax advantage ($\tau < 0$) or disadvantage ($\tau > 0$) to the private sector. The blue line represents the combinations (L, β) for which the tax wedge is zero, $\tau(L, \beta) = 0$: the private and public sector discount rates are equal on that line.

The area of tax advantage for the private sector is at the bottom right of the figure; it corresponds to assets with a high debt capacity and a low beta.[22] Conversely, the area of tax disadvantage for the private sector is at the top left of the figure; it corresponds to assets with a low debt capacity and a high beta. The boundary between the two areas is a straight line that cuts the x-axis at a strictly positive value;[23] assets with a debt capacity below that value always have a tax disadvantage for the private sector, regardless of how low risk they may be.

Besides τ, the tax wedge τR_F depends on the risk-free rate R_F. A larger risk-free rate increases the tax wedge, both in absolute value, $|\tau R_F|$, and relative to the public sector discount

[22] Assets with a high debt capacity and a high beta are unlikely to exist in practice.

[23] These two properties are easily derived by solving $\tau(L, \beta) = 0$ for $\beta(L)$.

rate, $\left|\tau R_F\right| / \left(R_F + \beta P\right)$. A larger risk-free rate therefore strengthens the private sector's preference for assets with negative tax wedge, $\tau < 0$, that is, assets with rapid tax depreciation schedule, low beta, and high debt capacity. This observation may provide a possible explanation for the lesser willingness recently of the private sector to invest in public infrastructure (Gomes, 2018): one feature of the post-credit-crisis environment has been the low level of interest rates; as the risk-free rate has fallen, so has the tax wedge $\left|\tau R_F\right|$, thereby reducing the private sector's willingness to invest in assets with negative tax wedge, such as some types of infrastructure.

5.6 Details of the tax system and multiple periods

Under Assumption 6, and as illustrated in Table 1 for example, it is clear that any tax advantage that the private sector may have over the public sector, $\tau < 0$, derives not from investor but from corporate tax: $\tau_1 < 0$, whereas $\tau_2 > 0$ and $\tau_3 > 0$. The private sector's tax advantage is attributable to the combination of depreciation and leverage: depreciation causes profit to be taxed at a lower rate (T_C^R) than it is shielded by leverage (T_C).

For a firm to be able to profit from that difference, however, it must be able to use the tax loss generated by depreciation and leverage to offset the tax payments elsewhere in the corporation. This will be immediate when the asset being depreciated is a relatively small part of a larger profitable firm. In contrast, when the tax loss is generated by a large collection of assets, for example by a regulated utility, the assets and losses must be consolidated into another profitable firm. Tax systems differ regarding the conditions under which such consolidation is allowed. Details of the relevant tax system therefore affect the extent to which this primary source of private sector tax advantage operates.

Details of the tax system also affect the tax efficiency of the hedging transactions used to neutralize the risk of a project. Recall that investors hedge the risk of a project by selling equities, taxed at T_{PE}, and buying debt, taxed at T_{PD}. If hedging were instead achieved by shorting stock index futures contracts, a transaction that may attract a different tax rate, then the private sector tax disadvantage will vary, possibly decreasing if the investor tax rate on stock index futures is lower than that on equities.[24]

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[24] Both $\partial \tau_2 / \partial T_{PE} > 0$ and $\partial \tau_3 / \partial T_{PE} > 0$ from (12) and (13).

The derivation in Section 5 assumes a single period, yet the life of most assets spans multiple periods. The tax rate on real investment T_C^R therefore should be viewed as an average of the rates paid over the life of an asset. These rates generally vary over time. For example, it may be possible to take large tax benefits early in the life of an asset, using a high tax rate corporation for that purpose, and then to transfer the asset to a low tax rate corporation once the tax benefits have been exhausted. Whether such a transfer is possible, and how much it lowers the effective tax rate on real investment, depends on the details of the tax rules and on the extent to which tax transfer markets are allowed to operate (Cooper and Franks, 1983).

6. Implications for transactions between the public and the private sector

The preceding analysis has shown that there is a tax-induced wedge between public and private discount rates for the same asset with the same pre-tax expected future cash flows, and that this wedge equals the value of the incremental tax revenues received or foregone by the public sector in the case in which the asset is owned by the private sector. This naturally implies that the resulting discount rate-induced difference in valuations between the public and the private sector does not constitute a legitimate motive for transactions between the public and the private sector: the difference in valuation amounts only to redistribution via the tax system; a higher private sector valuation means foregone public sector tax revenues, and a lower valuation means additional tax revenues. Thus, Proposition 5 and Corollary 1 imply that an asset has the same value to both public and private sectors when (i) both sectors generate the same cash flow from the asset and (ii) the public sector fully internalizes all incremental tax effects: no third party is affected by the changes in tax revenues that result from a change in ownership of the asset.[25]

The difference in valuation nonetheless introduces a preference in the private sector for certain types of asset, specifically those with rapid tax depreciation, a high debt capacity, and low risk. Unless adjusted for, this preference may distort public sector decisions regarding matters as varied as the privatization of government assets, the regulation of private utilities, and transactions that commit the government to making fixed payments to the private sector. In this section, we discuss such distortions and show how the government should analyse the

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[25] An example of such a party might be a foreign government. We return to that issue in Section 6.4.

aforementioned transactions to avoid disadvantaging its citizens. We further distinguish between the two cases in which all incremental taxes affect only the domestic government and in which they affect other governments as well.

To illustrate the type of error that may be made, consider a government contemplating the sale of an asset to the private sector. The apparently intuitive procedure that would have the government discount the cash flows associated with the asset at the government's cost of capital R_{PU} and compare the value thus obtained with the price offered by the private sector would be incorrect. Although that value represents the true value of the asset to the government, as shown in Proposition 3, it is not the value to be compared with the price offered by the private sector. This is because such a comparison ignores the change in tax revenues that the sale of the asset necessarily produces. An asset generally provides both a depreciation tax shield and an interest tax shield; *ceteris paribus*, these can be expected to decrease the government tax revenues. Failure on the part of the government to account for the tax implication of the sale of the asset would systematically distort the government decisions regarding the sale of tangible assets with a high debt capacity and a low beta, regardless of whether the private sector is actually more efficient than the public sector in the sense of generating a higher pre-tax cash flow from the asset.

6.1 Privatization with full internalization of all incremental taxes

When the public sector fully internalizes all the incremental tax effects, Proposition 5 holds. There are then two alternative procedures for making privatization decisions. Both involve the government evaluating the privatization decision as if it – the government – were subject to taxation in exactly the same manner as private firms. The first procedure reflects taxation in the discount rate and the second taxation in the cash flow. They are:

1. Discount the public sector cash flow $E[C]$ at the private sector discount rate R_{PR} in (10) and compare it with the price offered by the private sector.
2. Subtract the value of the change in tax revenue that would result from privatization $\Delta TAX = \tau R_F$ from the public sector cash flow $E[C]$, discount it at the public sector discount rate R_{PU}, and compare it with the price offered by the private sector.

Both procedures entail the government incurring the same cost ($\tau > 0$) or enjoying the same benefit ($\tau < 0$) as the private firm, which pays tax but also enjoys depreciation and interest tax shields.

The two procedures are equivalent from Corollary 1: the tax wedge in the discount rate equals the value of the change in the government tax revenues, that is, minus the change in the private sector cash flow.[26] It may nonetheless be useful to use both approaches, as these will complement each other, when the errors that necessarily will be made in estimating the discount rates and cash flows are not the same. By way of example, contrast the sale and leaseback of a real estate asset with an investment in a nuclear power plant. The greater uncertainty about the cost of capital of the latter suggests a greater need to rely on the cash flow in that case.

To illustrate the need for the change in discount rate mandated by the first procedure, consider a government's decision regarding whether to privatize an asset that, in accordance with Assumptions 1 and 2, has identical pre-tax cash flows $E[C]$ for both the public and the private sector. Normalize the present value (PV) to the private sector to 1 and follow the same steps as in Section 5.7 to obtain (16), $E[C] = 1 + R_F + \beta P + \tau R_F$. Further assume that the asset markets are competitive so that 1 would be the price paid by an acquiring firm to the government.

Now compute the value of the asset to the government. From Proposition 3, that value is:

$$\frac{E[C]}{1+R_F+\beta P} = \frac{1+R_F+\beta P+\tau R_F}{1+R_F+\beta P} = 1 + \frac{\tau R_F}{1+R_F+\beta P}, \tag{17}$$

where we have used (16). This is the true value of the project to the government, which, depending on the sign of τ, may be higher or lower than 1, the receipt from privatization. However, a positive τ is no more a reason for the asset to remain in government hands than a negative τ is a reason for the asset to be privatized: both the firm and the government generate the same pre-tax cash flow $E[C]$, and both can source financing in the same infinitely elastic capital market, which both taxpayers and shareholders can use to hedge the risk of the asset. The reason for the firm's PV being lower or higher than the government's is because the firm, unlike the government, pays tax; this alters both the cash flow and the discount rate. The purpose of using the adjustment in (10) is to account for this tax when comparing the two sectors'

[26] We further show this by way of an example in the following.

valuations. Indeed, having the government use $1+R_F+\beta P+\tau R_F$ from (10) as a discount rate, the government computes the PV:

$$\frac{E[C]}{1+R_F+\beta P+\tau R_F}=\frac{1+R_F+\beta P+\tau R_F}{1+R_F+\beta P+\tau R_F}=1. \tag{18}$$

The comparison is no longer distorted by the failure to account for the firm's tax payments. The general formula in (10) generalizes Baumol's insight discussed in Section 2 in that (10) incorporates risk, leverage, investor tax, and the differential taxation of debt and equity and of real and financial investment.[27]

It is easy to see that the second procedure achieves an identical result. Indeed, using Proposition 5 and (16), we have:

$$\frac{E[C]-\Delta TAX}{1+R_F+\beta P}=\frac{E[C]-\tau R_F}{1+R_F+\beta P}=\frac{1+R_F+\beta P+\tau R_F-\tau R_F}{1+R_F+\beta P}=1. \tag{19}$$

6.2 Regulation

Suppose that the purpose of regulation is to limit a private sector utility's return to its cost of capital and that such a limitation is achieved by having the government set regulated prices in such a way that the utility's pre-tax cash flow equals the utility's capital charge. If the utility's capital is normalized to 1, then the government would set the price such that the utility's pre-tax cash flow equals, by the same derivation as for (16),

$$E[C_{PR}]=1+R_F+\beta P+\tau R_F. \tag{20}$$

If the utility were owned by the government instead, and again assuming that the price is set to cover the utility's capital charge, then the price would be set such that the cash flow equals:

$$E[C_{PU}]=1+R_F+\beta P. \tag{21}$$

The government will be deemed to be too stringent in its regulatory policy, $E[C_{PR}]<E[C_{PU}]$, if $\tau<0$; it will be deemed to be too lax, $E[C_{PR}]>E[C_{PU}]$, if $\tau>0$.

[27] To recover Baumol's $2R_F$ result, insert $\beta=\beta'=0$, $L=0$, $T_{PD}=T_{PE}=0$, and $T_C=T_C^R=1/2$ into (10).

However, neither assessment would be correct. Instead, the government simply reflects in its regulatory pricing policy the tax benefits ($\tau < 0$) or costs ($\tau > 0$) that ownership of the regulated utility confers, or imposes, on the private sector. Thus, tangible-asset-rich utilities with rapid tax depreciation, low risk, and high debt capacity, such as water companies, will appear to be penalized, whereas intangible-asset-rich utilities with little depreciation, high risk, and low debt capacity, such as telecoms, will appear to be privileged. Both impressions would be mistaken.

6.3 Risk transfers and fixed payments

Many transactions between the public and the private sector involve either explicit or implicit risk transfers. These often take the form of fixed payments. In public–private partnerships for example, a private firm will assume the risks of financing, building, and maintaining an asset such as a school or a hospital in return for a series of fixed payments from the government agency that will use the asset. An oft-stated motivation for such a transaction is the private sector's often greater efficiency in controlling costs, a consequence of the private sector's generally higher-powered incentives: the fixed payments received by the private sector make it a residual claimant to any cost saving, thereby incentivizing it to engage in vigorous cost cutting.

Transactions such as these have the same safe cash flow C paid and received by the government and the firm, respectively. Essentially the same issues as in our analysis of privatization in Section 6.1 arise: the discount rate $R_{PU} = R_F$ ($\beta = 0$ as C is safe) that the government should use to determine the cost of the guarantee differs from the rate $R_{PR} = R_F + \tau R_F$ that it should use if it should wish to compare the cost of private sector provision with that of public sector provision.

6.4 Privatization with partial internalization of incremental taxes

Our analysis thus far has assumed that the taxes the effect of which the wedge τ is intended to capture are paid and received domestically: any tax benefit that investment in an asset provides is received by domestic firms and investors, whose gain is the domestic government's loss; the same is true of any tax cost.[28]

[28] The single exception is corporate taxes paid on the global market portfolio; see the discussion after Proposition 3.

When foreign investors or tax authorities are involved, however, either as recipients or as payers of tax, then the use of the tax wedge τ no longer accounts for the entirety of the tax effects: a positive τ would be too high if part of the tax were paid to foreign tax authorities, and a negative τ would be (algebraically) too low if part of the tax saved were at the expense of foreign tax authorities. For example, if a privatized asset acquired by a foreign firm were to decrease the foreign firm's tax payments in its home country, then even a difference in valuation due entirely to tax redistribution might justify the decision to privatize. This is because the privatizing government would enjoy the benefit (higher privatization proceeds) but not bear the cost (lower tax receipts) of the tax shield that ownership of the privatized asset provides. Such considerations can be accounted for by adjusting the tax wedge τ to distinguish between foreign and domestic taxes, but the formal analysis of such adjustments is beyond the scope of the present paper.

7. Examples

In this section, we illustrate the distortions discussed in Section 6 with a number of examples. We discuss independent power plants (IPPs) in some detail: the private financing of IPPs through project finance has proven to be pervasive. We show that IPPs fall into the area of highest tax advantage for the private sector; an IPP illustrates an extreme form of tax distortion to the benefit of the private sector.

IPPs have a low asset beta and high debt capacity, a consequence of the long-term 'take-or-pay' contracts that IPPs enter into with electricity distributors (Brealey, Cooper, and Habib, 2000). Such contracts effectively guarantee an IPP's revenues or its margin over fuel costs, thereby decreasing the IPP's cash flow volatility and in turn decreasing its asset beta and increasing its debt capacity. IPPs are therefore located at the bottom-right corner in Figure 1 above, indicating a tax-induced funding cost advantage for the private sector: $\tau_1 < 0$ in (11) is large in magnitude because the debt financing L is large, and $\tau_2 > 0$ in (12) and $\tau_3 > 0$ in (13) are small because the asset beta β and equity financing $1-L$ are small, respectively. The magnitude of τ_1 is further increased by the tax advantage to real investment enjoyed by high-capital-cost coal- or gas-fired power plants: T_C^R is markedly below T_C.

That IPPs are the archetypical asset funded by project finance is consistent with the private sector seeking to exploit IPPs' high debt capacity: a near defining characteristic of project finance is the high leverage that it entails. As argued in Section 6, the private sector's tax gains are the public sector's tax losses; a government is mistaken that concludes in the desirability of encouraging IPPs for electricity generation from the private sector's lower cost of capital, $\tau < 0$: the government in so doing neglects the consequent decrease in tax revenues. This is not to say that resorting to IPPs must always be eschewed, but simply that the government must beware not to partake in a transaction that may be designed solely to arbitrage the tax system.[29]

Table 2 shows stylized measures of (i) risk as measured by the asset beta, (ii) depreciation-induced tax benefits as measured by the difference between the tax rates on financial and real investment, (iii) debt capacity, and (iv) the tax wedge for IPPs (top row), as well as for nuclear power plants, toll roads, commercial/industrial and residential real estate, and routine services such as garbage collection. The choice of these other assets and services is motivated by (a) the difficulty encountered in privatizing nuclear power generation, (b) the growing recourse to private finance to fund infrastructure projects such as toll roads (as well as the previously discussed IPPs) throughout the world (Gatti, 2008), (c) the sale of government real estate assets,[30] and (d) the contracting out of government services.

For all these assets and services, we examine in Appendix 4 the variation of the tax wedge τ in the asset beta and debt capacity, the former depending on the operating leverage and systematic cash flow variability and the latter on the total cash flow variability and asset tangibility.[31] We continue to assume that Assumption 6 holds but now distinguish between those assets for which the difference between the tax rates on financial and real investment is small and those for which it is large. We relate the resulting tax wedge to the observed tendency to have an asset owned or a service provided by the public or the private sector. The overall pattern displayed is to a large extent consistent with the tax-induced advantages and disadvantages that our analysis has identified. This suggests that governments by and large do not adjust for tax distortions in their transactions with the private sector. At least some government transactions,

[29] When agency considerations confer an efficiency advantage on the private sector, then the gains from project-financed IPPs can be large (Brealey, Cooper, and Habib, 1996, 2000).
[30] An example is the sale of military housing in the UK.
[31] See Brealey, Myers, and Allen (2017, Chapter 9).

then, must in fact be unfavourable to the government in that they decrease the tax revenue more than the benefits that they may provide, through gains in efficiency for example.

8. Conclusion

Using a new approach based on a quasi-arbitrage argument similar to that of Modigliani and Miller, we have established the existence of a tax-induced wedge between the public and the private sector discount rates and examined its variation with asset risk and debt capacity. We have shown that, in circumstances where an asset has identical public and private sector valuation in the absence of taxes, the tax induced difference in valuation is identical to the change in government tax receipts that results from having the asset owned by the private rather than the public sector. Differences in valuations derived solely from taxation therefore should not affect the government's choice between public and private sector ownership or provision: any apparent gain will be entirely illusory and represent not value creation but value transfer through the tax system. If the government should fail to adjust for such a transfer, then it might enter into transactions that concurrently decrease government tax revenue and distort private sector incentives.

We have shown how the government should include the preceding considerations in its analysis of privatization (or nationalization), regulation, and transactions such as risk transfers and fixed payments. Interestingly, the pattern of ownership and transactions that would result from the failure to account for tax-induced distortions bears some resemblance to the prevailing patterns. In some cases at least, the government appears not to adjust for tax distortions, thereby unwittingly engaging in tax arbitrage against itself.

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Appendix 1: Proof of Proposition 2

We use a quasi-arbitrage argument to prove Proposition 2. Consider the consensus citizen who will receive the cash flow $C-(1+R_F)$ from the project. The citizen will hedge the systematic risk of that cash flow, as his prior allocation of risk was optimal and he wishes to conserve it. He achieves this by selling an amount α of the market portfolio and investing the proceeds in the risk-free asset.[32] We assume that foreign investors are the net counterparties to the consensus citizen's trades.

We decompose the market return into its expectation and a random part with expectation zero: $R_M = E[R_M]+\varepsilon$. The condition that the citizen's two transactions, which have zero net cost, have zero wealth impact in all states at date 1 defines the government's required return.

The cash flow from the real investment with beta β can be written as: $C = E[C]+\beta\varepsilon$. The combination of this cash flow with the sale of an amount α of the market portfolio and the offsetting purchase of α of the risk-free asset results in the cash flow at date 1:

$$E[C]+\beta\varepsilon-(1+R_F)-\alpha(1+E[R_M])-\alpha\varepsilon+\alpha(1+R_F). \tag{A1.1}$$

Setting $\alpha=\beta$ eliminates the random terms and hedges the investor's payoff. The transaction is self-financing and results in a deterministic cash flow at date 1:

$$E[C]-(1+R_F)-\beta(E[R_M]-R_F). \tag{A1.2}$$

This expression must equal zero for the project to have zero NPV. This establishes the required return part of Proposition 2. A simple extension gives the NPV in the proposition.

[32] The consensus citizen need not short sell equity but need only sell part of his holdings of the market portfolio.

Appendix 2: Proof of Proposition 4

The proof is similar to that of Proposition 2, with the difference that after-tax returns and cash flows are used in place of their pre-tax equivalents. The consensus shareholder hedges the after-tax cash flow:

$$(1-T_{PE})\left[(1-T_C^R)E[C-1]-(1-T_C)LR_F\right]+(1-L)+\beta'(1-T_{PE})\varepsilon. \tag{A2.1}$$

The first term is the after-tax profit. The term $1-L$ is the initial investment in equity, recovered at date 1. The last term is the after-tax, zero-mean, random component of the cash flow.[33]

The consensus shareholder hedges this cash flow by selling an amount α of the market portfolio and buying the same amount of the risk-free asset. His after-tax payoff is:

$$\begin{aligned}&(1-T_{PE})\left[(1-T_C^R)E[C-1]-(1-T_C)LR_F\right]+(1-L)+\beta'(1-T_{PE})\varepsilon\\&-\alpha\left[1+(1-T_{PE})E[R_M]\right]-\alpha(1-T_{PE})\varepsilon+\alpha\left[1+(1-T_{PD})R_F\right].\end{aligned} \tag{A2.2}$$

Setting $\alpha=\beta'$ eliminates the random terms. The expected cash flow corresponding to a zero-NPV project is $E[C]$ such that the resulting payoff equals the payoff that the shareholder would have obtained had he invested the amount $1-L$ in the risk-free asset rather than in the project:

$$\begin{aligned}&(1-T_{PE})\left[(1-T_C^R)E[C-1]-(1-T_C)LR_F\right]-\beta'\left[(1-T_{PE})E[R_M]-(1-T_{PD})R_F\right]=\\&(1-T_{PD})(1-L)R_F.\end{aligned} \tag{A2.3}$$

The first term on the LHS is the after-tax profit from the real project. The second term is the after-tax expected return to the hedge position of size β'. The RHS is the after-tax opportunity cost of the investment.

The preceding equation can be rearranged in three different ways to obtain:

1. *The after-tax required rate of return on equity*:

$$\begin{aligned}&\frac{(1-T_{PE})\left[(1-T_C^R)E[C-1]-(1-T_C)LR_F\right]}{1-L}=\\&(1-T_{PD})R_F+\frac{\beta'}{1-L}\left[(1-T_{PE})E[R_M]-(1-T_{PD})R_F\right],\end{aligned} \tag{A2.4}$$

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[33] The term $\varepsilon=R_M-E[R_M]$ is not pre-multiplied by $(1-T_C^R)$ because the return on the market will be recalled from Section 5 to be the post-corporate-tax return on the global market portfolio.

where the RHS is (6) in Proposition 4; the sum of the numerator and the denominator on the LHS is the after-tax cash flow to equity (7) in the proposition: this is because it is the total cash flow received by the shareholder that must be discounted, the sum of the net profit made (numerator) and the initial investment recovered (denominator).

2. *The after-tax required rate of return on the project*:

$$\frac{(1-T_{PE})(1-T_C^R)E[C-1]}{1}= \\ (1-T_{PD})(1-L)R_F+\beta'\left[(1-T_{PE})E[R_M]-(1-T_{PD})R_F\right]+(1-T_{PE})(1-T_C)LR_F, \tag{A2.5}$$

where the RHS is (8) in Proposition 4; the sum of the numerator and the denominator on the LHS is the after-tax cash flow from the project (9) in the proposition.

3. *The pre-tax required return on the project*:

$$\frac{E[C-1]}{1}=\left[\frac{1-T_{PD}}{(1-T_{PE})(1-T_C^R)}\right](1-L)R_F+\frac{\beta'}{1-T_C^R}\left[E[R_M]-\left(\frac{1-T_{PD}}{1-T_{PE}}\right)R_F\right]+\left[\frac{1-T_C}{1-T_C^R}\right]LR_F, \tag{A2.6}$$

where the RHS is (10) in Proposition 4; the sum of the numerator and the denominator on the LHS is the pre-tax cash flow from the project $E[C]$.

Appendix 3: Proof of Proposition 5

We define the auxiliary variables $\theta_1 \equiv (1-T_{PE})(1-T_C^R)$, $\theta_2 \equiv (1-T_{PE})(1-T_C)$, $\theta_3 \equiv (1-T_{PD})$, and $\theta_4 \equiv (1-T_{PE})$. We note that:

$$\tau_1 = L\left[\frac{\theta_2}{\theta_1}-1\right], \tau_2 = \beta\left[1-\frac{\theta_3}{\theta_4}\right], \tau_3 = (1-L)\left[\frac{\theta_3}{\theta_1}-1\right], \tag{A3.1}$$

from (11)–(13). The consensus shareholder has after-tax cash flow, hedged and net of investment cost:[34]

$$\begin{aligned} CF(aftertax) = {} & \theta_1 E[C-1] - \beta\theta_1 E[R_M] + \beta(1-T_{PD})(1-T_C^R)R_F \\ & -\theta_2 LR_F - \theta_3(1-L)R_F. \end{aligned} \tag{A3.2}$$

The preceding after-tax cash flow can be decomposed into the sum of the corresponding pre-tax cash flow and the incremental tax paid (or saved) by the shareholder as a consequence of having undertaken the project and entered into its associated hedging transaction:

$$CF(aftertax) = CF(pretax) + \Delta TAX, \tag{A3.3}$$

where:

$$CF(pretax) = E[C-1] + (\beta-\beta')\varepsilon - \beta'(E[R_M]-R_F) - LR_F - (1-L)R_F, \tag{A3.4}$$

$$\begin{aligned} \Delta TAX = {} & -(1-\theta_1)E[C-1] - \beta(1-\theta_1)\varepsilon + \beta' T_{PE}\varepsilon \\ & -\beta'(T_{PD}R_F - T_{PE}E[R_M]) + (1-\theta_2)LR_F + T_{PD}(1-L)R_F, \end{aligned} \tag{A3.5}$$

with:

$$\varepsilon = R_M - E[R_M], \tag{A3.6}$$

recalled to be the zero-mean, random component of the cash flow. Note that both the pre-tax cash flow and the incremental tax are stochastic, as both depend on ε. The consensus shareholder's hedging of the after-tax cash flow does not hedge the entirety of the pre-tax cash flow, for these two quantities differ by the amount of tax. The pre-tax cash flow therefore retains partial dependence on ε. Tax's dependence on ε reflects the role of the tax system as a risk-sharing mechanism between the public and the private sector.

The tax received by the public sector is the negative of that paid by the private sector, (A3.5). The government hedges the stochastic part of the tax on behalf of taxpayers. It does so

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[34] The RHS of (A3.2) is the LHS–RHS difference of (A2.3).

with a synthetic forward contract that sells one dollar of the market portfolio and buys one dollar of bonds. This has zero net cost and a payoff at date 1 equal to $R_F - E[R_M] - \varepsilon$. Thus, the public sector exchanges at date 1 the stochastic cash flow ε for the deterministic cash flow $Z \equiv R_F - E[R_M]$.

Again considering a project that has zero NPV to the private sector, that is, a project for which the after-tax, hedged, net cash flow (A3.2) equals zero, the expected cash flow $E[C-1]$ is such that:

$$E[C-1] = L\left[\frac{\theta_2}{\theta_1}\right]R_F + \beta E[R_M] - \beta\left[\frac{\theta_3}{\theta_4}\right]R_F + (1-L)\left[\frac{\theta_3}{\theta_1}\right]R_F . \qquad \text{(A3.7)}$$

Substituting (A3.7) into the negative of (A3.5) and replacing ε by Z yields:

$$\Delta TAX = (\tau_1 + \tau_2 + \tau_3) R_F . \qquad \text{(A3.8)}$$

Appendix 4: Further examples

Nuclear power plants: Nuclear power plants have very high fixed and low variable costs; they therefore have a very high operating leverage, implying a high asset beta and low debt capacity (Taylor, 2007). Nuclear power plants' debt capacity is further depressed by the uncertainty represented by future decommissioning costs, which can be extremely high (Ansolabehere et al., 2003). Nuclear power plants are therefore located in the top-left corner of Figure 1, indicating a tax-induced funding cost penalty to the private sector: $\tau_2 > 0$ in (12) and $\tau_3 > 0$ in (13) are large because the asset beta β and equity financing $1-L$ are large, respectively. Although the extremely high capital costs of nuclear power plants decrease the tax rate on real investment T_C^R considerably below tax on financial investment T_C, the magnitude of $\tau_1 < 0$ in (11) is small because debt financing L is small.

That the privatization of the nuclear electricity generator of England and Wales occurred well after that of the coal generators, that it necessitated a very high level of debt forgiveness on the part of the UK Government as well as other forms of government support, and that it ultimately resulted in what at least one observer described as 'the financial collapse of the nuclear industry' (Taylor, 2007) are consistent with our conclusion of a tax-induced penalty for the private sector, $\tau > 0$; this is despite the generous depreciation allowances that nuclear power plants enjoy.

Toll roads: Now consider toll roads. Although some such roads appear to benefit from government guarantees similar to those granted IPPs through 'take-or-pay' contracts, most toll roads do not. Toll roads therefore have a higher asset beta and lower debt capacity than IPPs but a smaller asset beta and higher debt capacity than nuclear power plants with very high operating leverage. Toll roads also enjoy a tax advantage to real investment, albeit one lower than that enjoyed by very-high-cost nuclear power plants. In terms of the overall tax-induced funding advantage or disadvantage, toll roads therefore fall somewhere between tax-advantaged IPPs and tax-disadvantaged nuclear power plants: $\tau_{IPP} < \tau_{toll} < \tau_{nuclear}$ with $\tau_{IPP} < 0$ and $\tau_{nuclear} > 0$. This may account for the lack of an apparent pattern in toll road financing, whether by the public or by the private sector.

Commercial/industrial and residential real estate: Compare commercial/industrial and residential real estate. They are similar in having a low to medium asset beta, a characteristic that favors reliance on debt finance. They differ in that investment in commercial and industrial real estate receives generous depreciation allowances, in contrast to investment in residential real estate, which receives only very limited allowances in most countries. This favours investment in commercial/industrial real estate: τ_1 in (11) is strictly negative for commercial/industrial real estate but zero for residential real estate, and τ_2 in (12) and τ_3 in (13) are more or less identical. That the privatization of government real estate in the UK concerned mainly commercial real estate, such as office buildings, is consistent with a tax-induced funding cost advantage for commercial/industrial real estate.[35]

Routine services: The payments received and costs incurred in the provision of routine services generally share the low asset beta and high debt capacity of the IPP. As such costs are for the most part expensed in the year in which they are incurred, they do not give rise to any depreciation allowance: $\tau_1 = 0$ in (11) because $T_C = T_C^R$. As it is further the case that $\tau_2 \approx 0$ in (12) and $\tau_3 \approx 0$ in (13) because asset beta β and equity financing $1-L$ are small, respectively, taxes bring neither an advantage nor a disadvantage to the provision of routine services, $\tau \approx 0$. This implies that the growing incidence of contracting out, whereby the public sector contracts out the provision of government services, such as garbage collection, to the private sector, is likely to be motivated not by tax distortions but by efficiency considerations.

[35] We exclude the privatization of public sector housing, sold to tenants at subsidized prices.

Figure 1: Combinations of asset beta and debt capacity and the tax advantage/disadvantage of the private sector

The figure shows the areas of tax advantage/disadvantage for the private sector, as measured by the tax wedge τ. The tax rates are $T_C = 30\%$, $T_C^R = 20\%$, $T_{PD} = 30\%$, and $T_{PE} = 15\%$.

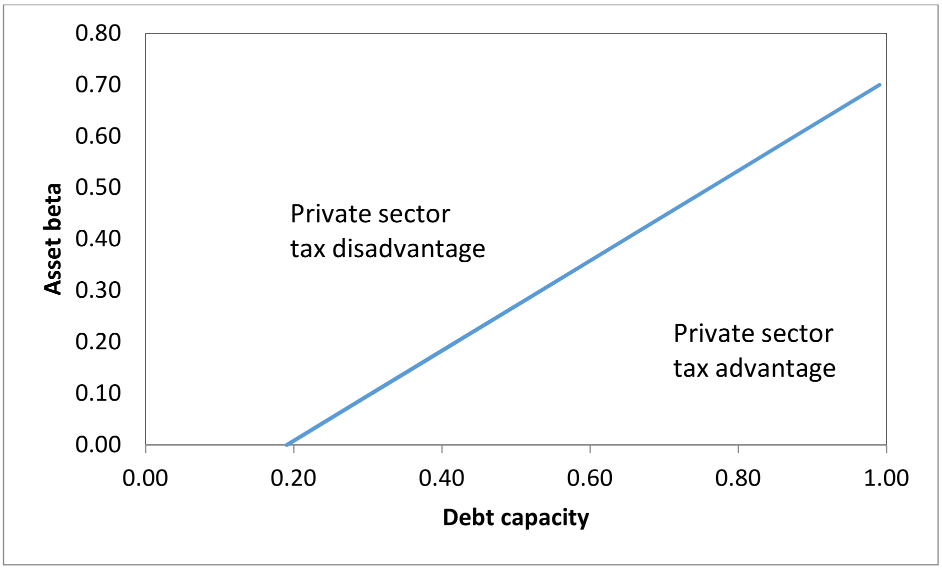

Table 1: The relative tax advantage of the public sector in terms of the pre-tax discount rate

The table shows the pre-tax discount rate advantage of the public sector, τ, and its three components. β is the asset beta. The tax rates are $T_C = 30\%$, $T_C^R = 20\%$, $T_{PD} = 30\%$, and $T_{PE} = 15\%$. The debt capacity, L, is 80% in Panel A and 20% in Panel B.

Panel A: $L = 0.8$				
β	0.80	0.60	0.40	0.20
τ_1	-0.1000	-0.1000	-0.1000	-0.1000
τ_2	0.1412	0.1059	0.0706	0.0353
τ_3	0.0059	0.0059	0.0059	0.0059
τ	0.0471	0.0118	-0.0235	-0.0588
Panel B: $L = 0.2$				
β	0.80	0.60	0.40	0.20
τ_1	-0.0500	-0.0500	-0.0500	-0.0500
τ_2	0.1412	0.1059	0.0706	0.0353
τ_3	0.0176	0.0176	0.0176	0.0176
τ	0.1088	0.0735	0.0382	0.0029

Table 2: Characteristics of different assets and services

Type of Asset	Asset Beta	$T_C - T_C^R$	Debt Capacity	τ
Independent Power Plant	Low	Medium	High	–
Nuclear Power Plant	High	High	Low	+
Toll Road	Medium	Medium	Medium	?
Comm./Ind. Real Estate	Low/Medium	Medium	High/Medium	?
Residential Real Estate	Low/Medium	Low	High/Medium	?
Routine Services	Low	Low	High	0