An optimal benefit-based corporate income tax

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Abstract

I explore the features of an optimal corporate income tax under the benefit principle. I derive an optimal benefit-based corporate income tax under a second-best setting using a modified Lindahl approach. I show that when the government is constrained to fund a public input through the use of a distortionary tax on corporate profits, the optimal tax rate is a function of three estimable elasticities: the direct public input elasticity of profit, the indirect public input elasticity of profit, and the (net of) tax elasticity of profit. Focusing on public capital as an empirically relevant form of the public input, I show that a benefit-based corporate tax generates quantitatively reasonable optimal tax rates. From an equity perspective, I show that benefit-based corporate taxation achieves inter-nation equity and gives us a formal definition of a firm's 'fair share of tax'.

JEL: H21; H25; H32; H41

Keywords: benefit taxation; optimal corporate tax; public input

1 Introduction

No consensus exists on the purpose of the corporate income tax. This lack of consensus on the purpose of the tax makes it almost impossible to agree on the design of the corporate tax system. Without guidelines on what we are trying to achieve, how do we assess any proposal for corporate tax reform? This concern is expressed most clearly by Weisbach (2015):

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> *"The basic point is that we cannot know what the optimal pattern of international capital income taxation should be without understanding the reasons for taxing capital income in the first place... To understand the design of firm-level taxation, however, we need to know why we are taxing firms."*

In this paper I take this duty seriously—to base our corporate tax policy recommendations on a clear normative purpose for the existence of the corporate tax. The reason for this approach should be made clear: if the corporate income tax "would not form part of an optimal tax system for a competitive economy" per Myles (1995) and distorts production, then without an explicit purpose for its existence there is no reason to persist with the corporate tax. There would be no reason to halt the slide in corporate tax rates propelled by tax competition. And there would be no reason to halt profit shifting by multinational firms.

The benefit principle is one potential justification for the existence of the corporate income tax.[1] The benefit rationale applied to corporate taxation says that firms should contribute to the provision of a productive public good according to the benefits they receive from the use of that productive public good. This justification implies that the corporate income tax *should* exist so that firms contribute fairly to the provision of the productive public good. Or put another way, without the corporate income tax firms would not contribute fairly to the provision of the productive public good.

In this paper I explore the characteristics of a benefit-based corporate income tax where the government provides a productive public good—from now on called *the public input*. The public input is used by firms as part of their production technology.[2] I derive the optimal benefit-based corporate income tax under first-best and second-best settings using a Lindahl (1919) approach.[3] I show that the second-best benefit-based tax rate can be expressed as a function of three estimable elasticities. Using public capital as a measure of the public input, I rely on estimates of the public capital elasticity of *output* to quantitatively illustrate the nature of benefit-based corporate taxation. I show that optimal benefit-based corporate tax rates are quantitatively reasonable, ranging from 25 percent to 58 percent in the second-best setting for United States data. I explore the equity characteristics of a benefit-based corporate tax. I show that a benefit-based tax would satisfy both broad and narrow consensus definitions of inter-nation equity. When the elasticity of substitution is less than 1, the benefit-based tax is also progressive.

The first contribution of this paper is to show that under first-best conditions where a lump-sum tax is available, the average rate of tax paid by each firm is equal to the marginal benefit the public input provides to the firm. This is measured as the *direct* public input elasticity of profit, holding all else constant. Under a constant returns to scale production function, this tax rate is equivalent to the share of total profits made up by returns to the public input. The total tax paid by the firm is therefore the portion of output that would accrue to the government if the public input were a private factor of production. This result

[1] The benefit principle is not the only potential justification put forward for the existence of the corporate tax. Bird (1996), Avi-Yonah (2004), and Schlunk (2002) are examples of works that examine a range of justifications for imposing a tax on corporations. The validity of any other purpose does not invalidate the benefit case for corporate taxation.

[2] I assume the public input is non-excludable and non-rival.

[3] The Lindahl approach is not the only approach to benefit-based taxation, but it is the most elegant. Other approaches can be found in Brennan (1976), Moulin (1987), and Hines (2000). Their characteristics are examined thoroughly in Scherf and Weinzierl (2019).

suggests the benefit principle presents a fundamental economic case for the imposition of a corporate tax when we incorporate a quantitatively relevant public input.

The second and most important contribution of this paper is to derive the optimal benefit-based corporate income tax when the government is constrained to fund the public input through the use of a distortionary corporate tax instrument levied on the profits of the firm—defined to be the sum of the returns to the public input and the normal returns to capital. To do so, I combine the Lindahl approach to benefit-based taxation with the modern approach to optimal taxation to define a *modified Lindahl approach* for second-best benefit-based taxation. The optimal benefit-based corporate tax rate is a function not only of the marginal benefit the public input provides to the firm, but also the negative fiscal externality from the corporate tax and the positive fiscal externality from the public input. The main stumbling block in achieving benefit-based taxation has always been the difficulty in implementing it. I overcome this problem by expressing the optimal tax rate formula as a function of three estimable elasticities: *direct* public input elasticity of profit, the *indirect* public input elasticity of profit, and the (net of) tax elasticity of profit.

The third contribution of this paper is to formally demonstrate the equity characteristics of a benefit-based corporate income tax that links the firm's location-specific rent to the taxing rights of the government. I am able to identify three clear principles of fairness and equity that follow from the logic of a benefit-based corporate income tax.

First, the benefit principle gives us a formal definition of what is a firm's *fair share* of tax. The view that 'corporations must pay their fair share' dominates public opinion. But the notion of a 'fair share' on its own does not give rise to a formal tax liability. The benefit principle formalises the notion of a fair share in a manner consistent with the neoclassical theory of the firm: the government provides a factor of production and receives a rate of return that is equal to the marginal product of the public input.

Second, benefit-based corporate taxation would automatically implement inter-nation equity. Musgrave and Musgrave (1972) write: "Inter-nation equity under the benefit principle would be self-implementing." Further, the IMF (2019) says that the only widely accepted principle of inter-nation equity is that taxing rights of location-specific rents should be allocated to the jurisdiction in which they arise. The public input is a location-specific factor of production, so that the returns to the public input are location-specific rents. By using the corporate tax to allocate returns to the public input to the government providing that factor, the benefit principle achieves the single consensus principle of inter-nation equity.

Third, the benefit principle provides clear guidance on where taxing rights should lie. Benefit-based taxation of corporations leads to the conclusion that firms should pay tax where profit-generating production takes place. The benefit-based view of corporate taxation supports the widespread norm that firms should pay tax where the relevant economic activity takes place (OECD, 2013; Pogge and Mehta, 2016). The benefit principle is arguably the original principle of international taxation on which the 1923 League of Nations consensus was built, which made the original case for source-based taxation of firm profits (Avi-Yonah, 2005).

This paper is intertwined with a range of existing literatures. This paper is closely related to Sandmo (1972), who took first steps in defining benefit-based firm taxation. He proposed that the shadow price for the optimal supply of the public input is the sum of the marginal profit accruing to firms from supplying the public input.[4] He suggests that measuring the benefits to the firm is possible since profits are observable. In examining the second-best, this paper builds on work by Huizinga and Nielsen (1997) and Keen and Marchand (1997), who tease out the idea that if we cannot fully tax location-specific rents, then it becomes optimal to tax the returns to capital. Some works take a positive approach, comparing the efficiency features of production taxes and capital taxes against the benefit-based holy grail of user fees (Gugl and Zodrow, 2015, 2019; Matsumoto and Sugahara, 2017). Incorporating public inputs into the firm's production function has also been an important element for the tax competition literature since Zodrow and Mieszkowski (1986), and examined clearly under profit shifting by Haufler and Schjelderup (1999), and examined empirically by Benassy-Quere et al. (2007). This paper is closely related to the recent approach taken by Weinzierl (2018b), who integrates the Lindahl (1919) thought experiment into modern tax theory under the case of a lump-sum labour income taxation by making income-earning ability a function of the public input. This paper differs from Weinzierl (2018b) most obviously by moving to the corporate tax setting, but I also extend his method by modifying the Lindahl approach to the case of a distortionary tax instrument. In addition, I also contribute to that literature by showing that a benefit-based tax is empirically relevant.

The paper proceeds as follows. In the following section, I present a model of optimal benefit-based taxation, both under lump-sum taxation and under the corporate income tax. In section 3, I consider the inter-nation equity features of the benefit-based corporate tax. In section 4, I quantitatively examine the characteristics of the benefit-based corporate income tax. I conclude in section 5.

2 A model of optimal benefit-based corporate taxation

There are a finite number of firm types. Each firm type is indexed by i. A firm of type i has access to a production technology which generates profit according to the function $\pi_i(k_i, G)$. The profit function depends on capital k_i invested by firm type i, and the public input G provided by the government. The profit function satisfies the restrictions that $\partial\pi_i/\partial k_i > 0$, $\partial\pi_i/\partial G > 0$, $\partial^2\pi_i/\partial k_i^2 < 0$, and $\partial^2\pi_i/\partial G^2 < 0$. The firm rents capital at the fixed rate of return r. Firms are price takers and there is no strategic interaction. I also normalise the output price to unity.

Meade (1952) identifies two types of public inputs: those that 'create atmosphere' and those that are 'unpaid factors of production'.[5] I focus on a public input that is an unpaid factor of production. This implies that the profit function is derived from a production function that is constant returns to scale in both private and public factors of production. Under competitive markets, we can define $\pi(k, G) = f(k, l, G) - f_l l$ where $f(k, l, G)$ is a constant returns to scale production function and f_l is the marginal product of labour. By Euler's theorem, $\pi(k, G) = f_k k + f_G G$. Profit is therefore defined to be the sum of the returns to capital and the returns to the public input. This is not the traditional definition of

[4] A similar literature examines benefit-based taxation where the public input is a technology or an 'atmosphere externality' according to Meade (1952). This includes Manning et al. (1985), Feehan (1998), Feehan and Matsumoto (2000), and Feehan and Matsumoto (2002)

[5] Creation of atmosphere public goods implies a production function that is constant returns to scale in private factors but increasing returns to scale in both private and public factors. There are no economic profits.

economic profits, but rather a tax-appropriate definition of profits which includes both normal and supernormal returns to capital.

Because the public input is an unpaid and immobile factor of production, the returns to the public input are location-specific rents. When location-specific rents exist, we move away from the setting where a small open economy is unable to impose a corporate tax on mobile capital (Gordon, 1986; Griffith et al., 2010). This implies that the public input presents the government with the ability to tax—even in a small open economy.

2.1 First-best lump sum taxation

I begin by characterising the first-best benefit-based lump sum tax on firms. This helps us to understand the primary mechanisms determining optimal benefit-based taxation. I rely on the Lindahl (1919) solution to sharing the cost of a public good. I use an approach similar to Weinzierl (2018b), who examines first-best classical benefit-based taxation for individuals with different levels of ability endogenous to the public good. The Lindahl approach relies on the idea of personalised tax shares. Consider a hypothetical situation where each firm type i is assigned a share τ_i, which measures the portion of the cost of the public good that firm type i must fund. Taking this share as given, the firm is allowed to choose a personalised level of the public input. That is, the firm chooses an amount of G_i to maximise income given that increasing G_i generates both profit and imposes a cost on the firm. The firm's objective is:

$$\max_{k_i, G_i} \quad \pi_i(k_i, G_i) - rk_i - \tau_i G_i.$$

The first order conditions for maximisation are:

$$\frac{\partial \pi_i(k_i, G_i)}{\partial k_i} = r; \quad \text{and} \quad \frac{\partial \pi_i(k_i, G_i)}{\partial G_i} = \tau_i.$$

The first order condition with respect to capital is familiar. It is mirrored by the first order condition with respect to the public input. They both say that the firm chooses factors up to the point where the marginal profit is equal to the marginal cost. For the public input, this means setting the marginal profit of the public input equal to the personalised tax share facing the firm, τ_i.

It is worth restating the conditions for a first-best Lindahl equilibrium laid out by Weinzierl (2018b) in the context of the firm.

Definition 1. *A first-best Lindahl equilibrium is a set of tax shares $\{\tau_i^{FB}\}_i$ and a level of public input provision G^{FB} which satisfy the first-order conditions for each firm type i, and satisfy the conditions $G^{FB} = G_i \forall i$ and $\sum_i \tau_i^{FB} = 1$.*

Lindahl's equilibrium refers us to the hypothetical process of a firm choosing its preferred provision of the public input, given that it bears a portion of the cost. In order to achieve an equilibrium, Lindahl requires the government chooses firm-specific tax shares so that each firm would choose the exact same level of public input provision when they face those tax shares. That level is the first-best level of public input provision, G^{FB}. The final condition limits us only to search among those combinations of the tax shares that will fully fund the provision of the public input.

The firm's profit function under the first-best Lindahl thought experiment mirrors the case where G_i is a competitively provided factor of production. In this case, τ_i is effectively the factor price facing firm type i—for each additional unit of G_i it wishes to use, it pays an additional cost $\tau_i G_i$. The key difference is that the factor prices facing the firm are allowed to vary across firms, while the level of the public input is the same across all firms. In contrast, for private factors of production, the factor price is the same while the factor usage varies.

Definition 2. *Define the direct elasticity of profit with respect to the public input for firm type i, e_i^G as:*

$$e_i^G = \frac{\partial \pi_i(k_i, G_i)}{\partial G_i} \frac{G_i}{\pi_i(k_i, G_i)}$$

Note that this is the *direct* elasticity of profit, implying that it relies only on the partial derivative of the profit function with respect to G. For each firm, we can define tax paid as a share of profit under a first-best Lindahl equilibrium. This allows me to express the average first-best tax rate as a function of the direct public input elasticity of profit.

Proposition 1. *The first-best Lindahl average tax rate on firm i's profits T_i^{FB} is equal to the direct elasticity of profit with respect to the public input, e_i^G.*

Proof. The average tax rate for firm type i is defined as $T_i^{\text{FB}} = (\tau_i G^{\text{FB}})/\pi(k_i, G^{\text{FB}})$. Substituting in the first order condition for G_i, we get:

$$T_i^{\text{FB}} = \left(\frac{\partial \pi_i(k_i, G^{\text{FB}})}{\partial G_i} \right) \left(\frac{G^{\text{FB}}}{\pi_i(k_i, G^{\text{FB}})} \right) = e_i^G. \tag{1}$$

If the corporate tax were a non-distortionary tax instrument, then this first-best policy could be replicated by setting the corporate tax rate equal to the first-best average tax rate T_i^{FB}. This first-best lump-sum tax sets a benchmark for benefit-based taxation.

2.1.1 A 'fair share' of tax

In 2017, Americans' biggest complaint about the federal tax system was the feeling that some corporations do not pay their fair share of tax. Sixty-two percent of respondents said they were bothered 'a lot' by corporations who did not pay their fair share (Pew Research Center, 2017). In 2018, only 26 percent of Americans believed that corporations paid their fair share of tax (Gallup, 2018). But what is a fair share? The term 'fair share' on its own does not define an objective measure of tax liability (Datt, 2014). Instead it requires a formal normative principle of taxation to give it structure.

Using the benefit principle to define the purpose of the corporate tax, I can formalise the notion of a fair share of taxation. Define the profit of the firm to be $\pi_i = f_i(k_i, l_i, G) - wl_i$ where l_i is labour, and k_i and G are defined as before. We can then rewrite the partial derivative of the profit function with respect to G as $\partial \pi_i / \partial G = \partial f_i / \partial G$. Under a constant returns to scale production function, we can define the share of a firm's output generated by the public input as $\gamma_i = G \frac{\partial f_i / \partial G}{f_i(k_i, l_i, G)}$. Then we can define the firm's fair share of taxation under benefit taxation.

Corollary 1. *In a first-best Lindahl equilibrium where firm i's production function $f_i(k_i, l_i, G)$ is constant returns to scale in all factors of production, the firm's tax burden $e_i^G \pi_i(k_i, G)$ is equivalent to the total returns to the public input in the case where the government provides the public input as a private factor of production under a competitive market equilibrium:*

$$T_i^{\text{FB}} \pi_i(k_i, G) = \gamma_i \cdot f_i(k_i, l_i, G), \tag{2}$$

where $\gamma_i = G\dfrac{\partial f_i/\partial G}{f_i(k_i, l_i, G)}$.

Under the benefit principle of taxation, a firm's fair share of tax is defined as the total output generated by the public input. This aligns with the neoclassical definition of the returns to a factor of production in a competitive market equilibrium. Under competitive market equilibrium, each factor is a paid the value of its marginal product.[6] Under benefit-based taxation, the government in effect acts as another factor owner in a competitive market equilibrium. The corporate tax is required to achieve this outcome because the public good is non-excludable and therefore the government can only obtain payment through the use of the tax. The benefit principle allows us to give a formal definition to what a firm's 'fair share' of tax is: for each firm, the government receives the share of output generated by the factor of production it provides.

Consider the extreme case where a firm does not benefit from the provision of the public input. Under benefit taxation, the firm should pay no corporate tax. Under the definition of a fair share, there would exist no justification for the government to impose a benefit-based tax on the firm if its choice of $G_i = 0$ for all τ_i. This is an extreme illustration of the benefit principle, but is unlikely to materialise—it is difficult to consider a firm which does not rely, at least to some extent, on the public input.

2.1.2 First-best public input provision

Using the definition of a first-best Lindahl equilibrium, I can write the benefit-based version of the Samuelson (1955) condition for the optimal provision of the public input in the context of the firm.

Proposition 2. *For profit maximising firms facing a lump-sum tax in the form of Lindahl shares, under a first-best Lindahl equilibrium the optimal provision of the public input is:*

$$\sum_i e_i^G \pi_i(k_i, G) = G^{\mathrm{FB}}. \tag{3}$$

Proof. If the first-best average tax rate is $T_i^{FB} = e_i^G$ and this is equal to $\tau_i G_i$ in equilibrium for all i, then we can sum the taxes paid across all firms to get $\sum_i e_i^G \pi_i = \sum_i \tau_i G_i$. By definition of Lindahl equilibrium $G_i = G^{\mathrm{FB}}$ and $\sum_i \tau_i = 1$, so that this simplifies to $\sum_i e_i^G \pi_i(k_i, G) = G^{\mathrm{FB}}$.

This says that the sum of the benefits (marginal benefit times profits) of the firms is equal to the optimal public input provision at the first-best. This is similar to the result of Sandmo (1972). A Lindahl equilibrium value of G^{FB} will depend on the number of firms in the economy contributing to the provision of the public input. To see this, consider an economy with two identical firms, each contribution $e_1^G = e_2^G$ share of their identical profits. Under these conditions, they both contribute $\tau_1 = 0.5 = \tau_2$, or half of the total provision of the public input. Adding a third identical firm does not directly alter the value of the contribution of firms 1 and 2. Instead, each firm now contributes one-third of the total value

[6] This is a version of the 'just deserts theory' put forward by Mankiw (2010), recast from the perspective of the government. If you consider it fair that each factor receives the value of their marginal product, then the benefit principle contains a compelling argument for the imposition of a corporate tax on the returns to the public input.

of the public input, and the public input provision increases by 50 percent. This assumes, for simplicity, that e^G is constant for all values of G. If it is not, then the indirect implication of adding a third firm is that e_1^G and e_2^G change as G increases due to the entrance of firm 3.

2.2 The optimal corporate income tax rate

The lump-sum tax allows us to clearly view the mechanisms underlying benefit-based taxation of firms. However, we typically do not have such a tax instrument available. I now turn to the realistic case where the government is constrained to fund the public input by a corporate income tax levied on the profit of the firm rather than by a lump-sum tax. Now the government must consider how the imposition of a corporate tax affects the firm's choice of capital, and therefore profits. This behavioural response is a standard concern in modern optimal tax literature. In this section I demonstrate a novel approach to incorporating the benefit principle into the standard optimal tax approach with a distortionary tax instrument. I use the term 'distortion' in the original sense of Atkinson and Stern (1974) as the excess burden the corporate income tax on profits generates compared to the alternative of lump-sum taxation (Browning and Liu, 1998). This distortion is created by the firm's behavioural responses to taxation, which we know to be empirically relevant (De Mooij and Ederveen, 2008; Devereux et al., 2014; Bachas and Soto, 2018; Coles et al., 2019).

Deriving the second-best benefit-based tax rate requires a two-step approach.

Step 1. In the first step, the firm chooses capital k_i to maximise income, taking the corporate tax rate t_i and the public input G as given. Firm type i solves the problem:

$$\max_{k_i} \quad (1-t_i)\pi_i(k_i, G) - rk_i,$$

where the first-order condition of the maximization problem with respect to k_i is now given by:

$$(1-t_i)\frac{\partial \pi_i(k_i^*, G)}{\partial k_i} = r.$$

The firm uses capital in production up to the point where marginal after-tax profit is equal to the cost of capital. This implies that the firm's optimal choice of capital, k_i^*, depends on the corporate tax rate.

Step 2. In the second step, the government chooses the corporate tax rate and the public input so as to maximise the firm's after-tax profits. However, unlike standard optimal tax approaches, the government chooses a personalised level of public input provision for each firm. The aim is to mimic the Lindahl approach while considering behavioural responses to taxation.

Definition 3. *The modified Lindahl approach is a thought experiment where the government chooses the optimal level of public input provision G_i and the optimal tax on profits t_i for each firm type i individually while satisfying the firm-level constraint*:

$$t_i\pi_i(k_i^*, G_i) - \tau_i G_i = 0 \tag{4}$$

so that the amount of tax paid by firm type i is equal to a fixed share τ_i of the cost of the chosen level of provision of the public input, G_i.

The key difference between the modified Lindahl approach and the original Lindahl approach is that the firm now does not internalise the link between the tax it pays and the amount of the public input it receives. Instead, the government links the two through the firm-level budget constraint defined by the Lindahl tax share.

The Lagrangian for the government's problem for firm type i is:

$$\max_{1-t_i, G_i} \quad \mathcal{L} = (1-t_i)\pi_i(k_i^*, G_i) - rk_i^* + \lambda\left(t_i\pi_i(k_i^*, G_i) - \tau_i G_i\right),$$

where λ is the Lagrange multiplier. In the second-best setting, we require another elasticity.

Definition 4. *Define the indirect elasticity of profit with respect to the public input for firm type i, ε_i^G as:*

$$\varepsilon_i^G = \left(\frac{\partial\pi_i(k_i, G_i)}{\partial k_i}\frac{\partial k_i}{\partial G_i}\right)\frac{G_i}{\pi_i(k_i, G_i)}.$$

The indirect public input elasticity of profit now captures the effect of G on profit *through* the behavioural response of the firm. That is, a change in G alters the firm's optimal choice of k_i, which in turn affects the firm's profit. The direct elasticity can almost be thought of as a mechanical effect, while the indirect elasticity is the behavioural effect. The term $\partial k_i/\partial G$ has long been thought to be positive. For example, work by Seitz (1994) suggests there is complementarity between public and private capital in the manufacturing sector in West Germany. Similarly, the theoretical literature typically assumes complementarity between private capital and the public input (Zodrow and Mieszkowski, 1986; Keen and Marchand, 1997; Haufler and Schjelderup, 1999; Gugl and Zodrow, 2015; Feehan and Matsumoto, 2017). Since firms are already optimising, the behavioural effect does not have a first-order impact on their profits. It does, however, affect the government's tax base. Holding the tax rate constant, this would increase the dollar amount of the firm's contribution to the public input.

I use the envelope theorem to simplify the analysis. The first order conditions of the government's problem are:

$$(1-t_i)\frac{\partial\pi_i(k_i, G_i)}{\partial G_i} + \lambda\left(t_i\left[\frac{\partial\pi_i(k_i, G_i)}{\partial G_i} + \frac{\partial\pi_i(k_i, G_i)}{\partial k_i}\frac{\partial k_i}{\partial G_i}\right] - \tau_i\right) = 0,$$

$$\pi_i(k_i, G_i) + \lambda\left(-\pi_i(k_i, G_i) + t_i\frac{d\pi_i(k_i, G_i)}{d(1-t_i)}\right) = 0.$$

Using $\tau_i = (t_i\pi_i)/G_i$ and multiplying throughout by G_i/π_i, we can rewrite this first order condition for G_i in terms of the direct and indirect public input elasticities of profit. Similarly, dividing the first order condition for $1-t_i$ by π_i we can rewrite it in terms of the elasticity of profit with respect to the net of tax rate, $e_i^T = \frac{d\pi_i(k_i,G_i)}{d(1-t_i)}\frac{1-t_i}{\pi_i(k_i,G_i)}$. Then combining the first order conditions, we can write:

$$\left(\frac{1-t_i}{t_i}\right)\left(\frac{e_i^G}{1-e_i^G-\varepsilon_i^G}\right) = \frac{1}{1-e_i^T\frac{t_i}{1-t_i}}. \tag{5}$$

I can now define a Lindahl equilibrium under second-best taxation.

Definition 5. Second-Best Lindahl Equilibrium: *A second-best Lindahl equilibrium is a policy comprising a set of personalised tax shares* $\{\tau_i^{SB}\}_i$*, corporate tax rates* $\{t_i^{SB}\}_i$ *and public input* G^{SB} *where the following conditions hold*:

$$\begin{aligned} \tau_i^{\mathrm{SB}} G_i^{\mathrm{SB}} &= t_i^{\mathrm{SB}} \pi_i, \qquad \forall i \\ G_i &= G^{\mathrm{SB}}, \qquad \forall i, \\ \sum \tau_i^{\mathrm{SB}} &= 1. \end{aligned}$$

The second-best Lindahl equilibrium accounts for the additional constraint imposed by the modified Lindahl approach. The modification to the Lindahl method requires that the corporate tax imposed on each firm's profits fully funds the share of the public input the firms must contribute under the Lindahl shares. As before, equilibrium is defined by the set of tax shares that leads the government to optimally choose the same level of public input provision for all firms. This level is the optimal level of public input provision G^{SB}. This equilibrium concept requires that these tax shares must completely fund the provision of the optimal level of public input provision.

Using equation 5, we can solve for the optimal benefit-based corporate income tax rate.

Proposition 3. *In a second-best Lindahl equilibrium optimising the after-tax profit of all firms, the optimal benefit-based corporate income tax rate,* t_i^{SB}*, for any firm type i is given by:*

$$t_i^{SB} = \frac{e_i^G}{1 - \varepsilon_i^G + e_i^G e_i^T}. \tag{6}$$

where e_i^G *is the direct elasticity of profit with respect to the public input,* ε_i^G *is the indirect elasticity of profit with respect to the public input, and* e_i^T *is the elasticity of profit with respect to the net of tax rate.*

In the second-best setting, two of the firm's behavioural responses distort the optimal tax rate: the firm's response to a change in the corporate tax rate and the firm's response to a change in the public input. The behavioural response to tax changes lowers the optimal tax rate, while the behavioural response to the public input increases the optimal tax rate. The second-best tax rate then accounts for the entire fiscal externality due to a combined change in the tax rate and public input. We consider not only the portion of the fiscal externality due to the distortionary effects of the corporate tax, but we also consider the fiscal externality due to the impact of increasing public inputs. We only care where these behavioural effects show up in changes to the government's tax revenue.

It is quantitatively ambiguous how this optimal tax formula compares with the first-best setting. In particular, it is not immediately clear without empirical evidence whether $1 - \varepsilon^G + e^G e^T$ could be expected to be greater than 1 or less than 1. This tax rate is similar to the marginal value of public funds from Hendren (2016), where the cost-benefit evaluation is the marginal willingness to pay divided by one plus the fiscal externality. In Hendren and Sprung-Keyser (2019), they empirically examine the size of the fiscal externality for a range of policies, accounting for both positive and negative effects of policy changes on the government's revenue.

2.2.1 Second-best Samuelson condition

Consider how the second-best Lindahl equilibrium alters the original Samuelson (1955) condition for the optimal provision of public goods. Using the government's Lindahl budget constraint that $t_i \pi_i(k_i, G_i) = \tau_i G_i$, setting $G_i = G^{\text{SB}}\ \forall i$, then summing across all firm types and noting that $\sum_i \tau_i = 1$, I substitute into equation 6 for t_i.

Corollary 2. *For profit-maximising firms facing a corporate tax on profits t_i^{SB} and a productive public input G, the definition of a second-best Lindahl equilibrium implies that the optimal provision of the public input is given by:*

$$\sum_i \frac{e_i^G \pi_i(k_i, G)}{(1 - \varepsilon_i^G + e_i^G e_i^T)} = G^{\text{SB}}, \tag{7}$$

In this expression $e^G e^T - \varepsilon^G$ reflects the fiscal externality due to the behavioural responses of the firm. Once again, since the size of the fiscal externality is ambiguous, we cannot make any clear statements about the under-provision or over-provision of the public input in the second-best. This modification to the Samuelson condition is in part a result due to Pigou (1947), Atkinson and Stern (1974) and Stiglitz and Dasgupta (1971), who acknowledged the importance of the distorting effect of tax collection when a lump-sum tax is not available. However, more recent work has acknowledged the importance of accounting not only for the distortionary impact of taxation on revenue, but also the impact that behavioural responses to the public good has on the government's revenue (Slemrod and Yitzhaki, 2001).

What is nice about this result—and the Lindahl approach to benefit-based tax in general—is that the optimal benefit-based corporate tax rate for firm i does not depend directly on the activities of any other firms. The influence of other firms comes only through the optimal choice of G^{SB} and its implications for the direct and indirect public input elasticities of profit insofar as they are not constant.

2.2.2 Profit shifting

Amending this setting to account for a multinational firm's ability to shift profits requires only a change in the definition of the elasticities. Rather than elasticities of actual profit, the elasticities would be redefined as elasticities of reported profits—which is what we observe in reality. This redefinition arises when we note that firms can shift some amount of profits q_i from a country at some increasing cost $c(q_i)$. At the optimum, the firm sets the marginal cost of profits shifted equal to the marginal benefit, $c'(q_i) = t_i$. This is similar to the tax evasion mechanism described by Feldstein (1995, 1999). Because the benefit approach does not account for benefits accruing to other agents, then we do not consider the critique of Chetty (2009) who suggests that profit shifting costs are in fact transfers to other agents.

2.2.3 The existence of the corporate tax

The benefit principle gives us not only a normative justification for the existence of the corporate tax, but also a positive justification for the existence of the corporate tax. The seminal work of Gordon (1986) suggests that a small open economy cannot impose a tax on multinational firms. But this result requires the absence of location-specific rents (Griffith et al., 2010). The existence, therefore, of a location-specific rent allows the corporate income tax to exist—even in a small open economy. McKeehan and Zodrow (2017) propose that the main reason corporate income taxes have not simply converged to zero is the existence of location-specific rents. In essence, location-specific rents give the government the ability to impose a non-zero corporate income tax.

The existence of location-specific rents also gives rise to the need to tax the normal returns to capital. If, as in Huizinga and Nielsen (1997), the government is constrained to tax location-specific rents at a less-than-complete rate, a non-zero tax on the returns to capital becomes optimal. In the same manner, Keen and Piekkola (1997) find that if profits arising from location-specific rents are not taxed, then taxing the returns to capital becomes optimal. Such a constraint is imposed in reality because a government is often forced to tax both the returns to capital and economic rents at the same rate because it cannot distinguish between returns to capital and rents (Auerbach and Devereux, 2018).

2.3 The tax base under a second-best setting

In the second-best setting, we have assumed that none of the cost of capital, rk, is deductible from the firm's tax base. It is useful to consider the implications of benefit-based taxation for the choice of the corporate tax base. Economists frequently perceive the narrowing of the corporate tax base as efficient if we can manage to isolate a rent-only tax base. This efficiency is behind the recommendations to exempt the normal returns to observable capital. Governments, in contrast, have frequently taken the opposite approach over the past few decades: base-broadening reforms have become the norm even as corporate tax rates have fallen (Kawano and Slemrod, 2016).

To consider the optimal tax base, I update firm i's profit function to be: $(1-t_i)\pi_i(k_i, G) - (1-at_i)rk_i$, where a is the tax base parameter representing the share of the normal returns to capital that are deductible. When $a = 0$, we move to the second-best setting examined above. When $a = 1$, all returns to capital are deductible and the corporate income tax is no longer distortionary. In practice, due to the existence of unobservable firm-specific assets, $a < 1$ so that we will never reach full deducitibility. Note that in reality, changing a will also change the firm's response to taxation (Kopczuk, 2005). The firm's first order condition for the optimal choice of capital is:

$$\frac{\partial \pi_i(k_i, G_i)}{\partial k_i} = r\left(\frac{1-at_i}{1-t_i}\right).$$

We can rewrite $at_i = m_i$ as the marginal effective tax rate. Under the modified Lindahl approach the government's problem is then to

$$\max_{1-m_i, 1-t_i, G_i} \quad (1-t_i)\pi_i(k_i, G_i) - (1-m_i)rk_i + \lambda(t_i\pi_i(k_i, G_i) - m_i rk_i - \tau_i G_i)$$

We can think of the government as choosing two tax instruments optimally for each firm type i: m_i and t_i. Combining the first order conditions for these two instruments, we get the optimality condition:

$$-\frac{\partial k_i/\partial(1-m_i)}{\partial k_i/\partial(1-t_i)} = \frac{rk_i}{\pi_i},$$

so that the negative of the ratio of the implicit partial derivatives of capital with respect to the two tax instruments should be equal to the share of the normal returns to capital in total profits. We can now state the formula for the optimal corporate tax rate under partial deductibility of the returns to capital.

Proposition 4. *In a modified Lindahl equilibrium where the share of the normal returns to capital that are deductible from the tax base is defined by the parameter $0 \leq a \leq 1$, the optimal benefit-based corporate income tax rate is:*

$$t_i^{\mathrm{SB}} = \frac{e^G}{(1-a)(1-\varepsilon_i^G + e_i^G e_i^T) + ae_i^G}. \tag{8}$$

It is useful to see how the tax base parameter works: by increasing a so as to make more of the returns to capital deductible from the tax base, it reduces the size of the fiscal externality. Whenever $a = 1$, the optimal corporate tax rate reduces to $t_i^{\mathrm{SB}} = 1$. This happens because the net fiscal externality of the corporate income tax and public input disappears entirely. In this case, the entire normal return to capital is deductible from the corporate tax base so that by assumption the tax base includes only the returns to the public input. This shows clearly that under optimal benefit-based taxation, the aim is to tax only the returns to the public good. As the tax base is broadened to include the normal returns to capital, the optimal tax rate falls. When $a = 0$, we move back to the optimal tax rate in equation 6. This says that the optimal tax rate should be equal to the share of the public input in profits.

Corollary 3. *For profit-maximising firms facing a corporate tax on profits t_i^{SB} and a productive public input G, and where the share of the normal returns to capital that are deductible from the tax base is defined by the parameter $0 \leq a \leq 1$, the definition of a second-best Lindahl equilibrium implies that the optimal provision of the public input is given by:*

$$\sum_i \frac{e_i^G(\pi_i(k_i, G^{\mathrm{SB}}) - ark_i)}{(1-a)(1-\varepsilon_i^G + e_i^G e_i^T) + ae_i^G} = G^{\mathrm{SB}}, \tag{9}$$

Notice that when $a = 1$ so that the normal returns to capital are totally deductible from the corporate tax base, the left side of this expression reduces to $\sum_i \pi_i(k_i, G^{\mathrm{SB}}) - rk_i$. Under the assumption that profits are the sum of normal returns to capital and the returns to the public input, then this term is equal to the total returns to the public input. Narrowing the tax base by increasing a moves us towards the first-best level of provision of the public input. Full taxation of location-specific rents accruing to public inputs is optimal, but often policymakers are constrained by the inability to distinguish between normal returns, firm-specific rents, and location-specific rents (Huizinga and Nielsen, 1997; Keen and Piekkola, 1997; McKeehan and Zodrow, 2017; Auerbach and Devereux, 2018). This means that it is almost impossible to ever achieve a tax system where all the normal returns to various forms of capital are deductible from the corporate tax base. Despite the practical difficulties that constrain us to the setting where $a < 1$, under benefit-based taxation, the optimal policy reform is to narrow the tax base as much as is possible so that the burden of taxation falls on the returns to the public input as much as is possible.

3 Inter-nation equity under benefit-based corporate taxation

Kaufman (1997) says that "fairness exists in the international tax system only when states distribute among themselves the competence to tax in a way that conforms to prevailing views of justice internationally." In practical terms, discussing fairness in the international tax system revolves around the question of who should have the ability to tax a multinational's profits—the source, residence, or destination country. To formally discuss fairness, I rely on the principle of inter-nation equity. In this section I examine the inter-nation equity characteristics of the benefit-based corporate tax.

There are two main formulations of inter-nation equity, the first from Musgrave and Musgrave (1972) and the second from IMF (2019). First, in the general setting of international taxation, Musgrave and Musgrave (1972) define inter-nation equity by the fundamental question of who gets to tax what. They define inter-nation equity as being determined by the allocation of national gains and losses resulting from the allocation of taxing rights. National gains include both public and private income. Therefore, Musgrave and Musgrave argue that it is not a matter of allocating tax revenues, but rather of allocating total incomes to each country and then allowing each government to impose the tax they wish on the incomes accruing to their country.

Second, in the specific context of corporate taxation, the IMF (2019) suggests that there is only one principle of inter-nation equity on which we agree: taxing rights of location-specific rents should be allocated to the jurisdiction in which they arise. The main concern they identify is the inability to convert this principle into a formal policy. It is often difficult to identify location-specific rents, and to separate them from other forms of economic rents.

Benefit-based taxation satisfies both formulations of inter-nation equity.

First, Musgrave and Musgrave (1972) propose that under a benefit based tax, their definition of inter-nation equity would be 'self-implementing'. To see this, consider a single multinational firm operating across three countries: A, B, and C. Country A is the headquarters of the multinational firm and owns the capital used in production. Country B is the country where the multinational firm produces. Country B is the owner of the public input used in the production process. Country C is the country where the final goods are sold. For clarity, we assume that production only takes in country B and no value is added in either countries A or B. Now apply the main allocation principle of neoclassical theory: each factor of production should ideally be paid its marginal product. Since country A is the location of the owner of capital, this definition of inter-nation equity implies that the normal returns to capital—and the right to tax them—should accrue to country A. Since country B is the owner of the public input, the returns to the public input should accrue to country B. Since country C plays no part in the production process, what it receives as national income is the consumer surplus from the final sale.

Now consider the case where each of countries A, B and C taxed the multinational firm using the benefit principle. Under a first-best setting, the government of country B would impose be able to levy a lump-sum tax on the profits of the multinational firm, taxing away the returns to the public input. Neither country A nor C would impose a tax on the profits of the multinational firm. The normal returns to capital would be kept by the multinational firm and repatriated to the residence country, A. Country A might choose to tax the normal returns of its residents while country C might choose to tax the consumption of its residents. These choices do not affect inter-nation equity as long as country B is given the right to tax the returns to the public input in its own country.

Second, the public input is a location-specific factor of production and therefore the returns to the public input are effectively location-specific rents. Taxing the returns to the public input would therefore satisfy the consensus principle of inter-nation equity set forth by the

IMF (2019) that a government should have taxing rights over location-specific rents. While the right to tax all location-specific rents is broad, it is often difficult to define what are location-specific rents. Kane (2015) explains how benefit-based taxation in large part resolves this problem by identifying one major source of location-specific rents:

> *"A more promising route is to rely on the distinguishing feature of whether the rent is a return on sovereign investment. This has the advantage that if we define the category in this way then the taxing right is clear. It should be allocated to only the sovereign that made the investment."*

Location-specific rents are typically difficult to define, so that relying on benefit taxation is a single clear way of defining a government's taxing rights over location-specific rents. Insofar as we can identify benefits, we can comply with this principle of inter-nation equity.

Both Musgrave and Musgrave (1972) and IMF (2019) express concern about the formalisation of these principles of inter-nation equity. Musgrave and Musgrave are of the opinion that benefit-based taxation is ideal for implementing inter-nation equity, but dismiss its usefulness since "most taxes are not benefits taxes". The IMF suggests that putting their concept of inter-nation equity "into legal language is challenging." These concerns highlight the usefulness of formalising the benefit-based corporate tax. Benefit-based taxation delivers a simple allocation of incomes and taxing rights: the owner of each factor of production is allocated the marginal product of their factor of production, and taxing rights over the returns to the factors of production are allocated to the government of the location of the factor of production.

If we were to rely on the benefit principle as the justification for the existence of the corporate tax, what does this imply for taxing rights? Graetz (2000) says:

> *The services a nation provides may contribute substantially to the ability of both residents and foreigners to earn income there. Taxing that income is one way for the source country to be compensated for its expenditures on the services it provides. One need not thoroughly embrace the benefit theory of taxation—the idea that the expenses of government should be paid by those who benefit in proportion to the benefits they receive—which is fraught with difficult problems of measurement and allocation, to recognize a country's legitimate claim to tax income produced within its borders.*

It is easy to see that the benefit principle would give rise to source-based taxation. This is, in fact, the principle on which the 1923 League of Nations consensus was built where active income was agreed to be taxed at source (Avi-Yonah, 2005). In reviewing the book *Global Tax Fairness* edited by Pogge and Mehta (2016), Weinzierl (2018a) approaches the question from the opposite direction. He draws implications from the persistent view of the contributors that firms should pay corporate income tax where income-generating activity takes place. He says "the idea that taxes should be paid where income is earned is a natural implication of CBBT (classical benefit-based taxation)." The benefit principle appears to be deeply embedded in our view of what is fair in international corporate taxation.

There are arguments that the benefit principle can be used to justify taxing arrangements other than what is viewed plainly as source-based taxation. For example, Schön (2009) argues that the country of residence will have a strong case to tax the profits of a multinational firm on the benefits principle. He argues that some activity will take place in the location of the corporate headquarters. Rather than an argument for residence-based taxation, this actually translates to an argument that the residence government provides an input that the corporate headquarters uses. That is, that what is perceived naïvely as the residence country is in part the 'source' country. Such arguments highlight the complexity of implementing source-based taxation. A nuanced view forces us to reconcile the fact that there can be more than one 'source' country in the generation of a firm's eventual profits.

By formalising the benefit principle as a link between taxing rights and the public input, we can also see that the benefit principle gives no legitimacy to destination-based taxation. The sale of a commodity itself makes no use of the public input and therefore gives rise to a taxing right in the country of destination. As above, however, it may be that the benefit principle gives rise to a source-based argument in what is naïvely viewed as the country of destination. For example, the retail activities of the multinational firm in the country of destination will use the public input of the destination country. Therefore, similar to the case of the residence government, the benefit principle demands a nuanced approach to the concept of source.

What would be required to implement a nuanced approach to source-based taxation that is consistent with the benefit principle? We would require an appropriate apportionment of profit across countries based on factors of production. Global formula apportionment attempts to identify the source of the profits by aligning tax payments with observable fundamentals—often either factors of production or third party sales. If real factors of production are complementary to the use of the public input, then formula apportionment on the basis of factors of production represents an appropriate method of allocation taxing rights in practice.

This is a simplification of what can be, in practice, a very complex problem. In particular, there are well-known concerns about the efficiency of source-based taxation (Auerbach and Devereux, 2018), and its long-run stability (Devereux and Vella, 2014). However, it allows us to observe in plain sight what the underlying principle of inter-nation equity in corporate taxation should be, and allows us to consider the other side of the trade-off between equity and efficiency that underpins the field of public economics. It is vital for the study of international tax economics that we balance efficiency concerns with safeguards about what constitutes an equitable allocation of income.

4 Quantitative characterisation of benefit-based taxation

In this section, I explore the quantitative characteristics of a benefit-based corporate income tax. I begin from a standard production function which includes the public input as a factor of production: $f(k, l, G)$. I make the assumption that there are constant returns to scale in public and private factors of production so that $f(k, l, G) = f_k k + f_l l + f_G G$. We can define the profit function under a competitive market as $\pi(k, l, G) = f(k, l, G) - wl$.

4.1 Numerical analysis with Cobb-Douglas production function

The central parameter in benefit-based corporate taxation is the direct public input elasticity of profit. A related concept for which there exists more empirical evidence is the direct public input elasticity of output. In a simple Cobb-Douglas production function such as $f(k, l, G) = k^\alpha l^\beta G^\gamma$, the public input elasticity of output is simply equal to γ. This is also equal to the share of output generated by the public input in a constant returns to scale production function. I can express the public input elasticity of profit in terms of shares of total output.

Proposition 5. *For a Cobb-Douglas production function $f(k,l,G) = k^\alpha l^\beta G^\gamma$ that is constant returns to scale in all factors of production, and where profits are given by $\pi(k,l,G) = f(k,l,G) - wl$, the direct public input elasticity of profit is expressed as:*

$$e^G = \frac{\gamma \cdot f(k,l,G)}{\pi(k,l,G)} = \frac{\gamma}{\alpha+\gamma}. \tag{10}$$

In a constant returns to scale production function, e^G is equal to the public input's share in profits.[7] Accordingly, we can express this term in shares of production for capital and the public input.

Second, we need an estimate of the indirect elasticity of profit with respect to the public input. The aim is to measure the effect that increasing the public input would have on profit through the change in the optimal level of private capital. This term is $(\partial\pi/\partial k)(\partial k/\partial G)$. Using the firm's optimal choice of k, and finding $\partial k/\partial G$ using the implicit function theorem, I can express the indirect public input elasticity of profit as a function of shares of total output.

Proposition 6. *For a Cobb-Douglas production function $f(k,l,G) = k^\alpha l^\beta G^\gamma$ that is constant returns to scale in all factors of production, and where profits are given by $\pi(k,l,G) = f(k,l,G) - wl$, the indirect public input elasticity of profit is expressed as:*

$$\varepsilon^G = \frac{\alpha\gamma}{(1-\alpha)} \cdot \frac{f(k,l,G)}{\pi(k,l,G)} = \left(\frac{\alpha}{1-\alpha}\right)\left(\frac{\gamma}{\alpha+\gamma}\right). \tag{11}$$

This is equal to the direct public input elasticity scaled by a factor $\alpha/(1-\alpha)$. This factor is less than 1 as long as $\alpha < 0.5$. We would expect α to be in that range, meaning that the indirect public input elasticity should typically be smaller than the direct public input elasticity.[8]

Consider these expressions in the context of aggregate data. I measure $\alpha+\gamma$ as the total share of profit in the output of corporations. I use the Bureau of Economic Analysis' (BEA) National Income and Product Accounts, which gives data on domestic corporate business (Table 1.14). Specifically, I measure $\alpha+\gamma$ as the ratio of corporate profits with inventory valuation adjustment and capital consumption adjustment, divided by gross value added of corporate business. For the years 1950 to 2018, the average share over this period is 0.148. The highest value is 0.215, while the lowest is 0.095.

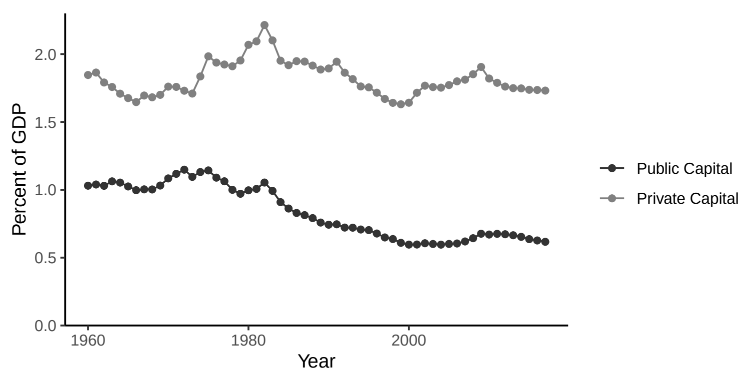
How do we measure γ? To answer this we must consider how we define the public input we are interested in. Where the public input is an unpaid factor of production, Negishi (1973) gives a common example: 'unpaid factor' public inputs are like the free transport service of roads. Unpaid factors are effectively those that can be supplied as private goods. In theory

[7] This assumes that firms capture the entire rents from production. This is not always true, particularly under wage bargaining. I control for this possibility later.

[8] In this section, I am effectively using k as equity capital, to which the profits of the firm accrue. This means that I am effectively lumping debt capital with labour—both of which bear no ownership of the firm and receive a pre-agreed rate of return. This is a simplification, but adding debt capital as a separate factor k^d would add nothing to this analysis.

the government or a private provider could charge a user fee for these public inputs. Instead, the government chooses to supply them free of cost because there is a high exclusion cost. Almost certainly the most important of these unpaid factors falls into the category of public capital. This is a category of the public input for which we can define. Figure 1 plots the estimated public and private capital stocks for the United States over the period 1960 to 2017. This data is taken from the IMF Investment and Capital Stock database, which follows the method proposed by Kamps (2006) to estimate the capital stock. What this figure makes quite clear is that the public capital stock is quantitatively important compared to the private capital stock. Over the period, the public capital stock was estimated to be around 46 percent of the size of private capital stock. Note that this measure of the private capital stock includes both residential and non-residential private capital. Over the period 1960 to 2017, data from the BEA shows that private non-residential fixed investment was 75 percent of total private fixed investment. If the business capital stock were 75 percent of the total private capital stock, then the public capital stock would be around 60 percent of the size of the business capital stock.

Figure 1: Public and private capital stock as a percent of GDP



Note: Data is sourced from the IMF Investment and Capital Stock Dataset, 2019. The public capital stock is measured as the general government capital stock at current cost, while the private capital stock is also measured at current cost. The underlying data is from the OECD's measures of government gross fixed capital formation and private gross fixed capital formation.

There is a substantial literature on the public capital elasticity of output, beginning with Aschauer (1989) and reviewed in Bom and Ligthart (2014) and Núñez-Serrano and Velázquez (2017). I use consensus estimates from this literature on the public capital elasticity of output to back out an estimate of the implied public input elasticity of profits. The average estimate of γ from the meta-study by Bom and Ligthart (2014) is 0.106 after correcting for publication bias. In the short run, the output elasticity of public capital provided by the central or federal government is 0.083. In the long run, this increases to 0.122. Considering only studies on the U.S., Bom and Ligthart (2014) find slightly higher estimates in the range of 0.104 to 0.142. These are estimates based on the production function approach, considering G as a factor of production. Cubas (2020) instead uses a share-based approach with the BEA's National Income and Product Accounts to reach a similar elasticity of 0.08.

In reality, not all of the location-specific rents from the public input are likely to accrue to the firm in the form of profits. Depending on the bargaining power of the worker, some of these rents might accrue to workers. The bargaining model estimated by Arulampalam et al. (2012) suggests that for every extra dollar of value added, around 25 cents is shared with workers in the long-run. This was estimated for European countries where workers likely carry higher bargaining power than in the United States. It represents a conservative estimate of the share of the returns to the public input accruing to the firm. I consider estimates where the lowest value of the firm's share of the returns to the public input are reduced by a quarter, from 0.08 to 0.06.

The final elasticity needed is the net of tax elasticity of profit. I rely on Coles et al. (2019) who use data on the population of private corporations in the U.S. from 2004 to 2014 sourced from the Internal Revenue Service. They use bunching methods that exploit variation in the 'kink' faced by corporations at zero taxable income due to heterogeneous net operating losses that can be carried forward. Their main results are based on the effective marginal tax rate, finding an elasticity of 0.88. Using the statutory tax rate, they find a smaller elasticity of 0.55. I use this elasticity, since e^T is defined with respect to the statutory tax rate. Note that these elasticities include both real and reporting responses to the tax rate. These represent the most recent and comprehensive estimates of the tax elasticity of corporate profits in the United States. A preceding study by Gruber and Rauh (2007) found a significantly smaller elasticity of 0.20 based on publicly traded firms using Compustat data.

Table 1: Optimal benefit-based corporate income tax rates

γ	$\alpha+\gamma$	α	ε^G	e^G	t^{SB}
0.060	0.148	0.088	0.052	0.405	0.346
0.060	0.215	0.155	0.068	0.279	0.257
0.080	0.148	0.068	0.039	0.541	0.430
0.080	0.215	0.135	0.058	0.372	0.325
0.106	0.148	0.042	0.031	0.716	0.526
0.106	0.215	0.109	0.060	0.493	0.407
0.122	0.148	0.026	0.022	0.824	0.576
0.122	0.215	0.093	0.058	0.567	0.453

Note: The first-best benefit-based tax rate is estimated as $t^{\text{FB}} = e^G$, while the second-best tax rate is estimated by $t^{\text{SB}} = e^G/(1-\varepsilon^G + e^G e^T)$. These results rely on a Cobb-Douglas production function, $f(k, l, G) = k^\alpha l^\beta G^\gamma$. The estimated value for the tax elasticity of public inputs is $e^T = 0.55$.

Based on these estimates, the public input elasticity of profit falls in the range from 0.279 to 0.824. This gives us the first-best level of taxation. Note this is a relatively broad range due to the uncertainty of the estimates. A central estimate using $\gamma = 0.6$ and $\alpha = 0.148$ would suggest that the public input accounts for around 40 percent of firm profits. Under the parameters used, the positive fiscal externality resulting from the increase in the public good is significantly smaller than the negative fiscal externality resulting from the corporate tax increase. The result is that the estimates of the second-best benefit-based tax rate can be substantially lower than the first-best estimates. The difference between the two ranges from 2 percentage points to 25 percentage points at the extreme. The lowest estimated second-best tax rate is 26 percent. Using $\gamma = 0.6$ and $\alpha = 0.148$, a central estimate would give an optimal tax rate around 35 percent. This is close to the previous top tax rate of 35 percent, and well above the current top U.S. corporate tax rate of 21 percent enacted by the Tax Cuts and Jobs

Act of 2017.

Ideally, an empirical measure of the public input elasticity of profit would aim to disaggregate the estimation of the public input elasticity at the firm type level. Firm types in policy terms can take on whatever classification a government sees fit. The ideal method of disaggregation would be to identify a mechanism that forces firms to reveal their type and therefore their marginal benefit. A more natural classification would be to group firms by industry, assuming that firms in the same industries have approximately similar production functions.

4.2 Tax progressivity with constant elasticity of substitution

If we assume that all firms have the same production function, then the progressivity of the first-best Lindahl tax depends on the specification of the profit function and the production function that underlies it. Consider first the Cobb-Douglas production function with a constant elasticity of substitution equal to 1. The public input elasticity of profit is expressed as a function constant shares $\gamma/(\alpha+\gamma)$. Therefore, for all firms—regardless of size—the average tax rate would remain the same.

I consider a more general constant elasticity of substitution production function that explicitly defines the constant elasticity of substitution as σ. I can derive the public input elasticity of profit under this production function.

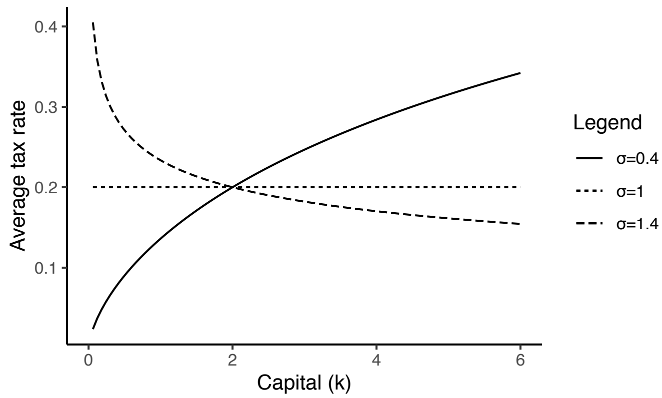
Proposition 7. *For a constant elasticity of substitution production function* $f(k,l,G) = (\alpha k^{\frac{\sigma-1}{\sigma}} + \beta l^{\frac{\sigma-1}{\sigma}} + \gamma G^{\frac{\sigma-1}{\sigma}})^{\frac{\sigma}{\sigma-1}}$ *that is constant returns to scale in all factors of production, and where profits are given by* $\pi(k,l,G) = f(k,l,G) - wl$*, the direct public input elasticity of profit is expressed as:*

$$e^G = \frac{\gamma G k^{1/\sigma}}{\alpha k G^{1/\sigma} + \gamma G k^{1/\sigma}}. \tag{12}$$

Under a constant elasticity of substitution production function, the progressivity of a benefit-based corporate tax depends on the elasticity of substitution. For an elasticity $\sigma < 1$, the tax is progressive so that firms with higher levels of capital and higher profits pay a higher average rate of tax. For an elasticity $\sigma > 1$, the tax is regressive, so that smaller firms pay higher average rates of taxation. The elasticity of substitution between public and private capital is therefore a key parameter in understanding the progressivity of benefit-based corporate taxation. Empirically realistic values of the elasticity of substitution tend to fall in the range of 0.4 to 0.7 (Antras, 2004; Chirinko, 2008; Chirinko and Mallick, 2017).

Figure 2 plots the progressivity of a first-best benefit-based corporate tax rate for firms. Note that since this makes up the numerator for the second-best tax rate, the analysis of progressivity also applies to the second-best. According to data from the IMF's Investment and Capital Stock Dataset, over the period 1960 to 2017, the aggregate private capital stock was on average 2.3 times the size of the public capital stock in the United States. This ratio peaked at 3 in 2006. I choose $G = 2$, and allow k to vary from 0 to 6, three times the size of the public capital stock. Where $G = k$, the tax rate is the same for all values of the elasticity of substitution. This shows that while progressivity depends on the substitutability between capital and the public input, under empirically realistic assumptions, the benefit-based tax would be progressive so that larger firms pay a higher share of their profits in tax.

Figure 2: Progressivity of average tax rates under first-best Lindahl equilibrium



Note: This chart plots the average tax rate using the CES functional form: $\pi(k, l, G) = (\alpha k^{\frac{\sigma-1}{\sigma}} + \beta l^{\frac{\sigma-1}{\sigma}} + \gamma G^{\frac{\sigma-1}{\sigma}})^{\frac{\sigma}{\sigma-1}} - wl$ for different values of K. Assuming all firms have the same production function, this measures the progressivity of the first-best Lindahl benefit-based tax. The values plotted are $G = 2$, $\lambda = 0.1$, $\alpha = 0.4$. I plot three lines for $\sigma = 0.4$, $\sigma = 1$, and $\sigma = 1.4$.

5 Conclusion

In this paper, I examine the benefit principle as a potential justification for the existence of the corporate income tax. I define the public input as an immobile productive public good which acts as an unpaid factor of production. By doing so, I derive the optimal benefit-based corporate income tax rate, relying on a modified version of the Lindahl (1919) approach to benefit taxation. The benefit principle, when applied to corporate taxation, has some appealing properties. First, it allows us to define what a firm's fair share of tax is. Second, it automatically satisfied inter-nation equity—both in its traditional definition (Musgrave and Musgrave, 1972) and in its more modern incarnation (IMF, 2019). Third, it provides a normative justification for the view that taxes should be paid where economic activity takes place—the source principle of international taxation.

The main downfall of benefit taxation has traditionally been the inability to measure the marginal benefit the public good generates. I am able to express the optimal corporate tax rate as a function of three estimable elasticities. And as pointed out by Sandmo (1972), these are easier to estimate in the context of the firm since profit—unlike utility—is directly measurable. In this paper, I quantitatively examine the direct and indirect public input elasticities of profit using the Cobb-Douglas production function in combination with estimates of the public input elasticity of output from Bom and Ligthart (2014). This provides a useful stepping stone for future research on the size of these elasticities and how it various across firm types.

There are common objections to the corporate tax as a benefit-based tax. The benefit justification for the corporate tax is frequently linked to the introduction of a two percent tax on the net income of corporations in the United States in 1909, when President William Taft stated that it was an "an excise tax upon the privilege of doing business as an artificial entity and of freedom from a general partnership liability enjoyed by those who own the stock." Musgrave and Musgrave (1989) point out that in fact the institution of limited liability is almost costless to society, and insofar as the benefit principle aims to fund the cost of a public good, the effectively costless corporate form does not justify the existence of a corporate tax. However, the reader may have picked up that the case I make in this paper for benefit-based taxation would apply to all forms of business. The broad benefits of the public input go beyond limited liability, and especially include the returns to public capital. Public capital is likely around 60 percent of the size of the business capital stock. These benefits are enjoyed both by corporate business and non-corporate business. The benefit principle is therefore simply a normative argument that businesses should pay tax to compensate the government for the provision of the public input. The focus on the corporation in this paper does not invalidate this argument: because other types of business are not presently subject to such taxation does not mean that they should not contribute to the provision of the public input. Corporate taxation is simply the matter at hand, because it is the tax that presently requires our immediate attention.

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