Pareto-Improving Minimum Corporate Taxation

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Abstract

The recent international agreement on a minimum effective corporate tax rate marks a profound change in global tax arrangements. The appropriate level of that minimum, however, has been, and remains, extremely contentious. This paper explores the strategic responses to a minimum tax, which——the policy objective being to change the rules of tax competition game——are critical for assessing the design and welfare impact of, and prospects for, this fundamental policy innovation. Analysis and calibration plausibly suggest sizable scope for minima that are Pareto-improving, benefiting low as well as high tax countries, over the uncoordinated equilibrium.

Keywords: Tax Competition, Minimum Taxation, Corporate Tax Reform, International Taxation

JEL Classification: H21, H25, F23

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1 Introduction

For decades, proposals to limit international corporate tax competition by agreeing on some common minimum effective tax rate have had virtually no practical traction.[1] In October 2021, however, 136 members of the OECD/G20-led 'Inclusive Framework' agreed to establish, as 'Pillar Two' of a wider package, a minimum effective corporate tax rate of 15%.[2] This is a profound change to the century-old international corporate tax architecture, and a pathbreaking innovation for global tax policies more generally.[3] The appropriate level of the minimum, however, has been—and is sure to remain—extremely contentious. Some countries, and much of civil society, argue forcefully that 15% is far too low. In contrast, and unsurprisingly, many traditionally low tax countries—notably Ireland, which, with a statutory rate of 12.5%, has played a pivotal role in the discussions—have expressed equally forceful reservations throughout the negotiations. Their doubts are understandable. Low tax countries, confronted by an externally-imposed increase in effective tax rates on profits booked there, face a trade-off: between, on one hand, a loss from reduced inward profit shifting[4] and, on the other, a potential revenue gain if they were to raise their rate to the minimum level (albeit on a base reduced by diminished profit shifting).[5] While this trade off is evidently something for low tax countries to ponder, it is clear that most firmly expect to be losers from adoption of a global minimum. It would, after all, force them away from their preferred tax policies.

Assessing the welfare implications for a low tax country of a binding minimum effective rate imposed ultimately requires, however, considering more than simply this trade off. It is necessary, in particular, to move beyond the common (generally implicit) presumption in the policy debate that a minimum tax will not change the tax-setting behavior of higher tax countries that it does not

[1] Outside the academic literature, the most prominent proposals have been in Europe, at rates that look outlandish by current standards: the Neumark Committee proposed a minimum rate of 50% in 1962 (Neumark, 1962); the European Commission one of at least 45% in 1975; and the Ruding Committee one of 30% in 1992 (Ruding, 1992). Only in the African regional trading blocs WAEMU and CEMAC have agreed minimum rates been established.

[2] The agreement is in OECD (2021).

[3] Strictly, approval of the agreement does not oblige a member to impose the minimum, but does oblige it to accept imposition by others even on earnings in that country.

[4] OECD (2020) (para. 256) estimate that a minimum rate of 12.5% might reduce profits booked in investment hubs by around 10 percent, a figure that excludes multinationals parented in the United States; for these, Clausing (2020) suggests that the minimum tax-like features of the 2017 US 'GILTI' provisions—which, roughly speaking, impose a minimum tax of between 10.5 and 13.125% on US affiliates' earnings abroad—might ultimately reduce the corporate tax base of low tax jurisdictions by about 12-16% (and by almost double that if the minimum were to be applied globally rather than country by country).

[5] Abstracting from reduced profit shifting, Devereux et al. (2020) (Table 2.3) put the additional revenue raised in each low tax country as a result of a 10% minimum tax at 5-10% of the profits of foreign affiliates present there; assuming a 12.5% minimum, and allowing for reduced profit shifting, OECD (2020) puts the revenue gain at around 0.3% of global CIT revenue (Table 3.13, again excluding affiliates of U.S. parents).

directly constrain, which precludes any spillback effects on those countries that it does constrain. The purpose of the minimum, after all, is precisely to alter the dynamics of tax competition. What those strategic effects will be, however, is far from clear. In some frameworks, previous results show that induced tax increases elsewhere mean that low tax countries may gain from a minimum tax rate set infinitesimally above the rate that they set in the Nash equilibrium. That leaves open, of course, the important questions of how high the minimum can be set while still bringing welfare gain to low tax countries, and of what their preferred minimum would be. Some commentators, in sharp contrast, worry that a minimum might become a floor, with unconstrained countries actually lowering their rates, to the detriment of low tax countries. Understanding the nature, extent and consequences of the induced impact of a minimum tax on the outcome of tax competition must thus be central to assessing the welfare impact of adopting such a minimum. Doing so is the central purpose of this paper.

To this end, we work through the implications of such a global minimum tax rate in tractable models of tax competition in the presence of profit shifting.[6] In particular, we focus on an extension of the model of Kanbur and Keen (1993), in which governments' objectives extend beyond revenue maximization to include also a concern with private income. The analysis inevitably abstracts from much important detail of the agreement, including, for instance, its less than global application and its inclusion of a 'carve out' to exclude a modest substance-based return from the scope of the minimum tax. Perhaps most important, we assume that the minimum is levied by the source rather than by the residence country. This may appear to run counter to the rule order envisaged in Pillar Two, which gives primacy to the 'Income Inclusion Rule' (in effect, topping up to the minimum by the residence country) over the 'Undertaxed Payments Rule' (topping up at source). Source countries, however, have a strong incentive to preempt a foreign government's imposition of a minimum rate by imposing that minimum itself: this has no impact on the investor but transfers revenue to itself.[7] This possibility is stressed in OECD (2020) and Devereux et al. (2020). And indeed Ireland has announced that it will respond to the 15% minimum exactly by raising its rate to that level for multinationals to which the minimum applies, an example that others can be expected to follow.

The plan of the paper is as follows. Section 2 explores in broad terms the strategic considerations

[6] We take this, rather than competition for real capital (which would be better dealt with in a setting like that of Zodrow and Mieszkowski (1986)) to be the principal concern underlying current proposals.

[7] The logic is the same as that behind the standard prescription—as, for example, in Gordon (1992)—that a source country attracting capital from a country offering a credit system should set its rate at the level of that in the residence country.

that shape the welfare impact of a minimum tax rate in a context of otherwise uncoordinated tax setting. Section 3 sets out the extended Kanbur-Keen model of tax competition between two asymmetric countries, which is then used to analyze the impact of a binding minimum rate. High tax countries, it is clear from the current debate, expect to gain from the introduction of such a minimum. It is thus the impact on low tax countries that is the principal concern. Previous results, as just noted, have identified circumstances in which a low tax country also gains from a minimum infinitesimally above the level it sets in the uncoordinated equilibrium. But even if that is the case—and we will see reasons why it may not be—key questions remain: it is hardly enough for policy to know that a country which initially sets a rate of 12.5% (which was until recently thought likely to be settled on under Pillar Two) will gain from a minimum rate of 12.6%. The two questions hinted at above then stand out. First: what is the Pareto efficient level of the minimum tax rate, beyond which further increases will reduce welfare in the low tax country? Second, how high can the minimum be set and still—even though above its most preferred level—leave the low tax country better off than in the uncoordinated equilibrium? Section 4 concludes.

2 When is a 'Modest' Minimum Tax Pareto-Improving?

Consider first the case in which the minimum tax, the level of which is denoted by μ, is 'modest' in the sense of being set only infinitesimally above the lowest tax rate in the initial equilibrium. Suppose too, as we shall throughout, that there are only two countries: that setting the lower tax rate, t, is indicated by lower case letters, that setting the higher rate, T, by upper case. Welfare in the low and high tax countries is then given, respectively, by $w(t,T)$ and $W(T,t)$. Imposing a minimum tax just above the initial rate of the low tax country obliges it to raise its tax by $dt > 0$, which induces some response by the high tax country.

The welfare impact of this depends on the nature of the strategic interaction between the two countries. Suppose first that both play Nash. The high tax country then responds to the minimum along its best response function $T(t)$, and the welfare effects of the minimum are given by[8]

$$dw = w_T(t^N, T^N)T'(t^N)dt \;\; ; \qquad dW = W_t(T^N, t^N)dt, \tag{1}$$

where the superscript N refers to the Nash equilibrium and use is made of the envelope conditions that $w_t(t^N, T^N) = W_T(T^N, t^N) = 0$. Complications and ambiguities arise in relation to all three

[8]Derivatives are indicated by a prime for functions of a single variable, and by subscripts for functions of several.

terms in (1).

Take first the cross effects, w_T and W_t. For the low tax country, it is natural to suppose that $w_T > 0$, especially in a context of profit shifting: an increase in T will tend to amplify profit shifting, and so increase revenue, hence also welfare, in the low tax country. Other effects, however, can also arise. If the low tax country is a capital exporter, for instance, then an increased tax rate abroad will tend to reduce the global demand for capital and so reduce the pre-tax return on those capital exports that it earns on world markets. This emerges as a possibility, for example, in the seminal model of tax competition with real capital of Zodrow and Mieszkowski (1986) and Wilson (1986).[9] A similarly adverse cross-effect can arise if there is cross-hauling of investment across borders, with a higher tax rate abroad reducing the post-tax earnings of domestic residents. Nonetheless, when, as in the current debate, profit shifting is the paramount concern, $w_T > 0$ seems a reasonable (and indeed commonplace, albeit unspoken) presumption.

Different considerations shape the cross effect W_t arising for the high tax country in the presence of profit shifting. A higher tax abroad serves to protect its tax base, and to that extent is a source of gain; but it also denies privately beneficial tax avoidance possibilities to its residents. We look at the implications of this in Section 3.1, for now simply noting that in the present policy debate it is evident that high tax countries do indeed expect to benefit from imposing a minimum rate.

Ambiguity also arises in relation to $T'(t)$, the reaction of the high tax country to an increase in the rate set by the low tax country. Given $w_T > 0$, (1) implies that it is this best response which determines whether the low tax country gains or is harmed by from a modest minimum imposed upon it. It gains if $T'(\mu) > 0$ (so that tax rates are strategic complements for the high tax country) and loses if $T'(\mu) < 0$ (strategic substitutes). Strategic complementary is the more instinctive assumption, but is not theoretically assured. Vrijburg and de Mooij (2016), in particular, show that the response to a tax increase abroad, leading to an inflow of investment and hence an increase in domestic revenue, may to be reduce the domestic tax rate if the degree of substitutability between the domestic public good and private consumption is sufficiently low. Empirically, however, as surveyed in Brueckner (2003), Leibrecht and Hocgatterer (2012) and most recently OECD (2020),[10] the weight of evidence suggests that statutory corporate tax rates—the most relevant for profit shifting concerns here—are strategic complements. The magnitude of the effect, however, has not been tied down with precision. Devereux et al. (2008), for example, estimate, for a sample of

[9] On the formalities in that context, see for instance Keen and Konrad (2013).
[10] Box 4.3.

advanced countries, that a one percentage point cut in the average foreign statutory rate lowers the rate at home between 0.34 and 0.67 percentage points; in a sample that includes developing countries, Crivelli et al. (2016) find a somewhat lower but significant response of between 0.25 to 0.3 points in response to a 1 point rate cut abroad.[11]

Further possibilities arise outside the one-shot Nash context of equation (1). In a Stackelberg context, strikingly, the low tax country loses (strictly, never gains) whichever country is first mover.[12] If the high tax country is the leader, then setting a minimum rate just above that initially set by the low tax country will lead the high tax country to reduce its rate (because it can now be sure that any further reduction in its own rate will not be met by a reduction in the low country's rate). The result is that while welfare increases in the high tax country, in the low tax country it falls.[13] If on the other hand it is the low tax country that is the leader, then by selecting its preferred point on the best response of the high tax country it is in effect already picking its preferred minimum rate; so the introduction of some formal minimum—which places the outcome at the corresponding point on the high tax country's best response—can never make it better off. Further complications arise in a repeated game context—Kiss (2012) shows that the imposition of a minimum may make it less likely that a cooperative outcome will be sustained, since it reduces the punishment from defecting—though it is not clear that these are central to understanding the differential impact of a minimum tax on low and high tax countries.

The welfare effects of a minimum corporate tax rate are thus potentially complex. Depending on modelling assumptions, it is conceivable that both high and low tax countries benefit from a modest minimum rate, that only one does, or that neither do. Nonetheless, the weight of evidence suggesting strategic complementarity, the clear expectation of high tax countries that they will gain from a minimum rate, and the centrality of profit shifting suggest a real possibility that not only the high tax country but also the low tax country would benefit from a modest minimum tax. As argued in the Introduction, however, such a local result provides little guidance for practical

[11] See also Zodrow (2010). While some empirical studies find strategic substitutability, this seems to arise mainly in the quite different context of tax competition across subnational governments. Buettner and Poehnlein (2021), for instance, find that high tax municipalities in Germany responded to binding minima imposed on neighbors by lowering their business tax rate, while Lyytikäinen (2012) finds no significant interaction in property tax rates across Finnish municipalities. Both settings are quite different—respectively, in the even greater disconnect between residents and firm ownership at municipal level, and relative immobility of the base—from that of profit shifting across national borders that is at issue here. Agrawal et al. (2020) discuss the distinct considerations that shape best responses in tax interactions between local governments.

[12] See for instance Kempf and Rota-Graziosi (2010) on the question of which country emerges as a leader.

[13] This Stackelberg point is established in the framework of Kanbur and Keen (1993) by Wang (1999); a more general diagrammatic exposition is in Keen and Konrad (2013). Konrad (2009) shows that in this sequential case the same results can obtain even with a minimum set strictly below the lowest initial rate.

policymaking. The challenge is to examine more practically relevant issues concerning the impact of minimum rates that are discretely above the initial low tax rate.

3 Analyzing a Discretely Binding Minimum Corporate Tax

The framework we use to analyze these questions is an extension of Kanbur and Keen (1993), interpreted as a model of Nash tax-setting in a context of profit shifting, the extension being in allowing policymakers to care not only about tax revenue but also about their citizens' after-tax incomes. The two countries of the model thus differ not only in 'size'—thought of here as the relative magnitude of the tax bases they would enjoy in the absence of profit shifting—but also in their taste for public spending.

To address the questions set out in the introduction, the essence of the exercise is to track out the welfare effects, starting from an asymmetric Nash equilibrium, of continually increasing the minimum tax rate μ. This has no effect until it reaches the lower of the Nash tax rates, t^N; beyond this, the rate set by the lower country will simply be μ.

3.1 Tax Competition with Profit Shifting

The representative citizen-multinational of each country earns a fixed amount of profit, π and Π (both strictly positive), which may, however, be declared for tax purposes in either country. The cost of shifting a proportion s of profit abroad is $(\delta/2)s^2$, so that profits will be shifted only out of the high tax country, in amount $(T-t)s\Pi/\delta$.[14]

Welfare in each country is taken to be the sum of private after-tax income and tax revenue, the latter weighted by a fixed marginal valuation of public spending: λ in the low tax country, Λ in the high, and in each case strictly greater than unity. For the low tax country, which is the recipient of profit shifting, this is

$$w(t,T) = (1-t)\pi + \lambda t\left(\pi + \left(\frac{T-t}{\delta}\right)\Pi\right). \tag{2}$$

Maximizing[15] with respect to t and rearranging gives the best response

$$t(T) = \frac{1}{2}\left[\left(\frac{\lambda-1}{\lambda}\right)\delta\theta + T\right], \tag{3}$$

[14] This is from maximizing the net gain from profit shifting of $(T-t)\Pi - (\delta/2)s^2\Pi$.

[15] None of the second order conditions of the problems considered in this paper is problematic.

where $\theta \equiv \pi/\Pi$ is the ratio of the profits accruing to the residents of the two countries, and so serves as an indicator of relative country size. Similarly, welfare of the high tax country is

$$W(T,t) = \Pi - T\left(1 - \left(\frac{T-t}{\delta}\right)\right)\Pi - t\left(\frac{T-t}{\delta}\right)\Pi - \left(\frac{1}{2}\right)\frac{(T-t)^2}{\delta}\Pi + \Lambda T\left(1 - \left(\frac{T-t}{\delta}\right)\right)\Pi, \quad (4)$$

where private income is reduced by taxes paid at home and abroad and (the fourth term) by the cost of profit shifting.[16] Combining the first four terms in (4) gives

$$W(T,t) = (1-T)\Pi + \left(\frac{1}{2}\right)\frac{(T-t)^2}{\delta}\Pi + \Lambda T\left(1 - \left(\frac{T-t}{\delta}\right)\right)\Pi, \quad (5)$$

where the second term captures the net private gain from profit shifting. The possibility arises, however, that a political and social aversion to avoidance results in this private gain being valued less highly than other forms of private income——an issue similar to that which arises, albeit in more extreme form, in the analysis of tax evasion.[17] There is indeed evidence of strong general public disapprobation of tax avoidance. In a survey reported by HMRC (2015), for example, 61% of respondents felt that tax avoidance is never acceptable, while Scarpa and Signori (2020) conclude from their review of the evidence that "...tax avoidance is widely perceived at least as a morally doubtful practice". It is also suggestive of policymakers' disapproval that several countries denied pandemic-related support to companies substantially present in low tax jurisdictions. Indeed if there were not some such aversion it is not clear why governments would adopt any domestic anti-avoidance legislation. To allow for the possibility of such discounting of the private gain from profit shifting, we generalize (5) by replacing the $1/2$ in the second term in (5) by a parameter α, so taking welfare in the high tax country to be

$$W(T,t) = (1-T)\Pi + \alpha\frac{(T-t)^2}{\delta}\Pi + \Lambda T\left(1 - \left(\frac{T-t}{\delta}\right)\right)\Pi, \quad (6)$$

where $\alpha \in [0, 1/2]$; the two extreme values of α correspond to either full ($\alpha = 1/2$) or zero ($\alpha = 0$) social valuation of the net private gain from profit shifting.[18]

[16] Shifting costs are for simplicity assumed either non-deductible or deductible but taxed at the same rate in the hands of the recipient.

[17] As discussed, for instance, in Cowell (1990), Chapter 7. There is a difference, of course, in that profit shifting is (or at least can be) legal, whereas evasion, by definition, is not. However, that distinction does not appear to be decisive one in framing attitudes to tax avoidance, in public perception at least.

[18] There are in principle other possibilities. It might be, for example, that shifting costs are not real resource use (as is assumed in (4)) but transfers of rent (perhaps to tax advisors), and so convey no social benefit. Indeed in the

From (6), $W_t.(\delta/\Pi) = (\Lambda - 2\alpha)T + 2\alpha t > 0$, so that the high tax country thus sure to gain from minima that force an increase in t. In considering the scope for Pareto gain, attention can thus focus on how the level of the minimum affects the low tax country.

As is evident from the discussion above, the best response of the high tax country, $T(t)$ will play a crucial role. Differentiating in (6) and rearranging, this is given by

$$T(t) = \frac{1}{2}\left[\left(\frac{\Lambda - 1}{\Lambda - \alpha}\right)\delta + \left(\frac{\Lambda - 2\alpha}{\Lambda - \alpha}\right)t\right]. \tag{7}$$

This best response is readily seen to be shifted upwards by an increase in either Λ or[19] α. The former is as one would expect; the latter arises because a higher valuation of the private gain from profit shifting implies a greater willingness to accept the increase in such shifting that is induced by raising T.

Differentiating in (7), $T'(t) = (\Lambda - 2\alpha)/2(\Lambda - \alpha) >)$, so that, consistent with the empirical evidence, tax rates are strategic complements for the high tax country. Clearly too, and unsurprisingly, a higher marginal valuation of revenue, Λ, leads to a steeper best response. A higher α, in contrast, while also shifting the best response of the high tax country upwards acts, flattens it. This arises from the convexity of profit shifting in the tax difference $T - t$, the quadratic form assumed above conveniently capturing an empirical reality found, for instance, in Dowd et al. (2017): convexity means that the higher is t the lesser is the increase in profit shifting resulting from an increase in T, an effect that has a stronger impact in dulling the high tax country's response the greater is the weight α it attaches to the private gain from such shifting. The implication is that a greater acceptance of profit shifting reduces the responsiveness of the high tax country to a minimum-induced increase in that of the low tax country, which dampens the gain enjoyed by the latter. This will be important later..

With these elements, the characterization of the Nash equilibrium—the benchmark against which the impact of a minimum rate is to be assessed—is straightforward:

Proposition 1. *If*

$$\frac{\Lambda - 1}{\Lambda} > \left(\frac{\lambda - 1}{\lambda}\right)\theta \tag{8}$$

extreme case in which they are entirely transfers, so that the penultimate term in (4) vanishes, it can be shown that tax rates are strategic substitutes for the high tax country. Given, however, the weight of evidence supporting strategic complementarity between national corporate tax rates, we do not pursue this possibility.

[19] The claim here regarding α requires that $t < (\Lambda - 1)\delta/\Lambda$; but without this, it will be seen around (11) below, the questions at issue become vacuous, in that any minimum rate then also binds the high tax country.

then there is a unique Nash equilibrium in which $t^N < T^N$*, with*

$$t^N = \delta\left(\frac{\Lambda - \alpha}{3\Lambda - 2\alpha}\right)\left[\left(\frac{\lambda - 1}{\lambda}\right)2\theta + \left(\frac{\Lambda - 1}{\Lambda - \alpha}\right)\right], \tag{9}$$

and $T^N = T(t^N)$.[20]

Proof. Substituting (7) into (3) and rearranging gives (9). Subtracting (9) from (7), rearranging, and recalling that $\Lambda > 2\alpha$ confirms that $T^N > t^N$ if and only if (8) holds. □

The condition in (8) implies, as one would expect, that the country which sets the lower tax rate in equilibrium is marked by a relatively small share of global profits—a size effect familiar in models of tax competition—and/or by a relatively low marginal valuation of public spending. The comparative statics of the Nash rates themselves are also mostly straightforward—both are increasing in each of the marginal valuations Λ and λ and decreasing in θ—though with the less familiar feature that they are also both increasing in α:[21] a higher social value attached to outward profit shifting by the high tax country leads it to increase its tax rate, which in turn induces a higher rate in the low tax country.

3.2 Implications of a Minimum Rate

Suppose now the constraint is imposed that no tax rate may be set below μ, which we take to exceed t^N and so to bind on the country that sets the lower tax rate in Nash equilibrium. The high tax country then simply sets its rate according to its best response $T(t)$ in (7).

As seen above, the high tax country prefers the highest possible rate in the low tax country, and hence the highest possible minimum. And, by the argument in Section 2, since[22] $w_T > 0$ and $T'(t) > 0$, the low tax country benefits, relative to its welfare w^N in the Nash equilibrium, from setting a minimum infinitesimally above t^N. The concern that leaves is with the implications for welfare in the low tax country of setting the minimum at levels discretely higher than that.

[20] The expression for T^N in terms of the underlying parameters is neither especially instructive nor needed later, so is omitted.

[21] This is most easily seen by recalling that a higher α shifts the best response of the high tax country upward while, from (3), having no impact on that of the low tax country.

[22] This is readily seen from (2).

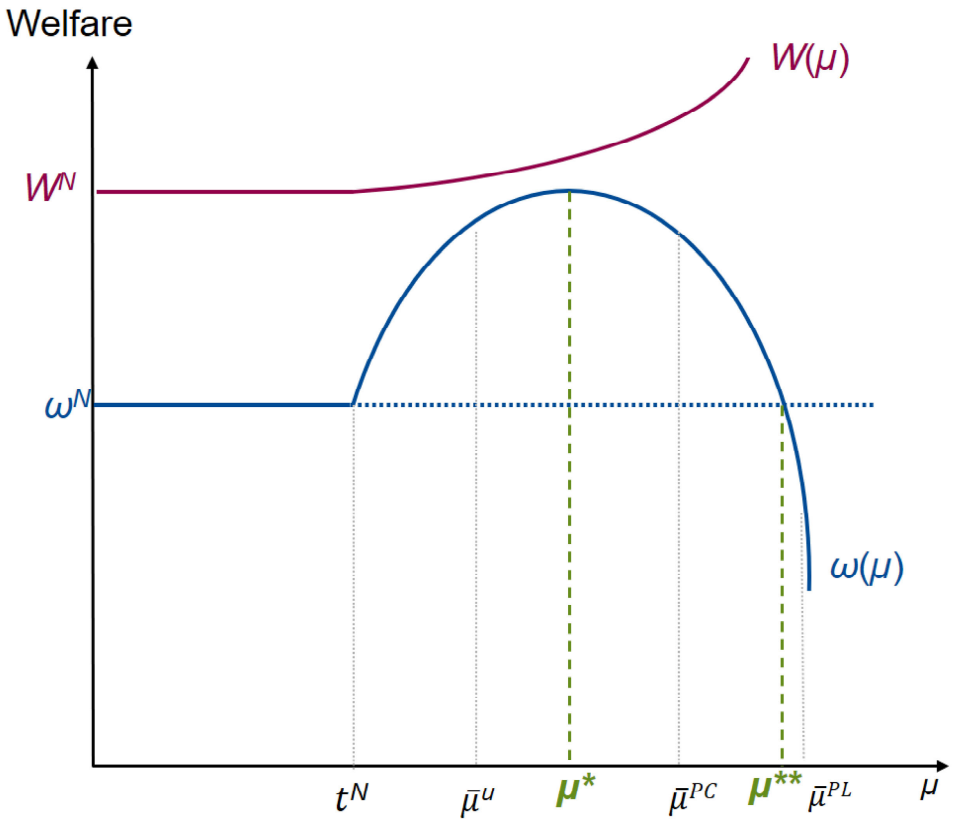
3.2.1 Analysis

When the minimum constrains the low tax country to set its rate at μ—leaving aside a complication returned to shortly—the high tax country sets its tax rate according to the best response $T(\mu)$ in (7). Using this in (2), welfare in the low tax country is then (with a slight abuse of notation)

$$w(\mu) \equiv w(\mu, T(\mu))\delta/\Pi = \delta\theta + \delta\left(\frac{\lambda(\Lambda-1)}{2(\Lambda-\alpha)} + (\lambda-1)\theta\right)\mu - \left(\frac{\lambda\Lambda}{2(\Lambda-\alpha)}\right)\mu^2. \tag{10}$$

The quadratic structure of $\omega(\mu)$ points to a pattern of effects, illustrated in Figure 1, that might plausibly apply in circumstances more general than those of the present model. Welfare in the high tax country $W(\mu)$, is strictly increasing, and (is readily seen to be) convex, at all levels of μ above t^N. For the low tax country, welfare of course rises with a minimum just above t^N, and continues to rise for some time, as it benefits from applying a higher rate with the induced increase in the high tax rate cushioning the adverse revenue impact it feels from the reduction in profit shifting. But the cushioning is only partial, because the high tax country, now made less vulnerable to profit shifting, does not increase its own tax rate one-for-one with μ: so profit shifting falls. Eventually, a further slight increase in the minimum rate produces a contraction in the profit-shifting-inclusive tax base of the low rate country that exactly matches the additional gain from charging that base at a higher rate. Welfare $w(\mu)$ thus reaches a peak at some minimum rate μ^*: this is the *Pareto efficient minimum tax rate*, in the sense that any other minimum rate will lead to lower welfare in the low tax country. As μ increases beyond this point, the reduction in the low tax country's shifting-inclusive tax base dominates the impact of taxing it at a higher rate, and welfare in the low tax country begins to fall. And at some minimum rate μ^{**} it falls to such a level that $\omega(\mu^{**}) = w^N$, so that welfare in the low tax country is as it was in the Nash equilibrium; at higher minima, it is strictly less. We refer to μ^{**} as the *maximal Pareto dominant minimum rate*, being the highest level at which the minimum can be set without making the low tax country worse off than in the Nash equilibrium.

Figure 1: *The Welfare Impact of Minimum Taxation*

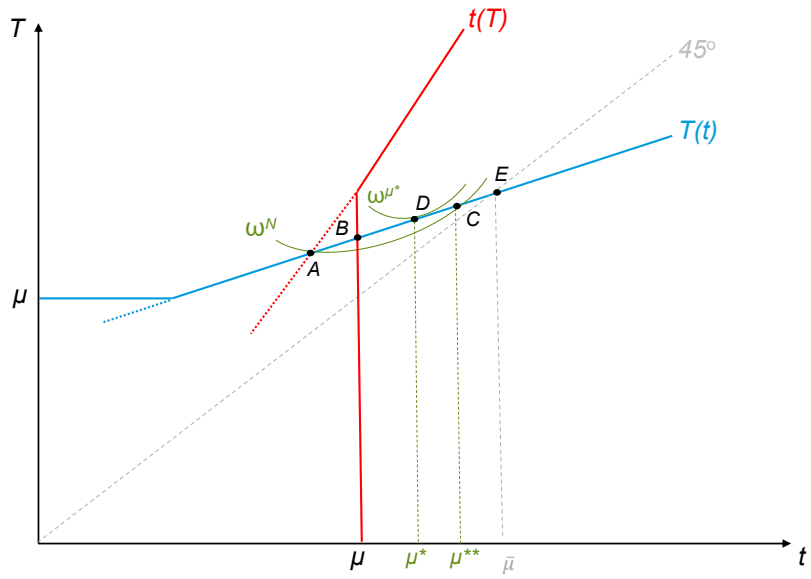


Note: The figure shows how welfare in each of the two countries varies with the level of the minimum tax rate μ. Welfare of the high tax country increases throughout. For the low tax country, welfare peaks at the Pareto efficient level μ^* and falls below the level of welfare in the Nash equilibrium, w^N, at the maximally Pareto dominant rate μ^{**}. Points $\bar{\mu}^U$, $\bar{\mu}^{PC}$ and $\bar{\mu}^{PL}$ represent alternative levels at which the minimum binds the high tax country, as discussed below. There is no significance to the relative levels of $w(\mu)$ and $W(\mu)$,

Figure 2 shows the impact of a minimum tax on the structure of the underlying game. By introducing flat segments in both best responses at rates below that level, the effect is to shift the Nash equilibrium from A to B. Consistent with the discussion in Section 2, the low tax country can be seen to be sure to gain from a sufficiently modest minimum (because its iso-welfare contours are horizontal where they meet its best response). It will continue to gain relative to the Nash equilibrium at any minimum rate below that at point C, where the iso-welfare contour through A intersects the best response of the high tax country. The low country's most preferred minimum, however, is at D, where an iso-welfare contour is tangential to the high tax country's best response.[23]

[23]This illustrates the remark in Section 2, that μ^* is the tax rate that the low tax country would set if it were the Stackelberg leader, and that in such a case, minimum taxation cannot be strictly Pareto-improving.

Figure 2: *Implications of a Minimum Tax Rate*



Note: A minimum rate of μ shifts the Nash equilibrium from A to B. The low tax country most prefers a minimum of μ^* (point D), but gains relative to the initial Nash equilibrium) from any minimum up to μ^{**} (point C). Once the minimum exceeds $\bar{\mu}$ it also constrains the high tax country (point E).

Before characterizing μ^* and μ^{**}, some consideration is needed of the complication mentioned above: since the rate set by the low tax country can be expected to increase less than one-for-one with the minimum rate, at some level, denoted $\bar{\mu}$, the minimum will come to bind on the high tax country too. From (7), this will be the case for any μ in excess of

$$\bar{\mu} \equiv \left(\frac{\Lambda - 1}{\Lambda}\right)\delta, \tag{11}$$

corresponding to point E in Figure 2, at which $T(t)$ cuts the 45° line. At minima higher than $\bar{\mu}$, both countries set their rate at the minimum, and it is then readily verified that (with both λ and Λ fixed and strictly greater than unity) welfare in each country rises indefinitely with further increases in μ. This is, however, a relatively uninteresting possibility, both because at some point the assumption that marginal valuations of public spending do not decline with revenue would become untenable and, perhaps still more fundamentally, because setting a minimum is then equivalent to complete harmonization.Indeed this possibility can only arise if the minimum is set strictly above the higher

of the Nash equilibrium rates—which is not on any political agenda.[24] For brevity, attention in what follows is therefore restricted to $\mu \leq \bar{\mu}$.

With this, it is straightforward to characterize the critical values of the minimum rate:

Proposition 2. *(a) The Pareto efficient minimum tax rate is given by* $\max(\mu^*, \bar{\mu})$*, where*

$$\mu^* = \delta\left(\frac{(\lambda-1)(\Lambda-\alpha)2\theta + \lambda(\Lambda-1)}{2\lambda\Lambda}\right). \tag{12}$$

(b) The maximal Pareto dominant minimum rate is given by $\max(\mu^{**}, \bar{\mu})$*, where*

$$\mu^{**} = \delta\left[\frac{(\Lambda-\alpha)^2}{\Lambda(3\lambda-2\alpha)}\right]\left[\left(\frac{\lambda-1}{\lambda}\right)4\theta + \left(\frac{2(\Lambda-1)}{\Lambda-\alpha}\right)\right] > \mu^*. \tag{13}$$

Proof. The expression for μ^* in part (a) follows from the first order condition for maximizing $\omega(\mu)$. For part (b), since $\omega(\mu)$ is quadratic, $\mu^{**} = t^N + 2(\mu^* - t^N)$, and the expression for μ^{**} then follows from comparing (9) and (12). □

The comparative statics of the Pareto efficient and maximal Pareto dominant rate in Proposition (2) are again mostly straightforward. For a given marginal valuation of public spending in the high tax country, for example, both are greater the higher is that marginal valuation in the low tax country and the greater its relative size: broadly, both characteristics point to a lesser inclination to set a low tax rate, meaning a greater potential gain from imposing on a minimum that counteracts competitive pressures to do so. But for present purposes these comparative statics are in an important sense beside the point, since such parameter variation also changes the Nash equilibrium tax rates: what is of interest are not the levels of μ^* and μ^{**} as such, but how these compare, in particular, with t^N. We turn to this in the next subsection.

Before doing so, however, the possibility that the minimum will also bind on the high tax country needs attention. Three possible cases arise, pointing to quite different conflict or congruence of interests across countries. Bearing in mind that $\mu^* < \mu^{**}$, these are:

- In Case U (*Unanimity*), $\bar{\mu} \leq \mu^*$: a higher minimum is always in the interests of both countries. Comparing (11) and (12), this will be the case iff

$$\frac{(\Lambda-1)/\Lambda}{(\lambda-1)/\lambda} < \left(\frac{\Lambda-\alpha}{\Lambda}\right)2\theta. \tag{14}$$

[24] To see this diagrammatically: with $T^N > t^N$, the upward-sloping best response of the high tax country in (t, T) space must cut the 45° line at a rate higher than T^N; so $\bar{\mu} > T^N$.

- In Case PC (*Potential conflict*), $\mu^* \leq \bar{\mu} < \mu^{**}$: although the low tax country always gains relative to the Nash equilibrium, there is potential conflict between the countries in that marginal increases in the minimum rate will not always be unanimously approved. This intermediate case arises when neither (14) not (15) below applies.

- In Case PL (*Potential loss*), $\mu^{**} < \bar{\mu}$: there is a potential (strict) loss of welfare for the low tax country, in the sense that there exist minima that do not bind the high tax country but nevertheless reduce w below its level in the unconstrained Nash equilibrium. Comparing (13) with (11), this case—which is that illustrated in Figure 2 above—arises iff

$$\frac{(\Lambda - 1)/\Lambda}{(\lambda - 1)/\lambda} > \left(\frac{\Lambda - \alpha}{\Lambda}\right)^2 4\theta. \tag{15}$$

These three possibilities are illustrated in Figure 1: Cases PL, PC and U arise if $\bar{\mu}$ is at the illustrative levels $\bar{\mu}^{PL}$, $\bar{\mu}^{PC}$ and $\bar{\mu}^{U}$, respectively.

Equations (14) and (15) confirm that, as one would expect, the scope for conflict—moving from cases U to PC to PL—is greater the more dissimilar are countries in either scale or the valuation of tax revenue. Suppose, for instance that $\alpha = 0$. Then if the two countries differ only in size, there is unanimity if $\theta > 0.5$ and potential loss for the low tax country if (as is far from implausible) $\theta < 0.25$. If they differ only in the valuation of revenue, then a similar partition applies in terms of the ratio of $(\lambda - 1)/\lambda$ to $(\Lambda - 1)/\Lambda$.[25] What also emerges is that conflict is more likely the higher is α.

3.2.2 Calibration

A strikingly sharp answer to the questions of where the Pareto efficient and maximally dominant rates stand relative to the unconstrained rate set by the low tax country emerges on comparing (12) and (13) with (9) to find that

$$\mu^* = \left(\frac{3\Lambda - 2\alpha}{2\Lambda}\right) t^N \tag{16}$$

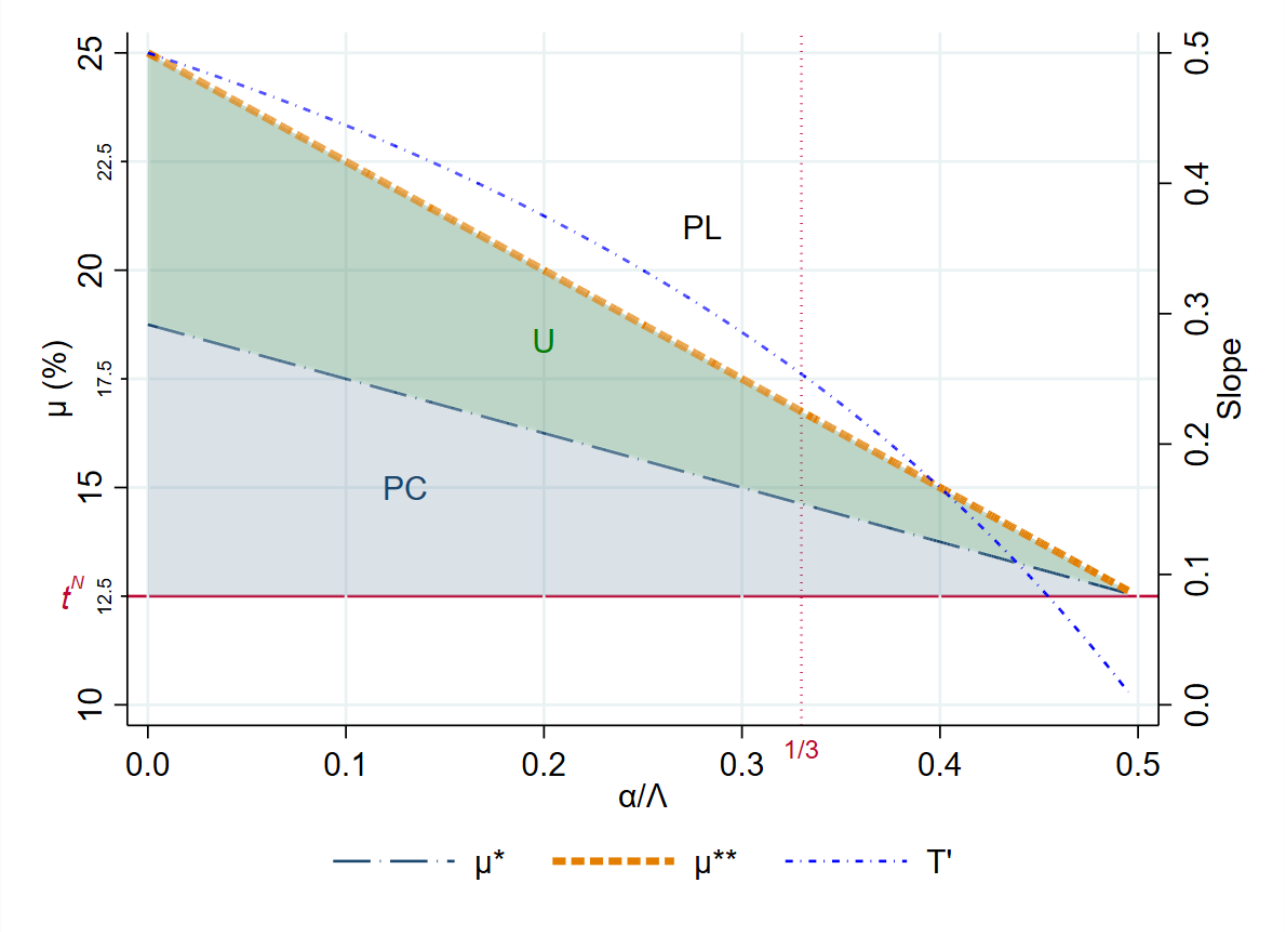
$$\mu^{**} = \left(\frac{2(\Lambda - \alpha)}{\Lambda}\right) t^N. \tag{17}$$

The gaps between these two rates and t^N, and between μ^* and μ^{**} themselves, thus depend upon

[25] So, for instance, if $\lambda = 1.2$ then Case U arises unless $\Lambda > 1.5$.

only, and are strictly decreasing in, the ratio α/Λ. The reason, as can be seen from Figure 2, is that the low tax country is more likely to gain from the imposition of a minimum rate the steeper is the best response of the high tax country, along which the minimum places the new equilibrium, since that implies a greater increase in the high tax rate—and the slope of that best response, as discussed above, is decreasing in α and increasing in Λ. Indeed it depends only on the ratio α/Λ: the best response of the high tax country is flatter the lower is the valuation there of the private gains from outward profit shifting relative to that of the tax revenue it dissipates.

Figure 3: *Efficient Minimum Tax Rates*



Note: This figure shows, conditional on an uncoordinated low tax rate of $t^N = 12.5\%$: on the left hand scale, the Pareto efficient and maximally Pareto dominant minimum tax rates μ^* and μ^{**}, from (16) and (17); on the right hand scale, the slope $T'(t)$ of the high tax country's best response, calculated from (7); and regions corresponding to the three cases described at the end of section 3.2.1.

Taking for illustration a benchmark low tax rate of $t^N = 12.5\%$ (not coincidentally, the current rate in Ireland, which has occupied a central place in the policy debate), Figure 3 illustrates the relationships in (16) and (17), showing also the ranges in which the three cases above arise and

the slope of the best response $T'(t)$. With α/Λ at its highest possible value of 0.5—attained when both the private gain from profit shifting and tax revenue are valued by the high tax country like other private income (so that $\alpha = 0.5$ and $\Lambda = 1$)—there is no possibility of any Pareto gain from imposing a minimum tax: the best response of the high tax country is perfectly flat. At the opposite extreme, when the high tax country cares only about tax revenue or attaches no value to the private gain from profit shifting ($\Lambda \to \infty$ or $\alpha = 0$, with $T'(t)$ reaching its maximum of $1/2$), both μ^* and μ^{**} reach upper bounds. And these are both very substantially above the initial low rate of 12.5%: the Pareto efficient rate is 18.75% and both countries gain from any minimum rate not exceeding 25%.

Outcomes are of course less extreme at intermediate values of α/Λ, but still suggest material scope for mutual gain. Suppose for instance that $\Lambda = 1.5$. If the private gains from profit shifting are fully valued ($\alpha = 0.5$), so that $\alpha/\Lambda = 1/3$, then $\mu^* = 14.6$ while $\mu^{**} = 16.7\%$. While these numbers may seem close to the low rate of 12.5%, in the context of the current policy debate the differences are highly material: it is a striking implication, for instance, that a country initially setting a rate of 12.5% might ultimately benefit from being subjected to a minimum of close to 17%. And the apparent scope for mutual gain becomes still wider at lower values of α/Λ, which imply (higher) values for the slope $T'(t)$ that are still within the range suggested by the empirical literature. Suppose, for instance, again taking $\Lambda = 1.5$, that profit shifting gains are valued at only half of other private income (so that $\alpha/\Lambda = 1/6$): then the low tax country's preferred minimum rate is then 16.7%, and it benefits from any minimum up to 20.8%.

The impression of significant prospect of Pareto improvement from the imposition of a minimum tax emerges from the calculations for a wider range of parameter values reported in Table 1. Again taking $t^N = 12.5\%$, this reports, along with implied values of μ^* and μ^{**}, the corresponding values of the high Nash rate, T^N, the level of the minimum at which the high tax country becomes constrained, $\bar{\mu}$, and which of the three possible configurations of interests applies. Unlike μ^* and μ^{**}, all of these depend on more than simply the ratio α/Λ. Their values can, however, be backed out as proportional to t^N (with the shifting cost parameter δ serving as the residual keeping t^N unchanged). The scope for some dissonance of interests, indicated by the last column, is evident: for example, in all cases in which the high tax rate is 20% or more—a plausible counterpart to calibrating the low rate at 12.5%—the low tax country may lose, relative to the Nash equilibrium, from some minimum rates that are ambitious but leave the high tax country unconstrained. Still more notable, however, is that it is only at levels in the order of $17 - 24\%$ that the adoption of a

minimum rate leaves the low tax country worse off than in the Nash equilibrium.

Table 1: *Efficient Minimum Tax Rates for Different Parameterization*

	Panel (a) ***α =0.5***						
	θ	**T^N**	$T'(t)$	**μ***	**μ****	$\bar{\mu}$	**CASE**
λ=1.2; Λ=1.7	1	17.23	0.29	15.07	17.65	19.18	PL
	0.75	18.59	0.29	15.07	17.65	21.10	PL
	0.5	20.25	0.29	15.07	17.65	23.45	PL
	0.25	22.33	0.29	15.07	17.65	26.38	PL
	0.1	23.85	0.29	15.07	17.65	28.52	PL
Λ = λ = 1.5	1	12.50	0.25	14.58	16.67	12.50	U
	0.75	14.06	0.25	14.58	16.67	14.58	PC
	0.5	16.25	0.25	14.58	16.67	17.50	PL
	0.25	19.53	0.25	14.58	16.67	21.88	PL
	0.1	22.43	0.25	14.58	16.67	25.74	PL
	Panel (b) ***α =0.3***						
	θ	**T^N**	$T'(t)$	**μ***	**μ****	$\bar{\mu}$	**CASE**
λ=1.2; Λ=1.7	1	16.96	0.39	16.54	20.58	19.85	PC
	0.75	18.30	0.39	16.54	20.58	22.06	PL
	0.5	19.98	0.39	16.54	20.58	24.82	PL
	0.25	22.13	0.39	16.54	20.58	28.36	PL
	0.1	23.74	0.39	16.54	20.58	31.02	PL
Λ = λ = 1.5	1	12.50	0.37	16.25	20	12.50	U
	0.75	13.92	0.37	16.25	20	14.87	U
	0.5	16.07	0.37	16.25	20	18.16	PC
	0.25	19.20	0.37	16.25	20	23.21	PL
	0.1	22.20	0.37	16.25	20	28.02	PL
	Panel (c) ***α =0.1***						
	θ	**T^N**	$T'(t)$	**μ***	**μ****	$\bar{\mu}$	**CASE**
λ=1.2; Λ=1.7	1	16.72	0.47	18.01	23.53	20.45	PC
	0.75	18.04	0.47	18.01	23.53	22.93	PC
	0.5	19.72	0.47	18.01	23.53	26.09	PL
	0.25	21.94	0.47	18.01	23.53	30.26	PL
	0.1	23.64	0.47	18.01	23.53	33.48	PL
Λ = λ = 1.5	1	12.50	0.46	17.92	23.33	12.50	U
	0.75	13.80	0.46	17.92	23.33	14.93	U
	0.5	15.73	0.46	17.92	23.33	18.53	PC
	0.25	18.89	0.46	17.92	23.33	24.43	PL
	0.1	21.98	0.46	17.92	23.33	30.20	PL

Note: The low tax rate t^N is in all cases 12.5%, with the values for μ^* and μ^{**} then given by (16) and (17). By eliminating δ, both T^N (combining (9) and (7)) and $\bar{\mu}$ (combining (9) and (11)) can be expressed as multiples of t^N that depend only on the parameters varied in the table.

4 Conclusions

The purpose of adopting a minimum rate of corporate taxation is to change the rules of the game of international tax competition. How countries respond to those changed rules—including those countries that are not directly affected—must thus be a central part of assessing the effects and desirability of such a minimum, and hence in providing some guidance both as to the level at which such a minimum might be set and to the potential conflicts of interest that arise in this choice.

These strategic responses, we have seen, mean that a low tax country may either benefit from or be harmed by a minimum tax at just above the rate they set in the initial equilibrium. Empirical results which strongly suggest tax rates to be strategic complements, and the likelihood in a context of profit shifting that each country benefits from a tax increase by the other, point to the most plausible outcome being a gain for the low tax country. The presumption that the high tax country gains from a minimum rate being strong, the implication is that an infinitesimally binding minimum rate is then Pareto-improving.

That, however, simply raises two more profound questions, critical for policy, that then arise in relation to minimum rates that impose discrete rather than infinitesimal rate increases on constrained countries: the levels of the Pareto efficient and maximal Pareto dominant minimum rates. No model can provide definitive answers. Analysis can, however, give a broad sense of possibilities and key drivers of the likely answers. In that spirit, what emerges as critical is not merely the sign but also the magnitude of the slope of the best response in the high tax country. In the model here, this turns on the valuation in the high tax country of the private gain from profit shifting relative to the public loss. From the perspective of the low tax country, however, is it immaterial what drives that slope: all that matters is the magnitude that results. Empirical work does not give much confidence in speculating on this. Nonetheless, the simulations reported here suggest that for plausible parameter values both efficient and maximal dominant rates may indeed lie materially above the initial low tax rate. It is not difficult, for instance, to provide reasonable parameter values which suggest, given an initial low rate of 12.5%, that the Pareto efficient minimum is around 15%, and that both high and low tax countries may gain from a minimum as high as 17%. These may seem small differences. But in the context of a debate in which candidate rates have been within the range 12.5-20%, and disagreement heated, they are quite salient. The implication is thus that national interests may align around minima that are substantially above the lowest urged by some.

There are of course many limitations to the analysis here. We have noted, for example, that there are details of the scope and rule order of the Pillar Two proposals not directly captured above. The presumption of a two-country world also stands out: there are countries with rates even lower than the 10-12.5% that debate has tended to focus on. Simulations calibrated to the many country case could of course usefully add realism. But the broad conclusions drawn here seem likely, if anything, to be reinforced.[26] Imagine for instance that there is a 'middle tax' country interposed between the high and low tax ones. Then the strategic response to a minimum binding on the low tax country involves an additional ripple-like effect, with an increased rate in the more proximate middle tax country not only providing an additional source of spillback gain to the low tax country but also amplifying the rate increase in the high tax country and so generating an additional beneficial spillback. All this seems likely to lead to a still higher maximal Pareto dominant rate, which may even be above the initial level of the tax in middle tax country. The scope for a congruence of interest in setting an ambitious minimum rate, it seems, may be larger than is commonly recognized.

[26]The intuition that follows derives from a model of N-country tax competition in a setting for profit shifting similar to, but without the underlying spatial roots of, that used here.

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