Heads I win, tails you lose: asymmetric taxes, risk taking, and innovation*

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ABSTRACT

When multinationals face lower tax rates abroad than in the US, transfer pricing strategies generate an asymmetry in the tax rates on a project's profits and losses. We show that the tax savings from transfer pricing can be expressed as a long position in a call option. We use a model to show that this transfer pricing call option leads a firm to choose riskier and larger projects than it would otherwise. Thus, transfer pricing strategies do not simply reduce a firm's taxes, they can influence the scale and types of projects undertaken.

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1 Introduction

The high level of the statutory corporate income tax rate in the US, relative to that of many developed economies, has received significant attention as a driving force behind US multinationals' business decisions. In the context of domestically operating firms, it has long been recognized that taxes can influence a firm's attitude towards risk (e.g., Domar and Musgrave (1944); Green and Talmor (1985); Smith and Stulz (1985)). In spite of this, there has been little attention paid to how firms' foreign operations and the differences in US and foreign corporate tax rates may affect the risk-taking of US firms.

In this paper, we show that the relatively high US tax rate, along with the ability of firms to shift intangible capital across their global operations at discounted transfer prices, can affect the riskiness and scale of projects undertaken by US firms.[1] For example, consider a firm that develops intangible capital in the US. The expenses associated with the development provides a valuable deduction against the firm's US income that is taxed at a relatively high US rate. In practice, the firm can use transfer pricing to move the intangible capital to its foreign subsidiary at a price below its fair market value, shifting overseas the profits generated by these assets. These profits are then taxed at relatively low foreign rates. We show that typical transfer pricing strategies produce an asymmetry in the tax rates faced on the gains and losses of a project with transferable capital. This generates convexity in the after-tax payoffs of these projects. Facing convex payoffs, firms have incentive to increase the riskiness and scale of these projects with transferable capital.

We use a model of a firm's joint decision of project risk and scale to illustrate how differential tax rates and transfer pricing strategies firm policies. The model shows that a transfer pricing strategy can be expressed as a long position in a call option on the development of transferable capital or intellectual property. This call option component of the after-tax payoff leads the firm to choose a project that is larger and riskier. We show that, somewhat

[1] Pomerleau (2017) reports that, as of 2017, the US has the fourth highest statutory corporate income tax rate in the world. While the Tax Cuts and Jobs Act of 2017 reduced the US federal corporate tax rate from 35% to 21%, it remains much higher than those in tax havens. For instance, Bermuda does not tax corporate income.

surprisingly, an increase in the US tax rate can lead to an *increase* in the choice of project scale and risk. Furthermore, we show that under certain conditions this can lead the firm to invest more in a project than it would in an alternative case of zero taxes. The model highlights the relevance of a firm's other taxable income and the *difference* in US and foreign tax rates for the choice of project scale and risk.

We then empirically test these predictions for the relationship between corporate tax rates and firm risk taking. Using geographic segment data, we construct a panel of the foreign operations of US firms for the period 1998–2015. We follow the prior literature in using the volatility of firm profitability as a proxy for corporate risk taking (John, Litov, and Yeung (2008)). With this sample, we perform two sets of analyses.

In our first approach, we consider the simple correlation between the tax convexity and risk taking. We find that the tax convexity and risk taking are positively related, as predicted by the model. A natural concern is that this correlation is driven by selection. For example, young tech firms may have both volatile cash flows and operations in tax havens. We evaluate this concern by controlling for age and including industry fixed effects. The positive association between the tax convexity and risk taking remains.

As a second approach, we consider the effect of major foreign tax changes. The advantage of this type of analysis is that it allows us to assess the dynamics of the effect of the tax convexity on risk taking. It also allows us to examine whether our effect is driven by trends in the treatment (firms subject to a major foreign tax change) or control (firms not subject to such a change) group prior to treatment. The estimates indicate that firms promptly adjust their risk taking following treatment and do not anticipate major tax changes. While this setting remains an approximation of the experimental ideal, the latter result is consistent with the notion that changes in tax convexity *cause* firms to adjust their risk taking. Broadly speaking, our results from both approaches are consistent with the prediction that the tax convexity generates the incentive for multinationals to undertake riskier projects.

It has long been recognized in the corporate finance literature that features of the corporate tax code can make the relationship between a firm's taxable income and its tax liability nonlinear. In particular, prior work has focused on two features—a progressive tax rate schedule and the limited ability to utilize loss carryforwards—that make a firm's tax liability a convex function of its taxable income.[2]

Smith and Stulz (1985) show that when a firm faces a convex tax liability, it can reduce its expected tax liability and increase firm value by hedging or engaging in other activities that reduce the volatility of its taxable income. They also note that taxes may give firms a motive to hedge in order to increase their debt capacity.[3] Graham and Smith (1999) estimate tax liability functions for a sample of Compustat firms and find convexity in about half of their sample. Graham and Rogers (2002) empirically find firms hedge in order to increase debt capacity but do not find evidence of hedging in response to tax function convexity.[4]

Green and Talmor (1985) and Majd and Myers (1985) show that the government's tax claim on a firm's profits can be viewed as a call option. The firm has a short position in this call option and therefore would like to reduce the volatility of taxable income to reduce its expected tax liability. Green and Talmor (1985) show that this convex tax liability reduces the firm's incentive to take on risk, giving incentive to underinvest and engage in conglomerate, diversifying mergers.[5] We show that in the international setting, this prediction for corporate risk taking may be reversed. Favilukis, Giammarino, and Pizarro (2016) and Schiller (2015) study how corporate taxes and the structure of tax loss carryforwards affect the riskiness of equity returns. Ljungqvist, Zhang, and Zuo (2017) use changes in the level of corporate tax rates across US states to study how tax rates affect firm risk-taking. They find that the average firm in their sample reduces its risk-taking in response to a state-level tax increase, but does not increase risk-taking in response to a cut. Becker, Johannesen, and Riedel (2018) studies the relation between taxes and the allocation of risk within the firm. In contrast, our focus is on firms' overall risk taking, not its distribution.

[2]See Graham (2006) for a review of the literature on taxes and corporate finance decisions.

[3]See also Ross (1996) and Leland (1998).

[4]Using survey data on firms' usage of derivatives, Nance, Smith, and Smithson (1993) find that firms facing a more convex tax function, proxied by the amount of net operating losses, are more likely to hedge.

[5]More recently, Langenmayr and Lester (2017) and Ljungqvist, Zhang, and Zuo (2017) provide empirical evidence consistent with Green and Talmor (1985). Osswald and Sureth-Sloane (2017) shows that country risk weakens the association between tax loss offsets and risk taking.

2 Transfer pricing of intangible capital

Large firms are often comprised of a set of legally distinct entities. To be concrete, consider the case of a pharmaceutical company headquartered in the US that is developing a drug for sale in both the US and foreign markets. Suppose the firm has an Irish subsidiary. Typically, the Irish subsidiary will be separately incorporated from the US parent. Legal contracts define the relationships among the entities that constitute the firm. Often, the US parent will wholly own the equity of the Irish subsidiary.

As a consequence, property must be sold (or similarly legally transferred, but not given) from the parent to the Irish subsidiary. IRS regulations require that these transfers occur at"arm's length" prices. In other words, if the Irish subsidiary handles the firm's non-US sales of the drug, it must pay the US parent the market value of the right to sell the drug abroad. If the parent bears the full risk of developing the drug, the payment from the subsidiary to the parent must be higher than if the subsidiary shares in the risk of development.

Although the transfers are required to take place at market prices, the item being transferred may be highly differentiated. As such, a market price may be difficult to determine. Following the example, the value of the drug developed by the pharmaceutical company's US parent may be genuinely ambiguous if it is new and lacks a counterpart that is sold in the market. Similarly, the share of the risk borne by the Irish subsidiary in developing the drug may be difficult to precisely quantify in economic terms.

In practice, if the development of the drug looks unlikely to produce a viable product, the US parent may choose to record the full development expense in the US, shielding its other domestic taxable income from the relatively high US corporate income tax rate. Conversely, if the drug's development looks primising, the parent may cost share the right to sell the drug abroad to the Irish subsidiary at price below its market value. The profits that accrue at the Irish subsidiary would then be subject to the relatively low Irish corporate tax rate.

Cost sharing agreements are generally not publicly available. Consequently, the degree to which transfer pricing undercuts the conceptual arm's length standard is difficult to ascertain. However, Bernard et al. (2006) suggests it is substantial for US multinationals, particularly for differentiated goods, where they estimate it ranges from 52.8% to 66.7%.[6] Moreover, anecdotally, the IRS rarely challenges cost sharing agreements. As a result, firms plausibly transfer intangible capital on favorable terms.

3 Model

A multinational firm can undertake a new project in which it jointly chooses the scale and riskiness. Specifically, the firm chooses an amount C to spend on R&D and project risk σ. The project produces intellectual property (IP), which can be transferred and utilized by all of the firms operations. The pre-tax value of the project's IP is XC^{α}, where $\alpha < 1$,

$$\log(X) \sim \mathcal{N}(\mu(\sigma), \sigma^2), \tag{1}$$

and

$$\mu(\sigma) = \overline{\mu} + (\gamma_1 - \gamma_2 \sigma)\sigma. \tag{2}$$

This specification for $\mu(\sigma)$ implies that there is a value of σ that maximizes the expected value of X and therefore the expected pre-tax payoff on the project.

In the event that the R&D investment is successful ($XC^{\alpha} - C > 0$), the firm can apply this IP to all of its operations. We assume a fraction θ of the firm's operations are abroad, and the income from these operations is subject to a foreign tax rate of τ_F. The remaining $1 - \theta$ of operations are located in the US and subject to a US tax rate of τ_{US}. All of the R&D is performed in the US and recorded as a US expense for tax purposes. The project payoffs before taxes are θXC^{α} abroad and $(1 - \theta)XC^{\alpha} - C$ in the US.

[6]For commodities, they estimate a price reduction of 8.8% to 17.6%. Cristea and Nguyen (2016) find similar magnitudes for tangible goods transferred within Danish firms. Davies et al. (2018) find intrafirm prices are 11% lower than market prices for French firms.

3.1 No taxes

With no taxes, the firm's problem is simply

$$\max_{C,\sigma} \; \mathbb{E}[XC^{\alpha} - C], \tag{3}$$

subject to the constraint $C > 0, \sigma > 0$. With our assumption of lognormality for X, the first-order condition for σ is

$$(\gamma_1 - 2\gamma_2\sigma + \sigma)e^{\overline{\mu} + \gamma_1\sigma - \gamma_2\sigma^2 + \frac{\sigma^2}{2}} = 0, \tag{4}$$

which gives the optimal volatility choice

$$\hat{\sigma} = \frac{\gamma_1}{2\gamma_2 - 1}. \tag{5}$$

The optimal choice of C is given by

$$\hat{C} = \left(\alpha e^{\overline{\mu} + (\gamma_1 - \gamma_2\sigma)\sigma + \frac{\sigma^2}{2}}\right)^{\frac{1}{1-\alpha}} \tag{6}$$

The NPV of the project is

$$NPV = -C + C^{\alpha} e^{\overline{\mu} + (\gamma_1 - \gamma_2\sigma)\sigma + \frac{\sigma^2}{2}} \tag{7}$$

3.2 Constant single tax rate

If the firm faces a single tax rate of τ for any level or source of income, then the optimal choice of scale C and risk σ for the project is the same as in the case of no taxes. The firm's problem is

$$\max_{C,\sigma} \; \mathbb{E}[(1-\tau)(XC^{\alpha} - C)]. \tag{8}$$

While taxes here will affect the NPV of the project, the first order conditions are the same as in the zero tax case and so the optimal choices of C and σ are unchanged by the presence of taxes.

3.3 U.S. and foreign taxes with transfer pricing

Now we consider the case where the firm faces a different tax rate on its foreign operations (τ_F) than domestic operations (τ_{US}). Throughout, we assume that the US corporate tax rate exceeds the foreign rate, $\tau_{US} > \tau_F$, giving the firm incentive to shift profits from the US to the lower tax foreign jurisdictions.

We assume that the R&D is performed entirely in the U.S., resulting in an expense for U.S. tax purposes. This assumption is loosely consistent with the fact that US multinationals perform more than 80% of their R&D in the US.[7] However, the intangible capital resulting from the R&D has value for both the domestic and foreign operations. We use θ to denote the fraction of foreign operations. That is, the pre-tax value of the intangible capital is $\theta X C^\alpha$ for the foreign operations and $(1-\theta)XC^\alpha$ for the domestic operations.

In the event that the project has a positive outcome where $XC^\alpha - C > 0$, we assume that the firm can transfer the intangible capital to its foreign operations at price $p(X, C, \theta)$. The firm is assumed to be able to transfer this intangible capital at a discount of its fair market value:

$$p(X, C, \theta) < \theta X C^\alpha. \tag{9}$$

The case in which the intangible capital is transferred at a price of θC corresponds to one where the R&D expense is allocated proportionally: θ fraction of the firm's operations are abroad and it allocates θ fraction of its R&D expense to these foreign operations. In computing comparative statics from the model, we assume the firm uses this proportional allocation such that its transfer price is $p(X, C, \theta) = \theta C$. Given the parameter values listed in Table 1, this implies a relatively conservative average discount of 9% in the transfer price.[8]

[7] In 2015 (the most recent year for which finalized data are available at the time of writing), the US parents of multinational firms performed $277,787 million in R&D. Their majority-owned subsidiaries performed $56,096 million. Majority owned subsidiaries represent the bulk of US multinationals' foreign operations, accounting for roughly 86% of all foreign subsidiaries' sales ($5,950,947 million of $6,871,187 million) (Bureau of Economic Analysis (2018)).

[8] That is, for the optimally chosen σ and C, the transfer price to market value ratio is $\frac{\theta C}{\mathbb{E}(\theta X C^\alpha)} = 0.91$.

We assume the firm has other contemporaneous US income from operations, $Y \geq 0$, and this is known in advance of the project decision. In this case, if the project generates a loss ($XC^{\alpha} - C < 0$) that exceeds the other taxable income Y, then the full amount of the project loss isn't captured for tax purposes. If we ignore the ability to carry forward losses, then the project's payoff can be divided into three regions:

- Region 1: $XC^{\alpha} - C < -Y$

  In this case, the project's losses exceed the other income Y and so the project reduces the firm's US taxes paid by $\tau_{US}Y$. In other words, the firm is unable to capture the full loss for tax purposes. The payoff on the project is $(XC^{\alpha} - C) + \tau_{US}Y$.

- Region 2: $-Y \leq XC^{\alpha} - C \leq 0$

  In this case, the project's losses are less than the other US income Y and so the full loss reduces the firm's taxable income. With the project loss, the firm's tax liability is lower by $\tau_{US}(XC^{\alpha} - C)$

- Region 3: $XC^{\alpha} - C > 0$

  In this case the project is profitable and the total after-tax payoff is

$$XC^{\alpha} - C - \tau_{US}[(1-\theta)XC^{\alpha} + p(X,C,\theta) - C] - \tau_F[\theta XC^{\alpha} - p(X,C,\theta)] \tag{10}$$

The firm chooses the scale C and the riskiness σ of the project to maximize the expected after-tax payoff. Combining the payoffs across the three regions described above, we can write the problem as

$$\begin{aligned}\max_{C,\sigma} \Big\{ &\int_{-\infty}^{(C-Y)C^{-\alpha}} (XC^{\alpha} - C + \tau_{US}Y) f(X) dX + \int_{(C-Y)C^{-\alpha}}^{C^{1-\alpha}} ((1-\tau_{US})(XC^{\alpha} - C)) f(X) dX \\ &+ \int_{C^{1-\alpha}}^{\infty} ((XC^{\alpha} - C) - \tau_{US}[(1-\theta)XC^{\alpha} - C + p(X,C,\theta)] - \tau_F[\theta XC^{\alpha} - p(X,C,\theta)]) f(X) dX \Big\},\end{aligned} \tag{11}$$

where $f(X)$ denotes the probability density function for X.

Equation (10) shows the project's payoff as the pre-tax payoff less the US and foreign tax liabilities in the case of a positive project payoff. Rearranging equation (10), we can write this as

$$(1-\tau_{US})(XC^{\alpha}-C)+(\tau_{US}-\tau_{F})(\theta XC^{\alpha}-p(X,C,\theta)). \tag{12}$$

Written this way, Equation (12) shows the value of transfer pricing. With a foreign tax rate below the US rate, the ability to transfer intangible capital at a price $p(X,C,\theta)$, less than its true market value θXC^{α}, allows the firm to save on taxes. The value of the tax savings generated by the transfer pricing is increasing in the amount of foreign operations, the difference between the US and foreign tax rates ($\tau_{US}-\tau_{F}$), and the difference in the value of the intangible capital to foreign operations and its transfer price ($\theta XC^{\alpha}-p(X,C,\theta)$).

3.3.1 Tax Options

The optimization problem in Equation (11) can equivalently be expressed as a maximization of the pre-tax profit and two tax options that characterize the firm's tax liability. In particular, the firm's problem can be written as

$$\max_{C,\sigma}\mathbb{E}\left[(XC^{\alpha}-C)+\tau_{US}Y-\tau_{US}\max\{XC^{\alpha}-C+Y,0\}+(\tau_{US}-\tau_{F})\max\{\theta XC^{\alpha}-p(X,C,\theta),0\}\right]. \tag{13}$$

Rearranging gives

$$\max_{C,\sigma}\mathbb{E}\left[(XC^{\alpha}-C)+\tau_{US}Y-\tau_{US}C^{\alpha}\max\{X-(C-Y)C^{-\alpha}),0\}+(\tau_{US}-\tau_{F})\theta C^{\alpha}\max\{X-\frac{p(X,C,\theta)}{\theta C^{\alpha}},0\}\right] \tag{14}$$

Equation (14) shows that the firm has a short position of $\tau_{US}C^{\alpha}$ units of a call option on X with strike of $(C-Y)C^{-\alpha}$ and a long position of $(\tau_{US}-\tau_{F})\theta C^{\alpha}$ units of a call on X with strike of $\frac{p(X,C,\theta)}{\theta C^{\alpha}}$. The short position in the first call will incentivize lower σ, while the long position in the second call will incentivize a higher choice of σ. The magnitudes of these competing effects will depend on number of units of each option as well as their strikes, which depend on other income Y, the choice of project scale C, and the transfer price $p(X,C,\theta)$.

In the case that the firm's other income is sufficiently large such that $Y>C$ for any choice of C, then the problem in Equation (14) simplifies to:

$$\max_{C,\sigma} \mathbb{E}\left[(1-\tau_{US})(XC^{\alpha}-C)+(\tau_{US}-\tau_F)\theta C^{\alpha}\max\{X-\frac{p(X,C,\theta)}{\theta C^{\alpha}},0\}\right]. \tag{15}$$

In this case, there is only the long position in a call option, meaning the firm has incentive to choose a larger σ than in the case of symmetric linear taxes or zero taxes.

3.4 Taxes with transfer pricing

Figure 1 plots the tax liability on the project as a function of the project's pre-tax income. In Panel A, we consider the case where the firm has positive other taxable income: $Y > 0$. In this case, the project's tax liability has two kink points, one where the project's losses equal the other income ($XC^{\alpha} - C = Y$) and the other where the project breaks even ($XC^{\alpha} - C = 0$). In the event that the project's losses exceed the other taxable income Y, these excess losses cannot be used to reduce the firm's tax liability. Thus, the project results in a pre-tax loss of $XC^{\alpha} - C$, but this loss generates a tax credit of only Y. In the case of a smaller loss, where $-Y < XC^{\alpha} - C < 0$, the full amount of the loss can be deducted from the firm's US taxes. This case, corresponding to Region 2 above, is shown by the solid green line in Panel A of Figure 1. Finally, for the case of positive profits on the project ($XC^{\alpha} - C > 0$), the solid blue line shows the taxes owed. The lower foreign tax rate τ_F, combined with the ability to transfer the intangible capital at a discounted price ($p(X, C, \theta) < \theta XC^{\alpha}$), results in a lower tax liability on the project. In contrast, if the firm were unable to transfer price at a discount, then it would effectively owe US taxes on all of its income. The dashed green line shows the taxes paid in this case where the firm cannot transfer price at a discount.

For comparison, the dashed green line shows the taxes that would be owed if the firm had to pay a tax rate of τ_{US} on all of its income. Alternatively, this dashed green line represents the tax liability on the project in the case that the firm were unable to transfer price at a discount.

Panel B of Figure 1 shows the case in which the firm has no other US taxable income

($Y = 0$). In this case, with no loss carryforward, the project's tax liability is convex in the project pre-tax income. This case of a convex tax liability is considered in Green and Talmor (1985) for a US firm with only domestic operations. They show that the firm's short position in this convex tax liability incentivizes less risk-taking and lower volatility of taxable income. In our setting, this effect is still present. In the case that $Y = 0$, the choice of C and σ are lower than $\hat{C}$ and $\hat{\sigma}$, the optimal choices in the case of zero taxes or a constant, symmetric marginal tax rate τ on both gains and losses. Panel B of Figure 1 shows that transfer pricing reduces the degree of convexity in the project tax liability. With no transfer pricing, the project's taxes would fall along the solid red line for losses ($XC^{\alpha} - C < 0$) and the dashed green line for positive project payoffs ($XC^{\alpha} - C > 0$). The solid blue line shows the case for transfer pricing. The ability to transfer price reduces the project's effective tax rate on positive profits, making the tax liability less convex than in the case without transfer pricing.

Figure 2 shows the project's after-tax payoff as a function of its pre-tax payoff, $XC^{\alpha} - C$. Panel A shows the after-tax payoff on the project for the case where the firm's other income is positive. As with Figure 1, the red, green, and blue lines correspond to Regions 1, 2, and 3, respectively. The dashed green line shows the project's after-tax payoff if the firm were unable to transfer price. Comparing this to the case of transfer pricing, represented by the solid blue line, we see that transfer pricing increases the after-tax payoff on the project. In addition, the transfer pricing changes the shape of this payoff as it generates convexity in the after-tax payoff. Panel B of Figure 2 shows the after-tax payoff for the case where the firm has no other income. Here, the after-tax payoff is concave in the pre-tax income. However, the ability to transfer price, shown by the solid blue line, reduces the convexity.

3.5 The effect of US and foreign tax rates

We now present comparative statics from the model to illustrate how the structure of tax rates and the ability to transfer price intangible capital to a low-tax jurisdiction affect the optimal choices of R&D spending C and project risk σ. Table 1 displays the parameter values used. Given our choice of $\gamma_1 = 0.1$ and $\gamma_2 = 0.7$, this implies the optimal choice of σ for the case of no taxes is given by, $\hat{\sigma} = 0.25$.

In Figures 3 and 4 we plot comparative statics for the optimal policies, C^* and σ^*, and the net present value of the project as a function of a parameter. In each case, we plot this for four cases of the firm's other income: $Y = \{0, 0.2, 1, 5\}$. Panel A of Figure 3 shows the optimal choice of risk σ^* as a function of the US tax rate τ_{US}. First, we see that the chosen amount of risk-taking, σ^*, is increasing in the firm's other income Y. This can be seen from the fact that the dotted blue line, where there is no other income ($Y = 0$), sits below the solid purple line where other income is high ($Y = 5$).

In the case of zero other income, the firm's tax liability is convex in the project's pre-tax income, as shown in Panel B of Figure 1. The firm has a short position in this convex tax liability and thus is incentivized to choose a lower σ. This convex tax liability that emerges from the limited use of losses, and the risk-averse behavior it induces, are shown by Green and Talmor (1985). In this instance, an increase in the US tax rate results in a more convex tax liability and thus a lower choice of risk. That is, the blue dotted line in Panel A is decreasing in τ_{US}. In contrast, when the firm's other income is sufficiently high, the optimal risk choice σ^* is *increasing* in the US tax rate.

Panel B of Figure 3 shows that the effect of the US tax rate on the optimal choice of project scale (C^*) is similar to its effect on the choice of project risk. For the case of zero other income (dotted blue line), R&D is slightly decreasing in the US tax rate. However, for sufficiently high other income, R&D is *increasing* in the US tax rate.

The plots in Panels A and B of Figure 3 show the counterintuitive result that a cut in the US tax rate could generate *less* R&D investment (C) and less risk-taking (σ^*). As we will show, the positive relation between the US tax rate and R&D spending and risk-taking relies on the firm's ability to transfer price intellectual property at a discounted value and having other US taxable income against which it can apply losses. Empirically, these conditions apply to many US multinational firms with R&D that generates intangible capital.

Panels D and E of Figure 3 show the optimal risk-taking and R&D expenditure as functions of the foreign tax rate τ_F. In contrast to the US rate, the risk-taking and optimal R&D are both declining in the foreign tax rate. While this declining relationship holds for all values of other income, the choices of σ^* and C^* are both increasing in the amount of other income. Panels C and F show that the project NPV is declining in both the US and foreign tax rates. However, the solid purple line of Panel C, where $Y = 5$, shows that the NPV is actually non-monotonic in the case where other income is sufficiently large. The project NPV is increasing in the amount of other income.

Figure 4 shows comparative statics for the effect of the fraction of foreign income θ and the returns to scale α on the optimal choice of risk and R&D as well as the NPV of the project. As the fraction of foreign income, θ, becomes larger, the firm optimally chooses a project of larger scale (C) and higher risk (σ). Additionally, Panel C shows that the project NPV is increasing in θ. The bottom row of Figure 4 shows an increase in α, the returns to scale parameter, increases the optimal project scale, but has a non-monotonic effect on the NPV of the project. Panel D illustrates that the effect of α on the choice of volatility depennds on the level of other income. For sufficiently high other income, riskiness is increasing in α, however for low values of other income, the risk choice can be decreasing.

3.6 The effect of the firm's other income

With Figure 5, we show more directly the effect of the firm's other income, Y, on its choice of policies and the NPV of the project. All parameters are set to the values reported in Table 1. Panel A shows that the optimal riskiness of the project is increasing nonlinearly in Y. Eventually, for a large enough value of other income ($Y > C$), the firm is able to deduct all of the project losses with certainty, and an increase in Y has no further effect on the choice of σ. Panels B and C similarly show that the optimal R&D expenditure and NPV are increasing in other income and again this relationship becomes flat for a sufficiently large amount of other income. The black dotted line in Panels A and B indicate the optimal policy for the case where the firm faces a single constant tax rate on all of its profits or losses from the project. For low other income, the firm chooses lower σ and C than these benchmark values. For higher values of Y, it chooses policies in excess of these respective benchmarks.

3.7 The effect of discounted transfer pricing

In order to show the effect of discounted transfer pricing, we compare the optimal policies for scale and riskiness in a case where the firm can transfer price at a discounted price to a case where it has to transfer the IP at the market value. In particular, we compare a case where the discounted transfer price is set to θC to a case where the IP is transferred at the market value of $\theta X C^{\alpha}$. Figure 6 compares the optimal choice of risk and project scale, as well as the project NPV for these two cases as a function of the US tax rate. Each row of panels correspond to a different value of the firm's other income Y. In each panel, the solid blue line depicts the optimal policy or NPV for the case of discounted transfer pricing and the dashed red line displays the case of no discount on the transfer price. Panels A, B, and C, show that in the case where the firm has no other income ($Y = 0$), the choice of risk and project scale, as well as the NPV, are slightly decreasing in the US tax rate for both cases. However, the second row (Panels D and E) show that with a small amount of other income Y the effect of the US tax rate on optimal policies has opposite signs for the two transfer pricing cases. When the firm is able to transfer price at a discount, the optimal scale and riskiness are slightly *increasing* in the US tax rate. However, when discounted transfer pricing is not allowed and the transfer price must be set to the market value, a higher US tax rate results in a slightly lower choice of project riskiness and scale.

The bottom two rows of Figure 6 show that when the firm has significant other income ($Y = 1$ and $Y = 5$), optimal riskiness and project scale increase significantly the US tax rate when the firm is able to transfer price at a discount ($p = \theta C$). In contrast, when the firm cannot transfer price at a discount, the choice of risk and project scale are unaffected by a change in the US tax rate. Panels I and L of the figure show that while an increase in the US tax rate reduces the NPV in all cases, the effect is significantly mitigated when a firm can transfer price at a discount compared to the case where it cannot.

3.8 The choice of project risk

We assume that the firm can jointly choose the project's scale C as well as its riskiness σ. To understand how these two choices interact, we consider an alternative case of the model where the riskiness σ is fixed and the firm can only choose the choice of project scale C. For the case of fixed riskiness, we set σ to $\hat{\sigma}$, the value that maximizes the expected value of X, given by Equation (5), while all other parameters are kept at their respective values reported in Table 1. The left column of Figure 7 plots the optimal choice of σ in the benchmark model as a function of the US tax rate for four different values of other income Y. In each panel, the black dotted line shows the value of $\hat{\sigma}$ for comparison. With no other income ($Y = 0$), Panel A shows that the optimal choice of risk is below and decreasing in the US tax rate. However, as the other income becomes larger, the optimal riskiness is higher than $\hat{\sigma}$ and increasing in the US tax rate.

The center column of Figure 7 compares the optimal choice of project scale C for the case where the firm jointly chooses the project risk (solid blue line) to the case where the project risk is fixed at $\hat{\sigma}$ (dashed red line). Moving down this middle column, we see that the firm's other income has an important effect on the relationship between the optimal scale in these two cases. In Panel B, with no other income, the firm would like to choose a value of σ less than $\hat{\sigma}$. When it is unable to do so, it invests less in the project relative to the case where it is free to choose the risk. As the US tax rate increases, the project scale declines significantly for the fixed risk case, whereas it is roughly unchanged when the riskiness can be jointly chosen. Panel J of the figure shows that with sufficiently large other income, there is a complementarity in the project scale and riskiness as functions of the US tax rate. As the US tax rate increases, the optimal project scale increases at a higher rate when the project risk can be jointly chosen than in the case of fixed project risk.

4 Data

4.1 Data description and sample selection

We construct our sample from the Compustat North America Fundamentals Annual data set. Into these data we merge the Compustat Historical Segments data set. The 1997 implementation of FAS 131 changed how publicly listed US firms reported their foreign business segments (Albertus, Bird, Karolyi, and Ruchti (2018)). Specifically, firms began reporting discontinuously more geographic segments starting in 1998. As a result, our sample begins in 1998. It ends in 2015, the last year comprehensive segment data were available at the time of writing.

We drop from the sample firms in the financial (NAICS 52-53), real estate (NAICS 53-54), and public administration (NAICS 92-99) industries, as they may be subject to unique regulatory regimes. In some cases, firmss' reported segment data correspond to regions, not countries. Since we wish to measure firms' exposure to foreign tax rates at the country-year level, we drop these regional segments. The result is a firm-country-year level panel, where each segment provides the sales by the firm in a specific country.

Into this panel we merge country-year level corporate income tax rates. To obtain as comprehensive a set of corporate income tax rates as possible, we combine data from several sources, including KPMG's Corporate and Indirect Tax Rate Surveys, the University of Michigan's World Tax Database, and the Tax Foundation. When combined, these sources offer nearly complete coverage over the sample period.

On this data we impose two restrictions. First, since the tax convexity at the center of this paper can only emerge when a firm has foreign exposure, we require that at least 10% of a firm's consolidated sales are reported outside the US. Second, to ensure that the firm can use the deductions associated with undertaking risky projects in the US, we require firms have positive net income. This results in a sample of 10,639 firm-year observations.

4.2 Variable construction

The key variables in the empirical analysis are the measure of risk taking and the degree of the tax convexity faced by the firm. Their construction is described here. For a comprehensive set of variable definitions, see Appendix A.

$Risk$, the volatility of firms' cash flows, is the main response variable. We construct this variable from firms' consolidated financial data.[9] We begin by calculating the ratio of EBITDA to assets for each firm-year. Then we calculate the standard deviation of this quantity for the current and three following years. If the ratio of EBITDA to assets nonmissing for fewer than three of these years, we set $Risk$ to be missing.

$TaxRate$, each firm's weighted average tax rate, is the key predictor variable. To construct this variable, we first calculate each firm's US sales as the difference between its consolidated sales and the sum of its sales across its foreign segments. We then obtain the firm's average statutory tax rate by weighting the tax rate for each country in which it has sales by the fraction of the firm's consolidated sales in that country. We use statutory tax rates to mitigate endogeneity concerns, following Dharmapala (2014).[10] Hence if $SalesFrac_{i,c,t}$ is the fraction of firm i's consolidated sales in country c in year t and $TaxRate_{c,t}$ is the country's tax rate, then

$$TaxRate_{i,t} = \sum_{c} SalesFrac_{i,c,t} \times TaxRate_{c,t}. \tag{16}$$

Conceptually, relative to the model, $TaxRate$ combines both the difference in the US and foreign tax rates ($\tau_{US} - \tau_F$) and the fraction of the firm's operations that are abroad (θ). Over the sample period, the US tax rate was constant at 35%. As a result, variation in the difference between the US and foreign tax rates is determined by variation in the foreign tax rate.

[9] The construction follows John, Litov, and Yeung (2008).

[10] A possible alternative would be firms' effective tax rates. These are directly determined by firm policy however, and may thereby exacerbate potential endogeneity problems.

4.3 Descriptive statistics

Table 2 display descriptive statistics. Each variable is winsorized at the 1% and 99% thresholds of its empirical distribution to mitigate the influence of outliers. For financial variables, we convert nominal values to 2012 values using the GDP deflator.

The mean and standard deviation of the primary response variable, $Risk$, are 0.069 and 0.124. The corrsponding values for the $TaxRate$ are 0.314 and 0.035. Sample firms have substantial foreign exposure. On average, they generate roughly 48% of their sales abroad. Alternatively, firms have segments in 2.3 foreign countries, on average.

5 Empirical evidence

5.1 Risk taking and taxes analysis

5.1.1 Regression specification

We begin by looking at the association between the convexity in a firm's tax rate, as proxied by $TaxRate$ and its cash flow volatility, as proxied by $Risk$. Specifically, we estimate the following regression specification with ordinary least squares, where i and t index firms and years.

$$Risk_{i,t} = \beta \times TaxRate_{i,t} + \gamma' X_{i,t} + \alpha_k + \epsilon_{i,t} \tag{17}$$

We are parsimonious in our use of controls, indicated by $X_{i,t}$, to avoid introducing endogeneity that may bias the estimate of β. In particular, we control for firm $Size$ and Age. In section 5.1.3, we show our results are robust to measuring firm size with either sales (our baseline) or assets.

We also include industry fixed effects, represented by α_k, to address potential selection concerns. For example, technology firms may tend to have both relatively risky cash flows and proportionally larger revenues in low tax foreign jurisdictions such as Ireland. Not accounting for this variation would result in a biased point estimate associated with $TaxRate$.[11]

[11]Indeed, the bias postulated here would go in the same direction as the economic effect we hypothesize.

Specifically, we used fixed effects corresponding to two-digit NAICS codes.

Throughout the paper, we cluster standard errors by firm.

5.1.2 Results

Table 6 contains estimates of the association between taxes and risk taking. In column one we omit controls and fixed effects. The correlation between $TaxRate$ and $Risk$ is negative and statistically significant. The effect is modest in economic terms, with a one standard deviation (3.5 percentage point) lower tax rate associated with a roughly 1/13th standard deviation (93 basis point) increase in $Risk$.

In column two we add controls for firm size and age. The point estimate on $TaxRate$ falls in magnitude while remaining statistically significant. This is driven by the negative correlation between $Risk$ and $Size$ and the positive correlation between $Size$ and $TaxRate$, as indicated in Table 3.

In column three we again omit the controls but now add industry fixed effects. The coefficient on $TaxRate$ is between its values in columns one and two and remains statistically significant.

Finally, in column four, we include both the controls and the fixed effects. The point estimate on $TaxRate$ falls somewhat in magnitude to -0.124, although it remains statistically significant. We refer to the estimates in this column as our baseline tax-risk taking estimates.

5.1.3 Robustness checks

Next, in Table 7, we turn to the robustness of the baseline taxes-risk taking result. We begin, in column one, by modifying our calculation of $Risk$. The modification follows one of the alternative measures described in John et al. (2008). Specifically, we first calculate the average ratio of EBITDA to assets by year. We then subtract this value from the ratio of EBITDA to assets at the firm-year level before calculating each firm's adjusted cash flow volatility. Arguably, this additional adjustment better isolates firms risk-taking choices from broader economic fluctuations. The resulting point estimate corresponding to $TaxRate$ is marginally higher than the baseline estimate and remains statistically significant.

The calculations of both the key variables, *Risk* and *TaxRate*, incorporate ratios with denominators that could take zero values. Hence a natural concern is that our results are driven by outliers and are therefore not representative of the typical firm. It is for this reason that we winsorize each variable at the 0.5% and 99.5% thresholds of its empirical distribution. In column two, we confirm that these thresholds are adequate. In particular, we winsorize each variable at the 5% and 95% thresholds and re-estimate the baseline specification. Again, the coefficient on *TaxRate* is similar in magnitude to the baseline and remains statistically significant.

In the baseline specification, we use the natural logarithm of one plus firm sales as a measure of firm size. We take this approach because assets appears in our calculation of *Risk*. A concern may be that including the same variable on both sides of equality in a regression specification may result in biased estimates. Nevertheless, in column three, we use the natural logarithm of one plus assets to measure firm size. The point estimate on *TaxRate* is slightly higher and again is statistically significant. If using assets to measure size biases the estimates, its effect is small.

5.2 Major tax changes

Thus far, we have presented evidence that taxes and risk taking are negatively correlated. The strength of the above analysis is that it relies on all the variation in *TaxRate* – both a firm's exposure to foreign tax rates and changes in the tax rates themselves – that we hypothesize should influence corporate risk taking. A drawback of this approach, however, is that it is difficult to ascertain whether firms' choices of *Risk* are *caused* by variation in *TaxRate*. That is, there is no clear way to evaluate whether variation in *TaxRate* is plausibly exogenous.

To make some headway on this dimension, we shift our focus to instances when firms are exposed to major tax cuts, following Giroud and Rauh (2015) and Akcigit, Grigsby, Nicholas, and Stantcheva (2018).[12] We define a major tax cut as an instance when a country reduces its tax rate by at least 10 percentage points and a sample firm has at least 10% of its consolidated sales in that country. Table 5 lists the countries, years, and magnitudes of these changes. We then define $MajorTaxCut$ as an indicator variable that equals one once a firm is subject to such a tax cut. If a firm is subject to more than one major tax cut, we omit observations for that firm in the year the second major tax cut occurs and thereafter.

With this new predictor variable, we estimate the following equation using ordinary least squares.

$$Risk_{i,t} = \beta \times MajorTaxCut_{i,t} + \gamma' X_{i,t} + \alpha_k + \epsilon_{i,t} \tag{18}$$

As in equation 17, i and t index firms and years, $X_{i,t}$ represents controls for $Size$ and Age, and α_k represents industry fixed effects. The results are in Table 8. We indeed find that major tax cuts are associated with increases in risk taking. Because $MajorTaxCut$ is an indicator variable, the sign is arguably more easily interpreted than the magnitude. Nevertheless, a firm exposed to a major tax cut increases $Risk$ by 1.1%. Recall the mean for this variable is 6.9%.

Next we turn to the dynamics of firms' reponses to $MajorTaxCut$.

$$\begin{aligned} Risk_{i,t} = {} & \beta_1 \times \mathbb{1}^{MTC}_{i,t-2} + \beta_2 \times \mathbb{1}^{MTC}_{i,t-1} + \beta_3 \times \mathbb{1}^{MTC}_{i,t} \\ & + \beta_4 \times \mathbb{1}^{MTC}_{i+1,t} + \beta_5 \times \mathbb{1}^{MTC}_{i+2+,t} + \gamma' X_{i,t} + \alpha_k + \epsilon_{i,t} \end{aligned} \tag{19}$$

This specification mirrors equation 18, except $MajorTaxCut_{i,t}$ has been disaggregated over time. Specifically, $\mathbb{1}^{MTC}_{i,t}$ is an indicator variable that equals one in the year a tax major cut occurs. $\mathbb{1}^{MTC}_{i,t-2}$, $\mathbb{1}^{MTC}_{i,t-1}$, $\mathbb{1}^{MTC}_{i,t+1}$ are defined similarly. $\mathbb{1}^{MTC}_{i,t+2+}$ is $MajorTaxCut_{i,t}$ lagged twice.

We find that $\hat{\beta}_1$ and $\hat{\beta}_2$ are insignificant, consistent with the notion firms do not anticipate

[12] Our focus on tax *cuts* instead of tax *changes* more generally is due to the fact that there were no major tax increases over the sample period.

major tax cuts. This, in turn, supports the interpretation that $MajorTaxCut$ is exogenous with respect to $Risk$.

In contrast, we find that $\hat{\beta}_3$, $\hat{\beta}_4$, and $\hat{\beta}_5$ are positive and statistically significant. Firms appear to adjust their risk-taking promptly in response to changes in the convexity of their tax schedule. Moreover, the response does not appear to substantially increase or decrease in subsequent years. The magnitudes of $\hat{\beta}_3$, $\hat{\beta}_4$, and $\hat{\beta}_5$ are near that for the point estimate associated with $MajorTaxCut$. These results suggest that changes in the convexity of a firm's tax schedule cause the firm to change the riskiness of the projects it undertakes.

6 Conclusion

This paper studies the role of transfer pricing in corporate risk taking. We use a model to show that the differential tax rates for profits in different countries combined with transfer pricing strategies can generate an asymmetry in the after-tax gains and losses of projects that produce intangible capital. This asymmetry can generate convexity in the payoffs to these projects. As a result, US multinationals face the incentive to undertake riskier and larger scale projects.

We construct a panel of US firms with foreign operations for the period 1998–2015 to test our predictions. Consistent with the model, we find that the tax convexity is positively associated with risk taking. This finding is robust to potential selection concerns and holds when we rely on major foreign tax changes as a source of variation in the tax convexity. Dynamic results indicate these changes are unanticipated by firms, mitigating the concern that our estimates are subject to endogeneity bias. In sum, our results suggest that the difference in tax rates US multinationals encounter domestically and abroad, in combination with their ability to transfer price intangible capital out of the US, can influence their risk taking activities.

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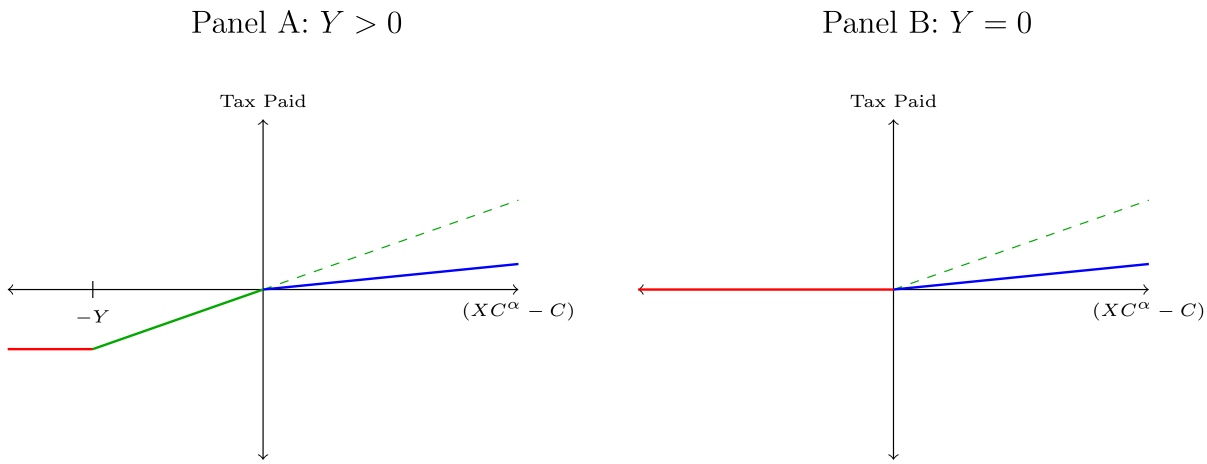

Figure 1: **Taxes paid as a function of project income.** The figure plots the taxes paid on the project as a function of the pre-tax project income $XC^{\alpha} - C$. Panel A shows the tax liability for the case in which the firm's other income, Y, is positive. Panel B shows the case in which the firm has no other taxable income ($Y = 0$). The red solid line corresponds to Region 1, the green solid line to Region 2, and the blue solid line to Region 3, described in the text in Section 3.3. The green dashed line is the tax liability if the firm had only domestic operations, or, alternatively if it had to transfer price at the market value.

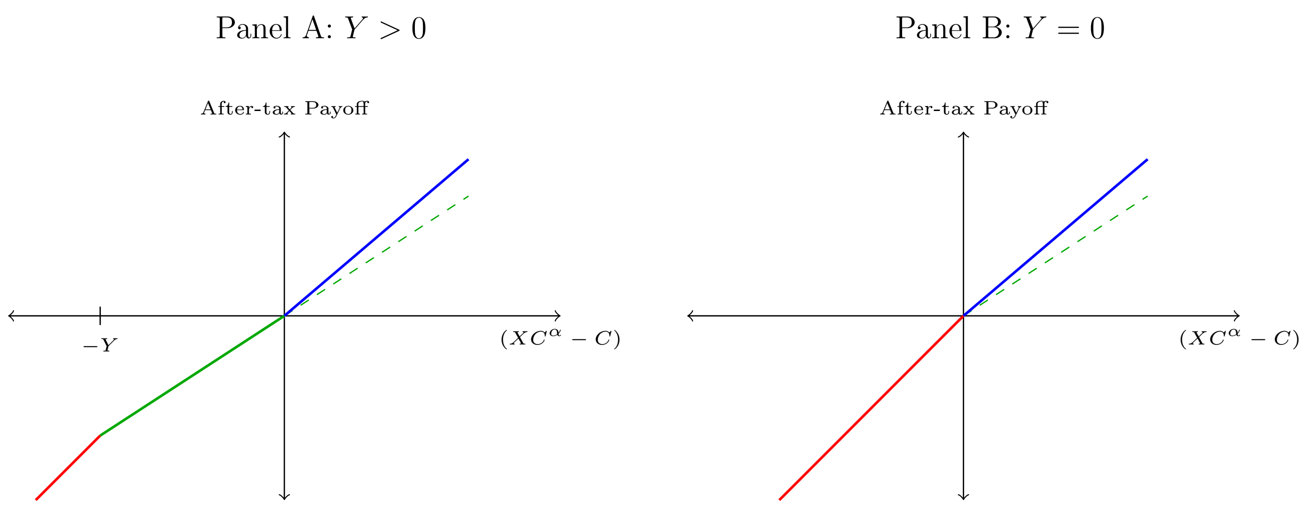

Figure 2: **Project after-tax payoff** The figure plots the after-tax payoff on the project as a function of the pre-tax project income $XC^{\alpha} - C$. The solid red, green, and blue lines correspond to Regions 1, 2, and 3, respectively, described in Section 3 of the text. The dashed green line indicates the after-tax payoff the firm would have if it faced the τ_{US} tax rate on all of its profits.

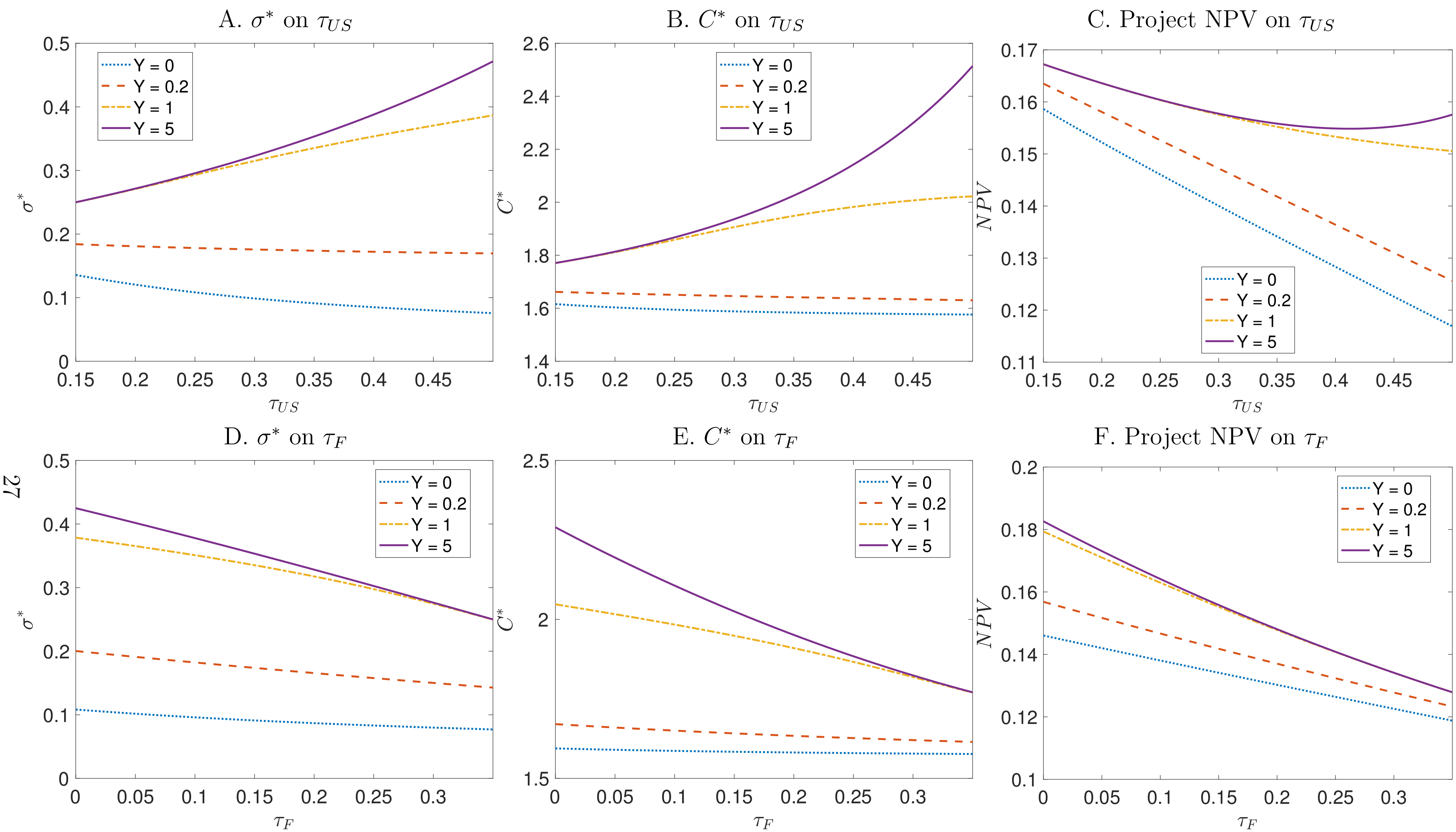

Figure 3: **Comparative statics for optimal policies and NPV.** The figure plots the optimal choice of scale C^* (left column), risk σ^* (center column), and project NPV (right column) as a function of the US tax rate τ_{US} (top row) and the foreign tax rate τ_F (bottom row) for four different levels of other income: $Y = \{0, 0.2, 1, 5\}$. All other parameters are fixed at their value reported in Table 1.

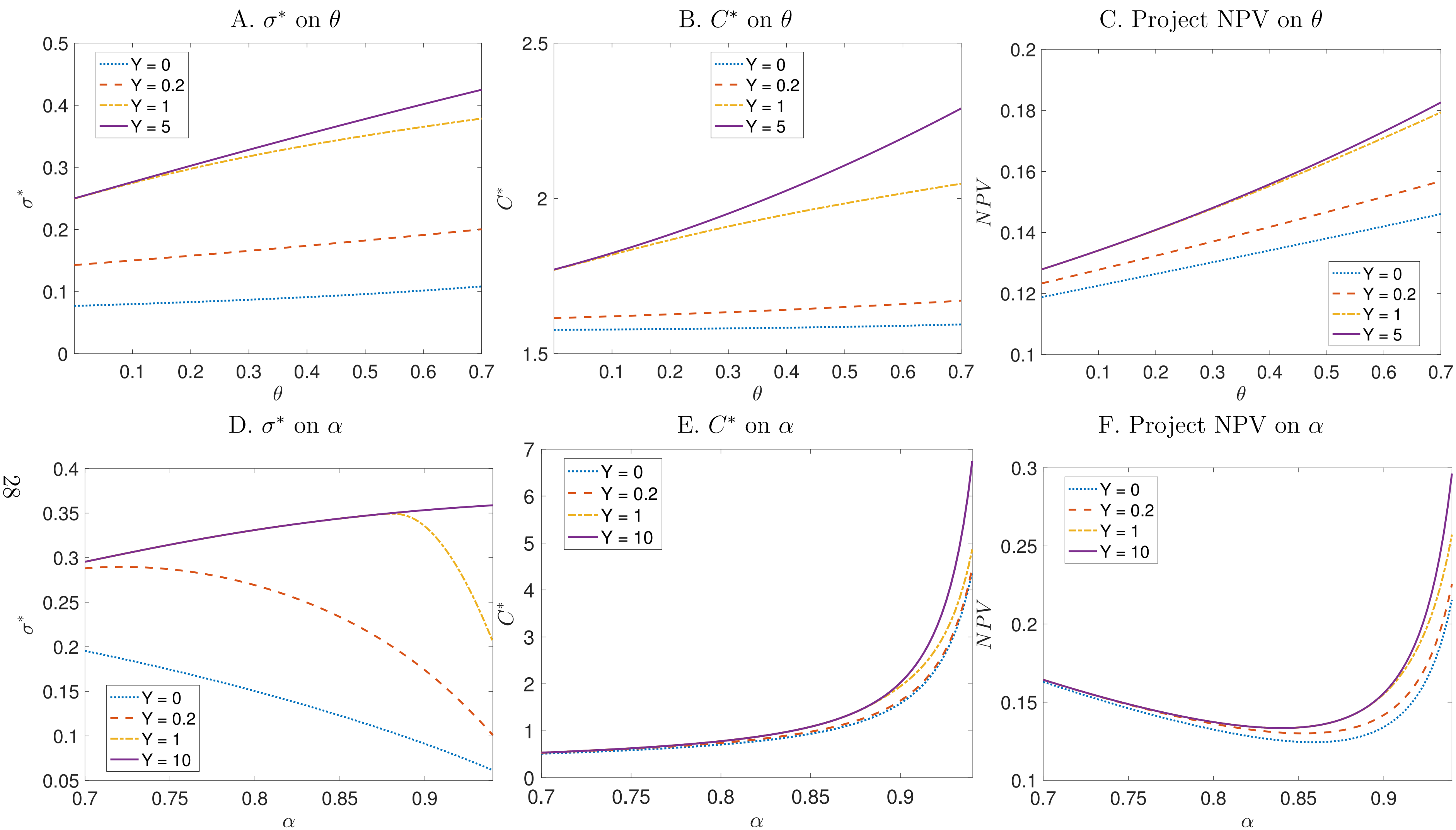

Figure 4: **Comparative statics for optimal policies and NPV.** The figure plots the optimal choice of scale C^* (left column), risk σ^* (center column), and project NPV (right column) as a function of the fraction of foreign income θ (top row) and the returns to scale parameter α (bottom row) for four different levels of other income Y. All other parameters are fixed at their value reported in Table 1.

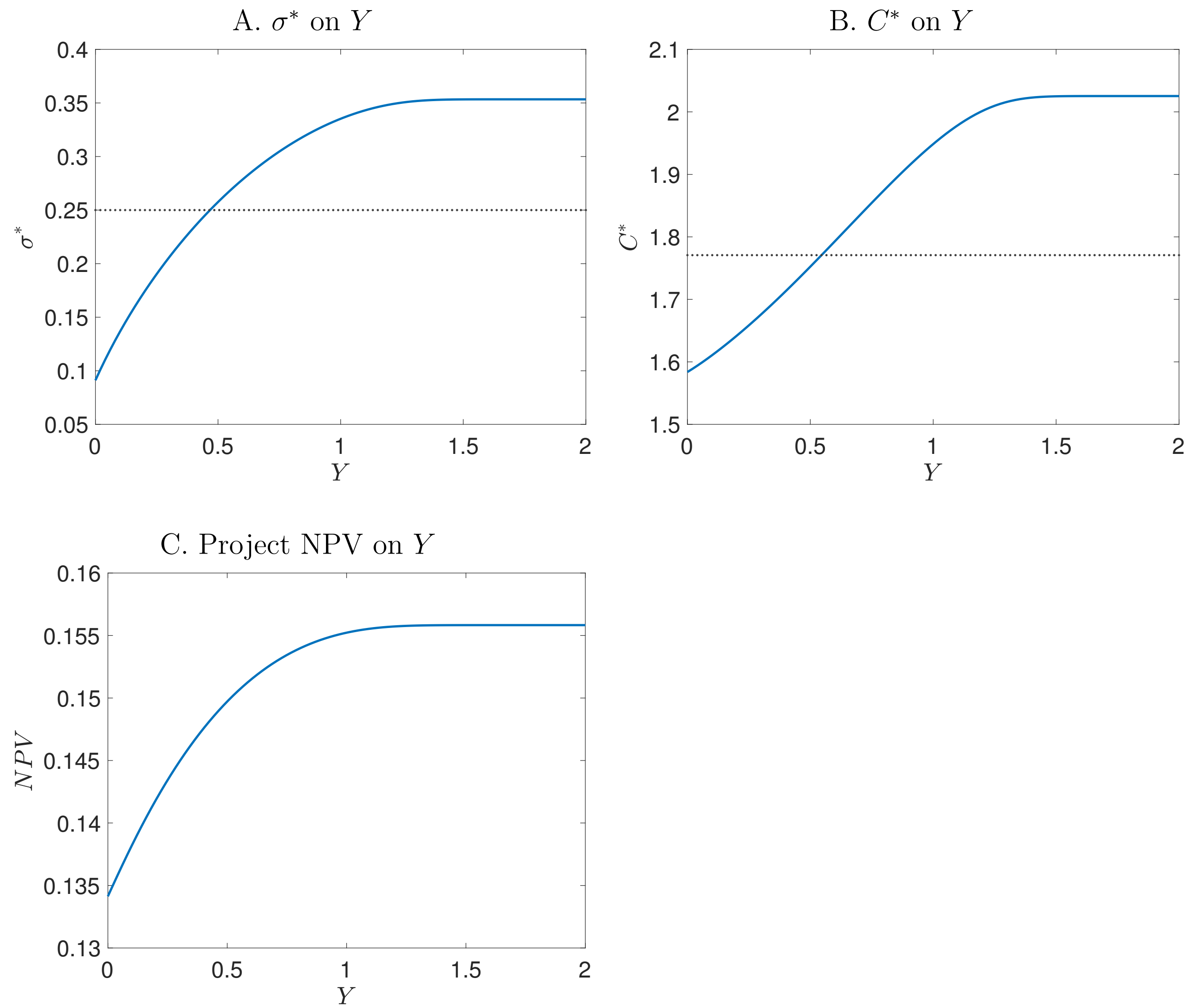

Figure 5: **Optimal policies and NPV on other income.** The figure plots the optimal choice of risk σ^* (Panel A), scale C^* (Panel B), and project NPV (Panel C) as a function of the firm's other income Y. In Panels A and B, the dotted black line corresponds to the optimal choice of σ and C, respectively, for the case in which the firm faces a single symmetric tax rate τ on all of its profits or losses.

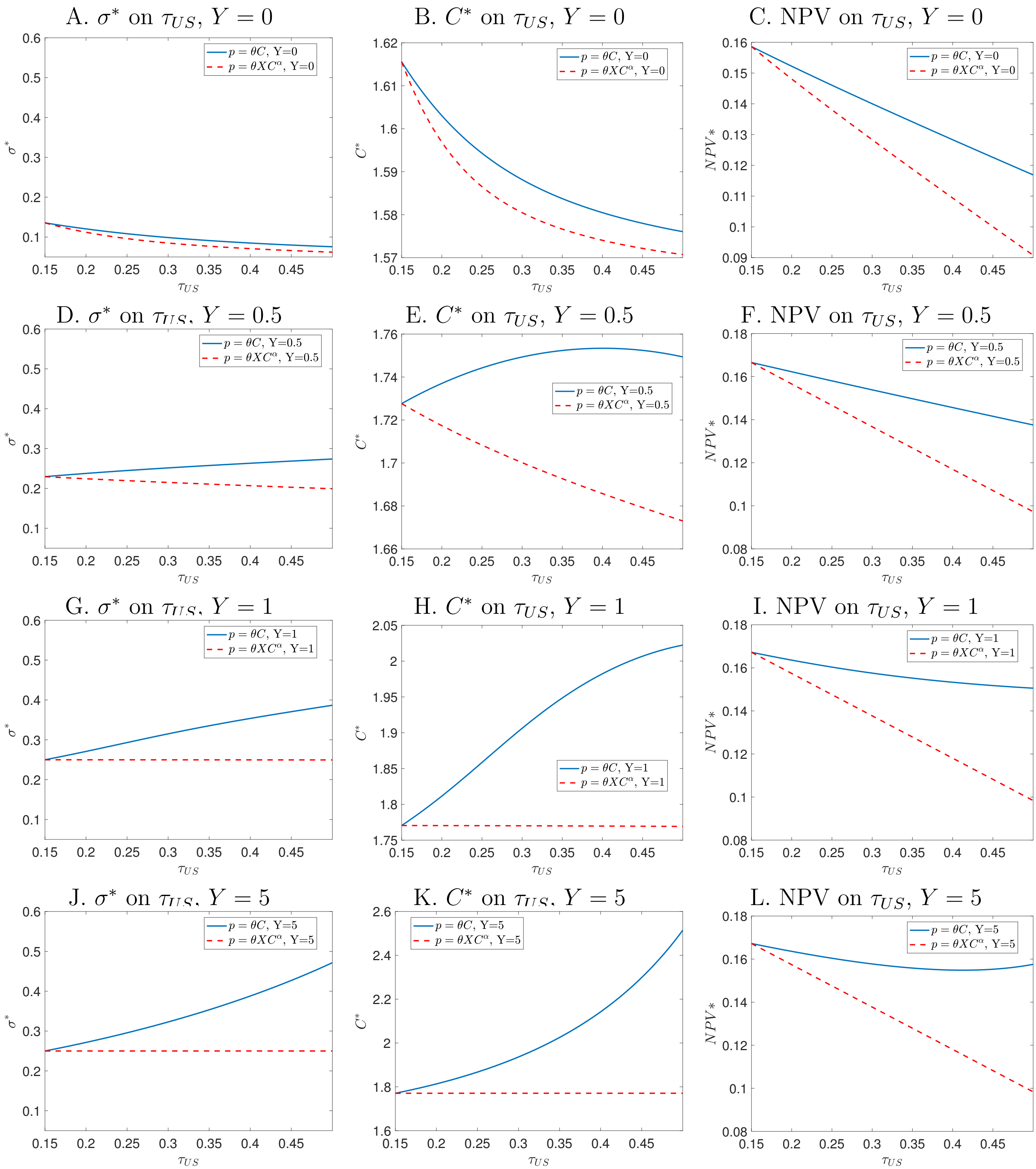

Figure 6: **The Effect of Discounted Transfer Pricing.** This figure plots the optimal choice of risk σ^* (left column), optimal choice of R&D C^* (center column), and the project NPV (right column) as a function of the US tax rate. Each row corresponds to a different value of the firm's other income $Y = \{0, 0.5, 1, 5\}$. In each panel, the solid blue line shows the policy when the firm can transfer its intangible capital at a discounted price of θC. The red dashed line shows the policy choice if the firm were not allowed to transfer price at a discount and instead had to transfer the intangible capital at a price equal to its market value, $\theta X C^{\alpha}$.

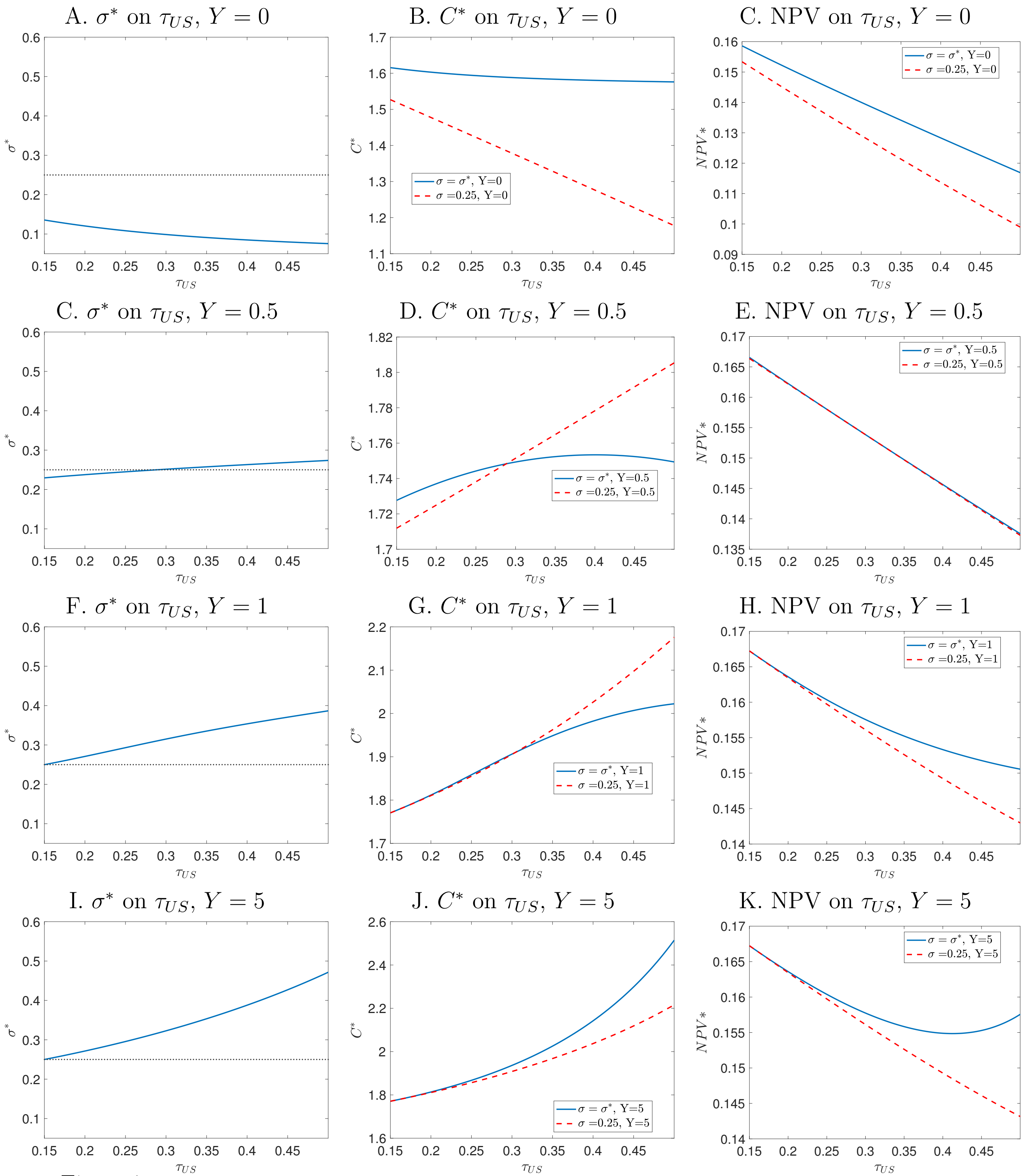

Figure 7: **The Effect of Risk Choice σ.** The left column shows the optimal choice of project risk σ^* (solid blue line) as a function of the US tax rate. The dotted black line shows $\hat{\sigma}$, the value that maximizes the expected pre-tax payoff. (See Section 3 for further discussion). The center column and right column display the optimal R&D choice (C^*) and project NPV as functions of the US tax rate. The solid blue line displays the optimal choice of R&D and project NPV for the case where the firm is free to choose project risk σ. The dashed red line shows these for the case where the firm cannot choose σ and instead it is fixed at $\hat{\sigma}$. Each row of the figure corresponds to a different value of the firm's other income, $Y = \{0, 0.5, 1, 5\}$.

Table 1: **Model parameter values**

Parameter	Value
$\overline{\mu}$	0.15
γ_1	0.1
γ_2	0.7
α	0.9
θ	0.4
Y	0.8
τ_{US}	0.35
τ_F	0.15

The table displays the benchmark parameter values used in the model. See Section 3 for more details. $\overline{\mu}$, γ_1, and γ_2 determine the mean of the project's productivity as a function of the choice of risk σ. Specifically, $\log(X) \sim \mathcal{N}(\mu(\sigma), \sigma^2)$ where

$$\mu(\sigma) = \overline{\mu} + (\gamma_1 - \gamma_2\sigma)\sigma.$$

α is the returns to scale parameter for the project, θ is the fraction of the firm's operations that are foreign, Y is the firm's other taxable income, τ_{US} is the US corporate tax rate, and τ_F is the foreign corporate tax rate. Unless stated otherwise, we set the discounted transfer price to θC.

Table 2: **Descriptive statistics**

	Obs.	Mean	Std. dev.
$Risk$	10,639	0.069	0.124
$TaxRate$	10,639	0.314	0.035
$Size$	10,639	6.96	2.14
Age	10,639	2.48	0.98
$FSaleFrac$	10,639	0.485	0.323
$SegCount$	10,639	2.31	2.49

This table contains descriptive statistics for the sample. $Risk$ measures a firm's cash flow volatility for the current and three future years. $TaxRate$ is a firm's average tax rate, as weighted by the global distribution of its sales. Detailed definitions for both these variables are contained in section 4.2. $Size$ is the natural logarithm of one plus sales. Age is the natural logarithm on one plus the number of years since the firm first appears in the data. $FSaleFrac$ is the ratio of the firm's foreign sales to its consolidated sales. $SegCount$ is the number of a firm's foreign geographic segments. All financial variables are denominated in millions of 2012 US dollars. Each variable is winsorized at the 1% and 99% thresholds of its empirical distribution to mitigate the influence of outliers.

Table 3: **Correlation matrix**

	$Risk$	$TaxRate$	$Size$	Age	$FSaleFrac$	$SegCount$
$Risk$	1.000					
$TaxRate$	-0.063	1.000				
$Size$	-0.153	0.119	1.000			
Age	-0.041	0.109	0.323	1.000		
$FSaleFrac$	0.061	-0.602	-0.146	-0.337	1.000	
$SegCount$	-0.002	-0.055	0.107	0.138	-0.018	1.000

This table displays the correlations between the main variables used in the analysis. $Risk$ measures a firm's cash flow volatility for the current and three future years. $TaxRate$ is a firm's average tax rate, as weighted by the global distribution of its sales. Detailed definitions for both these variables are contained in section 4.2. $Size$ is the natural logarithm of one plus sales. Age is the natural logarithm on one plus the number of years since the firm first appears in the data. $FSaleFrac$ is the ratio of the firm's foreign sales to its consolidated sales. $SegCount$ is the number of a firm's foreign geographic segments.

Table 4: **Foeign countries with greatest activity**

Panel A: 1998		
Rank	Country	Sales
1	Canada	64,469
2	Japan	59,033
3	Germany	36,775
4	France	33,876
5	Brazil	30,251
6	China	27,158
7	Venezuela	26,656
8	United Kingdom	20,169
9	Mexico	16,351
10	South Africa	11,252
Panel B: 2015		
Rank	Country	Sales
1	Japan	516,303
2	China	399,365
3	Germany	384,515
4	United Kingdom	334,309
5	Canada	282,249
6	Brazil	252,206
7	France	110,270
8	Russia	103,029
9	Italy	79,394
10	Mexico	59,619

This table lists the 10 countries with the greatest activity at the beginning (Panel A) and end (Panel B) of the sample period.

Table 5: **Major foreign tax cuts**

Country	Year	Change
Italy	1998	-16.2%
Romania	2001	-13.0%
Germany	2001	-15.8%
Iceland	2002	-12.0%
Russia	2002	-19.0%
Cyprus	2003	-13.0%
Paraguay	2005	-10.0%
Paraguay	2006	-10.0%
Saudi Arabia	2006	-10.0%
Turkey	2006	-10.0%
Germany	2008	-10.6%
Qatar	2010	-25.0%
Gibralter	2011	-12.0%
Yemen	2011	-15.0%

This table lists foreign tax cuts that exceed 10 percentage points and occur in a country in which a sample firm has a segment comprising at least 10% of the firms' consolidated sales. No tax increases satisfied analogous requirements. During the sample period, the US tax rate was constant at 35%.

Table 6: **Risk taking and taxes are negatively related**

	$Risk_{i,t}$			
	(1)	(2)	(3)	(4)
$TaxRate_{i,t}$	-0.261***	-0.171**	-0.217**	-0.124*
	(0.098)	(0.084)	(0.087)	(0.072)
$Size_{i,t}$		-0.013***		-0.013***
		(0.003)		(0.003)
$Age_{i,t}$		-0.001		-0.001
		(0.002)		(0.002)
Fixed effects	No	No	Yes	Yes
Adj. R^2	0.002	0.019	0.006	0.022
N	10,639	10,639	10,639	10,639

This table presents results on the association between the tax convexity and risk taking. *Risk* measures a firm's cash flow volatility for the current and three future years. $TaxRate$ is a firm's average tax rate, as weighted by the global distribution of its sales. Detailed definitions for both these variables are contained in section 4.2. *Size* is the natural logarithm of one plus sales. *Age* is the natural logarithm on one plus the number of years since the firm first appears in the data. Fixed effects are by two-digit NAICS codes. We refer to column four as the baseline estimates. Standard errors are clustered by firm. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 7: **The risk taking results are robust**

	$Risk_{i,t}$		
	(1)	(2)	(3)
$TaxRate_{i,t}$	-0.161**	-0.105**	-0.149**
	(0.071)	(0.041)	(0.075)
$Size_{i,t}$	-0.010***	-0.010***	-0.015***
	(0.003)	(0.001)	(0.003)
$Age_{i,t}$	0.003	-0.003***	-0.000
	(0.002)	(0.001)	(0.002)
Fixed effects	Yes	Yes	Yes
Adj. R^2	0.012	0.112	0.026
N	10,639	10,639	10,638

This table verifies the robustness of the negative association between taxes and risk taking. In column one we demean ratio of EBITDA to assets by year, following John, Litov, and Yeung (2008). In column two we winsorize each variable at the 5% and 95% thresholds of its empirical distribution. In column three we measure *Size* as one plus the natural logarithm of assets. Fixed effects are by two-digit NAICS codes. Standard errors are clustered by firm. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 8: **Major foreign tax cuts and their dynamics**

	$Risk_{i,t}$	
	(1)	(2)
$MajorTaxCut_{i,t}$	0.011**	
	(0.005)	
$\mathbb{1}^{MTC}_{i,t-2}$		-0.002
		(0.004)
$\mathbb{1}^{MTC}_{i,t-1}$		0.004
		(0.004)
$\mathbb{1}^{MTC}_{i,t}$		0.014***
		(0.005)
$\mathbb{1}^{MTC}_{i,t+1}$		0.010*
		(0.006)
$\mathbb{1}^{MTC}_{i,t+2+}$		0.011***
		(0.005)
Size	-0.016***	-0.016***
	(0.004)	(0.004)
Age	-0.001	-0.001
	(0.004)	(0.004)
Fixed effects	Yes	Yes
Adj. R^2	0.018	0.017
Observations	9,292	9,292

This table examines the effects on risk taking of major foreign tax cuts. *Risk* measures a firm's cash flow volatility for the current and three future years; a detailed definition for both this variable is contained in section 4.2. $MajorTaxCut_{i,t}$ is an indicator variable that equals one once a tax cut that exceeds 10 percentage points occurs in a country in which a sample firm has a segment comprising at least 10% of the firms' consolidated sales. $\mathbb{1}^{MTC}_{i,t}$ is an indicator variable that equals one in the year a tax major cut occurs. $\mathbb{1}^{MTC}_{i,t-2}$, $\mathbb{1}^{MTC}_{i,t-1}$, $\mathbb{1}^{MTC}_{i,t+1}$ are defined similarly. $\mathbb{1}^{MTC}_{i,t+2+}$ is $MajorTaxCut$ lagged twice. *Size* is the natural logarithm of one plus sales. *Age* is the natural logarithm on one plus the number of years since the firm first appears in the data. Fixed effects are by two-digit NAICS codes. Standard errors are clustered by firm. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

A Variable definitions

- *Age*: The natural logarithm of one plus the number of years since the firm first appears in the data.
- *FSaleFrac*: The ratio of a firm's foreign sales to its consolidated sales.
- *Risk*: The riskiness of firms' cash flows. See section 4.2 for a detailed definition.
- *SegCount*: The number of geographic segments corresponding to foreign countries.
- *Size*: The natural logarithm of one plus sales.
- *TaxRate*: The weighted-average tax rate. See section 4.2 for a detailed definition.