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RISKY BUSINESS: POLICY UNCERTAINTY AND INVESTMENT

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# Risky Business: Policy Uncertainty and Investment

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## Abstract

We generalize previous results on the effect of non-linear taxation on investment, showing that investment decisions are distorted when tax rates are correlated with marginal productivity. We demonstrate this result in a simple theoretical framework, which can also explain some well known results on the effects of tax progressivity and tax asymmetry on investment. Time-series estimates for the post-WW2 era suggest a negative correlation between effective tax rates and total factor productivity in the U.S., yielding an effect on firm investment equivalent to an investment subsidy of around 1 percent.

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# 1 Introduction

We develop a simple yet general framework that can explain several empirically documented effects of non-linear tax policies on investment, as well as shed light on some previously unexplored effects of policy uncertainty. We highlight the impact of uncertainty on investment and provide an empirical estimate of this impact. We find that the negative correlation between productivity shocks and tax burden provides a stimulus to investment equivalent to a subsidy of around 1%.

To fix ideas, let us start with a very simple model. Suppose that a firm aiming to maximize expected after-tax profits must pick how much to invest,  $x \geq 0$ , while it faces an uncertain productivity shock  $\epsilon$  and an uncertain tax rate on its profits,  $\tau$ .

$$\max_{x \geq 0} \mathbb{E} \left[ (1 - \tau)(\epsilon f(x) - x) \right],$$

where the production function  $f(\cdot)$  satisfies  $f''(\cdot) < 0 < f'(\cdot)$ . The optimal choice for the firm,  $x^*$ , will satisfy:

$$f'(x^*) = \frac{1 - \bar{\tau}}{(1 - \bar{\tau})\bar{\epsilon} - Cov(\epsilon, \tau)}, \tag{1}$$

where  $\bar{\epsilon}$  and  $\bar{\tau}$  indicate  $\mathbb{E}[\epsilon]$  and  $\mathbb{E}[\tau]$ , respectively. There are three main takeaways from equation 1. First, if  $Cov(\epsilon, \tau) = 0$ , then the choice of the firm will be identical to the efficient choice it would have made in the absence of taxation, namely  $x_0$  satisfying  $f'(x_0) = 1/\bar{\epsilon}$ .

Second, if  $Cov(\epsilon, \tau) > 0$ , then  $x^* < x_0$ . A positive correlation between productivity and tax rate will dampen investment, for the simple reason that facing a higher marginal tax rate when profits are higher means facing a higher tax rate on average. One way in which this correlation can materialize is through progressivity in the tax system or tax law asymmetries. In their study of how proportional income taxation affected risk-taking, Domar and Musgrave (1944) were the first to notice that failing to rebate taxes on losses would make risky investments less attractive. Following literature has expanded this reasoning and documented its effects empirically. Gentry and Hubbard (2000), for example, showed that states with more progressive tax schedules induced slower entry into entrepreneurship. Their later work has shown that tax progressivity also dampens job turnover by making it less rewarding to invest time and effort looking for a new job (2004a), and has ambiguous effects on innovation (2004b). More work has documented the effects of tax law asymmetries – for example, how imperfections in the tax carryback and carryforward systems lead to an ultimately asymmetric treatment of profits and losses, thus dampening investment. See Auerbach (1986) and Altshuler and Auerbach (1990) for a discussion of the effects of tax asymmetries, and Devereux

et al. (1994), Edgerton (2010), and Goodman et al. (2021) for empirical evidence.

Third, if  $Cov(\epsilon, \tau) < 0$ , then  $x^* > x_0$ . A negative correlation between tax rates and productivity will yield a higher expected payoff of investment, thus incentivizing it. While concave tax schedules tend not to be the norm, the correlation between tax rates and productivity need not be driven by non-linear tax schedules. A negative correlation could be the result of economies of scale in tax planning, whereby bigger, more productive firms face lower effective tax rates. Alternatively, it could be the result of policy linked to business cycles, or of ways in which the political process correlates with economic fundamentals. Naturally, the correlation resulting from policy uncertainty of this nature is ambiguous.

Previous literature has looked at the effect of policy uncertainty on investment. However, this literature is focused on the fact that higher uncertainty increases the option value of postponing irreversible or partially irreversible decisions. This line of reasoning can be traced back to Pindyck (1988). Bloom (2009), Baker et al. (2016), Handley and Limão (2017), and Caggiano et al. (2017) provide recent examples having to do with uncertainty about government policy. Yet, the mechanism we are investigating is distinct from the mechanism studied previously in this literature. In our model, we specifically preclude this channel, showing that ours is a distinct mechanism for distorting investment.

The rest of the paper proceeds as follows. Section 2 presents a more general version of the model briefly presented here. The general model allows for an arbitrary tax schedule and deduction rate, but ultimately yields similar results to the intuition we already provided. We then move on in sections 3 and 4 to an illustrative empirical exercise, finding a negative intertemporal relationship between tax rates and total factor productivity over the post-war period in the U.S. Our estimates suggest an impact on investment equivalent to about a 1 percent investment subsidy. Section 5 concludes.

## 2 Model

Consider a firm making a decision regarding the amount to invest  $x$ , and reaping its benefits in the following period. As investment only occurs in the initial period, effects à la Pindyck (1988) are precluded. For notational simplicity, assume the firm values equally profits in either period.

The firm solves the problem of picking its investment level  $x$  to maximize its expected after-tax profits, which depend on a stochastic productivity realization  $\epsilon$ . Let  $f(x)$  denote the normalized production function, so that  $\epsilon f(x)$  represents revenue given investment  $x$ . The firm faces an uncertain tax  $T(\epsilon f(x), x, \epsilon)$  which is allowed to depend on total output  $\epsilon f(x)$ , input costs  $x$ , and the productivity realization itself,  $\epsilon$ . We pick this representation to emphasize that the tax schedule might depend on a stochastic variable, meaning that

it might itself be random.

$$\max_{x \geq 0} \mathbb{E}[\epsilon f(x) - x - T(\epsilon f(x), x, \epsilon)]. \quad (2)$$

While we nominally describe  $\epsilon$  as a productivity term, it also incorporates the output price. Similarly, as in Rodrik (1991), one can effectively think of “tax collected” as any policy provision that reduces (or enhances) the profitability of investment, as long as government policy depends in any way on an (uncertain) final output.<sup>1</sup>

Assuming  $f$  is differentiable, increasing, and strictly concave, the interior solution for investment will satisfy:

$$f'(x^*) = \left( \frac{1 + \bar{T}_2(x^*)}{\bar{\epsilon}(1 - \bar{T}_1(x^*)) - C(x^*)} \right), \quad (3)$$

where:

$$\begin{aligned} \bar{T}_1(x) &= \mathbb{E}[T_1(\epsilon f(x), x, \epsilon)]; & \bar{\epsilon} &= \mathbb{E}[\epsilon]; \\ \bar{T}_2(x) &= \mathbb{E}[T_2(\epsilon f(x), x, \epsilon)]; & C(x) &= \text{Cov}(T_1(\epsilon f(x), x, \epsilon), \epsilon). \end{aligned}$$

Here  $T_1$  refers to the derivative of  $T(\cdot)$  with respect to its first argument, and similarly for  $T_2$ . It follows that  $\bar{T}_1$  is the marginal tax rate that the firm expects to face on its revenue, while  $-\bar{T}_2$  is the rate at which it expects to deduct input costs, given investment  $x$ .  $C(x)$  is the covariance between the marginal tax rate on revenue and productivity.

Equation 3 reveals the main takeaways of this paper. Note that the covariance term  $C(x)$  can be positive, thus deterring investment, or negative, thus encouraging it. When  $C(x) \equiv 0$ , we have the standard result that allowing firms to fully deduct their input costs induces the choice of investment that would be optimal in the absence of taxation. Indeed, in our setting this need only be true in expectation:  $\bar{T}_1(x) = -\bar{T}_2(x)$ .

Even in a world where there is no uncertainty in the tax schedule and where firms are allowed to fully expense their inputs, a non-zero covariance between productivity and marginal tax rates can be induced depending on the concavity of the tax schedule. Equation 3 implies that a progressive corporate tax<sup>2</sup> will disincentivize investment, even if firms can perfectly deduct costs. This applied historically to corporate taxation in the U.S., and still applies for European countries such as France and the Netherlands. Naturally, one could design a concave tax schedule, which would result in the opposite effect of overencouraging input use.

<sup>1</sup>For example, this might be the case for environmental or labor regulations that only apply to large firms.

<sup>2</sup>I.e. a convex tax schedule, generating positive covariance between productivity and the marginal tax rate.

Additionally, equation 3 tells us that investment can be encouraged or discouraged if tax policy is uncertain. As we saw in equation 1, a positive correlation will dampen investment, while a negative one will incentivize it. This effect is due to the simple fact that a firm’s expected after-tax return on investment will be lower if it gets taxed more in states of the world where the investment is more productive, and vice versa. Further, for a given correlation, greater uncertainty about  $\tau$  will magnify this effect.

### 3 Data and Methodology

In order to get a sense for how large the effect of this covariance might be, we require measures of productivity and tax rates. We gathered data on total factor productivity (TFP) percent changes, here expressed in levels, from the non-utilization-adjusted series produced by the San Francisco Federal Reserve from 1947 to 2019.<sup>3</sup> While aggregate data cannot differentiate between unexpected shocks to firm productivity and other shocks in profits, driven e.g. by changes in market power or changes in demand, the  $\epsilon$  variable in equation 2 represents all shocks to the marginal value product of a firm.

Using statutory rates as measures of  $\tau$  misses how effective tax rates change with details of the tax code, as well as the tax implications of changing firm structures and economic activities. Using effective tax rates (ETRs) as calculated by firms could give us the opposite problem, as firms may report ETRs greater than 100% or less than zero. Therefore, we elected to proxy effective tax rates via federal tax receipts. We gathered information on tax receipts as a percentage of U.S. GDP from the Bureau of Economic Analysis.<sup>4</sup> We aggregate all variables at the annual level to control for seasonal effects.

We are interested in the joint distribution of  $(\tau, \epsilon)$  given what an agent in period  $t$  knows from all past data. To that end, and to account for potential cointegration, we consider the vector error correction model (VECM), following Johansen (1995):<sup>5</sup>

$$\begin{bmatrix} \Delta\tau_t \\ \Delta\epsilon_t \end{bmatrix} = \mathbf{v} + \mathbf{\Pi} \begin{bmatrix} \tau_{t-1} \\ \epsilon_{t-1} \end{bmatrix} + \mathbf{\Gamma} \begin{bmatrix} \Delta\tau_{t-1} \\ \Delta\epsilon_{t-1} \end{bmatrix} + \boldsymbol{\delta}t + \begin{bmatrix} \nu_{1t} \\ \nu_{2t} \end{bmatrix} \quad (4)$$

The two-dimensional error vector  $\boldsymbol{\nu}_t$  is drawn from a white noise process with mean zero. Equations 1 and 4 imply that the covariance  $\sigma_{12} \equiv Cov(\nu_{1t}, \nu_{2t})$  affects period  $t - 1$  investment intended to obtain a

<sup>3</sup>We normalize TFP by setting the initial value to one.

<sup>4</sup>While we cannot observe marginal tax rates, our results will hold to what degree marginal tax rates strictly increase with average tax rates.

<sup>5</sup>Here  $\Delta$  denote changes in values, so that we consider a VECM with two lags. The choice of two lags minimizes the Hannan–Quinn information, Schwarz Bayesian information, and sequential likelihood-ratio criteria. Using the multiple trace test procedure from Johansen (1995), we strongly reject the null of zero rank condition, and so assume that the matrix  $\mathbf{\Pi}$  is of rank one.

return in period  $t$  equivalently to a tax on firm revenue of:<sup>6</sup>

$$\frac{\sigma_{12}}{\mathbb{E}_t[\epsilon_t] (1 - \mathbb{E}_t[\tau_t])}. \quad (5)$$

We can estimate the parameters of equation 4 as in Johansen (1995). We estimate  $\sigma_{12}$  by taking the average of the product of residuals:

$$\widehat{\sigma}_{12} = \frac{\sum_{t=1}^T \widehat{\nu}_{1t} \widehat{\nu}_{2t}}{T} \quad (6)$$

Under the null hypothesis that  $\sigma_{12} = 0$ , one can show that:<sup>7</sup>

$$\sqrt{T} \frac{\widehat{\sigma}_{12}}{\sqrt{\frac{\sum_{t=1}^T \widehat{\nu}_{1t}^2 \widehat{\nu}_{2t}^2}{T} - \widehat{\sigma}_{12}^2}} \xrightarrow{d} N(0, 1) \quad (7)$$

## 4 Results

Results are presented in table 1. Using reasoning as in equation 5, we can measure how this covariance distortion would affect investment relative to a tax or a subsidy with an arbitrary time-horizon. If we use a time horizon of one year, as in equation 5, we obtain that the distortion to firm investment is equivalent to an investment subsidy of around 0.9 percent. We repeat the process for up to a 20-year window, obtaining very similar results: the investment subsidy that would generate the same behavioral response varies between 0.88 and 1.02 percent.<sup>8</sup>

We can always reject the null hypothesis that the covariance is zero at 10% significance, and at 5% significance for the first eleven years of forecasts. It is important to note, however, that by looking at the aggregate covariance we are underestimating the effect this mechanism will have on some firms. After all, what firms care about is the covariance between *their* productivity and *their* effective tax rates. As we report aggregate results, we are bound to attenuate the most extremely positive covariances with the most extremely negative ones.

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<sup>6</sup>Note that  $\mathbb{E}_{t-1}[\epsilon_t \tau_t] = \mathbb{E}_{t-1}[\epsilon_t] \mathbb{E}_{t-1}[\tau_t] + \sigma_{12}$ . Then we can re-write  $\mathbb{E}_{t-1}[(1 - \tau_t)(\epsilon_t f(x) - x)] = (1 - \mathbb{E}_{t-1}[\tau_t]) \left[ \left(1 - \frac{\sigma_{12}}{(1 - \mathbb{E}_{t-1}[\tau_t]) \mathbb{E}_{t-1}[\epsilon_t]}\right) \mathbb{E}_{t-1}[\epsilon_t] f(x) - x \right]$ .

<sup>7</sup>This result requires that  $\mathbb{E}[\nu_{1t}^2 \nu_{2t}^2] > 0$ .

<sup>8</sup>We get qualitatively similar results when fitting a vector autoregression model with effective tax rates and differences in total factor productivity.

**Table 1: Measures of Tax-Productivity Covariance**

Years Forecast Ahead	$\hat{\sigma}_{12}$	Equivalent Investment Subsidy
1	-0.077**	0.89%
2	-0.088**	1.02%
3	-0.077**	0.89%
4	-0.082**	0.95%
5	-0.082**	0.95%
6	-0.084**	0.97%
7	-0.082**	0.94%
8	-0.077**	0.89%
9	-0.078**	0.90%
10	-0.080**	0.92%
11	-0.081**	0.94%
12	-0.079*	0.91%
13	-0.080*	0.93%
14	-0.077*	0.89%
15	-0.079*	0.91%
16	-0.081*	0.93%
17	-0.076*	0.88%
18	-0.077*	0.89%
19	-0.079*	0.91%
20	-0.080*	0.93%

Table 1: Results are the covariance between effective tax rates and TFP values in future years, given information available at the year of forecast. One star denotes statistical significance at the 10% level, while two stars denotes statistical significance at the 5% level. The equivalent investment subsidy is calculated from equation 4 using the average TFP and effective tax rate over the sample period.

## 5 Conclusion

In our model, any non-zero correlation between marginal tax rates and the marginal product of a firm will result in a distortion to a firm’s choice of investment. As we discussed in the introduction, this mechanism can explain phenomena documented both in the literature on the effects of progressive income taxation and the one on the effects of tax law asymmetries. Further, we note that if tax policy itself is uncertain and correlated with the outcome of the investment, either because of political mechanisms or because of explicit government policy in response to booms and recessions, this might encourage or discourage investment, depending on the sign of the correlation. For a given correlation, higher policy uncertainty will magnify this effect. For illustrative purposes, we use aggregate data from the post-WW2 period, and find a negative correlation between tax rates and productivity, which would generate a response similar to that of an investment subsidy of around 1 percent.



## References

- Altshuler, Rosanne and Alan J. Auerbach**, “The significance of tax law asymmetries: an empirical investigation,” *The Quarterly Journal of Economics*, 1990, *105* (1), 61–86.
- Auerbach, Alan J.**, “The dynamic effects of tax law asymmetries,” *The Review of Economic Studies*, 1986, *53* (2), 205–225.
- Baker, Scott R., Nicholas Bloom, and Steven J. Davis**, “Measuring economic policy uncertainty,” *The Quarterly Journal of Economics*, 2016, *131* (4), 1593–1636.
- Bloom, Nicholas**, “The impact of uncertainty shocks,” *Econometrica*, 2009, *77* (3), 623–685.
- Caggiano, Giovanni, Efrem Castelnuovo, and Juan Manuel Figueres**, “Economic policy uncertainty and unemployment in the United States: a nonlinear approach,” *Economics Letters*, 2017, *151*, 31–34.
- Devereux, Michael P., Michael Keen, and Fabio Schiantarelli**, “Corporation tax asymmetries and investment: evidence from UK panel data,” *Journal of Public Economics*, 1994, *53* (3), 395–418.
- Domar, Evsey and Richard Musgrave**, “Proportional income taxation and risk-taking,” *The Quarterly Journal of Economics*, 1944, *58* (3), 388–422.
- Edgerton, Jesse**, “Investment incentives and corporate tax asymmetries,” *Journal of Public Economics*, 2010, *94* (11-12), 936–952.
- Gentry, William M and R Glenn Hubbard**, “Tax policy and entrepreneurial entry,” *American Economic Review*, 2000, *90* (2), 283–287.
- and –, “The effects of progressive income taxation on job turnover,” *Journal of Public Economics*, 2004, *88* (11), 2301–2322.
- and –, ““Success Taxes,” entrepreneurial entry, and innovation,” *NBER Working Paper No. 10551*, 2004.
- Goodman, Lucas, Elena Patel, and Molly Saunders-Scott**, “Dynamic patterns of loss use and effective tax rates: owners of S-corporations,” *SSRN Working Paper No. 3592884*, 2021.
- Handley, Kyle and Nuno Limão**, “Policy uncertainty, trade, and welfare: theory and evidence for China and the United States,” *American Economic Review*, 2017, *107* (9), 2731–83.
- Johansen, Søren**, *Likelihood-based inference in cointegrated vector autoregressive models*, Oxford University Press, 1995.

**Pindyck, Robert S**, “Irreversible investment, capacity choice, and the value of the firm,” *American Economic Review*, 1988, 78, 969–85.

**Rodrik, Dani**, “Policy uncertainty and private investment in developing countries,” *Journal of Development Economics*, 1991, 36 (2), 229–242.