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Corporate tax competition and innovation: An inverted-U relationship

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Abstract

This paper studies how the downward corporate tax rate affects firms' innovations. Using a cross-country firm-level panel, we find that both higher and lower corporate income-tax could hinder firm innovations, which implies an inverted-U relationship between the statutory corporate income-tax rate and firm innovation. A potential explanation of nonlinearity is that a lower tax rate alters the market structure.

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1 Introduction

Corporate income-tax rates have been declining steadily around the world for decades due to international tax competition[1]. Proponents justify that a lower corporate tax rate encourages R&D investment, enhances domestic firms' competitiveness(Brill and Hassett (2007)), and leads to higher productivity and economic growth. However, existing studies find weak evidence that lowering the statutory corporate income-tax rate spurs innovation and economic growth in the long run[2].

Theoretically, lower corporate taxes could have either positive or negative effects on firm innovation. On the one hand, lowering the corporate income tax increases the profits and internal cash flows of incumbent firms, and thereby their likelihood to re-allocate the capital to R&D investment[3]. Moreover, lower tax rate could also encourage entrepreneurial activities and facilitate firm creation by easing the financial constraints for such activities(Venâncio et al. (2022)). As a result, more new products and innovations are introduced to the market, and the market competition increases. The intense competition, however, may trigger two outcomes. First, it may discourage innovations by the laggards firms in sectors that are not neck-to-neck, known as the Schumpeterian effect(Aghion et al. (2005)). Second, higher competition may suppress the profits of leading incumbent innovators and thus reduce their incentives to innovate. When these disincentives to innovate become high, the top innovators exit and the growth engine stalls. As such, the negative competition effects induced by the low corporate tax rate may also lead to a low rate of innovation.

The juxtaposition of these two forces gives rise to interesting non-linear possibilities: when the corporate tax rate is high, lowering the corporate tax rate would stimulate innovations by increasing profits of firms and encouraging new productive entrants; however, the negative competition effect on innovation may, in turn, dominate as tax rate continues to decrease. In other words, there may exist an inverted U-shaped relationship between corporate tax rate and firm innovations.

This paper provides evidence on how downward corporate income-tax rates affect firms' innovations in a nonlinear form using a cross-country firm-level data. To understand the channel through which corporate tax rates may affect firm innovations, we first examine how low corporate tax rates affect the industry competition. The results show that lower corporate tax rates increase domestic competition within an industry. Moreover, we show that this effect is more evident in industries with higher level of technology gap, indicating that low tax rates increase the market competition by inducing the entrepreneurial activities and the innovations by the laggards. However, the high competition also causes the profits of both leading firms and laggards to be squeezed out, which may lead to a reduction in R&D investments. Finally, we test whether this low tax-induced high competition implies any nonlinear effects on firm innovation. Our results confirm an inverted-U relationship between corporate tax rate and firm innovation, with an estimated optimal tax rate between

[1] For example, The Tax Cut and Job Act (TCJA) reduced the federal corporate income tax rate from 35 percent to 21 percent, dropping the U.S. combined rate from 38.9 percent to 25.7 percent and placing the U.S. nearer to the OECD average.

[2] see Hungerford (2013); Jaimovich and Rebelo (2017)

[3] e.g. Himmelberg et al. (1994); Mukherjee et al. (2017); Cai et al. (2018); Chen et al. (2018); Atanassov and Liu (2020)

9.6-16.9%.

Our results generate several implications. Given the important role innovation has played in driving the modern economic growth[4], our results suggest that a race to the bottom on corporate tax rates may not always effectively stimulate the innovation and the economic growth. There exists a competition effect as the corporate tax rate is lower than a certain threshold. In practice, countries should be more cautious when they lower corporate taxes to boost the economy. The policy of corporate tax cuts may result in short-term recovery but impede innovation in the long run.

2 Data

Our analysis builds on firm-level innovation data which consists of the global top 2000 corporate R&D investors from 2013-2016 retrieved from *"JRC-OECD COR&DIP© database, v.2, 2019"*. These firms are distributed across 43 countries, including 15 emerging and 28 industrialized economies. The innovations are proxied by patent counts, scientific publications, and R&D expenditures. To obtain the patent counts and scientific publication, we match the firms with the families of patent applications filed at the five top IP offices (IP5) in the world[5]. Since each patent and publication could be filed at different patent offices, we first collapse the number of patents by family ID and year, then assign the unique patent to each firm. The country-level statutory corporate income tax rate is the combined corporate income tax rate obtained from the OECD tax database.[6,7] Following Aghion et al. (2005), we also construct the indicator of competition as *1-Lerner index*.

We focus on the top 2000 corporate R&D investors for the following considerations. First, they are good representatives of global innovators. A plethora of evidence has shown the right skewness in the distribution of patents and scientific publications towards a small number of highly productive innovators. The top 2000 corporate R&D investors own almost two-thirds of patents filed at the largest 5 IP offices worldwide. Moreover, these corporates include both public listed and non-listed companies. Second, these corporates are major R&D investors and technology inventors, so focusing on these firms could shed light on how corporate tax affects innovations. Third, compared to small firms, these firms are more immune in terms of R&D investment consistency to exogenous shocks such as political instabilities, macroeconomic volatility, and economic crises. Therefore, we can exclude to some extent

[4]As in Romer (1990), Grossman and Helpman (1991), and Aghion and Howitt (1992), growth comes from innovation

[5]Namely: CNIPA (Chinese National Intellectual Property Administration), EPO, JPO (Japan Patent Office), KIPO (Korean Intellectual Property Office), and USPTO.

[6]This rate shows the basic combined central and sub-central (statutory) corporate income tax rate given by the central government rate (less deductions for sub-national taxes) plus the sub-central rate

[7]The effective rates could be better than the statutory rates as they reflect the reality of taxation. However, there are two obstacles to obtain the ideal effective tax rate, both at the firm level and at the country level. Specifically, 1) information on annual tax payments is not available in my firm-level dataset, therefore, I cannot calculate the effective tax rate based on profit information and thus calculate the average tax rate at the country level. 2) I also checked the country-level effective tax rate from OECD statistics (https://stats.oecd.org/index.aspx?DataSetCode=CTS_ETR#). However, this variable is only available from 2017 and cannot overlap with the span of my firm-level dataset from 2013-2016.

the potential negative effects of these shocks on firm innovations. Table 1 provides the summary statistics.

Table 1: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
Patent(log)	3.129	1.755	0.693	9.926	4422
Publication(log)	2.156	1.712	-1.792	7.515	4534
R&D(log)	18.429	0.976	17.239	20.263	7922
Employee(log)	8.934	1.479	6.41	11.112	7245
Profits(log)	19.283	1.508	11.863	21.362	6513
Capital expenditure(log)	18.167	2.213	7.363	24.457	7670
Net sales(log)	21.469	1.47	19.094	23.731	7784
Domestic_competition	0.934	0.085	0.343	1.232	7986
Global_competition	0.925	0.049	0.507	1.232	8000
Technology gap	0.062	0.039	0	0.178	7715
Profit gap	0.645	0.256	0	0.991	7548
Tax rate	25.128%	8.22	0%	48.316%	266
R&D tax subsidy rate	0.136	0.126	-0.02	0.45	238

3 The specifications

At first, we explore whether lowering the corporate income-tax rate infuences the degree of competition. To this end, we adopt the following regression model,

$$\text{Mkt\_str}_{c,s,t} = \alpha_0 + \beta_1 \text{tax}_{c,t} + \beta_2 \text{Ini\_str}_{c,s} + \beta_3 \text{glb\_str}_{s,t} + \delta_{c,t} + v_s + \varepsilon_{c,s,t} \tag{1}$$

where $\text{Mkt\_str}_{c,s,t}$ denotes the market structure of industry s in country c at time t, which is measured as the degree of competition within an industry[8]. $\text{tax}_{c,t}$ is the satutory tax rate in country c at year t. We include $\text{Ini\_str}_{c,s}$, the initial market structure of industry s in country c, to control for the inertia of market structure. The global market competition in industry s at time t, $\text{glb\_str}_{s,t}$, is also included to control for its impact on domestic competition. $\delta_{c,t}$ is the country-year fixed effect that absorbs time-varying country characteristics, such as the overall level of economic development, government policies, and country-wide reforms. v_s denotes the dummies for industry.

In the next step, we proceed to examine the potential nonlinear relationship between

[8]Specifically, it is calculated as

$$c_{c,s,t} = 1 - \frac{1}{N_{c,s,t}} \sum_{i \in s} \text{lerner}_{c,s,i,t}$$

where $c_{c,s,t}$ is the degree of competition, $N_{c,s,t}$ is the number of firms in industry s of coutry c at year t, $\text{lerner}_{c,s,i,t}$ is the Lerner index, which is the marginal profit of firm i at year t.

corporate income tax rate and firm innovation. We use the following specification

$$\text{Innovation}_{c,i,t} = (\alpha_1 \text{tax}_{c,t} + \alpha_2 \text{tax}^2_{c,t}) * \text{rdintensity}_{c,i,t} + \alpha_3 \mathbf{X}_{c,i,t} + v_{c,t} + e_i + \varepsilon_{c,i,t} \quad (2)$$

where $\text{Innovation}_{c,i,t}$ is the indicators of firm level innovation, including number of patent applications, number of scientific publication(fractional counts), and R&D expenditures. $\text{rdintensity}_{c,i,t}$ measures the R&D intensity of firm i at time t, calculated as the ratio of firm's R&D expenditure to firm's sales. $(\alpha_1 \text{tax}_{c,t} + \alpha_2 \text{tax}^2_{c,t})$ captures the potential nonlinear structure. $\mathbf{X}_{c,i,t}$ includes an array of firm and industry characteristics that affect innovation, such as Capital expenditure, Operating profits, Number of employees, and industry competition. We also include the implied tax subsidy rate for R&D spending at the country level because such tax incentives may encourage innovation and R&D spending. This variable is drawn from the OECD Statistics database. The database provides R&D tax incentive rates for large and small and medium-sized enterprises. We select tax subsidy rates for large corporations because our firm-level dataset consists of large global corporations. $v_{c,t}$ captures the country-year fixed effects. e_i is the dummies for firm.

4 Results

4.1 The Effect of Corporate Tax Rate on Market Competition

Columns (1) and (2) of Table 2 present results estimated by regression (1). The coefficients on tax are negative and significant, indicating that a decrease(an increase) in tax rate causes the competition within an industry to increase(decrease). A possible explanation of these results is that a higher tax rates scheme poses high barriers to potential entrants as well as shields potentially inefficient incumbents and obsolete capital stock. As a result, it leads to lower competition and rate of innovation. Lower corporate tax rates relax the financial constraints associated with entrepreneurial and innovative activities, making it easier for laggards and new entrants to participate in the market, thus promoting the market competition.

To test whether lower tax rates have promoted competition by encouraging laggards and new entrants, we consider how corporate tax rates affect market competition conditioning on the level of technology gap in an industry using the following specification

$$\text{Mkt\_str}_{c,s,t} = \gamma_1 \text{tax}_{c,t} + \gamma_2 \text{tech\_gap}_{c,s,t} + \gamma_3 \text{tech\_gap}_{c,s,t} * \text{tax}_{c,t} + X_{c,s,t} + \delta_{c,t} + v_s + \varepsilon_{c,s,t} \quad (3)$$

where $\text{tech\_gap}_{c,s,t}$ is the technology gap in an industry s of country c at year t. $X_{c,s,t}$ is a vector of control variables including initial market competition and global competition in an industry. We construct the industry-level technology gap following Aghion et al. (2005), a high value indicates a large technological distance between the frontier firm and laggards in an industry[9]. The coefficient on the interaction term between technology gap and tax rates

[9] According to Aghion et al. (2005), the technology gap is defined as

$$m_{it} = \frac{TFP_{Ft} - TFP_{it}}{TFP_{Ft}}$$

is of interest.

The result in Column (3) of Table 2 confirms the explanation. Specifically, the coefficient on the interaction term between tax and technology gap is negative and significant, while the coefficient on the tax rate turns to positive but not significant. This means that a lower tax rate itself does not have a significant impact on the competition but in the industries with a high level of the technology gap a percentage decrease in tax rate generates more competition.

Table 2: Corporate Tax Rate, Market Competition, and Profits Gap

	Competition	**Competition**	**Competition**	**Profit gap**
	(1)	**(2)**	**(3)**	**(4)**
Tax rate	-0.019***	-0.016***	0.064	0.574***
	(0.005)	(0.005)	(0.057)	(0.217)
Initial_competition	0.544***	0.564***	0.549***	-0.069*
	(0.168)	(0.168)	(0.171)	(0.037)
Global_competition		0.613***	0.607***	0.042
		(0.053)	(0.054)	(0.058)
Tax*tech_gap			-0.980**	0.340**
			(0.442)	(0.138)
tech_gap			3.368**	
			(1.479)	
Obs	3971	3971	3971	4550
R^2	0.507	0.747	0.752	0.290
Country-year	yes	yes	yes	yes
industry	yes	yes	yes	yes

Notes: Robust standard errors in parentheses and clustered by country. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

4.2 The Effect of Corporate Tax Rates on Firm Innovation

To understand how lowering the corporate tax rates affects firm innovations via market competition, we first verify whether a lower tax rate suppresses the profits and market shares of leading firms. Analogous to the concept of technology gap, we define a *Profit Gap* that measures the industry-level profit distance between leaders and laggards[10]. The result in Column (4) of Table 2 shows that lowering the tax rates narrows down the profits distance

where TFP_{Ft} is the frontier firm with the highest Total Factor Productivity(TFP) within the industry and TFP_{it} denotes the TFP of non-frontier firms. The industry-level measure of the technology gap is defined as the average across firms in the industry. To calculate this index, we first calculate the TFP for each firm according to

$$T\hat{F}P_{it} \approx y_{it} - \hat{\alpha} \times k_{it} - (1-\hat{\alpha}) \times l_{it}$$

where y_{it},k_{it}, and l_{it} denote firm revenue, capital expenditure, and number of employees, all in logarithmic form. The share of each factor is estimated by regressing the y on k and l. The estimated $\hat{\alpha} = 0.298_{(s.e:0.017)}$

[10]Operating profit variable are corrected for the inflation using the GDP deflator.

between leading firms and laggards due to high competition[11], and the marginal effect is more evident in industries with larger technology gap. With lower profits for both leaders and laggards, the incentives for investing in R&D activities fade. The results in Columns (3) and (4) of Table 2 explicitly reveal a channel through which low corporate tax rates may also impede firm innovation.

As suggested by existing studies and ours, both high and low corporate tax schemes may deter firms' innovation. Specifically, a high tax rate inhibits innovation mainly due to the reduced profits and internal cash flows. While lowering the corporate tax rate initially arguments the profit of the firm and encourages innovation, the market competition effect would restrain this benefit when the tax rate is lower than a certain level. Table 3 presents the results of the existence of an inverted-U relationship between the firm tax rate and innovations. In Column (1), the tax rate and its square term significantly affect the innovation proxied by the number of patent applications. Based on the signs of these two terms, an inverted-U relationship exists. The estimated threshold value of the tax rate is 9.349%. In Column (2), according to Aghion et al. (2005), we control for the nonlinear competition effect on innovation by adding competition and its square term. We also include a global competition to control for the potential influence of the global market on domestic firm innovations. The result in Column (2) is robust, and the estimated threshold value is 9.619%. Even if we use an alternative measurement of innovation, the log of the number of scientific publications, the results in Columns (3) and (4) are still robust with an estimated threshold between 15-16%. Columns (5) and (6) use the contemporaneous R&D expenditure as a dependent, we obtain a similar threshold between 14-16%. Notice that tax rate changes could have a lagged impact on firms' R&D investment decisions and thus the outputs, we consider first-order forward of R&D expenditure, patents, and publications as dependents. The results in Columns (7)-(9) are fully in accord with the previous columns.

The corporate tax rate could be endogenous due to omitted variables. For instance, a reduction in corporate tax may cause a government budget deficit to rise, which would reduce government subsidies for firm R&D activities and thus affect innovations. To address the endogeneity, we use as instruments the weighted average corporate tax rates in other countries, weighting by the inverse of the distance between the two countries(Lee and Gordon (2005)). The distance measures between two countries come from CEPII[12]. The IV estimates also give consistent results, as shown in Columns (10)-(12).

5 Conclusion

This paper has documented an inverted-U relationship between corporate income-tax rate and firm innovations using cross-country data. We find that both high and low corporate income-tax rates may hinder firms' innovation through the effect of tax on market structure. These findings suggest the possibility of an optimal corporate income tax rate. Therefore,

[11] One may think that the profits of both laggards and leaders have increased due to downward tax rates, thus, the shrink of profit gap is attributable to a relatively higher increase in laggards. This possibility could be ruled out as one notice the result in Column (3) of Table 2 that the market competition has increased.

[12] http://www.cepii.fr/. We use the natural geographic distance *distcap* instead of the trade adjusted distance because bilateral trade flow may correlate with the error term in regression (2).

governments should be more cautious in their choice of corporate tax as a policy instrument.

Table 3: The Nonlinear Effect of Corporate Tax Rate on Firm Innovation

	Regression 2(OLS)									IV regression(2SLS)		
	Patent	**Patent**	**Pub**	**Pub**	*R&D*	*R&D*	*F.R&D*	**F.Patent**	**F.Pub**	**Patent**	**Pub**	*R&D*
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
Tax*rdintensity	0.572**	0.554**	0.412**	0.413***	0.489***	0.463***	0.398***	0.599**	0.395***	0.546**	0.409***	0.463***
	(0.237)	(0.240)	(0.194)	(0.118)	(0.092)	(0.091)	(0.099)	(0.273)	(0.115)	(0.272)	(0.116)	(0.147)
Tax^2*rdintensity	-0.127*	-0.122*	-0.072*	-0.074**	-0.091***	-0.083***	-0.066**	-0.135*	-0.070**	-0.120*	-0.073**	-0.082*
	(0.071)	(0.072)	(0.033)	(0.035)	(0.027)	(0.027)	(0.030)	(0.067)	(0.034)	(0.060)	(0.034)	(0.042)
Employee	0.354***	0.351***	0.477***	0.467***	0.392***	0.383***	0.356***	0.364***	0.432***	0.351***	0.467***	0.389***
	(0.063)	(0.064)	(0.045)	(0.044)	(0.021)	(0.020)	(0.022)	(0.060)	(0.047)	(0.064)	(0.044)	(0.021)
Profits	0.210***	0.216***	0.116***	0.135***	0.168***	0.181***	0.179***	0.187***	0.165***	0.216***	0.135***	0.176***
	(0.046)	(0.046)	(0.038)	(0.039)	(0.016)	(0.016)	(0.018)	(0.033)	(0.035)	(0.035)	(0.038)	(0.009)
Capital	0.271***	0.271***	0.298***	0.293***	0.178***	0.177***	0.181***	0.271***	0.299***	0.271***	0.293***	0.180***
	(0.054)	(0.054)	(0.035)	(0.035)	(0.014)	(0.014)	(0.016)	(0.039)	(0.033)	(0.029)	(0.034)	(0.009)
R&D tax subsidy	6.463***	6.085***	8.807***	8.934***	1.136*	0.989	0.948	9.963***	10.501	6.067**	8.946***	1.011
	(1.607)	(1.679)	(1.321)	(1.327)	(0.647)	(0.643)	(0.661)	(2.392)	(18.181)	(2.403)	(1.294)	(0.989)
Comp		1.369		2.364***		1.213***	1.425***	-0.062	7.937***	1.373	2.363***	1.012***
		(1.068)		(0.605)		(0.232)	(0.533)	(2.680)	(1.949)	(1.007)	(0.588)	(0.250)
$Comp^2$		-0.513		-0.374***		-0.183***	-0.225	-0.016	-2.872***	-0.514	-0.347***	-0.126***
		(0.354)		(0.104)		(0.045)	(0.224)	(1.064)	(0.938)	(0.341)	(0.101)	(0.039)
glb_comp		2.937		-0.004		-0.119	-0.158	0.543	.766	2.938	-0.003	-0.328***
		(1.957)		(0.408)		(0.141)	(0.155)	(0.532)	(0.524)	(1.862)	(0.396)	(0.059)
Obs	2177	2177	2258	2258	3846	3846	2888	2175	2252	2177	2258	2908
R^2	0.625	0.625	0.451	0.454	0.816	0.819	0.802	0.618	0.434	0.625	0.454	0.817
Threshold	9.349	9.619	16.978	15.803	14.448	16.148	20.316	9.160	16.801	9.731	16.467	16.732
Country-year	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
firm	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Note: Robust standard errors in parentheses and clustered by firm. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

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