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Tax incentives for R&D: what drives cross-country differences?

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Abstract

We explore cross-country variation in the growing generosity of R&D-related tax breaks. Our findings suggest that these measures might compensate for the low government effectiveness and modest innovation policies of some countries.

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1. Introduction

Tax incentives for R&D activities of firms are widespread across developed and middle-income countries. Out of 48 countries surveyed by the OECD in 2021, 37 applied some measures that benefited companies incurring R&D expenditures. Moreover, the trend was clear, as 22 countries that were not offering tax incentives back in 2000 did so in 2021.

While there is a growing literature that evaluates, quite understandably, the efficiency of these policy instruments (see the metaanalyses by Castellacci and Lie, 2015, Dimos et al, 2022, and Pöschel, 2022), we would like to examine what drives countries to determine the levels of tax incentives in the first place. This is interesting because there are still considerable international differences in the generosity of these measures. As far as we know, this is the first study that examines these differences across a large group of countries.

In line with a large body of literature in development economics (see e.g. Keen and Lockwood, 2010, Besley and Persson, 2013), we utilize data from a panel of countries over a longer period of time (2000-2021), to examine the role of a variety of economic, institutional and political factors in shaping this particular aspect of tax systems, i.e. R&D tax breaks.

2. Background and Hypotheses

Tax incentives for R&D are well-rooted in the market-failure framework of economic policy. Indeed, the public goods character of R&D outputs and the positive externalities related to R&D processes have been recognized in neoclassical economic theory at least since Nelson (1959). It is fair to say that these arguments are well-understood in wider policy circles, especially given the growing interest in innovation related to the rise of ICT industries and to the digital revolution in the economies. On the other hand, tax exemptions are obviously costly from the fiscal point of view, so we would expect them to be implemented by more developed countries, which can afford them.

Notwithstanding the pervasiveness of tax-based R&D incentives, it is important to remember that for decades several countries, e.g., Scandinavia and East Asia, have done much more to support the innovation efforts of firms, and they acted more in the spirit of the postwar industrial policies (Edler and Fagerberg, 2017, Andreoni and Chang, 2019). Consequently, countries that implement more active innovation policies, as measured by the government's share in gross R&D expenditure, are less likely to offer generous R&D-tax breaks for businesses.

On a related note, while the implementation of a complex innovation policy requires skillful administration, tax incentives can be implemented even with modest government capabilities (Boon and Edler, 2018). Consequently, we would expect, ceteris paribus, the generosity of tax incentives to be inversely related to the quality of a country's bureaucracy.

One of the motives behind introducing tax breaks for domestic firms can be to support them in their rivalry with foreign firms. Prior research suggests that government R&D subsidies are more effective the lower the level of trade barriers (Haaland and Kind 2008) and the more intense the competitive pressure from foreign firms (Impullitti 2010). Consequently, we investigate if a country's exposure to foreign competition, as measured by the import share, is related to the amount of R&D tax breaks offered.

Finally, although the goal of supporting R&D is relatively uncontroversial, cutting taxes for businesses is less so. Therefore, we believe that left-leaning governments should be less likely to offer substantial tax incentives (Wang et al., 2019).

3. Data and Methodology

Our dependent variable is the *implied tax subsidy rate* as estimated by the OECD. This indicator is defined as one minus the B-index, where the B-index is "the present value of before-tax income that a firm needs to generate in order to cover the [on unit] cost of an initial R&D investment and to pay the applicable income taxes" (Warda 2002, p. 192). Thus, the value of the implied tax subsidy rate depends on the details of the tax system, such as the allowances and credits granted, the depreciation times and rates, etc. The implied tax subsidy rate is calculated using certain assumptions, such as the specific breakdown of R&D costs into personal and capital costs and the decomposition of the latter into equipment and building costs. The indicator is calculated separately for profit- and loss-making firms and separately for large firms and SMEs. Consequently, we run our regressions for four different dependent variables (*profit_sme_itsr, profit_large_itsr, loss_sme_itsr, loss_large_itsr*). Our sample covers 48 countries in the period 2000-2021 and, with few exceptions, data on the implied tax subsidy rates is available for the entire period.[1] Data in Table 1 shows that the mean values of the implied tax subsidy rates were between 0.12 and 0.18, depending on the type of indicator. Table 1 also illustrates the trend towards a bigger generosity of tax breaks for R&D, as both mean and median values of the indicators increased substantially between 2000 and 2021.

Table 1. Tax breaks for R&D in 2000 and in 2021 in a sample of countries surveyed by the OECD

		profit_sme_itsr	*profit_large_itsr*	*loss_sme_itsr*	*loss_large_itsr*
2000	*mean*	0.04	0.03	0.03	0.02
	sd	0.11	0.09	0.09	0.07
	min	-0.06	-0.06	-0.04	-0.04
	median	-0.01	-0.01	-0.01	-0.01
	max	0.44	0.44	0.34	0.34
2021	*mean*	0.18	0.16	0.15	0.12
	sd	0.16	0.13	0.14	0.11
	min	-0.02	-0.02	-0.02	-0.02
	median	0.18	0.15	0.15	0.12
	max	0.67	0.55	0.50	0.43

Source: own analysis based on the OECD data
Note: there were 45 countries surveyed in 2000 and 47 countries in 2021

[1] The countries in the sample are: Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, China, Colombia, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Latvia, Lithuania, Luxembourg, Malta, Mexico, Netherlands, New Zealand, Norway, Poland, Poland, Romania, Russia, Slovakia, Slovenia, South Africa, South Korea, Spain, Sweden, Switzerland, Thailand, Turkey, UK and USA. The data on implied tax subsidy rates is missing for Argentina (18 years), Croatia (12 years), Turkey (8), Greece (4), and Thailand (1).

We use the following indicators as independent variables:

- Economic development (*Log_GDP_pc*) – we use the World Bank data on GDP per capita (in constant 2015 US$; we take the logs to ensure a more regular distribution and ease the interpretation of results). We expect this variable to be positively correlated with the generosity of tax breaks for R&D, as more developed countries can afford higher tax exemptions;
- Government share of R&D expenditure (*GERD_govt*) – we refer to the OECD data on the share (0-100) of gross domestic expenditure on R&D financed by government. This variable measures the role of *active* government innovation policy and we expect it to be negatively correlated with the dependent variable.
- Quality of bureaucracy (*govt_effectiveness*) – we utilize data on the government effectiveness index from the V-Dem database. This is a continuous index variable: we standardize it by subtracting the mean value and dividing by standard deviation. We expect the quality of bureaucracy to be negatively correlated with tax incentives for R&D;
- Political position of the government (*left_right*) – we use the data from the V-Party dataset on the position of the ruling party on the economic left-right scale (standardized continuous index variable, where a higher number indicates a more right-leaning government). We expect more right-leaning governments to offer more generous tax breaks for businesses.[2]
- Total import to GDP ratio (*import_share*) – we use data from the World Bank, and we expect that countries with higher import shares can be more inclined to support firms through tax subsidies.

Descriptive statistics of all the explanatory variables are presented in Table 2. While for most variables data is available for the entire period 2000-2021 and for all the countries in our sample, information on the government share of R&D expenditure (*GERD_govt*) is missing for some countries and some years. For the period 2000-2019 the average number of countries for which there is data on *GERD_govt* is 36.3, while for 2020 it is 29. Data for 2021 was not available at the moment of writing, setting the upper limit for the time period covered by the econometric exercise presented in the next section.

Table 2. Descriptive statistics of the explanatory variables

		Log_GDP_pc	*GERD_govt*	*government_ effectiveness*	*left_right*	*import_share*
2000	*mean*	9.74	39.51	0.00	-0.10	40.84
	sd	0.94	15.82	1.14	0.92	24.44
	min	7.69	7.67	-2.49	-1.46	9.10
	median	9.84	38.65	0.04	-0.18	34.70
	max	11.44	70.72	1.53	1.62	128.37
	N	48	32	48	47	48

[2] In the original databases, these variables have the following labels: *e_wbgi_gee* (government effectiveness), and *v2pariglef* (economic left-right scale).

2021*	*mean*	10.14	34.64	-0.10	0.04	50.99
	sd	0.76	12.72	0.97	1.10	31.89
	min	8.68	15.19	-2.10	-1.75	14.59
	median	10.20	33.33	0.02	0.07	42.14
	max	11.61	76.89	1.39	2.38	176.69
	N	48	29	48	47	48

Source: own analysis based on the data sources listed in the text

** Due to data availability, data for GERD_govt and government_effectiveness is from 2020.*

We apply panel data regression and consider two types of models: a model with constant slopes and a mixed-effects model. In the first step, we estimate by fixed-effects the following basic model:

$$itsr_{it} = \beta_0 + \beta_1 Log\_GDP\_pc_{it} + \beta_2 GERD\_govt_{it} + \beta_3 gov\_effectiveness_{it} + \beta_4\, left\_right_{it} + \beta_5 import\_share_{it} + u_{i0} + \varepsilon_{it} \quad (1)$$

We apply a “from general to specific” approach, i.e., we eliminate the statistically insignificant variables, resulting in an ultimate specification without the *left_right* and *import_share* variables. The results are reported in Table 3. As expected, a higher GDP per capita is associated with more generous tax incentives for R&D. Direct government funding of R&D seems to be a substitute for tax incentives, and more effective governments are less likely to grant higher tax breaks.

Table 3. The estimates of model (1) of RD-tax breaks.

	(1)	(2)	(3)	(4)
VARIABLES	*profit_sme_itsr*	*profit_large_itsr*	*loss_sme_itsr*	*loss_large_itsr*
Log_GDP_pc	0.111***	0.110***	0.071**	0.083***
	(0.034)	(0.034)	(0.029)	(0.028)
GERD_govt	-0.004***	-0.004***	-0.003***	-0.003***
	(0.001)	(0.001)	(0.000)	(0.000)
government_effectiveness	-0.030*	-0.030*	-0.027**	-0.027**
	(0.016)	(0.015)	(0.013)	(0.013)
Constant	-0.892***	-0.890***	-0.536*	-0.659**
	(0.339)	(0.334)	(0.287)	(0.275)
Observations	700	700	700	700
R-squared	0.282	0.262	0.304	0.285
No. of countries	0.111***	0.110***	0.071**	0.083***

Standard errors in parentheses, time-dummies included

*** p<0.01, ** p<0.05, * p<0.1

To obtain more precise estimates, we apply a mixed-effect model (Demidenko, 2004; McCulloch et al., 2008), where the coefficient for *Log_GDP_pc* is allowed to vary across countries.

$$itsr_{it} = \beta_0 + \tilde{\beta}_1 Log\_GDP\_pc_{it} + \beta_2 GERD\_govt_{it} + \beta_3 gov\_effectiveness_{it} + u_{0i} + u_{1i} Log\_GDP\_pc_{it} + \varepsilon_{it}, \quad (2)$$

where $u_{0i} \sim N(0, \sigma_i)$ and $u_{1i} \sim N(0, \tilde{\sigma_i})$. Note that in this specification, as compared to model (1), the term β_1 was replaced by the sum $\tilde{\beta}_1 + u_{1i}$. In this version of the model, it is assumed that random slopes and individual effects are uncorrelated, i.e., $cov(u_{0i}, u_{1j}) = 0$,for any i, j.

As shown in Table 4, the average effect of a one-percent increase in GDP per capita is halved, to 0.034-0.048. As for the country-specific slopes, for instance in the case of *profit_sme_itsr,* they vary from 0.028 to 0.050 (not reported). In all four equations, the variance of u_{1i} is positive and statistically significant, suggesting that the model with varying slopes outperforms model (1).

The coefficient for *GERD_govt* remains significant but small: an increase in the government share of a country's R&D spending by one percentage point is associated with a decrease in the implied R&D tax subsidy by 0.003. On the other hand, a one-standard deviation improvement in government effectiveness reduces this tax subsidy by 0.02-0.03. For reference, a one-standard deviation is the distance between Switzerland, which tops the ranking in government effectiveness, and the US, or, the distance between US and China (that performs quite poorly but still better than most Latin American or Central and Eastern European countries).

Table 4. *The estimates of model (2) of RD-tax breaks with* $cov(u_{0i}, u_{1j}) = 0$ *assumed.*

	(1)	(2)	(3)	(4)
VARIABLES	*profit_sme_itsr*	*profit_large_itsr*	*loss_sme_itsr*	*loss_large_itsr*
Log_GDP_pc	0.048**	0.039*	0.039*	0.034*
	(0.024)	(0.023)	(0.020)	(0.019)
GERD_govt	-0.003***	-0.003***	-0.003***	-0.003***
	(0.001)	(0.001)	(0.000)	(0.000)
government_effectiveness	-0.026*	-0.027*	-0.022*	-0.024**
	(0.014)	(0.014)	(0.012)	(0.012)
Constant	-0.287	-0.215	-0.243	-0.200
	(0.233)	(0.227)	(0.199)	(0.186)
Observations	700	700	700	700
No. of countries	42	42	42	42

Standard errors in parentheses, time-dummies included
*** p<0.01, ** p<0.05, * p<0.1

Finally, we relax our assumption about the lack of correlation between u_{0i} and u_{1i}.This renders our estimates for *Log_GDP_pc* statistically insignificant (Table 5). In the case of SMEs, this is mainly because of the larger standard error, while the point estimate remains similar. On the other hand, for large firms we have a substantially smaller estimated coefficient. All other effects remain similar as before.

Table 5. *The estimates of model (2) of RD-tax breaks with* $cov(u_{0i}, u_{1j}) \neq 0$ *allowed.*

	(1)	(2)	(3)	(4)
VARIABLES	*profit_sme_itsr*	*profit_large_itsr*	*loss_sme_itsr*	*loss_large_itsr*
Log_GDP_pc	0.044	0.017	0.035	0.017
	(0.037)	(0.039)	(0.033)	(0.034)
GERD_govt	-0.004***	-0.004***	-0.003***	-0.003***
	(0.001)	(0.001)	(0.000)	(0.000)
government_effectiveness	-0.035**	-0.029**	-0.033***	-0.030**
	(0.015)	(0.015)	(0.013)	(0.012)
Constant	-0.211	0.048	-0.161	0.013
	(0.358)	(0.376)	(0.315)	(0.326)
Observations	700	700	700	700
No. of countries	42	42	42	42

Standard errors in parentheses, time-dummies included
*** p<0.01, ** p<0.05, * p<0.1

4. Conclusions

While tax incentives for R&D in firms are becoming ever more popular, there seems to be a certain regularity in their expansion across countries and over time. Our results suggest that there is a relationship between the generosity of R&D-related tax breaks and the innovation policy of a country; specifically, the tax incentives seem to be a substitute for more active government financing of R&D. We also confirmed our expectation about the negative correlation between government effectiveness and the level of tax exemptions; possibly more capable bureaucracies can handle more sophisticated types of innovation policy. On the other hand, we have to remain agnostic about the link between the level of economic development and R&D tax subsidies. Thanks to the mixed-effects model, we could demonstrate that while this correlation is positive for some countries, it is close to zero, or negative for others.

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