Supplemental Appendix
How Effective Are R&D Tax Incentives? Reconciling the Micro and Macro Evidence

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A R&D Tax Incentive Design

A.1 Variation in R&D Tax Incentive Design Across Countries

Countries differ markedly in how they structure their R&D tax incentives, with variations along several key dimensions:

1. **Type of Incentive**: Some countries use **R&D tax credits** (e.g., France, Japan, United States), while others provide **enhanced tax allowances** (e.g., Czechia, United Kingdom for SMEs).

2. **Volume-Based vs. Incremental Support**:

   - **Volume-based** incentives subsidise R&D from the first dollar spent—this is the most common approach globally.
   - **Incremental-based** incentives support increases in R&D over past levels (e.g., Italy, US).
   - **Hybrid models** combine volume-based and incremental incentives (e.g., Japan, Spain).

3. **Eligible R&D Expenditure**: Definitions of qualifying expenditure vary. While some countries only allow deductions for in-house current R&D (e.g., US), others also include capital investments in machinery (e.g., Italy), buildings (e.g., France), or outsourced R&D (e.g., France).

4. **Firm Size and R&D Volume Provisions**:

   - Some countries apply a flat rate regardless of firm size (e.g., Belgium, Czechia). Others impose ceilings (e.g., Norway) or reduce support above a threshold (e.g., Canada), effectively providing more generous support to smaller R&D performers.
   - Some offer preferential rates to SMEs (e.g., Australia) or start-ups (e.g., Netherlands).

5. **Treatment of Loss-Making Firms**:

   - Most countries allow **carry-forward** of unused tax relief.
   - Some provide **cash refunds**, either for SMEs (e.g., Australia) or for all firms (e.g., Sweden).

These design features shape both the accessibility and generosity of R&D tax support, with important implications for different types of firms.

A.2 Additional Details on B-Index Measures

In this section, we provide more details on the calculation of the B-Index. Let us start by considering Equation 3 in the paper, reported below for convenience:

$$c_j^C = \frac{ATC_j^C}{(1-\tau_j)} \ . \tag{1}$$

For each R&D cost component, the tax price c_j^C is computed as the after-tax cost (ATC_j^C) of one additional unit of R&D input, normalised by the share of revenue left over after paying tax. ATC_j^C can be calculated as one minus the combined net present value of allowances and credits applying to R&D outlays.[1] In the case of current R&D expenditures, which are fully deductible in most countries (i.e. the net present value equals 1), the after-tax cost is derived as

$$ATC_j^{current} = 1 - \tau_j * (1 + TA_j^{current}) - TC_j^{current} \ , \tag{2}$$

where $TA_j^{current}$ and $TC_j^{current}$, respectively, denote the enhanced tax allowance rate and tax credit rate applicable to a marginal unit of current R&D expenditure incurred by firm j. Importantly, the after-tax cost is calculated using the rates that apply to a marginal unit of R&D of a given firm. This matters, for example, if a tax incentive involves a ceiling on eligible R&D expenditure, or in the case of incremental incentives that apply only to R&D expenditure in excess of a pre-defined base amount (e.g. firm's average R&D expenditure in the previous 2 years).[2] The modelling also accounts for the taxability of R&D tax benefits in some OECD economies and the interaction of wage tax-related incentives and corporate tax offsets, where applicable.[3]

Calculating the B-Index requires detailed information on tax incentive design and applicable rates in each country and their evolution over time. To this end, we rely on information collected by the OECD and validated by experts from each country. In Table A.1, we report the key features and parameters of the modelled R&D tax incentives in the last sample year for each country. In Table A.2, we describe key changes in R&D tax incentives available in each country over the sample period.

[1]For machinery, equipment and buildings used in the context of R&D projects, the net present value and adjustment factor θ depends on the depreciation method and rate applicable in each country.

[2]In the case of incremental R&D tax incentives, the formulas also consider the impact that current decisions have on future baseline R&D levels. For the calculation of adjustment factors in this case, see http://www.oecd.org/sti/rd-tax-stats-design-subsidy.pdf.

[3]One limitation that our paper shares with previous studies is that, for most countries, we do not know which firms generate profit. Unless tax incentives are fully refundable, they represent a weaker stimulus for loss-making firms. We take the standard approach of assuming that all firms generate sufficient profit to use tax relief available to them.

Table A.1: R&D Tax Incentive Scheme Data

Availability of R&D tax incentives						Main R&D tax incentive design features, last year of observation				
Country	**Sample period**	**Name of scheme**	**Year introduced**	**Year repealed**	**Last year observation**	**Instrument**	**Eligible R&D expenditures**	**Tax credit/ allowance rate (%)**	**Base amount (if incremental)**	**Limitations (floor, threshold, ceiling)**
Baseline data sample (countries with BERD survey and tax relief microdata										
AUS	2005-2018	R&D tax concession measures	1985	2011	2011	Hybrid R&D tax allowance	C, MED	Volume: 25; Increment: 50	Average R&D spend in previous three years	Minimum R&D spend of AUD 20k; Maximum amount of R&D capped at AUD 2 million
		R&D tax incentive	2012	-	2018	Volume-based R&D tax credit[AUS]	C, MED	Large firms: 38.5; SMEs: 43.5	Average R&D spend in previous three years	Minimum R&D spend of AUD 20k; Maximum amount of R&D capped at AUD 100 million
BEL	2003-2019	R&D Investment Deduction	1992	-	2019	Volume-based R&D tax allowance	ME, Intangibles, B	13.5[BEL1]	-	-
		Payroll Withholding Tax Credit	2005	-	2019	Payroll Withholding Tax Credit[BEL2]	L	80	-	-
CZE	2000-2021	R&D tax allowance	2005	-	2021	Hybrid R&D tax allowance	C, MED	Volume: 100; Increment: 10	R&D spend in previous year	-
FRA	2001-2015	R&D tax credit - Crédit d'Impôt Recherche (CIR)	1983	-	2015	Volume-based R&D tax credit	C, MED, BD	30 (R&D expenses up to EUR 100 million), 5 (R&D expenses above EUR 100 million)	-	Treshold of EUR 100 million. Maximum amount of subcontracted R&D capped at EUR 12 million[FRA]
ITA	2008-2019	R&D tax credit (Law 296/2006)	2006	2009	2009	Volume-based R&D tax credit	C, ME, B, Intangibles	10	-	Maximum amount of R&D capped at EUR 50 million.
		R&D tax credit (Law 145/2013, Legge di Stabilità 2015, Budget Law 2017 and 2019)	2015	2019	2019	Incremental R&D tax credit	C, MED, Intangibles	25 (50 for R&D labour costs)	Average R&D spend in 2012-2014	Minimum R&D spend of EUR 30k
NLD	2014-2019	WBSO	1994	-	2019	Payroll Withholding Tax Credit[NLD]	C, ME, B, Intangibles	32 for eligible R&D costs up to EUR 350k, 16 above EUR 350k	-	Threshold of EUR 350k
		RDA	2012	2015	2015	Volume-based R&D tax allowance	C, ME, B, Intangibles	60	-	-
NOR	2001-2021	SKATTEFUNN R&D tax credit	2002NOR	-	2021	Volume-based R&D tax credit	C, ME	19	-	Maximum amount of R&D capped at NOK 25 million (intramural and purchased R&D)
NZL	2003-2019	R&D tax credit	2008	2009	2009	Volume-based R&D tax credit	C, ME, B	15	-	Minimum R&D spend of NZD 20k
		Research and Development Tax Incentive	2019		2019	Volume-based R&D tax credit	C, MED, BD	15	-	Minimum R&D spend of NZD 50k. Maximum amount of R&D capped at NZD 120 million.
PRT	2001-2019	SIFIDE tax credit I	1997	2003	2003	Hybrid R&D tax credit	C, ME, Intangibles	Volume: 20; Increment: 50	Average R&D spend in previous two years	-
		SIFIDE tax credit II	2006	-	2019	Hybrid R&D tax credit	C, ME, Intangibles	Volume: 32.5; Increment: 50	Average R&D spend in previous two years	Incremental Maximum amount of R&D capped at EUR 1.5 million
SVK	2010-2021	R&D tax allowance	2015	-	2021	Volume-based R&D tax allowance	C, ME, B, Intangibles	Volume: 200; Increment: 100	Dedicated formula[SVK]	-
SWE	2011-2017	Partial exemption of social security contributions[SWE]	2014	-	2017	Exemption	L	10	-	Maximum amount of R&D capped at SEK 2.76 million

Table A.1: R&D Tax Incentive Scheme Data (*continued*)

Availability of R&D tax incentives						Main R&D tax incentive design features, last year of observation				
Country	**Sample period**	**Name of scheme**	**Year introduced**	**Year repealed**	**Last year observation**	**Instrument**	**Eligible R&D expenditures**	**Tax credit/ allowance rate (%)**	**Base amount (if incremental)**	**Limitations (floor, threshold, ceiling)**
Additional countries (with BERD survey microdata) included in extended data sample										
AUT	2004-2015	R&D premium	2002	-	2015	Volume-based R&D tax credit	C	10	-	Maximum amount of subcontracted R&D capped at EUR 1 million
CHL	2009-2015	R&D tax credit for extramural expenses	2008	2012	2012	Volume-based R&D tax credit	C (extramural)	Gross rate of 35 (net: 28.05)[CHL1]	-	Minimum R&D spend of 100 UTM. Maximum amount of R&D capped at 5,000 UTM[CHL2]
		R&D tax credit for intramural and extramural expenses	2012	-	2015	Volume-based R&D tax credit	C, MED	Gross rate of 35 (net: 27.125)[CHL1]	-	Minimum R&D spend of 100 UTM. Maximum amount of R&D capped at 15,000 UTM[CHL2]
ESP	2007-2016	R&D&I tax credit[ESP]	-	-	2016	Hybrid R&D tax credit	C, ME, Intangibles	Volume: C: 25, +17 (R&D staff); ME and intangibles: 8; Increment: C: 17	Average R&D spend in previous two years	-
GBR	2000-2020	R&D tax allowance[GBR1]	2000	-	2020	Volume-based R&D tax allowance	C, Intangibles	SMEs: 130	-	-
		Research and Development Expenditure Credit (RDEC) Scheme[GBR2]	2013	-	2020	Volume-based R&D tax credit	C, Intangibles	Large firms: 13	-	-
JPN	2000-2016	Incremental-based R&D tax credit[JPN]	1967	2017	2016	Incremental R&D tax credit	C, MED, BD	5	Average R&D spend in previous three years	-
		General type R&D tax credit	2003	-	2016	Volume-based R&D tax credit	C, MED, BD	Large firms: 10, SMEs: 12	-	-

Table A.2: Major Changes in the Main R&D Tax Incentive Design Features Modelled over the Sample Period

Availability of R&D tax incentives						Major changes in the main R&D tax incentive design features modeled over the sample period				
Country	**Sample period**	**Name of scheme**	**Year introduced**	**Year repealed**	**Last year observation**	**Instrument**	**Eligible R&D expenditures**	**Tax credit/ allowance rate (%)**	**Base amount (if incremental)**	**Limitations (floor, threshold, ceiling)**
Baseline data sample (countries with BERD survey and tax relief microdata										
AUS	2005-2018	R&D tax concession measures	1985	2011	2011	-	-	-	-	Increase in R&D cap from AUD 1 million to AUD 2 million in 2009
		R&D tax incentive	2012	-	2018	-	-	Reduction of tax credit rate from 40 to 38.5 (45 to 43.5 for SMEs) in 2017 (from July 2016)	-	Introduction of R&D cap of AUD 100 million in 2014
BEL	2003-2019	R&D Investment Deduction	1992	-	2019	-	-	Increase in the tax allowance rate from 13.5 to 15.5 in 2010, reduction to 13.5 in 2011, increase to 15.5 in 2013, reduction to 14.5 in 2014 and reduction to 13.5 in 2015.	-	-
		Payroll Withholding Tax Credit	2005	-	2019	-	-	Increase in payroll withholding tax credit rate from 75 to 80 in 2013	-	-
CZE	2000-2021	R&D tax allowance	2005	-	2021	Introduction of incremental component in 2014	-	-	-	-
FRA	2001-2015	R&D tax credit - Crédit d'Impôt Recherche (CIR)	1983	-	2015	Incremental R&D tax credit becomes hybrid in 2004 and entirely volume-based in 2008	-	Introduction of volume-based rate of 5 (incresed to 10 in 2006) and reduction of incremental rate from 50 to 45 in 2004 and 40 in 2006. Introduction of threshold-dependent rates in 2008 (30 below EUR 100 million and 5 above)	-	Increase of R&D cap from EUR 6.1 million to EUR 8 million in 2004, EUR 10 million in 2006, and EUR 16 million in 2007. Removal of upper ceiling and introduction of a threshold of EUR 1000 million with threshold-dependent tax credit rates in 2008. Introduction of upper ceiling on subcontracted R&D of EUR 12 million in 2008.
ITA	2008-2019	R&D tax credit (Law 296/2006)	2006	2009	2009	-	-	-	-	Increase of R&D cap from EUR 15 million to EUR 50 million in 2008.
		R&D tax credit (Law 145/2013, Legge di Stabilità 2015, Budget Law 2017 and 2019)	2015	2019	2019	-	-	Increase of incremental rate from 25 to 50 in 2017 and reduction to 25 for non-labour related R&D costs in 2019	-	Increase of R&D cap from EUR 5 Million to EUR 20 million in 2017 and reduction to EUR 10 million in 2019.
NLD	2014-2019	WBSO	1994	-	2019	-	With the merger of the WBSO and RDA in 2016, the WBSO additionally covers other C (non-labour), ME, B, Intangibles	Reduction of tax credit rate from 35 to 32 below threshold (increase from 14 to 16 above) in 2016. Decrease of tax credit rate above threshold from 16 to 14 in 2018 and increase to 16 in 2019.	-	Increase of threshold from EUR 250k to EUR 350k in 2016.
		RDA	2012	2015	2015	-	-	Increase of tax allowance rate from 40 to 54 in 2013 and 60 in 2014.	-	-
NOR	2001-2021	SKATTEFUNN R&D tax credit	2002[NOR]	-	2021	-	-	Harmonisation of R&D tax credit rates for SMEs (reduced from 20 to 19) and large firms (increased from 18 to 20) in 2020.	-	Increase of cap on intramural/purchased/total R&D from NOK 4/8/8 million to NOK 5.5/11/11 million in 2009, NOK 8/22/22 million in 2014, NOK 15/33/33 million in 2015, NOK 20/40/40 million in 2016, and NOK 25/50/50 million in 2017. Removal of separate cap on intramural and purchased R&D and reduction of cap on total R&D from NOK 50 million to NOK 25 million in 2020.

Table A.2: Major Changes in the Main R&D Tax Incentive Design Features Modelled over the Sample Period (*continued*)

Availability of R&D tax incentives						Major changes in the main R&D tax incentive design features modeled over the sample period				
Country	**Sample period**	**Name of scheme**	**Year introduced**	**Year repealed**	**Last year observation**	**Instrument**	**Eligible R&D expenditures**	**Tax credit/ allowance rate (%)**	**Base amount (if incremental)**	**Limitations (floor, threshold, ceiling)**
Baseline data sample (countries with BERD survey and tax relief microdata										
NZL	2003-2019	R&D tax credit	2008	2009	2009	-	-	-	-	-
		Research and Development Tax Incentive	2019		2019	-	-	-	-	-
PRT	2001-2019	SIFIDE tax credit I	1997	2003	2003	-	-	-	-	-
		SIFIDE tax credit II	2006	-	2019	-	-	Increase of volume-based rate from 20 to 32.5 in 2009.	-	Introduction of R&D cap on incremental R&D expenses of EUR 1.5 million in 2013.
SVK	2010-2021	R&D tax allowance	2015	-	2021	-	-	Increase of volume-based rate from 25 (50 if labour) to100 in 2018, 150 in 2019 and 200 in 2020. Increase of incremental rate from 25 to 100 in 2018.	Base amount (average R&D spend in previous two years) redefined in 2018[SVK].	-
SWE	2011-2017	Partial exemption of social security contributions[SWE]	2014	-	2017	-	-	-	-	-
Additional countries (with BERD survey microdata) included in extended data sample										
AUT	2004-2015	R&D premium	2002		2015	-	-	Increase of tax credit rate from 8 to 10 in 2011.	-	Increase of R&D cap from EUR 100k to EUR 1 million in 2012.
CHL	2009-2015	R&D tax credit for extramural expenses	2008	2012	2012	-	-	No change in gross tax credit rates. Net tax credit rates changed with the value of corporate income tax rates.	-	-
		R&D tax credit for intramural and extramural expenses	2012	-	2015	-	-	No change in gross tax credit rates. Net tax credit rates changed with the value of corporate income tax rates.	-	-
ESP	2007-2016	R&D&I tax credit[ESP]		-	2016	-	-	Reduction of volume-based rate for C from 27 to 25 (9 to 8 for ME) in 2008, and introduction of enhanced volume-based rate for R&D staff (+17) in 2015. Reduction of incremental rate from 19 to 17 in 2009.	-	-
GBR	2000-2020	R&D tax allowance[GBR1]	2000	-	2020	-	-	Increase of tax allowance rate for SMEs from 50 to 75 (25 to 30 for large firms) in 2008, 100 in 2011, 125 in 2012, and 130 in 2015.	-	Removal of minimum R&D spend of GBP 10k
		Research and Development Expenditure Credit (RDEC) Scheme[GBR2]	2013	-	2020	-	-	Increase of tax credit rate for large firms from 10 to 11 in 2015, 12 in 2018 and 13 in 2020.	-	-
JPN	2000-2016	Incremental-based R&D tax credit[JPN]	1967	2017	2016	-	-	Reduction of the incremental tax credit rate from 15 to 5 in 2006.	-	-
		General type R&D tax credit	2003	-	2016	-	-	Introduction of volume-based tax credit rate of 12 for large firms and increase of the rate for SMEs from 10 to 15 in 2003. Reduction of the tax credit rate for SMEs from 15 to 12 (12 to 10 for large firms) in 2006.	-	-

The B-Index can vary among firms subject to the same tax regime for several reasons. Firstly, cost shares w_j^C are firm-specific, and eligibility and incentive rates often differ across cost components C. Secondly, tax allowance rates TA_j^C, tax credit rates TC_j^C and corporate income tax rates τ_j may vary across firms as a result of a preferential tax treatment of certain groups of firms (e.g. SMEs, young firms).[4] Thirdly, incremental incentives and thresholds, ceilings and floors on eligible R&D expenditure mean that each firm's B-Index depends on the level of its R&D expenditure.

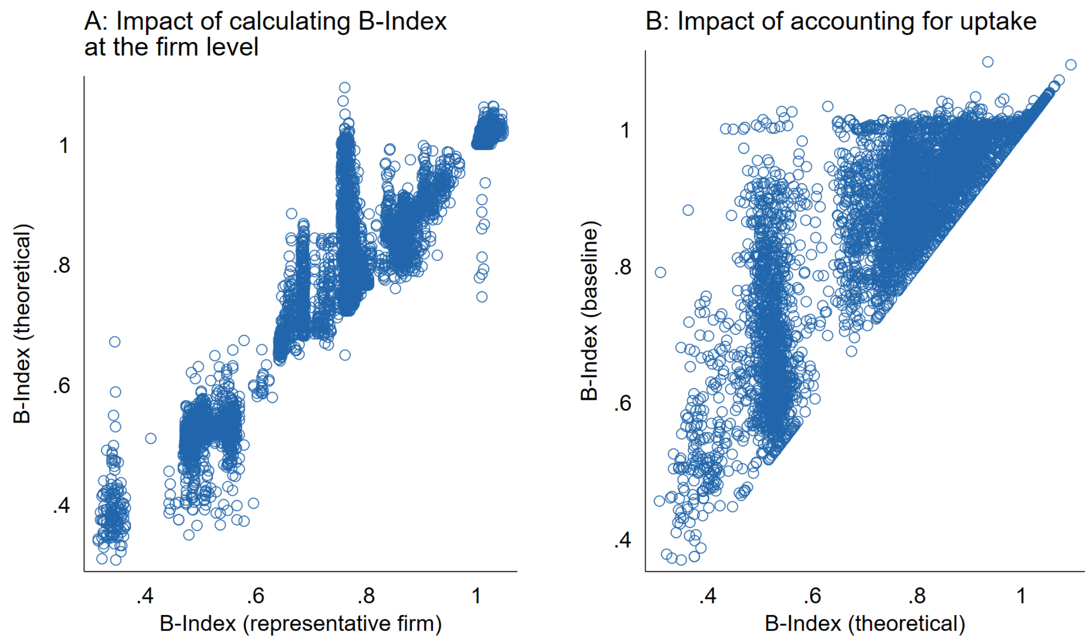
These factors can lead not only to differences between the marginal subsidy rates of individual firms, but also to sizeable systematic differences between firms of different size or in different industries. For example, in 2017, the tax credit offered to firms in Sweden was the same for both small and large firms, at 10%. However, an annual ceiling of 2.76 million Swedish krona (about USD 270,000) on eligible R&D expenditure, which is much more likely to bind for larger firms, meant that the implied marginal R&D tax subsidy rate (i.e. 1 - B-Index) was about 7% for an average small firm (10-49 employees) but only about 4% for an average large firm (250 or more employees). We illustrate these differences more systematically in the left panel of Figure A.1, which plots, for each country-industry-size class-year cell, the average of the theoretical B-index calculated at the firm level against the B-Index calculated for a representative firm. It shows that while the two B-Index measures are highly correlated ($r = 0.96$), the B-Index calculated at the firm level still exhibits substantial dispersion across country-industry-size class-year cells for each value of the representative-firm B-Index.[5]

In addition, we correct the theoretical B-Index for uptake. The right panel of Figure A.1 illustrates the relationship between the theoretical B-Index and the B-Index accounting for uptake: it plots the baseline B-Index measure, i.e. the average of the B-Index accounting for tax incentive uptake, against the average of the theoretical B-index. If R&D tax incentives in all countries had a 100% uptake, the two measures would be identical and all points in the scatter plot would lie on the diagonal. However, due to the partial uptake, the measures are highly but not perfectly correlated ($r = 0.87$). In most cases, the B-Index measure accounting for uptake is substantially larger than the

[4] In some countries, we can directly observe each firm's type in the administrative tax incentive data. When this information is not available, we determine each firm's type at each point in time using relevant official definitions and data on firms' characteristics such as employment, turnover, assets and age.

[5] The change in the SME definition for the purpose of R&D tax incentives in the UK provides another illustration of the advantages of calculating the B-Index at the firm level as compared to the representative-firm B-Index. When the SME definition changed, some firms that were previously classified as large began to be classified as SMEs. Our baseline approach reflects this in the form of a reduction in the B-Index (i.e. greater subsidy) for the firms that newly became eligible for the more generous SME scheme and, consequently, for the data cells to which these firms belong. In contrast, a representative-firm B-Index, used in previous studies, would not reflect the SME definition change in any way.

Figure A.1: **Comparison of B-Index Measures**

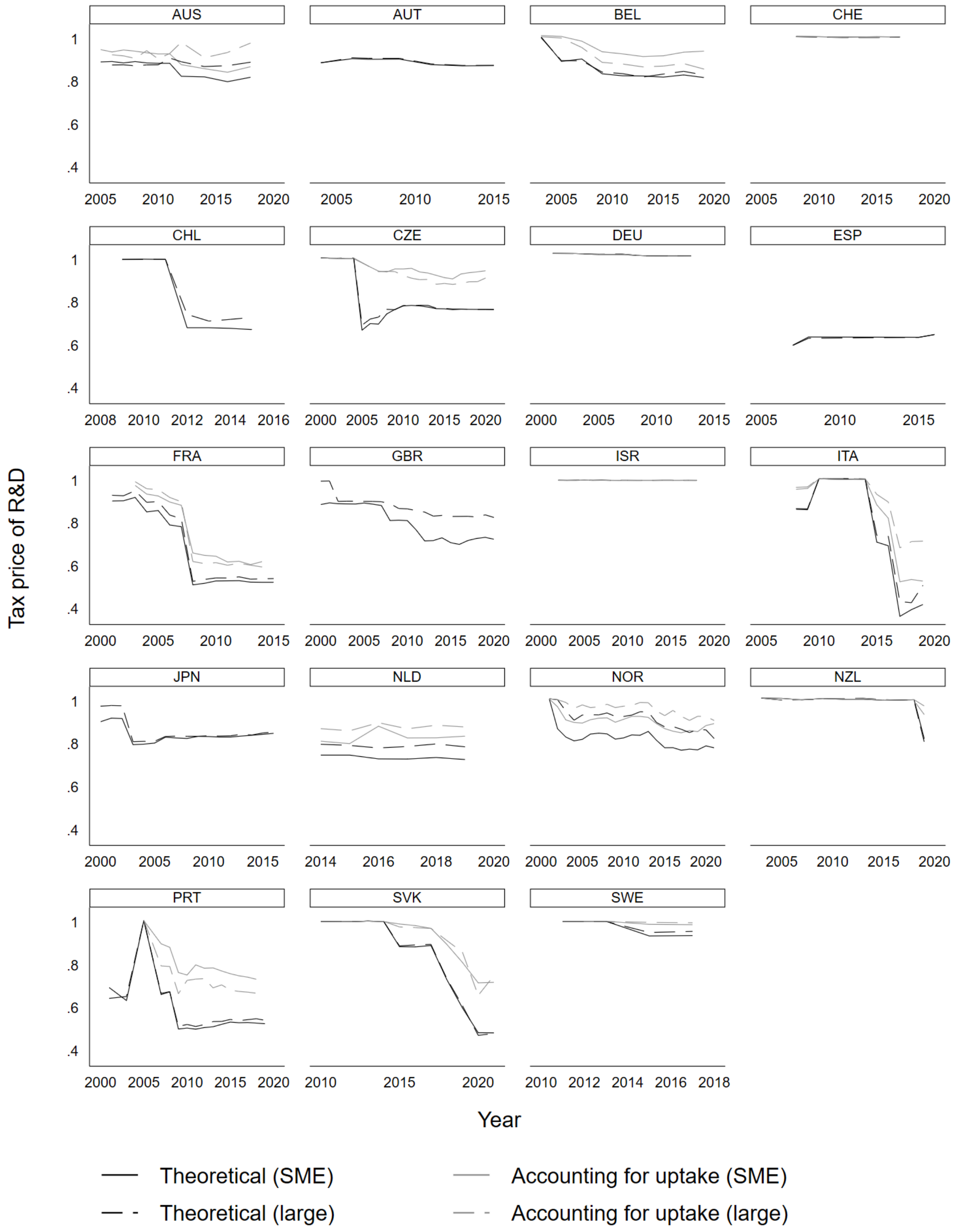


Notes: For each country-industry-size class-year, panel A plots the average of the theoretical B-index calculated at the firm level against the B-Index calculated for a representative firm, and panel B plots the average of the B-Index accounting for tax incentive uptake against the average of the theoretical B-index.

theoretical B-Index measure, which corresponds to a smaller marginal R&D tax subsidy rate.

Figure A.2 documents the evolution of average $BIndex_j^{the}$ and average $BIndex_j$, the baseline measure that takes into account uptake, in each country, separately for SMEs and large firms. The figure reveals several important features. Firstly, most countries in our sample experienced one or more important policy changes during the sample period (e.g. introduction of R&D tax incentives, subsidy rate change, change in the official SME definition...), and these changes led to strong variation in the tax price of R&D faced by firms over time, which we exploit to estimate the effects of R&D tax incentives. Secondly, in many countries, there is a substantial wedge between the theoretical and the baseline B-Indices. Thirdly, the theoretical B-Index is similar for SMEs and large firms in countries where R&D tax incentives do not involve features such as ceilings or preferential rates for SMEs (e.g. Austria, Czechia, Slovakia, Spain) and lower for SMEs where such features are present (e.g. Australia, the United Kingdom, Norway). Fourth, the baseline B-Index can actually be lower for large firms than for SMEs if the uptake is stronger among large firms (e.g. Belgium, Czechia, Portugal).

Figure A.2: **Average B-Index by Country and Firm Size**



Notes: For each country, size category (SME or large) and year, the figure shows the average theoretical B-index and the average B-Index accounting for tax incentive uptake. The average is calculated first across firms in each country-industry-size class cell and then across such cells in each country and size category.

B Data and Variables

B.1 Data Sources

For each R&D-performing firm, business R&D surveys provide basic demographic information such as employment and industry of the main activity along with detailed information on the firm's R&D. This includes, most importantly, information on R&D performed (intramural R&D) and outsourced (extramural R&D), the type of R&D costs (e.g. labour, current consumption of goods and services, capital), R&D employment (expressed in headcount and full-time equivalents) and sources of R&D funding (e.g. own, other business, government).

Business R&D surveys are generally designed to be representative of the population of R&D-performing firms in each country. To ensure the harmonisation of data across countries, we only keep firms that actually responded to the R&D survey, dropping imputed observations and reweighting the remaining observations accordingly. We also drop micro-firms with fewer than 10 employees, which several countries do not cover in their R&D surveys.

The second data source we rely on is firm-level information on R&D tax relief from tax record data. The tax relief records provide information on the amount of R&D tax benefits received by corporate tax relief recipients and, in some countries, also on firm status with respect to preferential tax treatment (e.g. as SME). We link the R&D survey responses with the R&D tax relief records at the firm level and identify the subset of R&D-performing firms using the R&D tax relief available to them and observe the amount of support received.

In total, the microdata underlying our analysis cover about 35,000 R&D-performing firms per year, located in 19 different countries.

Both the R&D microdata and the tax relief records are confidential. Thus we rely on a distributed microdata analysis — a method of studying microdata held in separate enclaves by means of a common, centrally designed routine — undertaken within the OECD microBeRD project (OECD, 2023a).[6]

The R&D data are available at an annual frequency for a majority of countries, and at a bi-annual frequency or a mix of annual and bi-annual frequency for most others.[7]

[6]See `http://oe.cd/microberd` and OECD (2020).

[7]The data are available at a bi-annual frequency for Belgium, Germany and Sweden. Australia, Austria, New Zealand and Portugal switch between an annual and a bi-annual frequency at some point during the sample period. In the case of Spain and Switzerland, the gaps between survey years are longer and irregular. Data for all other countries are available at an annual frequency. Table B.1 lists sample years for each country.

Table B.1: **Sample Years by Country**

Year	**AUS**	AUT	**BEL**	CHE	CHL	**CZE**	DEU	ESP	**FRA**	GBR	ISR	**ITA**	JPN	**NLD**	**NOR**	**NZL**	**PRT**	**SVK**	**SWE**
2000						x				x			x						
2001						x	x		x	x			x		x		x		
2002						x			x	x	x		x		x				
2003			x			x	x		x	x	x		x		x	x	x		
2004		x				x			x	x	x		x		x				
2005	x		x			x	x		x	x	x		x		x	x	x		
2006	x	x				x			x	x	x		x		x				
2007	x	x	x			x	x	x	x	x	x		x		x	x	x		
2008	x			x		x		x	x	x	x	x	x		x		x		
2009	x	x	x		x	x	x		x	x	x	x	x		x	x	x		
2010	x				x	x			x	x	x	x	x		x		x	x	
2011	x	x	x		x	x	x		x	x	x	x	x		x	x	x	x	x
2012	x			x	x	x			x	x	x	x	x		x		x	x	
2013		x	x		x	x	x		x	x	x	x	x		x	x	x	x	x
2014	x				x	x			x	x	x	x	x	x	x		x	x	
2015		x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x
2016	x					x		x		x	x	x	x	x	x		x	x	
2017			x	x		x				x	x	x		x	x	x	x	x	x
2018	x					x				x	x	x		x	x	x	x	x	
2019			x			x				x		x		x	x	x	x	x	
2020						x				x					x			x	
2021						x									x			x	

Notes: The table marks with "x" the years in which each country appears in our estimation sample. The countries for which administrative R&D tax relief microdata are available are marked in bold.

B.2 The Sample

The baseline sample represents an unbalanced panel covering 14 countries over the period of 2000-2021. It consists of 11 countries that had an R&D tax incentive in place at some point during the sample period and for which administrative R&D tax relief records are available (Australia, Belgium, Czechia, France, Italy, the Netherlands, New Zealand, Norway, Portugal, Slovakia and Sweden). It additionally covers 3 countries that did not offer any R&D tax incentives during the sample period but which are included because they help to pin down the industry-size class-year fixed effects and, thus, reduce the standard errors in the estimated regressions (Germany, Israel and Switzerland). There are an additional 5 countries that had an R&D tax incentive in place at some point but for which we only have information based on R&D microdata and not on the administrative R&D tax relief records (Austria, Chile, Japan, Spain and the United Kingdom). For these countries, we are not able to construct measures of the cost of R&D investment that take into account the actual use of the tax incentives — one of the key contributions of the paper. For this reason, we exclude these countries from our baseline sample but test the robustness of the results to using a broader sample in which they are included (using a specification that does not require availability of the tax relief data).

To ensure that the results are not driven by outliers, we drop the 1% country-industry-size classes with the largest proportional difference between the years with the largest and smallest intramural R&D expenditure. There are 8 such country-industry-size classes, representing 107 observations, and all of them have seen at least a 60-fold increase or decrease in R&D expenditure. We show in robustness checks that keeping these observations would have little effect on the results.

The resulting baseline sample counts 7,273 country-industry-size class-year observations with non-missing values of the key variables.[8] Table B.1 reports the years in which each country appears in the estimation sample and highlights the countries for which administrative R&D tax relief microdata are available. All financial variables are converted into 2005 USD using purchasing power parity (PPP) exchange rates. R&D expenditure is deflated using GDP-PPP deflators.

B.3 Variable Definitions

The variables used in the analysis are listed in Table B.2. Reflecting the level of the analysis, the variables are defined for each country c, industry i, size class s and year t.[9]

[8] The broader 19-country sample that includes countries for which administrative R&D tax relief records are not available counts 10,053 observations.

[9] We also report some specifications estimated at the country-industry-year level. Variables in these specifications are constructed in an analogous way to those described below but aggregating across size

All financial variables are expressed in 2005 USD using purchasing power parity (PPP) exchange rates (OECD, 2023c), and R&D expenditure is deflated using GDP deflators (OECD, 2023b).

The first set of variables describes firms' R&D performance. Our main outcome variable is the natural logarithm of the total intramural (in-house) R&D performance of firms in a given country-industry-size class data cell. We also separately explore current R&D expenditure (labour costs and current consumption of goods and services) and R&D-related capital expenditure (buildings and machinery). When investigating the uptake of R&D tax incentives, we also use the logarithm of average R&D expenditure across firms in a given country, industry, size class, and year.

The second set of variables consists of different measures of the tax price of R&D. To be able to interpret our estimates as elasticities, we enter them into our specifications as natural logarithms, and to obtain variables at the level of the analysis, we take averages across R&D-performing firms in each data cell. Our baseline explanatory variable represents an average logarithm of $BIndex_j$ across firms in a given country, industry, size class, and year, $\overline{\log BIndex}_{cist}$. We calculate the variable as an average of logarithms, but using instead a logarithm of the average B-Index would make almost no difference as the correlation between the two measures is 0.998.[10] In an analogous way, we also calculate the average logarithm of the theoretical B-Index that does not account for the actual uptake of R&D tax incentives, $\overline{\log BIndex^{the}}_{cist}$. In addition, for comparison with earlier studies, we also calculate a B-Index for a representative firm in each country-industry, $\log BIndex^{repr}_{cit}$. Finally, for the analysis of uptake in subsection 3.1 of the main paper, we calculate the marginal (theoretical) tax subsidy rate, $\overline{1 - BIndex^{the}}_{cist}$, as the average of (1 - theoretical B-Index) across firms in each data cell.

The third set of variables includes characteristics of firms in each data cell that are used to construct interaction terms designed to explore heterogeneity in the effects of R&D tax incentives. Most importantly, it includes dummies for small firms (10-49 employees), medium firms (50-249 employees) and large firms (250 or more employees). It also includes two dummies for R&D-intensive firms. The baseline measure is defined as data cells with an above-median ratio of R&D employment to the total employment in the first year in the sample.[11] Alternatively, we use an external measure, defined at the industry-level and based on the *OECD Taxonomy of Economic Activities Based on R&D Intensity* (Galindo-

classes.

[10]This is because B-Index tends to have values close to 1, where a logarithm is relatively well approximated by a linear function.

[11]We measure R&D intensity by the R&D employment share rather than the ratio of R&D expenditure and sales because the R&D microdata for some of our sample countries do not include information on sales. The median is defined within each country and size class.

Table B.2: **Variable Definitions**

Variable	Definition
log R&D expenditure	log total intramural R&D expenditure of firms in a data cell
log current R&D expenditure	log current intramural R&D exp. of firms in a data cell
log capital R&D expenditure	log intramural R&D exp. of firms in a data cell on R&D-related machinery and buildings
log mean R&D expenditure	log average R&D expenditure across firms in a data cell
log B-Index (baseline)	average log B-Index (accounting for uptake) across firms in a data cell ($\overline{\log BIndex}_{cist}$)
log B-Index (theoretical)	average log theoretical B-Index (not accounting for uptake) across firms in a data cell ($\overline{\log BIndex^{the}}_{cist}$)
log B-Index (represent. firm)	log B-Index for a representative firm in a data cell ($\log BIndex^{repr}_{cit}$)
marginal tax subsidy rate	average of (1 - theoretical B-Index) across firms in a data cell ($\overline{1 - BIndex^{the}}_{cist}$)
share receiving R&D tax relief	share of firms in a data cell receiving R&D tax relief
small	10-49 employees (1/0)
medium	50-249 employees (1/0)
large	250+ employees (1/0)
R&D intensive (baseline)	a data cell with an above-median ratio of R&D employment to the total employment in the first year in the sample (1/0)
R&D intensive (OECD)	industry classified as having high or medium-high R&D intensity by Galindo-Rueda and Verger (2016) (1/0)
low mean age	a data cell with below-median average firm age (1/0)
young firm share	the industry share of firms of <5 years (source: OECD DynEmp)
log value added (t-2)	log industry value added lagged by 2 years (source: OECD STAN)
intensity of direct support	total direct R&D support received by firms in a data cell relative to their mean intramural R&D expenditure over the sample period
log patent filings (t-2)	log USPTO patent applications by resident applicants lagged by 2 years (source: OECD)
5-year product. growth (t,t-5)	annualised growth in GDP per hour worked ($t-5$ to t, source: OECD)
year 1-4 since introduction	year 1-4 since the first introduction of R&D tax incentives (1/0)
incremental	incremental R&D tax incentive (1/0)
refundable	refundable R&D tax incentive (1/0)
payroll withholding	payroll withholding R&D tax incentive (1/0)
innovation authorities	innovation ministry or agency involved in administration of R&D tax incentives (1/0, source: OECD R&D Tax Incentive Database)
mandatory pre-registration	mandatory pre-registration (1/0, source: OECD R&D Tax Incentive Database)

Notes: The source of the data is the OECD microBeRD project, unless otherwise stated. Data cells are defined by a country, industry and size class, unless otherwise stated.

Rueda and Verger, 2016).[12] It marks 2-digit NACE industries as R&D-intensive if they are classified as having *high* or *medium-high* R&D intensity according to the taxonomy.[13]

[12] In contrast to the baseline indicator, the classification is defined at the industry level, based on R&D expenditure and industry value added, rather than R&D and overall employment, and the denominator corresponds to all firms in each industry, not just the R&D performers.

[13] We classify the following A38 industries as R&D intensive: *Manufacture of chemicals and chemical products*; *Manufacture of basic pharmaceutical products and pharmaceutical preparations*; *Manufacture of computer, electronic and optical products*; *Manufacture of electrical equipment*; *Manufacture of machinery and equipment*; *Manufacture of transport equipment*; *Computer programming, consultancy and*

Finally, when exploring the role of credit constraints, we use two different indicators related to firm age.[14] The first one is a dummy variable for data cells with a below-median average age of R&D-performing firms, as observed directly in the microdata underlying our analysis. The second one measures the share of firms younger than 5 years in all firms in a given country and industry (R&D performers or not) and comes from the OECD DynEmp database (OECD, 2025a).

Four additional variables serve as control variables in some specifications. Industry-level value added comes from the OECD STAN database (OECD, 2023e) and is deflated using industry-specific deflators from the same source. The intensity of direct support is defined as the ratio of the total direct R&D support received by firms in a data cell to the mean intramural R&D expenditure of these firms over the sample period. Information on patent filings comes from the OECD and measures the number of patent applications at the United States Patent and Trademark Office (USPTO) by resident patent applicants (OECD, 2024). Finally, the 5-year productivity growth is calculated as the annualised growth in GDP per hour worked between years $t-5$ and t and comes from the OECD Productivity Database (OECD, 2025b).

Finally, we use several binary indicators describing the implementation and design of R&D tax incentives in a given country (OECD, 2023d). They include indicators for incentives newly introduced in the past 4 years, incremental incentives, refundable incentives, payroll withholding incentives, incentives where an innovation ministry or agency is involved in their administration (either alone or together with tax authorities) and incentives requiring that R&D projects be pre-registered or pre-approved in order to be eligible for tax relief.[15]

C Additional Analysis of Uptake

Uptake is incomplete. Taking year 2019 as an example,[16] Figure C.1 shows, for each country and size class, the share of R&D-performing firms that used R&D tax relief. It clearly demonstrates that the uptake of R&D tax incentives is indeed highly incomplete as in all 11 countries many R&D-performing firms do not use the R&D tax support. In an average country-size class, less than half of eligible firms used R&D tax relief, with the share ranging from 80% of medium and large firms in France to just 10% of small

related activities - information service activities; and *Scientific research and development.*

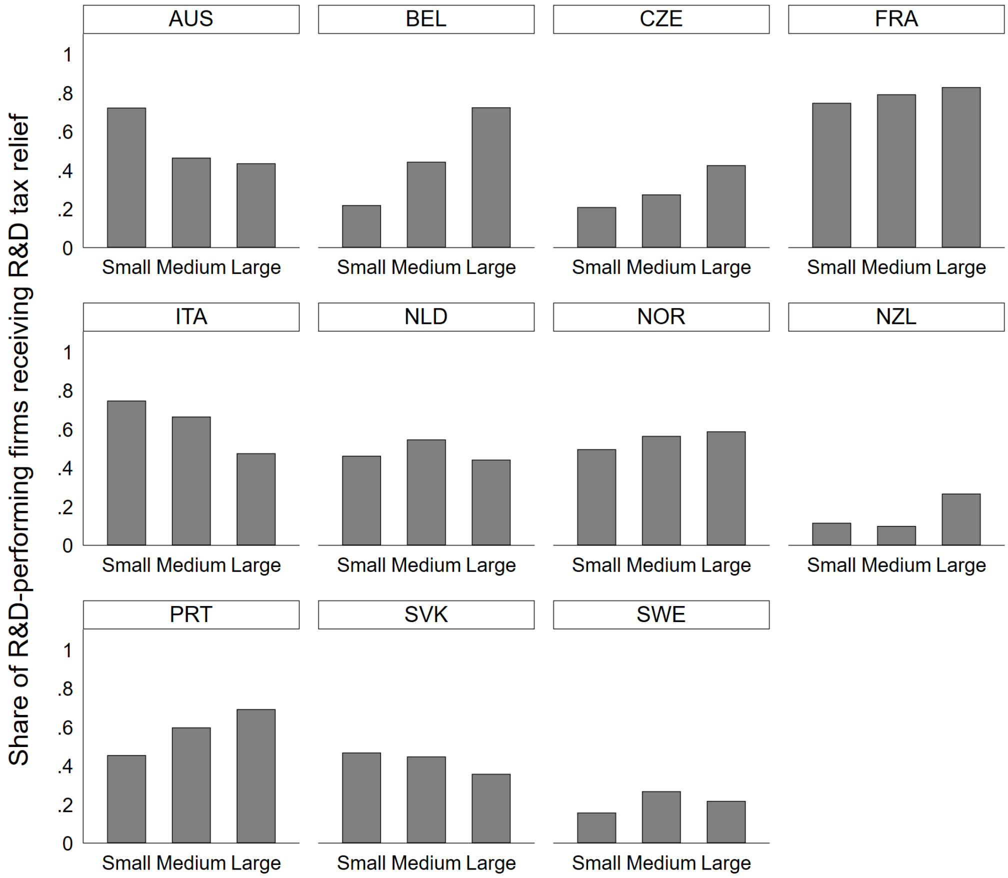
[14]For countries where a given age indicator is not available, we impute it using cross-country industry-size class-specific means.

[15]The last two design indicators are only available for year 2022.

[16]2019 is the most recent year available for the majority of countries in our data. We use year 2018 for Australia and Portugal, 2017 for Sweden and 2014 for France.

and medium R&D-performing firms in New Zealand.

Figure C.1: **Uptake of R&D Tax Incentives**



Notes: The figure is based on year 2019 with the exception of Australia (2018), France (2014), Portugal (2018) and Sweden (2017).

Which firm and policy characteristics are correlated with uptake of R&D tax incentives by R&D-performing firms?

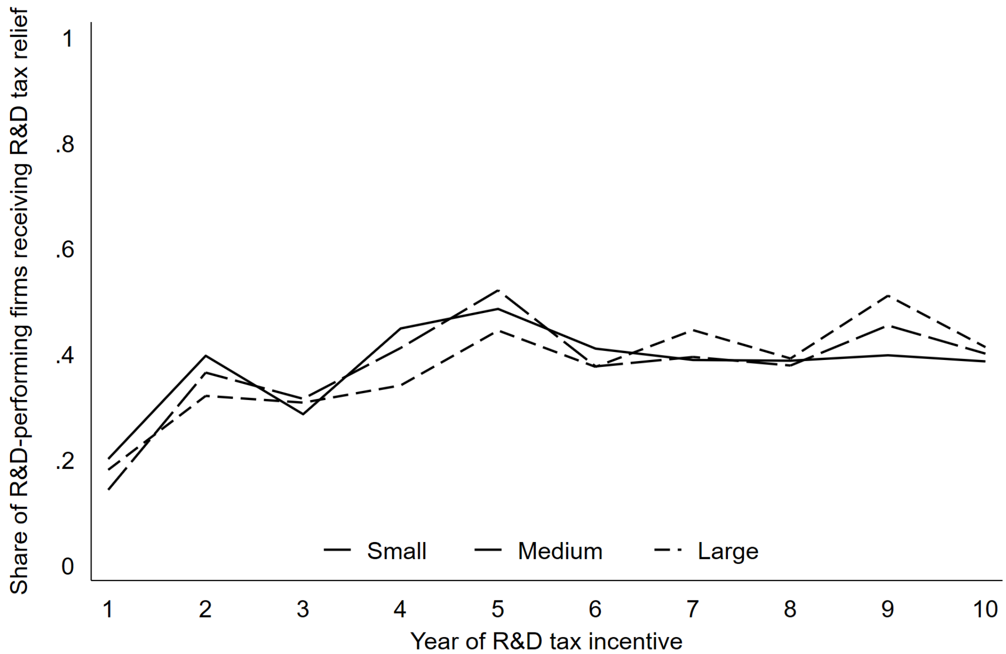
With regard to firm size, Figure C.1 does not show any clear pattern. The uptake of R&D tax incentives increases with firm size in Belgium, Czechia and Portugal, decreases with size in Australia and Italy, and exhibits a weak or non-linear relationship with size in the remaining countries.[17]

A lack of awareness of R&D tax incentives is likely to reduce uptake only in the initial years after their introduction as firms can be expected to learn about the incentives over time. Figure C.2 documents the uptake of R&D tax incentives over time since the first

[17] In the context of tax loss refunds in the US, Zwick (2021) documents a lower uptake among smaller firms, but, similar to our results, finds that even many large firms fail to claim the refund for which they are eligible.

introduction of R&D tax incentives.[18] The uptake is indeed rather low in the first year of an incentive (around 20%) and gradually increases over the next 3 or 4 years, after which it remains flat. Additionally, a firm might be unaware of an R&D tax incentive not just when the incentive is itself new, but when the firm has just started to perform R&D for the first time. Our data indeed indicate slightly lower uptake among new R&D performers (44%) compared to continuing R&D performers (50%).

Figure C.2: **Uptake of R&D Tax Incentives Over Time Since Their Introduction**



Notes: The figure shows the average (across countries) share of R&D-performing firms in each size class that benefit from R&D tax relief in years 1 to 10 since the first introduction of R&D tax incentives in a given country. For Italy, the incentives in place in years 2007-2009 and from 2015 onward are treated separately (the year count is reset). For New Zealand, the temporary incentive in place only in 2008 is ignored. For Portugal, the temporary removal of the incentives in years 2004-2005 is ignored (the year count is not reset).

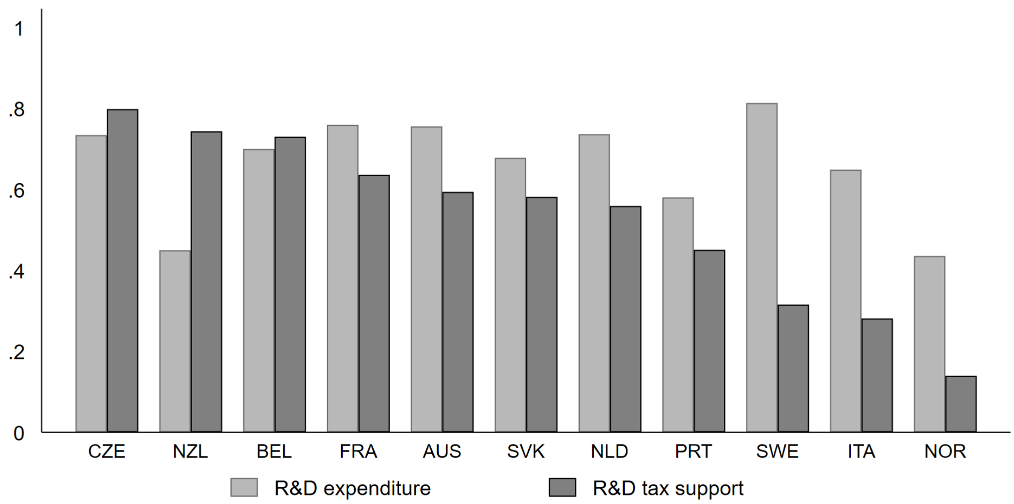
D Additional Evidence on Distribution of R&D Expenditure and R&D Tax Relief Across Countries

Figure D.1 reports the share of large firms in R&D expenditure and R&D tax relief separately for each country. While large firms account for the majority of all R&D

[18] R&D tax incentives were introduced in 1983 in France, 1985 in Australia, 1994 in the Netherlands, 1997 in Portugal, 2002 in Norway (2003 for large firms), 2005 in Belgium and Czechia, 2015 in Slovakia and Sweden and 2019 in New Zealand. In Italy they were in place between 2007-2009 and re-introduced in 2015; we count each instance separately, resetting the year count.

expenditure in all countries considered except New Zealand and Norway, the share of R&D tax relief going to large firms is more heterogeneous across countries. In countries with no limit on R&D eligible for the full support, such as Belgium, Czechia and Slovakia, the share of large firms in R&D tax relief is similar to, or greater than (thanks to stronger uptake), their share in R&D expenditure. In New Zealand, the share of large firms in R&D tax relief is much greater than their share in R&D expenditure, due to a very low SME uptake during the first year of the new tax incentive. In contrast, the share of large firms in R&D tax relief is lower than their share in R&D expenditure in countries that offer preferential tax subsidy rates for SMEs (Australia) and, in particular, that impose binding ceilings on eligible R&D (Norway, Sweden).[19]

Figure D.1: **Share of Large Firms in R&D Expenditure and R&D Tax Relief**



Notes: The figure is based on year 2019 with the exception of Australia (2018), France (2014), Portugal (2018) and Sweden (2017).

[19] In the case of Italy and Portugal, the lower share of large firms in R&D tax relief, relative to their share in R&D expenditure, is likely due to the use of incremental incentives in these countries, combined with a faster growth of R&D among smaller (and, on average, younger) firms.

E Additional Tables and Figures

Table E.1: **Homogenous R&D Tax Price Elasticities: First Stage**

	Outcome: log B-Index			
	Country-industry		Country-ind.-size class	
	(1) Theoretical	(2) Baseline	(3) Theoretical	(4) Baseline
log B-Index (synthetic)	1.062	0.662	1.035	0.637
	(0.010)	(0.019)	(0.009)	(0.015)
log value added (t-2)	0.018	0.045	0.010	0.047
	(0.010)	(0.012)	(0.008)	(0.010)
Observations	3490	3490	7273	7273

Notes: *** 1%, ** 5%, * 10%. Columns 1-4 show first-stage results corresponding to second-stage results reported, respectively, in columns 3 and 4 of panel A and columns 3 and 4 of panel B of Table 4. Observations are defined at the country-industry-year level (columns 1-2) or at the country-industry-size class-year level (columns 3-4). Standard errors in parentheses are clustered at the country-industry level (columns 1-2) or at the country-industry-size class level (columns 3-4). In columns 1 and 3, the outcome variable is the average log theoretical B-Index (not accounting for tax incentive uptake) across all R&D-performing firms in a given country and industry or country, industry and size class ($\overline{\log BIndex^{the}}_{ci(s)t}$). In columns 2 and 4, it is the average log of a B-Index accounting for tax incentive uptake ($\overline{\log BIndex}_{ci(s)t}$). The main explanatory variable is the synthetic B-Index ($\overline{\log BIndex}^{syn}_{ci(s)t}$). All regressions control for industry value added lagged by 2 years, country-industry (columns 1-2) or country-industry-size class (columns 3-4) fixed effects and industry-year (columns 1-2) or industry-size class-year (columns 3-4) fixed effects.

Table E.2: **R&D Tax Price Elasticities Controlling for Direct Support**

A: Country-industry level

	Outcome: log R&D expenditure			
	OLS		2SLS	
	(1)	(2)	(3)	(4)
log B-Index (representative firm)	-0.414			
	(0.061)			
log B-Index (theoretical)		-0.406	-0.426	
		(0.063)	(0.066)	
log B-Index (baseline)				-0.683
				(0.108)
intensity of direct support	1.596	1.597	1.595	1.616
	(0.236)	(0.238)	(0.237)	(0.230)
log value added (t-2)	0.230	0.222	0.225	0.248
	(0.085)	(0.086)	(0.085)	(0.087)
Observations	3490	3490	3490	3490
F-stat			11793	1228

B: Country-industry-size class level

	Outcome: log R&D expenditure			
	OLS		2SLS	
	(1)	(2)	(3)	(4)
log B-Index (representative firm)	-0.503			
	(0.045)			
log B-Index (theoretical)		-0.528	-0.560	
		(0.045)	(0.049)	
log B-Index (baseline)				-0.909
				(0.076)
intensity of direct support	1.759	1.762	1.758	1.788
	(0.101)	(0.100)	(0.100)	(0.099)
log value added (t-2)	0.195	0.186	0.192	0.229
	(0.067)	(0.067)	(0.067)	(0.069)
Observations	7273	7273	7273	7273
F-stat			13799	1724

Notes: *** 1%, ** 5%, * 10%. In panel A, observations are defined at the country-industry-year level, and, in panel B, observations are defined at the country-industry-size class-year level. Standard errors in parentheses are clustered at the country-industry level (panel A) or the country-industry-size class level (panel B). The outcome variable is the logarithm of the total intramural R&D expenditure by firms in a given country and industry (panel A) or country, industry and size class (panel B). In column 1 (of each panel), the main explanatory variable is a log of a B-Index calculated for a representative firm in each country-industry ($\log BIndex^{repr}_{cit}$). In columns 2-3, it is the average log theoretical B-Index (not accounting for tax incentive uptake) across all R&D-performing firms in a given country and industry or country, industry and size class ($\overline{\log BIndex^{the}}_{ci(s)t}$). In column 4, it is the average log of a B-Index accounting for tax incentive uptake ($\overline{\log BIndex}_{ci(s)t}$). Regressions in columns 1-2 are estimated by OLS, and regressions in columns 3-4 are estimated by 2SLS, instrumenting for the B-Index variables with the synthetic B-Index ($\overline{\log BIndex}^{syn}_{ci(s)t}$). All regressions control for industry value added lagged by 2 years, country-industry (panel A) or country-industry-size class (panel B) fixed effects and industry-year (panel A) or industry-size class-year (panel B) fixed effects.

Table E.3: **Heterogeneous R&D Tax Price Elasticities: First Stage**

	Outcome: log B-Index			
	(1)	(2)	(3)	(4)
	x large	x medium	x small	x R&D intens.
log B-Index (synthetic)	0.721	-0.003	0.002	0.022
	(0.021)	(0.006)	(0.007)	(0.015)
log B-Index (synthetic) x medium	-0.051	0.665	0.000	-0.014
	(0.028)	(0.019)	(0.001)	(0.023)
log B-Index (synthetic) x large	-0.197	-0.000	0.518	-0.089
	(0.036)	(0.002)	(0.030)	(0.031)
log B-Index (syn.) x R&D-intensive	-0.023	0.002	-0.008	0.634
	(0.026)	(0.013)	(0.016)	(0.021)
log value added (t-2)	0.047	0.018	0.010	0.019
	(0.010)	(0.006)	(0.006)	(0.007)
Observations	7273	7273	7273	7273

Notes: *** 1%, ** 5%, * 10%. Columns 1-4 show first-stage results corresponding to second-stage results reported in column 4 of Table 5. Observations are defined at the country-industry-size class-year level, and standard errors in parentheses are clustered at the country-industry-size class level. The outcome variables are based on the average log of a B-Index accounting for tax incentive uptake across all R&D-performing firms in a given country, industry and size class ($\overline{\log BIndex}_{cist}$). All regressions control for industry value added lagged by 2 years, country-industry-size class fixed effects and industry-size class-year fixed effects.

Table E.4: **R&D Tax Price Elasticities: Dropping One Country at a Time**

	Outcome: log R&D expenditure				
	(1)	(2)	(3)	(4)	(5)
Excluded country:	*none*	AUS	BEL	CHE	CZE
log B-Index	-1.464	-1.446	-1.546	-1.448	-1.193
	(0.140)	(0.141)	(0.138)	(0.144)	(0.130)
log B-Index x medium	0.234	0.221	0.284	0.217	0.233
	(0.166)	(0.168)	(0.165)	(0.168)	(0.156)
log B-Index x large	0.937	0.933	1.035	0.910	0.703
	(0.222)	(0.223)	(0.222)	(0.224)	(0.207)
log B-Index x R&D intens.	0.410	0.403	0.398	0.407	0.299
	(0.149)	(0.150)	(0.149)	(0.150)	(0.139)
Observations	7273	7062	6953	7091	6150
F-stat	79	77	77	78	82
	Outcome: log R&D expenditure				
	(6)	(7)	(8)	(9)	(10)
Excluded country:	DEU	FRA	ISR	ITA	NLD
log B-Index	-1.552	-1.552	-1.436	-1.798	-1.479
	(0.149)	(0.167)	(0.139)	(0.290)	(0.142)
log B-Index x medium	0.271	0.186	0.225	0.450	0.250
	(0.170)	(0.203)	(0.167)	(0.345)	(0.170)
log B-Index x large	0.993	0.830	0.906	0.770	0.966
	(0.234)	(0.328)	(0.229)	(0.347)	(0.224)
log B-Index x R&D intens.	0.456	0.450	0.420	0.619	0.431
	(0.154)	(0.184)	(0.150)	(0.264)	(0.151)
Observations	6783	6337	6967	6406	6961
F-stat	76	68	78	62	79
	Outcome: log R&D expenditure				
	(11)	(12)	(13)	(14)	(15)
Excluded country:	NOR	NZL	PRT	SVK	SWE
log B-Index	-1.327	-1.440	-1.407	-1.508	-1.466
	(0.139)	(0.139)	(0.137)	(0.145)	(0.141)
log B-Index x medium	0.225	0.145	0.193	0.287	0.228
	(0.167)	(0.166)	(0.162)	(0.169)	(0.166)
log B-Index x large	1.041	0.866	1.094	0.999	0.943
	(0.230)	(0.221)	(0.209)	(0.222)	(0.223)
log B-Index x R&D intens.	0.309	0.414	0.438	0.413	0.419
	(0.149)	(0.148)	(0.150)	(0.151)	(0.149)
Observations	6124	7104	6443	7058	7110
F-stat	82	78	77	71	77

Notes: *** 1%, ** 5%, * 10%. Observations are defined at the country-industry-size class-year level, and standard errors in parentheses are clustered at the country-industry-size class level. The outcome variable is the logarithm of the total intramural R&D expenditure by firms in a given country, industry and size class. Explanatory variables are based on the average log of a B-Index accounting for tax incentive uptake across all R&D-performing firms in a given country, industry and size class ($\overline{\log BIndex}_{cist}$). All regressions are estimated by 2SLS, instrumenting for the B-Index-based explanatory variables with corresponding variables based on the synthetic B-Index ($\overline{\log BIndex}^{syn}_{cist}$). All regressions control for industry value added lagged by 2 years, country-industry-size class fixed effects and industry-size class-year fixed effects. Each regression excludes one country (marked in the column header) from the sample.

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