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The Differential Impact of R&D Subsidies

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Promoting Innovation: The Differential Impact of R&D Subsidies

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ABSTRACT: We investigate the effect of R&D subsidies on firms' innovation by ownership, industry, and firm size using German firm-level data. The impact of R&D subsidies is heterogeneous across industries for multinational corporations (MNCs) and domestic firms while it does not differ substantially by firm size. Domestic firms have a larger response in R&D spending in low-tech manufacturing, knowledge-intensive services, and technological services while the response of domestic and foreign MNCs is broadly similar and is greater in medium-tech and high-tech manufacturing. Foreign MNC subsidiaries' response in terms of patents is greater than that of domestic MNCs in most industries.

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Introduction

Innovation is key to economic growth, and governments are keen to promote innovation using various tools at their disposal. Research and development (R&D) activities represent an important ingredient in the innovation process, and a standard tool used by government to encourage it is R&D subsidies. In this context, it is important for policymakers to know how effective R&D subsidies are beyond the average or aggregate effect. Indeed, it would be beneficial to know if the subsidy impact is differential depending on the ownership type (e.g., foreign owned vs. domestic), firm size, and industry (Blanes & Busom, 2004). This could help focus scarce resources while increasing the overall impact.

In this paper, using German firm-level data, covering the 2000s, we study the effect of R&D subsidies on innovation inputs such as R&D spending and outputs such as patents. We further study whether R&D subsidies have a differential effect on the subsidiaries of foreign multinational companies (MNCs) vs. domestic MNCs and domestic firms, whether the firm size matters, and whether the effect of subsidies differs by industry. We use a treatment model to identify the effect of R&D subsidies. Identification requires modeling the counterfactual, that is, how firms would have engaged in innovation activities had they not received any subsidy. We employ a propensity score matching and regressions on a matched sample to estimate the parameters of interest in a cross-section of firms.

The empirical evidence suggests that subsidies increase R&D spending compared to the comparable firms that do not receive subsidies[2], and moreover, result in higher future patenting activity. We find that the effect of R&D subsidies on R&D spending is broadly similar for foreign MNC subsidiaries and domestic MNCs. In contrast, there are significant differences in the effects on MNCs and domestic firms across industries, but not by firm size. The impact on R&D spending is larger for MNCs in medium- and high-tech manufacturing than for domestic firms but is lower in low-tech manufacturing and some service industries. The subsidy's effect on future patents is bigger for MNCs than domestic firms and interestingly, is bigger for foreign MNCs than domestic MNCs in most industries except for medium-tech manufacturing.

There are several reasons as to why R&D subsidies would increase the innovation effort and performance of firms. The alleviation of financial constraints would, for example, increase R&D and consequently, patenting activity. The fact that MNCs increase R&D spending more in certain industries and patenting activity in general than domestic firms, suggests that competing in international markets in medium- and high-tech manufactures requires a lot of innovation. The higher patenting of foreign MNCs compared to domestic MNCs could suggest more efficient use or allocation of resources toward patentable technologies or a signaling toward headquarters to pursue more innovation in a foreign location. In fact, pursuing more innovation at the technological frontier, resulting in better innovation outcomes like patenting, could be the result of knowledge spillovers and technology transfers across the MNC global network (Niosi, 1999; Cantwell and Mudambi, 2005; Un and Cuervo-Cazurra, 2008; Gelman and Imbens, 2013; Santangelo et al., 2016; Cantwell, 2017).

Economic theory provides a justification for the government's support of firms' innovation activities. Firms tend to underinvest in R&D spending due to a variety of market failures (e.g., Arrow 1962; Klette et al., 2000). Positive externalities such as knowledge spillovers, imperfect information about future returns, and market frictions as well as resource constraints would produce less than socially optimal investment and

[2] Given that the amount of the subsidy is not available in the dataset, we have evidence that the multiplier on R&D spending is positive but not necessarily greater than one.

innovation activities (Bozeman, 2000; David et al., 2000a; Feldman and Kelley, 2006; Ceh, 2009; Rigby and Ramlogan, 2012; Lazzarini, 2015; Holmes et al., 2016). In addition, governments may also intervene to tackle potential systemic problems in the innovation ecosystem (Salter and Martin, 2001). These include technological transitions, lock-in problems due to an excessive focus on existing technologies, and innovation network deficiencies (Chaminade and Edquist, 2008). The system of innovation approach emphasizes the importance of innovation networks in which firms do not innovate in isolation but continuously interact with other innovation agents such as other firms, universities, or public research organizations (Lundvall, 1992).

Although there is a debate about the effectiveness of R&D programs, a large literature in economics and management has mostly found a positive effect of these programs on innovation such as R&D spending and patents (Czarnitzki and Toole, 2007; Aerts & Schmidt, 2008; Gonzalez and Pazo, 2008; Zúñiga-Vicente et al., 2014; Jaffe and Le, 2015; Howell, 2017). Subsidies could narrow the scope of firms' innovation solutions (Ely et al., 2014), increase the costs of R&D inputs such as wages of researchers (David et al., 2000b; Clarysse et al., 2009), or prop up lagging firms in terms of innovation capacity rather than facilitate movement of skilled labor to high-tech firms (Acemoglu et al., 2018).

More important, subsidies could potentially crowd out R&D spending, resulting in no increase in R&D spending funded by firms, but the empirical evidence shows otherwise. Essentially, a zero multiplier implies that the incentive effect of subsidies to engage in more R&D and eventually patenting activities is offset by the reallocation of spending toward other activities that the freeing of firm resources allows after a subsidy receipt. Prior literature, however, suggests that overall, there is no or only partial crowding out of R&D investments (e.g., Jaffe and Le, 2015; Dimos and Pugh, 2016). Moreover, the elasticity of R&D to tax credits is equal to or greater than one (e.g., Bloom, Griffith, and van Reenen, 2002; Rao, 2016), and benefits of tax incentives exceed their costs (Lester and Warda, 2020). Targeted R&D subsidies could also encourage long-term research such as cancer research (Budish, Roin, and Williams, 2015). R&D subsidies could also potentially nudge subsidiaries of foreign MNCs to be more innovative (Birkinshaw and Hood, 1998; Cantwell and Mudambi, 2005; Cantwell, 2017).

R&D support to firms has strong impact on innovation outcomes such as patents. R&D subsidies have a statistically significant and economically large effect on patents and venture capital investment, enabling proof-of-concept that would not have been financially possible otherwise (Howell, 2017). In the UK, there is evidence that tax credits increase both patenting and citations (Dechezleprêtre, Einiö, Martin, Nguyen and van Reenen, 2016) while R&D subsidies increase patenting in Italy (Bronzini and Piselli, 2016). Tax credits also increase product and process innovation (Czarnitzki et al., 2011; Cappelen et al., 2012) while R&D support induces innovation collaboration among firms in the innovation ecosystem (e.g., OECD, 2006; Un et al., 2010; Gök and Edler, 2012) and increases labor productivity of firms (Minniti and Venturini, 2017).

In terms of the heterogeneity of the R&D subsidy impact, Sofka et al. (2021), using German firm-level data, find that both foreign and domestic MNCs increase R&D by the same amount but spend more on R&D than domestic firms. In addition, foreign MNCs patent more than domestic MNCs and domestic firms. In contrast, this paper explores the heterogeneous impact of subsidies by industry and firm size and assesses the subsidy impact on R&D spending and patents using matched-firm regressions.

Data, Descriptive Statistics, and Empirical Methodology

Government R&D policies in Germany

Germany is an interesting case study to analyze R&D policy's impact on innovation as it is both R&D intensive and open. The R&D intensity of the German economy is about 3 percent of GDP, and R&D expenditures have increased in both the government and business sectors (Sofka et al., 2018). Germany is also a major foreign direct investor in terms of outflows (FDI outflow positions of about 44 percent of GDP in 2017) as well as inflows (FDI inflow positions of about 26 percent of GDP in 2017) (OECD, 2019). In addition, MNCs have operated subsidiaries in Germany for a long time—for instance, investments by the US car manufacturers General Motors and Ford date back to the first half of the 20th century (de Faria & Sofka, 2010).

Using the German firm-level data allows us to better control for various institutional conditions, allowing us to focus on innovation implications of R&D policy. Germany has a stable institutional environment such as a strong intellectual property rights regime (Park, 2008; Papageorgiadis and Sofka, 2020) as well as continuous political support for innovation (EFI, 2017), which could positively affect R&D decisions. Germany provides information and administrative support for potential foreign investors (Germany Trade and Invest, GATI.de) but does not provide tax incentives. The country also has low restrictions for FDI, which could be beneficial for MNCs. Interestingly, there are no R&D tax credits (Sofka et al., 2018), and government R&D subsidies are application-based grants.

Research and innovation policy in Germany is the shared responsibility of the Federal Government and the 16 State ("Laender") Governments. At the federal level, the Federal Ministry of Education and Research (BMBF) drives most policy initiatives while the Federal Ministry of Economics and Energy (BMWi) is involved in specific areas (Sofka et al., 2018). Support for research and innovation in private firms is an important component of Germany's High-Tech Strategy and National Reform Programs (NRP, 2017). German firms can apply for government support, following a formal application process and the guidelines of the European Union (BMBF, 2016a). The typical support instrument is a grant.

There is a broad variety of support schemes in place, which are often operated by specialized project management organizations ("Projekttraeger") or associations like the German Federation of Industrial Research Associations (AiF) "Otto von Guericke" (Sofka and Sprutacz, 2017). Other policy initiatives target particular areas, e.g. IT security (BMBF, 2016c) or groups of firms like startups (e.g. High-Tech Startup Fund) or small and medium sized firms ("Mittelstand") (RKW, 2017). State governments complement the support schemes of the federal government with their own measures (BMBF, 2016b). Often these measures reflect the priorities or structures of the state. For example, the state of Baden-Wuerttemberg identifies sustainable mobility as one of its research priority topics (Sofka et al., 2018).

Data

Our dataset merges data from a representative innovation survey of firms in Germany with patent statistics from the European Patent Office (EPO). The innovation survey used is the "Mannheim Innovation Panel" (MIP), which is the German component of the Community Innovation Survey (CIS) of the European Union. In contrast to many other CIS surveys, the MIP is conducted annually and allows the construction of an unbalanced firm panel dataset. MIP respondents are responsible for innovation topics in their firms such as CEOs, heads of R&D, or innovation management. They are asked to answer a comprehensive set of questions about innovation inputs as well as outputs and to assign importance ratings (Criscuolo et al., 2005). The MIP provides a stratified random sample, which is representative of firms in Germany. Non-response analyses show no systematic distortions between responding and non-responding firms (Rammer et al., 2005), and Eurostat (2009) considers CIS data from Germany as high quality.

We obtain firm-level data from the MIP for the years 2000, 2002, 2003, 2004, and 2006. The survey waves for the years 2001 and 2005 are not useful for our analysis since they do not include questions on the receipt of R&D subsidies, which is the central variable in our study. The firm information obtained from the MIP is merged with the patent statistics from the EPO using assignee names and addresses. Patent statistics are available for longer time periods than the survey data. We use patent applications between 1997 and 2011 to construct the stock of patent applications prior to our survey period and patent applications for up to five years after the survey year.

As a dependent variable, we use both R&D expenditures reported as well as the number of a firm's EPO patent applications in the subsequent five years. Since there is a significant time delay between investing in R&D and arriving at a patentable invention and lengthy patent filing procedures, we use a five-year time window for the patent applications variable. Longer time windows for measuring patent numbers increase the risk of confounding factors.

Our central independent variables of interest are related to R&D subsidy (recipient vs. non-recipient), firm ownership (foreign MNC, domestic MNC, and domestic firm) and size (large vs. small), and industry (low-, medium- and high-tech manufacturing and various services). We use dummy variables to identify these groups as follows: The survey respondents indicate whether their firms have received R&D subsidy from the German government (state and/or federal level).[3] We classify firms into a domestic firm, a domestic MNC, or a subsidiary of a foreign MNC. The latter group is based on whether a firm is part of a company group with headquarters abroad, in line with previous research on the innovation activities of foreign MNC subsidiaries (Sofka et al., 2014). The firm size is based on the number of employees, and we split firms into three categories: small with 50 or less employees, medium with 51-500 employees, and large with more than 500 employees. Lastly, we create 6 industry dummies based on grouped two-digit NACE codes, which have been used frequently in previous innovation studies (Grimpe et al., 2017). These are low-tech manufacturing (e.g., food and textiles), medium-tech manufacturing (e.g., motor vehicles), high-tech manufacturing (e.g., medical devices), distributive services (e.g., logistics), knowledge-intensive services (e.g., consulting), and technological services (e.g., ICT-related services). The description is provided in the Appendix Table 1.

[3] The survey does not provide information on the subsidy amount. The related question in the survey introduces government subsidies as support for R&D and/or innovation with a short description. Then, respondents choose the funding source. Within our context, a government R&D subsidy can be obtained from the federal government or one of the 16 state governments in Germany in which the firm operates. Firms might obtain multiple grants from one or multiple government sources, but this information is not available in the survey.

We include additional control variables to capture other factors, which could potentially affect firm's innovation performance. We control for the overall size (number of employees) and age of firms (number of years since founded in Germany). We also attempt to account for differences in firms' innovation capacities by adding firm's patent applications in the year of observation since these inventions are likely to predate R&D potentially induced by a government subsidy. We also add the number of patent applications of firms in the three years preceding our sample, that is, 1997, 1998 and 1999, following Blundell et al. (2002). We capture differences in the skills of employees by controlling for the share of employees with college education. We add a dummy variable for whether the firm engages in R&D continuously. This variable is frequently used to indicate the presence of a dedicated R&D department (Czarnitzki and Licht, 2006; Koehler et al., 2012). We control for the degree of internationalization through the share of exports in firm sales since internationalization has been found to affect a firm's innovation activities (Cassiman and Golovko, 2011). Additionally, we include a dummy variable for whether a firm engages in process innovation from the same survey since such activities may affect its ability to patent. Lastly, we add time dummies to control for macroeconomic conditions.

Our dataset contains 6,052 firm observations after excluding firms that have not engaged in either product or process innovation and with less than 5 employees. After dropping outliers, the sample includes 5,717 observations, of which 5,623 can be matched with control firms.[4] In the patent regressions, the sample without outliers has 5,353 observations, while the matched sample contains 5,263 observations. We perform regressions on the full sample of 6,052 observations and the matched samples.[5]

Descriptive statistics

In the full sample, firms spend on average €1.6 million on R&D and file about 2.3 patents in a 5-year period. About a third of them has received an R&D subsidy from state or federal governments, irrespective of ownership or size. Large firms that receive a subsidy comprise about 12 percent of subsidy-receiving firms. Small firms account for one-half of subsidy-receiving firms. This distribution is similar to the firm distribution observed. About half of firms is small with less than 50 employees and about 13 percent is large firms with more than 500 employees. The subsidy receipt differs by industry with about half of firms in high-tech manufacturing and technological services receiving a subsidy while 10-15 percent of firms receive a subsidy in knowledge-intensive and distributive services (Appendix Tables 3-5). About half of the firms are engaged in continuous R&D activities and about two-thirds of them are process innovators. Foreign MNC subsidiaries comprise about 10 percent of firms, similar to that of domestic MNCs, i.e., headquartered in Germany. About a third of firms is in low-tech manufacturing, about 18 percent each in medium-tech and technological services, 10 percent each in high-tech manufacturing and knowledge-intensive services while 14 percent of firms is in distributive services.

A cursory look at R&D spending reveals a few interesting patterns (Table 1). MNCs, whether domestic or foreign MNC subsidiaries, do more R&D and file more patent applications than their domestic counterparts while domestic MNCs tend to outperform their foreign MNC subsidiaries (Figure 1). Yet interestingly, R&D spending in low-tech manufacturing by domestic firms is at par with foreign MNCs, albeit with far smaller dispersion in the latter (similarly, in distributive services). In contrast, domestic MNCs do much more R&D in low-tech manufacturing and in fact, on average exceed R&D in all the service industries, including

[4] The extreme values of the following variables—firms above 100 years of age as well as observations above the 99th percentile of the distributions of the number of employees, patent stock, share of R&D in sales, and exports—are dropped.

[5] The estimation results between the matched sample and the unmatched sample that excludes outliers are similar.

sophisticated ones, whether by domestic firms or foreign MNCs. The largest R&D spending of domestic MNCs is in medium-tech manufacturing, and although the second largest spending industry is high-tech manufacturing (both exceeding other industries by far), domestic MNCs, on average, slightly fall behind foreign MNC subsidiaries in high-tech manufacturing.

The patents statistics tell us a largely similar story (Table 2). One difference is that foreign subsidiaries tend to file more patents in low-tech manufacturing than domestic firms, but this pattern is reversed in knowledge-intensive service industry.

Large firms (with more than 500 employees), not surprisingly, also outperform their smaller counterparts (Tables 1-2). Even domestic large firms tend to spend more on R&D and file more patents on average than smaller domestic MNCs and foreign MNC subsidiaries. Interestingly, small domestic MNCs tend to file more patents than other firms, including even all medium-sized firms (but the sample size of medium-sized MNCs is relatively small).

In addition, whether by industry, size, or ownership, firms receiving a R&D subsidy tend to have larger R&D spending than firms that do not receive a subsidy (Figures 2-6). It is not just the large median or average with only a few firms skewing the impact; rather, many firms have higher spending with a large mass not far above the median of the distribution. The impact is much more pronounced in large firms, domestic MNCs, and foreign MNC subsidiaries. Both domestic MNCs and foreign MNC subsidiaries, receiving a subsidy, have greater R&D spending and patenting (Figure 4). Furthermore, firms in manufacturing and technological services tend to do more R&D and patenting with a subsidy receipt (Figure 5). while a subsidy seems to increase innovation activities of small firms substantially (Figure 6).

Table 1. R&D Spending (in million euros): Descriptive Statistics by Ownership, Industry, and Size

Industry		Domestic	Domestic MNCs	Foreign MNC Subsidiaries	All
Low-tech manufacturing	Mean	0.54	2.00	0.55	0.69
	St. Dev.	12.46	16.92	1.36	12.47
	Obs.	1562	204	172	1938
Medium-tech manufacturing	Mean	0.40	18.99	5.41	4.40
	St. Dev.	1.44	93.15	45.97	43.30
	Obs.	737	191	159	1087
High-tech manufacturing	Mean	0.32	11.84	15.92	4.19
	St. Dev.	1.34	51.21	59.41	30.16
	Obs.	427	75	92	594
Distributive services	Mean	0.49	1.09	0.35	0.53
	St. Dev.	7.91	5.14	1.42	7.43
	Obs.	702	72	59	833
Knowledge-intensive services	Mean	0.21	1.42	0.93	0.38
	St. Dev.	1.25	8.00	4.11	3.00
	Obs.	480	59	41	580
Technological services	Mean	0.33	1.57	0.72	0.43
	St. Dev.	1.68	3.44	2.10	1.89
	Obs.	901	67	52	1020
Size					
Small (Firms with up to 50 empl.)	Mean	0.06	0.15	0.12	0.07
	St. Dev.	0.18	0.48	0.27	0.19
	Obs.	2673	70	85	2828
Medium (Firms with 51-500 empl.)	Mean	0.21	0.61	0.62	0.32
	St. Dev.	0.51	1.36	1.39	0.85
	Obs.	1808	309	334	2451
Large (Firms with 500+ empl.)	Mean	4.43	17.27	14.74	11.31
	St. Dev.	29.56	81.24	64.75	60.91
	Obs.	328	289	156	773
All	Mean	0.42	7.77	4.38	1.60
	St. Dev.	7.79	54.03	34.25	22.08
	Obs.	4809	668	575	6052

Table 2. Patent Applications in the Next 5 Years: Descriptive Statistics by Ownership, Industry, and Size

Industry		Domestic	Domestic MNCs	Foreign MNC Subsidiaries	All
Low-tech manufacturing	Mean	0.42	2.77	1.37	0.75
	St. Dev.	3.21	8.34	4.12	4.20
	Obs.	1562	204	172	1938
Medium-tech manufacturing	Mean	2.74	29.72	3.90	7.65
	St. Dev.	27.49	111.86	17.57	53.39
	Obs.	737	191	159	1087
High-tech manufacturing	Mean	0.78	12.31	20.83	5.34
	St. Dev.	6.00	52.22	83.39	38.62
	Obs.	427	75	92	594
Distributive services	Mean	0.31	0.25	0.34	0.31
	St. Dev.	6.28	2.01	1.76	5.81
	Obs.	702	72	59	833
Knowledge-intensive services	Mean	0.04	0.05	0.00	0.03
	St. Dev.	0.47	0.29	0.00	0.43
	Obs.	480	59	41	580
Technological services	Mean	0.42	0.27	1.98	0.49
	St. Dev.	2.09	0.93	9.54	2.93
	Obs.	901	67	52	1020
Size					
Small (Firms with up to 50 empl.)	Mean	0.53	5.35	1.46	1.27
	St. Dev.	2.27	61.66	4.81	22.08
	Obs.	1808	309	334	2451
Medium (Firms with 51-500 empl.)	Mean	0.12	0.20	0.99	0.15
	St. Dev.	0.89	0.77	7.43	1.56
	Obs.	2673	70	85	2828
Large (Firms with 500+ empl.)	Mean	7.10	19.16	14.88	13.18
	St. Dev.	42.73	71.91	66.45	60.16
	Obs.	328	289	156	773
All	Mean	0.75	10.78	5.03	2.27
	St. Dev.	11.38	63.60	35.36	26.04
	Obs.	4809	668	575	6052

Figure 1. R&D Spending (log[1+R&D]) by Ownership

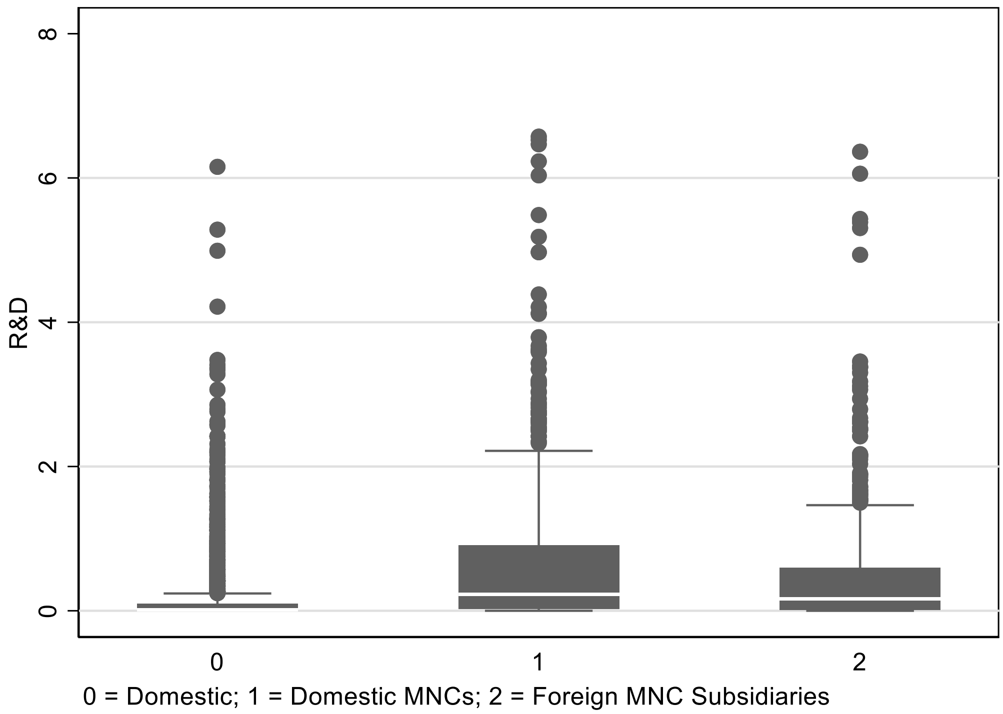


Figure 2. R&D Spending (log[1+R&D]) by Ownership and Subsidy (=1)

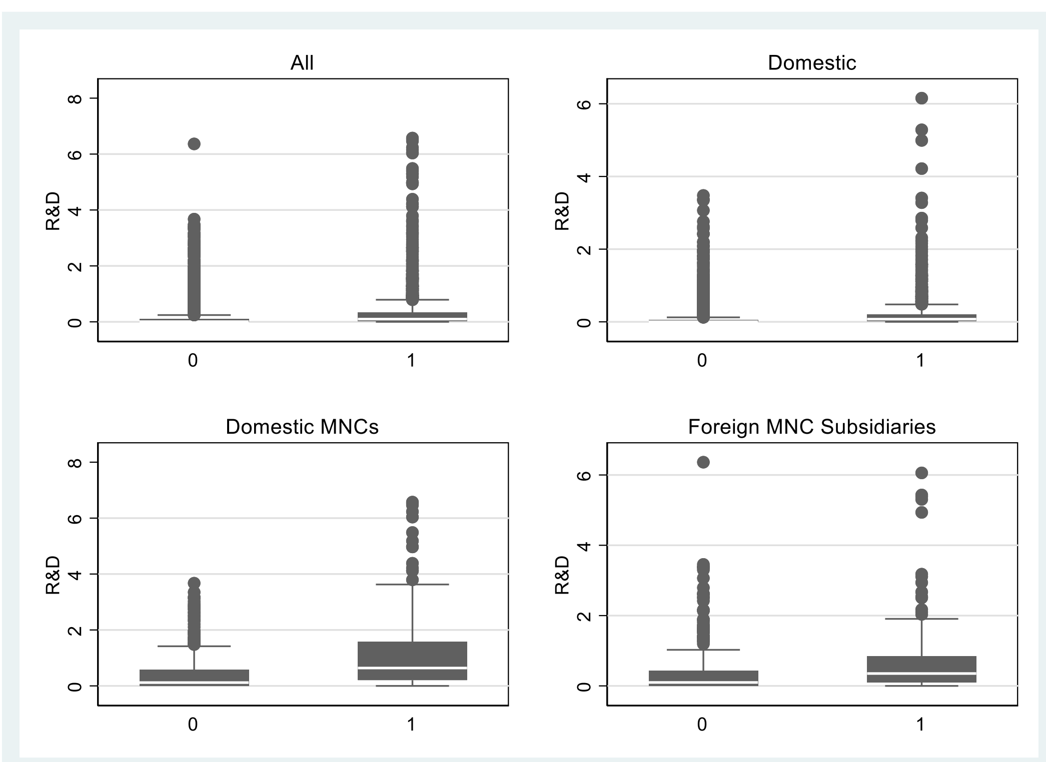


Figure 3. R&D Spending (log[1+R&D]) by Size and Subsidy (=1)

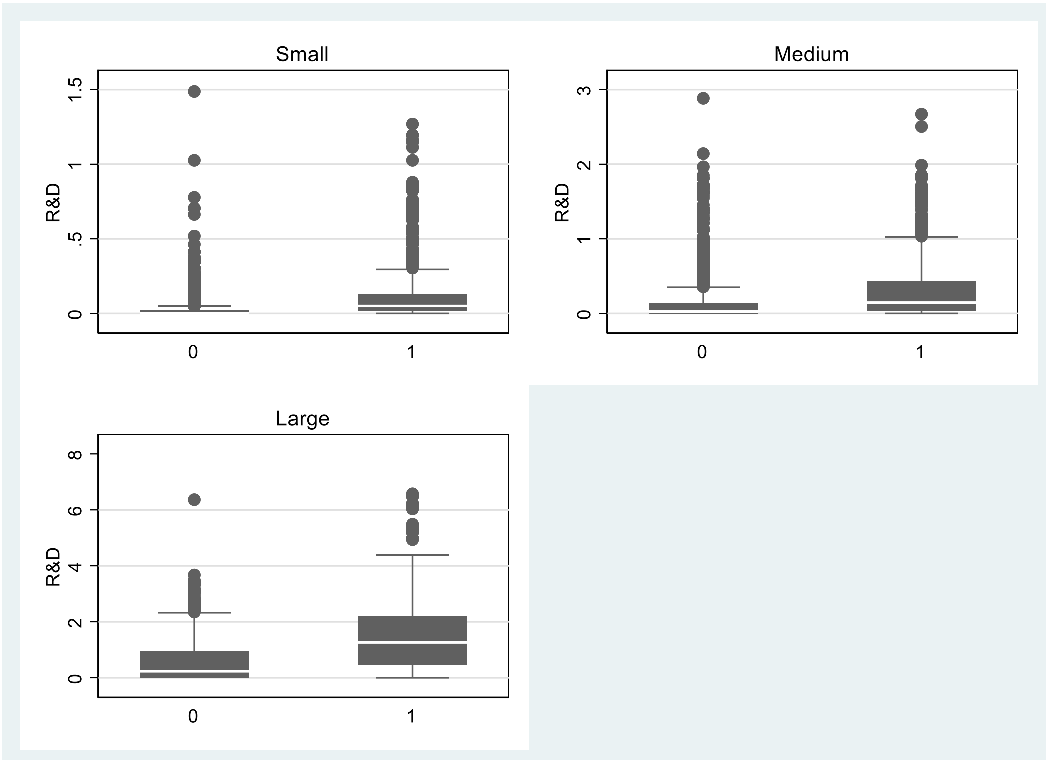


Figure 4. R&D Spending (log[1+R&D]) and 5-Year Ahead Patents (log[1+Patents]) by Ownership and Subsidy (Red)

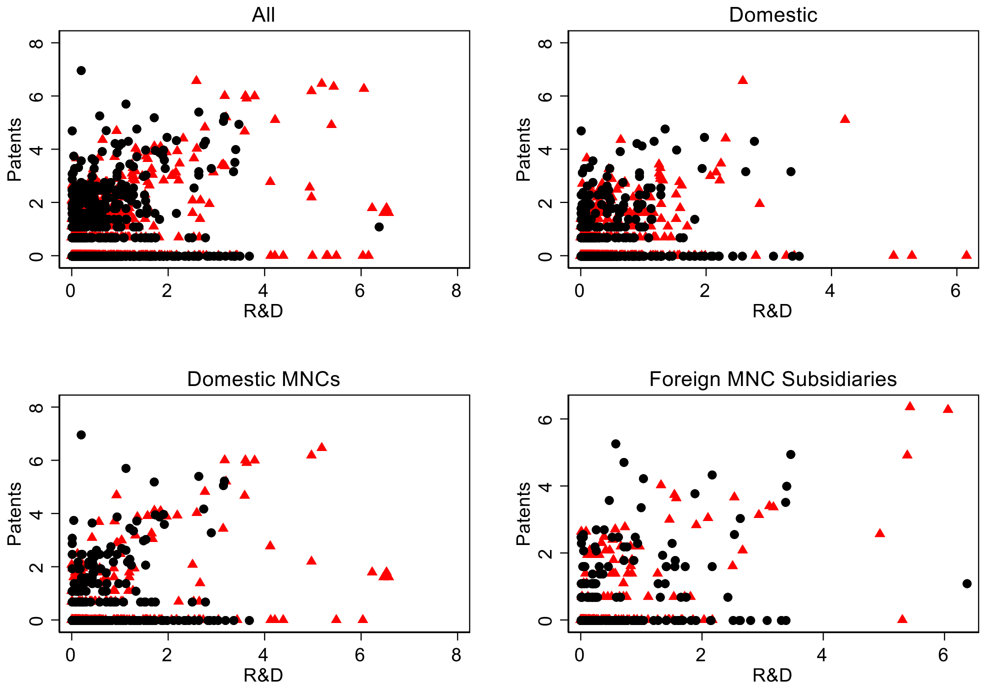


Figure 5. R&D Spending (log[1+R&D]) and 5-Year Ahead Patents (log[1+Patents]) by Industry and Subsidy (Red)

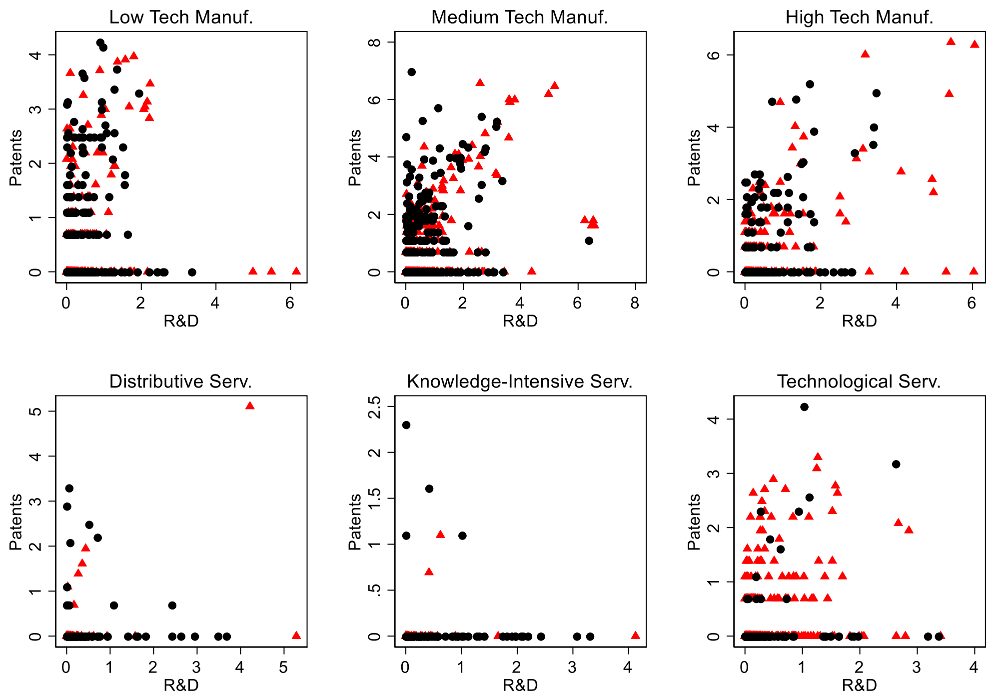
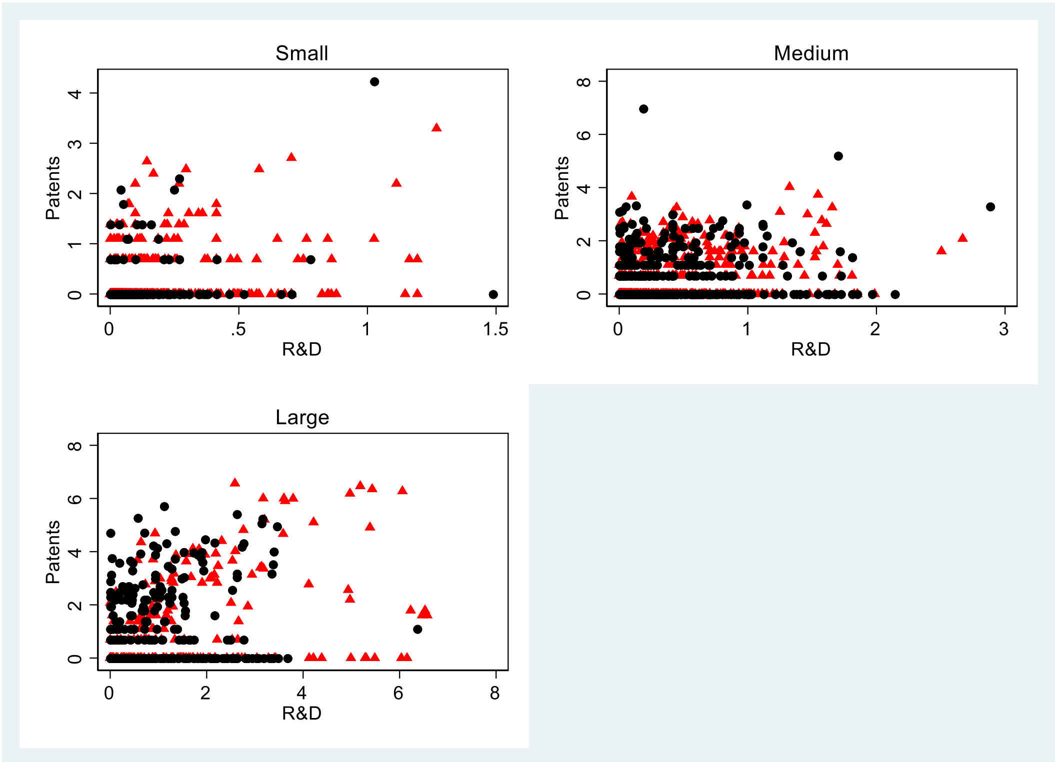


Figure 6. R&D Spending (log[1+R&D]) and 5-Year Ahead Patents (log[1+Patents]) by Size and Subsidy (Red)



Estimation strategy

To assess the effect of an R&D subsidy on innovation—R&D spending and 5-year ahead patent applications—by ownership, industry, and size, we estimate several models. We use both an unmatched full sample and matched sample without outliers. We estimate OLS regressions with time dummies and various firm controls. Since our dataset is repeated cross-sections over a few years (only a few hundred observations are of a panel structure), we cannot use fixed effects and attempt to control for firm heterogeneity using various firm characteristics (as discussed in the previous subsection). The matched sample is based on propensity score matching and is used to estimate a treatment model conditioning on observables. We cluster robust standard errors on the industry variable (which assumes correlation within the industry). We exclude dummies on domestic firms, the distributive services industry, and medium-sized firms in the regressions.

The R&D spending equations with relevant industry-subsidy-ownership and size-subsidy-ownership dummies and various controls are as follows:

$$\begin{aligned}\ln(1+RDspending_{it}) &= \alpha+\beta Subsidy_{it}+\mu_1 MNC_i^{Foreign}\cdot Subsidy_{it}+\mu_2 MNC_i^{Dom}\cdot Subsidy_{it}+\\ &\sum_{j=1}^{5}\theta_j Industry_{ij}\cdot Subsidy_{it}+\sum_{j=1}^{5}\lambda_j Industry_{ij}\cdot MNC_i^{Foreign}\cdot Subsidy_{it}+\\ &\sum_{j=1}^{5}\lambda_j Industry_{ij}\cdot MNC_i^{Dom}\cdot Subsidy_{it}+\gamma X_{it}+\delta T_t+\varepsilon_{it}\end{aligned} \tag{1}$$

$$\begin{aligned}\ln(1+RDspending_{it}) &= \alpha+\beta Subsidy_{it}+\mu_1 MNC_i^{Foreign}\cdot Subsidy_{it}+\mu_2 MNC_i^{Dom}\cdot Subsidy_{it}+\\ &\sum_{j=1}^{2}\theta_j Size_{ij}\cdot Subsidy_{it}+\sum_{j=1}^{2}\lambda_j Size_{ij}\cdot MNC_i^{Foreign}\cdot Subsidy_{it}+\\ &\sum_{j=1}^{2}\lambda_j Size_{ij}\cdot MNC_i^{Dom}\cdot Subsidy_{it}+\gamma X_{it}+\delta T_t+\varepsilon_{it}\end{aligned} \tag{2}$$

The patent regressions follow equations (1)-(2) except that R&D spending and its interactions are also added as control variables:

$$\begin{aligned}\ln(1+patents_{it+5}) &= \alpha+\beta Subsidy_{it}+\sigma\ln(1+RDspending_{it})+\\ &\rho\ln(1+RDspending_{it})\cdot Subsidy_{it}+\gamma X_{it}+\delta T_t+\varepsilon_{it}\end{aligned} \tag{3}$$

$$\begin{aligned}\ln(1+patents_{it+5}) &= \alpha+\beta Subsidy_{it}+\sigma\ln(1+RDspending_{it})+\mu_1 MNC_i^{Foreign}\cdot Subsidy_{it}+\\ &\mu_2 MNC_i^{Dom}\cdot Subsidy_{it}+\sum_{j=1}^{5}\theta_j Industry_{ij}\cdot Subsidy_{it}+\sum_{j=1}^{5}\lambda_j Industry_{ij}\cdot MNC_i^{Foreign}\cdot Subsidy_{it}+\\ &\sum_{j=1}^{5}\lambda_j Industry_{ij}\cdot MNC_i^{Dom}\cdot Subsidy_{it}+\gamma X_{it}+\delta T_t+\varepsilon_{it}\end{aligned} \tag{4}$$

In addition to standard OLS regressions, we apply a matching estimator to establish the effect of a subsidy (i.e., the treatment) on R&D investment and future patent applications. Matching estimation takes into account that the receipt of a subsidy is not random, i.e., some firms are more likely than others to apply for subsidies and some applications are more likely to be granted. Matching estimators rely on observable characteristics to match each treated firm, i.e., subsidy recipients, with a comparable control firm, thereby creating a quasi-experimental setting. A comparison between such matched treated and control firms would not suffer from selection biases (Heckman et al., 1998), and the difference in R&D investment between a subsidized firm and its matched control can be interpreted as induced by the subsidy.

In line with most matching studies, we rely on propensity score matching to match treated and control firms and compute average treatment effects. We first estimate the propensity for a firm to receive a subsidy based on observable characteristics using a probit estimation (Rosenbaum & Rubin, 1983). Subsequently, we match treated and control firms based on the propensity score and nearest neighbor matching.[6] We then test whether there are any remaining significant differences between the matched pairs, i.e., if the matched sample is balanced. To achieve a balanced match, we impose common support by dropping the 5 percent of treated observations for which the density of control observations is the lowest, i.e., it is increasingly unlikely to find good matches (Appendix Table 6).[7]

We use the following variables in line with previous literature to predict the propensity of a firm to receive an R&D subsidy: two dummy variables for whether the firm is part of a foreign or domestic MNC, respectively, firm size (number of employees in logs), firm age in years since founding, patent stock in logs, exports as a share of sales, five industry group dummies (described above) and four year dummies (2002, 2003, 2004, 2006). These variables are designed to make subsidized firms comparable to their counterparts, for example, regarding their historical R&D performance measured by the patent stock.

In addition to the matching estimator, we use a matched sample to run both unweighted and weighted regressions. The matched sample is obtained by dropping observations without common support (i.e., firms that were not matched). There are about 100 dropped observations, and our final matched sample has 5,623 observations for R&D regressions and 5,263 observations for patent regressions (see the data subsection above). We use the odds ratio based on the propensity score above to weigh observations to match the distributions of the observables between the treated and control groups. This approach essentially applies a matching estimator in the regression setting (Nichols 2007).

Since the dependent variables, whether R&D spending or patents, include many zeros and the distribution is skewed, we transform the variables into a logarithmic form. To obtain a log form, we take a natural logarithm after adding one to the value of the variable. Since many observations have small values (the sample mean of R&D spending is about 0.34 while that of patents is 0.67), it may be an acceptable transformation.[8]

[6] We also test whether results are sensitive to the choice of the matching estimator by using the Gaussian kernel matching but find that the results are similar. Matching estimations can be inefficient when they only use the nearest neighbor observation. We repeat the matching procedure using a Gaussian kernel matching procedure. Kernel matching does not rely on individual control observations for each treated firm but uses the weighted average of all control observations (Caliendo and Kopeinig 2008). Differences in the propensity score between a treated firm and control observations serve as weights and the kernel distribution determines how averages are calculated.

[7] We use psmatch2 command in Stata (Leuven and Sianesi 2003).

[8] We also attempted a zero-inflated negative binomial estimation as many firms do not do R&D or patent, but estimations did not converge. Zero-inflated negative binomial regressions require the definition of a condition determining zeros. Firms' R&D and patent propensity is typically determined by the technological and institutional conditions of the industry (Arundel & Kabla, 1998; Fontana et al., 2013). We capture these industry differences by calculating the share of firms in an industry (two-digit NACE) that filed for EPO patent applications between 1995 and 1999, prior to our estimation sample.

Results

Various estimation results show that a R&D subsidy has a positive impact on R&D spending. The matching estimator indicates that the average treatment effect (ATE) is about 0.1 while the average treatment effect on the treated (ATT) is about 0.2. These numbers suggest that R&D spending increases by about €0.2 million conditional on the receipt of the subsidy and by €0.1 million for a representative firm. The weighted regression results on the matched sample show about the same ATE. In the regression without firm controls, the coefficient on the subsidy dummy is about 0.1 and statistically significant.[9] With firm controls, the estimate of ATE falls to about 0.04 (Table 3, columns 1-4). The results from the unweighted regressions in the matched sample are similar (Appendix Tables 7-8).

The impact of a subsidy on R&D investment by ownership and size is broadly the same. Interacting the subsidy dummy with foreign and domestic MNC dummies, we get insignificant coefficients (Table 3, column 5), suggesting that there is no difference between domestic firms and MNCs, whether foreign or domestic, in extra R&D investment from a subsidy receipt. The firm size interactions do not produce significant estimates, either (Table 3, column 7). One exception is that for small firms receiving a subsidy, R&D investment is about €0.1 million lower than for those that do not receive a subsidy. It seems small firms reorient their spending when they receive a subsidy. Perhaps the subsidy alleviates financial constraints allowing firms to spend on other items that allow them to commercialize newly developed technologies before investing into creating new ones (Figure 3 and Figure 6).

Once we incorporate industry interactions, we do get heterogeneous effects of a subsidy (Table 3, column 6). Domestic firms have a larger response (0.05) to a subsidy in low-tech manufacturing, knowledge-intensive services, and technological services than MNCs. The response of domestic and foreign MNCs is largely the same and is larger in medium-tech manufacturing (0.1) and especially in high-tech manufacturing (about 0.4) than that of domestic firms. The only differential response between domestic and foreign MNCs is in knowledge-intensive services, where domestic MNCs undertake on average €0.2 million less R&D than foreign MNCs (and domestic firms).

[9] Since the dependent variable is ln(1+R&D spending), the coefficient estimate on the R&D subsidy dummy implies that at low levels of R&D spending (around the mean of 0.34), the impact is on the R&D spending level (by €0.1 million) while at high levels of R&D spending, the impact is on the R&D growth rate (0.1 or 10 percent).

Table 3. R&D Spending: Weighted Regressions, Matched Sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable: Log (1 + R&D spending)	OLS	OLS	OLS	OLS	OLS	OLS	OLS
National government R&D subsidy (d)	0.08***	0.09***	0.10***	0.04***	0.02	-0.02*	0.05
	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.03)
Domestic MNC * R&D subsidy					0.06	-0.12	-0.02
					(0.07)	(0.07)	(0.08)
Foreign MNC subsidiary * R&D subsidy					0.14	-0.01	0.04
					(0.08)	(0.02)	(0.08)
Low-tech manuf. * R&D subsidy						0.05***	
						(0.01)	
Medium high-tech manuf. * R&D subsidy						0.04**	
						(0.01)	
High-tech manuf. * R&D subsidy						-0.01	
						(0.02)	
Knowledge-intens. services * R&D subsidy						0.05***	
						(0.01)	
Technological services * R&D subsidy						0.05***	
						(0.01)	
Low-tech manuf. * R&D subsidy * Domestic MNC						0.02	
						(0.02)	
Medium high-tech manuf. * R&D subsidy * Domestic MNC						0.10***	
						(0.02)	
High-tech manuf. * R&D subsidy * Domestic MNC						0.47***	
						(0.02)	
Knowledge-intens. services * R&D subsidy * Domestic MNC						-0.20***	
						(0.02)	
Technological services * R&D subsidy * Domestic MNC						0.05	
						(0.04)	
Low-tech manuf. * R&D subsidy * Foreign MNC						-0.03	
						(0.03)	
Medium high-tech manuf. * R&D subsidy * Foreign MNC						0.09**	
						(0.03)	
High-tech manuf. * R&D subsidy * Foreign MNC						0.41***	
						(0.04)	
Knowledge-intens. services * R&D subsidy * Foreign MNC						-0.07	
						(0.04)	
Technological services * R&D subsidy * Foreign MNC						0.04	
						(0.03)	
Firm with up to 50 empl. * R&D subsidy							-0.09***
							(0.02)
Firm with 500+ empl. * R&D subsidy							0.46
							(0.24)
Firm with up to 50 empl. * R&D subsidy * Domestic MNC							-0.14
							(0.13)
Firm with 500+ empl. * R&D subsidy * Domestic MNC							-0.18
							(0.33)
Firm with up to 50 empl. * R&D subsidy * Foreign MNC							-0.05
							(0.10)
Firm with 500+ empl. * R&D subsidy * Foreign MNC							0.12
							(0.23)
Observations	5,623	5,623	5,623	5,623	5,623	5,623	5,623
Time dummies	Y	Y	Y	Y	Y	Y	Y
Ownership dummies	N	Y	Y	Y	Y	Y	Y
Industry dummies	N	N	Y	Y	Y	Y	Y
Other controls	N	N	N	Y	Y	Y	Y
Adjusted R-squared	0.01	0.14	0.37	0.44	0.45	0.46	0.50

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4. Patents: Weighted Regressions, Matched Sample

Dependent variable: Log (1 + 5-year ahead patents)	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS
National government R&D subsidy (d)	0.01	-0.02	0.00	0.03	-0.01
	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)
R&D spending (log)	0.15***	0.13*	0.17**	0.13	0.13*
	(0.03)	(0.06)	(0.05)	(0.06)	(0.06)
R&D spending * R&D subsidy	-0.03		-0.13		
	(0.09)		(0.12)		
Domestic MNC * R&D subsidy		-0.01	0.08	-0.06	-0.07
		(0.08)	(0.17)	(0.09)	(0.15)
Foreign MNC subsidiary * R&D subsidy		0.27**	0.17**	-0.02	0.31**
		(0.09)	(0.05)	(0.13)	(0.08)
R&D spending * R&D subsidy * Domestic MNC			-0.06		
			(0.18)		
R&D spending * R&D subsidy * Foreign MNC subsidiary			0.26		
			(0.17)		
Low-tech manuf. * R&D subsidy				-0.05***	
				(0.00)	
Medium high-tech manuf. * R&D subsidy				-0.07***	
				(0.01)	
High-tech manuf. * R&D subsidy				-0.09***	
				(0.02)	
Knowledge-intens. services * R&D subsidy				0.01	
				(0.03)	
Technological services * R&D subsidy				-0.02**	
				(0.01)	
Low-tech manuf. * R&D subsidy * Domestic MNC				0.18*	
				(0.08)	
Medium high-tech manuf. * R&D subsidy * Domestic MNC				0.17*	
				(0.08)	
High-tech manuf. * R&D subsidy * Domestic MNC				-0.04	
				(0.08)	
Knowledge-intens. services * R&D subsidy * Domestic MNC				-0.05	
				(0.05)	
Technological services * R&D subsidy * Domestic MNC				-0.13	
				(0.08)	
Low-tech manuf. * R&D subsidy * Foreign MNC				0.43***	
				(0.03)	
Medium high-tech manuf. * R&D subsidy * Foreign MNC				0.04	
				(0.06)	
High-tech manuf. * R&D subsidy * Foreign MNC				0.59***	
				(0.07)	
Knowledge-intens. services * R&D subsidy * Foreign MNC				-0.05	
				(0.07)	
Technological services * R&D subsidy * Foreign MNC				0.39***	
				(0.05)	
Firm with up to 50 empl. * R&D subsidy					-0.00
					(0.04)
Firm with 500+ empl. * R&D subsidy					-0.25
					(0.15)
Firm with up to 50 empl. * R&D subsidy * Domestic MNC					0.35***
					(0.08)
Firm with 500+ empl. * R&D subsidy * Domestic MNC					0.36
					(0.25)
Firm with up to 50 empl. * R&D subsidy * Foreign MNC					-0.20
					(0.17)
Firm with 500+ empl. * R&D subsidy * Foreign MNC					0.19
					(0.34)
Observations	5,263	5,263	5,263	5,263	5,263
Time, ownership, and industry dummies and other controls	Y	Y	Y	Y	Y
Adjusted R-squared	0.55	0.55	0.55	0.55	0.55

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Examining the impact of an R&D subsidy on the 5-year ahead patents, we find an additional and differential effect of an R&D subsidy for domestic and foreign MNCs, even accounting for R&D spending. Although the government R&D subsidy does not affect 5-year ahead patents separately (Table 4, column 1), the impact of the subsidy is larger for foreign MNC subsidiaries than domestic MNCs or domestic firms, about 0.3 extra patents for subsidy recipients (Table 4, column 2). However, the impact of the subsidy does not depend on the level of R&D spending (Table 4, column 3). Accounting for the differential effects by industry, we find larger impact for foreign MNCs than other firms in low-tech manufacturing and especially in high-tech manufacturing and technological services (Table 4, column 4).[10] Only in medium-tech manufacturing, the impact of the subsidy for domestic MNCs is larger than for foreign MNCs, about 0.2 extra patents. Ignoring industry interactions, we find that it is only domestic MNCs with less than 50 employees that tend to increase their patent applications upon receiving a subsidy. These results broadly suggest that foreign MNCs tend to benefit more from R&D subsidies than domestic MNCs and domestic firms.

Overall, our estimations show that it is important to account for the differential impact of the subsidy by industry and ownership and less so by firm size. The impact on R&D spending is largely similar between foreign and domestic MNCs and is larger than that for domestic firms in medium-tech and high-tech manufacturing. Domestic firms tend to benefit more in low-tech manufacturing and services than MNCs. However, the impact on future patents is mostly larger for foreign MNCs than domestic MNCs and domestic firms in low-tech and high-tech manufacturing and technological services. Only in medium-tech manufacturing, domestic MNCs tend to benefit more than other firms. Interestingly, the impact of the subsidy on future patent applications is slightly negative for domestic firm subsidy recipients than domestic firm non-recipients.

[10] The detailed estimation results are in Appendix Tables 9-10.

Conclusion

A government R&D subsidy has important impact on innovation, both R&D spending and patent applications. Our study suggests that MNCs, domestic and foreign, are more responsive to an R&D subsidy than domestic firms. Perhaps it is not surprising as MNCs compete internationally, and innovation is key to staying competitive. More important, the effect of subsidies depends on the industry, and our results suggest that a targeted subsidy could be more efficient. In medium- and high-tech industries, there should be a greater focus on both foreign and domestic MNCs while domestic firms should be more favored in low-tech manufacturing, knowledge-intensive services, and technological services.

A more surprising result is that foreign MNCs tend to file more patent applications in response to a subsidy than even domestic MNCs across several industries (except medium-tech manufacturing). Perhaps despite a similar effect of a subsidy on R&D spending, the impact on patent applications is higher for foreign MNCs because they use a host country subsidy more effectively or apply it toward more patentable technologies or products. It is also possible that foreign MNC subsidiaries use subsidies to signal their headquarters for a new or extended innovation mandate, allowing them to pursue research and patenting more vigorously (Birkinshaw and Hood, 1998; Cantwell and Mudambi, 2005; Alkemade et al, 2015; Sofka et al., 2021). This result is also consistent with the international technology sourcing argument. Pursuing R&D in technological frontier countries like Germany allows firms to source technology, benefit from knowledge spillovers, and improve innovation outcomes (Alcacer and Chung, 2007; Song et al., 2011; Belderbos et al., 2015; Chen and Dauchy, 2018; Belderbos & Grimpe, 2020).

In addition, the large impact of a subsidy on foreign MNC subsidiaries suggests that subsidy providers should not necessarily exclude foreign affiliates. Increasing the R&D activities of foreign MNC subsidiaries enlarges the knowledge pool within a host country, potentially spilling over to domestic firms. Our findings regarding the advantages of foreign MNC subsidiaries in translating R&D subsidies into higher R&D spending and more patents may provide policymakers with an additional rationale for the attraction of foreign direct investment. However, to mitigate potential negative effects of giving subsidies to foreign MNC subsidiaries, the government could facilitate collaboration between MNC subsidiaries and domestic firms to enable knowledge and technology transfer.

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Appendixes

Appendix Table 1. Industry Classification

Industry	NACE Code	Industry Group
Mining and quarrying	10 – 14	Low-tech manufacturing
Food and tobacco	15 – 16	Low-tech manufacturing
Textiles and leather	17 – 19	Low-tech manufacturing
Wood / paper / publishing	20 – 22	Low-tech manufacturing
Chemicals / petroleum	23 – 24	Medium high-tech manufacturing
Plastic / rubber	25	Low-tech manufacturing
Glass / ceramics	26	Low-tech manufacturing
Metal	27 – 28	Low-tech manufacturing
Manufacture of machinery and equipment	29	Medium high-tech manufacturing
Manufacture of electrical machinery	30 – 32	High-tech manufacturing
Medical, precision and optical instruments	33	High-tech manufacturing
Manufacture of motor vehicles	34 – 35	Medium high-tech manufacturing
Manufacture of furniture, jewellery, sports equipment and toys	36 – 37	Low-tech manufacturing
Electricity, gas and water supply	40 – 41	Low-tech manufacturing
Construction	45	Low-tech manufacturing
Retail and motor trade	50, 52	Distributive services
Wholesale trade	51	Distributive services
Transportation and communication	60 – 63, 64.1	Distributive services
Financial intermediation	65 – 67	Knowledge-intensive services
Real estate and renting	70 – 71	Distributive services
ICT services	72, 64.2	Technological services
Technical services	73, 74.2, 74.3	Technological services
Consulting	74.1, 74.4	Knowledge-intensive services
Other business-oriented services	74.5 – 74.8, 90	Distributive services

Appendix Table 2. Variable Description

Variable	Definition	Source
Company age (years)	No. of years since registration in Germany	CREFO company panel
Continuous R&D (d)	Firm performed R&D continuously in the reporting period	MIP survey
Domestic MNC (d)	Firm is part of a multinational group with headquarters in Germany	MIP survey
Foreign MNC subsidiary (d)	Firm is part of a multinational group with headquarters outside Germany	MIP survey
No. of employees (log)	Number of employees in reporting year (log transformed)	MIP survey
Patent appl. (t)	Number of EPO patent applications in reporting year	EPO patent statistics
Patent appl. (t+1, t+5)	Number of EPO patent applications 5 years after the reporting year	EPO patent statistics
Patent appl. 1997-1999	Number of EPO patent applications in the pre-sample period 1997-1999	EPO patent statistics
Process innovator (d)	Firm has introduced a process innovation during the reporting period	MIP survey
R&D investment (€ mil)	Total R&D investment in € mil in reporting year	MIP survey
Receipt domestic R&D subs. (d)	Firm has received an R&D subsidy from the Federal Government of Germany or a State Government during the reporting period	MIP survey
Share of empl. w/ college educ.	Share of employees with college education in reporting year	MIP survey
Share of exports in sales (ratio)	Share of exports in total sales in reporting year	MIP survey
Sales (log)	Total sales	MIP survey
Total patent stock	Number of EPO patent applications until reporting year	EPO patent statistics
Firm up to 50 empl. (d)	Whether a firm has up to 50 employees	MIP survey
Firm with 500+ empl. (d)	Whether a firm has 500+ employees	MIP survey
Industry dummies (1-6)	Industry classification according to **Error! Reference source not found.**	MIP survey
Year dummies (2000, 2002-2004, 2006)	Reporting year	MIP survey

(d) indicates a dummy variable

Appendix Table 3. Descriptive Statistics by Ownership

Sample	All				Domestic				Domestic MNCs				Foreign MNC Subsidiaries			
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
No. of patent applications in the next 5 years	2.27	26.04	0	1069	0.75	11.38	0	711	10.78	63.60	0	1069	5.03	35.36	0	574
R&D expenditures (€ mil)	1.60	22.08	0	714.79	0.42	7.79	0	469.88	7.77	54.03	0	714.79	4.38	34.25	0	579.29
Patent stock	1.79	14.68	0	492.49	0.64	5.23	0	252.49	7.39	37.10	0	492.49	4.87	19.68	0	206.06
National government R&D subsidy (d)	0.32	0.47	0	1	0.32	0.47	0	1	0.32	0.47	0	1	0.31	0.46	0	1
Domestic MNC (d)	0.11	0.31	0	1	0.00	0.00	0	0	1.00	0.00	1	1	0.00	0.00	0	0
Foreign MNC subsidiary (d)	0.10	0.29	0	1	0.00	0.00	0	0	0.00	0.00	0	0	1.00	0.00	1	1
Firms with up to 50 empl. (d)	0.47	0.50	0	1	0.56	0.50	0	1	0.10	0.31	0	1	0.15	0.36	0	1
Firms with 500+ empl. (d)	0.13	0.33	0	1	0.07	0.25	0	1	0.43	0.50	0	1	0.27	0.45	0	1
No. patent appl. in t	0.38	3.93	0	162	0.15	1.82	0	107	1.56	9.51	0	162	0.98	5.24	0	88
Sales (log)	2.13	2.02	-4.27	10.52	1.65	1.79	-4.27	10.52	4.15	1.84	-0.80	10.11	3.72	1.71	-1.71	10.31
No of employees	489.77	4809.79	5	240000	275.38	4559.60	5	240000	1704.80	6150.62	6	66393	871.28	4850.18	6	104000
No of employees (log)	4.25	1.64	1.61	12.39	3.89	1.45	1.61	12.39	5.91	1.62	1.79	11.10	5.36	1.46	1.79	11.55
Company age (years)	31.29	33.33	0	150	29.31	31.66	0	150	43.56	39.30	0	149	33.66	36.17	0	148
College educ. empl. (share)	25.22	26.09	0	100	25.54	26.94	0	100	23.61	22.26	0	100	24.46	22.63	0	100
Contin. R&D activities (d)	0.46	0.50	0	1	0.41	0.49	0	1	0.65	0.48	0	1	0.60	0.49	0	1
Share of exports in sales	0.35	0.49	0	2.13	0.28	0.43	0	2.00	0.58	0.55	0	2.06	0.68	0.58	0	2.13
Process innovator (d)	0.66	0.47	0	1	0.65	0.48	0	1	0.72	0.45	0	1	0.67	0.47	0	1
Low-tech manuf. (d)	0.32	0.47	0	1	0.32	0.47	0	1	0.31	0.46	0	1	0.30	0.46	0	1
Medium high-tech manuf. (d)	0.18	0.38	0	1	0.15	0.36	0	1	0.29	0.45	0	1	0.28	0.45	0	1
High-tech manuf. (d)	0.10	0.30	0	1	0.09	0.28	0	1	0.11	0.32	0	1	0.16	0.37	0	1
Distributive services (d)	0.14	0.34	0	1	0.15	0.35	0	1	0.11	0.31	0	1	0.10	0.30	0	1
Knowledge-intens. services (d)	0.10	0.29	0	1	0.10	0.30	0	1	0.09	0.28	0	1	0.07	0.26	0	1
Technological services (d)	0.17	0.37	0	1	0.19	0.39	0	1	0.10	0.30	0	1	0.09	0.29	0	1
Year 2000 (d)	0.24	0.43	0	1	0.24	0.43	0	1	0.25	0.43	0	1	0.23	0.42	0	1
Year 2002 (d)	0.19	0.39	0	1	0.19	0.39	0	1	0.21	0.41	0	1	0.22	0.41	0	1
Year 2003 (d)	0.11	0.32	0	1	0.11	0.31	0	1	0.14	0.35	0	1	0.11	0.32	0	1
Year 2004 (d)	0.29	0.46	0	1	0.29	0.45	0	1	0.28	0.45	0	1	0.31	0.46	0	1
Year 2006 (d)	0.16	0.37	0	1	0.17	0.38	0	1	0.12	0.33	0	1	0.13	0.34	0	1
No of observations	6,052				4,809				668				575			

Appendix Table 4. Descriptive Statistics by Industry

Sample	Low-tech manufacturing				Medium-tech manufacturing				High-tech manufacturing			
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
No. of patent applications in the next 5 years	0.75	4.20	0	68	7.65	53.39	0	1069	5.34	38.62	0	574
R&D expenditures (€ mil)	0.69	12.47	0	469.88	4.40	43.30	0	714.79	4.19	30.16	0	426.75
Patent stock	0.80	4.06	0	61.62	5.39	30.28	0	492.49	4.05	19.18	0	206.06
National government R&D subsidy (d)	0.25	0.44	0	1	0.42	0.49	0	1	0.52	0.50	0	1
Domestic MNC (d)	0.11	0.31	0	1	0.18	0.38	0	1	0.13	0.33	0	1
Foreign MNC subsidiary (d)	0.09	0.28	0	1	0.15	0.35	0	1	0.15	0.36	0	1
Firms with up to 50 empl. (d)	0.37	0.48	0	1	0.34	0.47	0	1	0.50	0.50	0	1
Firms with 500+ empl. (d)	0.13	0.34	0	1	0.18	0.38	0	1	0.11	0.32	0	1
No. patent appl. in t	0.13	0.93	0	18	1.25	8.24	0	162	0.86	5.11	0	88
Sales (log)	2.44	1.82	-4.20	10.52	2.76	2.00	-2.96	10.11	1.98	2.02	-2.30	10.31
No of employees	419.37	4664.01	5	193000	703.38	3926.42	5	53144	575.18	4716.15	5	104000
No of employees (log)	4.50	1.50	1.61	12.17	4.71	1.65	1.61	10.88	4.15	1.65	1.61	11.55
Company age (years)	38.78	36.21	0	150	34.99	35.06	0	149	25.09	28.13	0	148
College educ. empl. (share)	10.97	12.24	0	100	21.86	20.28	0	100	33.53	23.79	0	100
Contin. R&D activities (d)	0.37	0.48	0	1	0.66	0.47	0	1	0.74	0.44	0	1
Share of exports in sales	0.36	0.45	0	1.96	0.70	0.55	0	2.06	0.57	0.54	0	2.13
Process innovator (d)	0.71	0.46	0	1	0.60	0.49	0	1	0.54	0.50	0	1
Low-tech manuf. (d)	1.00	0.00	1	1	0.00	0.00	0	0	0.00	0.00	0	0
Medium high-tech manuf. (d)	0.00	0.00	0	0	1.00	0.00	1	1	0.00	0.00	0	0
High-tech manuf. (d)	0.00	0.00	0	0	0.00	0.00	0	0	1.00	0.00	1	1
Distributive services (d)	0.00	0.00	0	0	0.00	0.00	0	0	0.00	0.00	0	0
Knowledge-intens. services (d)	0.00	0.00	0	0	0.00	0.00	0	0	0.00	0.00	0	0
Technological services (d)	0.00	0.00	0	0	0.00	0.00	0	0	0.00	0.00	0	0
Year 2000 (d)	0.22	0.41	0	1	0.23	0.42	0	1	0.17	0.38	0	1
Year 2002 (d)	0.16	0.37	0	1	0.20	0.40	0	1	0.24	0.43	0	1
Year 2003 (d)	0.11	0.31	0	1	0.14	0.35	0	1	0.13	0.34	0	1
Year 2004 (d)	0.33	0.47	0	1	0.29	0.45	0	1	0.30	0.46	0	1
Year 2006 (d)	0.18	0.38	0	1	0.14	0.34	0	1	0.16	0.37	0	1
No of observations	1,938				1,087				594			

Appendix Table 4. Descriptive Statistics by Industry, continued

Sample	Distributive services				Knoweldge-intensive services				Technological services			
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
No. of patent applications in the next 5 years	0.31	5.81	0	164	0.03	0.43	0	9	0.49	2.93	0	68
R&D expenditures (€ mil)	0.53	7.43	0	196.06	0.38	3.00	0	60.84	0.43	1.89	0	29.17
Patent stock	0.17	2.22	0	58.53	0.10	1.17	0	23.36	0.77	5.47	0	112.38
National government R&D subsidy (d)	0.15	0.36	0	1	0.09	0.29	0	1	0.51	0.50	0	1
Domestic MNC (d)	0.09	0.28	0	1	0.10	0.30	0	1	0.07	0.25	0	1
Foreign MNC subsidiary (d)	0.07	0.26	0	1	0.07	0.26	0	1	0.05	0.22	0	1
Firms with up to 50 empl. (d)	0.53	0.50	0	1	0.43	0.50	0	1	0.74	0.44	0	1
Firms with 500+ empl. (d)	0.12	0.33	0	1	0.21	0.41	0	1	0.03	0.17	0	1
No. patent appl. in t	0.04	0.73	0	20	0.01	0.25	0	6	0.14	0.91	0	23
Sales (log)	2.18	1.87	-4.27	9.68	2.25	2.48	-2.30	10.39	0.82	1.59	-3.00	8.99
No of employees	727.98	8895.51	5	240000	572.53	1637.82	5	14201	104.55	506.40	5	8600
No of employees (log)	4.11	1.65	1.61	12.39	4.49	1.90	1.61	9.56	3.32	1.25	1.61	9.06
Company age (years)	29.97	30.08	0	134	35.84	38.76	1	150	15.24	18.08	0	138
College educ. empl. (share)	15.54	17.79	0	90	27.59	27.47	0	100	57.60	27.09	0	100
Contin. R&D activities (d)	0.19	0.39	0	1	0.24	0.43	0	1	0.58	0.49	0	1
Share of exports in sales	0.13	0.34	0	2.00	0.04	0.16	0	1.54	0.19	0.37	0	1.96
Process innovator (d)	0.69	0.46	0	1	0.76	0.43	0	1	0.60	0.49	0	1
Low-tech manuf. (d)	0.00	0.00	0	0	0.00	0.00	0	0	0.00	0.00	0	0
Medium high-tech manuf. (d)	0.00	0.00	0	0	0.00	0.00	0	0	0.00	0.00	0	0
High-tech manuf. (d)	0.00	0.00	0	0	0.00	0.00	0	0	0.00	0.00	0	0
Distributive services (d)	1.00	0.00	1	1	0.00	0.00	0	0	0.00	0.00	0	0
Knowledge-intens. services (d)	0.00	0.00	0	0	1.00	0.00	1	1	0.00	0.00	0	0
Technological services (d)	0.00	0.00	0	0	0.00	0.00	0	0	1.00	0.00	1	1
Year 2000 (d)	0.33	0.47	0	1	0.27	0.45	0	1	0.23	0.42	0	1
Year 2002 (d)	0.16	0.37	0	1	0.18	0.39	0	1	0.24	0.43	0	1
Year 2003 (d)	0.09	0.28	0	1	0.10	0.30	0	1	0.11	0.32	0	1
Year 2004 (d)	0.28	0.45	0	1	0.28	0.45	0	1	0.24	0.43	0	1
Year 2006 (d)	0.15	0.35	0	1	0.16	0.37	0	1	0.17	0.38	0	1
No of observations	833				580				1,020			

Appendix Table 5. Descriptive Statistics by Size

Sample	Small (up to 50 empl.)				Medium (51-500 empl.)				Large (500+ empl.)			
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
No. of patent applications in the next 5 years	0.15	1.56	0	68	1.27	22.08	0	1069	13.18	60.16	0	711
R&D expenditures (€ mil)	0.07	0.19	0	3.43	0.32	0.85	0	16.87	11.31	60.91	0	714.79
Patent stock	0.16	1.00	0	20.38	1.06	8.72	0	399.99	10.00	36.96	0	492.49
National government R&D subsidy (d)	0.35	0.48	0	1	0.30	0.46	0	1	0.29	0.45	0	1
Domestic MNC (d)	0.02	0.16	0	1	0.13	0.33	0	1	0.37	0.48	0	1
Foreign MNC subsidiary (d)	0.03	0.17	0	1	0.14	0.34	0	1	0.20	0.40	0	1
Firms with up to 50 empl. (d)	1.00	0.00	1	1	0.00	0.00	0	0	0.00	0.00	0	0
Firms with 500+ empl. (d)	0.00	0.00	0	0	0.00	0.00	0	0	1.00	0.00	1	1
No. patent appl. in t	0.04	0.31	0	8	0.22	2.14	0	93	2.15	10.12	0	162
Sales (log)	0.53	1.08	-4.27	4.87	2.95	1.07	-1.20	7.14	5.37	1.39	0.50	10.52
No of employees	21.20	12.91	5	50	172.54	113.56	51	500	3209.88	13143.56	501	240000
No of employees (log)	2.85	0.66	1.61	3.91	4.95	0.64	3.93	6.21	7.17	0.94	6.22	12.39
Company age (years)	20.35	22.94	0	142	37.29	35.75	0	150	52.34	41.56	0	150
College educ. empl. (share)	32.66	29.79	0	100	19.10	21.15	0	95	17.41	16.75	0	95
Contin. R&D activities (d)	0.40	0.49	0	1	0.46	0.50	0	1	0.63	0.48	0	1
Share of exports in sales	0.24	0.42	0	2.00	0.42	0.49	0	2.06	0.55	0.57	0	2.13
Process innovator (d)	0.60	0.49	0	1	0.68	0.47	0	1	0.77	0.42	0	1
Low-tech manuf. (d)	0.25	0.44	0	1	0.39	0.49	0	1	0.33	0.47	0	1
Medium high-tech manuf. (d)	0.13	0.34	0	1	0.21	0.41	0	1	0.25	0.43	0	1
High-tech manuf. (d)	0.11	0.31	0	1	0.09	0.29	0	1	0.09	0.28	0	1
Distributive services (d)	0.16	0.36	0	1	0.12	0.32	0	1	0.13	0.34	0	1
Knowledge-intens. services (d)	0.09	0.28	0	1	0.09	0.28	0	1	0.16	0.36	0	1
Technological services (d)	0.27	0.44	0	1	0.10	0.30	0	1	0.04	0.20	0	1
Year 2000 (d)	0.22	0.41	0	1	0.25	0.43	0	1	0.26	0.44	0	1
Year 2002 (d)	0.19	0.39	0	1	0.18	0.39	0	1	0.22	0.42	0	1
Year 2003 (d)	0.11	0.31	0	1	0.11	0.31	0	1	0.14	0.35	0	1
Year 2004 (d)	0.29	0.46	0	1	0.30	0.46	0	1	0.28	0.45	0	1
Year 2006 (d)	0.19	0.39	0	1	0.16	0.37	0	1	0.09	0.29	0	1
No of observations	2,828				2,451				773			

Appendix Table 6. Nearest Neighbor Matching: Mean Comparison

Variable	Mean, treated	Mean, control	t-test	P < t
Propensity score	0.42	0.41	1.24	0.21
Foreign MNC subsidiary (d)	0.10	0.10	0	1.00
Domestic MNC (d)	0.09	0.09	0	1.00
No of employees (log)	3.99	3.99	-0.03	0.98
Company age (years)	18.93	19.26	-0.53	0.60
Patent stock (ln)	-3.17	-3.24	1	0.32
Share of exports to sales (ratio)	0.43	0.40	1.45	0.15
Medium high-tech manuf. (d)	0.24	0.24	0	1.00
High-tech manuf. (d)	0.16	0.16	0	1.00
Distributive services (d)	0.06	0.06	0	1.00
Knowledge-intensive services (d)	0.02	0.02	0	1.00
Technological services (d)	0.25	0.25	0.08	0.94
Year 2002 (d)	0.20	0.20	0	1.00
Year 2003 (d)	0.11	0.11	0	1.00
Year 2004 (d)	0.22	0.22	-0.04	0.97
Year 2006 (d)	0.23	0.22	0.04	0.97

Appendix Table 7. R&D Spending: Unweighted Regressions, Matched Sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable: Log (1 + R&D spending)	OLS	OLS	OLS	OLS	OLS	OLS	OLS
National government R&D subsidy (d)	0.11***	0.11***	0.09***	0.03**	-0.00	-0.01	0.03
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
Domestic MNC * R&D subsidy					0.17**	0.00	0.09
					(0.05)	(0.05)	(0.05)
Foreign MNC subsidiary * R&D subsidy					0.15*	-0.03	0.07
					(0.06)	(0.02)	(0.04)
Low-tech manuf. * R&D subsidy						0.02*	
						(0.01)	
Medium high-tech manuf. * R&D subsidy						0.01	
						(0.01)	
High-tech manuf. * R&D subsidy						-0.06***	
						(0.01)	
Knowledge-intens. services * R&D subsidy						0.04*	
						(0.02)	
Technological services * R&D subsidy						0.03**	
						(0.01)	
Low-tech manuf. * R&D subsidy * Domestic MNC						0.06**	
						(0.02)	
Medium high-tech manuf. * R&D subsidy * Domestic MNC						0.20***	
						(0.03)	
High-tech manuf. * R&D subsidy * Domestic MNC						0.41***	
						(0.03)	
Knowledge-intens. services * R&D subsidy * Domestic MNC						-0.23***	
						(0.03)	
Technological services * R&D subsidy * Domestic MNC						0.07**	
						(0.02)	
Low-tech manuf. * R&D subsidy * Foreign MNC						0.03	
						(0.02)	
Medium high-tech manuf. * R&D subsidy * Foreign MNC						0.23***	
						(0.02)	
High-tech manuf. * R&D subsidy * Foreign MNC						0.39***	
						(0.02)	
Knowledge-intens. services * R&D subsidy * Foreign MNC						0.03	
						(0.02)	
Technological services * R&D subsidy * Foreign MNC						0.23***	
						(0.02)	
Firm with up to 50 empl. * R&D subsidy							-0.08**
							(0.02)
Firm with 500+ empl. * R&D subsidy							0.22*
							(0.10)
Firm with up to 50 empl. * R&D subsidy * Domestic MNC							-0.20*
							(0.09)
Firm with 500+ empl. * R&D subsidy * Domestic MNC							-0.01
							(0.22)
Firm with up to 50 empl. * R&D subsidy * Foreign MNC							-0.07
							(0.05)
Firm with 500+ empl. * R&D subsidy * Foreign MNC							0.21
							(0.23)
Observations	5,623	5,623	5,623	5,623	5,623	5,623	5,623
Time dummies	Y	Y	Y	Y	Y	Y	Y
Ownership dummies	N	Y	Y	Y	Y	Y	Y
Industry dummies	N	N	Y	Y	Y	Y	Y
Other controls	N	N	N	Y	Y	Y	Y
Adjusted R-squared	0.02	0.13	0.31	0.39	0.39	0.40	0.44

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix Table 8. Patents: Unweighted Regressions, Matched Sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable: Log (1 + 5-year ahead patents)	OLS	OLS	OLS	OLS	OLS	OLS	OLS
National government R&D subsidy (d)	-0.01	-0.01	-0.01	0.00	-0.00	-0.00	-0.02
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.00)	(0.02)
R&D spending (log)	0.09**	0.11**	0.09**	0.11**	0.09**	0.11***	0.09**
	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)
R&D spending * R&D subsidy	0.06		0.05		0.05		0.07
	(0.06)		(0.11)		(0.11)		(0.12)
Domestic MNC * R&D subsidy		-0.00	0.05	-0.11***	-0.09	-0.08	-0.01
		(0.04)	(0.13)	(0.03)	(0.07)	(0.08)	(0.15)
Foreign MNC subsidiary * R&D subsidy		0.12*	0.06	-0.04	-0.07	0.15**	0.09
		(0.05)	(0.05)	(0.06)	(0.07)	(0.06)	(0.06)
R&D spending * R&D subsidy * Domestic MNC			-0.11		-0.09		-0.18
			(0.24)		(0.26)		(0.21)
R&D spending * R&D subsidy * Foreign MNC subsidiary			0.08		0.10		0.13
			(0.19)		(0.17)		(0.22)
Low-tech manuf. * R&D subsidy				-0.02***	-0.03***		
				(0.00)	(0.01)		
Medium high-tech manuf. * R&D subsidy				0.00	-0.01		
				(0.00)	(0.02)		
High-tech manuf. * R&D subsidy				-0.04***	-0.05***		
				(0.01)	(0.01)		
Knowledge-intens. services * R&D subsidy				0.02	0.02		
				(0.02)	(0.02)		
Technological services * R&D subsidy				-0.00	-0.01		
				(0.01)	(0.01)		
Low-tech manuf. * R&D subsidy * Domestic MNC				0.22***	0.24**		
				(0.04)	(0.08)		
Medium high-tech manuf. * R&D subsidy * Domestic MNC				0.16***	0.19		
				(0.04)	(0.10)		
High-tech manuf. * R&D subsidy * Domestic MNC				-0.07	-0.03		
				(0.04)	(0.15)		
Knowledge-intens. services * R&D subsidy * Domestic MNC				0.02*	0.00		
				(0.01)	(0.06)		
Technological services * R&D subsidy * Domestic MNC				0.02	0.04		
				(0.02)	(0.06)		
Low-tech manuf. * R&D subsidy * Foreign MNC				0.27***	0.26***		
				(0.01)	(0.01)		
Medium high-tech manuf. * R&D subsidy * Foreign MNC				-0.04*	-0.09**		
				(0.02)	(0.03)		
High-tech manuf. * R&D subsidy * Foreign MNC				0.36***	0.30***		
				(0.02)	(0.03)		
Knowledge-intens. services * R&D subsidy * Foreign MNC				-0.06*	-0.07**		
				(0.03)	(0.03)		
Technological services * R&D subsidy * Foreign MNC				0.28***	0.23***		
				(0.02)	(0.02)		
Firm with up to 50 empl. * R&D subsidy						-0.01	0.00
						(0.01)	(0.01)
Firm with 500+ empl. * R&D subsidy						-0.02	-0.05
						(0.09)	(0.08)
Firm with up to 50 empl. * R&D subsidy * Domestic MNC						0.26*	0.21*
						(0.11)	(0.10)
Firm with 500+ empl. * R&D subsidy * Domestic MNC						0.18	0.28
						(0.26)	(0.15)
Firm with up to 50 empl. * R&D subsidy * Foreign MNC						-0.12	-0.08
						(0.09)	(0.09)
Firm with 500+ empl. * R&D subsidy * Foreign MNC						-0.09	-0.20
						(0.15)	(0.23)
Observations	5,263	5,263	5,263	5,263	5,263	5,263	5,263
Time, ownership, and industry dummies and other controls	Y	Y	Y	Y	Y	Y	Y
Adjusted R-squared	0.56	0.56	0.56	0.56	0.56	0.56	0.56

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix Table 9. R&D Spending: Weighted Regressions, Matched Sample

Dependent variable: Log (1 + R&D spending)	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS	(6) OLS	(7) OLS
National government R&D subsidy (d)	0.08***	0.09***	0.10***	0.04***	0.02	-0.02*	0.05
	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.03)
Domestic MNC * R&D subsidy					0.06	-0.12	-0.02
					(0.07)	(0.07)	(0.08)
Foreign MNC subsidiary * R&D subsidy					0.14	-0.01	0.04
					(0.08)	(0.02)	(0.08)
Low-tech manuf. * R&D subsidy						0.05***	
						(0.01)	
Medium high-tech manuf. * R&D subsidy						0.04**	
						(0.01)	
High-tech manuf. * R&D subsidy						-0.01	
						(0.02)	
Knowledge-intens. services * R&D subsidy						0.05***	
						(0.01)	
Technological services * R&D subsidy						0.05***	
						(0.01)	
Low-tech manuf. * R&D subsidy * Domestic MNC						0.02	
						(0.02)	
Medium high-tech manuf. * R&D subsidy * Domestic MNC						0.10***	
						(0.02)	
High-tech manuf. * R&D subsidy * Domestic MNC						0.47***	
						(0.02)	
Knowledge-intens. services * R&D subsidy * Domestic MNC						-0.20***	
						(0.02)	
Technological services * R&D subsidy * Domestic MNC						0.05	
						(0.04)	
Low-tech manuf. * R&D subsidy * Foreign MNC						-0.03	
						(0.03)	
Medium high-tech manuf. * R&D subsidy * Foreign MNC						0.09**	
						(0.03)	
High-tech manuf. * R&D subsidy * Foreign MNC						0.41***	
						(0.04)	
Knowledge-intens. services * R&D subsidy * Foreign MNC						-0.07	
						(0.04)	
Technological services * R&D subsidy * Foreign MNC						0.04	
						(0.03)	
Firm with up to 50 empl. * R&D subsidy							-0.09***
							(0.02)
Firm with 500+ empl. * R&D subsidy							0.46
							(0.24)
Firm with up to 50 empl. * R&D subsidy * Domestic MNC							-0.14
							(0.13)
Firm with 500+ empl. * R&D subsidy * Domestic MNC							-0.18
							(0.33)
Firm with up to 50 empl. * R&D subsidy * Foreign MNC							-0.05
							(0.10)
Firm with 500+ empl. * R&D subsidy * Foreign MNC							0.12
							(0.23)

Appendix Table 9. R&D Spending: Weighted Regressions, Matched Sample, cont.

Domestic MNC (d)		0.41***	0.17*	0.08	0.06	0.06	0.09
		(0.08)	(0.08)	(0.06)	(0.04)	(0.04)	(0.06)
Foreign MNC subsidiary (d)		0.35***	0.14**	0.06	-0.00	-0.00	0.03
		(0.08)	(0.04)	(0.03)	(0.02)	(0.02)	(0.02)
Patent stock (log)				0.01	0.01	0.01	0.01*
				(0.01)	(0.01)	(0.01)	(0.01)
Sales (log)				0.05**	0.05**	0.06**	0.05**
				(0.02)	(0.02)	(0.02)	(0.02)
No of employees (log)				0.07***	0.07***	0.07***	0.05*
				(0.02)	(0.02)	(0.02)	(0.02)
Company age (years)				-0.00	-0.00	-0.00	-0.00
				(0.00)	(0.00)	(0.00)	(0.00)
College educ. empl. (share)				0.00**	0.00*	0.00*	0.00**
				(0.00)	(0.00)	(0.00)	(0.00)
No of patent applications (log)				0.17**	0.17**	0.16**	0.12**
				(0.05)	(0.05)	(0.05)	(0.05)
Contin. R&D activities (d)				0.13***	0.13***	0.13***	0.13***
				(0.02)	(0.02)	(0.02)	(0.02)
Exports to sales (share)				-0.01	-0.01	-0.01	-0.01
				(0.01)	(0.01)	(0.01)	(0.01)
Process innovator (d)				0.01	0.01	0.01	0.00
				(0.01)	(0.01)	(0.01)	(0.01)
Low-tech manuf. (d)			-0.00	-0.02*	-0.02*	-0.02**	-0.01
			(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
Medium high-tech manuf. (d)			0.14***	0.02	0.03	0.02	0.04
			(0.02)	(0.01)	(0.01)	(0.01)	(0.02)
High-tech manuf. (d)			0.19***	0.10***	0.11***	0.09***	0.12***
			(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Knowledge-intens. services (d)			0.01**	0.02	0.02	0.02	0.02
			(0.00)	(0.01)	(0.01)	(0.01)	(0.02)
Technological services (d)			0.14***	0.07**	0.07**	0.05*	0.07**
			(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
Firm with up to 50 empl. (d)			-0.21***				0.07*
			(0.04)				(0.03)
Firm with 500+ empl. (d)			0.57***				0.17**
			(0.07)				(0.06)
Year 2002 (d)	0.04	0.03	0.04**	0.03	0.03	0.03*	0.03**
	(0.02)	(0.03)	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)
Year 2003 (d)	0.04	0.04	0.04	0.03	0.03	0.03	0.03
	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)
Year 2004 (d)	0.05**	0.05**	0.06**	0.05***	0.05**	0.05***	0.05**
	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
Year 2006 (d)	0.05***	0.04**	0.04**	0.01	0.02	0.01	0.02
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
Constant	0.16**	0.09**	0.07**	-0.38**	-0.37**	-0.36**	-0.33*
	(0.05)	(0.03)	(0.02)	(0.11)	(0.11)	(0.11)	(0.14)
Observations	5,623	5,623	5,623	5,623	5,623	5,623	5,623
Time dummies	Y	Y	Y	Y	Y	Y	Y
Ownership dummies	N	Y	Y	Y	Y	Y	Y
Industry dummies	N	N	Y	Y	Y	Y	Y
Other controls	N	N	N	Y	Y	Y	Y
Adjusted R-squared	0.01	0.14	0.37	0.44	0.45	0.46	0.50

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix Table 10. Patents: Weighted Regressions, Matched Sample

	(1)	(2)	(3)	(4)	(5)
Dependent variable: Log (1 + 5-year ahead patents)	OLS	OLS	OLS	OLS	OLS
National government R&D subsidy (d)	0.01	-0.02	0.00	0.03	-0.01
	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)
R&D spending (log)	0.15***	0.13*	0.17**	0.13	0.13*
	(0.03)	(0.06)	(0.05)	(0.06)	(0.06)
R&D spending * R&D subsidy	-0.03		-0.13		
	(0.09)		(0.12)		
Domestic MNC * R&D subsidy		-0.01	0.08	-0.06	-0.07
		(0.08)	(0.17)	(0.09)	(0.15)
Foreign MNC subsidiary * R&D subsidy		0.27**	0.17**	-0.02	0.31**
		(0.09)	(0.05)	(0.13)	(0.08)
R&D spending * R&D subsidy * Domestic MNC			-0.06		
			(0.18)		
R&D spending * R&D subsidy * Foreign MNC subsidiary			0.26		
			(0.17)		
Low-tech manuf. * R&D subsidy				-0.05***	
				(0.00)	
Medium high-tech manuf. * R&D subsidy				-0.07***	
				(0.01)	
High-tech manuf. * R&D subsidy				-0.09***	
				(0.02)	
Knowledge-intens. services * R&D subsidy				0.01	
				(0.03)	
Technological services * R&D subsidy				-0.02**	
				(0.01)	
Low-tech manuf. * R&D subsidy * Domestic MNC				0.18*	
				(0.08)	
Medium high-tech manuf. * R&D subsidy * Domestic MNC				0.17*	
				(0.08)	
High-tech manuf. * R&D subsidy * Domestic MNC				-0.04	
				(0.08)	
Knowledge-intens. services * R&D subsidy * Domestic MNC				-0.05	
				(0.05)	
Technological services * R&D subsidy * Domestic MNC				-0.13	
				(0.08)	
Low-tech manuf. * R&D subsidy * Foreign MNC				0.43***	
				(0.03)	
Medium high-tech manuf. * R&D subsidy * Foreign MNC				0.04	
				(0.06)	
High-tech manuf. * R&D subsidy * Foreign MNC				0.59***	
				(0.07)	
Knowledge-intens. services * R&D subsidy * Foreign MNC				-0.05	
				(0.07)	
Technological services * R&D subsidy * Foreign MNC				0.39***	
				(0.05)	
Firm with up to 50 empl. * R&D subsidy					-0.00
					(0.04)
Firm with 500+ empl. * R&D subsidy					-0.25
					(0.15)
Firm with up to 50 empl. * R&D subsidy * Domestic MNC					0.35***
					(0.08)
Firm with 500+ empl. * R&D subsidy * Domestic MNC					0.36
					(0.25)
Firm with up to 50 empl. * R&D subsidy * Foreign MNC					-0.20
					(0.17)
Firm with 500+ empl. * R&D subsidy * Foreign MNC					0.19
					(0.34)

Appendix Table 10. Patents: Weighted Regressions, Matched Sample, cont.

Domestic MNC (d)	0.03	0.03	0.02	0.03	0.02
	(0.06)	(0.08)	(0.09)	(0.08)	(0.09)
Foreign MNC subsidiary (d)	-0.09	-0.21	-0.22	-0.21	-0.22
	(0.14)	(0.13)	(0.13)	(0.13)	(0.14)
Patent stock (log)	0.08***	0.08***	0.08***	0.08***	0.08***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Sales (log)	0.01	0.01	0.01	0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
No of employees (log)	0.02	0.02	0.02	0.02	0.02
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Company age (years)	0.00	0.00	0.00*	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
College educ. empl. (share)	-0.00	-0.00	-0.00	-0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
No of patent applications (log)	0.89***	0.89***	0.89***	0.88***	0.88***
	(0.06)	(0.06)	(0.07)	(0.06)	(0.07)
Contin. R&D activities (d)	-0.02	-0.01	-0.02	-0.01	-0.02
	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)
Exports to sales (share)	0.06**	0.06**	0.06**	0.06**	0.06**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Process innovator (d)	-0.01	-0.02	-0.02	-0.02	-0.01
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Low-tech manuf. (d)	0.00	0.01	0.00	0.01	0.01
	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)
Medium high-tech manuf. (d)	0.02	0.02	0.02	0.05	0.03
	(0.02)	(0.03)	(0.03)	(0.03)	(0.02)
High-tech manuf. (d)	0.02	0.02	0.02	0.04	0.02
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Knowledge-intens. services (d)	-0.01*	-0.02**	-0.02**	-0.02*	-0.02**
	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)
Technological services (d)	0.03	0.03	0.02	0.02	0.02
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Firm with up to 50 empl. (d)					0.03
					(0.05)
Firm with 500+ empl. (d)					0.09
					(0.13)
Year 2002 (d)	-0.01	-0.01	-0.01	-0.00	-0.01
	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)
Year 2003 (d)	-0.01	-0.01	-0.01	-0.01	-0.01
	(0.05)	(0.04)	(0.05)	(0.04)	(0.04)
Year 2004 (d)	-0.06	-0.06	-0.06	-0.06	-0.06
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Year 2006 (d)	-0.06	-0.06	-0.06	-0.05	-0.06
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Constant	0.31**	0.31**	0.31**	0.30**	0.27**
	(0.10)	(0.10)	(0.09)	(0.10)	(0.08)
Observations	5,263	5,263	5,263	5,263	5,263
Time, ownership, and industry dummies and other controls	Y	Y	Y	Y	Y
Adjusted R-squared	0.55	0.55	0.55	0.55	0.55

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

PUBLICATIONS

Promoting Innovation: The Differential Impact of R&D Subsidies
Working Paper No. WP/2022/XX