Innovation at State-Owned Enterprises*

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Abstract

We investigate the impact of state ownership on the innovativeness of European listed firms. We find that state-owned enterprises (SOEs) invest more in R&D than private firms, thanks to easier access to bank financing. However, SOEs controlled by politicians with electoral concerns and SOEs with politically appointed managers invest no more than private firms. On the output side, SOEs produce fewer patents per dollar invested. We also find evidence that government-controlled SOEs produce patents with more citations, oriented towards sustainable-technologies, but with lower commercial value, consistent with the view that they emphasize innovation with public-good characteristics over commercial returns.

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1. Innovation at state-owned enterprises

Since Schumpeter's description of capitalism as "the perennial gale of creative destruction," a body of economic research has documented that innovation and technological progress are fundamental engines of economic growth (Solow, 1957; Aghion and Howitt, 2009; Kogan et al., 2016). Several contributions, however, have shown that the private-sector underfunds innovative activities due to high levels of risk, information asymmetries, and positive externalities, providing a rationale for state intervention to resolve these market failures (Nelson, 1959; Arrow, 1962; Hall and Lerner, 2010). Abundant anecdotal evidence supports the view that the state serves as an enabler of innovation, subsidizing if not directing the deployment of transformational technologies (Janeway, 2018).

Starting from the early days of FDR's Tennessee Valley Authority and Italy's Istituto per la Ricostruzione Industriale, to the more recent multibillion investments in information technology by sovereign wealth funds, governments have shown a commitment to promoting innovation by acquiring ownership and control rights in firms.[1] Yet, the literature on the government's role in innovation has largely focused on the effectiveness of government subsidies and tax credits to resolve these market failures,[2] while the impact of state ownership on firms' innovation is largely underexplored.[3] This remains true despite the persistent and ever-increasing role of state ownership of firms in western economies.[4] We aim to fill this gap by investigating the impact of state ownership, as distinct from other forms of public subsidies and grants, on the innovativeness of firms. Our goal is to evaluate how state ownership (considering both minority and majority stakes) affects investment in research and development (R&D),

[1] Since 2010, global sovereign wealth funds have spent a total USD 137 billion in technology-related industries, with the largest deal being Saudi's Public Investment Fund USD 50 billion investment in Softbank's Vision Fund (Bortolotti and Scortecci, 2019).

[2] Example of research on subsidies include Wallsten (2000), Lerner (2002), González, Jaumandreu, and Pazó (2005), Meuleman and De Maeseneir (2012), and Zúñiga-Vicente et al. (2014). A survey of the literature on tax credits for innovation is offered by Cappelen, Raknerud, and Rybalka (2012).

[3] Exceptions to the above are papers on government-sponsored venture capital funds (Grilli and Murtinu, 2014; Brander, Du, and Hellman, 2015) and a recent stream of the empirical literature (Fang, Lerner, and Wu, 2017; Rong, Wu, and Boeing, 2017; Zhou, Gao, and Zhao, 2017; Cao, Cumming, and Zhou, 2018) focused on the link between innovation and government ownership in China. Both of these streams focus on very different types of firms (small, private, young firms backed by venture capital vs. large publicly traded institutions) and institutional settings (China vs. Europe) than our manuscript. Also, many "government venture capital funds," despite the name, do not take equity stakes in firms (Lerner, 2002).

[4] Borisova et al. (2015) report that, "contrary to public perceptions and despite the worldwide success of state privatizations, from 2003 to 2013 governments have acquired more assets through stock purchases ($1.52 trillion) than they have sold through privatizations ($1.48 trillion)."

R&D efficiency, and the ultimate output of the R&D process, as measured by the number, quality, and value of patents generated.

The past two decades have seen not just an increase in state ownership of firms, following a previous wave of privatizations in western markets, but also substantial changes in the dominant type of state ownership model. In contrast to the old model of state-led entrepreneurship, in which the state owned and ran sprawling industrial conglomerates and monopolistic national champions, today the most common incarnation of state ownership is the holding of minority stakes in publicly traded firms (Bortolotti and Faccio, 2009; Megginson and Fotak, 2015).[5] A possible rationale for the persistence of government stakes in publicly traded firms is that corporate investment in R&D suffers from constraints that government shareholding could help relax. The high opacity and long-horizon of R&D investment lead to well-documented underfunding by the private sector (Arrow, 1962; Hall and Lerner, 2010). Governments are instead long-term, (mostly) patient shareholders, with multi-generational investment horizons, and a greater propensity to finance activities that generate social returns, such as R&D (Nelson, 1959; Arrow, 1962). In addition, government ownership, by providing implicit debt guarantees and access to state-owned banks, could relax external financial constraints.[6] Yet, government ownership is potentially a double-edged sword. While it facilitates access to debt markets, it could also increase the financial constraints of firms by preventing access to equity markets.[7] Accordingly, government ownership might not just affect the level of funding for innovation, but it may also alter the way in which

[5] The impact of government stakes on publicly traded firms has accordingly attracted substantial interest. Eckel and Vermaelen (1986) offer an early discussion on "mixed ownership" and governance. Borisova et al. (2012) investigate the impact of government shareholding in publicly traded firms on governance, while Borisova et al. (2015) document the impact of government shareholding on the cost of debt of publicly traded firms. Dewenter, Han, and Malatesta (2010), Kotter and Lel (2011), Knill, Lee, and Mauck (2012), and Bortolotti, Fotak, and Megginson (2015) discuss the impact of a prototypical type of sovereign minority investor, the sovereign wealth fund, on firm behavior and valuation.

[6] O'Hara and Shaw (1990), Faccio, Masulis, and McConnell (2006), Borisova and Megginson (2011), Iannotta, Nocera, and Sironi (2013), Acharya, Anginer, and Warburton (2016), and Borisova et al. (2015) all find that government ownership leads to implicit debt guarantees, which lower the cost of capital of state owned enterprises.

[7] Stulz (2005) shows that firms subject to the "twin agency" problems, where the threat of insider expropriation is compounded by that of government expropriation, face a higher cost of capital. Ben-Nasr, Boubakri, and Cosset (2012) find government ownership to be associated with a higher cost of equity due to the threat of political interference. Chen et al. (2015) find that SOEs underprice IPOs more than private-sector firms, suggesting difficulties in rising equity capital. D'Souza and Nash (2017) find that listed firms with majority government ownership face agency problems (due to conflicting priorities of the government and minority shareholders) that hinder access to foreign capital markets. Jiang, Lee, and Yue (2010) and Cheung, Rau, Stouraitis (2010) find evidence of government owners extracting rents from minority investors.

innovation is financed, leading to a greater reliance on debt, rather than the traditional model of equity financing.

Aside from a purely financial channel of impact, state ownership might affect incentives and governance. For example, managerial compensation at SOEs tends to be less responsive to performance than private-sector compensation (Borisova, Salas, and Zagorchev, 2019). Weaker incentives could lead to under-exertion of effort and excessive risk-aversion, implying a lower level of effort in general, and lower levels of investment in risky activities. Finally, state ownership could impose short-term social and political goals (Shleifer, 1998; Kahan and Rock, 2010) diverting resources away from investments with long-term payoff such as R&D. These conflicting hypotheses motivate our study.

In regards to the outputs of the innovation process, our predictions are more one-sided. The state-ownership literature documents that government-controlled and mixed-ownership firms are less efficient than private enterprises, due to conflicting objectives (Kahan and Rock, 2010; Shleifer, 1998), lower managerial incentives (Borisova et al., 2012), and politicians extracting rents from firms either to cater to their own constituencies, reward supporters or divert resources to themselves (Jiang, Lee, and Yue, 2010; Cheung, Rau, Stouraitis, 2010).[8] Hence, we expect state ownership to lead to lower efficiency in transforming R&D investment into usable technologies. To investigate this issue, we test whether government shareholding is associated with fewer patents per unit of invested capital. Lower efficiency could manifest not only in a lower patent count but also in patents of lower quality. Accordingly, we test whether government shareholding is associated not only with the sheer number of patents produced but also with the quality of the patents—which we proxy by the number of citations received from other patent filings.

Finally, Arrow (1951) and Debreu (1959) find that private agents underinvest in goods that produce high levels of positive social spillover and have low commercial value, as they are unable to fully internalize the benefits of such investments. Accordingly, private-sector firms underinvest in innovation

[8] Extant research finds that the efficiency of state-owned enterprises increases post-privatization. The early literature on privatizations is surveyed by Megginson and Netter (2001) and Djankov and Murrell (2002). More recent evidence includes Sun and Tong (2003), Boubakri, Cosset, and Guedhami (2005), and Estrin et al. (2009), among others. Empirical evidence of inefficiency in mixed-ownership enterprises is provided by Eckel and Vermaelen (1986), Boardman and Vining (1989), and Chen, Firth, and Xu (2008). Borisova et al. (2012) document that ownership by central and local governments is associated with weaker corporate governance.

in general, but also focus on technologies with immediate commercial value and ignore those generating significant social impact (Arrow, 1962; Hall and Lerner, 2010). Yet, governments and affiliated SOEs share some of those social goals and are thus better posed to internalize the benefits produced by innovation. This would imply higher levels of investment in innovation with social spillover—and, conversely, less focus on innovation with high commercial value.

In the empirical analysis, we focus on a sample of publicly-traded (listed) European SOEs, including firms that are majority-, and minority-owned by governments. Consistent with our focus on this new model of state capitalism, we adopt here a broad definition of the term "state-owned enterprise," encompassing every firm with a domestic government stake greater than zero, even if such stake is a small minority holding. We restrict our analysis to European firms to maintain a uniform intellectual-property regime, while still benefitting from a wide range of ownership structures. We employ a variety of data sources and substantial manual processing to generate a final sample of firm-level observations that span the years 2000 to 2009 and covers 4,246 firms, of which 1,297 have non-zero government ownership at some point during the time interval of interest. Our sample of patents extends to the year 2018 and contains 333,136 patents.

We report that SOEs invest substantially more in R&D: on an average, USD 51.9 million per year, compared to USD 16.45 million for privately owned firms. However, SOEs differ on other dimensions as well—they tend to be larger and more profitable, for example. Accordingly, in a multivariate regression setting, we control for time-variant firm characteristics, but also for country, year, and industry fixed effects. We further control for other forms of government-originated innovation subsidies, such as grants and tax incentives, as our interest is on the impact of governments on innovation via, specifically, the ownership channel. We confirm that the presence of a government shareholder increases investment in R&D by approximately 40%. Yet, when we control for the size of the stake owned by the government, we find that, while a minority stake is associated with a higher expenditure in R&D, a large, controlling stake is not—majority state-owned SOEs invest in R&D no more than their private-sector counterparts.

We recognize that state ownership is not random— descriptive statistics reveal that governments tend to hold stakes in large, profitable firms, clustered in manufacturing industries. While we control for firm characteristics to minimize such issues in all regressions, we note potential concerns with omitted variable bias and reverse causality (for example, if governments have a mandate to support, via direct ownership, innovative firms). Accordingly, we use "indirect" government stakes and two-stage models to minimize such concerns. That is, we include only stakes owned by institutions that are, in turn, majority-owned by government entities (ministries, central banks, and other branches of the public sector)—we label those "indirect stakes." We note that many of those indirect stakes are held by financial institutions that governments acquired as part of recapitalization efforts during the financial crisis of 2007-2009. For example, when the government of the United Kingdom acquired an 81.14% stake in the Royal Bank of Scotland in October 2008, as part of its efforts to stabilize the domestic banking system, it became an indirect minority shareholder with a 1.09% stake in Coffeheaven International Limited, a coffee chain operator headquartered in the United Kingdom. This stake enters our sample as an indirect, minority government stake. We posit that such stakes are less likely to be, in turn, affected by selection bias. In this reduced sample, our core results hold, suggesting that even arm's length government ownership has an impact on firms. As an additional test, we employ a two-stage model to control for the possibly endogenous nature of government ownership, mimicking the approach by Borisova et al. (2015). We instrument state ownership using variables that have been found to be related to state ownership, but which are unlikely to affect firm-level R&D expenditures directly: we use the political orientation of the ruling executive (left vs. right-wing), a measure of the size of government investment in the economy, and an index of restrictions on foreign investment as instruments for government ownership. Once more, we confirm our main findings.

We conjecture that the increased R&D investment we observe in conjunction with government minority stakes is due to relaxed financial constraints otherwise affecting investment in innovation. To further investigate this channel, we add to our models variables identifying firms that are more likely to be financially constrained. We find that the increase in R&D investment associated with the presence of a government shareholder is specific to firms that are otherwise financially constrained, consistent with the hypothesis that state ownership relaxes such financial constraints.

We question whether these relaxed financial constraints originate from implicit debt guarantees, which allow easier access to funding from the private sector (Borisova et al., 2015), or by allowing SOEs to access capital from state-owned banks. We note that, while extant literature suggests that the private sector will underfund innovation due to both information asymmetry and long-horizon, state-owned banks might be more prone to support innovation, by mandate. Consistently, we find that both private-sector and SOE investment in R&D is negatively related to the share of deposits controlled by private-sector banks (proxying for the role of private, rather than state-owned, banks in the economy). More relevant to our investigation, we find that the reluctance to fund innovation by state-owned banks is mitigated by state ownership, suggesting SOEs have an easier time accessing private-sector debt funding for innovation. In an additional analysis, we make use of a granular dataset on loan origination, to distinguish between debt funding from private and state-owned banks. We find that SOEs (private firms) tend to increase (decrease) investment in R&D after receiving loans from state-owned banks. The combined evidence points to the fact that state ownership facilitates investment in innovation by relaxing funding constraints both from private-sector and state-owned banks.

Our findings strongly suggest that the increased investment in innovation by SOEs is driven by easier access to funding. Yet, we are still left with the puzzle of why this higher investment in R&D is specific to minority government-owned SOEs, while majority government-owned SOE investment is similar to private sector firms. The same access to preferential funding available to minority SOEs should affect majority SOEs as well. Our findings indicate that a large government stake inhibits investment in R&D through some other channel. We set forth two main hypotheses. One is that a large government stake allows politicians driven by re-election concerns to divert resources towards other expenditures, such as employment maximization, that have a bigger short-term impact on political consensus (Shleifer and Vishny, 1994)—the "political objectives" hypothesis. The other is that managers of government-controlled SOEs are not compensated in a manner that incentivizes risk-taking and long-term innovation (Bos, 1991; Vickers and Yarrow, 1988; Borisova, Salas, and Zagorchev, 2019)—the "agency" hypothesis. Our empirical analysis finds strong support for the political objectives hypothesis. We find that SOE investment in innovation drops significantly in the years preceding national elections—and that the effect is driven by majority-owned SOEs. Our findings are consistent with D'Souza and Nash (2017), who document agency conflicts between the state and minority shareholders when the state owns controlling stakes in listed firms and Alok and Ayaggari (2015), who find that SOEs in India tend to redirect investment towards “visible” capital expenditures around elections. Further buttressing the political objectives hypothesis, we find that SOEs in countries in which politicians appoint SOE managers tend to invest less in innovation that SOEs in countries in which managers are not appointed by politicians. In contrast, we find no support for the role of SOE manager compensation—SOEs in countries allowing for performance-based compensation of SOE managers do not appear to invest more in innovation than SOEs in countries imposing fixed payouts.

Yet, over and above the determinants of investment in R&D, we are interested in innovation output. In a multivariate setting, we analyze the impact of government shareholding patent production over varying time horizons (from one to three years). We find that the presence of a government shareholder is not related to the number of patents produced over the following years. We note, however, that SOEs invest substantially more in R&D. Once we control for the magnitude of the R&D investment, we find that SOEs are significantly less efficient than private firms in producing patents. This is consistent with descriptive statistics, which reveal that SOEs produce one patent for every USD 3.22 million invested in R&D, while private sector firms produce one patent for every USD 2.37 million. Back of the envelope estimates point to a 40-50% greater expenditure per patent.

Given that governments have different goals than private-sector shareholders, we hypothesize that state ownership could affect not only R&D investment and the quantity of innovation but also the quality and type of innovation. We use citations as a proxy for the quality of patents and find that SOE patents are cited just as often as private-sector patents. Yet, once we isolate patents produced by majority government-owned SOEs, we find a higher number of citations. Another indirect measure of patent quality is the commercial value of the patent itself. While we cannot observe patent value directly, similar to Kogan et al. (2017), we estimate patent value by measuring the stock price reaction of the patenting firm at the announcement of a patent’s application. If SOE patents are more oriented towards social, rather than commercial, objectives, then the average market reaction at announcement should be weaker, reflecting a lower patent commercial value. In a series of event studies, we find that the publication of a patent by a private-sector firm leads to an abnormal return of about 0.06% over the three-days surrounding patent publication. In monetary terms, this translates into a mean estimate of patent value of approximately USD 23 million. In contrast, our estimate of patent value for SOEs (both minority and majority government-owned) leads to statistically insignificant results, suggesting that the mean or median, patent produced by a SOE has no commercial value (we estimate an average patent value of USD 7.96 million, but not statistically significant). Even high-citation patents produced by SOEs have lower commercial value than private-sector ones, suggesting a focus on a different set of technologies (basic science or technologies with social spillover). The high number of citations (for government-controlled SOEs), coupled with the low commercial value of the same patents suggest a focus on "basic-science" technologies for SOEs. This is consistent with anecdotal evidence cited by Munari (2002): following its 1989 partial privatization, which led to a switch from majority to minority state ownership, the Italian group ENEL revealed that it would refocus its research towards the field of electricity generation (which it labeled "competitive research") and away from research regarding the environment, transmission networks, or the efficient use of electricity ("system research").

The different priorities of government owners, as compared to private-sector shareholders, could consistently lead to a greater focus on new technologies that can provide benefits to society at a large and as such have intrinsic value that cannot be fully captured by the commercial value of the patent (Arrow, 1962; Hall and Lerner, 2010). For that reason, socially beneficial technologies will likely be underfunded by the private sector. Governments, on the other hand, are in a position to prioritize patents with such high social value. To proxy for such socially beneficial technologies, we use a unique feature of the European patent data which identifies technologies aimed at climate change mitigation and, in broader terms, related to clean energy sources. Our investigation is consistent with our priors, as SOEs produce more patents in the sustainable technology class than their private counterparts. We should caution, however, about over-generalizing these results, as they appear driven by a subset of research-intensive government-controlled manufacturing firms.

Our manuscript sits at the conjunction of two streams of the empirical corporate finance literature: the literature on government ownership and that on corporate innovations. We contribute to recent papers examining the effect of state ownership on listed firms (Dewenter, Han, and Malatesta, 2010; Kotter and Lel, 2011; Knill, Lee, and Mauck, 2012; Borisova and Megginson, 2011; Bortolotti, Fotak, and Megginson, 2015; Borisova et al., 2015). We confirm that government minority stakes have a strong impact on firm operations. This impact is distinct from government control of institutions originating as state-owned champions and subsequently privatized which are the focus of most of the existing empirical research. Within the literature on this new model of state capitalism and mixed ownership, we fill an important gap by showing that government shareholding allows for greater investment in R&D by facilitating access to funding, but that this effect is counterbalanced in majority-owned SOEs by political pressures to divert resources away from such long-term investments. While relaxed financial constraints for innovation have been often predicted in the theoretical discussion on state ownership, our manuscript is the first, to our knowledge, to provide robust empirical evidence in this regard.[9]

An exception to the above is a recent branch of the empirical literature (Fang, Lerner, and Wu, 2017; Rong, Wu, and Boeing, 2017; Zhou, Gao, Zhao, 2017; Cao, Cumming, and Zhou, 2018) that has focused on the link between innovation and government ownership in China.[10] We note that state ownership in China is likely to have a very different impact than state ownership in Western, European markets, due to its peculiar institutional characteristics relative to the developed economies we investigate (Feng, Lerner, and Wu, 2017 document important interactions between state ownership and property rights in determining firm innovativeness). As Cao, Cumming, and Zhou (2018) discuss in detail, government ownership in China dictates access to capital, but also access to talent and to important state contracts and projects. In addition, the focus of this literature is predominantly on firms with large government stakes and often exploits privatizations as a testing ground (as, for example, in Fang, Lerner, and Wu, 2017). In contrast, we show that minority government ownership has a very distinct impact from majority control. Finally, this stream of literature on innovation in Chinese firms suffers from the inability to control for patent quality, due to lack of data on patent citations, which is troublesome given concerns about frivolous patents.[11]

[9] Munari (2002) analyzes, in a series of case studies, how the privatization of seven Italian and French state-owned enterprises affects their investment in R&D and patent production. Consistent with our results, he finds anecdotal evidence of increased efficiency (patents per researcher) and a shift from basic-science research to development with commercial objectives.

[10] The literature on innovation at Chinese SOEs has so far led to conflicting findings. For example, Cao, Cumming, and Zhou (2018) find that state ownership improves innovative efficiency through the relaxation of financial constraints. In contrast, Fang, Lerner, and Wu (2017) document an increase in both firms' patent stock and patent ciations in the five years following proviatizations.

[11] While state ownership is not their main focus, we should also note Ayyagari et al. (2011), who examine innovation, broadly defined, in emerging economies and finds that new product lines and new technology development can be hampered by controlling state ownership.

We also recognize a large literature on government sponsorship of innovation. While those papers discuss the effectiveness of subsidies (Wallsten, 2000; González, Jaumandreu, and Pazó, 2005; Meuleman, and De Maeseneire, 2012; Zúñiga-Vicente et al., 2014) and tax credits (Cappelen, Raknerud, and Rybalka, 2012), our focus is specifically on the role of governments as shareholders. Closer to our aim, a subset of this literature has looked at the role of government-sponsored venture capital funds (Grilli and Murtinu, 2014; Brander, Du, and Hellman, 2015). While such funds focus on small, young, unlisted firms, in which governments take early and large stakes, our analysis examines large, publicly-traded firms with governments holding, on an average, small minority stakes. We also note that the term "government venture capital" has been used in a very loose sense in the government ownership literature. For example, the Small Business Innovation Research Program, described as a "venture capital fund" by Wallsten (2000) and Lerner (2002), does not make an equity investment and offers most funding in the form of research grants.

Extant research documents firm characteristics that influence innovation such as firm boundaries (Seru, 2014), corporate governance (Meulbroek et al., 1990), and executive characteristics (Chemmanur et al., 2015). More closely related to our work, is research investigating the role of concentrated and institutional ownership on innovation. Francis and Smith (1995), Bushee (1998), and Eng and Shackell (2001) find a positive relationship between institutional ownership and R&D investment. More recently, Aghion, Van Reenen, and Zingales (2013) document that institutional ownership leads to more patent citations, while Lerner, Sorense, and Strömberg (2011), Tian and Wang (2014), and Brav, Wei, Song, and Xuan (2018) document consistent findings associated with private equity blockholders, venture capital funds, and activist hedge funds, respectively. Our investigation reveals that government ownership has a distinct impact, leading to higher investment in R&D (as documented for institutional blockholders) but lower efficiency, in contrast with the institutional ownership impact documented by extant literature.[12]

Finally, a growing literature on financing constraints suggests that while equity capital may be preferential for the funding of risky projects (Hall and Lerner, 2010), firm innovation output can still be

[12] Due to data limitations, we are unable to formally control for institutional ownership in our full sample—yet, we note that Borisova et al. (2012) report, for a sample of European publicly traded firms that resembles our in terms of coverage, geography, and time window, no significant difference in average institutional ownership between firms with and without government shareholders. In untabulated robustness tests on a smaller sample, we find that controlling for institutional shareholding does not affect our findings.

influenced by the availability of access to debt markets (Amore, Schneider, and Žaldokas, 2013; Cornaggia et al., 2015). Using granular level data on syndicated loans, we provide support to the idea that debt markets are indeed important for the financing of innovation and that state ownership may facilitate access debt when traditional financial intermediaries fail to fund innovative activities.

2. Data and univariate statistics

In the sections below, we describe the sources from which we draw our data. In Table A1 (included in the appendix), we define the variables used in the tests that follow and the related data sources. In Table 1, we provide summary statistics for the industry composition, country distribution, and the full sample of firm-year observations. Table 2 reports univariate tests comparing firm characteristics for SOE and private-sector firms.

2.1 Intellectual property

Our data on patents originate from two sources. The initial patent information is from the Bureau Van Dijk Orbis database (Orbis), which provides granted patent data, with disambiguated ownership links. Orbis reports patents across 41 different patent offices and integrates raw patent information from the European Patent Office (EPO) Worldwide Patent Statistical Database (PATSTAT). Orbis provides a link between granted patents and firm accounting and ownership information. We obtain patent numbers from Orbis and consolidate them to patent families per firm-year using PATSTAT family identifiers as in Levine, Lin, and Wei (2017). As is custom in the literature, we use the year of application to associate the patent with its most likely time of invention, i.e. when the firm was most likely to expend effort and investment to produce the invention. We aggregate citation data from PATSTAT and consolidate patents to citing patent families. PATSTAT contains patent application and grant information for the EPC member offices and the EPO in addition to citation data for each patent. Using this we follow Hall, Jaffe, and Trajtenberg (2000) and Levine, Lin, and Wei (2017), to calculate the citation truncation adjustment for each industry patent class (IPC) and grant lag of the citation distribution and apply it to each patent citation count.[13]

[13] Because citations for a patent arrive at different frequencies, and patents aggregated in the study are of different "ages", it is important to adjust the observed number of citations to avoid truncation bias. Thus, we estimate the citation grant lag distribution, i.e. how quickly citations arrive after a patent is granted, for European patents over

While our focus is on state ownership's influence on innovation, governments hold additional tools such as grants and tax incentives to spur innovative activities. We collect cross-country data from the OECD on direct government funding of business R&D expenditures scaled by gross domestic product. If firms receive substantial government support in the form of grants for R&D which substitutes for other funding sources such as access to debt markets, the cross-country, and time-series nature of the metric should help alleviate such concerns. In addition, we incorporate country-specific information on R&D tax incentives. The OECD reports a country-level time series of tax subsidies for large firms that incorporates both tax credits and exemption rates for R&D expenditures. Thus our specifications are robust to concerns regarding the substitutability of tax incentives and government access to capital.

To identify socially beneficial patents, we use a recent innovation of the European Patent Office that identifies patents in sustainable technology areas. The EPO began a program in 2013 that identifies patents granted in sustainable technology classes. Through the program, the EPO tags patents with identifiers from the cooperative patent classification (CPC) system. Using PATSTAT we are able to identify patents that fall into one of the seven technology areas designated as sustainable. Important to the current study, the EPO also retroactively tagged existing patents that fit the sustainable categories. Appendix Table B3 describes the seven sustainable technology areas that revolve around climate change mitigation and renewable energy.

2.2 State ownership

We obtain data on government ownership from the Bureau van Dijik Orbis database.[14] We define a firm as a "state-owned enterprise" (SOE) if the government owns any share of voting rights in the firm.

a 30-year window for each grant year (1976-1985) and patent class (A-H). We then average the citation lag distribution for each industry class over the 10 years to generate an average citation lag distribution for European patents. We report the citation lag distribution for each IPC class in the appendix Table B1. To truncation adjust citation counts, this is important for two reasons. First, US citation adjustment factors are estimated for different technology classes rendering them unusable for our current exercise. Second, citation lag varies tremendously across EPO patent offices as shown in Table B2 of and Figure B1 of the appendix. This necessitates the calculation of an EPO specific citation adjustment.

[14] The version of the dataset we employ is accessed via an online platform made available starting in the summer of 2016 as part of a transition to a new database ("Orbis historical"). It contains data that was previously available only in compact-disk format, including historical data for both listed and delisted firms. Data coverage prior to 1999 is available, but scarce—hence our choice of starting year. We identify "direct" government stakes as those owned entities defined as "public authorities," "states," or "governments" in Orbis. We identify as "indirect" government stakes as those owned by any entity that is, in turn, directly or indirectly controlled (with an ownership stake, measured in terms of voting rights, exceeding 50%) by governments. In reconstructing indirect ownership, we track indirect stakes up to ten-levels down the ownership chain. In addition, we complement our

Aside from a binary indicator variable identifying the presence of a government shareholder, we further construct a continuous variable identifying the total size of the stake (as a proportion of voting rights) owned by the government. We restrict our analysis to domestic government ownership, direct or indirect. "Indirect" ownership is defined as ownership through controlled entities (any stake owned by an entity in which the government owns a majority of voting rights would be included in our definition of "government stake"). We focus on firms headquartered in one of the twenty-eight countries that are members of the European Union as of December 2016. We exclude financial firms and firms for which we have incomplete accounting data (as discussed in the following section). Our main firm-level dataset employed in empirical investigation spans the years 2000 to 2009.[15] Our final sample covers 4,246 firms, of which 1,297 have non-zero government ownership at some point during the time interval of interest, and 2,949 have no government ownership at any point in our sample.[16] Of the government-owned firms, 57 have an average government stake exceeding 50%, while the rest (1,240) have minority government ownership stakes.

In addition to data on government ownership, we obtain firm-level SIC codes, to identify the main industry in which the firm operates, and a variable identifying the country of headquarters. We report the industrial distribution of the firms in our sample in Table 1, Panel A. Both SOEs and non-SOE samples contain a large proportion of manufacturing firms (46% of the SOE sample and 39% of the non-SOE sample) and firms in the service industry (21% and 30%). "Transportation and Public Utilities"

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methodology with extensive manual checks (relying on firms' financial statements and websites) as well as databases assembled by the Sovereign Investment Lab at Bocconi University tracking European Privatizations and sovereign investments since 1980. While we do not have historical records of "ultimate ownership," which would have allowed us to identify such, and deeper, ownership chains, we do have such chains for the current period (at the time of data collection, December 2018). We accordingly test our methodology to identify, in a time-static format, indirect ownership as of December 2018. We find that our methodology identifies correctly over 95% of indirect majority government stakes, and over 80% of indirect minority (in the 25% to 50%) government stakes.

[15] Our choice is restricted by the availability of data. Prior to the year 2000, we do not have reliable ownership information. On the other side, we have patent grants until the end of 2018. Hence, we include, in our sample, patent applications up to 2012 (assuming, implicitly, that six years is sufficient time for most patents to be granted). Given that we allow for a maximum window of three years in investigating the link between ownership, R&D investment, and patent production, we accordingly include firm-year level observations until December 2009.

[16] In contrast, the World Federation of Exchanges reports a total of 8,681 listed firms in the European Union in 2014 (the latest available data). Our final sample is reduced by the availability of ownership information. While we do not report formal comparisons, we note that, compared to the universe of listed European firms, our sample is biased towards large institutions (for an in-depth discussion of biases in Orbis data, please refer to Kalemi-Ozcan et al., 2015). We attempt to mitigate such bias with manual data collection and by supplementing Orbis data as described; we nevertheless recognize this as a limitation inherent in our dataset.

constitute about 13.5% of the SOE sample and 9.5% of the non-SOE sample, while "Retail Trade" and "Mining and Construction" each constitute about 10% of both the SOE and non-SOE sample. We report the country-level distribution of the firms in our sample in Table 1, Panel B. The United Kingdom accounts for 44.02% of firms in our sample, France for 12.25%, Germany for 11.49%, Italy for 4.99%.

2.3 Accounting data

We obtain financial data from Thomson Reuter's Worldscope database (Worldscope). We match firms between Orbis and Worldscope by using International Securities Identification Numbers (ISINs), which are available in both datasets. All data is reported annually as of December 31 of the year of interest and in USD. We download metrics for firm size (total assets), profitability (return on assets), leverage (debt over total assets), capital expenditures, property plant and equipment, and investment in research and development to facilitate cross-country comparison. We further obtain dates of first addition in the database (as rough proxies for firm age) and dates of last update. We drop all observations following the date of the last update (as Worldscope stores the last available data point for all subsequent years). Continuous variables are winsorized at the 1% tails, to mitigate the impact of outliers and bad data points. In the descriptive tables, we report numbers unadjusted for inflation; in empirical analysis, we adjust all monetary values to the base-year 2004, using the Consumer Price Index (Urban) data from the St. Louis Federal Reserve.[17]

In the empirical analysis, we test whether government ownership relaxes financial constraints of firms. In order to identify financially constrained firms, we construct the Hadlock and Pierce (HP) index, as described by Hadlock and Pierce (2010). In particular, following their formula, we compute the index as:

$$\textit{HP index} = (-0.737 \times \textit{Size}) + (0.043 \times \textit{Size}^2) - (0.040 \times \textit{Age}) \quad (1)$$

Where *Size* is the log of inflation-adjusted (to 2004, as in the original formulation) total assets, and age is the number of years the firm has been listed in the Worldscope database. As in the Hadlock and

[17] In choosing a reference year, we mirror Hadlock and Pierce (2010), as their metric of capital constraints, which we replicate, is affected by inflation scaling.

Pierce formulation, size is replaced with log ($4.5 billion) and age with 37 years, if the actual values exceed those thresholds.[18]

As Koh and Reeb (2015) show, a portion of firms that fail to report R&D expenditures are likely investing in research and the standard practice of replacing missing R&D expenditures with a zero may bias our analysis. Following their work, we identify firms that fail to report R&D expenditures with an indicator (*Blank R&D*). We also incorporate a second indicator for firms that have non-zero granted patent applications in a year during which they fail to report R&D investment (*Pseudo blank*).

2.4 Other data

We utilize a detailed and granular dataset of syndicated loans to provide micro-level evidence that the link between government ownership and innovation is via the financing channel. In particular, we make use of the dataset described in detail in Fotak and Lee (2019). The raw data on syndicated loans is from the Thomson Reuters Dealscan database. Bank ownership data from Thomson Reuters Bankscope, as well as ownership data from the Sovereign Investment Lab databases on government ownership and privatizations and substantial manual cleanup (described in detail in Fotak and Lee, 2019), leads to the identification of government-owned banks and, in turn, syndicates including government-owned lenders.

We obtain data on financial crises from the database described in Laeven and Valencia (2013). Elections data is from the Comparative Political Data Set. [19] We complement the data with press reports to identify which national elections are unscheduled. Data on country-level legislation restricting CEO performance pay and on the appointment of SOE managers is from the OECD "Ownership and Governance of State-Owned Enterprises: A Compendium of National Practices."[20] Data on the political orientation of the ruling executive (used to identify left-wing governments) is from the Database of Political Institutions by the World Bank. Country-level data, including data on the proportion of deposits

[18] While the original HP index was developed on a sample of US-based firms, we note that the quantile distribution in our sample mirror closely the distribution reported by Hadlock and Pierce (2010). We choose to employ the Hadlock and Pierce (2010) metric, as other common metrics of capital constraints, such as those developed by Whited and Wu (2006) and Kaplan and Zingales (1997), have greater data requirements which lead to a loss of usable observations and a shrinkage of our sample of interest.

[19] The dataset is available at available at www.cpds-data.org. We thank Klaus Armingeon, Virginia Wenger, Fiona Wiedemeier, Christian Isler, Laura Knöpfel, David Weisstanner, Sarah Engler and the University of Berne for making the data available.

[20] The 2018 version of the report, from which we draw our data, is available at: hiips://www.oecd.org/corporate/ca/Ownership-and-Governance-of-State-Owned-Enterprises-A-Compendium-of-National-Practices.pdf

in private sector banks (which we use for a proxy for the role of private-sector banks in the economy) and on restrictions on foreign investment, are from the Fraser Institute Economic Freedom of the World Report (the 2018 edition).

2.5 Descriptive statistics

Our final sample contains 23,893 firm-years, spanning 2000 to 2009, with non-missing data. Of those, 20,097 are non-SOEs while 2,796 are SOEs (firms with a government stake greater than zero), with average government ownership of 8.27%. Approximately 4.4% of firms with government stakes are government-controlled (with a government stake exceeding 50%). Univariate statistics are reported in Table 1, Panel C, while differences between the SOE and private-sector samples are highlighted in Table 2. SOEs are much larger, with total assets over USD 6 billion, compared to USD 1.9 billion for non-SOEs. Further, SOEs are more profitable, with higher return on assets and have a higher proportion of tangible assets. SOEs and non-SOEs do not differ significantly in leverage nor capital expenditures. SOEs are slightly less capital constrained, as measured by the *HP index*, but operate in countries that are more likely to face a financial crisis and display lower GDP growth.

Most relevant to our investigation, SOEs invest more in R&D than private-sector firms (SOEs invest on average USD 51.9 million in R&D, non-SOEs USD 16.45 million). SOEs produce, on an average, 15.98 patents in each year, versus 7 patents for non-SOEs, but fewer patents "for each dollar invested": SOEs produce 0.31 patents for each USD 1 million invested in R&D, while non-SOEs produce 0.42. SOEs and non-SOEs do not differ significantly in the average number of citations per patent (10.59 for SOEs and 8.47 for non-SOEs, but the difference is not statistically significant). We also note that, despite the higher average level of R&D investment, SOEs are less likely to report investment in R&D (only 52.5% of SOEs in our sample report investment in R&D, versus 64.5% of private-sector firms).

3. Empirical Analysis

The first step in our analysis is to estimate the impact of government ownership and control on investment in R&D at the firm-year level. We do so, in a set of multivariate regressions in the following sections. We then turn our attention to the output side, discussing the impact of government ownership on the number of patents, on patent quality (proxied by citations), on patent value (in a series of event studies), and on the patent type (isolating "sustainable" innovation).

3.1 Government ownership and R&D investment, base regressions

In our base regression model, we test the hypothesis that government shareholding affects firm-level investment in innovation. Our base regression model is:

$$\ln(R\&D)_{i,t+1} = \alpha + \beta \times GovOwnership_{i,t} + \vec{\gamma} \times \overrightarrow{Firm}_{i,t} + \vec{\delta} \times \overrightarrow{Country}_{j,t} + \kappa \times Country_{j} + \lambda \times Year_{t} + \mu \times Industry_{k} + \varepsilon_{i,t}. \quad (2)$$

The subscripts *i*, *j*, *k*, and *t*, refer, respectively, to the firm, country, industry, and year of observation. We use, as a response variable, the natural logarithm of the R&D expenditure (in USD thousands), to mitigate skewness. *GovOwnership* is a set of variables identifying the presence or stake of government shareholders. In the base model, our main variable of interest is a binary variable, *SOE*, set equal to one for firms in which the domestic government holds a non-zero voting stake. We include a vector of firm-level, time-variant, observable characteristics ($\overrightarrow{Firm}_{i,t}$) and time-variant country-level characteristics ($\overrightarrow{Country}_{j,t}$), as well as country, year, and industry fixed effects. Standard errors are clustered at the country-level following Bertrand and Mullainathan (2003).

Our set of controls mirrors, as far as data allows it, the empirical setup by Fang, Lerner, and Wu (2017). We include firm-level variables that can influence research and development investment such as firm size (*Total assets*), profitability (return on assets, or *ROA*), leverage (debt-to-assets), capital expenditures (scaled by total assets), property plant and equipment (scaled by total assets), and financial constraints (a dummy variable, *Constrained*, set equal to one for firms with HP indices above the median each year). All metrics are as of December 31 of the previous year, to avoid issues related to simultaneity. We further recognize that R&D investment data is often missing in our dataset. Consistent with extant literature, we assume that a missing data-point indicates no investment in research and development. We address this issue in robustness tests discussed in following sections of the manuscript. In this model, to minimize the impact of this assumption, we add a variable identifying observations with non-reported R&D expenditures (*BlankRD*). All firm-level variables are expressed in USD, where relevant and winsorized at the 1st and 99th percentiles, to mitigate the impact of outliers or bad data points. Further, we recognize that governments might subsidize innovation via other means (rather than direct ownership of productive assets). Accordingly, we control for country-level metrics of government subsidies both via grants (*BERD*) and via taxation (*Profit tax subsidy* and *Loss tax subsidy*). In addition, we control for the overall country level of economic growth, proxied by changes in the gross domestic product (*GDP growth*). We recognize there may also be unobservable differences in the tax treatment of R&D investment at the country level that would encourage firms to systematically report R&D differently by country. We include a country fixed effects to address concerns with such omitted variables. Our sample consists of firm-year observations from 2000 to 2009. Because the global environment at that time included multiple macro-financial crisis periods that may influence firm-level investment, we include a financial crisis indicator representing the country-years identified as experiencing a financial crisis, as in Laeven and Valencia (2013). To further control for time trends, we add year fixed effects to our models. R&D investment can also vary widely by industry type with newer industries like healthcare and telecommunications demanding higher levels of R&D to remain competitive. To control for such industry-specific trends, we include two-digit SIC code industry fixed effects.

Results for this base model are presented in the first column of Table 3. The coefficient estimate associated with the main variable of interest, *SOE*, is positive and statistically significant at the 1% level. The estimated coefficients indicate that the presence of a government shareholder is associated with a 40.3% increase in R&D expenditure. While, for brevity, we refrain from discussing coefficient estimates associated with the other control variables in detail, we note that they are roughly consistent with expectations based on prior literature. For example, results indicate that capital-constrained firms invest substantially less in R&D.

We recognize that a simple minority stake might not reveal the full impact of government ownership. The imposition of social or political goals might be instead associated with larger stakes, allowing politicians to exercise a greater degree of influence and control over the firm. Accordingly, in a second model, we add a variable measuring the size of the government stake in the firm, *Stake*. Coefficient estimates from this second model, presented in column (2) of Table 3, indicate that, while the presence of a government shareholder is associated with an increase in R&D spending, larger stakes are associated with a decline in R&D. We confirm this finding with estimates from a third model, presented in column (3), in which we replace the continuous variable *Stake* with a binary variable, *Control*, set equal to one when the size of the government stake exceeds 50%, and zero otherwise. In both cases, the coefficient estimate associated with *SOE* is positive and significant at the 1% level, while coefficients of *Stake* and *Control* are negative and statistically significant at the 10% level. These findings suggest that, while a minority government stake increases R&D investment, a large or controlling stake seems to mitigate this effect, or possibly reverse it. To investigate the matter further, in an additional specification, we distinguish minority and majority government ownership with distinct variables (respectively, *Minority* and *Control*, which identify, in mutually exclusive terms, minority and majority government stakes). This specification reveals, more clearly, that the higher expenditure in R&D is specific to firms with minority government stakes. In contrast, firms with large (greater than 50% of voting rights) government stakes appear to invest in R&D just as much as private-sector benchmark firms.

In our base specifications, standard errors are clustered at the country-level. In the last two columns of Table 3, we show that clustering by year or industry does not affect the significance level of our estimates in any significant manner. In unreported tests, we further cluster standard errors in two dimensions and our results continue to remain significant.

3.1.1 Government ownership and R&D investment, omitting blank R&D observations

Before investigating further the channels behind these different findings, we run a series of tests to ensure the validity and robustness of our bases findings. Noting that a large number of firms (64.6% of SOE firm-years and 52.5% of private-sector firm-years) do not report R&D expenditures (which, in our main sample, we interpret as a "zero" expenditure), we replicate our analysis on a smaller sample, excluding firm-year with non-reported R&D expenditures. We report our findings in Table 4, mirroring the regression analysis presented in Table 3. We find that our core results still hold: minority government-owned SOEs invest more in R&D than private-sector firms, while majority-owned firms do not.

3.1.2 Government ownership and R&D expenditures, indirect stakes

It is likely that government ownership is non-random—the descriptive statistics of our sample indicate that SOEs tend to be larger, more profitable, and more highly levered than private-sector firms. As a consequence, the relationship between government ownership and a firm's investment in R&D could be confounded by an omitted-variable bias induced by unobserved firm characteristics. As a first attempt at mitigating such problem, we identify "indirect" stakes owned by government entities. The main idea behind this test is that, while government ownership might suffer from selection biases, linked to government preference for specific asset types and classes, indirect stakes are less likely to suffer from such biases.

We start by identifying "direct" stakes as those owned by political bodies identified, by Orbis, as either a "public authority," a "state", or a "government", such as ministries (our sample mostly contains stakes by ministries of finance or economics), central banks, treasury departments, and fully state-owned investment funds (such as pension funds, stabilization funds, development funds, and sovereign wealth funds). In contrast, we define as "indirect" stakes any stakes owned by entities that are controlled (where "control" implies a majority of voting rights), but not fully owned, by governments, such as partially government-owned banks, or partially-owned enterprises. So, for example, a 59.62% stake by the Romanian Ministry of Energy in Oil Terminal S.A. leads us to classify the company as having a (majority) direct stake by the Romanian government. In contrast, a 1.09% stake owned by the Royal Bank of Scotland (RBS) in Coffeehouse International in 2008 is classified as a (minority) indirect stake owned by the United Kingdom government after the latter acquired a controlling stake in RBS as part of an effort to stabilize the domestic banking sector during that year's financial crisis.

We present our findings in Table 5, mirroring the regression analysis presented in Tables 3 and 4. Once more, we confirm our main finding. Even in this reduced sample including only indirect government stakes, we find that minority government-owned firms invest about 40% more in R&D than private-sector firms. We also further confirm that the findings are specific to minority government-owned firms—firms in which governments owned majority indirect stakes do not invest more in R&D than private-sector benchmark firms. We recognize this test does not fully guarantee that our findings are free from selection bias—yet, we argue that it greatly mitigates such concerns. We present further robustness tests in the following section by implementing an instrumental variable approach.

3.1.3 Government ownership and R&D expenditures, a two-stage model

As an additional robustness test aimed at mitigating the impact of omitted variable biases, we use two-stage least-square instrumental variable models, mirroring the approach in Borisova et al. (2015). The initial selection equation is fit using models describing the characteristics associated with the presence of government owners. The first-stage equations include firm-specific and country-level variables present in the second-stage outcome equation, as well as industry, year, and country-level fixed effects. Most importantly, we include variables that are related to government ownership but are exogenous to the R&D outcome we intend to model in the second stage. Specifically, we employ a binary variable identifying the political party of the nation's chief executive in a given year, *Left wing*, as in Beck et al. (2001). Bortolotti and Faccio (2009) find higher government control in nations governed by left-wing political parties, who are more likely to pursue social goals via economic intervention. Accordingly, we expect a positive relation between *Left wing* and state presence. We also use the annual country-level measures *Investment* and *Foreign restrictions* from the firm's home nation. *Investment* is from the International Monetary Fund's (IMF) World Economic Outlook (WEO) Database and measures, at a country-year level, the total investment (defined as the total value of gross fixed capital formation and changes in inventories and acquisitions minus related disposals) scaled by GDP. Higher national values of *Total investment* indicate higher availability of funding to the government for investment purposes, and greater state holdings are possible in these cases. Yet, when total investment declines, as during macroeconomic crises, governments tend to step in and bail out struggling firms, possibly leading to an increase in government ownership. Accordingly, the relation between total investment and government ownership is a matter for empirical investigation. *Foreign restrictions* is from the Fraser Institute's Economic Freedom of the World Report. Restrictions on foreign ownership have been shown to correlate strongly with privatization programs and, thus, with foreign ownership. While we expect these country-level factors to predict government ownership, they are not likely to directly influence a firm's level of investment in R&D.

Noting the potential correlation between these instruments, we ensure the robustness of our estimates by including, first only *Left wing* (column 1), *Left wing* and *Foreign restrictions* (column 2), *Left wing* and *Investment* (column 3), and all three variables (column 4). Results are presented in Appendix Table B4. In all cases, the first-stage coefficient estimates indicate that government shareholding is less likely with left-wing governments in power. This puzzling result is very robust, as we find in extensive (unreported) robustness tests. While it does not meet our prior expectations, it is not an unreasonable finding. As discussed by Hicks (2016), during the period of study we investigate, many privatization programs in Europe were initiated by left-wing governments who effectively acted on a "delayed" privatization wave, compared to right-wing initiated privatization programs that swept Europe in the 1980s and 1990s (Bortolotti and Pinotti, 2008). Hence, left-wing ownership might correlate, in the post-2000 Europe, with a decline in government ownership on a "within-country" basis (our model is with country fixed-effects). Furthermore, our sample period covers partly the years following the global financial crisis, whereby governments of all stripes embarked in bailouts and recapitalizations. We further note that the level of *Investment* and the index on *Foreign restrictions* are both positively related to government shareholding, but the coefficient estimates are not statistically significant.

In Table 6 we present four different second-stage model estimates, corresponding to the four different first-stage models. In all cases, the instrumented variable SOE is associated with a positive and statistically significant coefficient. Compared to our base models presented in Table 3, we observe larger estimates of the magnitude of the impact of government shareholding on investment in R&D. Coefficient estimates indicate that SOE investment in innovation is between 100% and 120% larger than for comparable private-sector firms.

3.1.4 Government ownership versus institutional ownership

In additional, untabulated, robustness tests, we control for institutional ownership.[21] Due to data limitations, we lose a significant portion of our sample, as we discard firms with incomplete ownership information. Even in this reduced sample, our core findings persist. In a base specification, we find that the coefficient associated with SOE is 0.333 and statistically significant at the 1% level. In an additional specification, we find, once more, that the findings are driven by minority government stakes (investing 35.7% more in R&D than private-sector firms), while government-controlled firms invest in R&D just as much as private-sector firms (the coefficient is negative, equal to -0.085, but not statistically significant at conventional levels). This test suggests that government ownership acts in a manner that is distinct from that of other institutional shareholders.

3.1.5 Government ownership and R&D expenditures, financing channel

We note that, if the presence of a government shareholder acts by relaxing financial constraints, the impact should be stronger on firms that are facing high financial constraints *a priori*. Our setup mirrors Borisova et al. (2015), which documents that SOEs pay lower interest rates on loans than private

[21] We compute "institutional shares" as the sum of the voting stakes held by institutions identified in Orbis as either "Mutual and pension fund, nominee, trust, trustee," "Bank," "Insurance company," "Financial company," "Venture capital," "Private equity firm," "Foundation, research institute," or "Hedge fund."

firms with similar HP indices. We aim at using a more granular identifier of constraints than the binary variable so included thus far. We accordingly identify firms as either "not financially constrained" (NFC, with HP index smaller than -2.25), "partially financially constrained" (PFC, with HP index between -2.25 and -1.75), or "financially constrained" (FC, with HP index greater than -1.75). The cutoff points are drawn from Hadlock and Pierce (2010). We add binary variables identifying those groups (we leave out NFC firms) and their interactions with *SOE* to our base model. If the presence of a government shareholder reacts mainly via the relaxation of financial constraints, we expect the coefficient estimates associated with these interactions to be positive. The results, presented in Table 7, are consistent with our expectations. The coefficient associated with SOE is positive, but not statistically significant. We find no difference in the level of investment of NFC and PFC firms, but financially constrained firms invest significantly less in R&D, by approximately 42%. Consistent with our priors, the effect of financial constraints is greatly mitigated for SOEs—the interaction effect estimate reveals that SOEs that are identified as *a priori* financially constrained invest 31.4% more in R&D than private sector firms in the same portion of the HP index distribution. Importantly, it appears that our findings are specific to financially constrained firms—the presence of a government shareholder does not seem to increase investment in R&D for partially constrained or non-constrained firms.

In a second specification, we distinguished between minority and controlling government stakes in a similar setup. Estimates, presented in column (2), indicate that it is minority government stakes that are driving the results—minority government stakes in financially constrained firms lead to higher levels of R&D investment, but majority government stakes do not (the coefficient is positive, but not statistically significant).

As a further test of government ownership's ability to relax funding constraints, we rely on the insight that private banks are particularly reluctant to fund innovation, due to short-term pressures from shareholders. Accordingly, we add a variable to our model, measuring the proportion of deposits that are in the hands of private (rather than state-owned) banks—a proxy for the role of private banks in the economy. Results are presented in column (3). We find that, as predicted, a higher share of private banks leads to lower investment in R&D. Yet, when we interact this variable with *SOE*, we find that government ownership mitigates such effects. In the last specification, in column (4), we provide evidence that this effect is, once more, driven by minority government stakes. Our findings strongly suggest that government ownership reduces firm financial constraints by providing implicit debt guarantees that mitigate the private sector's reluctance to lend to fund long-term, risky investments, such as R&D.

We further hypothesize that, if government ownership relaxes financial constraints, this effect should be particularly valuable during a financial crisis. Accordingly, we interact the dummy variable identifying SOEs (and, in alternative specifications, dummy variables identifying minority and majority government stakes) with the dummy variable identifying financial crises from Laeven and Valencia (2013). While we find, as expected, that firms curtail R&D investment during crises, we do not find any evidence that government ownership mitigates this effect as we hypothesized (results are not tabulated, for brevity). We hypothesize that this might be due to the fact that SOEs rely more on bank financing (and, even more, on financing from state-owned banks) than private-sector firms, which makes them more vulnerable to a financial crisis than firms who rely more on public markets, which negates the benefits of government ownership. In our next series of tests, we provide evidence consistent with a greater reliance on bank financing for R&D at SOEs, compared to private-sector firms.

3.1.6 Government ownership and R&D expenditures, bank financing

In this section, we question whether government ownership provides implicit debt guarantees which facilitate access to funding from private-sector banks and whether it facilitates access to loans from state-owned banks to fund innovation. To test these hypotheses, we make use of a granular dataset on syndicated loans, based on the Thomson Reuters Dealscan database, and described in detail in Fotak and Lee (2019). Thanks to this dataset, we are able to identify both aggregated syndicated loans and syndicated loans that include, in the funding syndicate, state-owned banks—we call those, for brevity, "government loans." We create variables, at the firm-year level, measuring the total amount of funding linked to aggregate syndicated loans and to government loans, scaled by total firm debt (as of December 31st of the previous year). We add these variables and their interactions with *SOE* to our baseline regressions. The regression sample, with complete loan-level data, is a subset of the regression sample we used in previous tables, with 18,373 observations.[22] We find, in results presented in Table 8, that the total

[22] The sample of government-controlled firms with complete loan-level data is too small for reliable inference, so we present findings only for the aggregate SOE group. Given their dominance in the sample, the documented results should be interpreted as specific to minority government-owned SOEs.

amount of syndicated lending is negatively related to R&D expenditures for all firms, both private and SOEs, but no differential impact for SOEs versus private-sector firms. This appears to reflect a general reluctance by private banks to finance R&D, confirming the results presented in Table 7. Yet, in a second specification, where we isolate government loans, we find that syndicated loans with government funding are linked to lower R&D investment in private-sector firms, but higher investment in R&D for SOEs. Our findings indicate that a government loan equal to 1% of total firm debt leads to a 2.6% increase in R&D investment. While we don't investigate why state-owned banks appear to not fund R&D investment in private-sector firms (we hypothesize that at least a portion of those loans are linked to bailouts and rescue efforts), we note that this is direct evidence of state-owned banks providing funding to SOEs for R&D investment.

In additional robustness tests, presented in columns 3 and 4 of Table 8, we confirm that those main findings persist when isolating non-government loans and when including variables identifying government and non-government loans in the same model. Finally, in the last column of Table 8, we do not scale loans by firm total debt, to ensure that the findings are not affected by the way we define the variable. Even when measuring government loans in terms of absolute dollar value, we find that loans linked to state-owned banks increase R&D investment for SOEs, but not for private-sector firms.

3.1.7 Government ownership and R&D expenditures, the majority-owned SOE puzzle

The baseline findings presented in the previous tables present a puzzling result, namely that minority government-owned SOEs invest more in R&D than private-sector firms, but that majority government-owned SOEs do not. Our subsequent analysis indicates that higher investments in R&D are associated with SOEs' ability to access preferential funding both from private-sector banks—generally reluctant to invest in such risky and long-term projects—and from state-owned banks. Yet, this preferential funding, due to both implicit debt guarantees and subsidized funding channels, should affect firms that are majority government-owned as well—if anything, to a greater extent. We conjecture that the preferential access to finance must be counter-balanced by some other effect connected to majority (but not minority) government ownership. We hypothesize that one possibility is that government control leads to the imposition of short-term social and political goals (Kahan and Rock, 2010; Shleifer, 1998), such as the support of high levels of employment that divert firm resources away from investments with a long-term payoff, such as R&D. This "myopic government" channel also implies a lower level of investment in R&D. Alternatively, we note that extant literature emphasizes the lack of incentives for SOE managers, which could lead to under-exertion of effort and excessive risk-aversion.[23] This "quiet life" channel would imply a lower level of effort in general, and lower levels of investment in risky activities such as R&D. We set to test these hypotheses in this section of the manuscript.

First, to test the idea that political priorities distort the allocation of funds, we note that such distortions are particularly likely prior to elections, as politicians pressure firms to invest in visible and employment-maximizing projects, thus potentially diverting from investment in R&D (Alok and Ayyagari, 2015). We accordingly obtain data on national elections, to identify the timing of scheduled elections. Our prior is that, if political pressure diverts resources towards employment maximization prior to elections, we should observe a drop in R&D expenditure at SOE prior to scheduled elections. We further hypothesize this impact would be particularly strong at government-controlled SOEs, as large stakes allow the government to impose political goals on firms despite resistance from minority shareholders.

We construct a binary variable identifying the years preceding national elections and label it *Pre election*. Most European countries are on four-year election cycles, so the variable is usually set equal to one every four years. Yet, we note that election cycles are often disrupted by snap elections, generally triggered by a vote of no confidence in a ruling government or by the dissolution of a ruling coalition. In less common cases, we observe countries switching to new election cycles. We focus on scheduled elections, noting that unscheduled elections will not allow politicians to distort capital allocations at firms in advance (our approach mirrors a long-established literature; examples include Cole, 2009 and Ru, 2018). We replicate prior regression analysis, with the addition of this variable identifying years preceding elections and its interaction with *SOE*. We present the results in the first column of Table 9. We note that the coefficient associated with *Pre election* is negative, suggesting a 6.7% drop in investment in R&D prior to elections for all firms, but not statistically significant. The negative coefficient indicating a drop in investment among private-sector firms is consistent with a large literature finding a decline in

[23] Boubakri, Cosset, and Saffar (2013) examine the role of state ownership in corporate risk-taking, using evidence from privatizations. They find strong and robust evidence that state ownership is negatively related to corporate risk-taking.

corporate investment due to election-induced uncertainty (for example, Julio and Yook, 2012). Our interest lies in documenting whether SOEs curtail investment in R&D more than private-sector firms, prior to an election. The interaction with *Pre election* × *SOE* is also negative, indicating a further drop in investment in R&D by 10.2%, but not statistically significant. In a second specification, we add a metric for the size of the stake owned by the government and its interact with the binary variable identifying years preceding elections. We find, once more, a coefficient suggesting that all firms invest less in R&D prior to elections (by 6.5%, but not statistically significant), while the interaction coefficient indicates that this effect is even stronger for SOEs, indicating a further drop in R&D investment by 14.8%, statistically significant at the 5% level. In other words, while SOEs invest 54% more in R&D than private-sector firms during non-election years, they invest only 40% more in years leading to elections. Yet, the interaction *Pre election*× *Gov Stake* is not significant. In a third specification, we add a binary variable identifying controlling government stakes. Our findings, presented in column 3 of Table 9, have the predicted coefficients but lack statistical significance. The coefficients suggest that investment in R&D drops prior to elections, that the effect is stronger for SOEs than for private sector firms and even stronger for SOEs with a controlling government stake. We hypothesize that the lack of significance is due to the fact that our test is pooling minority and majority government ownership under the *SOE* binary variable. Accordingly, in the last specification, we distinguish minority and majority government ownership with distinct variables (respectively, *Minority* and *Control*). This test leads to statistically significant coefficient estimates. Minority government-owned firms invest more in R&D (by 48.2%), while government-controlled firms invest less in R&D than private-sector counterparties during years leading to elections (by 42%). We find some evidence supporting that minority government-owned SOEs invest less in R&D prior to elections than otherwise (coefficient estimates are negative, indicating a 9.9% drop in investment, but not statistically significant), but, more importantly, we do not find any evidence of lower investment by government-controlled firms during non-election years. In other words, the reluctance of government-controlled firms to invest in innovation appears fully explained by the election schedule.

In unreported tests, we use unscheduled elections as a counterfactual test. Given that those elections are unexpected, politicians should not be able to curtail investment in R&D at SOEs to favor employment maximization or other vote-generating expenditures. In untabulated findings, we find no evidence of lower R&D expenditures in majority-controlled firms in the years preceding unscheduled elections, consistent with the above.

We further investigate whether majority government-owned SOEs' reluctance to invest in innovation is due to the imposition of political goals, versus a lack of incentives associated with government control. We construct a new test, based on two country-level variables measuring, respectively, whether high-level SOE managers are appointed by politicians (*Political mgr*) and whether high-level SOE managers can be compensated with performance-related incentives (*Performance pay*). We add those variables, and relevant interactions, to the base regression models. We present the results in Table 10. While we do not discuss each result in detail for the sake of brevity, we note that government ownership (and, in particular, minority government stakes) is associated with higher investment in R&D. However, the effect is mitigated by high-level SOE managers being appointed by politicians (SOEs with politically appointed managers still invest more in R&D than private sector firms, but not as much as SOEs without politically appointed managers). In contrast, performance pay of SOE managers is not associated with R&D investment, suggesting that the lower investment in R&D is not due to a lack of incentives, as much as to the imposition of political goals and priorities.

3.2 Government ownership and the number of patents

The previous analysis focuses on the inputs of the innovation process, that is, expenditure on R&D. Yet, we have reason to suspect that government ownership and control affect the efficiency of the process. A vast literature finds that government ownership is generally associated with a less efficient firm, due to a lack of monitoring and incentives associated with government owners (Borisova et al., 2012), conflicting goals and priorities (Kahan and Rock, 2010; Shleifer, 1998), and outright rent extraction (Jiang, Lee, and Yue, 2010; Cheung, Rau, Stouraitis, 2010).

As a metric for innovation output, we use the count of the number of patents produced by a firm to measure how efficient the firm is in producing innovation. In the results presented in Table 11, we focus on a two-year timeframe; in unreported analysis, we test various time horizons, reaching similar conclusions. In more detail, we capture government ownership and firm characteristics at time *t* and investigate patent production in year *t*+2. As a response variable, we use the natural log of the number of patents, to minimize skewness. We utilize regression models with the same list of controls used when modeling investment in innovation in Table 3 and subsequent tables. We add an additional control variable (*Pseudo blank*): a binary variable identifying firm-years during which a firm has a non-zero number of patents applied for (and eventually granted) but fails to report R&D expenditures, as suggested by Koh and Reeb (2015). As before, we control for year, country, and industry fixed effects and we cluster standard errors at the country level.

The findings, presented in column 1 of Table 11 indicate that SOEs do not produce any more patents than their private-sector counterparts. Coefficient estimates are positive, but not statistically significant. In a second specification, presented in the second column of Table 11, we identify separately minority and majority government stakes, but with the same findings—while coefficient estimates are positive for both groups, the results are not statistically significant.

Yet, the previous analysis indicated that firms with government stakes (minority stakes, in particular) invest significantly more in R&D than private-sector firms. A higher level of investment, coupled with the same number of patents on the output side, suggest lower efficiency in producing innovation by government-owned firms. We test this conjecture by adding controls for the level of R&D investment (the natural logarithm of the R&D expenditure, in USD thousands) and by interacting this variable with the metrics of government ownership and control. We find that, after controlling for R&D expenditures, the coefficients associated with SOE and government minority shareholding (in the third and fourth column of Table 11) are negative and statistically significant (albeit only at the 10% level). The results presented in the last column of Table 11 reveal that the effect is driven by firms with minority government ownership (which are the ones investing more in R&D). Yet, the effect does not appear to scale with the level of R&D investment (the interaction coefficients are not statistically significant). Overall, our findings reveal profound differences from the findings by Cao, Cumming, and Zhou (2018), who document that government ownership increases R&D efficiency in Chinese state-owned enterprises. Yet, lower efficiency by SOEs is highly consistent with Munari (2002), who finds anecdotal evidence of an increase in efficiency (measured by the number of patents divided by the number of researchers employed) following the privatization of seven Italian and French SOEs. We conjecture that institutional differences between the Chinese market and European might account for these discrepancies; Cao, Cumming, and Zhou (2018), outline in detail the unique institutional characteristics of the Chinese market, in which SOEs have greater access to not just capital, but also talent, than private-sector firms. Our findings complement the large literature on institutional ownership and innovation by revealing that government ownership has a distinct, and opposite, impact than other institutional blockholders.

3.3 Government ownership and patent quality

The findings so far relate to the quantity of innovation (as proxied by the number of patents) that the firm produces. Yet, government ownership might affect not just the quantity of innovation, but also it's quality. Inefficiencies could translate into not only fewer patents, but into patents of lower overall quality. In addition, a greater orientation towards innovation with social and political spillover could lead to patents with lower commercial value. We investigate both issues in the following sections.

3.3.1 Government ownership and patent citations

To investigate the impact of government ownership on patent quality, we first focus on the number of citations and the number of citations per patent, which has often been employed as a standard metric of patent quality in the extant literature. Our setup and list of control variables mirror what we have first employed in Table 3. Coefficient estimates, presented in the first two columns of Table 12, indicate that SOEs are associated with a higher number of citations and a higher number of citations per patents, but the estimated coefficients are not statistically significant. In the third and fourth column of Table 12, we replicate the analysis, but we control for R&D investment. Once more, we find that the number of citations and citations per patent by SOEs are not significantly different from those produced by private-sector firms. In columns five through eight, we replicate the same type of analysis, but we now distinguish between minority government ownership and controlling government stakes. Results in column (6) reveal that government-controlled SOEs are actually associated with a greater number of cites per patent (but the result is only statistically significant at the 10% level). Results in column (7) and (8) reveal that, per dollar invested in R&D, government-controlled SOEs produce more citations and a higher number of cites per patent.

Overall, our findings indicate that minority government-owned firms invest more in R&D but produce the same number of patents, of similar quality to private-sector firms. In contrast, majority government-owned firms invest just as much as private sector firms, produce the same amount of patents, but there is some evidence, albeit not robust, that those patents are of higher quality. We hypothesize that majority government-owned firms might focus investment on "basic-science"—technologies that are not market-ready but might have greater social spillover. Such "basic-science" technologies might generate more citations, but, due to their "basic" nature, have lower commercial value. To investigate this in greater detail, in the next section we estimate the commercial value of patents produced by these firms.

3.3.2 The commercial value of patents—event studies

Kogan et al. (2017) find that the announcement of new patents leads, on average, to a positive market reaction, in the form of abnormal short-term returns on the stock prices of publicly traded firms. This market reaction is a measure of increased firm value attributed to the commercial value of the innovation being patented and, accordingly, interpret the abnormal market reaction as a measure of the commercial value of the invention. If SOEs produce patents with lower commercial value (and potentially higher social spillover or political benefits), we should observe a weaker market reaction.

To investigate the market reaction at loan initiation, we rely on event-study methodology. The main proxy for the impact of a new patent on firm value is the abnormal return at the time of the announcement of the patent approval. To estimate the abnormal market reaction at the announcement, we obtain daily total return indices, adjusted for dividends and splits, in USD, for the primary common equity issue for each firm in our sample. We also obtain local market indices, similarly adjusted for dividends and splits and denominated in USD. All data is from Thomson Reuter's Datastream database. Cumulative abnormal returns (CARs) are computed by subtracting the total market return from the patenting firm's stock total return on the day on which the loan initiation is announced (day 0). To account for possible news leakage and for after-market-close release of news, we also consider a two-day (days 0 and +1) and a three-day event window (days -1, 0, and +1). We are able to compute three-day abnormal returns for 4,820 patent announcements by minority SOEs. Observations are excluded from the analysis if return data is missing during the event window, or if another patent is announced with an overlapping event window. Results for minority government-owned SOEs are presented in Table 13, Panel A. We find a mean abnormal return of 0.04% over the three-day event window and a median abnormal return of -0.09%. Mean and median abnormal returns on the day of the patent announcement are, respectively, -0.04% and -0.05%. We test the statistical significance of mean abnormal returns using the standard Patell's z (Patell, 1976) test and employ a generalized sign test for medians. All tests are statistically insignificant (except for the one-day window median, which is negative and statistically significant at the 10% level). We find similar results for the sample of government-controlled SOEs, presented in Panel B (estimates are mostly tiny, negative, and not statistically significant). Overall, our estimates indicate that the mean, or median, patent produced by an SOE has no discernible commercial value. When applying the same methodology to the sample of private-sector patent announcements (results are presented in Panel C), we find very different results. In a sample of 10,540 patent announcements, we find a mean abnormal return of 0.11% over the three-day event window and a median abnormal return of 0.01%. Both parametric and non-parametric test statistics indicate high levels of statistical significance. Over the shorter two-day window, estimates are smaller but still statistically significant. The event-day estimates are also positive, but not statistically significant.

We multiply the abnormal return by the market capitalization of the firm to estimate the value of a patent in USD terms, focusing on the two-day event window, as in (Kogan et al., 2017). In untabulated results, the SOE sample suggests a point estimate of the mean patent value of USD 7.95 million, but the result is not statistically significant. In contrast, for the private-sector sample, we find a much larger and statistically significant mean estimate of USD 23.37 million.

We note that these lower estimates of commercial value for SOE patents could be due to either a fundamental difference in the quality of innovation or from a focus by SOEs on patents with fundamentally different characteristics—"basic science" with lower commercial value but greater societal benefits. In an attempt to provide insights into this distinction, we focus on a sample of high-citation patents—identified, as in Kogan et al. (2017), by focusing on a subset of patents with a number of citations in the upper decile of the distribution (in our sample, patents with twelve or more citations). When focusing on highly cited SOE patents (panels D and E for minority and majority government-ownership, respectively), we find larger estimates of market reaction, but still not statistically significant. The mean market reaction at announcement by government-controlled SOE is particularly large (at 0.39% for the three-day event windows), but the positive mean is associated with a negative median and the sample size (36 observations) is too small to draw much inference. In contrast, in the private-sector sample, we estimate the three-day market reaction at 0.19%, with a high degree of statistical significance. Overall, our tests reveal that even highly cited SOE patents have a lower commercial value than comparable private-sector patents. This is consistent with anecdotal evidence cited by Munari (2002): following its 1989 privatization, the Italian group ENEL revealed that it would refocus its research towards the field of electricity generation (which it labeled "competitive research") and away from research regarding the environment and the efficient use of electricity ("system research").

3.3.3 The commercial value of patents—basic research and green technologies

Given that governments have different goals than private-sector shareholders, government ownership could affect not only R&D investment and the quantity and quality of innovation but also the type of innovation produced by the firm. In particular, new technologies can provide benefits to society at a large, which cannot be fully captured by the commercial value of the patent. Such innovation is likely to be underfunded by the private sector. Governments, on the other hand, are in a position to prioritize patents with such high social value. We leverage a novel feature of the European patent data to identify a set of "sustainable patents," patents identified through the Cooperative Patent Classification system by the European Patent Office. These are patents related to technologies aimed at climate change mitigation and clean energy technology.[24] Our prior is that SOEs, given their greater concern for patents with social value, are more likely to pursue innovation aimed at such sustainable patents.

To test our hypothesis, we re-estimate the models in Table 11, but with a different response variable: we replace the total number of patents with a subset, the number of sustainable patents, at the firm-year level. We find, in results presented in column (1) of Table 14, that government ownership (both minority and controlling shares) is associated with positive coefficients, indicating a greater propensity to produce sustainable patents, but the estimated coefficients are not statistically significant. We conjecture that our tests suffer from weak power, due to the large number of firms in our sample that do not produce innovation at all. To test this conjecture, we replicate the analysis using a data subset including only firm-years with non-missing R&D investments. In this reduced-sample test, we find that minority government stakes are still associated with a positive, albeit insignificant, coefficient estimates, reported in column (2). But controlling stakes are now associated with a large positive coefficient, statistically significant at

[24] Each sub-group was devised in coordination with field experts using the United Nations Framework Convention on Climate Change and Intergovernmental Panel on Climate Change. For more information, please refer to Table B3 in the Appendix. The sub-group classification by the EPO is available at: hiips://www.epo.org/news-issues/issues/classification/classification.html

the 10% level, suggesting that the number of sustainable patents produced in a year is approximately 35% greater for government-controlled SOEs than for private-sector firms.

We further investigate whether the proportion of sustainable patents (out of the total number of patents produced at the firm-year level) is greater for SOEs. In a similar specification, results presented in column (3) of Table 14 indicate that the proportion of sustainable patents is approximately 7.4% higher for government-controlled SOEs than for private-sector firms. In a series of additional tests, we investigate whether the count of sustainable patents depends on the specific industry in which SOEs operate. We do not report all industry-level regressions. However, we note estimates for the manufacturing industry (accounting for approximately a third of our SOE firm-years) in column (4), where we report an economically and statistically significant effect. Government-controlled SOEs in the manufacturing sector produce twice as many sustainable patents as private-sector firms. In contrast, in results that aggregate all other sectors, presented in column (5), we find no statistically significant results.

The results presented in this section reveal that not all SOEs display a bias towards sustainable innovation. Our findings of a greater propensity to produce sustainable patents are specific to government-controlled SOEs in the manufacturing sector and R&D intensive firms. Overall, these findings buttress our previous results, offering further evidence that government control, rather than mere minority shareholding, leads to a different set of priorities.

4. Conclusions

We study the impact of state minority and majority ownership on the innovativeness of publicly traded European firms. The analysis of investment in research and development reveals important insights into the impact of state ownership on inputs in the innovation process and points to a nuanced picture. A minority government stake increases R&D expenditures for otherwise financially constrained firms. We find robust results in a series of tests aimed at mitigating selection and omitted variable biases. Using loan-level data, we find evidence suggesting that state ownership impacts investment in R&D by providing privileged access to both private-sector and state-owned banks. Yet, our evidence suggests that research and development expenditures for government majority-owned firms are similar to their private counterparts. Consistent with the "political objectives" hypothesis, we find that government majority-owned firms reduce R&D spending around elections, suggesting that government control has myopic consequences, by diverting resources away from long-term investment in innovation. We also provide evidence that the ability to appoint high-level managers by politicians is associated with lower levels of investment in R&D. Taken together, these tests suggest the increase in R&D spending generated by access to capital may be offset by additional frictions borne by government majority-owned firms.

On the output side, we find that SOEs, despite investing more in R&D, do not produce more patents, suggesting lower efficiency in the innovation process. For minority state-owned SOEs, we find no evidence of a difference in patent quality, but we do find evidence of lower patent commercial value. We find that the average private-sector patent has a commercial value of approximately USD 23.4 million, while our estimates for SOE patents are much lower, at USD 7.96 million, and not statistically significant. For majority government-owned SOEs, we find a greater focus on basic science and for innovation with greater social spillover, but lower commercial value.

Our data covers publicly traded firms in European countries. Accordingly, one limitation lies in the exclusion of non-listed firms with partial government ownership and of firms that are fully government-owned. While it is possible that the impact of full government ownership differs, qualitative and quantitatively, from that of partial ownership, data limitations do not allow us to test such effects directly. Additionally, Orbis ownership data is biased towards large firms (Kalemi-Ozcan et al, 2015) and our results should be interpreted accordingly. Finally, our dataset is limited to European firms, thus leaving open the question of whether the results would extend to regimes with substantially different financial systems, legal institutions, and cultural norms. A comparison with findings from extant literature focused on Chinese SOEs suggests that institutional characteristics might affect the link between state ownership and innovation.

We should also note that our manuscript identifies only one channel by which governments can impact innovation—direct ownership of firms. Yet, governments can promote innovativeness via subsidized lending, via grants, by financing research via educational institutions or think tanks, and by enhancing the protection of intellectual property rights, amongst other channels. While we do control for government subsidies and investments at the country-year level, we do not have detailed firm-level data and do not directly investigate their nature and effectiveness in a formal manner.

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Table 1: Summary Statistics

This table provides summary statistics for European publicly listed firms with government stakes (*SOEs*) versus firms without government stakes (*non-SOEs*), over the years 2000-2009. Panel A tabulates the number and proportion of firms (SOEs and non-SOEs) by industrial sector (one-digit SIC code). Panel B tabulates the number and proportion of firms by the country of headquarter location. Panel C provides the number of firm-year observations, the mean, standard deviation, and quantile distributions for the variables in the sample.

Panel A – Firms by industry

	Non-SOE		SOE	
	Number	Proportion	Number	Proportion
Mining and Construction	324	9.59%	136	9.39%
Manufacturing	1139	38.79%	525	45.78%
Transportation & Public Utilities	284	9.53%	211	13.50%
Retail Trade	286	10.56%	129	9.46%
Services	908	29.60%	292	20.69%
Public Administration and Non-Classified	8	0.34%	4	0.37%
	2949	100.00%	1297	100.00%

Panel B – Firms by country

Country	Number	Proportion	Country	Number	Proportion
AT - Austria	48	1.13%	IE - Ireland	88	2.07%
BE - Belgium	91	2.14%	IT - Italy	212	4.99%
CY - Cyprus	8	0.19%	LT - Lithuania	4	0.09%
CZ - Czech Republic	23	0.54%	LU - Luxemburg	32	0.75%
DE - Germany	488	11.49%	NL - Netherlands	133	3.13%
DK - Denmark	83	1.95%	PL - Poland	120	2.83%
EE - Estonia	6	0.14%	PT - Portugal	31	0.73%
ES - Spain	117	2.76%	RO - Romania	1	0.02%
FI - Finland	118	2.78%	SE - Sweden	136	3.20%
FR - France	520	12.25%	SI - Slovenia	15	0.35%
GB - United Kingdom	1,869	44.02%	SK - Slovakia	5	0.12%
GR - Greece	73	1.72%			
HU - Hungry	25	0.59%			

Table 1: Summary Statistics - Continued

Panel C

Variable	Number	Mean	Standard deviation	p25	p50	p75
lnR&D $_{i,t}$	23,893	3.008	4.403	0	0	7.427
R&D ($M) $_{i,t}$	23,893	20.59	89.05	0	0	1.680
Count $_{i,t}$	23,893	8.052	92.66	0	0	0
Citations $_{i,t}$	23,893	251.4	3373	0	0	0
SusCount $_{i,t}$	23,893	0.260	3.594	0	0	0
SusFrac $_{i,t}$	23,893	0.009	0.073	0	0	0
CitePer $_{i,t}$	23,893	8.768	68.51	0	0	0
SOE $_{i,t}$	23,893	0.117	0.321	0	0	0
Stake $_{i,t}$ (%)	23,893	0.968	6.284	0	0	0
Control $_{i,t}$	23,893	0.006	0.078	0	0	0
Minority $_{i,t}$	23,893	0.111	0.314	0	0	0
HP index $_{i,t}$	23,893	-1.857	0.551	-2.274	-1.676	-1.542
Total assets ($B) $_{i,t}$	23,893	2.387	7.405	0.042	0.175	0.901
ROA $_{i,t}$ (%)	23,893	-1.285	22.50	-1.550	4.270	8.380
PPE/TA $_{i,t}$	23,893	0.260	0.232	0.067	0.194	0.389
Debt/TA $_{i,t}$	23,893	0.211	0.195	0.037	0.177	0.326
CAPEX/TA $_{i,t}$	23,893	0.053	0.059	0.016	0.035	0.068
GDP growth $_{j,t}$	23,893	0.058	0.104	-0.011	0.068	0.146
BERD $_{j,t}$	23,893	0.084	0.031	0.069	0.080	0.099
Profit tax subsidy $_{j,t}$	23,893	0.080	0.106	-0.010	0.100	0.100
Loss tax subsidy $_{j,t}$	23,893	0.061	0.090	-0.010	0.070	0.080
Blank R&D $_{i,t}$	23,893	0.632	0.482	0	1	1
Crisis $_{j,t}$	23,893	0.244	0.429	0	0	0
Pseudo blank $_{i,t}$	23,893	0.032	0.176	0	0	0
Private deposits $_{j,t}$	23,893	9.043	1.792	8	10	10
Bank loan $_{i,t}$ / Debt$_{t-1}$	18,373	0.018	1.539	0	0	0
Gov loan $_{i,t}$ / Debt $_{t-1}$	18,373	0.014	1.526	0	0	0
Non-gov loan $_{i,t}$ / Debt $_{t-1}$	18,373	0.005	0.140	0	0	0
Political mgr $_{j}$	23,893	0.559	0.496	0	1	1
Performance pay $_{j}$	23,893	0.613	0.487	0	1	1
Left wing $_{j,t}$	23,893	0.662	0.473	0	1	1
Investment $_{j,t}$	23,893	20.26	3.233	18.00	19.21	22.19
Foreign restrictions $_{j,t}$	23,893	8.159	1.044	7.636	8.214	8.833

Table 2: Summary Statistics – SOE vs. private-sector firms

This table provides summary statistics for European publicly listed firms with government stakes (*SOEs*) versus without government stakes (*non-SOEs*), over the years 2000-2009. Variables are defined in appendix Table A1. The table presents the number of observations and means for two data subsets, the difference in means (between *SOEs* and *non-SOEs*) and the results of two-sided two-sample *t*-test for differences in means. ***, **, and * represent 1%, 5%, and 10% statistical significance levels respectively.

	SOE		Non-SOEs			
Variable	N	Mean	N	Mean	Difference	*t*
lnR&D $_{i,t}$	2,796	4.422	21,097	2.821	1.602***	18.20
R&D ($M) $_{i,t}$	2,796	51.88	21,097	16.45	35.43***	19.93
Count $_{i,t}$	2,796	16.08	21,097	7.058	9.019***	4.786
Citations $_{i,t}$	2,796	463.3	21,097	223.3	240.0***	3.537
SusCount $_{i,t}$	2,796	0.746	21,097	0.196	0.550***	7.607
SusFrac $_{i,t}$	2,796	0.021	21,097	0.007	0.014***	9.356
CitePer $_{i,t}$	2,796	10.66	21,097	8.517	2.147	1.557
HP index $_{i,t}$	2,796	-1.857	21,097	-1.616	-0.2411***	-17.21
Total assets ($B) $_{i,t}$	2,796	6.054	21,097	1.901	4.153***	28.33
ROA (%) $_{i,t}$	2,796	2.694	21,097	-1.813	4.507***	9.975
PPE/TA $_{i,t}$	2,796	0.279	21,097	0.257	0.022***	4.602
Debt/TA $_{i,t}$	2,796	0.216	21,097	0.210	0.006	1.506
CAPEX/TA $_{i,t}$	2,796	0.052	21,097	0.053	-0.001	-1.091
GDP growth $_{j,t}$	2,796	0.010	21,097	0.065	-0.055***	-26.39
BERD $_{j,t}$	2,796	0.079	21,097	0.085	-0.005***	-8.665
Profit tax subsidy $_{j,t}$	2,796	0.079	21,097	0.080	-0.000	-0.144
Loss tax subsidy $_{j,t}$	2,796	0.065	21,097	0.060	0.005***	2.830
Blank R&D $_{i,t}$	2,796	0.525	21,097	0.646	-0.120***	-12.43
Crisis $_{j,t}$	2,796	0.589	21,097	0.198	0.391***	47.27
Pseudo blank $_{i,t}$	2,796	0.032	21,097	0.032	-0.000	-0.086
Private deposits $_{j,t}$	2,796	8.964	21,099	9.053	-0.090**	-2.49
Bank loan $_{i,t}$ / Debt$_{t-1}$	2,496	0.014	15,877	0.019	-0.005	-0.165
Gov loan $_{i,t}$ / Debt $_{t-1}$	2,496	0.001	15,877	0.016	-0.149	-0.454
Non-gov loan $_{i,t}$ / Debt $_{t-1}$	2,496	0.013	15,877	0.003	0.009***	3.130
Political mgr $_{j}$	2,796	0.405	21,097	0.580	-0.174***	-17.56
Performance pay $_{j}$	2,796	0.581	21,097	0.617	-0.037***	-3.735
Left wing $_{j,t}$	2,796	0.444	21,097	0.690	-0.246***	-26.21
Investment $_{j,t}$	2,796	20.14	21,097	20.28	-0.142**	-2.189
Foreign restrictions $_{j,t}$	2,796	7.574	21,097	8.236	-0.662***	-32.17

Table 3: R&D expenditures and State Ownership

This table presents the OLS regression results where the natural log of R&D expenditures in year *t+1* is regressed on metrics of government ownership, time-varying firm-level characteristics, country, industry, and year fixed effects (all as of year *t*), as described in Equation (2). The sample covers European publicly listed over the years 2000-2009. *SOE* is a binary variable identifying firm-years with government stakes greater than zero. *Stake* is a continuous variable denoting the percent ownership of the domestic government. *Minority* and *Control* identify government stakes, respectively, below and above 50% of voting rights. Complete variable definitions are in Appendix Table A1. Firm-level characteristics are winsorized at the 1% and 99%. Standard errors are clustered by country unless otherwise noted. Two-sided *t*-statistics are reported in parenthesis. ***, **, and * represent 1%, 5%, and 10% statistical significance levels respectively.

Variables	(1) $lnR\&D_{t+1}$	(2) $lnR\&D_{t+1}$	(3) $lnR\&D_{t+1}$	(4) $lnR\&D_{t+1}$	(5) $lnR\&D_{t+1}$	(6) $lnR\&D_{t+1}$
$SOE_{i,t}$	0.403***	0.471***	0.432***			
	(5.08)	(8.15)	(6.23)			
$Minority_{i,t}$				0.432***	0.432***	0.432***
				(6.23)	(7.64)	(5.79)
$Stake_{i,t}$		-0.008*				
		(-1.91)				
$Control_{i,t}$			-0.503*	-0.071	-0.071	-0.071
			(-1.74)	(-0.22)	(-0.50)	(-0.55)
$Constrained_{i,t}$	-0.603***	-0.601***	-0.602***	-0.602***	-0.602***	-0.602***
	(-9.96)	(-9.87)	(-9.89)	(-9.89)	(-19.84)	(-5.57)
Total assets $_{i,t}$	0.094***	0.094***	0.094***	0.094***	0.094***	0.094***
	(20.90)	(20.97)	(21.02)	(21.02)	(18.02)	(12.44)
$ROA_{i,t}$	0.003	0.003	0.003	0.003	0.003***	0.003**
	(1.49)	(1.48)	(1.48)	(1.48)	(4.13)	(2.41)
$PPE/TA_{i,t}$	-0.059	-0.045	-0.050	-0.050	-0.050	-0.050
	(-0.49)	(-0.35)	(-0.40)	(-0.40)	(-0.86)	(-0.44)
$Debt/TA_{i,t}$	-0.658***	-0.662***	-0.661***	-0.661***	-0.661***	-0.661***
	(-4.23)	(-4.24)	(-4.26)	(-4.26)	(-9.45)	(-5.30)
$CAPEX/TA_{i,t}$	-0.206	-0.234	-0.222	-0.222	-0.222	-0.222
	(-0.62)	(-0.72)	(-0.68)	(-0.68)	(-1.02)	(-0.67)
GDP growth $_{j,t}$	-0.300	-0.255	-0.275	-0.275	-0.275	-0.275
	(-0.72)	(-0.61)	(-0.65)	(-0.65)	(-0.46)	(-0.75)
$BERD_{j,t}$	0.926	1.072	1.000	1.000	1.000	1.000
	(1.00)	(1.19)	(1.11)	(1.11)	(0.93)	(0.51)
Profit tax subsidy $_{j,t}$	0.952*	1.003**	0.959*	0.959*	0.959	0.959
	(1.95)	(2.11)	(2.01)	(2.01)	(1.20)	(1.22)
Loss tax subsidy $_{j,t}$	-0.797**	-0.840***	-0.794**	-0.794**	-0.794	-0.794
	(-2.60)	(-2.84)	(-2.65)	(-2.65)	(-0.90)	(-0.95)
Blank R&D $_{i,t}$	-6.730***	-6.730***	-6.729***	-6.729***	-6.729***	-6.729***
	(-22.00)	(-21.98)	(-21.98)	(-21.98)	(-71.19)	(-46.93)
$Crisis_{j,t}$	-0.033	-0.026	-0.030	-0.030	-0.030	-0.030
	(-0.72)	(-0.54)	(-0.65)	(-0.65)	(-0.50)	(-0.57)
Constant	7.928***	7.951***	7.943***	7.943***	7.943***	7.943***
	(28.39)	(28.93)	(28.93)	(28.93)	(26.73)	(27.19)

Table 3: R&D expenditures and State Ownership - Continued

Variables	(1) $lnR\&D_{t+1}$	(2) $lnR\&D_{t+1}$	(3) $lnR\&D_{t+1}$	(4) $lnR\&D_{t+1}$	(5) $lnR\&D_{t+1}$	(6) $lnR\&D_{t+1}$
Observations	23,893	23,893	23,893	23,893	23,893	23,893
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
SE Clustering	Country	Country	Country	Country	Year	Industry
# Clusters	24	24	24	24	10	71
R-squared	0.758	0.759	0.759	0.759	0.759	0.759
Adjusted R-squared	0.757	0.757	0.757	0.757	0.757	0.757

Table 4: R&D Expenditures and State Ownership—Excluding "Missing R&D Expenditures"

This table presents the OLS regression results where the natural log of R&D expenditures in year *t+1* is regressed on metrics of government ownership, time-varying firm-level characteristics, country, industry, and year fixed effects (all as of year *t*). The sample covers European publicly listed over the years 2000-2009. We exclude firms that do not report R&D investment in year *t*. *SOE* is a binary variable identifying firm-years with government stakes greater than zero. *Stake* is a continuous variable denoting the percent ownership of the domestic government. *Minority* and *Control* identify government stakes, respectively, below and above 50% of voting rights. Complete variable definitions are in Appendix Table A1. Firm-level characteristics are winsorized at the 1% and 99%. Standard errors are clustered by country unless otherwise noted. Two-sided *t*-statistics are reported in parenthesis. ***, **, and * represent 1%, 5%, and 10% statistical significance levels respectively.

Variables	(1) $lnR\&D_{t+1}$	(2) $lnR\&D_{t+1}$	(3) $lnR\&D_{t+1}$	(4) $lnR\&D_{t+1}$
SOE $_{i,t}$	0.793***	0.855***	0.821***	
	(4.81)	(4.89)	(5.01)	
Minority $_{i,t}$				0.821***
				(5.01)
Stake $_{i,t}$		-0.008		
		(-0.98)		
Control $_{i,t}$			-0.706	0.115
			(-0.98)	(0.17)
Constrained $_{i,t}$	-1.488***	-1.486***	-1.487***	-1.487***
	(-13.12)	(-13.12)	(-13.13)	(-13.13)
Total assets $_{i,t}$	0.110***	0.110***	0.110***	0.110***
	(21.38)	(20.81)	(21.01)	(21.01)
ROA $_{i,t}$	0.006**	0.006**	0.006**	0.006**
	(2.25)	(2.24)	(2.24)	(2.24)
PPE/TA $_{i,t}$	0.239	0.259	0.259	0.259
	(0.57)	(0.60)	(0.60)	(0.60)
Debt/TA $_{i,t}$	-1.143**	-1.150**	-1.150**	-1.150**
	(-2.70)	(-2.73)	(-2.73)	(-2.73)
CAPEX/TA $_{i,t}$	-3.056***	-3.094***	-3.087***	-3.087***
	(-3.24)	(-3.35)	(-3.35)	(-3.35)
GDP growth $_{j,t}$	0.568	0.622	0.602	0.602
	(0.69)	(0.74)	(0.71)	(0.71)
BERD $_{j,t}$	2.042	2.250	2.124	2.124
	(0.68)	(0.74)	(0.70)	(0.70)
Profit tax subsidy $_{j,t}$	3.798***	3.828***	3.748***	3.748***
	(3.76)	(3.88)	(3.66)	(3.66)
Loss tax subsidy $_{j,t}$	-2.581***	-2.627***	-2.537***	-2.537***
	(-3.09)	(-3.30)	(-2.99)	(-2.99)
Crisis $_{j,t}$	-0.358**	-0.346**	-0.351**	-0.351**
	(-2.53)	(-2.38)	(-2.44)	(-2.44)
Constant	7.891***	7.909***	7.907***	7.907***
	(9.39)	(9.54)	(9.52)	(9.52)

Table 4: R&D Expenditures and State Ownership—Excluding "Missing R&D Expenditures" – Continued

Variables	(1) $\ln R\&D_{t+1}$	(2) $\ln R\&D_{t+1}$	(3) $\ln R\&D_{t+1}$	(4) $\ln R\&D_{t+1}$
Observations	8,802	8,802	8,802	8,802
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
SE Clustering	Country	Country	Country	Country
# Clusters	23	23	23	23
R-squared	0.372	0.373	0.373	0.373
Adjusted R-squared	0.365	0.365	0.365	0.365

Table 5: R&D Expenditures and State Ownership, Indirect Stakes

This table presents the OLS regression results where the natural log of R&D expenditures in year *t+1* is regressed on metrics of government ownership, time-varying firm-level characteristics, country, industry, and year fixed effects (all as of year *t*). The sample covers European publicly listed over the years 2000-2009. We identify indirect government stakes as stakes not directly owned by government entities (ministries, central banks, and other branches of the public sector), but rather stakes owned by institutions that are, in turn, majority-owned by the government entities listed above. *SOE (indirect)* is a binary variable identifying firm-years with indirect government stakes greater than zero. *Stake (indirect)* is a continuous variable denoting the percent indirect ownership of the domestic government. *Minority (indirect) and Control (indirect)* identify indirect government stakes, respectively, below and above 50% of voting rights. Complete variable definitions are in Appendix Table A1. Firm-level characteristics are winsorized at the 1% and 99%. Standard errors are clustered by country unless otherwise noted. Two-sided *t*-statistics are reported in parenthesis. ***, **, and * represent 1%, 5%, and 10% statistical significance levels respectively.

Variables	(1) $\ln R\&D_{t+1}$	(2) $\ln R\&D_{t+1}$	(3) $\ln R\&D_{t+1}$	(4) $\ln R\&D_{t+1}$
SOE (indirect) $_{i,t}$	0.418***	0.471***	0.430***	
	(7.11)	(8.24)	(7.62)	
Minority (indirect) $_{i,t}$				0.433***
				(7.66)
Stake (indirect) $_{i,t}$		-0.010***		
		(-2.94)		
Control (indirect) $_{i,t}$			-0.470**	-0.124
			(-2.40)	(-0.65)
Constrained $_{i,t}$	-0.602***	-0.600***	-0.602***	-0.602***
	(-9.94)	(-9.87)	(-9.89)	(-9.88)
Total assets $_{i,t}$	0.095***	0.094***	0.094***	0.094***
	(21.38)	(21.36)	(21.29)	(21.27)
ROA $_{i,t}$	0.003	0.003	0.003	0.003
	(1.49)	(1.48)	(1.48)	(1.49)
PPE/TA $_{i,t}$	-0.043	-0.036	-0.037	-0.038
	(-0.35)	(-0.28)	(-0.30)	(-0.30)
Debt/TA $_{i,t}$	-0.662***	-0.663***	-0.665***	-0.664***
	(-4.21)	(-4.24)	(-4.22)	(-4.22)
CAPEX/TA $_{i,t}$	-0.226	-0.241	-0.233	-0.234
	(-0.67)	(-0.73)	(-0.70)	(-0.70)
GDP growth $_{j,t}$	-0.273	-0.243	-0.265	-0.265
	(-0.66)	(-0.58)	(-0.63)	(-0.63)
BERD $_{j,t}$	0.996	1.112	1.039	1.041
	(1.11)	(1.24)	(1.15)	(1.16)
Profit tax subsidy $_{j,t}$	0.998**	1.019**	0.997**	0.998**
	(2.11)	(2.12)	(2.12)	(2.12)
Loss tax subsidy $_{j,t}$	-0.857***	-0.873***	-0.852***	-0.851***
	(-2.96)	(-2.99)	(-2.97)	(-2.97)
Blank R&D $_{i,t}$	-6.732***	-6.731***	-6.731***	-6.731***
	(-21.98)	(-21.99)	(-21.98)	(-21.98)

Table 5: R&D Expenditures and State Ownership, Indirect Stakes - Continued

Variables	(1) $lnR\&D_{t+1}$	(2) $lnR\&D_{t+1}$	(3) $lnR\&D_{t+1}$	(4) $lnR\&D_{t+1}$
Crisis $_{j,t}$	-0.031	-0.028	-0.029	-0.029
	(-0.67)	(-0.60)	(-0.63)	(-0.62)
Constant	7.913***	7.938***	7.922***	7.920***
	(28.75)	(28.94)	(28.81)	(28.86)
Observations	23,893	23,893	23,893	23,893
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
SE Clustering	Country	Country	Country	Country
# Clusters	24	24	24	24
R-squared	0.758	0.759	0.758	0.758
Adjusted R-squared	0.757	0.757	0.757	0.757

Table 6: R&D Expenditures and State Ownership, two-stage IV models

This table presents two-stage least squared (2SLS) regression results where the natural log of R&D expenditures in year *t+1* is regressed on government ownership, time-varying firm-level characteristics, country, industry, and year fixed effects (all as of year *t*). In the first stage, the government ownership indicator *SOE* is instrumented by *Left wing* in column (1), *Left wing* and *Foreign restrictions* in column (2), *Left wing* and *Investment* in column (3), and all three instruments in column (4). The sample covers European publicly listed over the years 2000-2009. First stage results are reported in Appendix Table B4. Complete variable definitions are in Appendix Table A1. Firm-level characteristics are winsorized at the 1% and 99%. Standard errors are clustered by firm. Two-sided *t*-statistics are reported in parenthesis. ***, **, and * represent 1%, 5%, and 10% statistical significance levels respectively.

Variables	(1) $lnR\&D_{t+1}$	(2) $lnR\&D_{t+1}$	(3) $lnR\&D_{t+1}$	(4) $lnR\&D_{t+1}$
$SOE_{i,t}$	1.205**	1.256**	1.005*	1.030*
	(2.10)	(2.14)	(1.86)	(1.89)
$Constrained_{i,t}$	-0.575***	-0.573***	-0.582***	-0.581***
	(-9.44)	(-9.36)	(-9.54)	(-9.51)
Total assets $_{i,t}$	0.089***	0.089***	0.090***	0.090***
	(13.68)	(13.60)	(14.88)	(14.87)
$ROA_{i,t}$	0.002	0.002	0.002	0.002
	(1.37)	(1.36)	(1.40)	(1.40)
PPE/TA $_{i,t}$	-0.094	-0.096	-0.085	-0.086
	(-0.73)	(-0.74)	(-0.69)	(-0.69)
Debt/TA $_{i,t}$	-0.619***	-0.617***	-0.629***	-0.628***
	(-4.58)	(-4.59)	(-4.60)	(-4.61)
CAPEX/TA $_{i,t}$	-0.185	-0.183	-0.190	-0.189
	(-0.55)	(-0.54)	(-0.57)	(-0.57)
GDP growth $_{j,t}$	0.094	0.117	-0.004	0.006
	(0.14)	(0.17)	(-0.01)	(0.01)
$BERD_{j,t}$	2.403	2.488	2.035	2.072
	(1.48)	(1.48)	(1.39)	(1.40)
Profit tax subsidy $_{j,t}$	2.297**	2.383**	1.962*	2.003*
	(2.04)	(2.05)	(1.90)	(1.93)
Loss tax subsidy $_{j,t}$	-1.945**	-2.016**	-1.659*	-1.692**
	(-2.02)	(-2.00)	(-1.96)	(-1.96)
Blank R&D $_{i,t}$	-6.712***	-6.711***	-6.716***	-6.716***
	(-22.26)	(-22.24)	(-22.31)	(-22.30)
$Crisis_{j,t}$	0.108	0.117	0.073	0.078
	(1.06)	(1.12)	(0.85)	(0.89)
Observations	23,893	23,893	23,893	23,893
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
SE Clustering	Country	Country	Country	Country

Table 7: R&D Expenditures, State Ownership, and Financial Constraints

This table presents the OLS regression results where the natural log of R&D expenditures in year *t+1* is regressed on metrics of government ownership, time-varying firm-level characteristics, country, industry, and year fixed effects (all as of year *t*). The sample covers European publicly listed over the years 2000-2009. *SOE* is a binary variable identifying firm-years with government stakes greater than zero (the sample only includes firms with less than a 50% domestic ownership stake). *Minority* and *Control* identify government stakes, respectively, below and above 50% of voting rights. *PFC* is an indicator equal to one when the *HPindex* is between -2.25 and -1.75. *FC* is an indicator equal to one when the *HPindex* is greater than -1.75. *Private deposits* is an index of deposit ownership ranging from 0-10. High values of the index denote a greater fraction of bank deposits being controlled by private commercial banks. Complete variable definitions are in Appendix Table A1. Firm-level characteristics are winsorized at the 1% and 99%. Standard errors are clustered by country unless otherwise noted. Two-sided *t*-statistics are reported in parenthesis. ***, **, and * represent 1%, 5%, and 10% statistical significance levels respectively.

	(1) $lnR\&D_{t+1}$	(2) $lnR\&D_{t+1}$	(3) $lnR\&D_{t+1}$	(4) $lnR\&D_{t+1}$
$SOE_{i,t}$	0.253		-0.113	
	(1.35)		(-0.59)	
$PFC_{i,t}$	-0.219	-0.216	-0.217	-0.214
	(-1.36)	(-1.34)	(-1.35)	(-1.34)
$FC_{i,t}$	-0.419***	-0.415***	-0.417***	-0.414***
	(-4.20)	(-4.14)	(-4.22)	(-4.15)
$SOE_{i,t} \times PFC_{i,t}$	0.155		0.149	
	(0.58)		(0.56)	
$SOE_{i,t} \times FC_{i,t}$	0.314*		0.311*	
	(1.90)		(1.88)	
$Minority_{i,t}$		0.295		-0.017
		(1.63)		(-0.08)
$Control_{i,t}$		-0.305		-0.795
		(-1.08)		(-1.09)
$Minority_{i,t} \times PFC_{i,t}$		0.149		0.147
		(0.57)		(0.56)
$Minority_{i,t} \times FC_{i,t}$		0.287*		0.289*
		(1.73)		(1.73)
$Control_{i,t} \times PFC_{i,t}$		-0.842		-0.846
		(-0.48)		(-0.48)
$Control_{i,t} \times FC_{i,t}$		0.632		0.529
		(1.26)		(1.11)
Private deposits $_{j,t}$			-0.104***	-0.099***
			(-3.17)	(-3.01)
$SOE_{i,t} \times$ Private deposits $_{j,t}$			0.041**	
			(2.23)	
$Minority_{i,t} \times$ Private deposits $_{j,t}$				0.034*
				(2.03)
$Control_{i,t} \times$ Private deposits $_{j,t}$				0.067
				(0.63)

Table 7: R&D Expenditures, State Ownership, and Financial Constraints - Continued

	(1) $lnR\&D_{t+1}$	(2) $lnR\&D_{t+1}$	(3) $lnR\&D_{t+1}$	(4) $lnR\&D_{t+1}$
Total assets $_{i,t}$	0.100***	0.100***	0.100***	0.100***
	(22.09)	(22.08)	(21.87)	(21.84)
ROA $_{i,t}$	0.004**	0.004**	0.004**	0.004**
	(2.12)	(2.11)	(2.12)	(2.11)
PPE/TA $_{i,t}$	-0.143	-0.135	-0.140	-0.133
	(-1.27)	(-1.19)	(-1.26)	(-1.19)
Debt/TA $_{i,t}$	-0.579***	-0.582***	-0.581***	-0.583***
	(-3.92)	(-3.96)	(-3.94)	(-3.97)
CAPEX/TA $_{i,t}$	-0.135	-0.146	-0.135	-0.146
	(-0.38)	(-0.42)	(-0.38)	(-0.42)
GDP growth $_{j,t}$	-0.233	-0.201	-0.053	-0.047
	(-0.56)	(-0.48)	(-0.12)	(-0.11)
BERD $_{j,t}$	1.007	1.029	0.764	0.803
	(1.11)	(1.18)	(0.81)	(0.88)
Profit tax subsidy $_{j,t}$	0.804	0.796	1.051**	1.030**
	(1.60)	(1.62)	(2.32)	(2.29)
Loss tax subsidy $_{j,t}$	-0.563*	-0.549*	-0.933***	-0.898***
	(-1.82)	(-1.82)	(-3.40)	(-3.22)
Blank R&D $_{i,t}$	-6.765***	-6.765***	-6.765***	-6.765***
	(-21.77)	(-21.73)	(-21.79)	(-21.75)
Crisis $_{j,t}$	-0.025	-0.026	-0.051	-0.049
	(-0.56)	(-0.54)	(-1.12)	(-1.00)
Constant	8.069***	8.075***	9.103***	9.059***
	(25.32)	(25.76)	(18.98)	(18.93)
Observations	23,893	23,893	23,893	23,893
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
SE Clustering	Country	Country	Country	Country
# Clusters	24	24	24	24
R-squared	0.756	0.756	0.756	0.756
Adjusted R-squared	0.755	0.755	0.755	0.755

Table 8: R&D Expenditures, State Ownership, and Bank Loans

This table presents the OLS regression results where the natural log of R&D expenditures in year *t+1* is regressed on metrics of government ownership. The sample covers European publicly listed over the years 2000-2009. *SOE* is a binary variable identifying firm-years with government stakes greater than zero (the sample only includes firms with less than a 50% domestic ownership stake). *Bank Loan* is the dollar amount of syndicated loans received in year *t* for firm *i*. *Gov loan* (*Non-gov loan*) is the dollar amount of syndicated loans received in year *t* for firm *i* from lending syndicates with (without) a government-controlled commercial bank. Complete variable definitions are in Appendix Table A1. Firm-level characteristics are winsorized at the 1% and 99%. Standard errors are clustered by country unless otherwise noted. Two-sided *t*-statistics are reported in parenthesis. ***, **, and * represent 1%, 5%, and 10% statistical significance levels respectively.

	(1) $lnR\&D_{t+1}$	(2) $lnR\&D_{t+1}$	(3) $lnR\&D_{t+1}$	(4) $lnR\&D_{t+1}$	(5) $lnR\&D_{t+1}$
$SOE_{i,t}$	0.227*	0.226*	0.227*	0.226*	0.248*
	(1.96)	(1.97)	(1.97)	(1.95)	(1.76)
Bank loan $_{i,t}$ /$Debt_{t-1}$ × $SOE_{i,t}$	0.050				
	(0.37)				
Bank loan $_{i,t}$ /$Debt_{t-1}$	-0.004***				
	(-3.45)				
Gov loan $_{i,t}$ /$Debt_{t-1}$ × $SOE_{i,t}$		2.626***		2.628***	
		(11.84)		(11.81)	
Gov loan $_{i,t}$ /$Debt_{t-1}$		-0.005***		-0.006***	
		(-3.17)		(-2.84)	
Non-gov loan $_{i,t}$ /$Debt_{t-1}$ × $SOE_{i,t}$			-0.158	-0.169	
			(-0.59)	(-0.64)	
Non-gov loan $_{i,t}$ /$Debt_{t-1}$			0.187	0.198	
			(1.16)	(1.27)	
Gov loan $_{i,t}$ × $SOE_{i,t}$					6.451**
					(2.25)
Gov loan $_{i,t}$					0.753
					(0.36)
Non-gov loan $_{i,t}$ × $SOE_{i,t}$					0.810
					(0.37)
Non-gov loan $_{i,t}$					-0.905
					(-0.44)
Constrained $_{i,t}$	-0.627***	-0.628***	-0.626***	-0.627***	-0.619***
	(-10.42)	(-10.36)	(-10.37)	(-10.32)	(-10.66)
$SOE_{i,t}$ x Constrained $_{i,t}$	0.205	0.203	0.205	0.203	0.251
	(1.46)	(1.45)	(1.46)	(1.45)	(1.56)

Table 8: R&D Expenditures, State Ownership, and Bank Loans - Continued

	(1)	(2)	(3)	(4)	(5)
	$\ln R\&D_{t+1}$	$\ln R\&D_{t+1}$	$\ln R\&D_{t+1}$	$\ln R\&D_{t+1}$	$\ln R\&D_{t+1}$
Total assets $_{i,t}$	0.089***	0.089***	0.089***	0.089***	0.093***
	(23.06)	(23.02)	(23.07)	(23.03)	(22.52)
ROA $_{i,t}$	0.491**	0.490**	0.490**	0.489**	0.260
	(2.58)	(2.58)	(2.56)	(2.57)	(1.49)
PPE/TA $_{i,t}$	-0.131	-0.131	-0.131	-0.130	-0.060
	(-0.93)	(-0.92)	(-0.92)	(-0.92)	(-0.49)
Debt/TA $_{i,t}$	-0.704***	-0.706***	-0.703***	-0.705***	-0.652***
	(-3.25)	(-3.24)	(-3.24)	(-3.23)	(-4.08)
CAPEX/TA $_{i,t}$	-0.281	-0.280	-0.282	-0.280	-0.207
	(-0.77)	(-0.77)	(-0.77)	(-0.77)	(-0.61)
GDP growth $_{j,t}$	-0.661	-0.664	-0.663	-0.666	-0.318
	(-1.38)	(-1.39)	(-1.39)	(-1.40)	(-0.76)
BERD $_{j,t}$	0.931	0.935	0.910	0.924	0.919
	(0.88)	(0.88)	(0.86)	(0.88)	(1.00)
Profit tax subsidy $_{j,t}$	1.604***	1.607***	1.598***	1.603***	0.932*
	(3.56)	(3.57)	(3.55)	(3.57)	(1.90)
Loss tax subsidy $_{j,t}$	-1.499***	-1.502***	-1.494***	-1.499***	-0.754**
	(-4.60)	(-4.61)	(-4.59)	(-4.59)	(-2.43)
Blank R&D $_{i,t}$	-6.875***	-6.874***	-6.875***	-6.874***	-6.729***
	(-21.83)	(-21.86)	(-21.84)	(-21.86)	(-21.92)
Crisis $_{j,t}$	0.041	0.043	0.042	0.044	-0.038
	(1.17)	(1.22)	(1.20)	(1.25)	(-0.86)
Constant	8.303***	8.301***	8.304***	8.302***	7.921***
	(18.33)	(18.31)	(18.36)	(18.34)	(27.95)
Observations	18,373	18,373	18,373	18,373	23,893
Year FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
SE Clustering	Country	Country	Country	Country	Country
# Clusters	24	24	24	24	24
R-squared	0.769	0.769	0.769	0.769	0.759
Adjusted R-squared	0.767	0.767	0.767	0.767	0.757

Table 9: R&D Expenditures, State Ownership, and National Elections

This table presents the OLS regression results where the natural log of R&D expenditures in year *t+1* is regressed on metrics of government ownership, time-varying firm-level characteristics, country, industry, and year fixed effects (all as of year *t*). The sample covers European publicly listed over the years 2000-2009. *SOE* is a binary variable identifying firm-years with government stakes greater than zero. *Stake* is a continuous variable denoting the percent ownership of the domestic government. *Minority* and *Control* identify government stakes, respectively, below and above 50% of voting rights. *Pre election* is an indicator equal to one in the year preceding a national scheduled election. Complete variable definitions are in Appendix Table A1. Firm-level characteristics are winsorized at the 1% and 99%. Standard errors are clustered by country unless otherwise noted. Two-sided *t*-statistics are reported in parenthesis. ***, **, and * represent 1%, 5%, and 10% statistical significance levels respectively.

Variables	(1) $lnR\&D_{t+1}$	(2) $lnR\&D_{t+1}$	(3) $lnR\&D_{t+1}$	(4) $lnR\&D_{t+1}$
SOE_{t+1}	0.465***	0.537***	0.482***	
	(5.42)	(8.54)	(5.96)	
SOE_{t+1} × $Pre\ election_{t+1}$	-0.102	-0.148**	-0.099	
	(-1.35)	(-2.09)	(-1.20)	
$Minority_{t+1}$				0.482***
				(5.96)
$Minority_{t+1}$ × $Pre\ election_{t+1}$				-0.099
				(-1.20)
$Stake_{t+1}$		-0.009*		
		(-1.88)		
$Stake_{t+1}$ × $Pre\ election_{t+1}$		0.004		
		(1.38)		
$Control_{t+1}$			-0.322	0.160
			(-1.18)	(0.55)
$Control_{t+1}$ × $Pre\ election_{t+1}$			-0.322	-0.420**
			(-1.45)	(-2.20)
$Pre\ election_{t+1}$	-0.067	-0.065	-0.066	-0.066
	(-1.43)	(-1.37)	(-1.39)	(-1.39)
$Constrained_{i,t}$	-0.579***	-0.574***	-0.577***	-0.577***
	(-7.38)	(-7.12)	(-7.27)	(-7.27)
$Total\ assets_{i,t}$	0.089***	0.090***	0.089***	0.089***
	(12.63)	(12.67)	(12.69)	(12.69)
$ROA_{i,t}$	0.005**	0.005*	0.005**	0.005**
	(2.10)	(2.07)	(2.08)	(2.08)
$PPE/TA_{i,t}$	-0.038	-0.010	-0.022	-0.022
	(-0.19)	(-0.05)	(-0.11)	(-0.11)
$Debt/TA_{i,t}$	-0.813***	-0.818***	-0.818***	-0.818***
	(-4.63)	(-4.69)	(-4.68)	(-4.68)
$CAPEX/TA_{i,t}$	-0.273	-0.311	-0.295	-0.295
	(-0.52)	(-0.60)	(-0.57)	(-0.57)

Table 9: R&D Expenditures, State Ownership, and National Elections - Continued

Variables	(1) $lnR\&D_{t+1}$	(2) $lnR\&D_{t+1}$	(3) $lnR\&D_{t+1}$	(4) $lnR\&D_{t+1}$
GDP growth $_{j,t}$	-1.876***	-1.902***	-1.858***	-1.858***
	(-3.53)	(-3.44)	(-3.44)	(-3.44)
BERD $_{j,t}$	1.156	1.202	1.241	1.241
	(1.23)	(1.27)	(1.32)	(1.32)
Profit tax subsidy $_{j,t}$	-0.937	-1.255	-1.052	-1.052
	(-0.14)	(-0.18)	(-0.15)	(-0.15)
Loss tax subsidy $_{j,t}$	2.370	2.752	2.517	2.517
	(0.31)	(0.35)	(0.32)	(0.32)
Blank R&D $_{i,t}$	-6.996***	-6.995***	-6.995***	-6.995***
	(-24.13)	(-24.11)	(-24.09)	(-24.09)
Crisis $_{j,t}$	-0.091	-0.098	-0.094	-0.094
	(-0.80)	(-0.88)	(-0.86)	(-0.86)
Constant	7.705***	7.691***	7.692***	7.692***
	(25.47)	(25.48)	(25.26)	(25.26)
Observations	9,720	9,720	9,720	9,720
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
SE Clustering	Country	Country	Country	Country
# Clusters	22	22	22	22
R-squared	0.766	0.766	0.766	0.766
Adjusted R-squared	0.763	0.763	0.763	0.763

Table 10: R&D Expenditures, State Ownership, Politically Appointed Managers, and Incentive Pay

This table presents the OLS regression results where the natural log of R&D expenditures in year *t+1* is regressed on metrics of government ownership, time-varying firm-level characteristics, country, industry, and year fixed effects (all as of year *t*). The sample covers European publicly listed over the years 2000-2009. *SOE* is a binary variable identifying firm-years with government stakes greater than zero. *Stake* is a continuous variable denoting the percent ownership of the domestic government. *Minority* and *Control* identify government stakes, respectively, below and above 50% of voting rights. *Performance pay* is an indicator equal to one in countries if SOE controlled firms are able to employ convex pay contracts to incentivize risk-taking. *Political mgr* is an indicator equal to one in countries where sovereigns can appoint executives. Complete variable definitions are in Appendix Table A1. Firm-level characteristics are winsorized at the 1% and 99%. Standard errors are clustered by country unless otherwise noted. Two-sided *t*-statistics are reported in parenthesis. ***, **, and * represent 1%, 5%, and 10% statistical significance levels respectively.

VARIABLES	(1) $lnR\&D_{t+1}$	(2) $lnR\&D_{t+1}$	(3) $lnR\&D_{t+1}$	(4) $lnR\&D_{t+1}$
SOE $_{i,t}$	0.349***	0.408		
	(2.82)	(1.70)		
Minority $_{i,t}$			0.370***	0.439*
			(3.18)	(1.86)
Control $_{i,t}$			-0.007	0.104
			(-0.02)	(0.22)
SOE $_{i,t}$ × Political mgr $_j$		-0.333**		
		(-2.53)		
SOE $_{i,t}$ × Performance pay $_j$		0.131		
		(0.51)		
Minority $_{i,t}$ × Political mgr $_j$				-0.330**
				(-2.29)
Minority $_{i,t}$ × Performance pay $_j$				0.108
				(0.40)
Control $_{i,t}$ × Political mgr $_j$				-0.357
				(-0.85)
Control $_{i,t}$ × Performance pay $_j$				-0.065
				(-0.16)
Constrained $_{i,t}$	-0.615***	-0.614***	-0.614***	-0.614***
	(-9.57)	(-9.52)	(-9.55)	(-9.52)
Total assets $_{i,t}$	0.095***	0.095***	0.095***	0.095***
	(19.83)	(19.28)	(19.90)	(19.32)
ROA $_{i,t}$	0.003	0.003*	0.003	0.003*
	(1.71)	(1.72)	(1.71)	(1.71)
PPE/TA $_{i,t}$	-0.190	-0.189	-0.183	-0.182
	(-1.33)	(-1.32)	(-1.27)	(-1.26)
Debt/TA $_{i,t}$	-0.559***	-0.557***	-0.561***	-0.559***
	(-3.35)	(-3.33)	(-3.37)	(-3.36)

Table 10: R&D Expenditures, State Ownership, Politically Appointed Managers, and Incentive Pay - Continued

VARIABLES	(1) $lnR\&D_{t+1}$	(2) $lnR\&D_{t+1}$	(3) $lnR\&D_{t+1}$	(4) $lnR\&D_{t+1}$
CAPEX/TA $_{i,t}$	-0.036	-0.038	-0.049	-0.052
	(-0.10)	(-0.11)	(-0.15)	(-0.15)
GDP growth $_{j,t}$	0.642	0.287	0.671	0.295
	(0.71)	(0.33)	(0.74)	(0.34)
BERD $_{j,t}$	3.168	2.943	3.188	2.968
	(1.34)	(1.23)	(1.34)	(1.24)
Profit tax subsidy $_{j,t}$	-3.610*	-3.455*	-3.615*	-3.454*
	(-1.92)	(-1.84)	(-1.91)	(-1.83)
Loss tax subsidy $_{j,t}$	3.210	3.117	3.214	3.107
	(1.53)	(1.46)	(1.52)	(1.45)
Blank R&D $_{i,t}$	-6.828***	-6.828***	-6.827***	-6.827***
	(-19.82)	(-19.84)	(-19.79)	(-19.82)
Crisis $_{j,t}$	-0.239*	-0.209*	-0.239*	-0.206*
	(-2.01)	(-2.02)	(-1.99)	(-1.98)
Constant	7.052***	7.051***	7.050***	7.047***
	(12.52)	(12.74)	(12.52)	(12.71)
Observations	23,893	23,893	23,893	23,893
Year FE	YES	YES	YES	YES
Country FE	NO	NO	NO	NO
Industry FE	YES	YES	YES	YES
SE Clustering	Country	Country	Country	Country
# Clusters	24	24	24	24
R-squared	0.754	0.754	0.754	0.754
Adjusted R-squared	0.753	0.753	0.753	0.753

Table 11: Patenting Activity and State Ownership

This table presents the OLS regression results where the natural log of granted patents applied for in year *t+2* is regressed on government ownership, time-varying firm-level characteristics, country, industry, and year fixed effects (all as of year *t*). The sample covers European publicly listed over the years 2000-2009. *SOE* is a binary variable identifying firm-years with government stakes greater than zero. *Stake* is a continuous variable denoting the percent ownership of the domestic government. *Minority* and *Control* identify government stakes, respectively, below and above 50% of voting rights. Complete variable definitions are in Appendix Table A1. Firm-level characteristics are winsorized at the 1% and 99%. Standard errors are clustered by country unless otherwise noted. Two-sided *t*-statistics are reported in parenthesis. ***, **, and * represent 1%, 5%, and 10% statistical significance levels respectively.

Variables	(1) $lnCount_{t+2}$	(2) $lnCount_{t+2}$	(3) $lnCount_{t+2}$	(4) $lnCount_{t+2}$
$SOE_{i,t}$	0.082		-0.035*	
	(1.40)		(-1.78)	
$Minority_{i,t}$		0.070		-0.042*
		(1.23)		(-1.73)
$Control_{i,t}$		0.242		0.037
		(1.47)		(0.45)
$SOE_{i,t} \times lnR\&D_{i,t}$			0.020	
			(1.46)	
$Minority_{i,t} \times lnR\&D_{i,t}$				0.018
				(1.52)
$Control_{i,t} \times lnR\&D_{i,t}$				0.061
				(1.27)
$lnR\&D_{i,t}$			0.087***	0.087***
			(2.95)	(2.95)
$Constrained_{i,t}$	-0.084*	-0.084*	-0.036	-0.036
	(-2.06)	(-2.06)	(-1.30)	(-1.29)
Total assets $_{i,t}$	0.033***	0.033***	0.025***	0.024***
	(4.22)	(4.20)	(3.94)	(3.79)
$ROA_{i,t}$	0.001	0.001	0.001	0.001
	(1.36)	(1.37)	(1.25)	(1.27)
$PPE/TA_{i,t}$	0.132	0.129	0.116	0.111
	(1.17)	(1.18)	(1.16)	(1.17)
$Debt/TA_{i,t}$	-0.282**	-0.281**	-0.231**	-0.230**
	(-2.13)	(-2.12)	(-2.27)	(-2.26)
$CAPEX/TA_{i,t}$	0.567	0.573	0.595	0.603
	(1.41)	(1.42)	(1.43)	(1.44)
GDP growth $_{j,t}$	-0.191	-0.200	-0.185	-0.191
	(-1.02)	(-1.08)	(-1.14)	(-1.16)
$BERD_{j,t}$	0.443	0.423	0.304	0.255
	(0.89)	(0.86)	(0.61)	(0.51)
Profit tax subsidy $_{j,t}$	0.187	0.183	0.109	0.103
	(1.23)	(1.21)	(0.68)	(0.65)
Loss tax subsidy $_{j,t}$	-0.140	-0.142	-0.148	-0.142
	(-0.73)	(-0.76)	(-0.82)	(-0.80)

Table 11: Patenting Activity and State Ownership - Continued

Variables	(1) $lnCount_{t+2}$	(2) $lnCount_{t+2}$	(3) $lnCount_{t+2}$	(4) $lnCount_{t+2}$
Blank R&D $_{i,t}$	-0.240**	-0.240**	0.416***	0.416***
	(-2.34)	(-2.35)	(2.82)	(2.81)
Crisis $_{j,t}$	0.058***	0.057***	0.067***	0.064***
	(7.15)	(7.29)	(6.49)	(6.13)
Pseudo blank $_{i,t}$	0.561***	0.561***	0.627***	0.627***
	(7.28)	(7.29)	(7.12)	(7.15)
Constant	0.349***	0.344***	-0.328	-0.331
	(3.03)	(2.98)	(-1.21)	(-1.22)
Observations	20,091	20,091	20,091	20,091
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
SE Clustering	Country	Country	Country	Country
# Clusters	24	24	24	24
R-squared	0.303	0.304	0.342	0.342
Adjusted R-squared	0.299	0.300	0.338	0.339

Table 12: Patent Quality and State Ownership

This table presents the OLS regression results where the natural log of patent quality measures for granted patents applied for in year *t+2* is regressed on government ownership, time-varying firm-level characteristics, country, industry, and year fixed effects (all as of year *t*). The sample covers European publicly listed over the years 2000-2009. *SOE* is a binary variable identifying firm-years with government stakes greater than zero. The dependent variable in the odd columns, *lnCitations*, is the natural log of one plus the total citations generated by patents applied for in year *t+2*. The dependent variable in the even columns, *lnCitePer*, is the natural log of one plus the total citations generated by patents applied for in year *t+2* divided by the number of granted patents applied for in year *t+2*. *Stake* is a continuous variable denoting the percent ownership of the domestic government. *Minority* and *Control* identify government stakes, respectively, below and above 50% of voting rights. Complete variable definitions are in Appendix Table A1. Firm-level characteristics are winsorized at the 1% and 99%. Standard errors are clustered by country unless otherwise noted. Two-sided *t*-statistics are reported in parenthesis. ***, **, and * represent 1%, 5%, and 10% statistical significance levels respectively.

Variables	(1) $lnCitations_{t+2}$	(2) $lnCitePer_{t+2}$	(3) $lnCitations_{t+2}$	(4) $lnCitePer_{t+2}$	(5) $lnCitations_{t+2}$	(6) $lnCitePer_{t+2}$	(7) $lnCitations_{t+2}$	(8) $lnCitePer_{t+2}$
$SOE_{i,t}$	0.169	0.099	-0.032	0.017				
	(1.52)	(1.69)	(-0.73)	(0.60)				
$Minority_{i,t}$					0.137	0.078	-0.045	0.009
					(1.32)	(1.47)	(-0.91)	(0.27)
$Control_{i,t}$					0.601	0.380*	0.100	0.089
					(1.65)	(1.77)	(0.75)	(1.00)
$SOE_{i,t} \times lnR\&D_{i,t}$			0.030	0.010				
			(1.18)	(0.78)				
$Minority_{i,t} \times lnR\&D_{i,t}$							0.025	0.007
							(1.10)	(0.57)
$Control_{i,t} \times lnR\&D_{i,t}$							0.150*	0.087**
							(1.96)	(2.53)
$lnR\&D_{i,t}$			0.193***	0.109***			0.193***	0.110***
			(3.37)	(3.91)			(3.37)	(3.91)
$Constrained_{i,t}$	-0.212**	-0.133**	-0.106	-0.072*	-0.212**	-0.133**	-0.107	-0.073*
	(-2.27)	(-2.45)	(-1.59)	(-1.76)	(-2.27)	(-2.45)	(-1.58)	(-1.75)
Total assets $_{i,t}$	0.060***	0.027***	0.042***	0.017***	0.060***	0.027***	0.041***	0.017***
	(6.31)	(9.62)	(5.72)	(4.64)	(6.27)	(9.61)	(5.36)	(4.50)
$ROA_{i,t}$	0.002	0.001	0.002	0.001	0.002	0.001	0.002	0.001
	(1.44)	(1.53)	(1.31)	(1.36)	(1.45)	(1.54)	(1.33)	(1.39)

Table 12: Patent Quality and State Ownership – Continued

Variables	(1) $lnCitations_{t+2}$	(2) $lnCitePer_{t+2}$	(3) $lnCitations_{t+2}$	(4) $lnCitePer_{t+2}$	(5) $lnCitations_{t+2}$	(6) $lnCitePer_{t+2}$	(7) $lnCitations_{t+2}$	(8) $lnCitePer_{t+2}$
PPE/TA $_{i,t}$	0.284	0.173	0.246	0.150	0.275	0.167	0.234	0.143
	(1.25)	(1.40)	(1.22)	(1.36)	(1.26)	(1.42)	(1.23)	(1.39)
Debt/TA $_{i,t}$	-0.593**	-0.332***	-0.482**	-0.271***	-0.589**	-0.330***	-0.479**	-0.269***
	(-2.44)	(-3.01)	(-2.69)	(-3.44)	(-2.44)	(-3.02)	(-2.68)	(-3.47)
CAPEX/TA $_{i,t}$	1.091	0.528**	1.154*	0.564**	1.108	0.539**	1.174*	0.576**
	(1.70)	(2.18)	(1.72)	(2.23)	(1.71)	(2.21)	(1.73)	(2.24)
GDP growth $_{j,t}$	-0.732**	-0.468**	-0.691**	-0.429**	-0.758**	-0.484**	-0.702**	-0.436**
	(-2.13)	(-2.28)	(-2.19)	(-2.11)	(-2.20)	(-2.35)	(-2.22)	(-2.13)
BERD $_{j,t}$	0.792	0.361	0.488	0.189	0.739	0.326	0.355	0.105
	(0.56)	(0.32)	(0.34)	(0.17)	(0.53)	(0.29)	(0.25)	(0.09)
Profit tax subsidy $_{j,t}$	0.099	0.013	-0.079	-0.091	0.089	0.006	-0.094	-0.101
	(0.31)	(0.05)	(-0.23)	(-0.35)	(0.29)	(0.03)	(-0.29)	(-0.40)
Loss tax subsidy $_{j,t}$	-0.008	-0.010	-0.019	-0.013	-0.013	-0.013	-0.001	-0.002
	(-0.02)	(-0.04)	(-0.05)	(-0.05)	(-0.03)	(-0.05)	(-0.00)	(-0.01)
Blank R&D $_{i,t}$	-0.656**	-0.470***	0.786***	0.345***	-0.656**	-0.470***	0.789***	0.347***
	(-2.66)	(-3.04)	(3.16)	(3.52)	(-2.67)	(-3.05)	(3.15)	(3.49)
Crisis $_{j,t}$	0.163***	0.107***	0.180***	0.115***	0.159***	0.104***	0.172***	0.110***
	(5.37)	(3.47)	(4.38)	(3.10)	(5.34)	(3.44)	(4.27)	(3.06)
Pseudo blank $_{i,t}$	1.456***	1.093***	1.597***	1.171***	1.455***	1.092***	1.599***	1.172***
	(7.22)	(7.81)	(7.42)	(8.15)	(7.22)	(7.79)	(7.45)	(8.18)
Constant	0.958***	0.749***	-0.533	-0.094	0.944***	0.741***	-0.538	-0.097
	(3.84)	(4.15)	(-1.23)	(-0.56)	(3.78)	(4.09)	(-1.23)	(-0.57)
Observations	20,091	20,091	20,091	20,091	20,091	20,091	20,091	20,091
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SE Clustering	Country	Country	Country	Country	Country	Country	Country	Country
# Clusters	24	24	24	24	24	24	24	24
R-squared	0.301	0.264	0.338	0.290	0.302	0.264	0.339	0.291
Adjusted R-squared	0.297	0.259	0.334	0.286	0.298	0.260	0.335	0.287

Table 13: Market Reaction to Patent Announcements and State Ownership

This table presents summary statistics from event studies around patent publication dates. We examine the market-adjusted returns for each firm before and after the public release of patent application information following the method introduced by Kogan et al. (2017). Day 0 is the day on which a patent application is made public. *Obs* reports the number of observations, while mean (median) CAR refers to the mean (median) cumulative abnormal return over the relevant event window. *Patell z* reports the *z*-statistic of a two-sided test for mean abnormal returns, while *Gen z* reports the *z*-statistic for a generalized sign test for median abnormal returns. Panel A reports the results for SOEs with minority government stakes, Panel B for SOEs with majority government stakes, while Panel C refers to private-sector firms. Panels D-F mirror a similar split but focus on a subset of highly cited patents (patents in the top decile of citations, typically with twelve or more citations). ***, **, and * represent 1%, 5%, and 10% statistical significance levels respectively.

Panel A – All patents, government minority share SOEs

Days	Obs	Mean *CAR*	Patell *z*	Median *CAR*	Gen *z*
(0,0)	4,820	-0.04%	-1.52	-0.05%	-1.72*
(0,+1)	4,820	0.00%	-0.22	-0.06%	0.01
(-1,+1)	4,820	0.04%	0.93	-0.09%	0.39

Panel B – All patents, government-controlled SOEs

Days	Obs	Mean *CAR*	Patell *z*	Median *CAR*	Gen *z*
(0,0)	201	-0.04%	-0.30	-0.21%	-2.61***
(-1,+1)	201	-0.02%	-0.30	-0.02%	-0.21
(0,+1)	201	0.02%	0.15	-0.03%	-0.63

Panel C – All patents, private-sector firms

Days	Obs	Mean *CAR*	Patell *z*	Median *CAR*	Gen *z*
(0,0)	10,538	0.02%	1.46	<0.01%	1.08
(0,+1)	10,539	0.06%	2.11**	<0.01%	2.50**
(-1,+1)	10,540	0.11%	2.79***	0.01%	3.23***

Table 13: Market Reaction to Patent Announcements and State Ownership - Continued

Panel D – Highly cited patents, government minority share SOEs

Days	Obs	Mean *CAR*	Patell *z*	Median *CAR*	Gen *z*
(0,0)	1,571	0.04%	1.13	<0.01%	0.50
(0,+1)	1,573	0.11%	1.48	<0.01%	1.36
(-1,+1)	1,574	0.12%	1.49	0.02%	1.69*

Panel E – Highly cited patents, government-controlled SOEs

Days	Obs	Mean *CAR*	Patell *z*	Median *CAR*	Gen *z*
(0,0)	36	0.03%	0.75	-0.15%	-0.85
(0,+1)	36	0.48%	1.40	-0.14%	-0.52
(-1,+1)	36	0.39%	0.57	-0.01%	-0.18

Panel F – Highly cited patents, private-sector firms

Days	Obs	Mean *CAR*	Patell *z*	Median *CAR*	Gen *z*
(0,0)	3,352	0.09%	2.47**	0.01%	2.11**
(0,+1)	3,353	0.16%	2.90***	0.06%	3.06***
(-1,+1)	3,354	0.19%	2.97***	0.05%	2.53**

Table 14: Sustainable Patent Output and State Ownership

This table presents the OLS regression results where sustainable patent measures of granted patents applied for in year *t+2* is regressed on metrics of government ownership, time-varying firm-level characteristics, country, industry, and year fixed effects (all as of year *t*). The sample covers European publicly listed over the years 2000-2009. *lnSusCount* is the natural log of the count of granted sustainable patents applied for in year *t+2*. *lnSusFrac* is the natural log of the number of granted sustainable patents applied for in year *t+2* divided by the total number of granted patents that were applied for in year *t+2*. *Minority* and *Control* identify government stakes, respectively, below and above 50% of voting rights. Column (1) uses the full sample of firms while columns (2)-(3) focus on R&D intensive (non-missing) R&D firm-years. Column (4) is all firm-years in the Manufacturing SIC while column (5) is all other firm-year observations. Complete variable definitions are in Appendix Table A1. Firm-level characteristics are winsorized at the 1% and 99%. Standard errors are clustered by country unless otherwise noted. Two-sided *t*-statistics are reported in parenthesis. ***, **, and * represent 1%, 5%, and 10% statistical significance levels respectively.

	Full Sample	R&D Intensive	R&D Intensive	Manufacturing	All Others
	(1)	(2)	(3)	(4)	(5)
Variables	$lnSusCount_{t+2}$	$lnSusCount_{t+2}$	$lnSusFrac_{t+2}$	$lnSusCount_{t+2}$	$lnSusCount_{t+2}$
$Minority_{i,t}$	0.005	0.004	0.005	-0.006	0.016
	(0.17)	(0.07)	(0.78)	(-0.11)	(1.46)
$Control_{i,t}$	0.112	0.355*	0.074*	1.177***	0.070
	(1.13)	(1.97)	(1.84)	(5.39)	(0.70)
$Constrained_{i,t}$	-0.026	-0.053*	-0.009*	-0.034	-0.003
	(-1.65)	(-1.89)	(-1.80)	(-1.50)	(-0.45)
Total assets $_{i,t}$	0.014**	0.019**	0.001***	0.026**	0.005***
	(2.16)	(2.29)	(3.13)	(2.09)	(2.86)
$ROA_{i,t}$	0.000	0.000	-0.000	-0.000	0.000
	(0.83)	(0.11)	(-0.93)	(-1.36)	(0.76)
PPE/TA $_{i,t}$	0.033	0.180	0.025	0.079	-0.000
	(0.82)	(1.00)	(1.38)	(0.81)	(-0.01)
Debt/TA $_{i,t}$	-0.103*	-0.178*	-0.016**	-0.192***	-0.036
	(-1.95)	(-1.88)	(-2.52)	(-2.98)	(-1.61)
CAPEX/TA $_{i,t}$	0.302	0.886	0.052	0.833	0.045
	(1.18)	(1.27)	(0.92)	(1.24)	(1.35)
GDP growth $_{j,t}$	-0.007	-0.016	0.013	0.013	0.006
	(-0.15)	(-0.18)	(0.72)	(0.14)	(0.26)

Table 14: Sustainable Patent Output and State Ownership - Continued

Variables	Full Sample (1) $lnSusCount_{t+2}$	R&D Intensive (2) $lnSusCount_{t+2}$	R&D Intensive (3) $lnSusFrac_{t+2}$	Manufacturing (4) $lnSusCount_{t+2}$	All Others (5) $lnSusCount_{t+2}$
BERD $_{j,t}$	-0.058	-0.261	-0.074	-0.212	0.073
	(-0.29)	(-0.73)	(-0.61)	(-0.74)	(0.44)
Profit tax subsidy $_{j,t}$	0.031	0.445	0.100	-0.031	0.099
	(0.30)	(1.57)	(1.23)	(-0.22)	(1.51)
Loss tax subsidy $_{j,t}$	-0.006	-0.439*	-0.077	0.059	-0.092
	(-0.06)	(-1.82)	(-0.96)	(0.42)	(-1.32)
Blank R&D $_{i,t}$	-0.028			-0.070***	-0.032
	(-1.56)			(-3.06)	(-1.58)
Crisis $_{j,t}$	-0.002	-0.000	0.000	0.001	-0.004
	(-0.33)	(-0.05)	(0.09)	(0.06)	(-0.68)
Pseudo blank $_{i,t}$	0.040*			0.070**	0.100**
	(1.90)			(2.13)	(2.34)
Constant	-0.007	-0.189	0.025	0.069	-0.019
	(-0.11)	(-0.83)	(0.72)	(1.63)	(-0.90)
Observations	20,091	7,447	7,447	8,500	11,591
Year FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
SE Clustering	Country	Country	Country	Country	Country
# Clusters	24	23	23	22	24
R-squared	0.185	0.237	0.094	0.253	0.087
Adjusted R-squared	0.180	0.226	0.0811	0.249	0.0830

Appendix A

Table A1: Variable Definitions

This table provides definitions and data sources for the main variables of interest in the dataset.

Variable Name	Definition	Source
$lnR\&D_{i,t}$	The natural log of one plus the investment in research and development of firm *i* in year *t*, recorded in USD thousands, adjusted to the base year 2004. Missing R&D expenditures are replaced with a zero.	TR Worldscope
$lnCount_{i,t+n}$	The natural log of one plus the number of (eventually) granted patents applied for by firm *i* in year *t+n.*, We consolidate patents to their patent family as reported by the EPO.	BvD Orbis & EPO PATSTAT
$lnSusCount_{i,t+n}$	The natural log of one plus the number of (eventually) granted patents applied for by firm *i* in year *t+n* that fall within a Cooperative Patent Classification (CPC) sub-groups tagged as sustainable technologies. See Appendix Table 4 for a list of CPC sub-groups. We consolidate patents to their patent family as reported by the EPO.	BvD Orbis & EPO PATSTAT
$lnSusFrac_{i,t+n}$	The natural log of one plus the number of (eventually) granted patents applied for by firm *i* in year *t+n* that fall within a Cooperative Patent Classification (CPC) sub-groups tagged as sustainable technologies divided by the number of (eventually) granted patents applied for by firm *i* in year *t+n*.	BvD Orbis & EPO PATSTAT
$lnCitations_{i,t+n}$	The natural log of one plus the total number of citations received by granted patents applied for in year *t+n* for firm *i*. Citations are truncation adjusted following Hall et al. (2000)	EPO PATSTAT
$lnCitePer_{i,t+n}$	The natural log of one plus the total number of citations received by granted patents applied for in year *t+n* for firm *i* divided by the number of (eventually) granted patents applied for by firm *i* in year *t+n.*, We consolidate patents to their patent family as reported by the EPO and truncation adjust citations. We replace zero patent count observations with zero citations per patent count.	EPO PATSTAT
$SOE_{i,t}$	An indicator that firm *i* has non-zero domestic sovereign total (direct and indirect) ownership in year *t.*	BvD Orbis
$Minority_{i,t}$	An indicator that firm *i* has a domestic sovereign owner in year *t* with a total percentage of ownership less than 50%.	BvD Orbis
$Stake_{i,t}$	Total percent of ownership in firm *i* belonging to a domestic sovereign owner in year *t.*	BvD Orbis
$Control_{i,t}$	An indicator that firm *i* has a domestic sovereign owner in year *t* with a total percentage of ownership greater than 50%.	BvD Orbis

Variable Name	Definition	Source
Total assets $_{i,t}$	Total assets of firm *i* in year *t* scaled by the consumer pricing index with a base year of 2004 in USD billions.	TR Worldscope
Constrained $_{i,t}$	An indicator that firm *i* has an HP-index above the median HP-index in year *t*. HP-index is calculated from Hadlock and Pierce (2010) using the firm's size and age. We use the firm's total assets for size and the number of years a firm is present in TR Worldscope as the firm age.	TR Worldscope
ROA $_{i,t}$	Return on assets (%) of firm *i* in year *t.*	TR Worldscope
PPE/TA $_{i,t}$	Book value of plants, property, and equipment scaled by Total assets of firm *i* in year *t.*	TR Worldscope
Debt/TA $_{i,t}$	Outstanding debt scaled by Total assets of firm *i* in year *t.*	TR Worldscope
CAPEX/TA $_{i,t}$	Investment in capital expenditures scaled by Total assets of firm *i* in year *t*.	TR Worldscope
GDP growth $_{j,t}$	GDP growth of country *j* in year *t*	World Bank Open Data
BERD $_{j,t}$	For country *j* in year *t*, the R&D tax expenditure and direct government funding of business expenditures on research and development (BERD) scaled by gross domestic product	OECD
Profit tax subsidy $_{j,t}$	For country *j* in year *t*, Implied tax subsidy rates on R&D expenditures based on headline tax credit and allowance rates for profitable large firms	OECD
Loss tax subsidy $_{j,t}$	For country *j* in year *t*, Implied tax subsidy rates on R&D expenditures based on headline tax credit and allowance rates for non-profitable large firms	OECD
Blank R&D $_{i,t}$	An indicator that firm *i* has non-missing R&D expenditures in year *t*	TR Worldscope Koh & Reeb (2015)
Pseudo blank $_{i,t}$	An indicator that firm *i* has a non-zero number of patents applied for (and eventually granted) in year *t* but is missing R&D expenditures in year *t*	TR Worldscope Koh & Reeb (2015)
Bank loan $_{i,t}$ */ Debt* $_{t-1}$	The total dollar amount of syndicated loan package received by firm *i* in year *t*, divided by firm *i*'s outstanding debt in year *t-1*	Dealscan

Variable Name	Definition	Source
Gov loan $_{i,t}$ / *Debt* $_{t-1}$	The total dollar amount of syndicated loan package received by firm *i* in year *t* from a syndicate containing at least one government-owned bank, divided by firm *i*'s outstanding debt in year *t-1*	Dealscan
Crisis $_{j,t}$	Indicator denoting firm *i* is headquartered in a country experiencing a financial crisis in year *t*	Laeven and Valencia (2013)
Non-gov loan $_{i,t}$ / *Debt* $_{t-1}$	The total dollar amount of syndicated loan package received by firm i in year t from a syndicate containing no government-owned banks, divided by firm i's outstanding debt in year t-1	Dealscan
Private deposits $_{j,t}$	Index for country *j* in year *t* describing the percentage of bank deposits held in privately owned banks. When privately held deposits totaled between 95% and 100%, countries were given a rating of 10. When private deposits constituted between 75% and 95% of the total, a rating of 8 was assigned. When private deposits were between 40% and 75% of the total, the rating was 5. When private deposits totaled between 10% and 40%, countries received a rating of 2. A zero rating was assigned when private deposits were 10% or less of the total.	Fraser Institute: Economic Freedom of the World Report, 2018
PFC $_{i,t}$	An indicator that firm *i* is partially financially constrained which is one for firm-years with a HPindex between -2.25 and -1.75	TR Worldscope
FC $_{i,t}$	An indicator that firm *i* is financially constrained which is one for firm-years with a HPindex between -2.25 and -1.75	TR Worldscope
Pre election $_{j,t}$	Indicator equal to one for country *j* in year *t* if it is the year prior to a scheduled national parliamentary (lower house) election.	Swiss National Science Foundation Comparative Political Data Set
Political mgr $_{j}$	Indicator for country *j* equal to one if CEO's of sovereign owned enterprises are able to be appointed directly by a government official	OECD Corporate Governance of State-Owned Enterprises, 2005
Performance pay $_{j}$	Indicator for country *j* equal to one if sovereign owned enterprises are allowed remuneration based on performance	OECD Corporate Governance of State-Owned Enterprises, 2005

Variable Name	Definition	Source
Left wing $_{j,t}$	An indicator if country *j*'s chief executive belongs to a left-wing political party in year *t*.	Beck, Clarke, Groff, Keefer, and Walsh, 2001
Investment $_{j,t}$	Total investment divided by GDP for country *j* in year *t*. IMF defines the total investment as the total value of the gross fixed capital formation and changes in inventories and acquisitions minus disposals of valuables for a unit or sector	IMF World Economic Outlook (WEO) Database
Foreign restrictions $_{j,t}$	Index based on the following two questions from the Global Competitiveness Report: (1) "How prevalent is foreign ownership of companies in your country? 1 = Very rare, 7 = Highly prevalent"; (2) "How restrictive are regulations in your country relating to international capital flows? 1 = Highly restrictive, 7 = Not restrictive at all".	Fraser Institute: Economic Freedom of the World Report, 2018

Appendix B

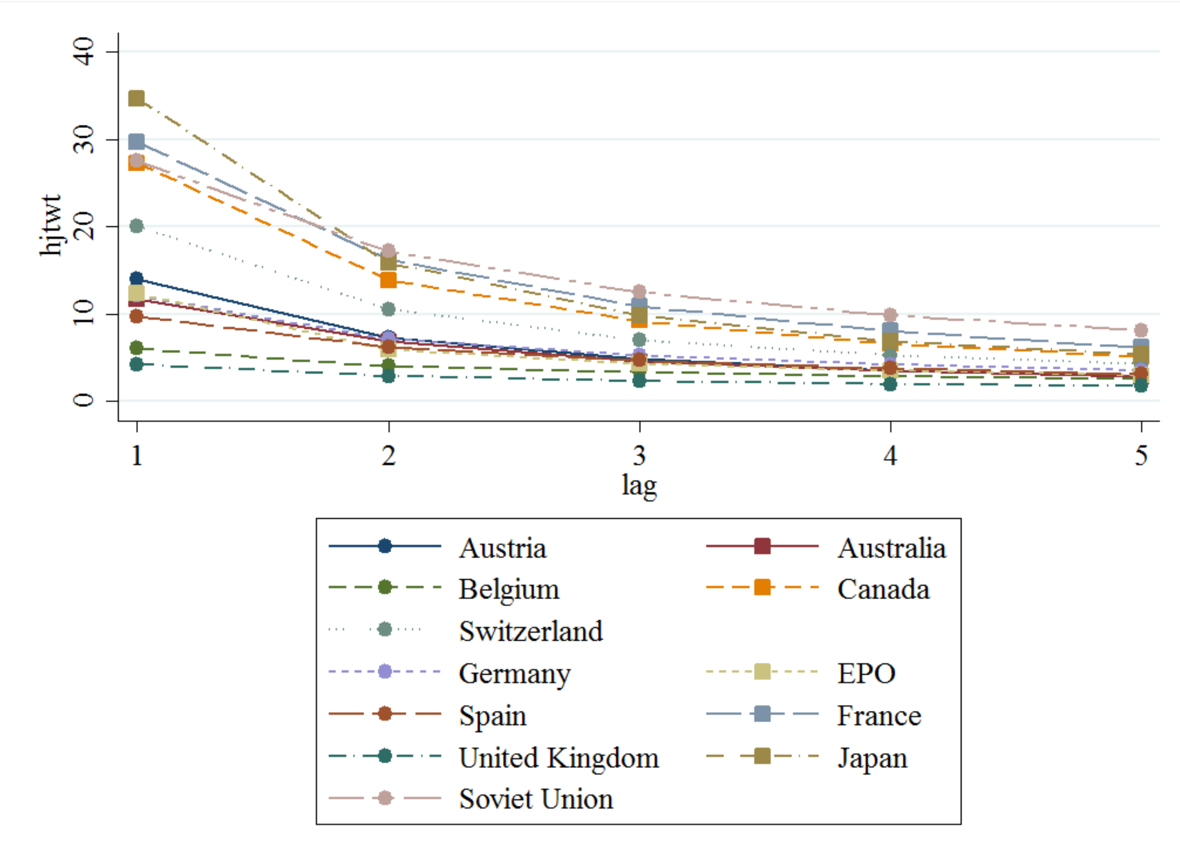

Figure B1: Patent Office Specific Citation Adjustment Factors

We graph the first five lags of patent citation adjustment factors for various individual patent offices using data from 1976-1985 to generate average citation lag adjustment factors by Patent Office-Industry section-lag. The graph above shows various adjustment factors for the IPC section A: Human Necessities at various patent offices.

Table B1: Aggregate Citation Adjustment

This table presents average citation adjustment factors used in this study for patents granted from all European Patent Convention (EPC) member offices. We use data from 1976-1985 to generate citation lag adjustment factors by Industry section-lag each year and then average across the ten years. Following the spirit of Hall et al. (2000), we report the adjustment factor for 29 lags across the 8 Industrial Patent Classification (IPC) codes reported by the EPO.

		IPC Section							
		A	B	C	D	E	F	G	H
Lag	0	60.465	43.668	32.393	33.313	50.019	31.989	30.936	31.754
	1	26.131	18.954	14.237	14.642	21.693	14.771	13.823	14.119
	2	16.226	11.776	9.008	9.320	13.529	9.564	8.745	8.971
	3	11.796	8.593	6.724	7.039	9.878	7.211	6.480	6.659
	4	9.289	6.807	5.433	5.710	7.851	5.877	5.202	5.363
	5	7.675	5.658	4.598	4.863	6.503	5.007	4.387	4.524
	6	6.539	4.851	4.015	4.238	5.571	4.389	3.812	3.942
	7	5.673	4.258	3.580	3.761	4.885	3.920	3.391	3.509
	8	5.005	3.796	3.239	3.392	4.336	3.552	3.066	3.176
	9	4.465	3.428	2.964	3.087	3.905	3.259	2.803	2.907
	10	4.014	3.125	2.729	2.829	3.558	3.009	2.583	2.682
	11	3.639	2.871	2.531	2.609	3.265	2.798	2.400	2.492
	12	3.320	2.651	2.362	2.418	3.012	2.616	2.244	2.330
	13	3.051	2.464	2.219	2.261	2.792	2.459	2.111	2.189
	14	2.817	2.303	2.094	2.125	2.600	2.317	1.996	2.065
	15	2.613	2.161	1.982	2.000	2.434	2.191	1.893	1.953
	16	2.430	2.032	1.882	1.886	2.282	2.076	1.800	1.850
	17	2.260	1.913	1.786	1.782	2.142	1.969	1.711	1.755
	18	2.096	1.800	1.695	1.681	2.003	1.863	1.627	1.664
	19	1.941	1.691	1.606	1.585	1.869	1.760	1.545	1.576
	20	1.800	1.589	1.523	1.500	1.746	1.660	1.467	1.494
	21	1.670	1.496	1.444	1.421	1.632	1.563	1.395	1.417
	22	1.550	1.410	1.371	1.346	1.525	1.473	1.327	1.346
	23	1.441	1.331	1.302	1.277	1.426	1.386	1.264	1.280
	24	1.342	1.259	1.237	1.216	1.334	1.305	1.207	1.220
	25	1.252	1.193	1.178	1.160	1.249	1.229	1.154	1.164
	26	1.173	1.133	1.123	1.109	1.174	1.160	1.107	1.114
	27	1.104	1.081	1.075	1.066	1.107	1.098	1.065	1.070
	28	1.047	1.037	1.034	1.030	1.048	1.045	1.030	1.032
	29	1	1	1	1	1	1	1	1

Table B2: Citation Lag Adjustment by Patent Office for IPC section A: Human Necessities

This table presents citation adjustment factors for individual patent offices (identified by country codes in the table header) adhering to the European Patent Convention (EPC) for Industrial Patent Code class (A). Following Hall et al. (2000), we report the adjustment factor for 29 lags.

		Patent Office												
		AU	AT	BE	CA	CH	DE	DD	ES	FR	GB	JP	SU	US
Lag	0	23.379	53.763	20.646	112.82	77.187	38.131	61.373	210.85	24.295	142.69	8.693	198.44	62.686
	1	11.659	13.998	6.052	27.323	20.038	12.152	17.255	46.903	9.748	29.698	4.266	34.694	27.526
	2	6.897	7.316	4.035	13.893	10.556	7.161	9.255	29.066	6.207	16.232	2.935	15.890	17.196
	3	4.684	4.819	3.347	9.248	6.987	5.255	6.041	21.117	4.733	10.906	2.338	9.872	12.510
	4	3.586	3.587	2.871	6.613	5.272	4.230	4.875	17.972	3.761	8.057	1.974	6.897	9.863
	5	2.917	2.913	2.570	5.160	4.269	3.545	3.924	14.846	3.142	6.183	1.745	5.384	8.157
	6	2.407	2.499	2.324	4.198	3.561	3.063	3.350	8.999	2.716	4.905	1.590	4.351	6.957
	7	2.093	2.190	2.151	3.598	3.066	2.714	2.891	6.360	2.532	3.940	1.479	3.652	6.035
	8	1.858	1.946	2.023	3.161	2.699	2.454	2.562	5.237	2.326	3.416	1.405	3.143	5.318
	9	1.637	1.758	1.909	2.737	2.424	2.226	2.364	3.779	2.084	2.941	1.351	2.729	4.738
	10	1.527	1.644	1.807	2.430	2.220	2.062	2.186	3.093	1.958	2.623	1.313	2.403	4.250
	11	1.445	1.542	1.722	2.185	2.049	1.916	2.015	2.708	1.846	2.388	1.282	2.155	3.843
	12	1.386	1.459	1.651	2.005	1.877	1.794	1.869	2.370	1.749	2.206	1.262	1.969	3.497
	13	1.315	1.395	1.579	1.827	1.734	1.691	1.758	2.139	1.676	2.062	1.248	1.810	3.204
	14	1.275	1.339	1.516	1.702	1.632	1.598	1.661	1.946	1.608	1.935	1.236	1.680	2.950
	15	1.235	1.291	1.451	1.592	1.540	1.521	1.563	1.809	1.561	1.838	1.226	1.573	2.728
	16	1.203	1.261	1.402	1.496	1.467	1.453	1.503	1.693	1.490	1.719	1.217	1.481	2.529
	17	1.174	1.228	1.356	1.423	1.400	1.395	1.440	1.589	1.456	1.608	1.208	1.407	2.344
	18	1.153	1.199	1.316	1.357	1.341	1.340	1.397	1.510	1.431	1.516	1.197	1.341	2.167
	19	1.141	1.174	1.269	1.304	1.294	1.291	1.342	1.417	1.375	1.444	1.187	1.290	1.999
	20	1.129	1.149	1.234	1.261	1.236	1.243	1.304	1.344	1.324	1.391	1.176	1.250	1.848
	21	1.110	1.130	1.197	1.219	1.199	1.209	1.263	1.290	1.276	1.324	1.162	1.212	1.708
	22	1.096	1.113	1.168	1.182	1.167	1.179	1.224	1.243	1.247	1.276	1.146	1.180	1.580
	23	1.084	1.099	1.133	1.152	1.135	1.150	1.191	1.209	1.207	1.238	1.130	1.155	1.465
	24	1.069	1.085	1.107	1.119	1.106	1.124	1.155	1.162	1.163	1.205	1.111	1.129	1.359
	25	1.054	1.066	1.081	1.090	1.080	1.097	1.110	1.121	1.128	1.168	1.091	1.106	1.265
	26	1.041	1.048	1.055	1.066	1.063	1.071	1.081	1.091	1.085	1.136	1.070	1.076	1.180
	27	1.028	1.026	1.033	1.045	1.037	1.046	1.053	1.058	1.048	1.100	1.047	1.047	1.108
	28	1.015	1.015	1.012	1.020	1.018	1.021	1.024	1.024	1.016	1.052	1.023	1.024	1.049
	29	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table B3: Sustainable Patent Tagging Scheme

This table lists the Cooperative Patent Classification (CPC) sub-groups created by the EPO to tag sustainable technologies. Each sub-group was devised in coordination with field experts using the United Nations Framework Convention on Climate Change and the Intergovernmental Panel on Climate Change. For more information see hiips://www.epo.org/news-issues/issues/classification/classification.html

Sub-group	Description	Comment
Y02A	Adaptation to climate change	Technologies for adaptation to climate change, i.e. technologies that allow adapting to the adverse effects of climate change in human, industrial (including agriculture and livestock) and economic activities.
Y02B	Climate change mitigation technologies related to buildings, including housing and appliances or related end-user applications	Integration of renewables in buildings, lighting, HVAC (heating, ventilation and air conditioning), home appliances, elevators and scalators, constructional or architectural elements, ICT, power management
Y02C	Capture, storage, sequestration or disposal of greenhouse gases (GHG).	CO2 capture and storage, also of other relevant GHG
Y02D	ICT aiming at the reduction of own energy use	Information and communication technologies [ICT] whose purpose is to minimize the use of energy during the operation of the involved ICT equipment
Y02E	Climate change mitigation technologies in energy generation, transmission, and distribution	Renewable energy, efficient combustion, nuclear energy, biofuels, efficient transmission and distribution, energy storage, hydrogen technology
Y02P	Climate change mitigation technologies in the production or processing of goods	Metal processing, chemical/petrochemical industry, minerals processing (e.g. cement, lime, glass), agroalimentary industries,
Y02T	Climate change mitigation technologies related to transportation	e-mobility, hybrid cars, efficient internal combustion engines, efficient technologies in railways and air/waterways transport
Y02W	Climate change mitigation technologies related to wastewater treatment or waste management	Wastewater treatment, solid waste mangament, bio packaging
Y04S	Smart grid technologies	Power networks operation, end-user applications management, smart metering, electric and hybrid vehicles interoperability, trading and marketing aspects
Y10S	Technical subjects	Covered by former USPC cross-reference art collections and digests
Y10T	Technical subjects	Covered by former US classifications

Table B4 - R&D expenditures and Sovereign Ownership - IV First Stage

This table presents the first stage of the two-stage least squared (2SLS) regression results from Table 6, where the is instrumented by *Left wing* in column (1), *Left wing* and *Foreign restrictions* in column (2), *Left wing* and *Investment* in column (3), and all three instruments in column (4). Columns (1)-(4) corresponds to the second stage columns in Table 6. *SOE* is an indicator that firm *i* has a domestic sovereign owner in year *t*. Definitions for the firm characteristics can be found in the Variable Appendix. Firm-level characteristics are winsorized at the 1% and 99%. Standard errors are clustered by firm. The numbers in parenthesis are t-statistics. ***, **, and * represent 1%, 5%, and 10% statistical significance levels respectively.

VARIABLES	(1) $SOE_{i,t}$	(2) $SOE_{i,t}$	(3) $SOE_{i,t}$	(4) $SOE_{i,t}$
Left wing $_{j,t}$	-0.110***	-0.110***	-0.106***	-0.106***
	(-3.99)	(-4.14)	(-4.15)	(-4.27)
Investment $_{j,t}$			0.009	0.010
			(1.04)	(1.08)
Foreign restrictions $_{j,t}$		0.005		0.003
		(0.22)		(0.14)
Constrained $_{i,t}$	-0.036***	-0.036***	-0.036***	-0.036***
	(-3.65)	(-3.64)	(-3.64)	(-3.64)
Total assets $_{i,t}$	0.006***	0.006***	0.006***	0.006***
	(2.78)	(2.78)	(2.78)	(2.78)
ROA $_{i,t}$	0.000***	0.000***	0.000***	0.000***
	(5.67)	(5.68)	(5.65)	(5.68)
PPE/TA $_{i,t}$	0.039**	0.039**	0.039**	0.039**
	(2.08)	(2.08)	(2.07)	(2.06)
Debt/TA $_{i,t}$	-0.044*	-0.044*	-0.044*	-0.044*
	(-1.91)	(-1.91)	(-1.90)	(-1.91)
CAPEX/TA $_{i,t}$	-0.023	-0.024	-0.025	-0.026
	(-0.59)	(-0.63)	(-0.65)	(-0.68)
GDP growth $_{j,t}$	-0.705***	-0.698***	-0.740***	-0.736***
	(-3.24)	(-3.10)	(-3.74)	(-3.64)
BERD $_{j,t}$	-1.260**	-1.256**	-1.469**	-1.466**
	(-2.31)	(-2.29)	(-2.21)	(-2.21)
Profit tax subsidy $_{j,t}$	-1.044***	-1.042***	-1.114***	-1.114***
	(-3.74)	(-3.59)	(-4.03)	(-3.92)
Loss tax subsidy $_{j,t}$	0.709**	0.695*	0.724**	0.716**
	(2.18)	(1.88)	(2.33)	(2.06)
Blank R&D $_{i,t}$	-0.021***	-0.021***	-0.021***	-0.021***
	(-4.91)	(-4.88)	(-4.94)	(-4.91)
Crisis $_{j,t}$	-0.146***	-0.144***	-0.138***	-0.138***
	(-3.21)	(-3.06)	(-2.85)	(-2.75)
Observations	23,893	23,893	23,893	23,893
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
SE Clustering	Country	Country	Country	Country