Government Share Ownership and Innovation: Evidence from European Listed Firms

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Abstract

We investigate the impact of government ownership on the innovativeness of European listed firms. We find that firms with minority government stakes invest more in research and development (R&D) than private firms, thanks to relaxed financial constraints. However, firms with majority government stakes invest less due to short-term political priorities distorting managerial objectives and incentives. Our results are robust to propensity score matching and instrumental variables to account for omitted variable bias and the endogenous nature of government ownership. On the output side, despite the higher investment in R&D, minority government ownership has no discernable impact on patent quantity and quality, as measured by citations. Our results indicate that government ownership is not an efficient policy to promote innovation in listed firms.

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1. Innovation and Government Share Ownership

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).

Most of the extant literature on the government's role in innovation has focused on the effectiveness of government subsidies and tax credits in resolving these market failures.[1] Yet, starting from the early days of FDR's Tennessee Valley Authority and Italy's Istituto per la Ricostruzione Industriale, to the more recent multibillion dollar investments in information technology by sovereign wealth funds, governments have shown a commitment to promoting innovation by acquiring ownership and control rights in firms.[2] In the West, interest in government ownership has been buoyed by a series of crises (the banking crisis of 2008-2009 and the COVID-19 economic shock) which led to an expansion in the economic role of governments. In the United States, we see to a new emphasis on industrial policy, with a strong focus on innovation: The plan championed by President Biden involves over USD 220 bn in

[1] 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).

[2] 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; Ma and Downs, 2021).

government investment in research.[3] A full understanding of the role of governments as sponsors of innovation is thus increasingly urgent.

In our empirical analysis, we focus on a sample of publicly traded (listed) European firms with government shareholdings, including both firms with majority and minority government stakes. 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 adopt here a broad definition of the term "Government-Owned Firm (GOF)," encompassing every firm with a domestic government stake greater than zero, even if such stake is a small minority holding.[4] We believe a focus on the link between government ownership and innovation within publicly traded firms to be important for two reasons. First, government stakes in publicly traded firms are increasingly common—while, in the past, the prevalent model of state ownership used to be the large, fully state-owned monopolist, the new model of "state capitalism" is leading to increasing reliance of governments on share ownership in publicly listed firms, especially in Western countries.[5] With governments owning as much as a fifth of all publicly traded equity (Borisova et al., 2012, document that state ownership accounted for nearly 20% of stock market capitalization worldwide in 2011), understanding the impact of government ownership is paramount. Second, theory leads to two-sided predictions. On one side, firms with government stakes could benefit from soft budget constraints leading to greater levels of investment in innovation. On the other side, managers of firms with government stakes—and especially those with large government stakes—might lack the proper incentives or might be subject to political

[3] See The Economist, on Sept 13, 2022, "Joe Biden's industrial policy is big, bold, and fraught with difficulty."
[4] We chose to use here the label "government-owned firm" as we believe it is clearer to a modern audience, rather than the "mixed corporation" label that was used in use decades ago (examples include Eckel and Vermaelen, 1986 and Boardman and Vining, 1989).
[5] 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)."

goals and priorities that detract from risky, long-term investment in innovation. As our findings reveal, these opposing effects lead to a meaningful distinction between small and large government stakes, as any government shareholding—even tiny stakes—leads to implicit debt guarantees and privileged access to financing via state-owned banks, facilitating investment in innovation while only firms with large government stakes appear affected by political priorities depressing long-term investment in innovation.

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 consider only ownership and investment up to the year 2009, so to allow a sufficient time period for investment in research to translate into patents and then for those patents to be subsequently cited (as we use the number of cites as a proxy for quality).

We report that GOFs 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, GOFs differ in 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 in 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 39%.

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 perform two additional tests to show our results appear robust to such concerns.

First, we verify that our findings are robust in a propensity score matched sample. That is, we identify a set of private-sector firms with observable characteristics mimicking GOFs. We then re-estimate our main regression models using this matched sample, confirming our main findings.

Second, we employ a two-stage model to isolate the portion of government ownership that is exogenous to omitted firm characteristics that governments use in ownership selection. This approach mimics Borisova et al. (2015) and Chen et al. (2021) and should minimize concerns that unobservable firm characteristics jointly correlate with government ownership and firm-level R&D. We instrument state ownership using a variable that has been found to be related to state ownership, but which is unlikely to affect firm-level R&D expenditures directly: the political orientation of the ruling executive (left vs. right-wing). 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 identify firms that are more likely to be financially constrained *ex-ante.* We find that the increase in R&D investment associated with the presence of a government shareholder is specific to firms that otherwise have limited access to capital, consistent with the hypothesis that state ownership relaxes such financial constraints. In additional tests, we provide evidence suggesting that GOFs enjoy not only implicit debt guarantees but also privileged access to loans by state-owned banks. In general, in contrast to private firms that tend to finance risky investment in innovation via equity capital (Binsbergen et al., 2010, Korteweg, 2010), our findings suggest that GOFs finance research at least in part via debt—specifically, via loans issued by state-owned banks.[6]

When we focus on the size of the stake owned by the government, we find that, while a minority stake is associated with a higher expenditure on R&D, a large, controlling stake is not—majority state-owned GOFs invest in R&D no more than their private-sector counterparts. We conjecture that all GOFs benefit from a boost in R&D expenditures due to relaxed financing constraints but that short-term political objectives are depressing long-term investment in R&D in firms in which governments exert substantial influence—that is, firms in which governments own large stakes (a "political objectives" hypothesis). In our baseline model, we find that the inflection point is approximately at a stake of 59%; we roughly interpret this as indicating that, when governments have majority control, political priorities prevail. In additional tests, we find that GOFs' investment in R&D drops significantly in the years preceding national elections—and that the effect is driven by majority-owned GOFs. 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 government-controlled firms in India tend to redirect investment towards "visible" capital expenditures around elections. Further buttressing the political objectives hypothesis, we find that GOFs based in countries in which politicians directly appoint managers tend to invest less in innovation.

[6] Our findings are consistent with Giebel and Kraft (2020), who likewise document the strong role of bank financing of corporate innovation in Germany.

Yet, we still do not know whether this increase in innovation investment produces meaningful intellectual property. In a multivariate setting, we analyze the impact of government shareholding on 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 GOFs invest substantially more in R&D and are significantly less efficient than private firms in producing patents. This is consistent with the descriptive statistics—the ratio of R&D expenditure to patent count reveals that GOFs produce one patent for every USD 3.23 million invested in R&D, while private sector firms produce one patent for every USD 2.33 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 of innovation. We use citations as a proxy for the quality of patents and find that GOF patents are cited just as often as private-sector patents.

In conclusion, while we recognize that positive spillovers could stem from enhanced R&D investment by publicly listed firms with minority government shareholders, our results cast doubts about the effectiveness of government share ownership as an effective policy in promoting innovation. While government stakes lead to a higher level of investment by facilitating access to capital, they also distort managerial priorities, especially when governments own controlling stakes and when politicians have the ability to appoint GOF managers. Further, higher levels of investment in innovation do not translate into higher levels of output, suggesting that the additional spending by GOFs is largely wasteful. Our findings are consistent with extant literature finding that state ownership is associated with lower levels of investment efficiency (Jaslowitzer et al., 2016; Chen et al., 2017).

Our manuscript sits at the conjunction of two streams of the empirical corporate finance literature: the literature on government ownership and that on corporate innovation. 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). A related stream of the literature has investigated the effect of state ownership of privatized firms on cash holdings (Chen et al., 2018), on stock liquidity (Boubakri et al., 2020), CSR intensity (Boubakri et al., 2019), trade credit (Chen et al., 2021), and investment efficiency (Chen et al., 2017). We confirm that government minority stakes have a strong impact on firm operations. This impact is distinct from the one originating from the residual government control in privatized firms, which is 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 the non-linear effect of government stake size on investment in innovation.

A recent branch of the empirical literature has focused on the link between innovation and government ownership in China (Fang, Lerner, and Wu, 2017; Rong, Wu, and Boeing, 2017; Zhou, Gao, Zhao, 2017; Cao, Cumming, and Zhou, 2018; Genin, Tan, and Song, 2021; Sun, Deng, Wright, 2021). We note that state ownership in China is likely to have a very different impact than state ownership in Western and 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 a lack of data on patent citations, which is troublesome, given concerns about frivolous patents.

Two manuscripts that are not directly about innovation nevertheless offer additional findings related to the link between government ownership and innovation. Boubakri et al. (2018) analyze the relation between government ownership and market valuation for listed Asian firms—and they find that government stakes between 30 and 50% lead to higher firm valuations. In attempting to explain this finding, they document that government ownership is not related to the level of R&D intensity of the firm (R&D expenditures scaled by sales). Chen et al. (2018) examine the allocation of cash in capital budgeting at partially privatized firms, and find that excess cash held by state owned firms is not spent on R&D but on acquisitions. Our findings differ, as we document a significant impact of minority government ownership on firm investment in innovation. One possible explanation lies simply in the different samples we use. Boubakri et al. (2018) focus on Asian firms, whereas our focus is on Europe. Chen et al. (2018), on the other side, focus on firms undergoing privatizations. Interestingly, both manuscripts document evidence of deleterious effects linked to large government stakes, consistent with our own evidence, presumably due to deteriorating governance effects.

Finally, Munari et al. (2010) study the effect of corporate governance on R&D investment by considering the different types of controlling shareholders in a sample of firms from six European countries and do not find any statistically significant relationship between the controlling stake held by the state and firms' R&D intensity. The estimated coefficient linking the government stake to R&D investment is negative, as in our analysis, but not statistically significant. Once more, there are significant differences between the sample in this manuscript and our analysis. Munari et al. (2010) focus on 1,088 publicly traded firms from France, Germany, Italy, United Kingdom, Norway, and Sweden, during a single year, 1996. In contrast, our sample is much more recent, spans twenty-four European countries, and is about four times as large in terms of the number of firms covered; our analysis is in a panel rather than purely cross-sectional. Our own evidence is consistent with case studies by Munari (2002), documenting that Italian and French firms reduce investment in R&D following privatizations.

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; Kong, 2020) 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 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 equity investments 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, Sorensen, and Strömberg (2011), Tian and Wang (2014), and Brav, Jiang, Ma, and Tian (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.

2. Hypotheses

The past two decades have seen not just an increase in government ownership of firms, following a previous wave of privatizations in Western markets, but also substantial changes in the dominant type of state governance. 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 is the government ownership of minority stakes in publicly traded firms (Bortolotti and Faccio, 2009; Megginson and Fotak, 2015). 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 even with minority shareholdings. 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; Nanda and Rhodes-Kropf, 2017). Governments are, instead, long-term, (mostly) patient shareholders with multi-generational investment horizons (Redding, 2005; Musacchio et al., 2015; Benito et al., 2016; Rygh, 2018; Bass and Chakrabarty, 2014; Filatotchev et al., 2007; Grøgaard et al., 2019), and a greater propensity to finance activities that generate social returns (Vernon, 1979; Shleifer, 1998; Kahan and Rock, 2010; Boubakri, 2019), such as R&D (Nelson, 1959; Arrow, 1962). Governments are also often willing to accept higher levels of risk in their investment (Vernon, 1979), partially due to the fact that government portfolios of firms tend to be highly diversified (Arrow and Lind. 1970; Filatotchev, Strange, Piesse, and Lien, 2007; Fogel, Morck, and Yeung, 2008; Grøgaard et al., 2019; Rygh, 2018; Samuelson and Vickrey, 1964). In addition, GOFs benefit from the possibility of a bailout (Benito et al., 2016; Cui and Jiang, 2012; Knutsen et al., 2011), which should similarly lead to more investment in risky activities, such as R&D. Finally, government ownership, by providing implicit debt guarantees and access to state-owned banks, could also relax external financial constraints: even a small government stake can act as a signal to both private-sector and state-owned investors, indicating the presence of implicit guarantees leading to lower risk of default, and hence greater access to funding (Borisova and Megginson, 2011; Borisova et al., 2015; Boubakri et al., 2015). Hence, our first hypothesis, a "soft budget constraints" hypothesis, is that:

H1: GOFs invest more in R&D than private-sector firms.

Aside from a purely financial channel of impact, state ownership might affect managerial incentives and corporate governance. For example, managerial compensation at state-owned firms tends to be less responsive to performance than private-sector compensation (Bos, 1991; Vickers and Yarrow, 1988; Borisova, Salas, and Zagorchev, 2019) and managers are often insulated from private-sector investor oversight (Krueger, 1990) or takeover threats (Su and Xue, 2023). This insulation from external oversight is often compounded by a lack of transparency in state-owned enterprises attempting to hide the political nature of their investment decisions (Bushman et al., 2004; Chaney et al., 2011; Guedhami et al., 2009). Weaker incentives could lead to under-exertion of effort and excessive risk-aversion, implying suboptimal investment in risky activities—the "agency" hypothesis.

The impact of state ownership on firm governance could also manifest itself by affecting the ultimate objectives of management. Vernon (1979) notes that sovereign owned enterprises tend to focus not just on shareholder wealth maximization but tend to incorporate social goals, such as national well-being, into their priorities. Consistently, a stream of the literature finds that state owned enterprises tend to prioritize job creation, with the ultimate goal of promoting social stability (Redding, 2005; John, Litov, and Yeung, 2008; Bai, Lu, and Tao, 2006). Other social goals pursued by state owned enterprises include economic development, national security, and the provision of underpriced goods and services (Boubakri et al., 2008). Hence, state ownership could impose short-term social and political goals (Shleifer, 1998; Kahan and Rock, 2010), diverting resources away from investments with long-term payoffs such as R&D —the "political objectives" hypothesis. A large government stake thus 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).

We expect the impact of government ownership on firm governance (both under the "agency" and "political" views) to manifest itself when governments own large stakes in firms. Our hypothesis is consistent with Benito et al. (2016), Grøgaard et al. (2019), Inoue et al. (2013), and Lazzarini and Musacchio (2018), who find that smaller government stakes lead to a lower likelihood of government interference in firm governance. It is also consistent with a large privatization literature that finds that governance improvements in firms undergoing privatization do not materialize until governments relinquish controlling stakes (Boubakri and Cosset, 1998; D'Souza and Megginson, 1999; Guedhami et al., 2009; Megginson et al., 1994). Finally, it is consistent with studies on the impact of government ownership that find deleterious effects linked to large government stakes. Among those, Boubakri et al. (2018) find that government stakes between 30 and 50% increase firm value but that larger stakes decrease it, presumably due to deteriorating firm governance; Chen et al. (2018) similarly find that markets discount the value of cash holdings by firms with large government stakes; Frydman et al. (2000) find that partially privatized firms controlled by outsiders perform better than partially privatized firms controlled by governments; Borisova et al. (2012) document that high levels of state ownership are associated with weak corporate governance.

Accordingly, while for small-government-stake firms we expect a higher level of R&D investment, compared to private-sector firms, for large-government stake firms, we do not have a clear prediction, as they are subject to both soft financing constraints (pushing towards a higher level of R&D investment) and governance effects (agency costs and political priorities lowering R&D investment). Hence, the net impact of large government stakes against the benchmark of private-sector ownership is a matter ripe for empirical observation. Yet, we can formulate a clear, one-sided hypothesis when comparing small government stakes (associated with softer financing constraints) and large government stakes (associated with both softer financing constraints and governance effects—agency costs and political objectives). This leads us to a second hypothesis:

H2: GOFs with larger government stakes invest less in R&D than GOFs with small government stakes.

3. 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 GOFs and private-sector firms.

3.1 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-level 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 European Patent Convention (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.[7]

While our focus is on the impact of state ownership 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. Hence, our specifications are robust to concerns regarding the substitutability of tax incentives and government access to capital.

3.2 Government Share Ownership in Listed Firms

We obtain data on government ownership from the Bureau van Dijk Orbis database.[8] We define a firm as a "Government-Owned Firm" (GOF) if the government owns any share of

[7] 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 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. The citation lag distribution for each IPC class is available from the authors.

[8] We identify "direct" government stakes as those owned entities defined as "public authorities," "states," or "governments" in Orbis. We also identify "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 total government ownership (the sum of direct and indirect), we track indirect stakes up to ten-levels down the ownership chain. In addition, we complement our 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

voting rights in the firm. 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.

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.[9] 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.[10] Of the government-owned firms, 57 have an average government stake exceeding 50%, while the rest (1,240) have minority government 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 GOF and non-GOF samples contain a large proportion of manufacturing firms (46% of the

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 majority government stakes, and over 80% of minority (in the 25% to 50%) government stakes.

[9] 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.

[10] 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.

GOF sample and 39% of the non-GOF sample) and firms in the service industry (21% and 30%). "Transportation and Public Utilities" constitute about 13.5% of the GOF sample and 9.5% of the non-GOF sample, while "Retail Trade" and "Mining and Construction" each constitute about 10% of both the GOF and non-GOF sample. We report the country-level distribution of the firms in our sample in Table 1, Panel B. For four countries, we have no usable observations with complete data; accordingly, our empirical samples span twenty-four countries. The United Kingdom accounts for 44.02% of firms in our sample, France for 12.25%, Germany for 11.49%, and Italy for 4.99%.

3.3 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 comparisons. 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. We adjust all monetary values to the base-year 2004, using the Consumer Price Index (Urban) data from the St. Louis Federal Reserve.[11]

[11] 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.

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:

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

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 Pierce formulation, size is replaced with log ($4.5 billion) and age with 37 years if the actual values exceed those thresholds.[12]

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*).

3.4 Other Data

We obtain data on financial crises from the database described in Laeven and Valencia (2013). Elections data is from the Comparative Political Data Set. [13] We complement the data with press reports to identify which national elections are unscheduled. Data on country-level

[12] 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.

[13] 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.

legislation restricting CEO performance pay and on the appointment of GOF managers is from the OECD "Ownership and Governance of State-Owned Enterprises: A Compendium of National Practices."[14] 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. Total investment at the country-year level, defined by the IMF as gross fixed capital formation and changes in inventories and acquisitions minus disposals of valuables for a unit or sector, is taken from the IMF World Economic Outlook Database. Country-level data, including data on the proportion of deposits in private sector banks (which we use as 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).

3.5 Descriptive Statistics

Our final sample contains 23,893 firm-years, spanning 2000 to 2009, with non-missing data. Of those, 20,097 are non-GOFs, while 2,796 are GOFs (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 government-owned and private-sector samples are highlighted in Table 2. GOFs are much larger, with total assets over USD 6 billion, compared to USD 1.9 billion for non-GOFs. Further, GOFs are more profitable, with a higher return on assets, and have a higher proportion of tangible assets. GOFs and non-GOFs do not differ significantly in leverage or capital expenditures. GOFs are slightly

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

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, GOFs invest more in R&D than private-sector firms (GOFs invest on average USD 51.9 million in R&D, non-GOFs USD 16.45 million). GOFs produce, on average, approximately 16 patents each year versus 7 patents for non-GOFs—the ratio of these statistics reveals fewer patents "for each dollar invested" for GOFs: GOFs produce 0.31 patents for each USD 1 million invested in R&D, while non-GOFs produce 0.43—or, conversely, a GOF patent costs on an average $3.23 million, versus $2.33 million for a private-sector patent. GOFs and non-GOFs do not differ significantly in the average number of citations per patent (10.7 for GOFs and 8.52 for non-GOFs, but the difference is not statistically significant). We also note that, despite the higher average level of R&D investment, GOFs are less likely to report investment in R&D (only 52.5% of GOFs in our sample report investment in R&D, versus 64.6% of private-sector firms).

We further compare the characteristics of specific subsets of the data – firms with minority government stakes and controlling government stakes—to the same baseline (firms with non-government stakes). For the sake of brevity, we note that firms with minority government stakes resemble the "overall" GOF subsample. Those firms are larger than non-GOF firms, spend more on R&D, produce more patents but fewer patents per dollar invested in R&D, and display slightly higher, but not statistically significantly different, citation counts. In contrast, firms with controlling government stakes spend more on R&D but are otherwise more akin to non-GOF firms than to minority-GOF firms.

4. 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 and on patent quality (proxied by citations).

4.1 Government Ownership and R&D Investment, Baseline Regressions

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

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

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, *GOF*, 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. All firm-level variables are expressed in USD, where relevant, and winsorized at the 1^{st} and 99^{th} percentiles to mitigate the impact of outliers or bad data points.

We further recognize that R&D investment data is often missing in our dataset: R&D expenditures are missing for 64.6% of GOF firm-years and 52.5% of private-sector firm-years. Consistent with extant literature, we assume that a missing data point indicates no investment in research and development. In this model, to minimize the impact of this assumption, we add a variable identifying observations with non-reported R&D expenditures (*BlankR&D*). In additional untabulated results, we replicate our analysis in the subset of firms with non-missing R&D expenditures and find consistent results.

Further, we recognize that governments might subsidize innovation via other means (rather than direct ownership of productive assets). Accordingly, we control for time-varying 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 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 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, *GOF*, 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 spending. The model allows us to estimate an inflection point, as the simple ratio of the coefficient estimates on the *GOF* dummy (0.471) and the coefficient estimate on *Stake* (0.008). The estimated inflection point is at a stake of approximately 59%. In other words, when a government owns a stake exceeding 59%, the political priorities prevail and neutralize the impact of reduced financing constraints. We recognize that there is some measurement error in all variables and suspect that our findings indicate that a majority stake (exceeding 50%) leads to political priorities affecting long-term investment decisions.

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 *GOF* is positive and significant at the 1% level, while the coefficient on *Control* is negative and statistically significant at the 10% level. These findings again 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 between 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 on 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 three columns of Table 3, we show that clustering by year, industry, or firm 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.

4.2 Mitigating Selection Bias via Propensity Score Matching

Descriptive statistics reveal systemic differences between government-owned and non-government-owned firms. For example, GOFs tend to be larger and more profitable. These systemic differences might be correlated with the degree of innovativeness of firms. While we attempt to control for these systemic differences in our regression analysis, we recognize that reverse causality and correlation among dependent variables might affect our findings. Accordingly, we try to mitigate those biases via propensity score matching (PSM). The main goal here is to identify non-GOFs that more closely resemble GOFs, to offer a better benchmark sample.

In the first-stage regressions, the response is a binary variable, set equal to one if the firm has a non-zero government stake in the year of interest (year *t*), and zero otherwise. The set of right-side variables mirrors the firm-level and country-level variables we use as controls in Table 3 and in subsequent analysis, all as of the end of the previous year (year *t*-1). We wish to find matches for each government-owned firm at the very beginning of our sample period, so we can then use the same match (or matches) for all subsequent analyses. The first year for which we have full firm-level data is 2000. Hence, we regress government ownership as of the end of the year 2001 on right-side variables as of the end of the year 2000. The model coefficients are estimated via probit regressions. We do not tabulate the results for brevity, but we find that consistent with the univariate findings, government ownership is associated with larger firms (as measured by total assets), more profitable firms (ROA), less financially constrained firms, higher levels of capital investment, higher rates of GDP growth, higher levels of support for innovation via grants and profit tax subsidies, but lower levels of loss tax subsidies. We then use the estimated coefficients to compute a "predicted probability" of a firm being government-owned ("*p*-score"). Then, for each GOF in our sample, we pick the two "nearest neighbors"—the two non-GOF firms with the closest (smallest absolute difference) *p*-scores. We test for differences in means between the sample of GOFs and the propensity-score matched sample (also untabulated, for brevity). While similar tests between GOFs and the universe of private-sector firms reveal significant differences in most operating performance metrics, we find that GOFs resemble the propensity score matched set of firms in virtually all dimensions. Some exceptions remain: GOFs are more profitable and have slightly lower leverage. Overall, we note that PSM mitigates selection biases but does not solve them completely.

We then include the two selected "nearest neighbors" and the same GOFs in a set of regressions resembling those in Table 3. Our findings are presented in Table 4. Our main inferences remain unchanged. Government stakes are associated with larger investments in R&D, but the effect appears specific to minority government ownership; majority government stakes are associated with positive, but not statistically significant, coefficients. In untabulated robustness tests, we find that using one-to-one matching or "five neighbors" produces consistent findings.

4.3 Mitigating Selection Bias via Instrument Variable Tests

We run a second set of robustness tests aimed at reducing endogeneity concerns by implementing an instrumental variable approach. An instrument variable is attractive in this setting as a successful instrument should remove any correlation between our variable of interest, *GOF*, and potentially unobservable characteristics that bias our main estimates. As is typically the case, the emphasis shifts to selecting instruments that meet the exclusion criteria and only influence firm level R&D investment through their influence on government ownership.

Mirroring Beck et al. (2001), Borisova et al. (2015), and Chen et al. (2021), we use, as an instrument, a variable likely to be exogenous to the firm level R&D outcome we intend to estimate in the second stage: *Left wing*. *Left wing* is a binary variable identifying the political party of the nation's chief executive in a given year; our construction of this variable mirrors 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. Our expectation is for *Left wing* to be positively related to the likelihood of government ownership.

Results are presented in Table 4. 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 post-2000 Europe, with a decline in government ownership on a "within-country" basis (our model includes 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 note that the Kleibergen and Paap (2006) rk LM statistic for the under-identification test is 5.892, with a *p*-value of 0.0152. This test suggests that our instrument is relevant. On the other side, we obtain mixed results in testing for weak identification. The Cragg-Donald (1993) Wald *F* statistic is estimated at 275.112, which is well above critical values at conventional levels of significance.

Yet, the Kleinberg-Papp rk Wald *F* statistic is estimated at 15.95. Stock and Yogo's (2005) critical value is 16.38—hence, we cannot reject the null hypothesis that our instruments are weak based on a conventional bias cutoff of 10%. We note, however, that Stock and Yogo's critical values, while commonly employed, presuppose an over-identified set of instrumental variables, which is not the case here. The general rule of thumb, with one-endogenous-variable-one-instrument settings, is to use 10 as a critical value—in which case, we would reject the null and conclude that our instrument is not weak. Overall, we conclude that our instrument is relevant, but we note that results should be interpreted with care, as tests for weak instruments produce mixed findings.

In the second stage, we find that the instrumented variable *GOF* is associated with a positive and statistically significant coefficient. Overall, our results are robust to this instrumental variable approach.

4.4 Government Ownership versus Institutional Ownership

In additional, untabulated robustness tests, we control for institutional ownership.[15] Due to data limitations, we lose a 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 GOF 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

[15] 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."

(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.

4.5 Government Ownership and Financial Constraints

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 *ex ante*. 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).[16] We add binary variables identifying those groups (using NFC firms as the base) and their interactions with *GOF* 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 5 are consistent with our expectations. The coefficient associated with *GOF* 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 GOFs—the interaction effect estimate

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[16] Our approach mirrors Hadlock and Pierce (2010; "HP" for brevity), but we use three groups, whereas they classify firms in a more granular fashion into five groups. While they do not report exact cutoff points, the means and medians of the five groups, from most to least constrained, are reported by HP as NFC, −3.678/−3.600; LNFC, −2.921/−2.973; PFC, −1.884/−2.058; LFC, −1.483/−1.620; and FC, −1.495/ −1.610. Accordingly, our "not financially constrained" group includes observations falling mostly in the NFC and LNFC groups in HP. Our "partially financially constrained" group roughly corresponds to the PFC group in HP. Our "financially constrained group" includes observations falling mostly in the "LFC" and "FC" groups in HP.

reveals that GOFs 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 *GOF*, 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 GOFs (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 GOFs 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 some of 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 GOFs, compared to private-sector firms.

4.6 Government Ownership and Loans

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 (2020). 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 (*Bank Loan*) and to government loans (*Gov Loan*), scaled by total firm debt (as of December 31st of the previous year). We add these variables and their interactions with *GOF* 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. We find, in the results presented in Table 6, that the total amount of syndicated lending is negatively related to R&D expenditures for all firms, both private and GOFs, but we find no evidence of a differential impact for GOFs versus private-sector firms. This appears to reflect a general reluctance by private banks to finance R&D, confirming the results presented in Table 5. 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 GOFs. 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 GOFs for R&D investment.

In additional tests, presented in column 3 of Table 6, we isolate non-government loans (*Non-gov Loan*) and find that loans from non-state-owned banks are not related to investment in R&D in GOFs. Finally, in the last column in Table 6, we confirm that the main findings persist when including variables identifying government and non-government loans in the same model.

4.7 The Majority GOF Puzzle

The baseline findings presented in the previous tables present a puzzling result, namely that minority GOFs invest more in R&D than private-sector firms, but that majority GOFs do not. Our findings strongly suggest that the increased investment in innovation by GOFs 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 GOFs, while majority government-owned GOF investment is similar to private sector firms. Preferential access to funding available to firms with minority government stakes should affect those majority stakes 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. A second competing hypothesis is that controlling stakes allow governments to appoint managers who may lack incentives to invest capital in risky activities – the "weak managerial incentives" hypothesis.

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 GOF prior to scheduled elections. We further hypothesize this impact would be particularly strong at majority GOFs, 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 *GOF*. We present the results in the first column of Table 7. 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 decline in investment among private-sector firms is consistent with a large literature finding a decline in corporate investment due to election-induced uncertainty (for example, Julio and Yook, 2012). Our interest lies in documenting whether government-controlled firms curtail investment in R&D more than private-sector firms prior to an election. The interaction with *Pre election* × *GOF* 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 interaction 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 GOFs, indicating a further drop in R&D investment by 14.8%, statistically significant at the 5% level. In other words, while GOFs invest 54% more in R&D than private-sector firms during non-election years, they invest only 39% 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 7, 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 GOFs than for private sector firms and even stronger for GOFs 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 *GOF* 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 GOF 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.

We further 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 GOFs 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 GOFs' reluctance to invest in innovation is due to a lack of incentives associated with government control versus the imposition of political goals shown above. We construct a new test based on two country-level variables measuring, respectively, whether high-level managers of state-owned firms are appointed by politicians (*Political mgr*) and whether those managers can be compensated with performance-related incentives (*Performance pay*).[17] We add those variables, and relevant interactions, to the base regression models. We present the results in Table 8. 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. We note that the effect is specific to minority government ownership. However, in firms that are minority government owners, the effect is mitigated by high-level managers being appointed by politicians. GOFs with politically appointed managers still invest more in R&D than private sector firms, but not as much as GOFs without politically appointed managers. We hypothesize that the effect is specific to small government stakes because, for firms with majority government ownership, political priorities dominate regardless of the nature of management (politically appointed or not). In contrast, performance pay 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.

4.8 Government Ownership and the Quantity of Innovation

The previous analysis focuses on the inputs of the innovation process, that is, expenditure on R&D. Our main findings indicate that GOFs invest more in R&D. Yet, we do not know whether this additional expenditure translates into a higher innovation output. We have reason to suspect that government ownership and control affect the efficiency of the process. First,

[17] These two variables are based on a report by the Organization for Economic Cooperation and Development, (OECD Corporate Governance of State-Owned Enterprises) dated 2005. Accordingly, the variables are static. While the OECD has not released similar multi-country studies more recently, they have released single-country and regional studies over the subsequent years. We have compared the 2005 dataset with following-year dataset for the countries for which such data is available, and found no substantial changes, which gives us some degree of reassurance in using this data. We nevertheless recognize that the static nature of this dataset is a limitation of this test.

favorable access to capital could lead government-owned firms to over-invest in innovation; this over-investment could lead to the acceptance of marginal projects with diminishing return-on-investment. In addition, 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 leading to under-exertion of efforts (Borisova et al., 2012) or less risk taking (Boubakri, Cosset, and Saffar, 2013), 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). Our priors are also consistent with a vast literature finding that state ownership is associated with lower levels of investment efficiency (Jaslowitzer et al., 2016; Chen et al., 2017). 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.

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 9, we focus on a two-year investment-intellectual property lag; 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 9 indicate that GOFs 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 9, we identify minority and majority government stakes separately 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, suggests 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 GOF and government minority shareholding (in the third and fourth column of Table 9) are negative and statistically significant (albeit only at the 10% level). The results presented in the last column of Table 9 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).

Our findings related to financial constraints indicate that the impact of government ownership in leading to higher levels of R&D investment is specific to ex-ante financially constrained firms. Accordingly, if the additional investment is indeed wasteful, we would expect this effect to be particularly discernable in ex-ante financially constrained firms. To test this, we replicate the analysis by adding dummy variables identifying financially constrained firms (partially constrained and constrained) and their interaction with *GOF*, *Minority*, and *Control*, to the models tested in columns 1 and 2. Our findings reveal government ownership to not be associated with the count of patents in any subgroup we investigate, regardless of the size of the government stake or the ex-ante level of financial constraints (we leave the results untabulated for brevity).

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 GOFs 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 state-owned enterprises. Our findings are also consistent with Chen et al. (2017), who similar document that state ownership has an adverse effect on investment efficiency. 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 state-owned enterprises 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 compared to other institutional blockholders.

4.9 Government Ownership and the Quality of Innovation

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 its 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.

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 10 indicate that GOFs 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 columns of Table 10, 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 GOFs are not significantly different from those produced by private-sector firms.

As we did with the prior tests in Table 9, we replicate the analysis by adding dummy variables identifying financially constrained firms (partially constrained and constrained) and their interaction with *GOF*, *Minority*, and *Control*, to the models tested in columns 1 and 2. Our findings reveal government ownership to not be associated with the quality of patents in any subgroup we investigate, regardless of the size of the government stake or the ex-ante level of financial constraints (we leave the results untabulated for brevity).

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.

5. 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. Yet, our evidence suggests that research and development expenditures for government majority-owned firms are similar to the expenditures of 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 GOFs, despite investing more in R&D, do not produce more patents, suggesting lower efficiency in the innovation process. For minority GOFs, we find no evidence of a difference in patent quality.

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, qualitatively 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 state-owned enterprises 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, grants, financing research through educational institutions or think tanks, and 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 leave those questions to future research.

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Table 1: Summary Statistics

This table provides summary statistics for European publicly listed Government-Owned Firms (*GOFs*) versus firms without government stakes (*non-GOFs*) over the years 2000-2009. Panel A tabulates the number and proportion of firms (GOFs and non-GOFs) by industrial sector (one-digit SIC code). Panel B tabulates the number and proportion of firms by the country of headquarters 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-GOF		GOF	
	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
CitePer $_{i,t}$	23,893	8.768	68.51	0	0	0
GOF $_{i,t}$	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

Table 2: Summary Statistics – GOF vs. Private-sector Firms

This table provides a comparison of mean summary statistics for firms without government stakes (non-GOFs), European publicly listed Government-Owned Firms (GOFs), and two subsets of the latter sample, respectively, with minority and majority (controlling) government stakes, over the years 2000-2009. Variables are defined in appendix Table A1. The table presents the number of observations and means for five data subsets and the results of two-sided two-sample *t*-test comparing the difference in means between the Non-GOF firm-years and firm-years in the GOF, Minority, Control, and GOF-indirect categories. Statistical differences at the 10%, 5%, and 1% levels are represented by *, **, and ***, respectively.

Variable	Non-GOF	GOF	Minority	Control
lnR&D $_{i,t}$	2.82	4.42***	4.5***	2.93
R&D ($M) $_{i,t}$	16.4	51.9***	52.1***	47.4***
Count $_{i,t}$	7.06	16.1***	16.3***	12.1
Citations $_{i,t}$	223	463***	473***	284
CitePer $_{i,t}$	8.52	10.7	10.4	14.6
HP index $_{i,t}$	-1.62	-1.86***	-1.85***	-2.01***
Total assets ($B) $_{i,t}$	1.9	6.05***	5.81***	10.4***
ROA (%) $_{i,t}$	-1.81	2.69***	2.61***	4.28***
PPE/TA $_{i,t}$	0.257	0.279***	0.264	0.549***
Debt/TA $_{i,t}$	0.21	0.216	0.215	0.245**
CAPEX/TA $_{i,t}$	0.0534	0.0521	0.0512*	0.069***
GDP growth $_{j,t}$	0.0646	0.00991***	0.00527***	0.0936***
BERD $_{j,t}$	0.0847	0.0793***	0.0791***	0.0832
Profit tax subsidy $_{j,t}$	0.0797	0.0794	0.0804	0.0624**
Loss tax subsidy $_{j,t}$	0.0604	0.0655***	0.0664***	0.0497
Blank R&D $_{i,t}$	0.646	0.525***	0.517***	0.673
Crisis $_{j,t}$	0.198	0.589***	0.61***	0.197
Pseudo blank $_{i,t}$	0.0321	0.0318	0.0294	0.0748***
Private deposits $_{j,t}$	9.05	8.96**	8.99*	8.54***
Political mgr $_{j}$	0.58	0.405***	0.414***	0.252***
Performance pay $_{j}$	0.617	0.581***	0.603	0.184***
Observations	21,097	2,796	2,649	147

Table 3: R&D expenditures and State Ownership

This table presents 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 firms over the years 2000-2009. *GOF* 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 in the first four models and by year, industry, and firm, respectively, in the last three models. Two-sided *t*-statistics are reported in parenthesis. ***, **, and * represent 1%, 5%, and 10% statistical significance levels respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	$lnR\&D_{t+1}$	$lnR\&D_{t+1}$	$lnR\&D_{t+1}$	$lnR\&D_{t+1}$	$lnR\&D_{t+1}$	$lnR\&D_{t+1}$	$lnR\&D_{t+1}$
GOF $_{i,t}$	0.403***	0.471***	0.432***				
	(5.08)	(8.15)	(6.23)				
Minority $_{i,t}$				0.432***	0.432***	0.432***	0.432***
				(6.23)	(7.64)	(5.79)	(5.85)
Stake $_{i,t}$		-0.008*					
		(-1.91)					
Control $_{i,t}$			-0.503*	-0.071	-0.071	-0.071	-0.071
			(-1.74)	(-0.22)	(-0.50)	(-0.55)	(-0.28)
Constrained $_{i,t}$	-0.603***	-0.601***	-0.602***	-0.602***	-0.602***	-0.602***	-0.602***
	(-9.96)	(-9.87)	(-9.89)	(-9.89)	(-19.84)	(-5.57)	(-11.06)
Total assets $_{i,t}$	0.094***	0.094***	0.094***	0.094***	0.094***	0.094***	0.094***
	(20.90)	(20.97)	(21.02)	(21.02)	(18.02)	(12.44)	(18.12)
ROA $_{i,t}$	0.003	0.003	0.003	0.003	0.003***	0.003**	0.003***
	(1.49)	(1.48)	(1.48)	(1.48)	(4.13)	(2.41)	(2.60)
PPE/TA $_{i,t}$	-0.059	-0.045	-0.050	-0.050	-0.050	-0.050	-0.050
	(-0.49)	(-0.35)	(-0.40)	(-0.40)	(-0.86)	(-0.44)	(-0.42)
Debt/TA $_{i,t}$	-0.658***	-0.662***	-0.661***	-0.661***	-0.661***	-0.661***	-0.661***
	(-4.23)	(-4.24)	(-4.26)	(-4.26)	(-9.45)	(-5.30)	(-5.04)
CAPEX/TA $_{i,t}$	-0.206	-0.234	-0.222	-0.222	-0.222	-0.222	-0.222
	(-0.62)	(-0.72)	(-0.68)	(-0.68)	(-1.02)	(-0.67)	(-0.68)

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) $lnR\&D_{t+1}$	(7) $lnR\&D_{t+1}$
GDP growth $_{j,t}$	-0.300	-0.255	-0.275	-0.275	-0.275	-0.275	-0.275
	(-0.72)	(-0.61)	(-0.65)	(-0.65)	(-0.46)	(-0.75)	(-0.79)
BERD $_{j,t}$	0.926	1.072	1.000	1.000	1.000	1.000	1.000
	(1.00)	(1.19)	(1.11)	(1.11)	(0.93)	(0.51)	(0.72)
Profit tax subsidy $_{j,t}$	0.952*	1.003**	0.959*	0.959*	0.959	0.959	0.959
	(1.95)	(2.11)	(2.01)	(2.01)	(1.20)	(1.22)	(1.31)
Loss tax subsidy $_{j,t}$	-0.797**	-0.840***	-0.794**	-0.794**	-0.794	-0.794	-0.794
	(-2.60)	(-2.84)	(-2.65)	(-2.65)	(-0.90)	(-0.95)	(-0.94)
Blank R&D $_{i,t}$	-6.730***	-6.730***	-6.729***	-6.729***	-6.729***	-6.729***	-6.729***
	(-22.00)	(-21.98)	(-21.98)	(-21.98)	(-71.19)	(-46.93)	(-73.29)
Crisis $_{j,t}$	-0.033	-0.026	-0.030	-0.030	-0.030	-0.030	-0.030
	(-0.72)	(-0.54)	(-0.65)	(-0.65)	(-0.50)	(-0.57)	(-0.47)
Constant	7.928***	7.951***	7.943***	7.943***	7.943***	7.943***	7.943***
	(28.39)	(28.93)	(28.93)	(28.93)	(26.73)	(27.19)	(24.17)
Observations	23,893	23,893	23,893	23,893	23,893	23,893	23,893
Year FE	YES	YES	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES	YES
SE Clustering	Country	Country	Country	Country	Year	Industry	Firm
# Clusters	24	24	24	24	10	71	4246
R-squared	0.758	0.759	0.759	0.759	0.759	0.759	0.759
Adj R-squared	0.757	0.757	0.757	0.757	0.757	0.757	0.757

Table 4: R&D Expenditures and State Ownership, PSM and IV

This table presents 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 firms over the years 2000-2009 with a non-zero government stake, and a propensity score matched benchmark sample. *GOF* 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. The last two columns contain results from an instrumental-variable approach, in which *GOF* is instrumented by *Left wing*. 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)	(2)	(3)	(4)	1st Stage IV	2nd Stage IV
VARIABLES	$lnR\&D_{t+1}$	$lnR\&D_{t+1}$	$lnR\&D_{t+1}$	$lnR\&D_{t+1}$	$GOF_{i,t}$	$lnR\&D_{t+1}$
$GOF_{i,t}$	0.302**	0.319**	0.309**			1.205**
	(2.24)	(2.73)	(2.43)			(-2.1)
$Minority_{i,t}$				0.309**		
				(2.43)		
$Stake_{i,t}$		-0.002				
		(-0.51)				
$Control_{i,t}$			-0.100	0.208		
			(-0.29)	(0.53)		
Left wing					-0.110***	
					(-3.99)	
$Constrained_{i,t}$	-0.760***	-0.759***	-0.759***	-0.759***	-0.036***	-0.575***
	(-13.50)	(-13.46)	(-13.47)	(-13.47)	(-3.65)	(-9.44)
Total $assets_{i,t}$	0.072***	0.072***	0.072***	0.072***	0.006***	0.089***
	(8.73)	(8.75)	(8.84)	(8.84)	(2.78)	(13.68)
$ROA_{i,t}$	0.009***	0.009***	0.009***	0.009***	0.000***	0.002
	(5.61)	(5.66)	(5.66)	(5.66)	(5.67)	(1.37)
$PPE/TA_{i,t}$	-0.090	-0.085	-0.087	-0.087	0.039**	-0.094
	(-0.54)	(-0.51)	(-0.53)	(-0.53)	(2.08)	(-0.73)
$Debt/TA_{i,t}$	-0.840***	-0.841***	-0.841***	-0.841***	-0.044*	-0.619***
	(-3.10)	(-3.10)	(-3.10)	(-3.10)	(-1.91)	(-4.58)
$CAPEX/TA_{i,t}$	0.095	0.084	0.089	0.089	-0.023	-0.185
	(0.13)	(0.12)	(0.12)	(0.12)	(-0.59)	(-0.55)

Table 4: R&D Expenditures and State Ownership, PSM and IV - Continued

VARIABLES	(1) $lnR\&D_{t+1}$	(2) $lnR\&D_{t+1}$	(3) $lnR\&D_{t+1}$	(4) $lnR\&D_{t+1}$	1st Stage IV $GOF_{i,t}$	2nd Stage IV $lnR\&D_{t+1}$
GDP growth $_{j,t}$	-1.724***	-1.711***	-1.717***	-1.717***	-0.705***	0.094
	(-4.90)	(-4.74)	(-4.74)	(-4.74)	(-3.24)	(-0.14)
BERD $_{j,t}$	-1.011	-0.988	-1.004	-1.004	-1.260**	2.403
	(-0.35)	(-0.34)	(-0.35)	(-0.35)	(-2.31)	(-1.48)
Profit tax subsidy $_{j,t}$	0.477	0.485	0.475	0.475	-1.044***	2.297**
	(0.73)	(0.75)	(0.73)	(0.73)	(-3.74)	(-2.04)
Loss tax subsidy $_{j,t}$	-0.227	-0.233	-0.221	-0.221	0.709**	-1.945**
	(-0.34)	(-0.35)	(-0.33)	(-0.33)	(-2.18)	(-2.02)
Blank R&D $_{i,t}$	-7.161***	-7.160***	-7.161***	-7.161***	-0.021***	-6.712***
	(-28.82)	(-28.86)	(-28.83)	(-28.83)	(-4.91)	(-22.26)
Crisis $_{j,t}$	0.142**	0.144**	0.143**	0.143**	-0.146***	0.108
	(2.58)	(2.75)	(2.65)	(2.65)	(-3.21)	(-1.06)
Constant	8.922***	8.920***	8.922***	8.922***		
	(12.37)	(12.45)	(12.38)	(12.38)		
Observations	8,800	8,800	8,800	8,800	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	Country	Country
# Clusters	13	13	13	13	13	13
R-squared	0.787	0.787	0.787	0.787		
Adj R-squared	0.785	0.785	0.785	0.785		
Kleinbergen-Paap rk LM					5.892	
Kleinberg-Papp rk Wald *F*					15.95	
Cragg-Donald Wald *F*					275.112	

Table 5: 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 firms over the years 2000-2009. *GOF* 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) $lnR\&D_{t+1}$
$GOF_{i,t}$	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)
$GOF_{i,t} \times PFC_{i,t}$	0.155		0.149	
	(0.58)		(0.56)	
$GOF_{i,t} \times FC_{i,t}$	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)

Table 5: R&D Expenditures, State Ownership, and Financial Constraints - Continued

	(1) $\ln R\&D_{t+1}$	(2) $\ln R\&D_{t+1}$	(3) $\ln R\&D_{t+1}$	(4) $\ln R\&D_{t+1}$
GOF $_{i,t}$ × Private deposits $_{j,t}$			0.041**	
			(2.23)	
Minority $_{i,t}$ × Private deposits $_{j,t}$				0.034*
				(2.03)
Control $_{i,t}$ × Private deposits $_{j,t}$				0.067
				(0.63)
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 6: R&D Expenditures, State Ownership, and 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. *GOF* 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.

VARIABLES	(1) $lnR\&D_{t+1}$	(2) $lnR\&D_{t+1}$	(3) $lnR\&D_{t+1}$	(4) $lnR\&D_{t+1}$
$GOF_{i,t}$	0.348***	0.346***	0.348***	0.346***
	-5.09	-5.06	-5.1	-4.99
$GOF_{i,t}$ × Bank Loan $_{i,t}$	0.046			
	-0.34			
Bank Loan $_{i,t}$	-0.004***			
	(-3.48)			
$GOF_{i,t}$ × Gov Loan $_{i,t}$		2.672***		2.674***
		-11.18		-11.14
GovLoan $_{i,t}$		-0.005***		-0.005***
		(-3.20)		(-2.85)
$GOF_{i,t}$ × Non-gov Loan $_{i,t}$			-0.165	-0.175
			(-0.61)	(-0.66)
Non-gov Loan $_{i,t}$			0.189	0.2
			-1.17	-1.27
Constrained $_{i,t}$	-0.614***	-0.615***	-0.613***	-0.614***
	(-9.73)	(-9.68)	(-9.70)	(-9.65)
Total assets $_{i,t}$	0.090***	0.090***	0.090***	0.090***
	-22.69	-22.66	-22.69	-22.66
ROA $_{i,t}$	0.005**	0.005**	0.005**	0.005**
	-2.58	-2.58	-2.56	-2.57
PPE/TA $_{i,t}$	-0.13	-0.13	-0.13	-0.129
	(-0.92)	(-0.91)	(-0.91)	(-0.91)
Debt/TA $_{i,t}$	-0.709***	-0.711***	-0.707***	-0.710***
	(-3.31)	(-3.30)	(-3.30)	(-3.29)
CAPEX/TA $_{i,t}$	-0.284	-0.283	-0.284	-0.283
	(-0.79)	(-0.79)	(-0.79)	(-0.79)

Table 6: R&D Expenditures, State Ownership, and Loans – Continued

VARIABLES	(1) $lnR\&D_{t+1}$	(2) $lnR\&D_{t+1}$	(3) $lnR\&D_{t+1}$	(4) $lnR\&D_{t+1}$
GDP growth $_{j,t}$	-0.64	-0.643	-0.641	-0.645
	(-1.33)	(-1.33)	(-1.33)	(-1.34)
BERD $_{j,t}$	0.926	0.929	0.904	0.919
	-0.87	-0.87	-0.85	-0.86
Profit tax subsidy $_{j,t}$	1.615***	1.617***	1.609***	1.614***
	-3.59	-3.6	-3.58	-3.59
Loss tax subsidy $_{j,t}$	-1.516***	-1.518***	-1.511***	-1.515***
	(-4.63)	(-4.64)	(-4.62)	(-4.63)
Blank R&D $_{i,t}$	-6.876***	-6.875***	-6.876***	-6.875***
	(-21.90)	(-21.92)	(-21.91)	(-21.93)
Crisis $_{j,t}$	0.044	0.046	0.045	0.047
	-1.26	-1.3	-1.29	-1.34
Constant	8.309***	8.307***	8.310***	8.308***
	-18.49	-18.46	-18.52	-18.5
Observations	18,373	18,373	18,373	18,373
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	0.769	0.769	0.769	0.769
Adjusted R-squared	0.767	0.767	0.767	0.767

Table 7: 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 firms over the years 2000-2009. *GOF* 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) $lnR\&D_{t+1}$
GOF_{t+1}	0.465***	0.537***	0.482***	
	(5.42)	(8.54)	(5.96)	
GOF_{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)

Table 7: 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) $lnR\&D_{t+1}$
CAPEX/TA $_{i,t}$	-0.273	-0.311	-0.295	-0.295
	(-0.52)	(-0.60)	(-0.57)	(-0.57)
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 8: 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 firms over the years 2000-2009. *GOF* 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 GOF 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) $lnR\&D_{t+1}$
$GOF_{i,t}$	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)
$GOF_{i,t}$ × Political mgr_j		-0.333**		
		(-2.53)		
$GOF_{i,t}$ × 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)

Table 8: 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) $lnR\&D_{t+1}$
Debt/TA $_{i,t}$	-0.559***	-0.557***	-0.561***	-0.559***
	(-3.35)	(-3.33)	(-3.37)	(-3.36)
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 9: 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 firms over the years 2000-2009. *GOF* 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) $lnCount_{t+2}$
$GOF_{i,t}$	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)
$GOF_{i,t} \times lnR\&D_{i,t}$			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)

Table 9: Patenting Activity and State Ownership - Continued

Variables	(1) $lnCount_{t+2}$	(2) $lnCount_{t+2}$	(3) $lnCount_{t+2}$	(4) $lnCount_{t+2}$
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)
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 10: 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 firms over the years 2000-2009. *GOF* 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) $lnCitePer_{t+2}$
$GOF_{i,t}$	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)
$GOF_{i,t} \times lnR\&D_{i,t}$			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)

Table 10: 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$_{t+2}$
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)
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

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
$lnCitations_{i,t+n}$	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
$GOF_{i,t}$	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)

Variable Name	Definition	Source
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)
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
Crisis $_{j,t}$	Indicator denoting firm *i* is headquartered in a country experiencing a financial crisis in year *t*	Laeven and Valencia (2013)
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
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

Variable Name	Definition	Source
Political mgr $_j$	Indicator for country *j* equal to one if CEOs 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
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