Government Sponsorship and Nature of Patenting Activity of US Universities and Corporations[☆]

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Abstract

This paper studies the relationship between government sponsorship and nature of innovation produced by US universities and corporations. Using detailed patent data information and, in particular, from the patent document wrapper, where the applicant is obliged to disclose any federal support, we examine whether (i) federally funded patented innovations are more basic than their non-federally funded peers, and (ii) federally funded corporate and university patented innovations are very different from their existed research agenda. Our results strongly support that federally funded corporate patents are more basic in nature, while the evidence for universities is less nuanced. Also less pronounced and conclusive are the findings about university patented inventions and their ties to university's own research agenda. Results, however, may vary depending on university (corporation) size. While the federal government finances high risk, basic projects, it appears that some firms do not incorporate them in their overall research portfolio.

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1. Introduction

Much of the economic growth of recent decades has been driven by innovation. The central role of innovation in economic growth has been also affirmed theoretically, by the emergence of new theories of growth, and empirically in the literature.[1] Innovation, in turn, is driven, in large part, by research and development (R&D).

R&D activity figures prominently in the agenda of many government and policy makers and is promoted in various ways, from government-sponsored R&D consortia, national R&D laboratories, and public-private research synergies to various fiscal incentives (e.g., subsidies, tax cuts). Universities and corporations are significant components of innovation policies.

Governments support university research. One important argument for state financing of university research is because of its nature. Universities' research and, consequently, produced innovations are supposed to be 'basic' in nature: they are fundamental, path-breaking and serve as stepping stones to subsequent technological developments. Basic research, performed by universities, leads to the creation of

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[1] See theoretical contributions of Romer (1990), Grossman and Helpman (1991), Aghion and Howitt (1998), Jones (2005), and Aghion and Howitt (2005). The relationship between innovation and growth has been also established empirically in many ways and at many levels (e.g. firm-, industry- and country-level). See empirical contributions of Coe et al. (1997), Keller (2002), Scarpetta and Tressel (2002), Griffith et al. (2004), and Cameron et al. (2005).

new fields - developed later by the private sector - with associated social benefits that would not have emerged without the university's research involvement. The generating benefits of basic research innovations, however, are often difficult to appropriate as it is hard to commercialize them and establish property rights to prevent their exploitation by others. Coupled with high risk and long-term development, basic research creates less incentive for the private sector to undertake it. Due to the benefits of basic research and associated difficulties, governments back-up financially universities in order to perform basic scientific research.

Governments also facilitate corporate research. An important tool to support technology policy is R&D subsidies, which has been the main practice in the last decades in the OECD countries.[2] Further, governments promote private regional innovation by encouraging the location of incubators and research parks near government labs and by sharing expertise with businesses. Governments also support public-private partnerships to advance markets, for example, in manufacturing, medical industry, information technology sector, with key technologies to serve vital national objectives. This is because the financial return from large investments would have been difficult for any single company to capture and the returns could only be seen after many years, making long-term projects that improve social welfare ideal candidates for government involvement.[3]

The federal US government, in particular, has been always an active supporter of university and corporate research through various programs and actions. For instance, federal research grants account for a substantial proportion of the budget of leading universities, while the passage of the Bayh-Dole (BD) Act in 1980, with its subsequent refinements, set a unified framework where universities could retain property rights on inventions that had benefited from federal funding (Grimaldi et al., 2011).[4] These legal changes led, in some cases, to increasingly aggressive patenting activity of university-based innovation.[5] Although the BD policy was at first relevant only for universities and small firms, in 1984, it was refined to also include large corporations (Eisenberg, 1996).

This paper aims to study the relationship between federal government sponsorship of research and the nature of innovation output produced in the US. In particular, we examine whether federally funded university as well as corporate patented inventions are different in nature compared to their non-federally funded counterparts. As federal government funding accounts for approximately 60% of university and 10-20% of corporations research (National Scence Foundation, 2010), government sponsorship and the type of research eventually conducted consists an issue of particular importance.

Our paper closely relates to a rather recent, but growing strand of research that has examined the nature of university and corporate research and research output. The seminal paper of Trajtenberg et al. (1997) (hereafter THJ) examines whether university research outcomes are more basic and harder to appropriate than corporate research outcomes. THJ construct measures of basicness and appropriability of research to test their priors for a number of US universities and corporations for the years 1975 and 1980 and their findings confirm their priors. Subsequent studies also support THJ findings. Czarnitzki et al. (2009) using German professors' patents linked to patent opposition data from the European Patent Office (EPO), provide empirical evidence on the basicness of academic patents. The latter, are found to be opposed less

[2]Government R&D and innovation policies are perceived as crucial elements of many success stories in the private sector around the world. Of particular interest is the Israeli experience because of its boomed high-tech sector and considerable subsidization of R&D activity there (Lach, 2002; Trajtenberg, 2002).

[3]One leading example of a long-term funding project, initially funded from the US Defense Advanced Research Projects Agency (DARPA) in the early 1960s, and then later by the US National Science Foundation (NSF), was the development of the Internet that has massively improved the lives of many people in the US and around the world. Internet-related technologies and businesses have also developed as the result of federal support, including Google. Furthermore, government support for research in medical science has led to the creation and expansion of the biotechnology industry with particularly important benefits given its impact on the expected length and quality of life.

[4]Universities also fund their research by non-federal funds (i.e., universities' and colleges' own institutional funds, state and local government funds, industry funds, nonprofits funds, and other organizations funds). Nevertheless, the federal government remains the largest funder of their research. For example, the federal government provided 59% of academic spending on science and engineering R&D in 2009.

[5]Henderson et al. (1998) document a sharp increase in university patenting accompanied by a decrease in the relative 'importance', in terms of path-breaking, of university innovation over the later part of their 1965-1992 sample.

frequently than a control group of corporate patents, indicating that academic patents cover rather basic inventions with a low immediate commercial value without threatening current returns of potential plaintiffs. The effect is found to be, however, weaker for academic patents in collaboration with the business sector. Further, Conti et al. (2003) compare knowledge externalities generated by university and corporate patents related to genetically modified (GM) crop research. Knowledge externalities are approximated by the total number of third party cites generated by a patent and conclude that patented university research is not associated with greater knowledge externalities than corresponding corporate patents.

A parallel, also closely related to our study, literature investigates the role of government sponsorship in academic technology management and direction of university research. The studies of Agrawal and Henderson (2002) and Fabrizio and DiMinin (2008) find no substitutability or complementarity between university patents (which approximates applied research output) and research papers (which approximates basic research output), whereas Foltz et al. (2003) show no correlation between government funding and the ratio of academic research papers to patents. In a more recent paper, Jacob and Lefgren (2011) did not find a significantly different research trajectory between researchers granted an National Institutes of Health (NIH) grant and those who did not. They conclude that researchers that were not granted an NIH grant opt for other research sponsors and perform the same quality and quantity of work that would otherwise do with an NIH grant. However, none of the studies have explicitly examined whether government sponsored innovations differ from non-government sponsored ones, both for universities and corporations, and to what extent their sizes can influence the nature of innovation produced.[6]

We build upon the important aforementioned work by bringing more systematic evidence on the role of federal government, as funder of university and corporate research, and the nature of research outcome eventually produced. In the present paper, we consider a piece of information obtained from the patent document wrapper, where the applicant is obliged to disclose any federal support, and, therefore, distinguish between government sponsored versus non-government sponsored (university and corporate) patented inventions and examine their nature.[7] We further account for different (university and corporate) sizes and study the nature of innovation performed. Our aim is to shed some light on issues concerning whether state financing indeed facilitates the development of more basic innovations, and whether the size of the fund-receiver plays any role to the nature of innovation generated (basic or applied) as well as to the relation it has (close or remote) to the rest of the (university or corporation) research agenda.

We use detailed patent data and peripheral information related to patent data, namely patent citations, to asses the nature of innovative outcome. Citations provide good evidence of the links both between an innovation and the body of knowledge that preceded it. We construct patent metrics, in the spirit of THJ, based on citations, which display the degree of 'basicness' for each innovation. We also construct measures of 'appropriability' by employing the number of self-citations (citing patents that are assigned to the same organization as the original patented invention); these latter measures indicate the patented invention's relevance with the research agenda of the institution (university or corporation).

One would expect that the degree of basicness of federally funded (university or corporate) innovations to be higher than that of non-federally funded due to the 'public good' nature of basic research and difficulties related in generating it, both by a university and corporation. Universities would use the state financing to produce more basic innovations, as they have the resources and the expertise in producing scientific research. Corporations would use this funding to also produce basic research that they would not have produced otherwise. However, due to competitive pressure, universities and corporations could well spend state funding in less basic innovations pursuing more applied research endeavors.

With respect to appropriability our expectations are less concrete. Given that we observe self-citations at the university (and not at the department or faculty) level, it is difficult to form expectations about the

[6]For example, THJ find that university patents are more basic in nature compared to the corporate patents and that corporate patents, in general, build significantly more on own patents, and, therefore, have higher degree of appropriability, than university patents; however they do not distinguish between federally versus non-federally funded patents and do not account for different university or corporation sizes.

[7]The 'exploitation' of the information provided on the patent document wrapper was actually motivated by the work of Pressman et al. (2006) who used information of the patent document to identify which DNA patents had disclosed support from NIH to examine whether NIH licensing guidelines are violated.

appropriability of university innovations, independent of the source of funding, as the overall effect would mask important variations across departments. With respect to corporate innovation output, government policy again would pursue to finance projects that fall within the corporation's research expertise, therefore, one would expect a high degree of appropriability. Nonetheless, it could also be the case that government finances research that is remote to the corporation's research agenda, but relevant to its product line.[8]

Based on a sample that consists of all US patents, which are assigned to at least one US corporation or to one US university, issued between 1996 and 2000 we purport to answer two key questions: (i) Are federally funded patented innovations more basic than their non-federally funded peers? and (ii) Are federally funded corporate and university patented innovations very different from their existed research agenda?

Prefiguring our results, we can say that with respect to the first question posed in the paper, overall, we find no clear evidence that federally financed university patents are more basic compared to university patents that have generated without federal support. Only for small- and medium-sized universities, there is some more pronounced difference between federally funded and non-federally funded university patents with the former to be relatively more basic in nature than the latter. Federal funding is significantly associated with more basic innovation output for the case of corporations, indicating that federal government finances corporations' research projects that are more basic in nature than the generic private sector research portfolio and that the industry seeks federal funding for predominantly more basic than usual research projects. The result is more nuanced and driven, primarily, by small- and medium-sized corporations.

With respect to our second question, again the evidence is less clear for the relevance of federally funded university patented inventions to the university research agenda. While for small- and medium-sized universities federally funded university patents have greater ties to own past and future research than non-federally funded patents, for large-sized universities results are inconclusive. One could argue that the presence of federal funding in small and medium universities can lead to an overarching research agenda that can stem research output in the long run that is connected with the past and future output. This phenomenon, while present in larger universities, can be diluted by other types of funding or by a higher number of independent research grants financing university research. Concerning corporations, we find that federally funded corporate patents are assimilated to small and large firms' patenting portfolios, whereas the opposite holds the for medium-sized corporations, whose government financed patents are more remote from the corporation's research agenda. An important implication of our findings, considering the actual objectives of financing industry research, is that while the federal government finances high risk and upstream projects, certain types of firms do not incorporate them in their overall research portfolio.

At the outset of this paper we would also like to stress what the paper does *not* do. This paper does not offer a causality explanation. It rather states that at equilibrium the federal government will fund research projects in the private sector that are predominantly more basic than the corporate generic research portfolio and that the private sector would seek federal funding for basic research. In terms of universities, the interpretation of these inconclusive estimates is more subtle. University inventors may not disclose federally funded inventions as they might only pursue scientific publications in contrast with private funding that may vigorously require from the inventor to disclose all inventions. Further, this paper does not consist an evaluation study of federal funding to universities and firms as we condition all our observations post patenting.

The remainder of the paper proceeds as follows. Section 2 briefly summarizes main works in the literature on the role of federal government in supporting research innovation outcomes. Section 3 introduces the specification(s) under estimation, patent measures, and the data. Section 4 discusses the results. Finally, Section 5 summarizes and concludes.

[8]For instance, many of of the big oil companies are financed, in one fashion or the other, by the federal government to conduct research on renewable resources e.g. biofuels (Wahburn, 2010). While this area is somewhat unknown to those firms, it could well become very familiar to the firms in the future.

2. Literature Review

In this section, we provide a brief literature review on two related strands of literature, namely the implications of federal government's financial support on university and corporate research performance, respectively.

Federal Government as Research Funder of University/Academic Research

University technology management has always attracted attention in the innovation literature. Since the passage of the Bayh-Dole Act in 1980 and its subsequent refinements, it has even become more a topic of greater interest to scholars and policy makers, alike. The main premise of the BD was to facilitate the way universities could retain ownership of federally funded inventions (Grimaldi et al., 2011). Over the last decades, universities have experienced a dramatic increase in their patenting activity. While US universities accounted for approximately 0.75% of US patents granted to US entities in 1980, in 2005 they accounted for approximately 5% (AUTM, 2008).[9] Universities use patents as a tool to protect their inventions and subsequently market them to firms for further research and development (Elfenbein, 2007; Hellmann, 2007). Unlike firms, universities cannot commercialize their inventions; therefore, finding a licensee is essential in commercializing university inventions. Indeed, Jensen and Thursby (2001) surveyed university technology transfer managers and reported that 71% of university inventions are of embryonic nature.

However, this increase in patenting has been met with skepticism. In particular, Henderson et al. (1998) found that the quality of university patents, as that approximated by their forward citations, has declined after the BD Act. Even though (Sampat et al., 2003) showed that the main reason of universities' quality decrease was due to the lack of previous experience in patenting activity, the concern of decreased quality in university innovations remains (Azoulay et al., 2009; Rosell and Agrawal, 2009). In the backbone of university patenting and its direction, there is significant discussion about the role of the research funder. Corporations are the second largest research funders (after the federal government) to university research and concerns have been raised if corporations divert university to more applied research endeavors (Press and Washburn, 2000). However, studies have not documented significant evidence to support this claim (Foltz et al., 2003).

One of the main reasons that the government finances university research is because of its nature: basic, path-breaking and fundamental. As there is less incentive for the private sector to pursue such type of research, which has great benefits for firms and society as a whole, the government becomes the major funder of basic scientific research. In this paper, we put under scrutiny this presumption and explore whether state financing is associated with basic and fundamental research endeavors or universities pursue, through this financing, a different research strategy.

Therefore, we first examine whether federally funded university research results are systematically different in innovation output compared to its non-federally funded counterpart. To account for different research behaviors, we also consider the size of the university. Moreover, we examine whether state financed university innovations are close or far away from the university's existed research portfolio.

Federal Government as Research Funder of Corporations/Industry Research

Federal funding is an issue of importance also for corporate innovation. Even though, the BD policy was initially relevant for universities and small firms, in 1984, was refined to also include large corporations (Eisenberg, 1996). However, unlike universities, most corporations do not use patents as a tool to license and develop their technologies to commercialization stage. It is still likely that some firms, in particular small or start-up firms, not to have the resources to develop their inventions in a finalized product. Therefore, licensing for them might also be the only means in realizing returns to their innovation investments. Nonetheless, the role of patents in corporate innovation is still a topic of great interest. In principle, a patent creates a temporary monopoly to the patent holder, in exchange of full disclosure of the invention to the public. However, survey studies have shown that patents are not among the most frequent means that

[9]For more details, see https://sites.google.com/site/patentdataproject/Home.

firms use to appropriate the benefits from their innovation investment (Cohen et al., 2000). Similar surveys have found that patents are one of the most important mechanisms to protect their inventions (Graham et al., 2009). In any case, patenting is a common practice and a standard procedure that US firms use in order to protect their inventions.

The federal government has frequently attempted to finance industry research projects through formalized channels. Two examples constitute the Advanced Technology Program, which finances firms for high-risk projects (Ruegg, 1998; Feldman and Kelley, 2003), and the Small Business Innovation Research Program, which is focused on small firms (Link and Scott, 2010). Therefore, even though the federal government supports 10-20% of overall industry R&D it is evident that historically the ramifications of government funding in industry innovations have been an important policy issue (Harbridge, 1968).

One of the main reasons that the government finances industry research is to finance projects that are at early stage or more basic in nature and accompanied with high-risk but have high value to the society, as a whole. Projects that would have been difficult for any single company to develop and the return could only be seen after many years.

Therefore, we examine whether corporate innovation output that stems from federal support is of different nature compared to corporate innovation output, which is financed by non-federal funds. To account for different research behaviors, we also consider the size of the corporation. We further explore whether government financing is associated with research projects that are similar to corporations' research agenda or very different ones.

3. Methodology

In this section, we first discuss how we approach innovation outcome and its nature, then present the empirical specifications we estimate to answer the questions posed in the paper, and finally, discuss the data used in our empirical analysis.

3.1. Nature of Innovation Output

Before embarking on presenting the empirical specifications under estimation, we first need to explain how we capture innovation output and consequently its nature. The literature has extensively used patents to approximate innovation output (Griliches, 1990; Eaton and Kortum, 1995). Patents are materialized innovations of business value, give a monopoly right to the inventor, and are actively traded in intellectual property markets. Each innovation has a past and a future: there is a body of knowledge that precedes and follows from it, and therefore, there are technological advances that stem from and build upon it.

An advantage of patent data is that they offer peripheral information about the innovation,the inventor, the assignee, the technological antecedents of the invention. An item of particular importance for our purposes are the citations of a patent. Upon filing a patent application to the US Patent and Trademark Office (USPTO), the applicant discloses all the prior art regarded as relevant for the patentability of the invention by referring to prior patents and to the non-patent literature; moreover, the patent examiner adds references if s/he finds it appropriate.[10]

This information is used to construct forward and backward patent and non-patent citation based metrics as in THJ. [11] The nature of an innovation, in this paper, relates to the degree of basicness and appropriability of a patent. The degree of basicness denotes the importance, upstreamness, fundamentality and breakthrough aspects of an innovation. The degree of appropriability relates to the the benefits captured by the original inventor, which can be high for the inventor if an innovation can generate a stream

[10] Alcacer and Gittelman (2006) show that two thirds of the prior art is inserted by the examiner.

[11] Forward citations are citations to a given patent from patents that are 'forward in time' from this patent. In contrast, backward citations to a given patent are patents that are 'backward in time' from this patent. Therefore, forward citations capture the prior effects of an innovation, while backward citations capture the posterior effect of an innovation. We use backward and forward citations to asses the nature of patents.

of innovations. These innovations, in turn, could have tight (or loose) links, via citations, with the original innovation (and research agenda, in general) and, therefore, could be remote or close to inventor's (or organization's) research agenda and accordingly they can exhibit low or high appropiability.[12]

To account all different aspects of basicness and appropriability and for robustness purposes, we construct six patent metrics of basicness and two of appropriability. Therefore, in all model specifications discussed below, the dependent variable is a patent metric that takes a range of definitions, depending on what we want to examine.

Below, we briefly present six patent metrics for basicness and two for appropriability.

The first metric of basicness proposed by THJ and used extensively in the literature [13] shows whether the innovation is close to the existed scientific literature:

(1) $Science_i = \frac{NPCITES_i}{NPCITES_i + NCITED_i}$

where $NPCITES_i$ is the number of non-patent sources cited by the patent of interest, i (backward non-patent citations) and $NCITED_i$ is the number of patents cited by the patent of interest, i (backward patent citations).

The rationale behind this metric is that the closer the invention to the scientific literature is, the more basic the invention is. THJ find that university patents had, on average, a higher number of *Science* than corporate patents.

The second metric, *Downstream*, introduced by Lei and Wright (2009), shows how upstream (or downstream) a patent is to the technology trajectory. Downstream innovations relate to technologies that are closer to end-use products than upstream innovations that relate to technologies employed for the downstream inventions. A high number of patent citations a patent has made to prior art in comparison to the citations it has received is indicative of a downstream patent. The metric is defined as follows:

(2) $Downstream_i = \frac{NCITED}{NCITED_i + NCITING_i}$

where $NCITING_i$ is the number of patent citations the patent of interest, i, has received (forward citations).

The more basic a research outcome is, the more upstream to the technology trajectory the innovation is.

The third measure, *ImportB*, is a backward-looking measure that proxies the importance of the prior art a patent has cited and is expressed as:

(3) $ImportB_i = NCITED_i + \lambda \sum_{j=1}^{NCITED_i} NCITING_{i-1j}$

where $NCITING_{i-1j}$ is the number of patent citations received by the patent j that the patent of interest i has cited.

The premise here is that more basic and original patents are less likely to build on important than applied and generic patents. Put differently, important and breakthrough inventions are more likely to build on a less congested field. For instance, THJ found that university patents have a lower number of *importB* than industry patents.

The fourth metric, *ImportF*, is the forward-looking counterpart of the metric *ImportB*:

(4) $ImportF_i = NCITING_i + \lambda \sum_{j=1}^{NCITING_i} NCITING_{i+1j}$

where $NCITING_{i+1j}$ is the number of patent citations received by each patent j citing patent i.

This metric examines the diffusion of the citing patents. The latter are more likely to diffuse when they cite basic and original patents.[14]

Lastly, there are two patent measures, a backward-looking, *Original*, and a forward-looking, *General*, that approximate whether patents stem from research in the same field (*Original*) or themselves contribute

[12]For a discussion about the notion of basicness and appropriability of research outcome, see Trajtenber et al. (1992).

[13]For instance, Lowe (2002) has used this metric to examine whether more basic university patented inventions are more likely to be licensed to start-up firms than established firms

[14]For both metrics, *ImportB* and *ImportF*, we choose $\lambda = 0.5$ as in THJ. In Table A.1 in the Appendix, we offer results also for values $\lambda = 0.25$ and $\lambda = 0.75$.

to a wide array of technological fields (*General*). These metrics have been heavily used in the literature (Bessen, 2008; Serrano, 2010) and are defined as:

(5) $Original_i = 1 - \sum_{k=1}^{N_i} (\frac{NCITED_{ik}}{NCITED_i})^2$

where N_i is the number of US Classifications that patent i belongs to and $NCITED_{ik}$ the number of patent citations that patent i has made in the k_{th} US Classification.[15]

This measure is a Herfindahl index of concentration depicting, for a given patent, whether the backward knowledge is concentrated in just a handful or a variety of fields. THJ find no compelling evidence that university patents have higher $Original$ than industry patents.

The forward-looking equivalent metric, $General$, is defined as:

(6) $General_i = 1 - \sum_{k=1}^{N_i} (\frac{NCITING_{ik}}{NCITING_i})^2$

where $NCITING_{ik}$ is the number of patent citations that patent i has received from the k_{th} US Classification. THJ find that university patents have a higher number of *General* than industry patents, implying that academic patents find a wider array of applications.

We also employ two measures of appropriability.

These measures are (1) $SelfcitesB$ and (2) $SelfcitesF$. The former is the number of self-citations a given patent i makes, while the latter is the number of self-citations that a given patent i receives. These two metrics serve as measures of remoteness as they reflect, for each patent, how much past knowledge the corporation or university has exploited to produce this innovation output ($SelfcitesB$) and how much own future innovation output builds on this specific patent ($SelfcitesF$).

Next, we proceed with the specifications under estimation.

3.2. *Empirical Specification and Estimation*

We begin our empirical analysis by comparing the degree of basicness and appropriability of university and corporate patents along the spirit of THJ. The reason is that we want to test whether the THJ dataset is of similar attributes as the dataset compiled in this study and further the THJ findings are robust in a larger sample as ours. As in THJ, we only differentiate between entities (i.e., whether it is university or corporate patents) and not between financing sources (i.e., federally versus non-federally funded innovations). The specification we estimate is the following:

$$Y_i = \alpha_0 + \alpha_1 University_i + \alpha_2 Z + \epsilon_i \tag{1}$$

where Y_i, is a patent metric for patent i; $University_i$ takes the value of one, if patent i is assigned to a US university and zero, if it is assigned to US corporation; Z is a set of variables, which includes the number of patent claims, $NumberOfClaims$, length of patent application, $AppLength$, Number of four digit International Patent Classifications (IPC) $Numb4DigitIPC$, Number of three Digit US Classifications $Numb3DigitUSClass$, number of inventors, $NumOfInventors$, number of assignees, $NumberOfAssigness$, year dummies of issued patents, $IssueYearDummies$, and US patent classification dummies, $USClassification$ $Dummies$; and ϵ is iid error term.

We estimate equation (1) eight times, as we have six patent metrics for basicness and two for appropriability for a each patent i.

Now, we turn to the first aim of the paper that is, to examine whether federal government sponsored patents are more basic in innovation nature than their non-federal government counterparts for US universities and US corporations. We, therefore, estimate the following specification:

$$Y_i = \beta_0 + \beta_1 Corporation_i + \beta_2 FedFund_i + \beta_3 Corporation_i x FedFund_i + \beta_4 Z + \epsilon_i \tag{2}$$

[15] We consider 419 US Classifications in our sample.

where Y_i is a patent metric of basicness for patent i; $Corporation_i$ takes the value of one, if patent i is assigned to a US corporation and zero, if it is assigned to US university; $FedFund_i$ takes the value of one, if patent i discloses federal support and zero otherwise; Z a set of variables defined as in equation (1); and ϵ is iid error term.

The way the regression (2) is outlined defines as a control group the university patents without federal support. Consequently, β_1 depicts the difference between university and corporate patents that are not federally funded and β_2 the difference between university patents, which are federally funded and university patents, which are not. β_3 is the coefficient of the interaction term. Thus, to captures the difference between corporate patents that are federally funded, with corporate patents that are not, one should add the coefficients β_2 and β_3.

Different entities, in terms of size, could produce different types of innovative output as they may have different research endeavors. We, therefore, extent specification (2) to account for the size of the entity and accordingly classify entities into small-, medium- or large-sized based on their patent production. We estimate the following equation for each entity separately:

$$\begin{aligned} Y_i = \gamma_0 + \gamma_1 MediumEnt_i + \gamma_2 LargeEnt_i + \gamma_3 FedFund_i + \gamma_4 MediumEnt_i x FedFund_i \\ + \gamma_5 LargeEnt_i x FedFund_i + \gamma_6 Z + \epsilon_i \end{aligned} \tag{3}$$

where Y_i is a patent metric of basicness for patent i; $MediumEnt$ and $LargeEnt$ capture the size of entity whether it is university or corporation (the suffix Ent denotes each time the entity and refers to university or corporation); $FedFund$ and Z are defined as in equations above; and ϵ_{it} is iid error term.

Equation (3) is estimated separately for universities and for corporations. In both cases, the way equation (3) is outlined, the control group is small-sized entity patents without federal funding. In all estimations, we are interested in the coefficients of γ_3, γ_4, and γ_5. The former coefficient shows the difference of federally funded patents versus non-federally funded patents for small-sized entities. Therefore, the difference of federally funded patents versus non-federally funded patents for medium-sized entities is given by the addition of the coefficients γ_3 and γ_4. Lastly, the difference of federally funded patents versus non-federally funded patents for large-sized entities is reflected in the summation of γ_3 and γ_5.

We estimate specifications (1) to (3) using Ordinary Least Squares (OLS) technique. Establishing causality between type of funding (i.e., federal and non-federal) and resulting innovation outcome is beyond the scope of this paper. A proper treatment of causality would require more detailed information, for example, at inventor or research grant level. Had we had such disaggregate level data, estimation techniques such as propensity score matching and instrumental variables approach would offer solutions to tackle endogeneity.[16]

One would expect that the degree of basicness of federally funded (university or corporate) patents to be higher than that of non-federally funded for reasons explained before in the paper. However, due to competitive pressure, universities, in particular, and corporations could resort in spending state financing in less basic and upstream innovations showing a more aggressive research profile.

Next, we turn to the second aim of this paper that is, whether federally funded corporations' and universities' patented innovations are different from their existed research agenda.

We estimate again specifications (2) and (3), but only this time the dependent variable, Y_i captures the degree of appropiability and approximated by the two measures (also employed by THJ), $SelfcitesB$ and $SelfcitesF$. We use Poisson techniques, as the dependent variable in both patent measures ($SelfcitesB$ and $SelfcitesF$) is counts. The OLS estimates with count data would lead to biased estimates when the endogenous variable under consideration has a skewed distribution, as in our case, where for many patents we have zero self-citations (Santos Silva and Tenreyro, 2006).

[16]Indeed, two recent papers, one by Jacob and Lefgren (2011), who use instrumental variables to examine the impact of NIH on productivity of academic scientists, and one by Azoulay et al. (2011), who employ propensity score matching to compare the effect of an NIH and Howard Hughes Medical Institute research grant on scientific productivity have employed such techniques since their data disaggregation allows them to do so. Although there is some disaggregated information for universities, there is no much, to our knowledge, about corporations.

The expectations we build with respect to appropriability are the following. Concerning the appropriability of university innovation output, the role of government funding is more subtle, as state finance could drive research output to different avenues compared to the university research agenda. However, given that we observe self-citations at the university (and not at the department) level, it is difficult to derive nuanced conclusions with respect to university innovation appropraibility. Concerning the appropriability of corporate innovation output, government policy again would pursue to finance projects that fall within the corporation's research expertise, even if they are highly risky and upstream. Nonetheless, it could also be the case that government finances research that is remote to the corporation's research agenda, but relevant to its product line.

At this point, we would like to mention that, as any constructed measure, our patent metrics may have some caveats. However, the question is whether they can be reliable tools in examining hypotheses and eventually assessing research outputs. A major critique for the validity of these metrics is the extent that citations reflect actual knowledge spillovers. Prior to the landmark paper of Jaffe et al. (1993), economists' main notion was that "knowledge flows are invisible; they leave no paper trail by which they may be measured and tracked" (Krugman, 1991). The work of Jaffe et al. (1993) was the first and most compelling effort in offering a solution to the above popular quote by employing patent citations as an approximation to knowledge flows. Later studies confirmed that an important share of patent citations reflects knowledge spillovers. For example, Jaffe et al. (1998), in a case study of NASA-issued patents, find that two thirds of citations are associated with knowledge spillovers, while Jaffe et al. (2000) in a survey of patentees find that half of citations are or maybe related to knowledge spillovers. Even though there is some noise in citation data, a big sub-set of patent citations reflects research output related to the cited patent. It is worth noting here that in this paper the interest does not lie in the absolute size of the constructed patent metrics, but rather in their relative performance.

Variables used in our analysis and statistical comparisons of the aforementioned patent measures are discussed in the next section.

3.3. Data

Our sample consists of all US patents, which are assigned to at least one US corporation or to one US university and are issued between 1996 and 2000. Data are retrieved from various sources.

Patent data are collected from two main sources. The first source is the National Bureau of Economics Research (NBER) *Patent Data Project*.[17] The database provides patent numbers and assignee information. The patent assignees are classified based on their entity's status and their location. Consequently, we have: (i) patents awarded to at least one US located corporation and no government, nonprofit or university co-assignee, and (ii) patents awarded only to at least one US university and no US corporation, or foreign entity co-assignee.[18] For the remainder of the paper we refer to patents in group (i) as corporate patents and to group (ii) as university patents. We, therefore, have 286,416 corporate patents, 4,322 (1.5%) of them have disclosed federal support, and 13,070 university patents, 5,625 (43%) of them have disclosed federal support.[19] The second source of patent information is Lai et al. (2011).[20] Once we collect from the NBER database the patents assigned to US universities and corporations for the period of investigation, we proceed with constructing our dependent variable, Y, which is a set of patent metrics that reflect the degree of basicness and appropriability of a patent. We collect relevant information (i.e. backward and forward citations to patent and to non-patent literature, unique identification numbers for each corporation and university and US patent classifications) in order to calculate six measures of basicness ($science$, $Downstream$, $ImportB$, $ImportF$, $Original$, and $General$) and two measures of appropriability ($SelfcitesB$ and $SelfcitesF$) as they are defined in Section 3.

[17]The database is available at: http://sites.google.com/site/patentdataproject.

[18]There are additionally 1,716 patents that are awarded to at least one US located firm and US located university and 383 (22.3%) of them have disclosed federal support. We have examined this sub-sample, but due to the relatively small size, it is difficult to draw meaningful inferences. Results are available upon request.

[19]Our sample includes 336 US universities, the vast majority of the US universities that produce patents, and 35,656 firms.

[20]The dataset is available at: http://dvn.iq.harvard.edu/dvn/dv/patent.

Data on explanatory variables, size of entity (university and corporation) small ($SmallEnt$), medium ($MediumEnt$), large ($LargeEnt$), and control variables included in Z are compiled from Lai et al. (2011).

The main variable of interest $FedFund$ takes the value of one, if the patent discloses federal support, and zero otherwise. This information is obtained from the patent document wrapper, where the applicant is obliged to disclose any federal support. A generic statement on the documentation wrapper is the following: "The invention was made with Government support (Grant Number).[21] The main reason for disclosing a federal sponsor is that enables federal agencies to track the innovation output they have supported. A more practical reason is that federal agencies reserve the right to "march-in" to a federally funded invention (Bayh, 2004), per BD, if the patentee or a subsequent licensee shelves it in order to reap the benefits of a substitute technology. In that event, the federal agency can remove the invention from the licensee and put it in the public domain or seek for another licensee.[22]

The size of the entity refers to size of patents produced by the entity. We divide the entities in our sample into three types, according to the amount of patents they produced within the last five years. We classified universities to small-sized if they produced less than 80 patents, medium-sized universities if they produced from 81 to 240 patents, and large-sized universities if they produced more than 240 patents.[23] Small-sized corporations are the ones that produce less than 20 patents, medium-sized corporations the ones that produce from 21 to 460 patents, and finally large-sized corporations those that produce more than 460 patents.[24] The cut-off points are chosen to split our sample entities fairly evenly.[25]

Lastly, the variable Z contains a number of control variables to capture different aspects of patents. Specifically, it includes the number of patent claims ($NumberOfClaims$), the length of patent application ($AppLength$), the number of four-digit International Patent Classifications ($Numb4DigitIPC$), the number of three-digit US Classifications ($Numb3DigitUSClass$), the number of inventors of the patent ($NumOf Inventors$), the number of patents assignees, ($NumberOfAssigness$), which shows to how many entities a patent is assigned to, year dummies of issued patents ($IssueYearDummies$), and 419 US patent classification dummies ($USClassificationDummies$). Both the US classifications and IPC classifications are classifications where the USPTO assigns patents based on their technology field. By including US patent classification dummies based on the primary classification of the patent, we hope to control for technology-specific nuances.

Table 1 presents statistics for university and corporate patents that have (or have not) received federal support. As Table below shows most of the patent characteristics are statistically different between the patents with and without federal support regardless of the type of entity.

Overall, without taking the size of universities and corporations into account, in terms of basicness, almost all constructed patent metrics reveal that federally funded corporate patents appear to be more basic (and upstream) in nature compared to their non-federally funded counterparts, while there is no conclusive

[21]For example, for patent 6,015,106, the statement is: "This invention was made with Government support under Agreement No. NMA202-97-9-1050 awarded by the National Imagery and Mapping Agency. The Government has certain rights in the invention". In another example, for patent 6,030,819: "This invention was made with Government support under Government Contract No. 70NANB5H1135, awarded by the National Institute of Science and Technology. The Government has certain rights in this invention". Pressman et al. (2006) use this information to identify which DNA patents had disclosed support from the National Institutes of Health (NIH) and examine whether NIH-licensing guidelines are violated.

[22]Even though NIH has received three petitions to exercise "march-in" rights (BayhDole25, 2006), they have never been exercised to this date.

[23]Out of 4,345 patents assigned to small universities, 1,350 (31%) disclose government sponsorship; out of 4,439 patents assigned to medium universities, 1,835 (41%) are federally funded; and finally, 2,440 (57%) patents out of 4,286 that are assigned to large universities disclose federal support.

[24]Out of 94,699 patents assigned to small firms, 1,217 (1.3%) disclose government sponsorship; out of the 95,720 patents assigned to medium firms, 1,969 (2.1%) are federally funded; and finally out of 1,136 patents that are assigned to large firms, 95,997 (1.2%) disclose federal support.

[25]The division rule we applied is the following: Large-sized entity > 66th percentile of the university (corporate) patents distribution; small-sized entity < 33rd percentile of the university (corporate) patents distribution. For robustness purposes we have also considered a different cut-off point: Large-sized entity > 75th percentile of the university (corporate) patents distribution; 75th percentile >medium-large-sized> 50th; 50th percentile > medium-small-sized > 25th percentile; and small-sized entity < 25th percentile of the university (corporate) patents distribution. See Table A.2 and Table A.3 for university and corporation results, respectively.

evidence for the university patents. In terms of appropriability, the patent metrics $SelfcitesB$ and $SelfcitesF$ show that federally funded corporate patents are more remote to own firm's research portfolio than their non-federally counterparts, whereas the opposite holds for federally funded university patents, which appear to have greater ties with past and future own university patents and, therefore, lie closer to the university's research portfolio.

4. Empirical Results

This section presents our empirical results. Before embarking on answering the questions posed in this paper, we examine whether we obtain similar results to THJ's paper, as we rely on patent measures mostly suggested by them.

Table 2 below shows the results when estimating equation (1) for university and corporate patents without accounting, as in THJ, for the source of their financing, i.e., whether they are federally or non-federally funded. In all columns of Table 2 the dependent variable, Y_i, is a patent measure, for a given patent i. The first six columns refer to the degree of basicness of a patent and in this case Y_i is expressed as $Science$, $Downstream$, $ImportB$, $ImportF$, $Original$, or $General$, respectively, while the last two columns refer to the degree of appropriability and Y_i is now expressed as $SelfcitesB$ and $SelfcitesF$, respectively. As explained in Section 3.1, the higher the values of $Science$, $ImportF$, $Original$, and $General$ (lower values of $Downstream$ and $ImportB$) are, the higher the degree of basicness of an innovation is. And the higher the values of $SelfcitesB$ and $SelfcitesF$ are, the higher the degree of the appropriability of an innovation is. The control group in equation (1) is corporate patents and the coefficient of interest in all columns is that of $University$. After controlling for a number of patent factors - all included in the set Z in equation (1) - results, in their majority, are statistically significant.

As Table shows, our presumptions about the type of innovation produced by universities and corporations, independent of the source of funding are justified. Further, our results are in line with the literature (Trajtenberg et al., 1997; Conti et al., 2003; Czarnitzki et al., 2009).

Briefly, the patent measure $Science$ in column (1) seems to be higher for university patents compared to corporate peers. The latter indicates that universities produce innovations closer to the scientific literature and, therefore, more basic in nature. Also in line with this finding is the value of $Downstream$ in column (2), which is higher for corporations, implying that patents generated by universities are more upstream in the research ladder than corporate patents.[26] Further, university patents appear in less (research-wise) fertile fields than corporate patents - the patents, which university patents cite, are less cited than the ones corporate patents cite as it is captured by the patent metric $ImportB$ in column (3), which has a lower value for universities. Nonetheless, patents generated by universities spur a number of patents that they themselves influence subsequent research, as that is evident from their patent citations and depicted by the high value of $ImportF$ in column (4).[27] A somewhat peculiar finding emerges in column (5) as the value of $Original$ is negative and does not comply with our intuition. However, it is small and statistically insignificant as it is also the case in THJ . Column (6) states that university patents have a higher value of $General$ than corporate patents and, therefore, produce more basic innovations, as a wider array of fields are influenced from such patents .

Next, we move to the degree of appropriability of patents. Estimates in columns (7) and (8) suggest that corporate patents build more on own past patents ($SelfcitesB$) and these patents are cited more by own future patents ($SelfcitesF$) than university patents do - findings in line with those of THJ. The reason is that corporations have research portfolios that focus on specific research agendas, which lead to follow-up patenting that builds on own prior patents. That may not be the case with universities, which have an array of research departments and faculty inventors that will not necessarily build on their colleagues' or fellow

[26]This patent measure is not available in THJ; the coefficient we display here agrees with intuition.

[27]Table A.1 in the Appendix reports results for different values of λ. We report results for $\lambda = 0.25$ and $\lambda = 0.75$. As the Table displays, results are qualitatively similar. Since results do not alter, for the rest of the paper, we only display results for $\lambda = 0.5$.

research departments' research output. As a result, a university is a more diversified and less integrated research unit than a corporation, therefore, one could observe less consistency in research profile.

Overall, results from Table 2 confirm that the patent metrics used in this study can be informative and reliable as they are consistent with in the literature and our presumptions.

In the upcoming section, we differentiate between (i) federally funded university versus non-federally funded university patents allowing for different university sizes and, (ii) federally funded corporate versus non-federally funded corporate patents allowing for different corporation sizes.

4.1. Are Federally Funded Patented Innovations more Basic than Non-federally Funded?

This section explores whether federal government sponsorship of the research produces different types of innovation outcomes in terms of basicness and appropriability. Table 3 below presents results when estimating equation (2). The control group is university patents without federal support. As such, the coefficient of *Corporation* shows the difference between corporate versus university patents without federal support. The coefficient of *FedFund* shows the difference between federally funded versus non-federally funded university patents. Lastly, the addition of the coefficients of the terms *FedFund* and *CorporationxFedFund* shows the difference between federally funded versus non-federally funded corporate patents.

Are Federally Funded University Patents more Basic than Non-federally Funded Peers?

To answer the question of whether federally funded university patents are more basic in nature than their non-federally funded counterparts, we focus, in Table 3, on the coefficient of *FedFund* as it reflects this difference. We consider all six different measures of baciness in order to have a robust outcome.

With respect to *Science* measure (column (1)), government funded university patents appear to have more ties with the scientific literature than non-government funded patents. In addition, and as column (2) shows, university patents stemmed with government support appear to be more upstream in the research ladder than their non-government university counterparts. Concerning the backward-looking, *ImportB*, and forward-looking, *ImportF*, measures in columns (3) and (4), respectively, coefficients appear to be statistically insignificant. Government funded patents are less *Original*, as column (5) depicts, than non-government funded patents, while in column (6) the forward-looking counterpart metric of *Original*, that of *General*, is not significantly different between federally funded and non-federally funded university patents.

In sum, results do not provide clear support that universities' federally funded patents are, on average, different in nature from their non-federally funded peers as the evidence is mixed.

We pursue the exploration of this issue further and examine whether the size of the university matters in the research output it produces. We, therefore, decompose universities in three sizes, small, medium, and large, based on the amount of patents they produce and estimate equation (3) only for university patents. The control group is small-sized university patents produced without government's financial support. Results are shown in Table 4 below.

We begin with the coefficient of *FedFund*, which shows the difference of small-sized university patents produced with federal support and small-sized university patents produced without federal support. For patent measures, *Science*, *Downstream*, and *General* results show that federally funded small-sized university patents are significantly more upstream and basic than their non-federally funded counterparts. However, for the measures *ImportF* and *Original* coefficients contradict with the previous findings. For *ImportB*, while federally funded university patents have higher value, the coefficient is not significant. The evidence weakly support the basicness nature of federally funded patents of small-sized universities.

We now turn our attention to medium-sized universities. Thus, the addition of the coefficients of the terms *FedFund* and *MediumEntxFedFund* reflects the difference of medium-sized university patents produced with federal support and medium-sized university patents produced without federal support.

As one can see, results are qualitatively similar with small-sized university findings as the coefficient of *MediumEntxFedFund* is, in most cases, close to zero and statistically insignificant. Thus, for medium-sized universities, there is weak evidence as in the case of small sized universities in terms of basicness for federally funded patents.

Lastly, we consider large-sized universities. We focus on the sum of the coefficients of the terms *FedFund* and *MediumEntxFedFund* to compare federally funded patents and non-federally funded patents assigned to large-sized universities. As Table 4 shows for three out of six we find no systematic difference between federally and non-federally funded patents. Only for *ImportB*, federally funded patents appear to be more 'basic' than their non-federally funded counterparts while for *ImportF* and *General* the opposite holds. Consequently, results seem to be less conclusive with respect to the basicness of federally funded patents of large-sized universities. One explanation could be that large-sized, in patent production, universities have a greater range of means to fund their research and may enjoy more freedom as to the completion and deliverables of the research.

Overall, when considering the size of the university, we find weak evidence in terms of basicness between federally funded and non-federally funded university patents only for small- and medium-sized universities, while for larged-sized universities there is clear evidence.[28]

Are Federally Funded Corporate Patents more Basic than Non-federally Funded Peers?

Now, we swift our discussion on whether there is systematic difference, in terms of basicness, between federally funded and non-federally funded corporate patents. From Table 3 and in particular from the addition of the coefficients of the terms *FedFund* and *CorporationxFedFund* we conclude the following. *Science* in column (1) indicates that government funded corporate patents appear to have more ties with the scientific literature than their non-federal counterparts. Continuing with *Downstream* in column (2), we see that corporate patents that have stemmed from government support appear to be more upstream in the research ladder than their non-government counterparts. Federally funded patents build on fields that are relatively less fertile than the non-federally funded patents as column (3) indicates, which confirms the basicness nature of the former group. While for *ImportF* in column (4) results show that government funded corporate patents appear to influence a set of subsequent innovation of higher importance than non-government funded patents, the difference between the two groups is not statistically significant. In terms of *Original* in column (5), there is a statistically significant difference between government and non-government funded corporate patents. The basicness nature of government funded corporate patents is supported from *General* in column (6), which confirms that federally funded corporate patents are cited by patents from a larger array of technologies compared to non-federally funded patents.

These findings sharply contrast with the evidence found for university patents. Results massively confirm the basic nature of the federally funded corporate innovation output.

As before, we dig further the data and examine whether the results vary with the size of the corporation. As in the case of universities, we divide corporations to small, medium, and large based on the amount of patents they produce. We estimate equation (3) for corporations only. The control group is small-sized university patents produced without government's financial support. Table 5 presents the results.

We begin our discussion with the coefficient of *FedFund*, which shows the difference of small-sized corporate patents produced with federal support and small-sized corporate patents that produced without federal support. In terms of *Science*, *Downstream* and *General* federally funded small-sized corporate patents are more basic and upstream than their non-federally funded counterparts. While for the other three patent measures the coefficients are not significant, with the exception of *ImportF*, they have a consistent sign with a basicness interpretation. We, therefore, conclude that for small-sized corporations, their federally funded patents are more basic than their non-federally funded peers.

Next, we proceed to medium-sized corporations. The addition of the coefficients of the terms *FedFund* and *MediumEntxFedFund* reflects the difference of medium-sized corporate patents produced with federal

[28]For robustness purposes we have also considered different cut-off points. See Table A.2. Results, overall, do not change.

support and medium-sized corporate patents produced without federal support. As we observe, findings are similar to the small-sized corporations.

Lastly, we consider large-sized corporations. We focus on addition of the coefficients of the terms $FedFund$ and $MediumEntxFedFund$ to compare federally funded patents and non-federally funded patents assigned to large-sized corporations. As Table 5 shows, results are statistically insignificant in all patent metrics and, therefore, not conclusive. One can infer that large corporations do not pursue government funding for necessarily more upstream and basic research projects than they would otherwise undertake.

Overall, the results for corporations corroborate with our presumption that federally funded corporate patents are more basic and upstream in nature than their non-federally funded counterparts. This result is driven primarily from patents originating from small- and medium-sized corporations in our sample.[29] In terms of innovation policy, this is an anticipated outcome. The private sector seeks federal funding support for research projects that are more basic and upstream that they would otherwise undertake and federal government supports financially such projects.

4.2. Are Federally Funded Patented Innovations Different from Corporations' and Universities' Research Agenda?

In this section, we examine whether there is a systematic difference in the degree of appropriability, which, in turn, could reflect the degree of innovation remoteness from existed research agenda, between state financing versus non-state financing (university/corporate) patents.

We estimate two specifications of equation (2), one where the dependent variable, Y_i, is the patent metric $SelfcitesB$ and another when it is $SelfcitesF$. Estimated coefficients are reported in columns (1) and (2), respectively, of Table 6 below. The control group is non-federally funded university patents. Consequently, the coefficient of $FedFund$ captures the difference in the degree of appropriability between non-federally and federally funded university patents.

As Table 6 shows both coefficients of $FedFund$ in columns (1) and (2) are significant. The Poisson estimate 1.302 means that university patents with government support have a rate 1.302 times greater of own (backward) citations compared to the non-government funded university patents. The finding that federally funded university patents are more connected to past and future own university research implies perhaps the size and consistency of federal funding. Big federal research grants are likely to generate a stream of related patents as the same research groups are likely to obtain subsequent federal funding with similar research objectives and, therefore, lead to related patenting.

Next, we turn to examine whether there is systematic difference in the degree of appropriability between non-federally and federally funded corporate patents. Contrary to the linear models, where the addition of the coefficients of the terms $FedFund$ and $CorporationxFedFund$ would express this difference, in non-linear model estimated by Poisson, interpretation of the coefficients is more complicated. Ai and Norton (2003) show that the magnitude of the coefficient of the interaction term in non-linear models (such in our case Poisson) is not the same as the marginal effect of interaction term in linear models. They present a way to estimate the magnitude of interaction terms in non-linear models and in this paper we follow their approach.[30] From the calculations, we find that federally funded corporate patents are less related to corporation's own research portfolio compared to non-federally funded peers.[31] This implies that corporations, which obtain federal funding for research, create innovation output that is remote to the corporation's own research portfolio. The latter could indicate that corporations seek federal funding for high risk and unexplored research areas.

We now want to unfold what type of entity, in terms of size, drives the delivered results. Our next step involves the division of entities into three groups, based on the patents they produce. Table 7 below reports results for different university sizes.

[29] For robustness purposes we have also considered different cut-off points. See Table A.3. Results, overall, do not change.

[30] For an elaboration, see Ai and Norton (2003).

[31] Calculations are available upon request.

We see that for small universities, federally funded university patents have greater links to own past and future research than non-federally funded ones. This result holds also for medium-sized universities, whereas for large-sized universities results are not significant at all. The presence of federal funding in small- and medium-sized universities could lead to an overarching research agenda that can manifest to research output that is inter-connected with own research output from the same university. This phenomenon, while present in larger universities, can be diluted by other types of funding or by a higher number of independent research grants financing university research.[32]

Next, Table 8 reports the estimated coefficients when estimating equation (3) for different corporation sizes.

What we observe is that for small corporations, federally funded corporate patents are assimilated to own research portfolio as all other non-federally funded corporate patents. Similar is the case for large-sized corporations. However, in the case of medium-sized corporations, we observe a significant difference. Federally funded corporate patents appear to divert from own corporation's research portfolio compared to non-federally funded corporation patents. We can interpret this evidence in the following way: government finances medium-sized corporations to do specific type of research that they would not have the motive to do it otherwise, and medium-sized corporations choose to obtain federal research for projects that *ex post* lead in innovation output that is not in alignment with corporation's own past or future research agenda.[33]

Overall, federally funded corporate patents are, on average, less related to corporation's own research portfolio compared to non-federally funded peers. This result is driven by medium-sized corporations, which generate patents that are financed from the government that are considerably less related to own firm's past and future research than all other non-government patents. In contrast, small- and large-sized corporations appear to assimilate, in their research portfolio, the innovation output that stems from state funding in the same way as all other non-funded patents.

5. Conclusion

The present paper studied the relationship between federal government sponsorship of research and nature of innovation output. In particular, we examined whether the US federally funded university as well as corporate patented inventions are different in nature compared to their non-federally funded counterparts. As state funding accounts for approximately 60% of university research and 10-20% of corporate research, state sponsorship and the type of research eventually conducted consists an issue of particular importance. More specifically, the paper aimed to answer two specific questions: (i) Are federally funded patented innovations more basic than their non-federally funded peers? and (ii) Are federally funded corporate and university patented innovations very different from their existed research agenda?

Based on a sample that consists of all US patents, which are assigned to at least one US corporation or to one US university, issued between 1996 and 2000 and on related peripheral information that patent data offer, we construct measures of basicness and approprriability that reflect the nature of a patent in terms of importance and proximity to an existed research agenda, respectively. Our results are easy to summarize. In both issues raised, however, we do not offer causal explanations, but rather associations between government sponsorship and nature of innovation.

With respect to the first question posed in the paper, overall we find no clear evidence that federally financed university innovations are more basic in nature compared to university innovations that have generated without federal support. After controlling for university size it appears that for small- and medium-sized universities there is some more pronounced difference between federally and non-federally funded university patents, with the former to be relatively more basic than the latter. These results could add to the discussion that corporate funding of university patents diverts research towards more applied

[32]For robustness purposes we have also considered different cut-off points. See Table A.2. Results, overall, do not change.

[33]For robustness purposes we have also considered different cut-off points. See Table A.3. Results, overall, do not change.

venues. However, findings in this paper do not yield support toward these criticisms. Results, however, should be interpreted cautiously since we condition our study at the patent and not at the invention disclosure. In contrast, federal funding is significantly associated with more basic innovation output for the case of corporations, indicating that federal government finances corporate research projects that are more basic in nature than the generic private sector research portfolio and that the industry seeks federal funding for predominantly more basic, than usual, research projects. This finding is more nuanced and driven by primarily small- and medium-sized corporations.

With respect to the second question, again the evidence is less clear for the relevance of federally funded university innovations to the university research agenda. While for small- and medium-sized universities federally funded university patents have greater ties to own past and future research than non-federally funded patents, for large-sized universities results are inconclusive. One could argue that the presence of federal funding in small- and medium-sized universities can lead to an overarching research agenda that can stem research output in the long run that is connected with the past output. This phenomenon, while present in larger universities, can be diluted by other types of funding or by a higher number of independent research grants financing university research. Concerning the corporations, we find that federally funded corporate patents are assimilated to small and large firms' patenting portfolios, whereas the opposite holds the for the case of medium-sized corporations. An important implication of our findings, considering the actual objectives of financing corporation research, is that while the federal government finances high risk and upstream projects, certain types of corporations create rather alien patent portfolio within the corporation.

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Appendix

Table 1: Summary Statistics for Patents from US Corporations and US Universities. Distinguish between Patents with (w/) and without (w/o) Federal Support

	Corporate Patents w/o Fed Support Group A		**Corporate Patents w/ Fed Support Group B**		**Difference between Groups A& B**	**Corporate Patents w/o Fed Support Group C**		**Corporate Patents w/ Fed Support Group D**		**Difference between Groups C& D**
	Obs	Mean	Obs	Mean	p-value	Obs	Mean	Obs	Mean	p-value
Patent Characteristics										
NCITED	282094	12.88	4322	10.53	0	7445	8.86	5625	6.68	0
		(17.72)		(13.32)			(11.78)		(8.98)	
NPCITES	282094	3.54	4322	7.86	0	7445	15.29	5625	18.84	0
		(12.78)		(21.01)			(22.40)		(25.95)	
NCITING	282094	17.85	4322	17.31	0.24	7445	17.14	5625	15.99	0.02
		(28.98)		(25.20)			(30.18)		(25. 40)	
NumberofClaims	282094	17.70	4322	19.60	0	7445	18.47	5625	18.78	0.26
		(13.66)		(15.33)			(15.44)		(15.44)	
ApplicationLength	282094	2.13	4322	2.35	0	7445	2.46	5625	2.58	0
		(1.00)		(1.46)			(1.08)		(1.12)	
NumberofIPC	282094	1.20	4322	1.30	0	7445	1.44	5625	1.53	0
		(0.49)		(0.60)			(0.72)		(0.75)	
NumberofUSClasses	282094	1.79	4322	1.87	0	7445	1.96	5625	2.04	0
		(0.95)		(0.99)			(1.04)		(1.04)	
NumberofInventors	282094	2.38	4322	2.58	0	7445	2.43	5625	2.70	0
		(1.60)		(1.54)			(1.35)		(1.47)	
NumberofAssignees	282094	1.01	4322	1.02	0.04	7445	1.05	5625	1.07	0
		(0.12)		(0.14)			(0.23)		(0.29)	
Patent Metrics										
BASICNESS										
Science	280228	0.14	4292	0.28	0	7400	0.50	5582	0.60	0
		(0.23)		(0.32)			(0.35)		(0.34)	
Downstream	280995	0.49	4305	0.45	0	7300	0.43	5468	0.38	0
		(0.26)		(0.26)			(0.26)		(0.26)	
ImportB	282094	322.98	4322	224.33	0	7445	235.38	5625	186.09	0
		(824.44)		(436.04)			(551.19)		(416.58)	
ImportF	282094	100.50	4322	81.81	0	7445	89.37	5625	72.57	0
		(283.62)		(198.40)			(290.62)		(175.71)	
Original	276258	0.46	4131	0.47	0	6652	0.44	4701	0.41	0
		(0.27)		(0.27)			(0.29)		(0.29)	
General	267509	0.47	4102	0.50	0	6843	0.49	5127	0.49	0.39
		(0.27)		(0.27)			(0.27)		(0.27)	
APPROPRIABILITY										
SelfcitesB	282094	1.25	4322	0.84	0	7445	0.46	5625	0.57	0
		(2.86)		(1.94)			(1.23)		(1.60)	
SelfcitesF	282094	1.96	4322	1.63	0	7445	0.79	5625	1.10	0
		(6.82)		(5.28)			(2.40)		(3.17)	

Note: *NPCITES* is the number of backward non-patent sources, *NCITED* is the number of backward patents, and *NCITING* is the number of forward citations. Numbers in parentheses are standard errors. Forward citations have been collected until December 31, 2010.

Table 2: Comparisons of Basicness and Appropriation between University and Corporation Patents

	Basicness						Appropriability	
	Science	Downstream	ImportB	ImportF	Original	General	SelfcitesB	SelfcitesF
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
University	0.183***	-0.0711***	-100.1***	14.91***	-0.00533	0.0470***	0.459***	0.556***
	(0.0176)	(0.00419)	(18.26)	(4.609)	(0.00929)	(0.0112)	(0.0215)	(0.0426)
NumberOfClaims	0.000783***	-0.000737***	6.668***	1.787***	0.000987***	0.00145***	1.004***	1.009***
	(9.51e-05)	(7.00e-05)	(0.716)	(0.189)	(6.02e-05)	(6.71e-05)	(0.000569)	(0.00115)
AppLength	0.0133***	0.0102***	27.05***	-1.630***	0.0142***	0.00659***	0.973**	0.932***
	(0.00240)	(0.000977)	(3.163)	(0.629)	(0.00147)	(0.00107)	(0.0106)	(0.00944)
NumberOfIPC	0.0109*	0.00144	-4.154	-2.617	0.00993**	0.00146	1.002	0.967
	(0.00589)	(0.00274)	(7.883)	(1.641)	(0.00418)	(0.00297)	(0.0150)	(0.0243)
NumberOfUSClasses	-0.000196	-0.00929***	31.69***	15.62***	0.0627***	0.0523***	1.003	1.089***
	(0.00191)	(0.00122)	(6.322)	(1.853)	(0.00396)	(0.00320)	(0.0110)	(0.0143)
NumberOfInventors	0.00323***	-0.00544***	26.78***	8.269***	0.00555***	0.00785***	1.095***	1.100***
	(0.000356)	(0.000520)	(3.215)	(0.941)	(0.000751)	(0.000916)	(0.00621)	(0.00950)
NumberOfAssignees	0.00956	-0.00569	-2.705	-10.60***	-0.00849*	0.00665	0.830	0.454***
	(0.00638)	(0.00538)	(46.32)	(3.553)	(0.00460)	(0.00474)	(0.193)	(0.0361)
Constant	0.0746***	0.551***	62.56	-5.313	0.268***	0.286***	0.442***	2.938***
	(0.0168)	(0.00861)	(52.89)	(11.70)	(0.0133)	(0.0116)	(0.111)	(0.304)
Observations	297,502	298,068	299,486	299,486	291,742	283,581	299,486	299,486
R-squared	0.439	0.151	0.120	0.159	0.171	0.168	-	-

Note: Specifications in Columns (1)-(6) are estimated with OLS, while specifications in Columns (7) and (8) are estimated with Poisson. All regressions include grant year fixed effects and US Classification fixed effects. Standard errors, in parentheses, are clustered at the US classification level.

Table 3: Comparisons of Basicness of Federally vs. Non-federally Funded Patents

	Basicness Metrics					
	Science	Downstream	ImportB	ImportF	Original	General
	(1)	(2)	(3)	(4)	(5)	(6)
Corporation	-0.172***	0.0557***	98.81***	-16.24***	-0.00468	-0.0459***
	(0.0165)	(0.00367)	(20.28)	(5.141)	(0.00780)	(0.0102)
FedFund	0.0325***	-0.0393***	-7.227	-2.930	-0.0238***	0.00467
	(0.00792)	(0.00619)	(12.56)	(5.408)	(0.00676)	(0.00899)
CorporationxFedFund	0.0469***	-0.000475	-54.93***	6.302	0.0340***	0.0249**
	(0.00739)	(0.00951)	(19.17)	(8.485)	(0.00768)	(0.0107)
Constant	0.247***	0.495***	-36.24	10.86	0.273***	0.332***
	(0.0187)	(0.00912)	(63.39)	(12.94)	(0.0136)	(0.0164)
Observations	297,502	298,068	299,486	299,486	291,742	283,581
R-squared	0.441	0.152	0.120	0.159	0.171	0.168

Note: Table reports OLS estimates. All specifications include grant year fixed effects and US Classification fixed effects. Standard errors, in parentheses, are clustered at the US classification level.

Table 4: Comparisons of Basicness of Federally vs. Non-federally Funded University Patents. Distinguish by University Size

	Basicness					
	Science	Downstream	ImportB	ImportF	Original	General
	(1)	(2)	(3)	(4)	(5)	(6)
MediumUni	0.0461***	-0.0152**	-12.60	9.221	-0.0127*	0.00500
	(0.00888)	(0.00728)	(17.60)	(9.113)	(0.00745)	(0.00989)
LargeUni	0.0412***	-0.0568***	52.63**	44.10***	-0.00377	0.0563***
	(0.00957)	(0.00795)	(24.38)	(13.00)	(0.00912)	(0.00821)
FedFund	0.0609***	-0.0419***	-2.517	-3.823	-0.0122	0.0210***
	(0.0133)	(0.00968)	(17.96)	(5.701)	(0.00910)	(0.00696)
MediumUnixFedFund	-0.00274	-0.00378	-12.99	6.360	-0.00516	-0.0149
	(0.0153)	(0.0117)	(21.54)	(10.04)	(0.0141)	(0.0147)
LargeUnixFedFund	-0.0579***	0.0362***	-75.71**	-29.81**	-0.0176	-0.0421***
	(0.0117)	(0.0123)	(29.22)	(12.49)	(0.0110)	(0.00975)
Constant	0.361***	0.559***	53.25	-34.00*	0.311***	0.312***
	(0.0255)	(0.0183)	(34.58)	(19.12)	(0.0213)	(0.0190)
Observations	12,982	12,768	13,070	13,070	11,353	11,970
R-squared	0.433	0.132	0.096	0.162	0.182	0.188

Note: Table reports OLS estimates. All specifications include the control set Z but for economizing purposes coefficients of Z variables are not reported. The variable *MediumUniv* takes the value of 1 if the patent is assigned to a university that has between 81 and 240 patents within the last five years and 0 otherwise. The variable *LargeEnt* takes the value of 1 if the patent is assigned to a university that has more than 240 patents within the last five years an zero otherwise. *MediumUnixGovernment* is defined as $MediumUni * Government$ and *LargeUnixGovernment* as $LargeCorp * Government$. Standard errors are clustered at the US classification level.

Table 5: Comparisons of Basicness of Federally vs. Non-federally Funded Corporate Patents. Distinguish by Corporation Size

	Basicness					
	Science	Downstream	ImportB	ImportF	Original	General
	(1)	(2)	(3)	(4)	(5)	(6)
MediumCorp	0.00208	0.00223	37.67***	-13.01***	-0.0111***	-0.0138***
	(0.00330)	(0.00320)	(14.12)	(3.756)	(0.00345)	(0.00335)
LargeCorp	-0.00111	-0.0145***	-72.83***	-22.13***	-0.0236***	-0.0181***
	(0.00353)	(0.00360)	(16.40)	(5.823)	(0.00396)	(0.00421)
FedFund	0.109***	-0.0464***	-43.44	-4.330	0.0141	0.0412***
	(0.00993)	(0.0107)	(36.94)	(10.36)	(0.0103)	(0.00975)
MediumCorpxFedFund	-0.0192	-0.00888	-83.76***	7.008	-0.0101	-0.0115
	(0.0132)	(0.0145)	(30.52)	(10.62)	(0.00980)	(0.0104)
LargeCorpxFedFund	-0.0865***	0.0357**	43.73	15.98	-0.00108	-0.0278**
	(0.0144)	(0.0173)	(42.12)	(14.11)	(0.0148)	(0.0140)
Constant	0.0755***	0.554***	76.31	9.007	0.278***	0.296***
	(0.0126)	(0.00880)	(61.64)	(10.48)	(0.0133)	(0.0122)
Observations	284,520	285,300	286,416	286,416	280,389	271,611
R-squared	0.378	0.152	0.124	0.162	0.174	0.171

Note: Table reports OLS estimates. All specifications include variables on number of claims, application length, number of IPC classifications, number of US classifications, number of inventors, number of assignees include, grant year fixed effects and US Classification fixed effects. *MediumCorp* takes the value of 1 if the patent is assigned to a corporation that has between 21 and 460 patents within the last five years and 0 otherwise. *LargeCorp* takes the value of 1 if the patent is assigned to a corporation that has more than 460 patents within the last five years an zero otherwise. *MediumCorpxGovernment* is defined as $MediumCorp * Government$ and *LargeCorpxGovernment* as $LargeCorp * Government$. Standard errors, parentheses, are clustered at the US classification level.

Table 6: Comparisons of Appropriation of Federally vs. Non-federally Funded Patents

	Appropriability Metrics	
	SelfcitesB	SelfcitesF
	(1)	(2)
Corporation	2.474***	2.132***
	(0.127)	(0.200)
FedFund	1.302***	1.427***
	(0.115)	(0.128)
CorporationxFedFund	0.528***	0.581***
	(0.0596)	(0.0775)
Constant	0.179***	1.380***
	(0.0479)	(0.168)
Observations	299,486	299,486

Note: Table reports Poisson estimates. All regressions include grant year fixed effects and US Classification fixed effects. Standard errors, in parentheses, are clustered at the US classification level.

Table 7: Comparisons of Appropriation of Federally vs. Non-federally Funded University Patents

	Appropriability Metrics	
	SelfcitesB	SelfcitesF
	(1)	(2)
MediumUni	1.116	1.081
	(0.147)	(0.133)
LargeUni	1.945***	1.444***
	(0.257)	(0.177)
FedFund	1.519**	1.397**
	(0.319)	(0.196)
MediumUnixFedFund	0.751	0.924
	(0.160)	(0.147)
LargeUnixFedFund	0.612**	0.816
	(0.119)	(0.128)
Constant	0.191***	0.440***
	(0.0414)	(0.105)
Observations	13,070	13,070

Note: Table reports Poisson estimates. All regressions include grant year fixed effects and US Classification fixed effects. *MediumUnixGovernment* is defined as $MediumUni * Government$ and *LargeUnixGovernment* as $LargeUni * Government$. Standard errors, in parentheses, are clustered at the US classification level.

Table 8: Comparisons of Appropriation of Federally vs. Non-federally Funded Corporate Patents

	Appropriability Metrics	
	SelfcitesB	SelfcitesF
	(1)	(2)
MediumCorp	2.661***	1.831***
	(0.0960)	(0.102)
LargeCorp	3.892***	2.086***
	(0.169)	(0.154)
FedFund	0.871	1.207
	(0.0970)	(0.238)
MediumCorpxFedFund	0.509***	0.339***
	(0.0808)	(0.0752)
LargeCorpxFedFund	1.096	1.029
	(0.142)	(0.222)
Constant	0.168***	1.900***
	(0.0434)	(0.217)
Observations	286,416	286,416

Note: Table reports Poisson estimates. All regressions include grant year fixed effects and US Classification fixed effects. *MediumCorpxGovernment* is defined as $MediumCorp * Government$ and *LargeCorpxGovernment* as $LargeCorp * Government$. Standard errors, in parentheses, are clustered at the US classification level.

Table A.1: Degrees of Appropiability for Different λ's

	ImportB			ImportF		
	$\lambda = 0.5$	$\lambda = 0.25$	$\lambda = 0.75$	$\lambda = 0.5$	$\lambda = 0.25$	$\lambda = 0.75$
	(1)	(2)	(3)	(4)	(5)	(6)
University	-100.1***	-51.63***	-148.5***	14.91***	8.569***	21.25***
	(18.26)	(9.352)	(27.18)	(4.609)	(2.619)	(6.603)
Constant	62.56	33.96	91.16	-5.313	-0.268	-10.36
	(52.89)	(27.04)	(78.75)	(11.70)	(6.313)	(17.08)
Observations	299,486	299,486	299,486	299,486	299,486	299,486
R-squared	0.120	0.119	0.120	0.159	0.167	0.157

Note: Table reports OLS estimates. Each regression includes variables on number of claims, application length, number of IPC classifications, number of US classifications, number of inventors, number of assignees include, grant year fixed effects and US Classification fixed effects. Standard errors, in parentheses, are clustered at the US classification level.

Table A.2: Comparisons of Basicness and Appropriability of Federally vs. Non-federally University Patents. Distinguish by University Size

	Science	Downstream	ImportB	ImportF	Original	General	SelfcitesB	SelfcitesF
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
UnivInQuar2	0.0534***	-0.0213**	-36.75*	10.24	-0.0234**	0.00116	1.093	1.514***
	(0.00923)	(0.00919)	(21.25)	(7.234)	(0.00971)	(0.00740)	(0.120)	(0.178)
UnivInQuar3	0.0511***	-0.0338***	3.310	23.28*	-0.0116	0.0271**	1.338*	1.431***
	(0.0118)	(0.00740)	(29.66)	(13.34)	(0.00941)	(0.0121)	(0.226)	(0.193)
UnivInQuar4	0.0599***	-0.0650***	67.89**	59.21***	0.00191	0.0591***	1.846***	1.704***
	(0.0115)	(0.00916)	(29.97)	(17.00)	(0.0112)	(0.00950)	(0.242)	(0.191)
Government	0.0620***	-0.0473***	-12.91	2.933	-0.0173	0.0128	1.620**	1.662***
	(0.0163)	(0.0121)	(21.50)	(6.537)	(0.0106)	(0.00791)	(0.345)	(0.297)
UnivInQuar2xGovernment	-0.00912	-0.00323	41.38*	1.758	0.0197	0.0102	0.601**	0.732
	(0.0144)	(0.0146)	(24.54)	(9.387)	(0.0149)	(0.0137)	(0.143)	(0.140)
UnivInQuar3xGovernment	-0.0102	0.0362**	-25.14	-16.56	-0.00588	-0.0246*	0.837	0.788
	(0.0228)	(0.0150)	(32.35)	(13.32)	(0.0142)	(0.0137)	(0.182)	(0.189)
UnivInQuar4xGovernment	-0.0703***	0.0347**	-97.34***	-46.13***	-0.0257*	-0.0334***	0.529***	0.638***
	(0.0146)	(0.0157)	(35.33)	(16.58)	(0.0142)	(0.00951)	(0.114)	(0.0964)
Constant	0.347***	0.566***	60.70	-38.84*	0.316***	0.311***	0.197***	0.361***
	(0.0261)	(0.0169)	(36.99)	(20.15)	(0.0224)	(0.0197)	(0.0449)	(0.0925)
Observations	12,982	12,768	13,070	13,070	11,353	11,970	13,070	13,070
R-squared	0.433	0.133	0.097	0.163	0.183	0.187	-	-

Note: Columns (1)-(6) report OLS estimates, while columns (7) and (8) report Poisson estimates. All regressions include variables on number of claims, application length, number of IPC classifications, number of US classifications, number of inventors, number of assignees include, grant year fixed effects and US Classification fixed effects. $UnivInQuar2$ takes the value of 1 if the patent is assigned to a university that has between 61 and 140 patents within the last five years and 0 otherwise (50th percentile > medium-small-sized universities > 25th percentile). $UnivInQuar3$ takes the value of 1 if the patent is assigned to a university that has between 141 and 315 patents within the last five years and zero otherwise (75th percentile > medium-large-sized universities > 50th percentile). $UnivInQuar4$ takes the value of 1 if the patent is assigned to a university that has more than 315 patents within the last five years and zero otherwise (Large-sized university > 75th percentile). The intersection terms are defined as: $UnivInQuar2xGovernment = UnivInQuar2 * Government$, $UnivInQuar3xGovernment = UnivInQuar3 * Government$, and $UnivInQuar4xGovernment = UnivInQuar4 * Government$.

Table A.3: Comparisons of Basicness and Appropriability of Federally vs. Non-federally Corporate Patents. Distinguish by Corporation Size

	Science	Downstream	ImportB	ImportF	Original	General	SelfcitesB	SelfcitesF
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$CorpInQuar2$	0.00478*	0.00375	110.8***	-3.275	-0.00256	-0.00865***	2.904***	2.286***
	(0.00262)	(0.00259)	(15.90)	(3.450)	(0.00268)	(0.00262)	(0.0912)	(0.115)
$CorpInQuar3$	3.41e-05	-0.00253	17.64	-16.99***	-0.0180***	-0.0191***	4.123***	2.319***
	(0.00405)	(0.00351)	(17.57)	(4.689)	(0.00473)	(0.00497)	(0.183)	(0.162)
$CorpInQuar4$	0.00144	-0.0143***	-56.98***	-25.64***	-0.0233***	-0.0178***	6.161***	2.542***
	(0.00364)	(0.00426)	(17.97)	(6.888)	(0.00436)	(0.00453)	(0.317)	(0.176)
$Government$	0.110***	-0.0444***	-34.06	-7.958	0.0103	0.0444***	1.036	1.397**
	(0.0112)	(0.00939)	(30.49)	(8.122)	(0.0120)	(0.00933)	(0.152)	(0.238)
$CorpInQuar2$	-0.0122	-0.0103	-89.92***	7.211	-0.00661	-0.0218*	0.531***	0.360***
	(0.0117)	(0.0120)	(30.12)	(8.086)	(0.0121)	(0.0114)	(0.0986)	(0.0544)
$CorpInQuar3$	-0.0558***	0.00252	-61.92*	13.47	-0.00441	-0.00343	0.546***	0.492***
	(0.0149)	(0.0142)	(32.27)	(10.26)	(0.0143)	(0.0131)	(0.0947)	(0.112)
$CorpInQuar4$	-0.0716***	0.0359*	47.76	22.19	0.0106	-0.0419***	0.929	0.906
	(0.0146)	(0.0209)	(37.88)	(15.67)	(0.0155)	(0.0145)	(0.156)	(0.172)
$Constant$	0.0742***	0.553***	48.50	9.421	0.278***	0.296***	0.123***	1.492***
	(0.0128)	(0.00889)	(63.02)	(10.38)	(0.0132)	(0.0124)	(0.0330)	(0.169)
Observations	284,520	285,300	286,416	286,416	280,389	271,611	286,416	286,416
R-squared	0.377	0.152	0.126	0.162	0.174	0.171	-	-

Note: Columns (1)-(6) report OLS estimates, while columns (7) and (8) report Poisson estimates. All regressions include variables on number of claims, application length, number of IPC classifications, number of US classifications, number of inventors, number of assignees include, grant year fixed effects and US Classification fixed effects. $CorpInQuar2$ takes the value of 1 if the patent is assigned to a corporation that has between 10 and 120 patents within the last five years and 0 otherwise (50th percentile > medium-small-sized corporations > 25th percentile). $CorpInQuar3$ takes the value of 1 if the patent is assigned to a corporation that has between 121 and 900 patents within the last five years and zero otherwise (75th percentile > medium-large-sized corporations > 50th percentile). $CorpInQuar4$ takes the value of 1 if the patent is assigned to a corporation that has more than 900 patents within the last five years and zero otherwise (Large-sized corporation > 75th percentile). The intersection variables are defined as $CorpInQuar2xGovernment = CorpInQuar2 * Government$, $CorpInQuar3xGovernment = CorpInQuar3 * Government$, and $CorpInQuar4xGovernment = CorpInQuar4 * Government$.