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What promotes R&D? Comparative evidence from around the world

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ABSTRACT

R&D drives innovation and productivity growth, but appropriability problems and financing difficulties likely keep R&D investment well below the socially optimal level, particularly in high-technology industries. Though countries around the world are increasingly interested in using tax incentives and other policy initiatives to address this underinvestment problem, there is little empirical evidence comparing the effectiveness of alternative domestic policies and institutions at spurring R&D. Using data from a broad sample of OECD economies, we find that financial market rules that improve accounting standards and strengthen contract enforcement share a significant positive relation with R&D in more innovative industries, as do stronger legal protections for intellectual property. In contrast, stronger creditor rights and more generous R&D tax credits have a negative differential relation with R&D in more innovative industries. These results suggest that domestic policies directly dealing with appropriability and financing problems may be more effective than traditional tax subsidies at promoting the innovative investments that drive economic growth.

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1. Introduction

There is extensive interest from policymakers and academic researchers alike in identifying the policies, laws, and institutions that promote private-sector investment in R&D (e.g., [European Commission, 2003, 2004, 2010](#); [Hall and Van Reenen, 2000](#)). Two related factors motivate this interest. First, R&D is a key driver of innovation and productivity growth (e.g., [Romer, 1990](#); [Aghion and Howitt, 1992](#)). Second, there are strong theoretical reasons to expect that the private level of R&D investment falls well below the socially optimal level (e.g., [Griliches, 1992](#); [Hall, 1996](#); [Jones and Williams, 1998](#)).

There are two main reasons for underinvestment in R&D. The first is that because of weak or incomplete intellectual property

protection, firms do not appropriate all of the returns to innovation, causing the social returns to R&D to be substantially higher than the private returns (see the survey in [Hall et al., 2010](#)). The second reason is that financing constraints are likely pronounced for R&D investment ([Brown et al., 2012](#)). In particular, limited collateral value and asymmetric information between investors and firms can sharply curtail access to external finance, keeping R&D investment well below the level that would prevail if there were no capital market imperfections (e.g., [Arrow, 1962](#); [Hall, 2002](#)).

These appropriability problems and financing difficulties are likely particularly severe in high-technology industries. For example, appropriability problems are more pronounced for high-tech firms because they tend to focus on product innovation, the details of which are more difficult to conceal from competitors than that of process innovation. High-tech R&D is also more susceptible to financing constraints for several reasons, including more severe asymmetric information problems, greater uncertainty, and the fact that high-tech firms tend to exhaust internal finance given the magnitude of R&D investments (e.g., [Brown et al., 2009](#)). An

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important consequence (and central to the tests in our study) is that if public policies directed at reducing capital market imperfections and appropriability problems are effective at promoting R&D, they should matter relatively more for R&D investment in innovative-intensive industries.

Despite the recognition that economies underinvest in R&D, there is little comparative cross-country evidence on the effectiveness of alternative policies and institutions at spurring innovation. This paper makes some initial progress by evaluating a broad set of country-level policies with the potential to move R&D closer to the socially optimal level. Our analysis focuses on: (i) tax incentives for R&D investment, perhaps the most widely used innovation policy tool, (ii) the strength of intellectual property (IP) protections, and (iii) financial market rules that affect the availability of external financing and nature of financial intermediary development.

We use a difference-in-differences approach to evaluate the association between these country-level policies and investment in R&D. Our empirical tests build on the insights in Rajan and Zingales (1998), who study how cross-country differences in financial market development affect economic growth. As Rajan and Zingales (1998) note, if financial market development facilitates growth, it should be *relatively* more important for growth in the industries with a high innate, technologically-driven reliance on external financing. Extending this approach to our setting, we estimate the *differential* association between country-level policies and R&D investment across industries that differ in their innate innovative intensity. In keeping with the Rajan and Zingales (1998) approach, we use U.S. data to measure the innate innovative intensity of different industries because the U.S. has strong property rights, financial markets, and enforcement institutions.¹ Specifically, we compute a measure we refer to as *Innovative intensity*, which is the ratio of R&D-to-sales for the median U.S. firm in each ISIC 2-digit industry. Notably, four key industries – chemicals, computers, communications technology, and scientific instruments – have an *Innovative intensity* far greater than all other industries in the sample. Consistent with other studies, we refer to these four industries as the “high-tech” sector.

The dependent variable in our regressions is industry-level R&D investment across countries, compiled from the OECD’s STAN database. The main explanatory variables are interactions between country-level tax incentives, IP protection, and financial market rules and the industry *Innovative intensity* measure. The logic behind this test is that if IP protection and financial market rules promote R&D, the association will be relatively stronger in industries with a high *Innovative intensity* (e.g., high-tech) because appropriability and financing problems lead to a greater *scope* for policies and institutions to impact R&D in these sectors. This estimation strategy has many advantages, including the fact that by isolating within-country differences across industries, it controls flexibly for a wide array of unobserved factors at the country- and industry- levels that confound inference in policy studies. Nonetheless, the potential endogeneity of some of the policies we study affects how we can interpret our findings, an issue we discuss in more detail below.

To evaluate the effectiveness of tax incentives for R&D, we construct time-series measures of the generosity of R&D tax credits using user-cost estimates from the OECD (Thompson, 2009).

¹ As such, observed differences in innovative intensity across U.S. industries are less likely to be distorted by institutional factors, and thus more likely to reflect the fundamental characteristics of the industry. This also follows the approach Claessens and Laeven (2003) use to study how stronger private property rights influence growth in industries with more intangible assets. Other studies relying on U.S. data to measure an industry’s innovative intensity include Acharya and Subramanian (2009) and Ilyina and Samaniego (2011).

We measure cross-national differences in the level of IP protection using an index of patent protections from Park (2008). We focus on the three financial market rules that Levine (1999) and Rajan and Zingales (2003) identify as the fundamental ingredients of a developed financial system: accounting standards, contract enforcement, and creditor rights. Stronger accounting standards and contract enforcement are important determinants of an economy’s supply of arm’s length financing (of both debt and equity), while creditor rights is more narrowly relevant for the supply of private credit. As we review in the next section, there is considerable debate in the literature regarding whether better access to credit has a positive impact on innovation; our study sheds new light on this issue by directly comparing how creditor rights and other financial market rules affect R&D investment across industries.

Our final sample consists of roughly 5600 observations over the period 1990–2006 for the 19 OECD countries with information on industry-level R&D and the country-level policies and institutions noted above. We report several findings new to the literature. First, more generous tax treatment of R&D is associated with relatively *less* R&D investment in more innovative industries. Second, countries with stronger IP protections have relatively higher R&D levels in high-tech industries. Third, stronger accounting standards and better contract enforcement are associated with relatively more R&D investment in high-tech industries, whereas stronger creditor protection is associated with comparatively less high-tech R&D. Thus, financial market rules that increase the supply of arm’s length financing appear to be more effective than rules related specifically to private credit supply at promoting high-tech R&D.

We conduct a number of additional tests to check robustness and explore the mechanisms underlying these findings. First, instead of sorting industries based on the innovative intensity of U.S. firms, we estimate the difference-in-differences regressions using a high-tech dummy variable and find similar results. We also find similar results if we collapse the time-dimension of the data and focus on the long-run connection between innovation policies and R&D investment. Finally, we replace the innovative intensity measure with three other industry characteristics measured with U.S. data: the level of internal cash flow the typical firm generates, the amount of income taxes it pays, and its reliance on external finance. We find that stronger accounting standards are associated with relatively more R&D investment in industries where the typical firm generates less internal cash flow, pays lower income taxes, and is more dependent on external finance. On the other hand, more generous tax credits for R&D share a relatively stronger relation with R&D in the industries that generate more internal cash flow, pay higher income taxes, and rely less on external finance. These findings provide important insights on the mechanisms underlying our overall results. In particular, since high-tech firms tend to generate less taxable income and internal finance, our findings suggest that policies affecting the availability of external finance are more important than policies providing more generous tax credits for R&D investment in the high-tech sector.

Our study contributes to several different literatures on the institutions and tax policies that support innovative activity. Most research on the tax treatment of R&D focuses on estimating the overall tax price elasticity of R&D.² Our contribution is to provide the first systematic cross-national study of the differential association between tax incentives and R&D investment in the economy’s

² Early studies report a relatively weak R&D response to the introduction of an R&D tax credit in the US in 1981 (e.g., Mansfield, 1986a). More recent studies from a number of different countries tend to find stronger effects, though the magnitude and precision of the estimates vary (e.g., Hall, 1993; Bloom et al., 2002; Berube and Mohnen, 2009; Czarnitzki et al., 2011; Bond and Guceri, 2012; Lokshin and Mohnen, 2012; Cappelen et al., 2012; Yang et al., 2012; Rao, 2013).

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