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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 subsides at promoting the innovative investments that drive economic growth.

Keywords: R&D, Innovation, R&D tax credits, Financial markets, Intellectual property protection, Technological change

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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, Mairesse, and Mohnen, 2010). The second reason is that financing constraints are likely pronounced for R&D investment (Brown, Martinsson, and Petersen, 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, Fazzari, and Petersen, 2009). An 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 polices 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 (RZ, 1998), who study how cross-country differences in financial market development affect economic growth. As RZ (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 RZ 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). 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

[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).

directly comparing how creditor rights and other financial market rules affect R&D investment across industries.

Our final sample consists of roughly 5,600 observations over the period 1990 to 2006 for the 19 OECD countries with information on industry-level R&D and the country-level polices 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 polices 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 high-tech sector. Since we focus on the differential effects of R&D tax credits across industries, our

[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, Griffith, and Van Reenen, 2002; Berube and Mohnen, 2009; Czarnitzki, Hanel, and Rosa, 2011; Bond and Guceri, 2012; Lokshin and Mohnen, 2012; Cappelen, Raknerud, and Rybalka, 2012; Yang, Huang, and Hou, 2012; Rao, 2013).

baseline results are not directly comparable to the findings in the R&D tax credit literature. However, when we estimate the relation between the *level* of R&D and a measure of its tax treatment (user cost) across all countries and industries in our sample, we recover a positive and significant tax price elasticity for R&D, consistent with Bloom, Griffith, and Van Reenen (2002) and related studies. When we estimate this levels regression separately for subsamples of high- and low-tech industries, we find that reductions in the user cost are associated with higher levels of R&D investment in low-tech but not high-tech industries. These findings reconcile our differential estimates with the overall effects documented in prior studies, while continuing to cast doubt on the effectiveness of tax credits at promoting R&D in industries where innovative investment is likely furthest below the socially optimal level.

Our study also contributes to the literature that explores the real effects of stronger IP protection. In a thorough review of the literature, Hall (2007) notes that fundamental questions about the importance of stronger IP protection for innovation remain unsettled.[3] One challenge in identifying the impact of IP protections is the potential for alternative country-specific factors to drive both innovative activity and the strength of IP protection. By focusing on the differential effects of IP protection across industries within a given country, our approach makes progress in addressing concerns that left-out variables drive the empirical relation between IP protection and R&D. This evidence is particularly relevant given the growing controversy regarding the value of stronger IP protection (e.g., Lerner, 2009; Boldrin and Levine, 2013).

Our findings also add to the growing literature on how laws and financial market rules that impact the supply of external finance affect innovative activity. The micro-level evidence in several studies suggests that financing constraints limit R&D investment, particularly in smaller, younger, and technology-intensive firms.[4] Our study also points to an important connection between the availability of arm's length financing and R&D, but our findings differ from prior studies in several ways. Most notably, we focus on the fundamental determinates of an economy's supply of arm's length financing and we directly compare the importance of these financial market rules with the effectiveness of IP protections and tax-based innovation policies.

Finally, given the importance of high-tech R&D for productivity growth and technological change, our findings also provide insights into the workings of the broader connections between

[3] Studies on the link between IP protection and innovative activity include Mansfield (1986b), Park and Ginarte (1997), Sakakibara and Branstetter (2001), Lerner (2009), Hall and Ziedonis (2001), Cohen et al. (2002), Kanwar and Evenson (2003), Branstetter, Fisman, and Foley (2006), Zhao (2006), Allred and Park (2007), Qian (2007), and Wang (2010). A related literature focuses on patenting decisions and subsequent real performance (e.g., Helmers and Rogers, 2011).

[4] For example, see Hall (1992), Himmelberg and Petersen (1994), Bond, Harhoff, and Van Reenen (2005), Hyytinen and Toivanen (2005), Brown, Fazzari, and Petersen (2009), Czarnitzki and Hottenrott (2011), Brown, Martinsson, and Petersen (2012 & 2013), and Aghion et al. (2012). In addition to relaxing financing constraints, better access to arm's length financing can facilitate innovation by both encouraging firms to pursue more novel innovations (Atanassov, Nanda, and Seru, 2007; Atanassov, 2015), and by reducing the incentives for firms to free-ride on the innovative efforts of competing firms (Yung, 2015).

institutions, finance, and aggregate economic performance explored in numerous studies (e.g., King and Levine, 1993; Aghion and Howitt, 2005; Levine, 2005; Brown, Martinsson, and Petersen, 2016). In particular, to the extent that prior studies like RZ (1998) and Levine (1999) link some of the financial market rules we focus on with economic growth, our work identifies a particular mechanism – more R&D investment in innovative-intensive industries – through which these fundamental determinants of capital market development are growth-enhancing.

Having covered these contributions, let us be clear about the limitations of our work. First, we limit the comparative analysis to tax credits, intellectual property protections, and a set of key determinants of financial market development. Our findings thus have nothing to say about the comparative effectiveness of other institutional and organizational factors at promoting R&D.[5] Second, our evidence shows how spending on R&D differs across institutional environments, but does not speak directly to the performance of these innovative investments. While most evidence suggests that the marginal returns to additional R&D investment are quite high (e.g., Hall, 2002), it is possible the mix of institutions and innovation policies also affects the productivity of R&D. We leave this topic for future research. Finally, though our comparative analysis, rich set of fixed effects, and focus on the differential effects of innovation policy across industries makes progress in dealing with standard concerns about endogeneity and omitted factors, we do not have external instruments or a clean natural experiment to exploit for additional help with identification. It is thus prudent to be cautious in the way our findings are used and interpreted.

2. Data, measurement, and differences across high- and low-tech industries

2.1 R&D underinvestment in innovative intensive industries

Appropriability problems and financing constraints are widely thought to cause underinvestment in R&D and there are strong reasons to believe this is particularly so in innovative intensive industries. Appropriability problems are likely more pronounced in high-tech industries because R&D in new industries is typically focused on creating new products as opposed to process innovation (e.g., Teece, 1986, Figure 4). The details of product innovation are likely much more difficult to conceal from competitors than the details of process innovation for obvious reasons (e.g., products are readily available for reverse engineering). In addition, product innovation in new industries often lacks complementary assets, which reduces the ability of firms to appropriate value (e.g., Teece, 1986). These arguments suggest that IP protection should be more important for both product innovation as well as for R&D in high-tech industries. Levin et al. (1987, Table 1) survey executives on strategies for appropriating the returns to R&D and report that patents are substantially more important for product innovation compared to process innovation. A follow-up study by Cohen

[5] A non-exhaustive list of recent studies on other national and organizational determinants of R&D and innovation includes Acharya and Subramanian (2009), Manso (2011), Hillier et al. (2011), Brown and Floros (2012), Atanassov (2013), Ederer and Manso (2013), He and Tian (2013), Aghion, Howitt, and Prantl (2015), Aghion et al. (2014), Aggarwal and Hsu (2014), and Tian and Wang (2014).

et al. (2004) confirms this finding and also reports that executives view patents as more valuable for appropriating returns to R&D in high-tech industries (e.g., pharmaceutical, computers, medical instruments) compared to low-tech industries.[6]

Capital market imperfections likely also matter more for R&D investment in innovative intensive industries. One reason is simply that "cutting-edge" science is particularly difficult for investors to evaluate, leading to potentially severe asymmetric information problems in high-tech firms (e.g., Brown, Fazzari, and Petersen, 2009; O'Mahony and Vecchi, 2009; Czarnitzki and Hottenrott, 2011). In addition, the nature of some forms of external financing – namely debt finance – are poorly suited for financing investments with high probability of failure but some chance of extremely high returns, characteristics of high-tech R&D. Finally, R&D intensity in high-tech industries dwarfs that of low-tech industries, often forcing high-tech firms to exhaust internal finance and thus out of necessity turn to more costly external finance for funding marginal R&D investments.

The notion that appropriability problems and financing constraints should matter more for high-tech industries is central to the tests that follow. In particular, they imply that policies and institutions that affect capital market development and the appropriability of intellectual capital should matter relatively more for R&D investment in innovative intensive industries.

2.2 Sample construction

To create our sample, we merge time-series observations on industry-level R&D investment from the OECD's STAN database with country-level measures of R&D tax incentives, financial market rules, and IP protection collected from several different sources. The STAN database is attractive for our purposes for several reasons. Most importantly, it is the only data source we know of that provides internationally comparable estimates of R&D activity across industries and over time. In addition, the industry-level R&D figures in the STAN database capture the innovative activities of both private and public firms, overcoming a limitation of innovation studies that rely only on samples of public firms. Accounting for the full extent of R&D in an industry is essential for evaluating the more aggregated effects of alternative innovation policies.

Table 1 reports variable descriptions, data sources, and overall sample statistics for the main variables we use in the study. The dependent variable in our main regressions is R&D-to-value added (*R&D*), reported in the STAN database at the 2-digit ISIC industry level.[7] We also report results with R&D scaled by industry output rather than value added, but focus on results using R&D-to-value

[6] That said, there are potentially sharp differences in the importance of appropriability *across* the individual high-technology industries. In particular, appropriability (and therefore patent protection) is likely most important in the high-tech industries with innovations that are easy to imitate, and less important in the high-tech industries with natural barriers to imitation, such as highly complex technologies or high set up costs. We thank an anonymous referee for bringing this issue to our attention.

[7] In a few cases, the STAN database also reports *R&D* at a more disaggregated level (e.g., Pharmaceuticals (ISIC 2423) is reported separately from Chemicals (ISIC 24)). We focus on *R&D* at the 2-digit level to keep the level of aggregation consistent across industries, but all of our findings are as strong (or stronger) if we use the more disaggregated industry groupings when they are available.

added because it has better coverage in the STAN data. For a country to be included in the study, we require that it have coverage of *R&D* in the STAN database and information on R&D tax incentives, financial market rules, and IP protection at the start of the sample period. Finally, we drop the U.S. because we use the U.S. to construct measures of the innate characteristics of industries. The final sample consists of roughly 5,600 country-industry-year observations for 22 manufacturing industries in 19 countries over the period 1990 to 2006. The sample ends in 2006 due to the data we have on R&D tax credits.

2.3 Measuring the tax treatment of R&D

McFetridge and Warda (1983) develop the *B-index* and it is, to our knowledge, the only measure of the user cost of R&D that is available over time and across countries. The *B-index* flexibly captures a wide range of tax incentives for R&D, including deductions, allowances, and credits. As discussed in Thompson (2009), the general formula for the *B-index* is:

$$B_{i,t} = \frac{1 - A_{i,t}}{1 - T_{i,t}} \qquad (1)$$

where T is the corporate income tax rate for country i at time t and A is the combined net present value of all reductions to tax liabilities resulting from a one dollar investment in R&D. The *B-index* therefore represents the present value of before-tax income a "representative" firm needs to generate to cover the cost of an additional $1 of R&D investment. Clearly, the lower the *B-index*, the more generous is the tax treatment of R&D.

We use yearly estimates of the *B-index* from Thompson (2009, Tables 7 and 8). In line with other studies using the *B-index*, we take one minus the *B-index* and simply call this variable *R&D tax credits*. Measured this way, a higher value of *R&D tax credits* means more generous tax treatment of R&D. The next to last column in Table A.1 reports the average value of *R&D tax credits* for each sampled country over the 1990 to 2006 sample period. During this period Spain, Canada, and Australia are the most generous with tax incentives for R&D, while Germany, Italy, Sweden, Greece, Finland, Denmark, and Belgium are the least generous.

In addition to tests using the level of *R&D tax credits*, we construct an indicator variable that tracks changes in tax credits following the approach that Acharya and Subramanian (2009) use to track changes in creditor rights. Specifically, for countries that introduce more generous R&D tax incentives during our sample period, the variable *Change in tax credits* starts at zero and increases by one in each year a new tax incentive is introduced. For countries that remove an R&D tax incentive in place at the beginning of our sample period, *Change in tax credits* starts at one and decreases to zero in the year the tax incentive is removed. Finally, for countries with no change in R&D tax incentives during our sample period, either because they never have an R&D tax credit or because the tax credit in place at the start of the sample never changes, the *Change in tax credits* variable is set to zero throughout the sample period.

We recognize that it is challenging to estimate the *causal* impact of R&D tax credits. In particular, estimates of the impact of tax incentives will be biased if governments strategically change R&D tax credits when the economy is doing poorly (Bloom, Griffith, and Van Reenen, 2002; Chang, 2014). In the next section, however, we will present some suggestive evidence that this particular concern is not a problem; in particular, Figure 1 shows that there is no trend in the R&D differential across industries with high- and low *Innovative intensity* in the years before the introduction of more generous R&D tax incentives. In addition, our methodology makes some progress in dealing with this endogeneity concern because we include country-level time dummies in the regressions, and we estimate how the *differential* level of R&D between low- and high-tech industries responds to changes in R&D tax credits.

2.4 Financial market rules

Our focus on financial market rules follows the framework in Levine (1999) and Rajan and Zingales (2003). Notably, Levine (1999) concludes that stronger creditor rights, more effective contract enforcement, and more comprehensive and accurate financial reporting are fundamental determinants of an economy's financial intermediary development. Rajan and Zingales (2003, p. 18) identify a similar set of factors in their set of "essential ingredients" of a developed financial system; in particular, they also point out the importance of "an accounting and disclosure system that promotes transparency" and "a legal system that enforces arm's length contracts cheaply". We therefore focus on three key factors that determine the nature and extent of financial intermediation across countries: *Accounting standards*, *Contract enforcement*, and *Creditor rights*. In addition to following the approach in Levine (1999), these measures are attractive because we can obtain reliable cross-country estimates for each measure at the *start* of our sample period. We refer to these measures as "financial market rules." Of the three financial market rules we study, *Accounting standards* and *Contract enforcement* are arguably the most important determinants of an economy's supply of arm's length financing. Moreover, while these measures support arm's length contracting of all forms (debt and equity), *Creditor rights* is more narrowly relevant for the supply of private credit.

Following RZ (1998), we focus heavily on *Accounting standards*, an index created by The Center for International Financial Analysis and Research (CIFAR) to measure the comprehensiveness of corporate annual reports. As the values in Table A.1 show, there is substantial cross-country variation in *Accounting standards* in our sample, with the highest values in Australia, Canada, Finland, Norway, Sweden and the U.K. Of the various measures of financial market development employed by RZ (1998) in their seminal study, *Accounting standards* is the most robust, as well as the measure they utilize most extensively. In motivating the use of *Accounting standards*, RZ (1998) argue that "the higher the standards of financial disclosure in a country, the easier it will be for firms to raise funds from a wider circle of investors." We note that a "wider circle of investors" is a good description of arm's length suppliers of finance, particularly equity finance, as opposed to private lenders (e.g., bank loans). Notably, both RZ (1998) and Brown, Martinsson, and Petersen (2013) find that *Accounting standards* shares a strong positive correlation with country equity market activity, but not with credit market development.

Our choice of *Contract enforcement* is motivated by the fact that several studies discuss the importance of efficient contract enforcement for facilitating arm's length financial contracting (e.g., La Porta et al., 1997; Rajan and Zingales, 2003), and there is strong evidence linking an economy's fundamental "contracting institutions" with financial intermediary development (e.g., Levine, 1999). Stronger contract enforcement appears to be particularly important for the development of arm's length financing *per se*, as agents are forced to rely on monitored, reputation-based lending when contract enforcement is weak (Acemoglu and Johnson, 2005). Following Levine (1999) we use an index of *Contract enforcement* constructed by the International Country Risk Guide (ICRG) to measure how effectively a country's legal system enforces contracts. The values for our sampled countries are reported in Table A.1.

The last financial market rule is *Creditor rights,* a measure of creditor protection in the event of a default. The *Creditor rights* measure was first proposed by La Porta et al. (1997 & 1998), and we use the values reported in Djankov, McLeish, and Shleifer (2007). Across all country-years in our sample there are only four changes in *Creditor rights*, and three of these occur in the first five years of the sample. We thus use each country's value for *Creditor rights* in 1995.[8] Table A.1 shows large variation in *Creditor rights* across the countries in our sample, with values of zero in France and Mexico, values of only 1.00 in highly developed countries such as Canada, Finland, and Sweden, and strong creditor rights (3.00 or higher) in seven of the 20 countries.

Relative to financial market rules that broadly facilitate access to arm's length financing of all types, the importance of *Creditor rights* for innovative activity is less clear. There are literatures suggesting three possible effects of stronger *Creditor rights* on innovation: i) little or no effect, ii) negative effect, and iii) positive effect. In the first literature, increased credit supply from stronger creditor protections may have little or no impact on high-tech R&D investments if firms rely primarily on equity to finance innovative investments (Hall, 2002; Brown, Fazzari, and Petersen, 2009). In the second literature, more creditor-friendly bankruptcy codes may harm innovation if it *discourages* firm risk-taking; indeed, Acharya and Subramanian (2009) show that stronger *Creditor rights* reduces patenting in more innovative-intensive industries. Finally, in the third literature, several recent studies show that innovative activity is positively related to within-country changes in the supply of credit (e.g., Aghion et al., 2012; Amore, Schneider, and Zaldokas, 2013; Cerqueiro et al., 2014). These findings suggest that, at least in some circumstances, stronger *Creditor rights* can foster innovation by increasing the supply of private credit. Clearly, more evidence on the impact of *Creditor rights* on

[8] Specifically, the value for Canada changes from 2 to 1 in 1992, the value for Finland changes from 3 to 1 in 1993, and the value for Sweden changes from 2 to 1 in 1995. The only change after 1995 occurs in Japan, which moves from 3 to 2 in 2000. Our results are essentially identical if use the post-2000 value for Japan, or if we allow the *Creditor rights* value to change for these four countries.

innovation is needed, particularly its impact on high-tech R&D investment, which to our knowledge has not been examined in previous studies.

In the regressions that follow, we will assume that these predetermined "financial market rules", all measured at the beginning of our sample period, are exogenous variables. This assumption has precedent in the literature. In particular, Levine (1999) refers to rules and policies that promote better financial reporting and provide stronger contract enforcement as "the exogenous component of financial intermediary development". In addition, Djankov, McLeish, and Shleifer (2007, Table A.1.) report that, over the period 1978-2004, the large majority of countries have no change in their measure of creditor rights (and the remaining countries have only limited changes). They conclude (p. 307) that "the stability of creditor rights scores over time, and the absence of convergence across legal origins, is broadly consistent with the view that these particular measures of investor protection reflect relatively permanent features of the institutional environment, deeply rooted in national legal traditions." Likewise, Acharya, Amihud and Litov (2011) take *Creditor rights* as predetermined and RZ (1998) argue that *Accounting standards* are largely exogenous given the lack of variation over time.

2.5 Intellectual property protections

To measure the strength of intellectual property protections, we collect information on patent rights from Ginarte and Park (1997) and Park (2008) and call this measure *IP protection*. This variable is an index based on a coding scheme applied to the various countries' patent laws and includes five categories (Ginarte and Park (1997, p. 284)): i) extent of coverage, ii) membership in international patent agreements, iii) provisions for loss of protection, iv) enforcement mechanisms, and v) duration of protection. Each country receives a score ranging from 0 to 1 (with intermediate values possible) in each category and the *IP protection* index is the sum of the five categories. A higher value indicates stronger, more comprehensive IP protection, arguably allowing firms to appropriate more of the returns to their innovative efforts.[9] The *IP protection* index is reported at five-year intervals, so in our sample the first value is in 1990 and the last value is in 2005. Thus, to construct a full time-series over 1990 to 2006, we update the value of *IP protection* every five years.

Like R&D tax credits, there is some concern that countries may change IP protection strategically (e.g., when R&D investment is relatively low, or when the high-tech sector is particularly influential). Though we cannot fully address the endogeneity of IP protections, we do note that nearly all of the time-series variation in IP protection – which is substantial for some countries – appears to be caused by NAFTA and the WTO's Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), both of which are arguably exogenous shocks to IP protection. Average values for the *IP protection* index appear in the second to last column of numbers in Table A.1.

[9] For more thorough discussions of the various issues associated with stronger IP protection, see Mansfield (1986b), Hall (2002), and Hall et al. (2014).

2.6 Measuring technological characteristics of industries

Our approach tests for the differential effects of innovation policies across sectors that differ in their innate innovative intensity. Following the general approach that RZ (1998) use to proxy for an industry's dependence on external finance, we construct a baseline measure of innate industry innovative intensity using data on publicly listed U.S. firms with coverage in Compustat. The logic for using U.S. data to create this measure is that the U.S. has not only the most developed capital markets for financing innovation, but also strong legal and enforcement institutions. The U.S. is also widely viewed as the most technologically advanced major economy in the world based on factors such as R&D/GDP. So the U.S should provide a good benchmark of cross-industry differences in innate innovative intensity. Similar to the arguments in RZ (1998) and subsequent studies (e.g., Claessens and Laeven, 2003; Ilyina and Samaniego, 2011), we are not arguing that the U.S. provides the "right" absolute innate value for each industry, but rather actual innovation rates in U.S. firms reflect relative *differences* in fundamental innovative intensity across industries.

To construct a baseline measure of industry innovative intensity we compute an R&D-to-sales ratio for each firm using total (summed) values of R&D investment and sales over the period 1990 to 2000, and then call the median R&D-to-sales ratio across firms in each industry *Innovative intensity*. All of our inferences and results are similar if we measure *Innovative intensity* using R&D-to-total investment (R&D plus capital spending), R&D-to-book assets, or R&D per employee instead of the R&D-to-sales ratio. Values for *Innovative intensity* for all 2-digit ISIC manufacturing industries are listed in the third column of Table 2. The average value for *Innovative intensity* is 0.037 with several "low-tech" industries (e.g., food products, apparel, wood products) having values below 0.010. In contrast, four industries -- chemicals, computers, communications technology and scientific instruments (ISIC code 24, 30, 32, and 33, respectively) -- have *Innovative intensity* above 0.100, which is much greater than the values for any of the remaining 18 industries. These four R&D-intensive industries are routinely classified as constituting the high-technology sector (e.g., Hall, Jaffe, and Trajtenberg, 2001; Bloom, Sadun, and Van Reenen, 2012) and typically account for a very large share of the corporate R&D of most developed countries.

This suggests a simple alternative to measure an industry's technological intensity: we create an indicator variable for whether or not the industry is typically considered a part of the high-technology sector. The variable *High-tech* is set equal to one for industries with ISIC code 24, 30, 32, and 33 and zero otherwise. One advantage of the *High-tech* approach to identifying innovative industries (as opposed to *Innovative intensity*) is that the measure is not based on the activities of any single country (e.g., publicly traded US firms) and thus provides a good check of robustness.

We also examine alternative industry characteristics to provide further checks on our main findings and inferences. Following the approach we use to construct *Innovative intensity*, we use data from U.S. firms to compute industry measures of *Cash flow, Income taxes*, and *External finance*. *Cash flow* is equal to the median firm's internally generated cash flow as a fraction of its total assets, *Income taxes* is the median firm's income taxes paid as a fraction of its total assets, and *External finance* is equal to the median firm's (net) use of external financing relative to its total investment spending (R&D plus capital spending).

The industry characteristics reported in Table 2 show that high-tech industries differ in several important ways from their non high-tech counterparts. First, as noted above, *Innovative intensity* is far larger in high-tech industries than in the non high-tech sector. Second, high-tech industries are far more dependent on external finance than other industries. Notably, on average, the *External finance* value is around three times larger for the high-tech sector compared to the non high-tech sector. *Cash flow*, on the other hand, is much larger in the non high-tech sector, consistent with a relative lack of dependence on external finance. Similarly, the non high-tech sector has a much higher measure of *Income taxes*. The pattern of values for *External finance, Cash flow,* and *Income taxes* suggests that financial market rules promoting arm's length financing should be particularly important for R&D investment in high-tech industries, while more generous tax credits may matter more for the non high-tech sector.

In Panel B of Table 2 we report cross-industry correlations between the alternative industry characteristics. Of particular note, *Innovative intensity* is strongly positively correlated with *External finance* and negatively correlated with *Cash flow* and *Income taxes*. Furthermore, industries with high *Cash flow* and low *External finance* tend to also be industries with high *Income taxes*. These correlations are useful for interpreting the results from the difference-in-differences regressions that follow in the next section.

3. Regression evidence on differential effects

3.1 Difference-in-differences specification

We employ a difference-in-differences approach pioneered by RZ (1998) and used in a number of subsequent studies to evaluate the causal connections between institutions and economic performance (e.g., Beck and Levine, 2002; Claessens and Laeven, 2003). The RZ approach makes progress in identifying the causal effects of country-specific characteristics by focusing on the differential impact a country-level variable has across industries with different innate, technological characteristics. Whereas RZ are interested in the differential effects of financial development across industries with varying dependence on external finance, we are interested in the differential effects innovation policies have across industries with varying *Innovative intensity*. Here, the identifying assumption is that if public policies are successful at promoting R&D, the effects will be relatively stronger in industries with a higher innate *Innovative intensity*. For example, for reasons already described, the nature of high-tech R&D should make it particularly sensitive to policies that affect capital market development and the strength of IP protection. That is, because innovative intensive, high-tech industries are relatively more prone to underinvestment, there is greater scope for public policy to impact their R&D investment.

Our primary regression is:

$$R\&D_{i,j,t} = \alpha(R\&D\ tax\ credits_{i,t} \times Innovative\ intensity_j) + \beta(IP\ protection_{i,t} \times Innovative\ intensity_j) + \gamma(Financial\ market\ rules_i \times Innovative\ intensity_j) + \eta_j + \eta_i \times \eta_t + \varepsilon_{i,j,t}. \quad (2)$$

In equation (2), $R\&D_{i,j,t}$ is R&D investment divided by value added for industry j in country i in year t. *Innovative intensity*$_j$ is industry j's innovative intensity (which by construction does not vary across time or countries). *R&D tax credits*$_{i,t}$ is R&D tax credits in country i in year t and is measured as one minus the user cost of R&D (i.e., one minus the *B-index*). *IP protection*$_{i,t}$ measures the level of patent protection in country i in year t. *Financial market rules*$_i$ refer to either *Accounting standards*, *Contract enforcement*, or *Creditor rights* in country i. Finally, η_j and $\eta_i \times \eta_t$ are sets of dummy variables that control for unobserved industry and country-year fixed effects, respectively. Notably, this fixed effects structure controls for any industry-level determinates of R&D intensity that are common across countries, as well as all time-varying country-specific factors that affect the overall propensity to invest in R&D, such as the level of economic development, political and regulatory environment, quality of research universities, and appetite for risk taking.[10] In all cases we estimate equation (2) with robust standard errors clustered at the country level.[11]

We focus on the interaction between industry *Innovative intensity* and country measures of *R&D tax credits*, *IP protection*, and *Financial market rules*. We also estimate equation (2) using the *High-tech* dummy variable in place of *Innovative intensity*. In these difference-in-differences regressions, a positive coefficient on an interaction term indicates that an increase in a particular country-level characteristic is associated with a larger *difference* in the level of R&D investment between industries with high and low *Innovative intensity*. We are thus evaluating whether the size of the within-country gap in R&D investment across industries with high and low *Innovative intensity*, varies with changes in *R&D tax credits*, *IP protection*, and *Financial market rules*. Since we lack meaningful time-series variation in financial market rules, for some regressions we collapse the time dimension of the data and estimate cross-sectional regressions using sample period averages.

Our empirical approach helps deal with the endogeneity concerns noted in Section 2, though in some cases our estimates are best interpreted conservatively as conditional correlations. First, our regressions include a set of country-specific time dummy variables ($\eta_i \times \eta_t$). These controls partially alleviate the concern that countries strategically adjust R&D tax credits (or IP protection) when the

[10] Note that with these fixed effects make it is not necessary to include the uninteracted *level* of either industry *Innovative intensity* or the country policy rules in the regression equation. In addition, because the financial market rules we focus on are not time-varying, we cannot account for country-industry fixed effects in our baseline specifications. We do, however, report results with country-industry fixed effects for regressions that exclude the financial market rules.

[11] We also explored bootstrapping the standard errors (using resampling with replacement and 50 replications) and using two-way clusters at the country and year level. In each case the standard errors were uniformly *smaller* than those generated by clustering in the country dimension. We thus report results using the more conservative approach.

economy (and R&D) is performing poorly. Second, we are estimating the *differential* relation between the policy variables and R&D across low and high-tech industries. As such, if endogeneity is a problem for our estimates, it has to be the case that endogeneity biases the results more for one sector than another. Finally, we simultaneously evaluate the effects of alternative policy variables. In addition to addressing concerns about omitted variables, evidence of differing but theoretically plausible effects for the alternative policy variables supports a stronger, causal inference.[12]

3.2 Baseline results

In Table 3 we report OLS estimates of equation (2). We postpone to Table 5 a discussion of economic magnitudes implied by the estimates. We begin in column (1) by including only the interaction between *Innovative intensity* and the level of *R&D tax credits*. The coefficient estimate on the interaction term is negative and statistically significant, indicating that more generous tax treatment of R&D is associated with relatively *less* R&D investment in more highly innovative industries. We find similar evidence in column (2) after replacing the level of R&D tax credits with the *Change in tax credits* variable. Namely, the negative and significant coefficient on the *Change in tax credits x Innovative intensity* interaction indicates that the within-country difference in R&D across high- and low-innovation industries *decreases* following an increase in the generosity of R&D tax incentives compared to similar changes in R&D differentials in countries without a simultaneous change in R&D tax incentives. As Acharya and Subramanian (2009) discuss in the context of changes in creditor rights, triple difference-in-differences evidence of this type offers particularly compelling evidence that policy changes have causal effects. For example, to explain away this finding one has to believe that countries systematically introduce more generous tax incentives in anticipation of a relative decline in R&D investment between high- and low-innovative sectors.

A related concern with the tax credit findings is the potential for pre-trends: the gap in R&D across high- and low-innovation industries could have been trending downward prior to the policy change. We evaluate this possibility in Figure 1. Here, we show how R&D investment in the most innovative industries (top 25 percent in *Innovative intensity*) and least innovative industries (bottom 25 percent) evolves in the years surrounding increases in the generosity of R&D tax incentives. Specifically, we find the average level of R&D in each group of industries (after removing country-year fixed effects), and normalize each series to start at a magnitude of zero. (Note that in absolute terms, R&D intensity is substantially higher in the more naturally innovative industries.) The figure shows that there are no trends in R&D in either high- or low-innovative industries prior to the implementation of R&D tax incentives (at t = 0). In particular, the significant negative R&D

[12] It is also possible that there are important complementarities in the effects of the alternative policy variables. We have explored this possibility by adding triple interaction terms to equation 2. In each case, the triple interaction term is insignificant and the estimates on our main (double) interaction terms are unchanged, suggesting, at a minimum, that our conclusions are not biased by complementarities across the key factors. More direct evidence on complementarities in R&D policies and institutions is an important topic for future research.

differential across high- and low-innovative industries does not emerge until after the tax credits are in place, at which time the differential exhibits a consistent downward trend. The lack of any pre-trends supports the validity of our difference-in-differences approach.[13]

In column (3) we focus only on the interaction term *IP protection x Innovative intensity*. The point estimate on the *IP protection* interaction term is positive and statistically significant, indicating that moving from a low to a high *IP protection* country is associated with a significant increase in the differential R&D intensity across high and low *Innovative intensity* industries.

In column (4) we include only the *Accounting standards x Innovative intensity* interaction. The coefficient estimate on the interaction term is positive and statistically significant, indicating that stronger *Accounting standards* are associated with relatively higher levels of R&D investment in more innovative industries.

In columns (5) and (6) we simultaneously evaluate the full set of policy variables. In column (5) we use the level of *R&D tax credits*, and in column (6) we use the *Change in tax credits*. In either case, we continue to find negative and significant differential effects of more generous R&D tax incentives on R&D investment across industries with varying *Innovative intensity*. Similarly, we continue to find significant positive differential effects of stronger *IP protection* and *Accounting standards* in the full specification.

The regressions in Panel B are identical to Panel A except we replace *Innovative intensity* with the *High-tech* dummy variable. Consistent with the evidence in Panel A, we find a negative coefficient on the interaction between *High-tech* and the level of *R&D tax credits*, though this coefficient is no longer statistically significant. Stronger *IP protection* and *Accounting standards*, however, are associated with significantly higher rates of R&D in high-tech compared to low-tech industries. Thus, we reach the same qualitative conclusions when we switch from the continuous, U.S.-based measure of *Innovative intensity* to the dichotomous and non-US specific high-tech/non-high-tech approach.

3.3 Alternative financial market rules: Contract enforcement and creditor rights

In Table 4 we explore the relation between R&D investment and two other financial market rules discussed above: *Contract enforcement* and *Creditor rights*. In the regressions that follow, we continue to include *IP protection* and the measures of R&D tax credits in the difference-in-differences specification. In regressions (1), (3), and (5), the coefficient estimate on the level of *R&D tax credits* is negative, although statistically significant only in regression (3). In regressions (2), (4), and (6), the estimates for *Change in tax credits* are negative, statistically significant, and similar in magnitude to the values in Table 3. Similarly, the coefficient estimates for *IP protection* in all regressions are positive, statistically significant, and similar in magnitude to the estimates in Table 3.

[13] Unfortunately, we are not able to explore pre-trends in the other policy variables. The financial market rules exhibit almost no variation and are measured at the start of our sample period, while the *IP protection* index only updates at five-year intervals, making it impossible to identify the exact year in which changes occur.

Turning to the alternative financial market rules, in the first two regressions we estimate equation (2) using *Contract enforcement* in place of *Accounting standards*. In each case, the estimated coefficient on the *Contract enforcement x Innovative intensity* interaction term is positive and statistically significant, consistent with our findings for *Accounting standards* in Table 3. The regressions in columns (3) and (4) use *Creditor rights* in place of *Accounting standards* in our baseline regression. In sharp contrast to the strong positive estimates for *Accounting standards* and *Contract enforcement*, the coefficient estimates on the *Creditor rights x Innovative intensity* interaction term are negative (though statistically insignificant).

In the last two regressions in Table 4 we include the full set of financial market rules in the same regression. In this specification we continue to find positive and significant effects on the *Accounting standards* and *Contract enforcement* interaction terms, suggesting that these alternative financial market rules contain unique information about the fundamental financial market characteristics that promote R&D. In contrast, the negative estimates for *Creditor rights* are substantially larger (in absolute value), and become statistically significant. These estimates indicate that after conditioning on a country's level of *Accounting standards* and *Contract enforcement*, stronger creditor rights is associated with a *smaller* gap in R&D investment between high and low innovative-intensive industries.

As always, establishing causality is a challenge, particularly when evaluating policy variables in a cross-country context. Yet, almost all reasonable concerns about endogeneity of institutions or omitted factors that we can think of would have trouble rationalizing our full set of results. In particular, we find *different* effects for different types of financial market rules. Most notably, stronger creditor rights share a much different relationship with R&D than stronger accounting standards or stronger contract enforcement, and these differences are consistent with theory (e.g., arm's length financing is better suited than private credit for financing high-tech innovation).

3.4 Quantifying economic magnitudes

In Table 5 we report alternative estimates of the economic magnitude implied by our difference-in-differences estimates. We focus on the implied differential effects from the final specification in Table 4 (column (6)). The reported differentials compare how (all else equal) a change in the policy variable from the 25^{th} to 75^{th} percentile affects the gap between R&D investment across industries with different *Innovative intensity*. In the first two rows we compute the predicted R&D differentials by following the approach in RZ (1998) and comparing industries at the 75^{th} percentile and 25^{th} percentile in *Innovative intensity*. In our sample, the industry at the 75^{th} percentile (Machinery and equipment, not including office and computing equipment) and the industry at the 25^{th} percentile (Leather) are both non high-tech sectors, so this approach focuses on the size of the gap in R&D intensity between two non high-tech industries. In the first row, we report the size of this differential effect relative to the sample average R&D intensity, and in the second row we report the effect relative to the sample median. Depending on the scale factor, our estimates suggest that the introduction of more generous R&D tax credits (a one unit increase in *Change in tax credits*) reduces the gap between R&D in a sector like Machinery and equipment compared to a sector like Leather by an amount equivalent to 2% of the sample average R&D intensity or 7% of the sample median. Using the same approach, stronger *IP protection* is associated with an increase in the R&D gap between relatively high- and low-innovative sectors that amounts to 3% (8%) of the sample average (median) R&D. The corresponding values from increases in *Accounting standards* (3% and 9%), *Contract enforcement* (5% and 15%), and *Creditor rights* (-5% and -14%) suggest slightly larger economic effects from changes in the financial market rules.

While the approach in the first two rows is the standard way to quantify economic effects, it does not reflect the differential we have most emphasized, which is the gap in R&D between high-tech and low-tech industries. In the final two rows we thus compute the predicted R&D differentials by comparing R&D investment in the average high-tech industry to the average low-tech industry. We report the size of this differential effect as a percentage of both the sample average *R&D* in high-tech industries (third row) and the sample average *gap* in *R&D* across high- and low-tech industries (fourth row). In the first column, an increase in R&D tax credits is associated with a reduction in the gap between R&D in the high- and low-tech sector that amounts to 6% of sample average R&D in high-tech industries (or 7% of the sample average gap between high- and low-tech R&D). Similarly, stronger *IP protection, Accounting standards*, and *Contract enforcement* are all associated with significant increases in the gap between high- and low-tech R&D. In particular, the difference in *R&D* across high- and low-tech industries is larger in a country at the 75th percentile in *Accounting standards* (*Contract enforcement*) compared to a country at the 25th percentile by an amount equivalent to 9% (15%) of the sample average gap in high-tech versus low-tech R&D. In contrast, the corresponding effect from stronger *Creditor rights* is a 14% *reduction* in the difference between high- and low-tech R&D. These estimates suggest that the policy variables we focus on are associated with R&D activity in an economically important way.

4. Alternative approaches and additional evidence on innovation policies and R&D

4.1 Regressions using collapsed (long-run) data

As discussed above, there is no meaningful time-series variation for our three financial market rules. We therefore consider an alternative estimation approach: we collapse the time dimension of our variables by computing averages (for those variables with time-series variation) and then estimate the difference-in-differences regression using purely cross-sectional observations. While this approach is useful for testing how initial financial market rules relate to subsequent (long-run) levels of R&D investment, it cannot be used for estimating how changes in the generosity of tax credits affect R&D. Nonetheless, we estimate a specification that mirrors equation (2), except the country-industry level of *R&D* and the country levels of *R&D tax credits* and *IP protection* are averaged across the full sample period. In addition, since we remove the time-series variation, we use a full set of country dummies in place of the country-year dummies. The results are reported in Table 6 with standard errors clustered in the country dimension.

The first four regressions in Table 6 are the counterparts to regressions (1), (3), (4) and (5) of Table 3. The first regression in Table 6 includes only the interaction between *R&D tax credits* and *Innovative intensity* and the estimated coefficient is negative, statistically significant, and somewhat larger (in absolute value) than the corresponding estimate in Table 3. The next regression focuses only on *IP protection* and the estimate for the *IP protection x Innovative intensity* interaction is statistically significant and considerably larger than the corresponding estimate in Table 3. In the third regression, we include only *Accounting standards* and find coefficients that are positive, statistically significant, and nearly identical in magnitude to the counterpart regressions in Table 3. Regression (4) in Table 6 includes all three of the interactions noted above. The coefficient estimates in this regression are quite similar to the estimates in the corresponding regression (fifth column) in Table 3; the estimate for the *R&D tax credit* interaction in Table 6, however, is no longer significant. The fifth regression in Table 6 adds *Contract enforcement* and *Creditor rights* and thus corresponds to regression (5) in Table 4. Once again, the point estimates across these corresponding regressions are very similar. Finally, in column (6) we estimate the full specification using averages computed over the 1990s rather than over the full sample period, and continue to draw similar inferences about the (long-run) relation between financial market rules and R&D investment in highly innovative industries. Thus, the only notable impact from collapsing the data is a loss of precision on the estimates for *R&D tax credits* and *IP protection* in some specifications.

4.2 Other industry characteristics

In Table 7, we examine the differential link between the country policy variables and R&D investment using industry characteristics other than the innovative intensity measures. In the first two columns of Table 7 we replace *Innovative intensity* with the measure of industry dependence on external finance (*External finance*). Of course we expect that financial market rules should matter relatively more in industries with high external finance dependence. In fact, the coefficient estimate for *Accounting standards* is positive and statistically significant, consistent with our expectations regarding financial market rules. Furthermore, there is a negative differential for *R&D tax credits* (as well as *Change in tax credits*) showing that more generous tax treatment of R&D has relatively weaker effects on R&D in sectors that depend more on external finance.

In the middle two columns (3 and 4) and the final two columns (5 and 6) of Table 7, we replace *Innovative intensity* with industry *Cash flow* and *Income taxes*, respectively. If we are interpreting the findings for *Innovative intensity* (and *High-tech*) correctly, then we expect to find the *opposite* differential effects if we substitute industry measures of internally generated funds and income taxes paid for *Innovative intensity*. Since stronger financial market rules should increase access to arm's length financing, the impact of stronger rules should *decline* in importance the more plentiful an industry's internally generated finance (as well as income taxes paid) and thus the less need for outside funds. On the other hand, more generous tax credits should matter most in profitable industries where income taxes are high, and thus tax credits are more valuable. Based on Table 2, we know that more innovative intensive industries are more reliant on external finance, generate less internal cash flow, and pay lower income taxes compared to less innovative industries.

As expected, the estimates in columns (3)-(6) show that more generous tax treatment of R&D is associated with relatively more R&D investment in industries with higher levels of cash flow and income taxes. In contrast, negative coefficients on the *Accounting standards* and *IP protection* interactions show that stronger *Accounting standards* and *IP protection* matter relatively less in industries with high cash flows and greater income tax payments. The findings in Table 7 are particularly helpful for shedding light on why we obtain a negative effect for the *R&D tax credits* interaction in our main regressions: R&D tax credits have relatively weaker effects in more innovative industries because income tax burdens are lower in these industries. We will explore the tax credit findings in more detail in Table 9.

4.3 Other robustness checks

In Table 8 we report a number of robustness checks for our main results. In the first two columns, we check the robustness of our dependent variable to scaling R&D by output (instead of value added). All three interaction variables are statistically significant and have the same pattern of coefficients as reported in our main tables. In the next two columns we compute *Innovative intensity* based on 1980s data (instead of the 1990s) and continue to employ the same dependent variable as used in our previous tables (*R&D*). The estimated coefficients for all three interactions are consistent with our baseline findings, the only notable difference being that the negative coefficient on the level of *R&D tax credits* is not as precisely estimated and is no longer statistically significant.

In columns (5) and (6) we add two additional control variables: *GDP per capita* x *Innovative intensity* and *Schooling* x *Innovative Intensity.* The logic for these additional variables is to control for the possibility that a country's standard of living or level of human capital might be both: i) correlated with the tax credits, IP protection, and financial market rules we study, and ii) differentially important for R&D investment in the high-tech sector. When these additional controls are added to the regression, the estimated coefficients for the three main policy interactions are statistically significant and the point estimates are very similar to the corresponding regressions in Table 3 (regressions (5) and (6)).

In columns (7) and (8) we address the potential concern that country-level policy changes are correlated with changes in R&D investment opportunities at the country-industry-year level by adding the industry's *forward* rate of value added growth to the baseline regression. This is a particularly strong control for differences in industry growth options across countries and over time.[14] Although we lose a number of observations when including the control for time variation in industry growth rates, our main inferences are not affected.

Finally, in columns (9) and (10) we estimate the baseline specification with country-industry fixed effects. Since there is no time-series variation in *Accounting standards* for a given country-industry pair, the *Accounting standards* x *Innovative intensity* interaction falls out of the regression when the country-industry fixed effects are included. For R&D tax credits and patent protections – which do vary somewhat over time – the estimates with country-industry effects are generally consistent with the other estimates, though the coefficients on the tax credit interactions are no longer statistically significant. For patent protections, however, we continue to recover a positive and significant coefficient on the key interaction term, even with the richer fixed effects structure. Overall, these results support the main findings that patent protections have a significant positive differential impact on R&D in more innovative industries, while tax credits do not.

5. Additional evidence on tax credits and R&D

In this section we explore in more detail what drives the negative differential effect of R&D tax credits in highly innovative industries. Our evidence indicating that R&D tax credits have a negative differential association with R&D investment across high and low *Innovative intensity* industries is not necessarily at odds with a fairly substantial literature that finds a positive responsiveness of R&D investment to the introduction of R&D tax credits (e.g., Hall, 1993; Bloom, Griffith, and Van Reenen, 2002). While this literature shows that tax credits are associated with overall R&D increases, our findings indicate that the increases are, on average, relatively weaker in more innovative sectors.

To explore this finding in more detail, we use our industry level data to estimate a levels regression broadly similar to the approach in prior studies. The regression equation is:

$$log(R\&D)_{i,j,t} = \alpha log(Output)_{i,j,t} + \beta log(B\text{-}index)_{i,t} + \eta_i + \eta_j + \eta_t + \varepsilon_{i,j,t} \quad (3)$$

Here, *Output* is industry output for each country-industry-year. We include the log of the *B-index* rather than the log of the *R&D tax credits* variable we used earlier to be consistent with the approach of regressing R&D on its user cost (and to avoid losing observations when taking the log). Although other studies use different calculations of the user cost of R&D, the main finding from this literature is that a lower after-tax cost of R&D increases the overall level of R&D, suggesting a negative estimate of β. Equation (3) also includes country, industry, and year fixed effects.

We report estimates of equation (3) in Table 9. We report separate results for all industries (column (1)), non high-tech industries (column (2)), and high-tech industries (column (3)). In the regression with all industries, and in the regression with only non high-tech industries, we find a

[14] This approach follows several prior studies (e.g., Almeida, Campello, and Weisbach, 2004). The results are similar if we replace the forward growth rate with contemporaneous and/or lagged values.

negative and statistically significant coefficient on the user cost term, consistent with previous studies. However, in the regression using data only for high-tech industries, we find a positive but very small and insignificant coefficient on the *B-index*. Together, these results suggest that the impact of more generous tax treatment of R&D (lower user cost) is confined entirely to non high-tech industries. This finding is useful for interpreting the differential results we documented earlier: more generous tax treatment of R&D has a negative differential effect across high- and low-tech industries because R&D increases only in less innovative industries.

There are multiple reasons why R&D tax credits may matter very little for R&D investment in high-tech industries. One obvious reason is that compared to the low-tech sector, high-tech firms pay much lower corporate income taxes (see Table 1), making tax credits less effective (on average) in this sector. This explanation is supported by our findings in Table 7 showing a positive differential effect of tax credits in industries with higher cash flows and income taxes. An alternative explanation -- which we cannot entirely dismiss -- is that countries introduce more generous R&D tax incentives when R&D investment in high-tech is expected to lag behind R&D in other sectors.

6. Conclusions

Given the growing fears that many countries around the globe have entered a period of secular stagnation, it is important to understand what public policies are effective at promoting R&D investment. We focus on high-tech R&D because it is arguably particularly sensitive to appropriability and financing problems, and thus the sector where innovative investment is most likely to fall far below the social optimum. We use international data and a difference-in-differences approach to evaluate the comparative effectiveness of a broad set of country policies and institutions at encouraging R&D investment in the high-tech sector. We find that stronger accounting standards and contract enforcement at the national level share a positive differential association with R&D investment in more innovative industries, while the opposite is true for stronger creditor rights. Stronger IP protection is also associated with differentially higher rates of R&D investment in high-tech industries. In contrast, more generous R&D tax credits are associated with relatively more R&D in non high-tech industries, consistent with high-tech industries paying comparatively little taxes. Overall, our findings suggest that policies that directly deal with appropriability and financing problems are much more effective at promoting high-tech R&D compared to traditional tax subsidies.

Our findings on IP protection are important because fundamental questions remain concerning the desirability and effectiveness of stronger IP protection. For example, the counter agenda, sometimes referred to as the "New International IP Agenda" (see Schultz and Walker, 2005), argues that IP protection is often too strong, may impede innovation, and is harmful to developing countries. Our findings indicate a positive link between IP protection and R&D in high-tech industries, an important consideration in any discussion of the pros and cons of weakening IP protection.

To our knowledge, this paper provides the most comprehensive examination of the role of financial market rules in promoting R&D investment.[15] Financial market rules that improve access to external financing may be particularly effective at promoting R&D because firms in more innovative industries frequently have investment levels well in excess of internal finance. But different financial market rules are likely to have different impacts on high-tech R&D as this sector is funded principally by equity finance (both cash flow and stock issues) rather than credit (Hall, 2002). Consistent with this idea, we find that stronger creditor rights is negatively associated with R&D investment in the high-tech sector while stronger accounting standards and contract enforcement -- financial market rules that are particularly important for equity finance -- share a positive robust relation with high-tech R&D.

[15] One qualification is that our study does not speak at all to the costs that may be associated with implementing and enforcing such rules.

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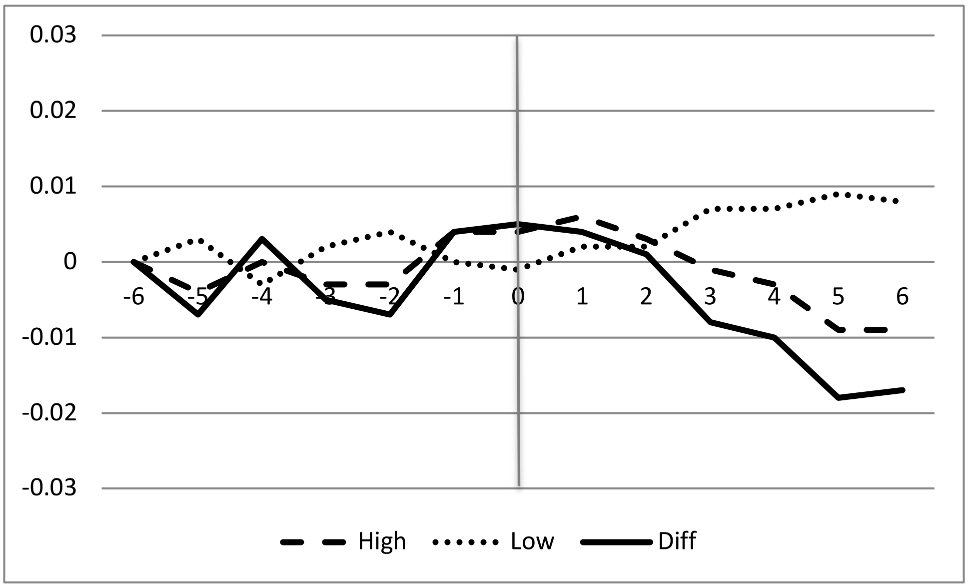

Figure 1. This figure plots trends in R&D investment across industries with high- and low *Innovative intensity* in the years surrounding the introduction of more generous R&D tax incentives. The values reflect the average level of R&D in high and low innovative industries after removing country-year fixed effects and normalizing each series to start at zero. High *Innovative intensity* industries (dashed line) have an *Innovative intensity* in the top 25th percentile of industries listed in Table 2, and low *Innovative intensity* industries (dotted line) have an *Innovative intensity* in the bottom 25th percentile. The solid line represents the difference in (residual) R&D intensity across the high and low industry groupings.

Table 1
Variable descriptions and sample summary statistics

Variable name	Description	Source	Mean	25th	Median	75th	Std. Dev
R&D	Industry research and development expenditures scaled by value added. Reported at the country, industry, year level from 1990 to 2006.	OECD STAN Database	0.060	0.006	0.020	0.067	0.094
R&D tax credits	Equal to 1 - *B-index*, where the *B-index* measures the user cost of R&D. A higher value implies more favorable tax treatment of R&D. Reported at the country, year level from 1990 to 2006.	OECD and Thompson (2009)	0.065	-0.020	0.000	0.110	0.117
Change in tax credits	A variable indicating a change in R&D tax credits. The variable starts at zero (one) and increases (decreases) by one in each year a country's R&D tax credits increase (decrease).	OECD and Thompson (2009)	0.399	0	0	1	0.733
IP protection	An index of the degree of legal patent protection in a country based on five categories: i) extent of coverage, ii) membership in international patent agreements, iii) provisions for loss of protection, iv) enforcement mechanisms, and v) duration of protection. Reported every five years from 1990 to 2006. We use the same value for each five year period.	Ginarte and Park (1997) and Park (2008)	4.135	3.883	4.333	4.542	0.541
Accounting standards	An index of the comprehensiveness of corporate annual reports constructed by the Center for International Financial Analysis and Research (CIFAR). We take the index value in 1990 (divided by 10).	CIFAR and Levine (1999)	6.537	6.20	6.40	7.40	1.01
Contract enforcement	A measure of how effectively the legal system enforces contracts. Constructed by the International Country Risk Guide (ICRG) and averaged over 1982 to 1995.	ICRG and Levine (1999)	8.901	8.59	9.17	9.58	0.920
Creditor rights	An index aggregating different creditor rights. We take the index value in 1995.	Djankov, McLeish and Shleifer (2007)	1.877	1.000	2.000	3.000	1.082

Variable name	Description	Source	Mean	25th	Median	75th	Std. Dev
Innovative intensity	The ratio of R&D-to-sales for the median US firm in each ISIC 2-digit industry. Both R&D and sales are summed over the period 1990-2000 prior to computing the ratio.	Compustat	0.037	0.007	0.012	0.023	0.064
External finance	The ratio of net external finance (gross stock issues – stock buybacks + new long-term debt issues – long-term debt reductions) to total investment spending (R&D + capital spending) for the median US firm in each ISIC 2-digit industry. Both numerator and denominator are summed over the period 1990-2000 prior to computing the ratio.	Compustat	0.361	0.223	0.346	0.510	0.294
Cash flow	The ratio of internally generated cash flow (operating income before depreciation)-to-total assets for the median US firm in each ISIC 2-digit industry. Both numerator and denominator are summed over the period 1990-2000 prior to computing the ratio.	Compustat	0.095	0.093	0.110	0.116	0.057
Income taxes	The ratio of total income taxes paid-to-total assets for the median US firm in each ISIC 2-digit industry. Both numerator and denominator are summed over the period 1990-2000 prior to computing the ratio.	Compustat	0.014	0.009	0.010	0.014	0.015

Table 2
Industry characteristics

This table lists the 2-digit ISIC industries included in the study. The industries in bold (24, 30, 32, and 33) comprise the high-technology sector of manufacturing. The industry characteristics reported in columns (3)-(6) are based on the activities of US firms over the period 1990 to 2000. The variables are described in Table 1.

(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Industry characteristics					
ISIC code	*Industry*	*Innovative intensity*	*External finance*	*Cash flow*	*Income taxes*
15	Food products	0.0065	0.3555	0.1129	0.0104
16	Tobacco	0.0045	-0.3522	0.1889	0.0759
17	Textiles	0.0127	0.2415	0.1200	0.0099
18	Apparel	0.0000	0.8201	0.0969	0.0139
19	Leather	0.0069	0.0018	0.1084	0.0280
20	Wood	0.0048	0.0693	0.1136	0.0173
21	Paper	0.0097	0.2233	0.1267	0.0165
22	Publishing	0.0082	0.4398	0.1165	0.0145
23	Petroleum	0.0057	0.2316	0.1017	0.0104
24	**Chemicals**	**0.2748**	**1.0261**	**-0.1242**	**0.0000**
25	Rubber and plastics	0.0139	0.3508	0.1251	0.0066
26	Non-metallic minerals	0.0116	0.2024	0.1151	0.0092
27	Basic metals	0.0069	0.3458	0.1019	0.0098
28	Metal products	0.0096	0.2866	0.1150	0.0141
29	Machinery and equip	0.0232	0.3079	0.0871	0.0116
30	**Office and computing**	**0.1205**	**0.5342**	**0.0396**	**0.0085**
31	Electrical machinery	0.0318	0.3464	0.0960	0.0097
32	**Radio and tv**	**0.1054**	**0.6421**	**0.0728**	**0.0076**
33	**Scientific instruments**	**0.1053**	**0.7956**	**0.0485**	**0.0037**
34	Motor vehicles	0.0166	0.3745	0.1159	0.0175
35	Other transport	0.0206	0.1966	0.1120	0.0109
36	Furniture and other manufacturing	0.0177	0.5102	0.0935	0.0100
	Average across all industries	0.0371	0.3614	0.0947	0.0144
	Average across high-tech only	0.1515	0.7495	0.0092	0.0050
	Average across non high-tech only	0.0117	0.2751	0.1137	0.0164

Panel B: Correlations across industry characteristics

	Innovative intensity	*External finance*	*Cash flow*	*Income taxes*
Innovative intensity	1			
External finance	0.667	1		
Cash flow	-0.930	-0.775	1	
Income taxes	-0.337	-0.710	0.544	1

Table 3
Innovation policy and industry R&D intensity

Table 3 reports OLS estimates of equation (2). The dependent variable is the industry R&D-to-value added ratio (*R&D*). In Panel A, country policy variables are interacted with a continuous measure of industry *Innovative intensity* constructed from U.S. data. In Panel B, country policy variables are interacted with a *High-tech* indicator variable that takes the value of one in industries with ISIC codes 24, 30, 32, 33. In addition to the interaction terms, each regression includes full sets of industry and country-year dummy variables. The reported standard errors are robust to clustering in the country dimension. All variables are defined in Table 1.

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Country policy interacted with industry *Innovative intensity*						
R&D tax credits ×	-0.859				-0.745	
Innovative intensity	(0.372)**				(0.297)**	
Change in tax credits ×		-0.162				-0.124
Innovative intensity		(0.051)***				(0.045)**
IP protection ×			0.344		0.259	0.274
Innovative intensity			(0.073)***		(0.080)***	(0.080)***
Accounting standards ×				0.172	0.129	0.111
Innovative intensity				(0.036)***	(0.035)***	(0.036)***
Constant	0.032	0.032	0.035	-0.013	0.027	0.029
	(0.009)***	(0.009)***	(0.007)***	(0.009)	(0.007)***	(0.007)***
Observations	5,606	5,606	5,606	5,606	5,606	5,606
R-squared	0.632	0.634	0.642	0.641	0.653	0.653
Panel B: Country policy interacted with industry *High-tech* dummy variable						
R&D tax credits ×	-0.134				-0.117	
High-tech	(0.089)				(0.077)	
Change in tax credits ×		-0.034				-0.027
High-tech		(0.011)***				(0.009)***
IP protection ×			0.054		0.037	0.040
High-tech			(0.016)***		(0.016)**	(0.016)**
Accounting standards ×				0.033	0.027	0.023
High-tech				(0.009)***	(0.009)***	(0.009)**
Constant	0.032	0.032	0.035	-0.013	0.027	0.029
	(0.009)***	(0.009)***	(0.007)***	(0.009)	(0.007)***	(0.007)***
Observations	5,606	5,606	5,606	5,606	5,606	5,606
R-squared	0.632	0.638	0.642	0.649	0.658	0.662

Table 4
Comparing alternative financial market rules

Table 4 reports OLS estimates of equation (2). The dependent variable is the industry R&D-to-value added ratio (*R&D*). In addition to the interaction terms, each regression includes full sets of industry and country-year dummy variables. The reported standard errors are robust to clustering in the country dimension. All variables are defined in Table 1.

	(1)	(2)	(3)	(4)	(5)	(6)
R&D tax credits ×	-0.485		-0.799		-0.492	
Innovative intensity	(0.384)		(0.359)**		(0.342)	
Change in tax credits ×		-0.117		-0.155		-0.085
Innovative intensity		(0.042)**		(0.050)***		(0.048)*
IP protection ×	0.175	0.183	0.355	0.355	0.158	0.164
Innovative intensity	(0.081)**	(0.082)**	(0.079)***	(0.077)***	(0.072)**	(0.075)**
Accounting standards ×					0.091	0.078
Innovative intensity					(0.032)**	(0.035)**
Contract enforcement ×	0.174	0.168			0.188	0.191
Innovative intensity	(0.061)**	(0.054)***			(0.073)**	(0.070)**
Creditor rights ×			-0.038	-0.029	-0.086	-0.082
Innovative intensity			(0.049)	(0.045)	(0.035)**	(0.034)**
Constant	0.023	0.023	0.033	0.039	-0.017	-0.018
	(0.007)***	(0.007)***	(0.006)***	(0.006)***	(0.009)*	(0.009)*
Observations	5,606	5,606	5,606	5,606	5,606	5,606
R-squared	0.653	0.655	0.646	0.648	0.661	0.661

Table 5
Quantifying the economic effects of changes in innovation policy

Table 5 reports estimates of the economic magnitude of the coefficients reported in the final regression in Table 4. The differentials compare how (all else equal) a change in the policy variable from the 25th to 75th percentile affects the gap between R&D investment across industries with different *Innovative intensity*. In the first two rows we compute the predicted R&D differentials by comparing industries at the 75th percentile and 25th percentile in *Innovative intensity*. In the final two rows we compute the predicted R&D differentials by comparing the average *Innovative intensity* across the high-tech sector to the corresponding average in the low-tech sector.

	(1)	(2)	(3)	(4)	(5)
	Change in policy variable from 25th – 75th percentile:				
	Change in tax credits	*IP protection*	*Accounting standards*	*Contract enforcement*	*Creditor rights*
R&D differential effect computed as:					
75th – 25th pct in *Innovative intensity* / sample avg R&D	-0.02	0.03	0.03	0.05	-0.05
75th – 25th pct in *Innovative intensity* / sample median R&D	-0.07	0.08	0.09	0.15	-0.14
HT – non HT in *Innovative intensity* / sample avg HT R&D	-0.06	0.07	0.07	0.12	-0.11
HT – non HT in *Innovative intensity* / sample avg HT - non HT R&D	-0.07	0.08	0.09	0.15	-0.14

Table 6
Innovation policy and industry R&D intensity: Estimating effects using long-run averages

Table 6 reports OLS estimates of equation (2). The dependent variable is the industry R&D-to-value added ratio (*R&D*), averaged over 1990-2006 in columns (1)-(5) and 1990-1999 in column (6). In addition to the interaction terms, each regression includes full sets of industry and country dummy variables. The reported standard errors are robust to clustering in the country dimension. All variables are defined in Table 1.

	(1)	(2)	(3)	(4)	(5)	(6)
R&D tax credits ×	-1.342			-0.682	-0.578	-0.487
Innovative intensity	(0.572)**			(0.448)	(0.454)	(0.356)
IP protection ×		0.682		0.493	0.261	0.157
Innovative intensity		(0.131)***		(0.137)***	(0.230)	(0.164)
Accounting standards ×			0.169	0.093	0.086	0.097
Innovative intensity			(0.035)***	(0.041)**	(0.030)**	(0.034)**
Contract enforcement ×					0.169	0.213
Innovative intensity					(0.091)*	(0.076)**
Creditor rights ×					-0.085	-0.106
Innovative intensity					(0.034)**	(0.037)**
Constant	0.059	0.040	0.055	0.041	0.035	-0.005
	(0.007)***	(0.006)***	(0.006)***	(0.006)***	(0.006)***	(0.007)
Observations	382	382	382	382	382	379
R-squared	0.704	0.724	0.712	0.730	0.736	0.696

Table 7
Innovation policy and industry R&D intensity: Alternative industry characteristics

Table 7 reports OLS estimates of equation (2). The dependent variable is the industry R&D-to-value added ratio (*R&D*). In addition to the interaction terms, each regression includes full sets of industry and country-year dummy variables. The reported standard errors are robust to clustering in the country dimension. All variables are defined in Table 1.

	(1)	(2)	(3)	(4)	(5)	(6)
	Country policy interacted with industry:					
	External finance		*Cash flow*		*Income taxes*	
R&D tax credits ×	-0.139		0.718		2.401	
Industry characteristic	(0.053)**		(0.266)**		(0.588)***	
Change in tax credits ×		-0.022		0.103		0.306
Industry characteristic		(0.008)**		(0.044)**		(0.091)***
IP protection ×	0.041	0.044	-0.261	-0.276	-0.538	-0.608
Industry characteristic	(0.015)**	(0.015)***	(0.077)***	(0.079)***	(0.240)**	(0.236)**
Accounting standards ×	0.027	0.023	-0.113	-0.098	-0.793	-0.687
Industry characteristic	(0.009)***	(0.009)**	(0.031)***	(0.033)***	(0.194)***	(0.211)***
Constant	0.150	0.146	0.222	0.215	0.115	0.109
	(0.035)***	(0.032)***	(0.041)***	(0.037)***	(0.016)***	(0.017)***
Observations	5,606	5,606	5,606	5,606	5,606	5,606
R-squared	0.642	0.642	0.644	0.644	0.635	0.634

Table 8
Innovation policy and industry R&D intensity: Alternative estimation approaches

Table 8 reports OLS estimates of equation (2). In columns (1) and (2) the dependent variable is the industry R&D-to-output ratio. In columns (3)-(6) the dependent variable is the industry R&D-to-value added ratio (*R&D*). In addition to the interaction terms, the regressions in columns (1)-(8) include full sets of industry and country-year dummy variables, while the regressions in columns (9) and (10) include country-industry fixed effects in place of the industry dummy variables. The reported standard errors are robust to clustering in the country dimension. All variables are defined in Table 1.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	R&D-to-output as the dependent variable		*Innovative intensity* computed over the 1980s		Add GDP and Human capital interactions		Control for industry growth options		Country-industry fixed effects	
R&D tax credits ×	-0.382		-1.915		-0.839		-0.727		-0.111	
Innovative intensity	(0.115)***		(1.178)		(0.271)***		(0.381)*		(0.173)	
Change in tax credits ×		-0.049		-0.427		-0.125		-0.159		0.002
Innovative intensity		(0.020)**		(0.147)***		(0.042)***		(0.052)***		(0.020)
IP protection ×	0.064	0.071	0.681	0.726	0.199	0.230	0.272	0.297	0.110	0.105
Innovative intensity	(0.028)**	(0.030)**	(0.266)**	(0.265)**	(0.084)**	(0.090)**	(0.090)***	(0.091)***	(0.048)**	(0.047)**
Accounting standards ×	0.051	0.046	0.421	0.360	0.101	0.088	0.146	0.119		
Innovative intensity	(0.018)**	(0.021)**	(0.142)***	(0.136)**	(0.036)**	(0.036)**	(0.040)***	(0.041)***		
GDP per capita ×					0.023	0.019				
Innovative intensity					(0.033)	(0.037)				
Schooling ×					0.452	0.377				
Innovative intensity					(0.304)	(0.308)				
Industry growth							0.031	0.031		
							(0.014)**	(0.014)**		
Constant	-0.116	-0.108	-0.008	-0.004	0.010	0.010	0.001	0.008	0.047	0.048
	(0.028)***	(0.029)***	(0.014)	(0.014)	(0.010)	(0.010)	(0.005)	(0.004)*	(0.007)***	(0.007)***
Observations	5,197	5,197	5,606	5,606	5,387	5,387	4,469	4,469	5,606	5,606
R-squared	0.680	0.677	0.664	0.667	0.653	0.652	0.650	0.652	0.217	0.214

Table 9
Industry level R&D user cost regressions

Table 9 reports OLS estimates of equation (3) with log $(R\&D)_{i,j,t}$ as the dependent variable. Log (output) is the industry-country-year value of sales and log(B-index) is the log of the country-year value of the *B-index*. In column (1) we use all 22 manufacturing industries, in column (2) we only include the 18 non-high tech industries, and in column (3) we only include the four high-tech industries. Country, industry, and year dummies are included in all regressions. Reported standard errors are robust to clustering in the country dimension.

	(1)	(2)	(3)
	Full sample (all industries)	Only non high-tech industries	Only high-tech Industries
log (output)	0.838	0.834	0.994
	(0.053)***	(0.056)***	(0.115)***
log (B-index)	-0.010	-0.014	0.001
	(0.003)***	(0.005)***	(0.010)
Adj. R-squared	0.857	0.849	0.872
Nr of observations	4,205	3,545	660

Table A.1
Country characteristics

Countries	Accounting standards	Contract enforcement	Creditor rights	IP protection	R&D tax credits	First year of tax credits
Australia	75	8.71	3.00	3.90	0.16	1985
Austria	54	9.60	3.00	4.13	0.07	1992
Belgium	61	9.48	2.00	4.53	-0.01	No R&D tax credits
Canada	74	8.96	1.00	4.16	0.17	1962
Denmark	62	9.31	3.00	4.40	-0.01	No R&D tax credits
Finland	77	9.15	1.00	4.16	-0.01	No R&D tax credits
France	69	9.19	0.00	4.40	0.09	1983
Germany	62	9.77	3.00	4.25	-0.05	No R&D tax credits
Greece	55	6.62	1.00	3.54	-0.01	No R&D tax credits
Italy	62	9.17	2.00	4.38	-0.04	1992 for small firms
Japan	65	9.69	3.00	4.36	0.02	1967
Korea	62	8.59	3.00	3.95	0.09	1988
Mexico	60	6.55	0.00	2.86	0.09	1997
Netherlands	64	9.35	3.00	4.50	0.07	1994
Norway	74	9.71	2.00	3.88	0.04	2002
Portugal	36	8.57	1.00	3.26	0.11	1997
Spain	64	8.40	2.00	4.07	0.34	1990
Sweden	83	9.58	1.00	4.31	-0.02	No R&D tax credits
UK	78	9.63	4.00	4.48	0.04	2001

Correlations across country characteristics

	Accounting standards	*Contract enforcement*	*Creditor rights*	*IP protection*	*R&D tax credits*
Accounting standards	1				
Contract enforcement	0.347	1			
Creditor rights	0.077	0.512	1		
IP protection	0.459	0.794	0.487	1	
R&D tax credits	-0.049	-0.253	-0.088	-0.246	1