4-2019

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Disciplines

Business and Corporate Communications | Environmental Indicators and Impact Assessment | Finance and Financial Management | Operations and Supply Chain Management

Comments

This accepted article is published as Brown, J.R., Martinsson, G., Does Transparency Stifle or Facilitate Innovation? *Management Science* April 2019; 65(4), 1600-1623. doi: 10.1287/mnsc.2017.3002. Posted with permission.

Does Transparency Stifle or Facilitate Innovation?

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October 15, 2017

Abstract

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Keywords: Corporate transparency, R&D, Innovation, Insider trading, European Union, IFRS, International accounting, Security market regulation, Disclosure

JEL Classification: G14, G15, G18, M48, O30

We appreciate the many helpful comments we received from conference and seminar participants at the American Accounting Association International Accounting Section 2014 Midyear Meeting, 8th Financial Markets and Corporate Governance Conference, Swedish Ministry of Finance, Institute for Financial Research (SIFR), Iowa State University, and University of Colorado-Boulder. We also thank Jim Cannon, Tony Cookson, John Core, Rawley Heimer, Shawn Huang, Sam Lee, Zhejia Ling, Sergey Mityakov, Per Olsson, Mattias Nilsson, Bruce Petersen, Valentina Salotti, Tami Dinh Thi, Qian Wang, Olena Watanabe, two anonymous referees, and an anonymous associate editor for providing detailed feedback on previous versions of the paper. We are grateful to the Mistra Financial Systems research program and Ivy College of Business for funding support. This paper was previously circulated under the titles "Financial Disclosure, Corporate Transparency, and Innovation" and "The Real Consequences of Corporate Transparency: Evidence from R&D Activity".
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1. Introduction

High information costs are a fundamental friction in financial markets and a potential constraint on economic growth (Levine, 1997). Accordingly, there is widespread agreement that by reducing information asymmetries between firms and corporate outsiders, a richer information environment generates broad capital market benefits – for example, Rajan and Zingales (2003) point to corporate transparency as one of "the essential ingredients of a developed financial system". But the overall impact a country's information environment has on different types of real corporate activities is less clear, in part because the capital market benefits of increased transparency are potentially offset by higher proprietary costs arising from information leakage to competitors (e.g., Bhattacharya and Ritter, 1983; Healy and Palepu, 2001; Ellis, Fee, and Thomas, 2012).

This tension between the costs and benefits of transparency is especially apparent in the case of innovation. In contrast to traditional investments in physical capital, investment in research and development (R&D) is intangible, firm specific, and produces highly uncertain outcomes. These characteristics lead to information asymmetries between firms and outside suppliers of capital, and make R&D relatively more dependent on information-sensitive financing sources, particularly external stock issues (Hall, 2002; Lev, 2004; Brown, Fazzari, and Petersen, 2009). As a consequence, a richer information environment can facilitate innovative investment by reducing information asymmetries and lowering the cost of external equity finance. But at the same time, a richer information environment makes it harder for firms to conceal their innovative activities from the marketplace, and the costs associated with information leakage to competitors are particularly severe when it comes to the development of new products and ideas.[1] If these proprietary costs are sufficiently large then transparency can discourage innovative efforts.

In this study we evaluate the net effect a country's broad information environment has on innovation, and provide contrasting evidence on the consequences of transparency for physical capital accumulation. While scholars have long recognized that transparency can have competing effects on innovation, prior work focuses on modeling firm-level disclosure incentives, financing choices, and the decision to go public or private,[2] rather than empirically evaluating how the information environment in which firms operate affect overall levels of innovative activity. Studying the effects of transparency on innovation is important not only for identifying the institutional and organizational factors that influence corporate innovation (e.g., Ederer and Manso, 2013; Tian and Wang, 2014; Atanassov, 2016), but also for understanding how policies that change the corporate transparency environment affect the nature of real economic activity. In particular, evidence on how a richer corporate information environment affects the mix of innovation and capital accumulation is

[1] Hall (2002, p.38) discusses this idea: "Firms are reluctant to reveal their innovative ideas to the marketplace and the fact that there could be a substantial cost to revealing information to their competitors reduces the quality of the signal they can make about a potential project."

[2] For example, see Bhattacharya and Ritter (1983), Maksimovic and Pichler (2001), and Ferreira, Manso, and Silva (2014).

especially relevant for anticipating the economic consequences of security market reforms, which often explicitly focus on increasing overall levels of corporate transparency (Leuz and Wysocki, 2016).

We test the real effects of cross-sectional and time-series variation in the corporate information environment in a broad sample of countries. To measure long-run cross-national differences in the overall information environment, we focus primarily on broad measures of transparency that account for financial disclosures, auditing activity, the enforcement of insider trading laws, and media development, all of which affect the extent to which firm-specific information is available to corporate outsiders (e.g., Francis et al., 2009). Our identification strategy focuses on the within-country differential effect a richer information environment has on investment across industries with different *ex ante* sensitivities to the information environment. Building on the approach in Rajan and Zingales (1998), we use data from US firms to construct proxies for each industry's sensitivity to the information environment, focusing primarily on an industry's dependence on external equity financing.

Using information on industry-level rates of investment from the STAN Indicators Database – a data set compiled by the OECD to provide internationally comparable estimates of R&D spending – we find strong evidence that a richer information environment is associated with higher overall rates of R&D investment. Specifically, the difference in R&D investment between sectors with high and low dependence on external equity is substantially larger in countries with high levels of corporate transparency compared to countries with low levels of transparency. To evaluate the economic magnitude of our estimates, we compare the difference in R&D investment across industries with high (75^{th} percentile) and low (25^{th} percentile) external equity dependence in countries with high transparency (75^{th} percentile) relative to the corresponding difference in countries with low transparency (25^{th} percentile). The magnitude of this difference-in-differences effect is typically around ten percent of the sample average R&D intensity, which is substantial, especially given innovation spillovers and the high social returns to R&D (e.g., Bernstein and Nadiri, 1988; Hall, 1996).

Although our baseline approach accounts for industry- and country-specific fixed effects, thereby ruling out a number of standard concerns about omitted factors, we show that our findings are not an artifact of the positive correlation between transparency and other institutional characteristics that may also differentially foster innovation in information-sensitive industries. In particular, there is likely more demand for corporate transparency in countries with strong stock markets,[3] in which case the positive association between transparency and R&D we identify in the initial tests may simply reflect a strong positive connection between financial market development and innovation (e.g.,

[3] For example, Levine (1997, p. 695) says: "Stock markets may also influence the acquisition and dissemination of information about firms. As stock markets become larger... and more liquid..., market participants may have greater incentive to acquire information about firms."

Brown, Martinsson, and Petersen, 2013; Hsu, Tian, and Xu, 2014). However, we continue to find significant positive effects for the transparency measures even after controlling for the differential effects of financial market development. Similarly, we continue to find strong evidence of a positive connection between transparency and R&D if we directly control for other characteristics that are potentially important for innovation in equity-dependent industries, such as the country's level of economic development, human capital, patent protection, and R&D tax credits.

Several additional findings also indicate that transparency has a positive impact on innovation. First, we find that the effects of transparency are stronger in industries that are relatively more dependent on market-based financing sources than on bank debt, as expected given the higher information costs associated with arm's-length financing (e.g., Myers and Majluf, 1984). Second, we build an expanded sample of countries using information on firm-level investment spending from Compustat Global. Estimates from these tests also show a strong, positive association between corporate transparency and R&D in more information-sensitive industries. Finally, we measure innovation with industry patenting activity rather than R&D spending. Focusing on innovative outputs (compiled from an entirely different data source) addresses any concerns one might have about difficulties measuring R&D across countries (e.g., Bhagat and Welch, 1995). Consistent with our evidence for R&D, we find a positive differential association between the country's overall level of transparency and the level of patenting activity in equity-dependent sectors.

We repeat the analysis for fixed capital spending rather than R&D. In addition to providing a more complete picture of how transparency affects real activity, evidence on capital accumulation presents a placebo exercise: because tangible assets suffer from fewer information asymmetries than innovation, capital spending should be less sensitive to changes in an economy's overall information environment. Indeed, we find no evidence that cross-national differences in transparency have a meaningful effect on fixed capital accumulation. This evidence is notable because it helps rule out alternative explanations for our findings, almost all of which would predict similar effects on both R&D and capital spending.

Next, we move to tests that exploit time-series shocks to the country information environment. For plausibly exogenous changes in the overall information environment we focus on two regulatory events: i) the first prosecution for violating legal restrictions on insider trading (Bhattacharya and Daouk, 2002), and ii) the implementation of a set of transparency directives across securities markets in the European Union (EU) (Enriques and Gatti, 2008).[4] Studying the initial enforcement of insider trading laws is attractive because there is extensive evidence linking the mitigation of insider trading with broad improvements in an economy's information environment (e.g., Bushman, Piotroski, and

[4] We also present corroborating results from a third transparency-related event, the adoption of International Financial Reporting Standards (IFRS). We do not focus on these results because IFRS directly impacted the reporting of R&D, making it potentially challenging to interpret the mechanism behind the R&D changes we document.

Smith, 2004 and 2005; Hail, Tahoun, and Wang, 2014). Similarly, the EU directives focused explicitly on improving corporate transparency for outside investors by standardizing and enforcing corporate disclosure provisions and insider trading rules, and recent evidence suggests these directives had substantial capital market benefits (Christensen, Hail, and Leuz, 2016).

Extending our identification approach to these time-series events, we find strong evidence that shocks to the information environment disproportionately affect R&D in sectors that are more reliant on external equity finance. Moreover, the positive differential effects of insider trading enforcement and the EU transparency directives appear only in the years *after* the first enforcement and implementation events, supporting a causal inference (Bertrand and Mullainathan, 2003). In addition, while these events have a strong positive impact on R&D, they do not lead to higher levels of capital spending. Together with the cross-sectional regressions, these quasi-experimental results offer compelling evidence that improvements to the corporate information environment have an independent and economically important impact on innovative activity.

Our final set of tests focus on differences in the way transparency affects real investment in different types of firms. Although our main findings show that the overall (net) effects of improvements to the information environment are positive, both academic and anecdotal evidence suggests information leakage and proprietary costs are an important concern among some types of firms (e.g., Fox et al., 2013). In particular, improvements to the country's information environment should be relatively less important for R&D in profitable firms, as such firms face the costs of information leakage but benefit less from a reduction in the cost of external finance. We test this idea by exploring how the time-series shocks to the information environment affect firms with sufficient free cash flow to fully fund R&D internally. These estimates show a relative *reduction* in R&D investment among dividend-paying firms and firms with positive free cash flow. Together with our main findings, these results show that higher levels of transparency have heterogeneous effects on different types of firms, and suggest that the positive overall effects we document are driven by increases in innovation among firms that rely on capital markets for funding.

Our study contributes to multiple literatures across several related disciplines. First, an important theoretical literature explores the trade-offs that innovative firms face when deciding on information disclosure to outside investors and evaluating whether to go public or private. We take a broader perspective and provide the first empirical evidence on the level of innovative activity in different information environments. In this way, our findings add to a growing literature on the institutional and organizational factors that influence corporate innovative efforts.[5]

[5] For example, see Barker and Mueller (2002), Cohen, Nelson, and Walsh (2002), Åstebro (2004), Brown, Fazzari, and Petersen (2009), Zhao (2009), Acharya and Subramanian (2009), Sauermann and Cohen (2010), Manso (2011), Tambe, Hitt, and Brynjolfsson (2012), Atanassov (2013 and 2016), Brown, Martinsson, and Petersen (2013 and 2017), Ederer and Manso (2013), Aggarwal and Hsu (2014), Cerqueiro, Hegde, Penas, and Seamans (2017), Tian and Wang (2014), Flammer and Kacperczyk (2016), and Bradley, Kim, and Tian (2017).

Second, our findings are relevant for a large literature on the effects of a country's accounting and disclosure environment.[6] While this literature is increasingly interested in evaluating real outcomes, the tension between corporate transparency and innovation has not been studied, nor has prior work considered the potential for a country's information environment to affect intangible activities like innovation differently than it affects the overall rate of capital accumulation.[7] Given the recent shift from fixed investment to R&D in developed economies (e.g., Brown and Petersen, 2015), and the widespread appreciation of innovation's importance for both firm and macroeconomic performance (Aghion and Howitt, 1992; King and Levine, 1993; Hall, Mairesse, Mohnen, 2010), our work thus highlights an increasingly relevant mechanism linking the financial reporting environment with the real economy.

Finally, we provide new insights on the real consequences of transparency-related security market reforms (e.g., Bushee and Leuz, 2005; Mulherin, 2007; Zingales, 2009).[8] Although our work does not provide a full accounting of the costs and benefits of these reforms, it does identify an explicit and unappreciated channel through which reform can have economically important aggregate effects. Moreover, our study provides novel evidence on the heterogeneous effects these reforms have for different types of real investment and for different types of firms. As Leuz and Wysocki (2016) note, understanding the nature of these real economic effects is essential for evaluating the desirability of changes in the regulation and oversight of financial markets.

2. Empirical Strategy

There are several challenges in empirically evaluating how transparency affects innovation. One key challenge is that firm-level disclosure incentives are partially determined by the real investment opportunities facing the firm – that is, there is a potential for reverse causality, wherein real firm decisions drive the aggregate transparency environment, rather than the other way around. Another primary challenge is distinguishing the effects of transparency from other aspects of the institutional and economic environment in which firms operate.

We address these challenges in multiple ways. First, our empirical approach focuses on the within-country effects of transparency across industries with different underlying sensitivities to the

[6] For example, see Botosan (1997), Leuz and Verrecchia (2000), Healy and Palepu (2001), Bhattacharya, Daouk, and Welker (2003), Francis, Khurana, and Pereira (2005), La Porta, Lopez-de-Silanes, and Shleifer (2006), Biddle and Hilary (2006), Li and Shroff (2010), Biddle et al. (2011), Fu, Kraft, and Zhang (2012), and Shroff, Verdi, and Yu (2014).

[7] Biddle, Hilary, and Verdi (2009) include R&D along with capital expenditures in a measure of firm investment spending, but their focus and tests differ substantially from ours. In particular, they provide compelling evidence that financial reporting quality improves investment efficiency, but there is no way to infer from their evidence that a richer corporate transparency environment leads to more innovation but has no impact on the level of investment in fixed capital.

[8] More precisely, we provide novel empirical evidence on the real effects of three specific security market reforms: insider trading enforcement, the EU transparency directives, and IFRS adoption. In this way, our work is among a small number of concurrent studies that explore how particular legal reforms influence technological innovation and other real outcomes (e.g., Chen et al., 2014; Cumming, Ji, and Peter, 2016). In particular, Levine, Lin, and Wei (2016) focus specifically on the link between insider trading and innovation.

information environment. In this way, we use a difference-in-differences approach that accounts for any arbitrary country-specific characteristics that broadly influence the real economic outcomes we study. Second, we study the effects of transparency on both innovation and fixed capital spending. Because capital spending is less information-sensitive than innovation, it represents a type of placebo exercise, which helps establish that our findings are driven by transparency rather than some other institutional characteristic. Finally, we study how time-series shocks specific to the country's broad information environment impact R&D activity. Quasi-experimental evidence of this type is particularly difficult to dismiss with standard concerns about omitted factors (e.g., Bertrand and Mullainathan, 2003).

Our empirical tests broadly follow the identification approach pioneered by Rajan and Zingales (1998) and utilized in many subsequent studies (e.g., Beck and Levine, 2002; Claessens and Laeven, 2003). In general, we estimate specifications with the following form:

$$Outcome_{i,j} = \beta_0 + \beta_1\, Transparency_i \times Information\ sensitivity_j + \eta_j + \eta_i + \varepsilon_{i,j} \qquad (1)$$

where we observe differences in real outcomes for industry *j* in country *i* ($Outcome_{i,j}$). $Transparency_i$ measures the overall information environment in country *i*, whereas $Information\ sensitivity_j$ is a measure of industry *j*'s sensitivity to the information environment. The specification includes industry and country fixed effects (η_j and η_i), which flexibly control for any country-specific factors that impact real outcomes across all industries, including financial and economic development and institutional quality, as well as any industry-specific attributes that are constant across countries (such as the overall propensity for a certain sector to engage in innovation).

A positive coefficient on the interaction term (β_1) indicates that the difference in the *Outcome* variable across industries with high and low *Information sensitivity* is higher in countries with high levels of *Transparency* compared to countries with low *Transparency*.[9] Note that by focusing on these difference-in-differences, an omitted country characteristic is only a concern to the extent that it is both correlated with the information environment *and* disproportionately important for real outcomes in sectors with a relatively high *Information sensitivity*. With this potential concern in mind, we show that our findings are robust to including additional interaction terms in equation (1) which directly control for any differential effects alternative country institutions and characteristics may have on innovative activity in sectors with a high *Information sensitivity*.

3. Data and Measurement

[9] In the cases where we use the staggered introduction of security market reforms to measure changes in *Transparency* for a given country, we include country-year fixed effects and equation (1) amounts to a triple difference-in-differences test. In this case, the estimate on the interaction term captures how the difference in real outcomes across industries with different *Information sensitivity* change following a given country's implementation of the transparency reform, relative to the baseline differences established by country-year's where the transparency reform has not been implemented. We discuss this approach in section 5.

We study the effects of transparency using several different samples and outcome measures. This section describes how we build the regression samples and measure the key variables of interest. Table A1 in the appendix provides detailed definitions and data sources for the full set of variables we use in the study, while Tables 1 and 2 report sample characteristics and variable descriptive statistics.

3.1. OECD Sample

We start with a sample that uses data on industry-level R&D expenditures compiled from the Organisation for Economic Co-operation and Development (OECD)'s STAN Indicators database. The OECD notes that the STAN data "…was developed to provide analysts with comprehensive and internationally comparable data on industrial R&D expenditures that address the problems of international comparability and breaks in the time series of official business enterprise R&D data (OFFBERD) provided to the OECD by its member countries through the joint OECD/Eurostat survey." In this way, the R&D measures in the STAN data are compiled using a refined survey methodology and a consistent standard for what constitutes R&D (as outlined in the Frascati Manual (OECD, 2002)). As such, the values are not subject to standard concerns about cross-country comparability of R&D figures that arise from differences in the way public firms report or expense/capitalize R&D expenditures.

Because the STAN database reports R&D at the industry level, the measures reflect the total R&D expenditures of both private and public firms. To the extent that the transparency environment should matter primarily (if not exclusively) for public firms, the effects of transparency may be camouflaged to some extent in these broad industry-wide measures. However, this is unlikely to have a significant influence on our inferences because public firms account for a large share of R&D (e.g., Hall and Oriani, 2006). Moreover, focusing on the aggregated measures is attractive for evaluating whether transparency has an economically important impact on a country's overall level of innovative activity.

We merge the industry R&D information from the STAN database with several alternative measures of country-level transparency (as discussed below). We focus on non-U.S. countries with sufficient data on both the transparency environment and industrial R&D.[10] Finally, because some of our tests rely on the original measures of external finance dependence constructed by Rajan and Zingales (1998), we focus on a set of industries that correspond as closely as possible to the industry groupings in their study. The final sample covers 25 industries in 20 countries over the period 1990 to 2006.[11]

[10] We drop the U.S. because we use data from U.S. firms to construct measures of industry sensitivity to the information environment. The countries with coverage in the STAN sample are listed in Table 1. The R&D requirement excludes New Zealand, Israel, Luxembourg, Switzerland, and Turkey. The requirement that countries have coverage of at least some transparency measures excludes the former communist states and Iceland.

[11] The STAN Indicators database reports sporadic information on R&D for some countries up to 2008. We stop the sample in 2006 because this is the last year we have comprehensive coverage across the full set of countries

3.2. Compustat Global Sample

We build a companion sample using firm-level data from Compustat Global. The Compustat database reports standardized financial statement information for publicly listed firms in a broad sample of countries. There are limitations to relying exclusively on the Compustat data to measure R&D activity; most notably, there can be sharp differences the way public firms report and expense R&D, even within the same country. Nonetheless, there are also several advantages to studying R&D using the Compustat database. First, evidence on the level of R&D spending in public firms provides a robustness check on the inferences we draw from the OECD sample. Second, coverage in the Compustat database extends well beyond the OECD countries covered in the STAN data, allowing us to evaluate the real consequences of corporate transparency in a broader sample of countries. Third, the OECD data is not useful for studying the EU transparency directives because the directives come into force in the mid- to late-2000s, when R&D coverage in the STAN Indicators database is sporadic at best.

We focus on non-U.S. Compustat firms with fully consolidated financial statements, a primary industry classification in one of the industries in our main sample, and at least three non-missing R&D observations over the period 1990 to 2012. Requiring firms to report positive R&D substantially reduces the sample size, so we also build a broader sample using firms with at least three non-missing capital spending (Capx) observations. In this broader sample we set all missing R&D observations equal to zero. We require countries to have at least ten firms with useable data since we need cross-industry coverage of investment spending to conduct the difference-in-differences tests.

Table 1 lists the 38 different countries that appear in either the STAN or Compustat samples. The last column in Table 1 reports the number of R&D-reporting firms in each country in the Compustat sample. Only Mexico and Portugal have coverage in the STAN database but not enough firm-level data to be included in the expanded sample. Consistent with other studies using cross-national data at the firm level (e.g., Daske et al., 2008), observation counts differ markedly across countries, with Japan and Taiwan contributing the most observations and Sri Lanka and Thailand contributing the least.

and industries in our sample, but all our results are unaffected if we include additional data (when available). In an alternative database, the OECD reports similarly constructed measures of R&D spending from 2000 through 2013 (for selected countries), but for a different set of industry definitions. We bypass the difficulties and imperfections of mapping across alternative industry classifications by focusing on the sample from the original STAN Indicators database.

3.3. Measuring Differences in the Aggregate Information Environment

3.3.1. Indicators of Long-Run Cross-National Differences in Transparency

The first three columns in Table 1 report the alternative measures of cross-national differences in corporate transparency. Our primary measure of the transparency level in a given country, *Transparency*, is the comprehensive measure of the information environment constructed by Francis et al. (2009). Building on the framework in Bushman, Piotroski, and Smith (2004), Francis et al. (2009) construct *Transparency* from each country's relative ranking across a number of transparency indicators, including accounting disclosures, auditing activity, analyst coverage, insider trading enforcement, and media coverage. We focus on *Transparency* for two reasons. First, it is a broad measure of the country's aggregate information environment that "combines the quality of the firm-specific financial reporting environment in a country with private information acquisition and information dissemination activities" (Francis et al., 2009, p. 958), thereby capturing more than just financial disclosures or accounting quality. Second, all inputs to the *Transparency* measure are taken from the 1980s or from 1990, thus giving us an *ex ante* measure of the country information environment that is not affected in any mechanical way by R&D activity over our sample period.[12]

We also report results using two alternative measures of a country's information environment. First, we use *Financial transparency*, the Bushman, Piotroski, and Smith (2004) proxy for "the prevalence of disclosures concerning research and development (R&D) expenses, capital expenditures, product and geographic segment data, subsidiary information, and accounting methods" (p. 212). Though more narrow than *Transparency*, this measure has the advantage of placing more weight on disclosures about real investment activity. Second, we use *Earnings transparency*, based on the aggregate measure of earnings management constructed by Leuz, Nanda, and Wysocki (2003). As Daske et al. (2008) discuss, this measure captures the transparency of firm-level reporting practices, and thereby serves as a proxy for cross-country differences in corporate transparency. Following Daske et al. (2008), we multiply the Leuz, Nanda, and Wysocki (2003) measure of earnings management by minus one so that, consistent with the other measures, higher values of the *Earnings transparency* score indicate a richer corporate information environment.[13]

Each of these measures is constructed by using an index or relative ranking of transparency indicators across countries. As such, they are best viewed as measuring longer-run, institutionally-

[12] While focusing on an *ex ante* measure is clearly an advantage for evaluating the link between transparency and innovation early in the sample period, it is a disadvantage in later years if there are important changes over time in relative levels of transparency across countries. We address this concern by providing sub-sample results that focus only on the early part of the sample period, and we bypass the issue entirely by moving to tests based on contemporaneous variation in both transparency and R&D.

[13] The three alternative measures of transparency are positively correlated across countries, suggesting they capture similar information about cross-national differences in the transparency environment. Specifically, the correlation coefficients between *Transparency* and *Financial transparency* and *Earnings transparency* are 0.80 and 0.81, respectively, while the correlation coefficient between *Financial transparency* and *Earnings transparency* is 0.57.

determined differences in the information environment across countries (Daske et al., 2008). We thus use these measures in conjunction with average (long-run) measures of real investment, which is useful for quantifying long-run effects and broadly consistent with other work on the economic consequences of cross-national differences in financial rules and institutions (e.g., Rajan and Zingales, 1998; Francis et al., 2009). However, there are clear advantages to also exploring whether within-country changes in transparency lead to corresponding changes in R&D activity. For these tests, we turn to quasi-experimental variation in the country information environment.

3.3.2. Time-Series Shocks to the Transparency Environment

We focus primarily on two events that affected the corporate information environment in a sub-set of the countries we sample. First, we take information on the initial prosecution for insider trading in a given country from Bhattacharya and Daouk (2002). Several studies conclude that the initial enforcement of insider trading laws leads to changes in corporate disclosure and information acquisition activities that ultimately improve corporate transparency (Bushman, Piotroski, and Smith, 2004 and 2005). Consistent with these arguments, Bhattacharya and Daouk (2002) find that the initial enforcement of insider trading restrictions is associated with substantial reductions in the cost of equity capital. Our use of insider trading enforcement as a shock to transparency is consistent with Hail, Tahoun, and Wang (2014), who, in their study on dividend policies under different information regimes, treat the initial enforcement of insider trading laws as an exogenous improvement in the overall information environment.

Column (4) in Table 1 reports the year of the first insider trading prosecution for each country. Using these dates we create a dummy variable, $Insider\ enforce^{post}$, which equals one in all years starting with the year insider trading is first enforced, and zero otherwise. Note that for some of our sampled countries $Insider\ enforce^{post}$ is always equal to one (if the first prosecution was in 1990 or earlier), for other countries $Insider\ enforce^{post}$ is always equal to zero (no prosecutions prior to or during our sample period), and for the remainder of countries $Insider\ enforce^{post}$ changes from zero to one during our sample period (the first prosecution occurs during our sample period).

It is possible that the first instance of insider trading enforcement indicates a broad within-country shift to a stronger enforcement or regulatory regime. This is not a problem for our inferences as long as the primary impact from the new regime is an improvement in the country's information environment. Nonetheless, we also consider the effects of recent securities market regulations in the EU which are more narrowly targeted to the corporate transparency environment. As part of a broad Financial Services Action Plan established in the EU in 1999, EU member countries were required to implement three directives directly related to corporate transparency: the Prospectus Directive (PRO), Market Abuse Directive (MAD), and Transparency Directive (TPD). Enriques and Gatti (2008) and Christensen, Hail, and Leuz (2016) discuss these directives and the nature of their implementation in detail, but in general the PRO directive focuses on the disclosure obligations of firms initially issuing securities to the public, the MAD directive focuses on disclosure of insider trading activities and enforcement of insider trading and market manipulation rules, and the TPD directive focuses on the supervision and enforcement of corporate reporting requirements.[14] The implementation of these transparency directives is staggered across EU countries, typically over a period of two to three years. To identify a shift in the transparency environment, we focus on the year a country first begins to implement the transparency directives, which typically corresponds to a country's implementation of the MAD directive.[15] Christensen, Hail, and Leuz (2016) find that the introduction of the MAD directive had significant positive effects on market liquidity, suggesting that our approach captures an important change in the information environment.

Column (5) in Table 1 reports the year the first directive is put into force in the EU countries in our sample. Following the same approach we used for the *Insider enforce*^{post} variable, we construct an *EU directive*^{post} indicator variable that equals one in all years starting with the first year a directive is put into force, and zero otherwise. As Table 1 shows, all the EU countries we sample with the exception of Germany begin to implement the transparency directives in the same year (2005), raising the possibility that implementation of the directives happened to coincide with some other EU-specific shock that differentially affected R&D in equity dependent industries. We thus also report results using an alternative indicator variable that equals one starting with the first year the TPD directive is implemented (*EU directive TPD*). A key advantage of this measure is that the implementation dates are more staggered across EU countries during the 2007 to 2009 interval.

3.4. Measuring Industry Differences in Sensitivity to the Information Environment

To implement the difference-in-differences tests, we need measures of each industry's *ex ante* sensitivity to the information environment. If the transparency environment matters for innovation, the effects should be relatively stronger in the sectors most sensitive to information asymmetries between firms and outside suppliers of capital. Our primary measure of information sensitivity is the industry's dependence on external equity financing. External equity not only plays a key role in funding innovation (e.g., Brown, Fazzari, and Petersen, 2009), but is also plagued by high information costs due to adverse selection (e.g., Myers and Majluf, 1984; Krasker, 1986; Asquith and Mullins, 1986). Intuitively, our tests will explore whether the *gap* in R&D activity between industries with high and low dependence on external equity is sensitive to the country-level information environment.

[14] As Christensen, Hail, and Leuz (2016) emphasize, the directives focused primarily on standardization, clarification, and improved enforcement of existing disclosure regulations. In addition to the transparency directives, the Financial Services Action Plan included several other legislative measures focusing on banking, insurance, and capital markets. See Kalemli-Ozcan, Papaioannou, and Peydro (2010 and 2013) for details and transposition dates for the various directives included in the plan.

[15] We collect this information from the transposition and entry-into-force dates reported in Kalemli-Ozcan, Papaioannou, and Peydro (2010) and Christensen, Hail, and Leuz (2016). We convert the dates they report at the monthly or quarterly frequency to yearly values to match the annual frequency of our data. In almost all cases, the MAD and PRO directives are implemented in the first year, while the TPD directive is implemented in the next two to three years.

We construct proxies for the fundamental characteristics of each industry using information on publicly listed US firms with coverage in the Compustat North America database. We start by computing an external equity-to-assets ratio for each firm using the cumulative (sums) of their net stock issues (stock issues minus stock buybacks) and total assets over the period 1990 to 2006.[16] We then use the median external equity-to-assets ratio across firms in each industry to measure that industry's reliance on external equity financing (*External equity*).

We also report results using alternative measures of an industry's sensitivity to the information environment. First, we construct a corresponding measure of each industry's dependence on debt financing (*Debt finance*). Because debt is not the preferred source of funding for R&D (e.g., Hall, 2002), and the nature of debt financing makes it less sensitive to information problems (e.g., Bolton and Freixas, 2000), evidence of differences in the effects of transparency across debt and equity dependent industries can help establish the causal mechanism we emphasize. Second, we construct a measure of industry *Equity dependence* based on the median firm's equity-to-debt ratio, which is an alternative way to capture differences in the relative importance of equity over debt finance across industries (e.g., Atanassov, 2016). Third, we build two broader measures of an industry's reliance on arm's-length financing, because transparency should be more important for market-based sources of funds (stock and bond issues) than for private bank financing. The first, *Arm's length financing*, is based on the share of firms in a given industry that use arm's-length financing (as indicated by a public bond rating or positive net stock issue), and the second, *Market dependence*, is based on the share of industry firms that rely on stock and bond markets rather than private bank financing, where we use the lack of a public bond rating but non-trivial debt-to-assets ratio to identify bank dependent firms. Finally, we construct a measure of reliance on outside capital from the original dependence measures reported in Rajan and Zingales (1998) (*RZ dependence*), which are based on the share of capital expenditures not financed with internal operating cash flow.

4. Cross-Sectional Difference-in-Differences Tests

4.1. Investment in Different Information Environments

Figure 1 shows how actual rates of R&D and capital spending in industries with high and low dependence on external equity vary across countries with different levels of corporate transparency. We first obtain the residual investment intensity for each country-industry pair from a regression of average investment intensity over the full sample period on a complete set of country and industry fixed effects. Next, for each country we find the average residual R&D and capital spending level in the three sectors most reliant on external equity finance and in the three sectors least reliant on

[16] Our results are not sensitive to the time period over which the industry characteristics are measured. Rajan and Zingales (1998) note that the product lifecycle for foreign firms may lag that of US firms, particularly if the foreign countries are less developed. In this case it may be more appropriate to measure industry characteristics using data from the *prior* decade. We find identical results if we construct dependence measures using data from the 1980s rather the 1990s and 2000s.

external equity. Third, we find the *difference* in R&D and fixed capital spending across high and low external equity sectors in each country. Finally, we find the sample average of this differential for countries with "high" and "low" transparency, where for each measure of transparency we put countries into the "high" ("low") group if the transparency measure is above (below) the sample median.

We report the differentials using the OECD sample in Figure 1a and the differentials for the broader Compustat sample in Figure 1b. The dark bars show the estimated R&D differentials, while the lighter bars show the capital spending differentials. In both samples, the difference in residual R&D intensity across high and low *External equity* industries is much larger in countries with higher levels of *Transparency*, *Financial transparency*, and *Earnings transparency*. In sharp contrast, there is little or no difference in capital spending intensity across high and low *External equity* industries in countries with higher levels of transparency, and in a couple cases these capital spending differentials are slightly negative. These descriptive results preview our findings from the more formal regression analysis by pointing to a strong, positive connection between corporate transparency and differential rates of R&D investment across industries with high and low external equity dependence, but no corresponding connection between transparency and investment in fixed capital.

4.2. Baseline Regressions

Working with the long-run, time-invariant measures of a country's overall level of transparency, we collapse the time dimension of the R&D data and estimate the following regression:

$$R\&D\text{-}intensity_{i,j} = \beta_0 + \beta_1\, Transparency_i \times External\ equity_j + \eta_j + \eta_i + \varepsilon_{i,j}, \qquad (2)$$

where $R\&D\text{-}intensity_{i,j}$ is R&D investment divided by value added for industry j in country i (computed as the average value over the sample period), $External\ equity_j$ is industry j's dependence on external equity finance, and $Transparency_i$ measures the information environment in country i. The specification also includes country- and industry-fixed effects (η_i and η_j), which subsume the direct (uninteracted) measures of country *Transparency* and industry *External equity*. We estimate equation (2) with robust standard errors clustered at the country level. We start with findings for the OECD sample and report results for the expanded Compustat sample below.

Table 3 reports estimates of equation (2) using the three alternative measures of a country's level of corporate transparency. Observation counts differ slightly across regressions because of differences in coverage of the transparency measures across countries (see Table 1). In each case, we find a significant positive coefficient on the interaction term (β_1), indicating that higher levels of transparency are associated with positive differential rates of R&D investment in the industries relatively more dependent on external equity finance. To evaluate the economic magnitude of this estimate, at the bottom of the table we report the estimated differential impact that an increase in the relevant measure of transparency from the 25th to 75th percentile has on the gap in R&D intensity between an industry at the 75th percentile of *External equity* and an industry at the 25th percentile. The estimates indicate a differential impact on R&D intensity ranging from approximately 6% to 12% of the mean R&D intensity.[17]

A possible concern with the baseline estimates is that the measures of transparency are correlated with omitted country characteristics, and that these other characteristics are actually behind the differential effects on R&D we document. As mentioned above, the only way an omitted factor can explain the findings in Table 3 is if it is positively correlated with a country's level of transparency *and* it is differentially beneficial for R&D in sectors with a high dependence on external equity financing. We summarize in Figure 2 how directly controlling for the factors with the greatest potential to satisfy both of these conditions affects our estimate of the interaction between *Transparency* and *External equity*. Specifically, we augment equation (2) by adding the interaction between industry *External equity* and country-level measures of financial market development (*Financial development*), GDP-per-capita (*Economic development*), schooling (*Human capital*), patent protection (*IP protection*), and the user cost of R&D (*R&D user cost*), the latter of which directly accounts for country efforts to encourage R&D with credits and other tax incentives. Figure 2 reports coefficient estimates (with 95 percent confidence intervals) on the main *Transparency x External equity* term when these additional interactions are included. The figure shows that whether these additional interaction terms are included one-by-one or simultaneously, the estimate of β_1 remains positive, statistically significant, and similar in magnitude to the baseline estimate. Thus, a richer information environment matters for R&D over and above the potential *differential* effects of alternative country characteristics that have been shown to influence innovation in prior work (e.g., Hall and Ziedonis, 2001; Bloom, Griffith, and Van Reenen, 2002; Qian, 2007; Hsu, Tian, and Xu, 2014).

4.3. Alternative Measures of Industry Dependence on External Finance

In Table 4 we explore the effects of *Transparency* using the alternative ways to measure an industry's reliance on information-sensitive financing sources. We start by augmenting equation (2) with an interaction between country *Transparency* and industry *Debt finance*. This comparison across equity- and debt-dependent industries is instructive because external equity is widely considered to be more information-sensitive than debt. Indeed, the estimates in column (1) show that although the coefficient estimate on the *External equity* interaction term remains positive and statistically significant, the coefficient on the *Debt finance* interaction is negative and insignificant. The *lack* of a

[17] To illustrate this computation, consider the results in column (1). Using the coefficient estimate of 0.058 and the descriptive statistics in Table 2, the difference in R&D intensity across industries with high (75th percentile) and low (25th percentile) *External equity* in a country with high *Transparency* (75th percentile) is equal to 0.0197 (0.058 x 26.1 x 0.013). The corresponding difference in R&D intensity across high and low *External equity* industries in a country with low *Transparency* (25th percentile) is equal to 0.0120 (0.058 x 15.9 x 0.013). Thus, the difference-in-differences across countries with high and low *Transparency* is equal to 0.0077 (0.0197 – 0.0120), which is approximately 12% (0.0077/0.063) of the sample mean.

positive effect of transparency in more debt-reliant industries, coupled with a significantly positive effect in equity-reliant industries, provides strong support that our estimates capture the effects of the information environment per se on R&D, rather than some omitted factor.[18]

In the remainder of Table 4 we study alternative measures of an industry's dependence on external equity and other market-based financing sources. In column (2) we replace industry *External equity* with a measure of industry *Equity dependence* based on the median firm's equity-to-debt ratio. In column (3) we use a broader measure of the industry's dependence on all forms of arm's-length financing (*Arm's length financing*), while in column (4) we use a measure of the industry's dependence on market-based (rather than bank-based) financing (*Market dependence*). Beyond the higher information costs associated with market-based financing, these measures build on the evidence in Atanassov (2016) highlighting the importance of arm's-length financing (public issues of both stock and bonds) over private bank-based financing for encouraging innovation. In each case, the coefficient on the interaction term is positive and significant, showing robustness to our primary industry measure and supporting our inferences on the link between transparency and R&D in information-sensitive industries. Finally, we use the industry measures of external finance dependence originally constructed by Rajan and Zingales (1998). These measures differ from our other industry characteristics in that they capture the share of capital expenditures not financed out of internally generated cash flow. The results in column (5) show a positive, significant, and economically sizeable interaction between *RZ dependence* and *Transparency*, which is also consistent with transparency lowering the information costs associated with external finance.

4.4. Estimates Using the Expanded Sample

In Table 5 we report results using the expanded sample based on data from Compustat Global. Here, we measure R&D intensity as the firm R&D-to-assets ratio, though we show later that the results are similar if we use the R&D-to-sales ratio instead. As in the prior tests, we collapse the time dimension of the data and focus on the average R&D-to-assets ratio over the full sample period. We winsorize the pooled observations at the 1% level prior to finding the average R&D intensity for each firm.

The first two columns in Table 5 report results using our primary measure of corporate transparency (*Transparency*). The specification in the first column mirrors equation (2) and includes only the key interaction term and the industry and country fixed effects. In the second column we add several firm-level control variables to the specification, including firm size, age, cash flow, cash reserves, sales growth, and leverage, all of which are standard controls in studies that model R&D at the firm level (e.g., Hall, 1992). As with R&D intensity, these firm characteristics are averaged across the full sample period. In both specifications, we find a positive and significant coefficient on the *Transparency x External equity* interaction, consistent with our results using the OECD sample.

[18] We are grateful to an anonymous referee for suggesting this test.

Similarly, in columns (3)-(6) we estimate equation (2) using the expanded sample and alternative measures of the country transparency environment. The results using *Financial transparency* and *Earnings transparency* also indicate positive differential effects from a richer information environment. Finally, in columns (7) and (8) we include a broader sample of firms by assuming that R&D is zero if it is missing but capital spending is not. The results using this larger sample of firms are consistent with our previous estimates.

In terms of economic magnitudes, the estimates in Table 5 suggest that the difference in firm-level R&D intensity across high (75th percentile) and low (25th percentile) *External equity* industries is larger in a country at the 75th percentile of the relevant transparency measure compared to a country at the 25th percentile by an amount ranging from 2.8% to 14.1% of the average R&D intensity across sampled firms. Although the estimated magnitudes of R&D differentials in the OECD and Compustat samples are not directly comparable due to differences in sample composition and the way R&D intensity is measured, our inferences on the strong, economically meaningful link between transparency and R&D are broadly consistent across the two different samples.

4.5. Transparency and Other Real Outcomes

Table 6 reports estimates of equation (2) using measures of patenting activity and fixed capital spending in place of R&D intensity.[19] In the first two columns we replace R&D with *Patent citations* and *Patent counts*, respectively. Consistent with the findings for R&D, in each regression the coefficient on the *Transparency x External equity* interaction is positive and statistically significant, indicating that higher levels of transparency are associated with relatively more patenting activity in equity-dependent industries. This evidence linking transparency with patenting activity is important for at least two reasons. First, it shows that the effects of transparency are not confined only to inputs in the innovation process, but are associated with more innovative output as well. Second, because the patenting measures are completely independent from the R&D measures – in particular, they are not compiled from surveys or financial disclosures – these results show that our inferences on the link between transparency and innovation are not biased by the way R&D is measured or aggregated across countries.

The remainder of Table 6 reports estimates of equation (2) with fixed capital spending as the outcome variable. In columns (3) to (5) we report results using industry levels of capital accumulation from the STAN Indicators database. For each measure of country transparency, the coefficient on the interaction term is small and statistically insignificant, indicating that higher levels of transparency are unrelated to the level of capital accumulation. These findings are consistent with the idea that tangible assets have less severe information problems than R&D. We draw similar inferences from the broader

[19] These regressions have fewer observations than the corresponding regressions in Table 3 for two reasons. First, the patenting data used in columns (1) and (2) is reported for a slightly more aggregated (and hence smaller) set of industry groupings. Second, for the regressions in columns (3)-(5), the STAN database does not report any information on industry capital formation for Australia, Mexico, or Japan.

sample of Compustat firms. The estimates in columns (6) and (7) use capital spending-to-assets as the dependent variable and include the set of firm-level control variables we included in the R&D regressions. Whether we focus only on R&D-reporting firms (column 6), or we include all firms with information on capital spending (column 7), the coefficient estimate on the *Transparency x External equity* interaction is slightly negative. Although the economic magnitude of this negative estimate is very small (amounting to only 0.5% to 0.9% of the average capital spending ratio), it suggests that a low level of transparency may encourage some firms to shift toward tangible investments, perhaps because these types of investments are more readily financed by sources that are not sensitive to the information environment (e.g., private debt).

4.6. Other Tests

We report additional robustness checks in Tables A2 and A3 in the appendix. In Table A2 we explore whether transparency is relatively more important for high-tech R&D. To the extent that high-tech R&D suffers from more severe information asymmetries due to the difficulties outsiders have in evaluating intangible and highly specialized investments (e.g., Brown, Martinsson, and Petersen, 2017), transparency should have a relatively stronger effect on high-tech R&D. Consistent with this idea, the results show that a higher level of *Transparency* is relatively more important for high-tech R&D compared to R&D in other industries. Similarly, the estimates in columns (3) and (4) show that patenting activity is also differentially higher in high-tech industries when there is more transparency. The final two columns in the table show that transparency is unrelated to differences in capital expenditures across high- and low-tech industries, consistent with our prior findings.

In Table A3 we show that our main results are not sensitive to the sample time period or the way R&D activity is measured. First, we split the full sample period into sub-samples and explore how the initial level of *Transparency* relates to R&D activity averaged over either 1990 to 2000 (columns (1)-(2)) or 1996 to the end of the sample period (columns (3)-(4)). This sample split addresses any concerns one might have about security market reforms in the 2000s, such as IFRS, unduly biasing our inferences on the long-run connection between transparency and R&D. For both the OECD and Compustat samples, we find positive and significant coefficients on the key interaction term in each sub-period, consistent with our findings for the full sample period. We find similar results if we focus on other sub-periods, most notably the results are almost identical if we split the sample into roughly equivalent non-overlapping periods, such as 1990-1997 and 1998-2006.

Next, we show robustness to alternative measures of R&D intensity. In column (5) we report results for the OECD sample if we scale industry R&D by output rather than value added, and in column (6) we report results for the Compustat sample using R&D-to-sales in place of R&D-to-assets. In each case, we continue to find a positive and significant association between a country's overall level of *Transparency* and R&D investment in sectors with high dependence on external equity.

5. R&D Activity Following Shocks to the Information Environment

Our findings thus far are based on long-run cross-sectional levels of country transparency and average rates of R&D investment. While these long-run results are certainly of interest for evaluating the real consequences of an economy's information environment, time series changes in that environment may also have important real effects, and there are several advantages to studying the contemporaneous relation between changes in transparency and changes in R&D. Notably, corroborating evidence from time series shocks in the information environment would help address any lingering concerns about measurement, omitted factors, and endogeneity, thereby strengthening our inferences from the cross-sectional difference-in-differences analysis.

5.1. Tests Using Time-Series Variation

We focus on two events that caused substantial changes in the country-level information environment. As discussed above, several studies document a significant improvement in corporate transparency and the overall information environment following the first prosecution of insider trading (e.g., Bhattacharya and Daouk, 2002; Bushman, Piotroski, and Smith, 2004 and 2005). Similarly, recent legislative directives in the EU focus specifically on corporate disclosures and transparency, and their implementation appears to have had significant capital market benefits in a way that is consistent with an improved information environment (e.g., Christensen, Hail, and Leuz, 2016).

To test whether time-series changes in the transparency environment affect R&D activity, we estimate the following regression:

$$R\&D\text{-}\ intensity_{i,j,t} = \beta_0 + \beta_1 Transparency\ event_{i,t} \times External\ equity_j + \eta_j + \eta_i \times \eta_t + \varepsilon_{i,j,t}, \quad (3)$$

where *Transparency event* is a variable indicating either the first prosecution of insider trading (*Insider enforce^{post}*) or the initial implementation of the EU transparency directives (*EU directive^{post}*). As before, *External equity* is industry *j*'s dependence on external equity finance. The specification controls for industry (η_j) and country-year ($\eta_i \times \eta_t$) fixed effects. The country-year fixed effects replace the overall country effects we included in the previous regressions. Note that this specification flexibly controls for both constant and time-varying country characteristics, including the long-run transparency measures we focused on in the initial tests.

We continue to focus on β_1, which now captures the within-country differential impact that changes in the information environment have on R&D investment across sectors with varying dependence on external equity finance. Since the *Insider enforce^{post}* and *EU directive^{post}* events are staggered across countries and across time, identification comes from comparing within-country R&D intensity across *External equity* industries in country-years where the *Insider enforce^{post}* and *EU directive^{post}* variables are equal to one (the years with enforcement or implementation in place) to corresponding within-country differentials in country-years where the *Insider enforce^{post}* and *EU directive^{post}* variables are equal to zero (the years with no enforcement or implementation in place). By focusing on *changes* in within-country, across-industry effects around the transparency events, our tests revolve around triple differences, permitting stronger inferences about causality and making the estimates even more difficult to rationalize with standard critiques (Acharya and Subramanian, 2009). For example, given the structure of our tests, for omitted factors to bias our inferences they would have to be correlated with the staggered introduction of the regulatory events *and* differentially beneficial for R&D in the sectors most sensitive to the information environment.

5.2. Evidence from Insider Trading Enforcement

In Table 7 we report estimates of equation (3) using *Insider enforce*^{post} to measure a change in the information environment. In Panel A we use the OECD sample, and in Panel B we use the expanded Compustat sample. In both samples, the baseline estimate in column (1) shows a positive and highly significant coefficient on the *Insider enforce*^{post} *x External equity* interaction, indicating that a shift from an information environment where there is no insider trading enforcement to the environment after insider trading restrictions have been enforced is differentially beneficial for R&D in sectors that use more external equity finance. The implied R&D differential from such a change in the information environment is roughly 10% of the mean R&D intensity using the estimates in Panel A, and 4% of mean R&D in Panel B.

The next three columns report robustness checks. First, for the estimates reported in column (2), we stop the sample in the year 2000 in order to limit the number of post-enforcement years that are included in the regression (the last countries to report a first instance of insider trading enforcement are India and Spain in 1998). Estimating the baseline regression using this shorter sample continues to generate a positive and significant coefficient on the *Insider enforce*^{post} *x External equity* interaction, and the magnitude of this estimate is very similar to the baseline estimate in column (1). Next, we focus on changes in within-country R&D differentials around the first prosecution of insider trading using only the sub-set of countries with a first prosecution during our sample period. For this analysis we exclude countries that have a first prosecution before the start of our sample period (1990 or earlier), as well as countries that never have a prosecution during the period. The estimate in column (3) shows a positive and significant coefficient on the interaction between *Insider enforce*^{post} and *External equity*, consistent with our estimates that relied on the full sample of countries to identify the effects of insider trading enforcement.

In column (4) we address potential concerns about reverse causality by evaluating whether the effects of insider trading enforcement show up before the actual enforcement event. Clearly, if our findings are causal, we should not find evidence that insider trading enforcement impacts R&D differentials *prior* to the initial enforcement year. We test this idea by including an interaction between industry *External equity* and a dummy variable equal to one in each of the two years prior to the year insider trading is first enforced (*Insider enforce*^{pre}). The results in column (4) show that the *Insider enforce*^{pre} *x External equity* interaction attracts a small and insignificant coefficient estimate, which strongly suggests that reverse causality is not driving our results. At the same time, the coefficient on the *Insider enforce*^{post} *x External equity* interaction remains positive, statistically significant, and large in magnitude, indicating that the effects of insider trading enforcement are only present in the years following the initial enforcement event.

In column (5) we report results for the expanded sample (Panel B) assuming any missing R&D values in Compustat Global are equal to zero. The coefficient on the *Insider enforce*^{post} *x External equity* term is positive and statistically significant, and the economic magnitude is actually slightly larger in the expanded sample. In the final column in Table 7 we estimate equation (3) using capital spending rather than R&D. The coefficients on the interaction term are small and insignificant, indicating no change in the level of fixed investment following insider trading enforcement. These estimates corroborate our conclusions from the cross-sectional analysis on the lack of an important link between the corporate transparency environment and the accumulation of tangible assets.

5.3. Evidence from the EU Transparency Directives

We conduct a similar set of tests using the implementation of the EU transparency directives. Table 8 reports estimates of equation (3) with the *EU directive*^{post} indicator variable used in place of *Insider enforce*^{post}. We use the Compustat sample to evaluate the implementation of the EU transparency directives because we do not have sufficient data in the OECD sample to measure R&D differentials in the years after the transparency directives are in force. In addition, we include an indicator variable to control for whether or not the firm follows IFRS, which standardized the reporting of R&D and roughly coincided with the implementation of the transparency directives in several of the sampled countries (e.g., Daske et al., 2008). [20]

In the first column of Table 8 we report estimates from a baseline regression using pooled observations from the 16 EU countries in our sample. The estimate in column (1) indicates significantly higher R&D differentials across high *External equity* industries in the years following the initial implementation of the transparency directives. In terms of magnitudes, the estimate suggests that the gap in R&D intensity between industries with high and low *External equity* is larger after the directives are implemented by an amount equivalent to approximately 3% of the sample average R&D intensity.

[20] IFRS adoption itself can be viewed as an event that increased corporate transparency and facilitated access to arm's-length financing (see, e.g., Horton, Serafeim, and Serafeim, 2013; Ball, Li, and Shivakumar, 2015; Florou and Kosi, 2015; Bhat, Callen, and Segal, 2016; and De George, Li, and Shivakumar, 2016). In Table A4 in the appendix we report estimates of equation (3) with the firm-specific measure of IFRS adoption as the *Transparency event*. Consistent with our findings from the other transparency shocks, IFRS adoption is associated with a strong positive differential increase in R&D, but is unrelated to investment in fixed capital. Although these results are potentially affected by the impact IFRS adoption had on the reporting of R&D, at a minimum they corroborate our other evidence on the link between transparency and innovation, and they suggest that IFRS may have had unappreciated effects on real activity. We thank an anonymous referee for suggesting this test.

We perform three robustness checks on these initial estimates in columns (2) to (4) of Table 8. In column (2), we drop all observations prior to 2001 to avoid having the benchmark sample dominated by observations from the 1990s. The estimate in column (2) is statistically significant and slightly larger in magnitude than the baseline estimate in column (1). In column (3), we perform the analysis using only firms that follow IFRS. Using this smaller sample, the coefficient estimate on *EU directive^{post} x External equity* is positive, significant, and larger in magnitude than the other estimates, which provides additional evidence that differences in R&D reporting conventions are not somehow behind the results we document. Finally, in column (4) we evaluate whether the effects from implementation of the EU directives are present prior to the actual event. Following the approach we used in Table 7, we include an interaction between industry *External equity* and *EU directive^{pre}*, a dummy variable equal to one in each of the two years prior to the year the transparency directives are first put into force. Reassuringly, while the coefficient on the main interaction variable remains positive and statistically significant, the estimate on *EU directive^{pre} x External equity* is small and statistically insignificant.

In the next two columns of Table 8 we report results using alternative ways to code the introduction of the transparency directives. As discussed earlier, our main *EU directive^{post}* indicator variable is set to one starting with the first year a country implements one of the key transparency directives. While this coding is useful for comparing R&D differentials before and after the transparency directives are in force, it is not useful for estimating the marginal effects from implementation of additional directives. We thus follow the method Acharya and Subramanian (2009) use to evaluate the effects of incremental changes in creditor rights and define a new indicator variable, *EU directive chg*, which equals zero when no directives are in place and increases by one unit in any year that an additional directive is put into force. Column (5) reports estimates of equation (3) using the *EU directive chg* measure. The coefficient estimate on the interaction term is positive and significant, and indicates that the implementation of an additional directive (a one unit increase in *EU directive chg*) is associated with a differential increase in R&D intensity equivalent to 1.5% of the sample average R&D intensity.

In column (6) we use an alternative definition of the *EU directive^{post}* indicator based on each country's implementation of the TPD directive. We focus primarily on the implementation of the first transparency directive (MAD) because it represents the clearest distinction between the pre- and post-directive information environments. We can, however, check whether the results hold if we focus only on the introduction of the TPD directive, which lags the initial implementation by two to three years. Specifically, we construct an alternative measure, *EU directive TPD*, which is equal to zero until the TPD directive is put into force. One advantage of this approach is that the TPD implementation dates are slightly more staggered across countries, making it even less likely that alternative shocks specific to the EU can explain our findings. As the results in column (6) show, we find positive and significant differential effects when we measure the implementation of the EU directives focusing only on the TPD directive.

In column (7) we add the non-EU countries to the sample. In this case, we identify the effects of the EU directives by comparing R&D intensity across industries sorted by *External equity* in country-years after the transparency directives are in force (the post implementation years for all EU countries) to the corresponding within-country differentials in country-years where the directives are not in force (all sample years for non-EU countries and pre-enforcement years for EU countries). The coefficient on the key interaction term is positive, significant, and roughly twice as large as the baseline estimate in column (1).

The next to last column of Table 8 reports results using a sample that assumes missing R&D values are equal to zero. Consistent with our previous estimates, we find a positive and significant relation between the implementation of the transparency directives and investment in R&D. In the final column of Table 8 we report results for capital spending. The estimate on the *EU directive*^{post} *x External equity* interaction is negative and, although statistically significant, the coefficient is very small in economic magnitude (-0.6%). Overall, the results in Table 8 show that the EU transparency directives had important real effects, and provide strong additional evidence that improvement in the corporate information environment positively affects the level of investment in R&D but not the accumulation of fixed capital.

6. Heterogeneous effects across different types of firms

Our findings thus far show that transparency has a positive overall effect on innovation. Yet there are strong theoretical reasons to expect that the effects of transparency may differ considerably across different types of firms. For example, ample anecdotal and survey evidence suggests that some firms are particularly concerned about the competitive consequences of information leakage (e.g., Hall, 2002; Fox et al., 2013), suggesting they would not benefit to the same extent from a more transparent information environment. We thus proceed by considering how transparency affects R&D in situations where proprietary costs are likely particularly severe. [21] Although we do not have a direct way to sort firms on the basis of proprietary costs, the costs of increased transparency should be high (relative to the benefits we have emphasized) among the firms that can fund R&D without the need for arm's-length financing. In this way, to the extent that proprietary costs are an important concern, we expect improvements to the information environment to have a relatively weaker effect on R&D in more profitable firms.

We test this idea in Table 9 by interacting the country-level *Insider enforce*^{post} and *EU directive*^{post} measures with firm-specific indicators that equal one if the firm generates positive free cash flow (*Free cash flow*) or has relatively high dividend payouts (*Dividends*). The results in columns (1)-(4) show that the transparency events are associated with a relative *decline* in R&D

[21] We thank an anonymous referee for encouraging us to explore this issue.

intensity in firms that generate positive free cash flow and have relatively high dividend payouts, while the estimates in columns (5)-(8) show no change in their level of fixed capital spending. These heterogeneous effects across different types of firms are consistent with the theoretical mechanism we emphasize, and suggest that the positive overall effects we document are driven by higher levels of innovation in the firms that rely on external capital markets to fund R&D.

7. Conclusions

This study documents a positive link between an economy's aggregate information environment and innovation. The financial market benefits of more transparency are widely acknowledged both theoretically and empirically (e.g., Rajan and Zingales, 2003; Bhattacharya, Daouk, and Welker, 2003), but the net effects of the aggregate information environment on innovation are ambiguous (e.g., Bhattacharya and Ritter, 1983). In particular, the key benefits of a more transparent information environment – reduced information asymmetries and a lower cost of arm's-length financing – should be particularly important for innovative investments because the nature of R&D makes it more equity-dependent and information-sensitive than other investments. Yet, at the same time, increases in transparency may be detrimental to innovative activity given the costs associated with information leakage about product development to competitors.

Using several different measures of a country's long-run, overall level of corporate transparency, we find strong evidence that a more transparent information environment is associated with differentially higher levels of R&D and patenting in sectors that rely on external equity financing. In addition, we treat the first prosecution of insider trading and implementation of EU securities market regulations related to corporate transparency as quasi-experimental shocks to an economy's broad information environment. These information shocks also lead to substantial increases in R&D. In sharp contrast, a more transparent information environment has little to no impact on the rate of fixed capital accumulation, consistent with tangible assets having lower information asymmetries than innovation.

These findings contribute to important literatures on the determinants of innovation (e.g., Manso, 2011), the real effects of the accounting and financial reporting environment (e.g., Biddle and Hilary, 2006; Francis et al., 2009), and the economic consequences of transparency-related security market reforms (e.g., Leuz and Wysocki, 2016). In particular, our findings suggest that to the extent these reforms affect economic performance the causal connections work through intangible investments rather than the accumulation of physical capital. However, our work also shows that there are important heterogeneities in the types of firms that benefit from more transparency; namely, there is a relative decline in R&D spending among firms that can finance innovation internally.

Although our work highlights a seemingly positive aspect of efforts to improve corporate transparency, our analysis does not consider the full set of costs and benefits associated with security market reforms; notably, our work has nothing to say about the implementation and enforcement costs associated with reforming the transparency environment. In addition, although we link transparency with higher levels of R&D and patenting, our findings do not speak to the influence transparency has on the kinds of innovations that take place. For example, to the extent that our findings are driven by a shift in the location of innovation from firms with high cash flow to firms that depend on arm's-length financing, it is reasonable to expect that transparency not only affects the level of innovation, but also the nature of innovative activity (e.g., Atanassov, 2016) and, more broadly, the extent of innovation-driven creative destruction (e.g., Aghion and Howitt, 1992). Important topics for future work are to study whether corporate transparency affects how exploratory and risky innovative projects are, and to evaluate the dynamic consequences of this innovation for industry competitive structure and long-run performance.

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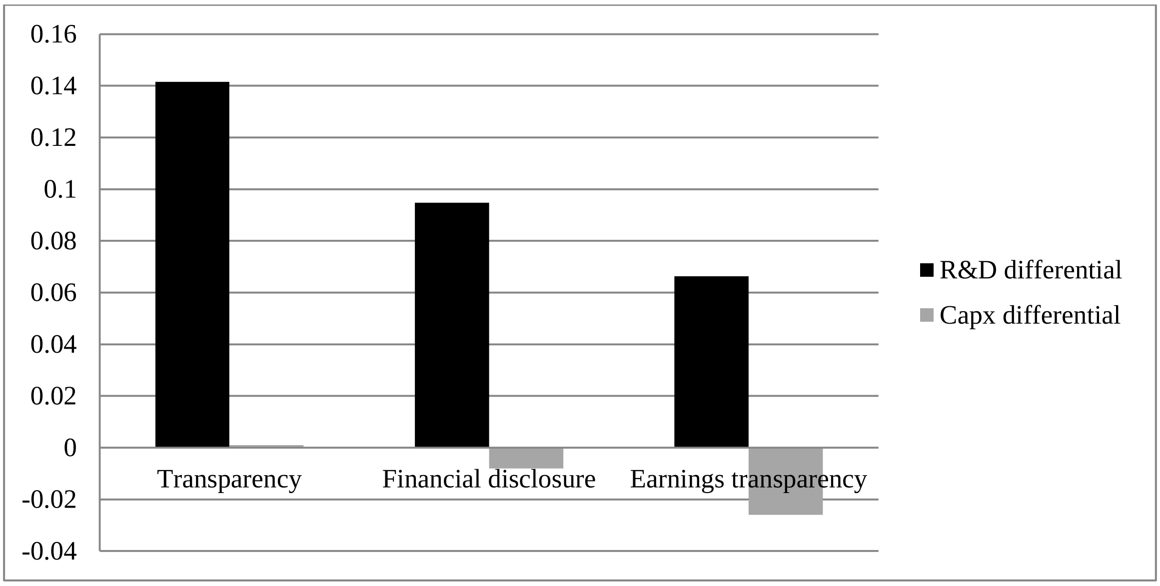
Figure 1
The country information environment and differences in investment spending across high and low *External equity* industries

The figures show how the difference in residual R&D and Capx intensity across high and low external equity dependent industries compares across countries with high and low corporate transparency. The residual R&D (Capx) intensity is equal to the residual from a regression of R&D (Capx) investment on a full set of country and industry fixed effects. For each country we find the difference in average residual R&D (Capx) intensity between the three highest *External equity* sectors (Drugs, Office and computing, and Scientific instruments) and three lowest *External equity* sectors (Wood, Leather, and Tobacco). We then compare the average of this differential in countries with "high" transparency to the corresponding average difference in countries with "low" transparency, where for each measure of transparency we sort countries into the "high" ("low") group if the transparency measure is above (below) the sample median. Panel A reports the magnitude of this difference-in-differences using the STAN Indicators sample of OECD countries, while Panel B uses the sample from Compustat Global.

Panel A. STAN Indicators sample



Panel B. Compustat sample

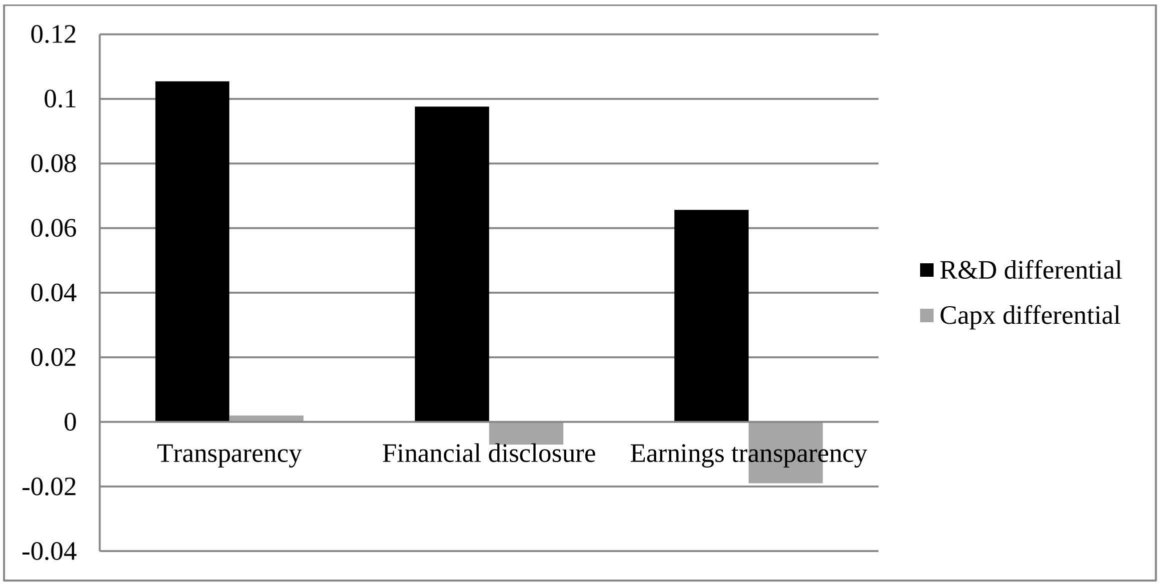


Figure 2
Robustness of the estimated relation between transparency and R&D to alternative mechanisms

The figure summarizes how adding a series of alternative country-level control variables to equation (2) affects the coefficient estimate on *Transparency x External equity*. The additional country-level variables are interacted with industry *External equity* and added to the regression alongside the country and industry fixed effects. The data is from OECD's STAN Indicators database and covers 25 industries in 20 countries during 1990-2006. Standard errors are clustered by country. The columns in the figure indicate the coefficient estimate on *Transparency x External equity*, while the bands represent 95% confidence intervals. Table A1 defines all variables.

Dependent variable: R&D-to-value added
Coefficient estimates on *Transparency x External equity*

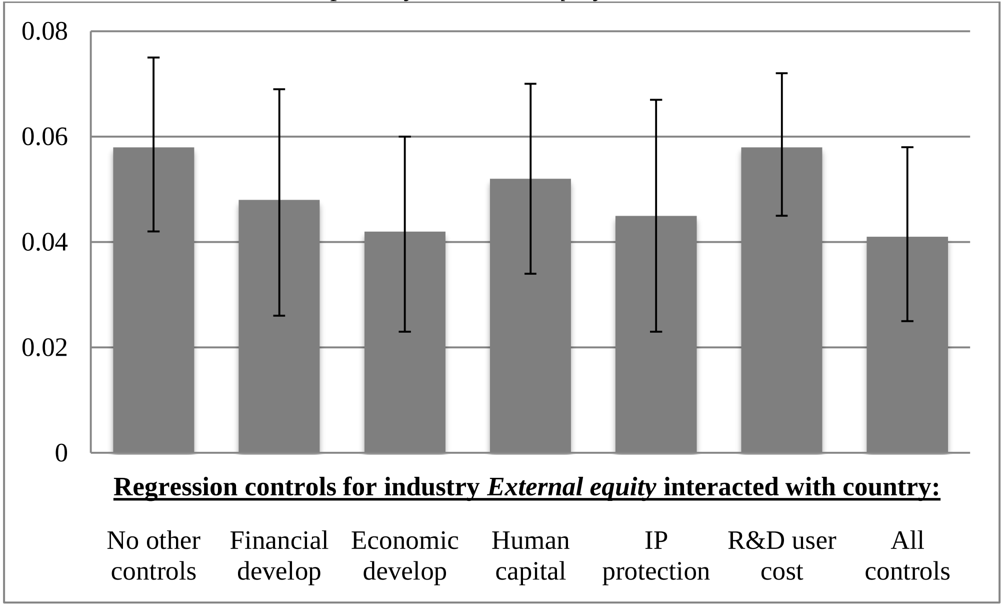


Table 1
Sampled countries and key characteristics

Table 1 lists the sampled countries and reports country values for the key transparency measures. The insider trading column reports the first year the country has a case of insider trading enforcement as reported by Bhattacharya and Daouk (2002). The EU directive column reports the year a country first implements the Prospectus Directive (PRO), Market Abuse Directive (MAD), or Transparency Directive (TPD) as reported by Kalemli-Ozcan, Papaioannou, and Peydro (2010) or Christensen, Hail, and Leuz (2016). Table A1 provides detailed variable descriptions and data sources.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Country	**Trans-parency**	**Financial transparency**	**Earnings transparency**	**Insider trading**	**EU directive**	**STAN sample**	**R&D-reporting firms**
Australia	23.7	100	-4.8	1996		Yes	261
Austria	15.6	70.29	-28.3	No	2005	Yes	36
Belgium	17.5	92.75	-19.5	1994	2005	Yes	47
Brazil	17.4	57.25		1978			26
Canada	28.1	100	-5.3	1976		Yes	381
Denmark	23.8	86.96	-16	1996	2005	Yes	53
Finland	26.1	100	-12	1993	2005	Yes	74
France	26.4	100	-13.5	1975	2005	Yes	196
Germany	22.8	100	-21.5	1995	2004	Yes	274
Greece	10.4	44.57	-28.3	1996	2005	Yes	48
Hong Kong		79.71	-19.5	1994			24
India	8.6	79.35	-19.1	1998			767
Indonesia			-18.3	1996			30
Ireland		100	-5.1	No	2005	Yes	19
Israel	13.3	100		1989			122
Italy	21	100	-24.8	1996	2005	Yes	73
Japan	22.9	100	-20.5	1990		Yes	1644
Korea	14.7	65.22	-26.8	1988		Yes	109
Luxembourg		55.43		No	2005		14
Malaysia	18.8	100	-14.8	1996			124
Mexico	15.9	68.12		No		Yes	
Netherlands	25	100	-16.5	1994	2005	Yes	56
New Zealand	16.7	100		No			31
Norway	22.8	76.45	-5.8	1990	2005	Yes	52
Pakistan	9.9	68.48	-17.8	No			32
Philippines	9.9	80.07	-8.8	No			21
Poland				1993	2005		26
Portugal	10.9	81.16	-25.1	No		Yes	
Singapore	28.1	100	-21.6	1978			96
South Africa	18	88.41	-5.6	No			45
Spain	21.9	92.75	-18.6	1998	2005	Yes	27
Sri Lanka	11.25	63.41		1996			10
Sweden	27.9	100	-6.8	1990	2005	Yes	143
Switzerland		100	-22	1995			120
Taiwan		59.78	-22.5	1989			1268
Thailand		51.07	-18.3	1993			10
Turkey	9.4	59.06		1996			87
UK	30.9	100	-7	1981	2005	Yes	501

Table 2
Sample descriptive statistics

Table 2 reports descriptive statistics for the main variables used in the study. The statistics in Panel A are based on the set of countries listed in Table 1 with available information on the transparency measure in question. In Panel B, the statistics on *R&D-to-value added* and *Capx-to-value added* are based on pooled observations from the OECD's STAN Indicators database covering 25 industries in 20 countries over the period 1990 to 2006; the statistics on *Patent counts* and *Patent citations* are based on pooled observations from the NBER Patent database covering 20 industries in 20 countries over the period 1990 to 2004; and the statistics on *R&D-to-assets* and *Capx-to-assets* are based on pooled observations from the Compustat Global database covering firms in 25 industries in 36 countries over the period 1990 to 2012. The statistics in Panel C are based on the characteristics of 25 industries constructed from firms with coverage in the Compustat North America database. Table A1 provides detailed variable descriptions and data sources.

	(1)	(2)	(3)	(4)	(5)
Variable	**Mean**	**Median**	**25th**	**75th**	**Std dev**
Panel A: Country-level transparency measures					
Transparency	21.49	22.80	15.9	26.1	5.82
Financial transparency	88.91	100	78.81	100	16.07
Earnings transparency	-16.12	-16.50	-24.8	-6.8	8.50
Insider enforce^{post}	0.74	1	0	1	0.44
EU directive^{post}	0.45	0	0	1	0.50
EU directive TPD	0.31	0	0	1	0.46
Panel B: Innovation and investment variables					
R&D-to-value added	0.06	0.02	0.01	0.07	0.10
R&D-to-assets (non-missing only)	0.05	0.02	0.01	0.05	0.10
R&D-to-assets (missing to zero)	0.03	0.00	0.00	0.02	0.06
Patent counts	2.09	1.70	0.51	3.21	1.79
Patent citations	3.58	3.37	1.74	5.15	2.33
Capx-to-value added	0.17	0.15	0.11	0.21	0.10
Capx-to-assets	0.06	0.05	0.03	0.07	0.05
Panel C: Industry characteristics					
External equity	0.03	0.00	0	0.01	0.06
Equity dependence	1.78	1.19	0.98	1.54	1.36
Arm's length financing	0.37	0.33	0.25	0.49	0.15
Market dependence	0.47	0.45	0.42	0.53	0.08
RZ dependence	0.38	0.28	0.16	0.46	0.42

Table 3
Transparency and R&D investment: Differential effects across sectors based on reliance on external equity finance

Table 3 reports OLS estimates of equation (2) with industry R&D-to-value added as the dependent variable. The differential R&D intensity measures the difference in R&D intensity (as a share of the sample average) between an industry at the 75th percentile level of *External equity* with respect to an industry at the 25th percentile level when it is located in a country at the 75th percentile of either *Transparency*, *Financial transparency*, or *Earnings transparency* rather than in a country at the 25th percentile. Country and industry fixed effects are included in all regressions. Standard errors are clustered in the country dimension. The data is from OECD's STAN Indicators database and covers 25 industries in 20 countries during 1990-2006. Table A1 defines all variables.

	(1)	(2)	(3)
Dependent variable: R&D-to-value added			
Transparency × *External equity*	0.058 (0.008)***		
Financial transparency × *External equity*		0.014 (0.004)***	
Earnings transparency × *External equity*			0.024 (0.010)**
Constant	-0.183 (0.058)***	0.026 (0.008)***	0.331 (0.064)***
Observations	433	456	431
R-squared	0.724	0.693	0.713
R&D differential (% of mean)	0.123	0.062	0.089

Table 4
Transparency and R&D investment: Alternative measures of industry sensitivity to the information environment

Table 4 reports OLS estimates of equation (2) with industry R&D-to-value added as the dependent variable. The differential R&D intensity measures the difference in R&D intensity (as a share of the sample average) between an industry at the 75th percentile level of the relevant industry characteristic with respect to an industry at the 25th percentile level when it is located in a country at the 75th percentile of *Transparency* rather than in a country at the 25th percentile. Country and industry fixed effects are included in all regressions. Standard errors are clustered in the country dimension. The sample is constructed from OECD's STAN database and covers 25 industries in 20 countries during 1990-2006. Table A1 defines all variables.

	(1)	(2)	(3)	(4)	(5)
Dependent variable: R&D-to-value added					
Transparency × *External equity*	0.058 (0.008)***				
Transparency × *Debt finance*	-0.056 (0.076)				
Transparency × *Equity dependence*		0.003 (0.001)***			
Transparency × *Arm's length financing*			0.017 (0.003)***		
Transparency × *Market dependence*				0.021 (0.005)***	
Transparency × *RZ dependence*					0.009 (0.002)***
Constant	-0.175 (0.057)***	-0.120 (0.091)	-0.309 (0.072)***	-0.119 (0.022)***	-0.128 (0.069)***
Observations	433	433	433	433	433
R-squared	0.724	0.715	0.696	0.685	0.721
R&D differential (% of mean)	0.123	0.270	0.646	0.364	0.444

Table 5
Transparency and R&D investment: Evidence from an expanded sample

Table 5 reports OLS estimates of equation (2) with R&D-to-assets as the dependent variable. Regressions reported in even-numbered columns include the following firm-level control variables: cash flow-to-assets, sales-to-assets, sales growth, cash-to-assets, total debt-to-assets, (log) age, and (log) employees. The differential R&D intensity measures the difference in R&D intensity (as a share of the sample average) between an industry at the 75th percentile level of *External equity* with respect to an industry at the 25th percentile level when it is located in a country at the 75th percentile of either *Transparency*, *Financial transparency*, or *Earnings transparency* rather than in a country at the 25th percentile. Country and industry fixed effects are included in all regressions. Standard errors are clustered in the country dimension. The data is from the Compustat Global database and covers firms in 25 industries in 36 countries during 1990-2012. The sample used in columns (7) and (8) assumes R&D is equal to zero if capital spending is reported but R&D is not. Table A1 defines all variables.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable: R&D-to-assets								
Transparency ×	0.028	0.012					0.023	0.013
External equity	(0.005)***	(0.002)***					(0.004)***	(0.002)***
Financial transparency ×			0.012	0.007				
External equity			(0.005)**	(0.002)***				
Earnings transparency ×					0.029	0.009		
External equity					(0.006)***	(0.004)**		
Constant	-0.004	-0.035	0.003	-0.020	0.009	0.001	0.009	-0.002
	(0.007)	(0.019)*	(0.015)	(0.020)	(0.011)	(0.020)	(0.006)	(0.010)
Firm-level controls	no	yes	no	yes	no	yes	no	yes
Observations	5,336	4,101	6,791	4,329	6,531	4,192	10,259	7,030
R-squared	0.449	0.587	0.414	0.589	0.420	0.580	0.426	0.533
R&D differential (% of mean)	0.070	0.030	0.092	0.053	0.089	0.028	0.141	0.071

Table 6
The real effects of transparency: Patents and capital spending

Table 6 reports OLS estimates of equation (2) with industry patenting activity and fixed capital investment as the dependent variables. The differential measures the difference in the dependent variable (as a share of the sample average) between an industry at the 75th percentile level of the relevant industry characteristic with respect to an industry at the 25th percentile level when it is located in a country at the 75th percentile of *Transparency* rather than in a country at the 25th percentile. Country and industry fixed effects are included in all regressions. Standard errors are clustered in the country dimension. The sample used in columns (1)-(2) is constructed from the NBER Patent database and covers 20 industries in 20 countries during 1990-2004. The sample used in columns (3)-(5) is constructed from OECD's STAN Indicators database and covers 25 industries in 20 countries during 1990-2006. The sample used in columns (6)-(7) is from the Compustat Global database and covers firms in 25 industries in 36 countries during 1990-2012. The estimates for Capx-to-assets in column (6) only use firms who also report information on R&D investment, whereas the estimates in column (7) use all firms whether or not R&D is reported. The regressions in columns (6)-(7) include the following firm-level control variables: cash flow-to-assets, sales-to-assets, sales growth, cash-to-assets, total debt-to-assets, (log) age, and (log) employees. Table A1 defines all variables.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable:	Patent citations	Patent counts	Capx-to-value added			Capx-to-assets	
Transparency × *External equity*	0.546 (0.193)**	0.635 (0.201)***	-0.001 (0.016)			-0.002 (0.001)**	-0.004 (0.001)***
Financial transparency × *External equity*				0.002 (0.003)			
Earnings transparency × *External equity*					0.002 (0.006)		
Constant			0.081 (0.008)***	0.140 (0.008)***	0.183 (0.014)***	0.043 (0.010)***	0.031 (0.013)**
Observations	375	375	372	395	395	4,085	7,030
R-squared	0.949	0.920	0.530	0.535	0.535	0.331	0.354
Differential (% of mean)	0.035	0.024	-0.001	0.001	0.001	-0.005	-0.009

Table 7
Time series changes in the information environment: Evidence from insider trading enforcement

Table 7 reports OLS estimates of equation (3) with R&D investment and fixed capital spending as the dependent variables. The differential in the last row of each panel measures the difference in R&D or capital spending (as a share of the sample average) in an industry at the 75th percentile of the relevant industry characteristic with respect to an industry at the 25th percentile when it is located in a country-year with insider trading enforcement rather than in a country-year with no insider trading enforcement. Industry and country-year fixed effects are included in all regressions. The sample in Panel A is constructed from OECD's STAN Indicators database and covers 25 industries in 20 countries during 1990-2006. The sample in Panel B is constructed from the Compustat Global database and covers firms in 25 industries in 36 countries during 1990-2012. Table A1 defines all variables.

	(1)	(2)	(3)	(4)	(5)	(6)
	Baseline	End sample in 2000	Changes only	Event study	Missing R&D to zero	Capital spending
Panel A: Results using STAN Indicators sample						
Insider enforce^{post} × *External equity*	0.512 (0.110)***	0.470 (0.114)***	0.276 (0.092)**	0.282 (0.108)**	n/a	-0.000 (0.059)
Insider enforce^{pre} × *External equity*				0.029 (0.055)		
Constant	-0.014 (0.006)**	-0.014 (0.007)**	0.029 (0.008)***	0.029 (0.008)***		0.152 (0.017)***
Observations	6,664	4,079	3,331	3,331		5,622
R-squared	0.622	0.618	0.590	0.590		0.408
Differential (% of mean)	0.106	0.098	0.057	0.059		0.000
Panel B: Results using Compustat Global sample						
Insider enforce^{post} × *External equity*	0.178 (0.053)***	0.247 (0.044)***	0.134 (0.039)***	0.130 (0.048)***	0.137 (0.044)***	0.021 (0.020)
Insider enforce^{pre} × *External equity*				-0.011 (0.048)		
Constant	0.025 (0.005)***	0.033 (0.015)	0.062 (0.010)***	0.062 (0.010)***	0.025 (0.005)***	0.051 (0.010)***
Observations	34,634	5,700	8,761	8,761	57,088	57,088
R-squared	0.425	0.446	0.471	0.471	0.390	0.240
Differential (% of mean)	0.043	0.060	0.032	0.031	0.071	0.005

Table 8
Time series changes in the information environment: Evidence from the EU transparency directives

Table 8 reports OLS estimates of equation (3) with R&D-to-assets as the dependent variable in columns (1)-(8) and Capx-to-assets as the dependent variable in column (9). The differential in the last row measures the difference in R&D or capital spending (as a share of the sample average) in an industry at the 75th percentile of the relevant industry characteristic with respect to an industry at the 25th percentile when it is located in a country-year where the EU transparency directives are in force rather than in a country-year where the directives are not in force. Industry and country-year fixed effects are included in all regressions. The data is from the Compustat Global database and covers firms in 25 industries from 36 countries during 1990-2012. Table A1 defines all variables.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Baseline	Start sample in 2001	IFRS firms only	Event study	Subsequent directives	Last directive only (TPD)	Include non-EU firms	Missing R&D to zero	Capital spending
EU directive^{post} × *External equity*	0.119 (0.043)***	0.140 (0.050)***	0.177 (0.071)**	0.122 (0.044)***			0.274 (0.041)***	0.118 (0.032)***	-0.025 (0.012)**
EU directive^{pre} × *External equity*				0.023 (0.057)					
EU directive chg × *External equity*					0.061 (0.024)**				
EU directive TPD × *External equity*						0.097 (0.043)**			
Constant	0.045 (0.025)*	0.063 (0.030)**	-0.050 (0.032)	0.045 (0.025)*	0.044 (0.025)*	0.043 (0.025)*	0.021 (0.005)***	0.015 (0.006)**	0.141 (0.017)***
Observations	10,688	7,836	5,704	10,688	10,688	10,688	34,634	20,808	20,808
R-squared	0.426	0.416	0.442	0.426	0.426	0.426	0.439	0.444	0.206
Differential (% of mean)	0.029	0.033	0.043	0.030	0.015	0.023	0.066	0.051	-0.006

Table 9
Changes in the information environment: The impact of transparency on firms with high internal finance

Table 9 reports OLS regressions with R&D-to-assets as the dependent variable in columns (1)-(4) and Capx-to-assets as the dependent variable in columns (5)-(8). In columns (1)-(2) and (5)-(6) the indicator *Free cash flow* is equal to one for firms that generate positive free cash flow, and zero otherwise. In columns (3)-(4) and (7)-(8) the indicator *Dividends* is equal to one for firms that have above median dividend payouts, and zero otherwise. All regressions include the following firm-level control variables: cash flow-to-assets, sales-to-assets, sales growth, cash-to-assets, total debt-to-assets, (log) age, (log) employees, an indicator for whether the firm follows IFRS, and the uninteracted firm-level sort indicator. Industry and country-year fixed effects are included in all regressions. The data is from the Compustat Global database and covers firms in 25 industries in 36 countries during 1990-2012. The sample in the odd-numbered columns is comprised of all countries with an initial enforcement of insider trading laws at some point during the sample period. The sample in the even-numbered columns is comprised of all countries implementing an EU transparency directive at some point during the sample period. Table A1 defines all variables.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable:	R&D-to-assets				Capital spending-to-assets			
Firm-level sort:	*Free cash flow*		*Dividends*		*Free cash flow*		*Dividends*	
Insider enforce^{post} × *Firm-level sort*	-0.024 (0.002)***		-0.026 (0.008)***		0.004 (0.009)		-0.005 (0.008)	
EU directive^{post} × *Firm-level sort*		-0.014 (0.006)**		-0.018 (0.007)***		-0.000 (0.002)		-0.001 (0.002)
Constant	0.067 (0.010)***	0.019 (0.023)	0.070 (0.010)***	0.028 (0.024)	0.074 (0.011)***	0.036 (0.017)**	0.073 (0.010)***	0.035 (0.017)**
Observations	8,761	10,688	8,761	10,688	21,995	20,808	21,995	20,808
R-squared	0.475	0.432	0.475	0.439	0.241	0.211	0.241	0.205

Table A1
Variable descriptions

Table A1 provides definitions and data sources for the key variables used in the study.

Variable	Description
Transparency	A comprehensive measure of the information environment based on each country's relative ranking across a number of disclosure and transparency measures in the mid-1980-to-1990 period, including accounting disclosures, auditing activity, analyst coverage, insider trading enforcement, and media coverage. From Francis et al. (2009).
Financial transparency	A measure of "the prevalence of disclosures concerning research and development (R&D) expenses, capital expenditures, product and geographic segment data, subsidiary information, and accounting methods" in 1995 annual reports. From Bushman, Piotroski, and Smith (2004).
Earnings transparency	An aggregate measure of earnings management constructed by Leuz, Nanda, and Wysocki (2003) using accounting data in the 1990-1999 period, multiplied by minus one so that higher values indicate less earnings management and more corporate transparency.
Financial development	Log of the sum of the value of listed shares on a country's stock exchanges and deposit money bank credit to the private sector divided by GDP. From the World Bank.
Economic development	Log of gross domestic product (GDP) divided by country population. From the World Bank.
Human capital	Log of average years of secondary education in the population over 25 years old. From Barro and Lee (2013).
IP protection	Log of the IP protection index in Park (2008), which is 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.
User cost R&D	A measure of the income a representative firm in a given country needs to generate to cover the cost of an additional dollar of R&D spending. From Thompson (2009).
Insider enforce^{post}	A dummy variable taking the value of one in all years starting with the first year the country has a case of insider trading enforcement, and zero otherwise. Constructed from the dates reported in Bhattacharya and Daouk (2002).
EU directive^{post}	A dummy variable taking the value of one in all years starting with the first year the Market Abuse or Prospectus directive is implemented, and zero otherwise. Constructed from the dates reported in Kalemli-Ozcan, Papaioannou, and Peydro (2010) and Christensen, Hail, and Leuz (2016).
EU directive TPD	A dummy variable taking the value of one in all years starting with the first year the Transparency directive is implemented, and zero otherwise. Constructed from the dates reported in Christensen, Hail, and Leuz (2016).
IFRS^{post}	A dummy variable taking the value of one in all years in which a firm follows the International Financial Reporting Standards (IFRS), and zero otherwise. Constructed from Compustat data item ACCTSTD, which equals "DI" if the firm follows IFRS.
R&D-to-value added	Industry research and development expenditures per dollar of value added. Observations for 25 industries in 20 countries over the period 1990 to 2006. From the OECD STAN Indicators database.
R&D-to-assets	Firm-level research and development expenditures scaled by the book value of total

	assets. Observations for firms in 25 industries in 36 countries over the period 1990 to 2012. From the Compustat Global database.
Patent counts	The natural logarithm of one plus the number of patents in industry j and country i. Observations for 20 industries in 20 countries over the period 1990 to 2004. From the USPTO and NBER Patent database (Hall, Jaffe and Trajtenberg, 2001).
Patent citations	The natural logarithm of one plus the number of citations in industry j and country i. Observations for 20 industries in 20 countries over the period 1990 to 2004. From USPTO and NBER Patent database (Hall, Jaffe and Trajtenberg, 2001).
Capx-to-value added	Industry expenditures on fixed capital per dollar of value added. Observations for 25 industries in 20 countries over the period 1990 to 2006. From the OECD STAN Indicators database.
Capx-to-assets	Firm-level capital expenditures scaled by the book value of total assets. Observations for firms in 25 industries in 36 countries over the period 1990 to 2012. From the Compustat Global database.
Free cash flow	An indicator equal to one for firms that generate positive free cash flow, and zero otherwise. Free cash flow is measured as income before extraordinary items plus depreciation expenses minus changes in working capital minus capital expenditures. Constructed from the Compustat Global database.
Dividends	An indicator equal to one for firms with an average dividend-to-assets ratio above the sample median, and zero otherwise. Constructed from the Compustat Global database.
External equity	The ratio of net stock issues-to-assets for the median US firm in a given industry, where net stock issues is equal to gross stock issues minus stock buybacks. Both net external financing and assets are summed over the period 1990-2006 prior to computing the ratio. Constructed from firms with coverage in the Compustat North America database.
Equity dependence	The ratio of stockholder's equity-to-total debt for the median US firm in a given industry. Both stockholder equity and total debt are summed over the period 1990 to 2006 prior to computing the ratio. Constructed from firms with coverage in the Compustat North America database.
Arm's length financing	The share of a given industry's total firm-year observations indicating the use of arm's length financing, where arm's length financing is indicated by the presence of a bond rating or a net stock issue of at least 1% of total assets. Constructed from firms with coverage in the Compustat North America database over the 1990 to 2006 period.
Market dependence	The share of firms in a given industry that are not bank dependent, where firms are classified as bank dependent if they have a total debt-to-assets ratio of at least 10% but do not have a bond rating. Constructed from firms with coverage in the Compustat North America database over the 1990 to 2006 period.
RZ dependence	The share of capital spending not financed with operating cash flow for the median US firm in a given industry over the 1980 to 1990 period. From Rajan and Zingales (1998).

Table A2

Transparency and real investment: Differences across high-tech and low-tech industries

Table A2 reports OLS regressions on the association between *Transparency* and investment in high-tech industries. High-tech industries have 2-digit ISIC code of 24 (chemicals), 30 (office and computing), 32 (radio and tv), or 33 (scientific instruments). Country and industry fixed effects are included in all regressions. Standard errors are clustered in the country dimension. The sample used in columns (1) and (5) is constructed from the OECD's STAN Indicators database and covers 25 industries in 20 countries during 1990-2006. The sample used in columns (2) and (6) is constructed from the Compustat Global database and covers firms in 25 industries in 36 countries during 1990-2012. The firm level regression includes the following firm-level control variables: cash flow-to-assets, sales-to-assets, sales growth, cash-to-assets, total debt-to-assets, (log) age, and (log) employees. The sample used in columns (3) and (4) is constructed from the NBER Patent database and covers 20 industries in 20 countries during 1990-2004. Table A1 defines all variables.

	(1)	(2)	(3)	(4)	(5)	(6)
	R&D-to-value added	R&D-to-assets	Patent citations	Patent counts	Capx-to-value added	Capx-to-assets
Transparency × *High tech*	0.008	0.002	0.091	0.096	-0.003	0.000
	(0.002)***	(0.000)***	(0.036)**	(0.036)**	(0.004)	(0.000)
Constant	-0.192	-0.033	4.575	1.910	0.127	0.032
	(0.061)***	(0.019)*	(0.860)***	(0.860)**	(0.014)***	(0.013)**
Observations	433	4,101	375	375	372	7,030
R-squared	0.730	0.583	0.953	0.926	0.537	0.352

Table A3

Transparency and R&D Investment: Alternative sample periods and measures of R&D activity

Table A3 reports OLS estimates of equation (2) for alternative sample periods and measures of R&D activity. The dependent variable is R&D-to-value added in columns (1) and (3), R&D-to-assets in columns (2) and (4), R&D-to-output in column (5), and R&D-to-sales in column (6). Country and industry fixed effects are included in all regressions. Standard errors are clustered in the country dimension. The sample in odd-numbered columns is constructed from OECD's STAN Indicators database and covers 25 industries in 20 countries. The sample in even-numbered columns is constructed from the Compustat Global database and covers firms in 25 industries in 36 countries. The alternative sample periods are identified in the table. Table A1 defines all variables.

	(1)	(2)	(3)	(4)	(5)	(6)
Sample period:	1990-2000		1996-End of sample		1990-End of sample	
Dependent variable:	R&D-to-value added	R&D-to-assets	R&D-to-value added	R&D-to-assets	R&D-to-output	R&D-to-sales
Transparency × *External equity*	0.059 (0.008)***	0.039 (0.005)***	0.061 (0.009)***	0.033 (0.003)***	0.024 (0.004)***	0.463 (0.070)***
Constant	0.014 (0.007)**	-0.001 (0.013)	0.025 (0.006)***	-0.010 (0.008)	-0.074 (0.006)***	0.104 (0.063)
Observations	429	2,765	428	4,402	346	5,299
R-squared	0.689	0.420	0.715	0.422	0.766	0.305

Table A4

Time series changes in the information environment: Evidence from IFRS adoption

Table A4 reports OLS estimates of equation (3) using a firm-specific indicator of IFRS adoption as the *Transparency event*. The dependent variable is R&D-to-assets in columns (1)-(3) and capital spending-to-assets in column (4). Country-year and industry fixed effects are included in all regressions. The sample is constructed from the Compustat Global database and covers firms in 25 industries in 36 countries over the time period 1990 to 2006. Standard errors are clustered by country. Table A1 defines the variables.

	(1)	(2)	(3)	(4)
	Baseline	Start sample in 2001	Missing R&D to zero	Capital spending
$IFRS^{post}\times$ *External equity*	0.204 (0.033)***	0.240 (0.034)***	0.183 (0.026)***	-0.010 (0.010)
Constant	0.022 (0.005)***	0.026 (0.035)	-0.005 (0.004)	0.088 (0.010)***
Observations	34,634	28,934	57,088	57,088
R-squared	0.434	0.438	0.241	0.241