Financial Disclosure, Corporate Transparency, and Innovation

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ABSTRACT

We explore the connection between the country-level financial disclosure environment and innovative investment. There is strong evidence a more transparent disclosure environment lowers the cost and increases the availability of external equity finance, which should, in turn, impact the real activities most dependent on such financing. Using a variety of proxies for disclosure and transparency across countries, we find that more transparency has a strong positive impact on long-run rates of R&D investment in sectors that are more reliant on external financing and in sectors with a higher natural innovative intensity. These findings are not an artifact of the positive correlation between financial transparency and other institutional factors known to affect innovative investment. In addition, we treat the initiation of insider trading enforcement as a quasi-experimental shock to the disclosure environment and find substantial increases in R&D investment around the insider trading event, where again the effects are strongest in industries most reliant on external finance. Our findings link the disclosure environment with the external-finance dependent investments that drive economic growth.

Keywords: Financial disclosure, accounting information, cost of capital, R&D, innovation, finance and growth

JEL codes: O16; O32; N20; M40; G18; H20

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1. Introduction

This study provides novel evidence on the real consequences of a country's financial information environment. There is now extensive evidence demonstrating the broad capital market benefits of better financial disclosure and increased corporate transparency. In particular, a number of studies show that more extensive financial disclosures and a richer information environment are associated with reduced information asymmetries, more market liquidity, and a reduction in firms' cost of equity capital.[1] Moreover, though the real effects of the country-level disclosure environment has received less attention, there is evidence that the quality of financial reporting and overall level of corporate transparency improve investment efficiency at the firm level and resource allocation across industries (Biddle and Hilary, 2006; Biddle, Hilary, and Verdi, 2009; Francis et al., 2009). We extend these literatures by addressing a heretofore unexplored question of fundamental importance for understanding the real effects of corporate transparency: How do cross-country differences in the financial disclosure environment impact innovation?

Our new insight is that the capital market benefits of a more transparent information environment should be especially important for innovative investment. The reason for this is straightforward: innovative investment in research and development (R&D) is intangible, uncertain, and highly variable in nature, making it much more information-sensitive and external equity-dependent than other (fixed capital) investment (e.g., Lev, 2004; Brown, Fazzari, and Petersen, 2009). More specifically, when it comes to financing R&D, both theoretical and empirical evidence suggests that information costs introduce a substantial wedge between the cost of internal and external finance (e.g., Hall and Lerner, 2010), and external equity is the primary marginal source of external finance (e.g., Brown, Martinsson, and Petersen, 2013). As a consequence, by reducing information asymmetries and lowering the cost of external equity, a richer information environment can facilitate higher *levels* of R&D investment, particularly in sectors where the typical firm relies more on external sources to fund R&D. Given the importance of innovation for productivity and economic growth

[1] For example, see Diamond and Verrechia (1991), Botosan (1997), Healy, Hutton, and Palepu (1999), Leuz and Verrecchia (2000), Healy and Palepu (2001), Botosan and Plumlee (2002), Hail (2002), Bhattacharya, Daouk, and Welker (2003), Bushee and Leuz (2005), Hail and Leuz (2006), La Porta, Lopez-de-Silanes, and Andrei Shleifer (LLS, 2006), and Fu, Kraft, and Zhang (2012).

(Romer, 1990; Aghion and Howitt, 1992; Griffith, Redding, and Van Reenen, 2004), these arguments suggest that the financial disclosure environment can matter for long-run economic performance.

Our empirical tests exploit both cross-sectional and time series variation in the aggregate information environment in a sample of 20 OECD countries over the period 1990 to 2006. To measure cross-country differences in the aggregate level of financial disclosure and corporate transparency, we borrow several measures from the literature. We focus primarily on the broad measure of a country's information environment used by Francis et al. (2009), which accounts for financial disclosures, auditing activity, the enforcement of insider trading laws, and media development. But our findings are robust to a number of different measures of disclosures and transparency, including the Center for International Financial Analysis and Research (CIFAR) measure of the comprehensiveness of corporate annual reports, the Bushman, Piotroski, and Smith (2004) measure of disclosures related specifically to investments (including R&D), segments, and accounting methods, and the Leuz, Nanda, and Wysocki (2003) measure of earnings management.

Our dependent variable is industry R&D as a share of value added, collected from the OECD STAN database. This measure is especially attractive for our purposes because it is completely independent from reported R&D on financial accounting statements. We begin by collapsing the time dimension of the data and exploring the longer-run, cross-sectional connection between the transparency environment and innovative investment. Our identification strategy follows the 'difference-in-differences' approach Rajan and Zingales (RZ, 1998) use to evaluate the causal connections between financial development and economic growth. RZ (1998) argue that if financial development matters for growth, it should be disproportionately beneficial for growth in industries that have a higher technological demand for external funds. Extending this logic and approach to our setting, we estimate the within-country *differential* effect a richer information environment has across industries sorted by their technological dependence on external finance and, alternatively, their natural R&D intensity. As in RZ (1998), we drop the US from the regression sample and use data from US firms to construct proxies for the technological characteristics of an industry.

For each different measure of country-level transparency, we find that higher levels of transparency are associated with a strong, positive *differential* effect on the long-run (average) rate of

R&D investment across sectors sorted by dependence on external finance and natural R&D intensity. That is, the difference in R&D investment between a sector highly dependent on external finance and a sector less dependent on external finance is much larger in a country with high levels of transparency compared to a country with low levels of transparency, as it should be if transparency promotes R&D by lowering the cost of external equity finance. The economic magnitude of the differential effect implied by our estimates can be evaluated by comparing the difference in R&D intensity across high (75^{th} percentile) and low (25^{th} percentile) external finance dependent industries in countries with high transparency (75^{th} percentile) relative to countries with low transparency (25^{th} percentile). The magnitude of this differential effect is around five to ten percent of the sample average R&D intensity depending on the measure of country transparency we use. We find this estimate both plausible and economically meaningful.[2]

Though these estimates account for country-specific fixed effects and reveal differential effects across sectors where more transparency *should* matter, a potential concern is that our aggregate measures of transparency simply proxy for other country institutions that are the more fundamental force behind the positive differential effects on R&D we document. We address this potential concern in two ways. First, we follow Daske et al. (2008) and orthogonalize each measure of country transparency with respect to the country's legal origin and level of economic development. Working with the residual level of transparency left unexplained by the country's fundamental institutions, we re-estimate the RZ-regressions and continue to find a strong positive connection between transparency and R&D. Second, we continue to find strong evidence of a (residual) transparency-R&D connection if we include additional interactions to directly control for the differential effects of country-level human capital, patent protection, and financial market development on R&D. We also show that our findings are robust to alternative sample periods and a number of different ways to measure industry need for external finance and dependence on R&D investment.

[2] One way to to put this estimate in perspective is to compare it to the differential effects from financial development on industry growth reported in RZ (1998). RZ report growth differentials of around 30 percent of the sample average industry growth rate. That we find smaller yet still meaningful differentials is not surprising given our focus on transparency (rather than financial development) and R&D (rather than industry growth).

Next, we introduce an additional 'difference' by comparing the estimated effects of transparency in sub-sets of countries sorted based on the strength of legal and regulatory enforcement. This test is motivated by the finding in several studies that financial disclosures have the strongest impact on the cost of capital in countries with strong supporting enforcement institutions (e.g. Daske et al., 2008). We find that the transparency environment benefits R&D primarily in the countries with high quality enforcement institutions, highlighting the importance of the intersection of transparency and enforcement for real activities and providing further support for the plausibility of our results.

We conclude by exploring how a time-series shock to the information environment affects innovation. For a plausibly exogenous change in the information environment we focus on the first prosecution of insider trading laws (Bhattacharya and Daouk, 2002). Not only does the mitigation of insider trading directly reduce the level of private information of corporate insiders and enhance corporate transparency (e.g., Bushman et al. (2004)), but it also tends to be associated with other policy initiatives to improve the information environment and has been shown to substantially lower the cost of equity capital (Bhattacharya and Daouk, 2002; Bushman, Piotroski, and Smith, 2005). Thus, extending our earlier arguments to this 'event', we expect the change in the information environment following the first prosecution of insider trading to be disproportionately beneficial for R&D in the sectors most reliant on external finance. Our estimates strongly support this prediction.

Our full set of results provides compelling evidence that a more transparent financial disclosure environment promotes innovative investment. These findings advance the literature in several ways. First, though an extensive accounting literature studies the measurement, accounting treatment, and "value-relevance" of the R&D expenditures a firm undertakes, this is the first study to consider the potential for a country's overall disclosure environment to influence how large those R&D expenditures are in the first place.[3] As such, our findings contribute to the influential literature studying the real and financial effects of the country-level disclosure environment. A number of prior studies find that higher quality and more informative disclosures are associated with reduced

[3] Examples of studies on the accounting treatment and/or value-relevance of R&D include Hirschey and Weygandt (1985), Sougiannis (1994), Lev and Sougiannis (1996), Cañibano, Garcia-Ayuso, and Sánchez (2000), Healy, Myers, and Howe (2002), Kothari, Laguerre, and Leone (2002), Gu (2005), Eberhart, Maxwell, and Siddique (2008), and Ciftci and Cready (2011).

information problems and a lower cost of equity capital, and our findings show that these financial market benefits extend to the real sector in a theoretically plausible yet previously undocumented manner. Thus, our work is related to the relatively small number of studies that link financial reporting and transparency with real outcomes. Whereas these studies have focused on the efficiency of firm-level investment and resource allocation across sectors (e.g., Biddle and Hilary, 2006; Biddle et al., 2009; Francis et al., 2009), our contribution is to link the disclosure environment with the *level* of investment in an input widely viewed as critical for innovation and economic growth.[4]

Our findings are also important for the broad literatures on the cross-country determinants of R&D and innovation and the growth effects of financial market rules and access. Though there is extensive recent interest in uncovering the various legal and institutional characteristics that foster innovative activity (e.g., Fan and White, 2003; Acharya and Subramanian, 2009; Manso, 2011; Tian and Wang, 2014; He and Tian, 2013; Aghion, Van Reenen, and Zingales, 2013; Matray and Hombert, 2013), the potential importance of the financial disclosure environment has not been considered. In particular, by linking a fundamental determinant of the cost of external equity finance with innovation, our findings add to the strand of the innovation literature emphasizing the role of financial sector development and access (Brown, Fazzari, and Petersen, 2009; Chava et al., 2013; Brown, Martinsson, and Petersen, 2013; Hsu, Tian, and Xu, 2013). More broadly, given the importance of R&D for productivity growth and technological change, our findings provide insights into the causal workings of the connection between financial markets and aggregate economic performance documented in several studies (e.g., Levine (1998 and 2005)).

Finally, by treating the first prosecution of insider trading as a quasi-natural experiment to test whether a "shock" to the information environment affects R&D, our findings also advance the influential literature on the effects of insider trading enforcement. Whereas prior studies show that insider trading enforcement is associated with a significant reduction in the cost of capital (Bhattacharya and Daouk, 2002), our findings suggest that such enforcement also has important real effects.

[4] Biddle et al. (2009) include R&D in their measure of firm-level investment but their focus and tests are much different than ours.

2. Data, measurement, and sample characteristics

2.1. Sample construction and industry R&D data

We use the OECD's STAN database for time series information on R&D by industry. We merge the industry-level data from the STAN database with country measures of financial disclosure and legal institutions taken from a variety of different sources (see Table A.I for a complete list of variable descriptions and data sources). The final sample consists of countries with sufficient data on both corporate financial disclosure and industry R&D.[5] We drop the US because we use the US as a benchmark to rank the industries based on their technological characteristics (as described below). The final sample covers 25 manufacturing industries in 20 countries over the period 1990 to 2006.

The primary dependent variable we study is industry R&D investment scaled by industry value added (*R&D intensity*). For the initial cross-sectional tests we collapse the time dimension of the data and focus on the average (long-run) level of R&D investment in a given industry over the full sample period. We exploit time series variation in industry *R&D intensity* in additional tests at the end of the paper. One important concern in any international study of R&D, and particularly a study of financial disclosure and R&D, is cross-country comparability of R&D figures given differences in the accounting treatment and reporting of R&D expenses (e.g., see the discussion in Bhagat and Welch (1995)). This concern is lessened in our case for at least two reasons. First, we use industry-level data aggregated by the OECD rather than firm-level data reported on financial statements. The explicit objective of the STAN database is to construct industry-level R&D measures that are comparable across countries and over time. The OECD notes that the data we use "…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." Thus, we avoid the concern that any documented connection between financial disclosure and R&D is driven by differences in the propensity to *report* R&D, rather than differences in the propensity to *engage* in R&D. Second, our empirical approach includes country and

[5] The R&D requirement excludes New Zealand, Israel, Luxembourg, Switzerland, and Turkey. The requirement that countries have coverage of at least some financial disclosure measures excludes the former communist states and Iceland.

industry fixed effects, so identification is based on within-country, across-industry differences in the responsiveness of R&D to particular innovation policies. Thus, even if the OECD is unable to completely adjust for country-specific conventions and incentives to report R&D, it will not bias our inferences from the within-country difference-in-difference regressions.

2.2. Measuring disclosure and transparency across countries

We take measures of financial disclosure and corporate transparency from related studies. Detailed variable definitions and data sources are reported in Table A1. Table 1 reports the transparency measures for each sampled country. Our primary proxy for 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 disclosure and transparency measures, including accounting disclosures, auditing activity, analyst coverage, insider trading enforcement, and media coverage. We focus on *Transparency* because it is a broad measure of corporate transparency which "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).

We also proxy for the country level of financial disclosure with the index created by The Center for International Financial Analysis and Research (CIFAR) to the measure the comprehensiveness of corporate annual reports (*Disclosure intensity*). The CIFAR index is based on the average number of 90 different items disclosed by a sample of firms in each country. This measure widely used to measure cross-country differences in accounting standards and disclosure intensity, and is one component of the Francis et al. (2009) *Transparency* measure discussed above.

Our third measure of disclosure intensity, *Financial disclosure*, is 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 somewhat more narrow than the other measures, this proxy has the advantage of placing more weight on disclosures related to R&D, which is of obvious interest given the focus of our study.

Our last measure of disclosure is *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 (or lack thereof) 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 more corporate transparency.

It is widely acknowledged that a country's "fundamental" institutions impact disclosure intensity and the overall information environment (e.g., Bushman, Piotroski, and Smith, 2004; Daske et al., 2008; Francis et al., 2009). As a consequence, even though our tests are based on within-country, across-industry differential effects, one potential concern is that these measures of disclosure and transparency simply proxy for other institutional factors that impact R&D, making it difficult to draw strong inferences about the independent importance of disclosure per se on innovative activity. As discussed in more detail below, we address this concern in two ways. First, we follow the approach in Daske et al. (2008) and focus on the (residual) level of transparency left unexplained by the country's more fundamental institutions. Specifically, we orthogonalize each of the disclosure measures with respect to the country's legal institutions and level of economic development by regressing the disclosure measure on the country's legal origin (La Porta et al., 1998) and (log) level of GDP per capita. We then use the residuals from these regressions in the majority of our empirical tests. In addition, we show that our findings are robust to directly controlling for three country characteristics which may be especially important for innovative activity: the level of human capital, the strength of intellectual property protection, and the extent of financial market development.

2.3. Measuring technological differences across industries

Our identification approach exploits the fact that a country's disclosure environment should matter more for R&D in some sectors compared to other sectors. In particular, financial disclosures that lower the cost of equity finance and reduce information asymmetries should be relatively more important for R&D investment in sectors that: a) rely more heavily on external finance, and b) are more R&D intensive. Following the logic in Rajan and Zingales (1998) and numerous subsequent

studies, we use US data to measure the technological characteristics of industries.[6] We construct our primary measure of industry dependence on external finance as follows: i) for all publicly listed US firms with coverage in the Compustat database we sum total external financing (net stock and long-term debt issues) and total assets over the period 1990 to 2006, ii) using these cumulative totals we compute an external finance-to-assets ratio each firm, and iii) we call the median external finance-to-assets ratio across firms in each industry *External finance*. Using a similar approach we construct alternative measures of industry reliance on external finance, as well as industry measures of R&D intensity. Table 2 reports summary statistics for all of the industry-level variables we use in the study.

3. Cross-sectional difference-in-difference tests

3.1. Actual investment under different disclosure environments

We start in Figure 1 by showing how actual (long-run) rates of investment in high and low external finance industries differ across countries with different disclosure environments. We first obtain the residual R&D-intensity for each country-industry pair from a regression of the industry investment measures on a full set of country and industry fixed effects. Next, for each country we find the average residual R&D level in the three sectors most reliant on external finance and the three sectors least reliant on external finance.[7] Third, we find the *difference* in R&D intensity across high and low external finance sectors in each country. Finally, we find the sample average of this differential for countries with "high" and "low" financial disclosures, where for each measure of transparency we put countries into the "high" ("low") group if the disclosure measure is above (below) the sample median.

Figure 1 shows that the difference in residual R&D intensity across high and low *External finance* industries is much higher in countries with higher levels of *Transparency*, *Disclosure intensity*, *Financial disclosure*, and *Earnings transparency*. These results preview our findings from the more formal regression analysis by pointing to a strong, positive connection between the

[6] Rajan and Zingales (1998) focus on the industry technological demand for external finance. Several studies look other technological characteristics of industries, including R&D intensity, such as Beck and Levine (2002), Claessens and Laeven (2003), Carlin and Mayer (2003), Krozner, Laeven, and Klingebiel (2007), and Ilyina and Samaniego (2011).

[7] Industry reliance on external finance is taken from a ranking of the variable *External finance*. This approach is similar in spirit to the evidence RZ (1998, Table 5) report on differences in (residual) industry growth rates across countries with high and low financial development.

disclosure environment and rate of R&D investment in sectors that rely extensively on external finance.

3.2. Baseline estimates: Transparency and R&D

We begin with a similar identification strategy to the one pioneered by RZ (1998) in their seminal study on finance and economic growth and utilized in many subsequent studies (e.g., Beck and Levine (2002); Claessens and Laeven (2003); Aghion et al. (2012); Laeven and Valencia (2013)). Here we collapse the time dimension of the data and estimate the following cross-sectional regression:

$$R\&D\text{- intensity}_{i,j} = \beta_0 + \beta_1 \, Transparency_i \times External\ finance_j + \eta_j + \eta_i + \varepsilon_{i,j}. \quad (1)$$

$R\&D\text{-intensity}_{i,j}$ is R&D investment divided by value added for industry j in country i (computed as the average value over the sample period). $External\ finance_j$ is industry j's technological dependence on external finance. $Transparency_i$ measures of the level of financial disclosure and corporate transparency in country i. Finally, η_i and η_j are fixed effects that control for unobserved country and industry characteristics. In all cases we estimate equation (1) with robust standard errors clustered at the country level.

Following the logic in RZ and related studies, we focus on the *interaction* between industry *External finance* and country *Transparency*. A positive coefficient on the interaction term (β_1) indicates that an increase in the country-level disclosure variable has a stronger differential effect on R&D intensity in industries that rely relatively more on external finance. We thus have a difference-in-difference test, with the estimate on the interaction term reflecting differences in the impact of *Transparency* across industries that differ in terms of their reliance on external finance.

We report our baseline estimates of equation (1) in Table 3. We report the estimate of β_1 for each alternative measure of corporate transparency. In each case, we find a significant positive coefficient on the interaction term, indicating that higher levels of transparency are associated with positive *differential* rates of R&D investment in the industries that most depend on external finance. To get a sense for 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 R&D intensity in an industry at the 75th percentile of *External finance* compared

to an industry at the 25th percentile. The various measures suggest differential impacts on R&D intensity equivalent to 7% to 13% of mean R&D intensity. We find the strongest economic effects with *Transparency* and the weakest effects with *Financial disclosure*, but all measures suggest similar and economically important effects on innovative activity from increases in the disclosure information environment.

3.3. Alternative channels

The most obvious concern with the findings in Table 3 is that the measures of transparency we examine merely proxy for other country-level institutions and characteristics, and these other characteristics are actually behind the differential effects on R&D we document. Indeed, the CIFAR measure of accounting disclosures is often used as a proxy for the overall level of financial market development in a given country (e.g., Rajan and Zingales (1998)). Moreover, a number of studies discuss the importance of a country's 'fundamental' legal institutions for the country's overall disclosure environment, making it potentially difficult to disentangle the benefits of additional transparency from the effects of the broader institutional environment.

We thus proceed in two ways. First, we follow the approach in Daske et al. (2008) and orthogonalize each of the transparency measures with respect to the country's legal origin and stage of economic development. Specifically, we capture the residuals from a regression of the transparency measure against country GDP-per-capita a dummy variable indicating whether the country is of common or civil law legal origin. Using these residual values – which represent the overall level of transparency left unexplained by a country's fundamental institutions – we re-estimate equation (1) and report the results in the first four columns of Table 4. As in Table 3, for each measure of (residual) transparency we find a positive, significant, and economically meaningful coefficient on the key interaction term. The estimates suggest that moving from the 25th to 75th percentile in *residual* transparency is associated with a positive differential increase in R&D intensity in high *External finance* sectors that amounts to between 4% (using the *Financial disclosure* measure) and 7% (using *Transparency*) of the sample average R&D intensity. We will focus on these residual measures of transparency for the remainder of the paper, but all of the findings that follow are just as strong, or stronger, if we use the overall (non-orthogonalized) measures instead.

Next, we directly control for three key alternative country characteristics that could potentially rationalize our findings. We note that omitted factors are less of a concern here than in some settings because we have already orthogonalized the transparency measures with respect to country fundamental institutions and our identification approach focuses on differential, within-country effects. As a consequence, for 'omitted factors' to be a valid concern it must be the case that alternative country characteristics exist that are both: a) positively correlated with the *residual* level of transparency in a country, and b) *disproportionally* beneficial for R&D investment in the most external finance dependent sectors. Three potentially important alternative characteristics are the country's level of human capital, strength of intellectual property (IP) protection, and extent of financial market sector development. Notably, R&D typically requires a highly-skilled workforce (e.g., Hall and Lerner, 2010), several studies find a strong link between IP protection and investment and growth in innovative, intangible-intensive sectors (e.g., Claessens and Laeven (2003)), and recent evidence indicates that R&D investment is particularly sensitive to financial market conditions (e.g., Brown, Martinsson, and Petersen (2013)).

We explore these alternative channels in the final three columns of Table 4. We focus on the residual measure of *Transparency*, but the results are very similar regardless which measure of disclosure we use. We start in column four by adding the interaction between a country-level measure of human capital (*Schooling*) and industry *External finance* to our baseline regression (equation (1)). The coefficient estimate on the new *Schooling x External finance* interaction is positive and significant, indicating that a higher level of human capital is differentially beneficial for R&D in high *External finance* sectors, but controlling for this factor has little impact on our estimate of the key *Transparency* interaction term. In column five we add the interaction between country *Patent protection* and industry *External finance.* The coefficient estimate on the *Patent protection* interaction is positive and significant, and while controlling for IP protection turns the human capital interaction insignificant, the coefficient estimate on residual *Transparency* remains positive and significant (though slightly smaller in magnitude). Finally, in the last column we add a *Financial development* interaction to the regression, which has little impact on the other coefficient estimates. Perhaps surprisingly, the coefficient estimate on the *Financial development* interaction is not significant.

However, if we include *only* the *Financial development x External finance* interaction we recover a positive and significant coefficient, consistent with the findings in other recent studies. One interpretation of these results is that broad measures of financial development are dominated by the more fundamental factors driving the availability of finance in a given country, in particular the level of corporate transparency.

3.4. Sorting industries by R&D intensity

Our findings thus far focus on the differential effects of transparency across sectors more and less reliant on external financing. We have argued that the benefits of increased disclosure should also extend to industries that are naturally more R&D intensive, both because these sectors tend to rely more on external equity financing and because information asymmetries between firms and outside investors should be increasing with respect to the industry R&D intensity. Moreover, R&D intensive industries are increasingly important sources of innovation and growth in modern economies, so evidence of a differential benefit in such sectors from increased corporate transparency would suggest potentially important economic effects. As before, we use US data to measure an industry's natural (or technological) R&D intensity. Though perhaps less obvious than the original Rajan and Zingales (1998) approach of relying on US-based measures of external finance usage, the use of US data to construct measures of each industry's natural R&D or innovative intensity has precedent (e.g., Beck and Levine (2002); Acharya and Subramanian (2009)).

In Table 5 we report results with industry *R&D intensity* interacted with the four different residual measures of transparency we used in the prior table. The results in the first four columns show positive and significant coefficients on the key interaction term, indicating that higher levels of (residual) transparency are associated more R&D in sectors with a higher natural R&D intensity. We obtain similar results in the final column when we include additional interactions of industry *R&D intensity* with country *Schooling, Patent protection,* and *Financial development*. The magnitudes of the implied R&D differentials (reported at the bottom of the table) are in the range of 6% to 10% of the sample average R&D intensity, which suggest economically important effects generally consistent with our prior findings.

3.5. Alternative sample periods and industry characteristics

In Table 6 we report results using alternative sample periods and interactions with alternative industry characteristics. In the first two columns we split the sample into the first decade (1990-2000) and the last decade (1996-2006) of our overall sample, respectively. In each case, consistent with our findings for the full sample period, we find a positive and significant coefficient on the interaction between country residual *Transparency* and industry *External finance*. The magnitude of the predicted R&D differential is also consistent with what we find for the full sample period (7% to 8% of mean R&D intensity). We find similar results if we focus on other sub-periods.

In the last five columns of Table 6 we examine several alternatives to *External finance* and *R&D intensity* as measures of industry sensitivity to the disclosure environment. We start with four alternative measures of an industry's technological need for external financing, and finish with an alternative measure of industry R&D intensity. First, in column (3) of Table 6 we base the measure of industry use of external finance on the financing activities of US firms in the 1980s, the decade preceding the start of our sample period. The interaction between (residual) *Transparency* and *External finance 1980s* is positive and significant, and with a predicted R&D differential of around 15% of the sample mean R&D intensity, indicates even larger economic effects than our main results. Second, we construct a measure use of the industry's reliance on external *equity* only by finding the net stock issues to total assets ratio for the median US firm in each industry. Consistent with our main results, the *Transparency x External equity* interaction is positive and significant (column (4)), indicating that increases in the residual level of *Transparency* are disproportionately beneficial for R&D investment in sectors more technologically dependent on external equity financing.

Next, we use the industry measures of external finance dependence originally constructed by Rajan and Zingales (1998) in their classic paper (*RZ dependence*). The original RZ approach measures industry dependence on external finance as the fraction of industry capital expenditures not financed with operating cash flow. The industries we use (in the STAN database) are in some cases more aggregated than the industries in the original RZ study, so we find *RZ dependence* measures for our sectors by either: i) taking the value reported in RZ if their industry maps directly to ours (e.g., Tobacco, Drugs), or ii) taking the average of RZ values across the component industries when our industry grouping is more aggregated than RZ's (e.g., *RZ dependence* for our industry 'manufacturing

of food products and beverages' is 0.11, or the average of the external dependence measures RZ report for beverages (0.08) and food products (0.14)). The results in column (5) show a positive and significant interaction between residual *Transparency* and *RZ dependence*, and the magnitude of the coefficient estimate suggests a sizeable R&D differential.

In column (6) we focus on the amount of internal cash flow the typical firm in an industry generates. An alternative way to view our main idea is that increases in the disclosure environment should be relatively *less* important in industries that generate sufficient cash flow to finance their investment internally. Indeed, the interaction between residual *Transparency* and industry *Cash flow intensity* is negative and significant, indicating that increases in the disclosure environment have less impact on industries that generate high levels of internal cash flow compared to the impact a richer disclosure environment has on industries that generate low levels of cash flow.

In the final column of Table 6 we sort industries based on R&D's share of total investment (R&D + fixed capital spending) in the typical firm. Consistent with our findings for industry *R&D intensity* in Table 5, the estimates indicate that more *Transparency* is disproportionately beneficial for R&D in sectors where R&D naturally comprises a larger share of total investment. Moreover, the coefficient estimate in column (7) indicates that differences in residual *Transparency* are associated with very large differential effects across sectors sorted by the *R&D share of total investment*.

3.6. Sample splits by strength of legal enforcement

A recurring finding in cross-country studies linking financial disclosures with a lower cost of capital is that the benefits of increased disclosure hinge on the quality of supporting legal and regulatory enforcement (e.g., Daske et al., 2008; Ball, Robin, and Wu, 2003; Ball and Shivakumar, 2005; Burgstahler, Hail, and Luez, 2006). This evidence suggests potentially important heterogeneities across countries in the impact transparency has on innovative investment: if financial disclosures have a stronger effect on the cost of capital in countries where legal enforcement is strong, then we should find the strongest evidence of a transparency-innovation connection in countries with strong legal enforcement.

In Table 7 we test this idea by estimating the key difference-in-difference regression (equation (1)) separately for countries with high and low levels of legal enforcement. We thus continue to focus

on within country differential effects, but we compare the estimated magnitude of these effects across sub-samples of countries sorted by the strength of legal enforcement. We report results using two different enforcement measures to sort countries: the *Rule of law* measure from Daske et al. (2008) and the measure of regulatory staff to country population (*Regulatory staff*) from Jackson and Roe (2009). In Panel A we report estimates of the interaction between residual *Transparency* and industry *External finance* for each sub-sample of countries. We do the same in Panel B for the interaction between residual *Transparency* and industry *R&D intensity*.

The first column reports coefficient estimates of the key interaction term for "high" *Rule of law* countries only, where countries are included in the "high" sub-sample if they have a *Rule of law* score above the sample median. The second column reports the corresponding interaction effect for the "low" *Rule of law* sub-sample, and the third column reports the *p-value* from a test that the coefficient estimates across the two sub-samples are statistically different. For both the *External finance* (Panel A) and *R&D intensity* (Panel B) interactions the coefficient estimate on the key interaction term is positive in both the "high" and "low" sub-samples, though the estimate is only statistically significant in the sample of "high" *Rule of law* countries. The coefficient estimate using the "low" *Rule of law* sub-sample is statistically insignificant and smaller in magnitude than the estimate for the "high" sub-sample, but the *p-values* reported in column (3) show that we cannot reject the hypothesis that the two coefficient estimates are equal, largely due to a relatively high standard error on the coefficient estimate in the "low" sub-sample.

In the final three columns of Table 7 we repeat this exercise using the *Regulatory staff* variable to divide countries. As with the *Rule of law* splits, we find a larger coefficient estimate in the "high" *Regulatory staff* sub-sample, and only for the "high" sub-sample is the coefficient estimate statistically significant. Moreover, in this case the coefficient estimates across the two sub-samples are statistically different (see the *p-values* in column (6)) whether we look at the *External finance* (Panel A) or *R&D intensity* (Panel B) interactions. Overall, the findings in Table 7 support the idea that improvements in

the disclosure environment are more beneficial for R&D when countries also have strong legal enforcement mechanisms in place.[8]

4. Time-series changes in the information environment: Insider trading enforcement

For our findings thus far we work with cross-sectional levels of country transparency and average rates of investment across industries. By collapsing the time-series dimension of the industry data we thus uncover the longer-run connection between transparency and innovative investment. While such longer-run relations are of particular interest for evaluating the real consequences of financial disclosures, our arguments also suggest that time series changes in the disclosure environment should have important real effects. Moreover, corroborating evidence from time series changes in transparency would provide strong support for the validity our inferences in the prior section. Since the broad disclosure measures like we examine in prior tests are typically not time-varying (and, indeed, would change little over our sample period even if time-series observations were available), we exploit a plausibly exogenous "shock" to the information environment: the first prosecution of insider trading laws (Bhattacharya and Daouk, 2002).

Focusing on insider trading enforcement is attractive for several reasons. First, identification is aided by the fact that there is substantial cross-country variation in the timing of the first instance of insider trading enforcement (see the relevant dates for each country Table 1). More importantly, as several studies have argued, the mitigation of insider trading reduces the level of private information of corporate insiders and enhances corporate transparency (e.g., Bushman et al. (2004)). The enforcement of insider trading laws is also likely correlated with additional efforts of policy makers to increase financial reporting and improve the information environment; for example, Bushman,

[8] Some readers may wonder if *controlling* for legal enforcement affects our baseline estimates of the transparency-innovation link. Recall that our transparency measures are already purged of country fundamental institutions and our approach already controls for country fixed effects. The only mechanism through which controlling for legal enforcement could affect our results is if *Rule of law* or *Regulatory staff* is positively correlated with the *residual* transparency measures and also disproportionately beneficial for R&D in high *External finance* sectors. Regarding the potential positive correlation between measures, across countries the correlation between residual *Transparency* and *Rule of law* (*Regulatory staff*) is only 0.045 (-0.192) – in contrast, the corresponding correlation using the non-residual measure of *Transparency* is 0.547 (0.305). Nonetheless, we have re-estimated the baseline specification with an additional interaction (either *Rule of law x External finance* or *Regulatory staff x External finance*) included in the regression. While this additional interaction term attracts a positive coefficient (and is statistically significant in the case of *Rule of law*), it has no impact on our estimate of the key interaction between (residual) *Transparency* and *External finance*.

Piotroski and Smith (2005) show that following the enforcement of insider trading laws there is a significant increase in analyst following. Consistent with these arguments, Bhattacharya and Daouk (2002) find that enforcement of insider trading laws is associated with substantial reductions in the cost of equity capital.[9] It thus follows from our earlier arguments that an increase in corporate transparency following insider trading enforcement should have a positive, differential benefit on R&D in the sectors most reliant on external finance.

4.1. Pooled time-series regressions for all countries

To test whether R&D responds to a change in transparency associated with insider trading enforcement, we start by pooling data across all industries, countries, and years and estimating the following specification:

$$R\&D\text{- }intensity_{i,j.t} = \beta_0 + \beta_1 Insider\ enforcement_{i,t} \times External\ finance_j + \eta_i + \eta_j + \eta_i \times \eta_t + \varepsilon_{i,j,t}. \quad (2)$$

The variable *Insider enforcement* is an indicator variable equal to one in all country-years starting with the first year a prosecution of insider trading occurs, and zero otherwise. As before, the variable *External finance* is industry *j*'s technological dependence on external finance, so β_1 captures the within-country differential impact that insider trading enforcement has on R&D investment across sectors with varying dependence on external finance. The specification also controls for country (η_i), industry (η_j), and country-year ($\eta_i \times \eta_t$) fixed effects.

We report estimates of equation (2) in Table 8. The reported standard errors (in parenthesis) are robust to clustering in the country dimension. The baseline estimate in column (1) shows a positive and highly significant coefficient on the *Insider enforcement x External finance* interaction. The estimate indicates that moving from an information environment where there are no insider trading prosecutions to the environment after the first prosecution has occurred is differentially beneficial for R&D in sectors that use more external finance. The predicted R&D differential from such a change is roughly 11% of the mean R&D intensity, suggesting an economically important effect.

In the second column we include the *Transparency x External finance* interaction that was the focus of our earlier tests. As before, the coefficient estimate on this interaction term is positive and

[9] The first prosecution of insider trading laws is one of the components in Bushman et al.'s (2004) conceptual framework of what determines corporate transparency.

significant, but including it in specification (2) has little impact on the *Insider enforcement* term. In addition, we find similar evidence of positive, differential effects from insider trading enforcement in column (3) if we stop the sample in the year 2000, which we do because the last year that a country reports the first instance of insider trading enforcement is 1998 (Spain). In column (4) we sort industries by *R&D intensity* rather than *External finance* and find strong positive differential effects on R&D following insider trading enforcement.

5. Conclusions

We study the connection between the financial disclosure environment and innovative investment. The financial market benefits of better financial disclosure and more corporate transparency are widely acknowledged both theoretically and empirically (e.g., Rajan and Zingales, 2003; Bhattacharya, Daouk, and Welker, 2003). But the real consequences of the aggregate transparency environment have received much less attention. We argue that the key benefits of a more transparent environment – reduced information problems and a lower cost of external equity finance – should be particularly important for innovative investment in R&D because the nature of R&D makes it more information-sensitive and equity-dependent than other investments.

We provide two key empirical tests of the disclosure-R&D connection. First, we use a 'difference-in-difference' approach similar to the methodology developed by Rajan and Zingales (1998) in their classic study on finance and growth. Identification with this approach exploits the fact that some industries are more naturally dependent on external financing than other industries: if the transparency environment matters for R&D by lowering the cost of external equity finance, it should matter *disproportionately* more for R&D in the sectors most (technologically) dependent on external financing. Using several different measures of the aggregate transparency environment, including measures orthogonalized with respect to the country's fundamental legal and economic institutions, we find strong evidence that a richer information environment is associated with higher levels of R&D in the sectors most dependent on external funding. Second, we treat the first prosecution of insider trading as a quasi-natural experiment and test how R&D responds to the increase in transparency that generally accompanies insider trading enforcement. Consistent with our findings using the RZ (1998)

approach, we find that a positive differential increase in R&D investment follows the initiation of insider trading enforcement. Overall, our findings show that the level of transparency in a given country has an economically important impact on the innovative investments that drive economic growth.

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Figure 1
Differential in residual R&D intensity across high and low *External finance* industries

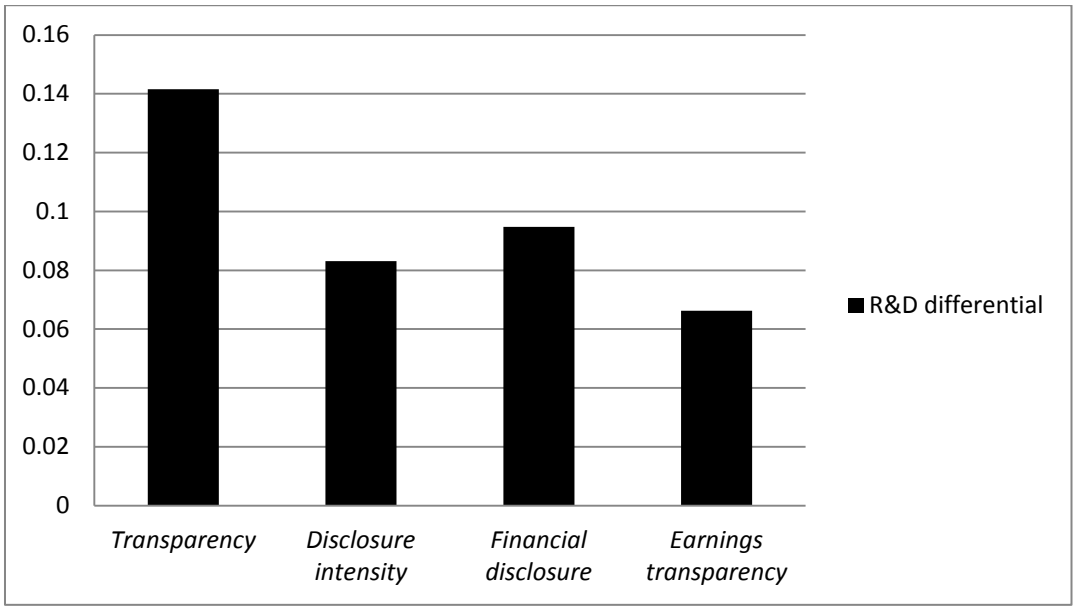

Table 1
Sampled countries and key characteristics

This table lists the 20 sample countries and reports country values for the key financial disclosure and legal enforcement variables. The insider trading column reports the first year the country has a case of insider trading enforcement. All variables and data sources are explained in Table A.1.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Country	**Trans-parency**	**Disclosure intensity**	**Financial disclosure**	**Earnings transparency**	**Rule of Law**	**Regulatory staff**	**Insider trading**
Australia	23.7	68	100.00	4.8	1.749	34.44	1996
Austria	15.6	62	70.29	28.3	1.849	9.97	no
Belgium	17.5	68	92.75	19.5	1.270	2.68	1994
Canada	28.1	75	100.00	5.3	1.693	38.93	1976
Denmark	23.8	75	86.96	16.0	1.889	10.85	1996
Finland	26.1	83	100.00	12.0	1.942	11.23	1993
France	26.4	78	100.00	13.5	1.378	5.91	1975
Germany	22.8	67	100.00	21.5	1.626	4.43	1995
Greece	10.4	61	44.57	28.3	0.817	12.16	1996
Ireland	-	81	100.00	5.1	1.564	23.32	no
Italy	21.0	66	100.00	24.8	0.654	7.25	1996
Japan	22.9	71	100.00	20.5	1.265	4.32	1990
Korea	14.7	68	65.22	26.8	0.840	11.55	1988
Mexico	15.9	71	68.12	-	-0.471	5.19	no
Netherlands	25.0	74	100.00	16.5	1.723	23.53	1994
Norway	22.8	75	76.45	5.8	1.908	20.78	1990
Portugal	10.9	56	81.16	25.1	1.203	14.5	no
Spain	21.9	72	92.75	18.6	1.230	8.5	1998
Sweden	27.9	83	100.00	6.8	1.821	7.19	1990
UK	30.9	85	100.00	7.0	1.652	19.04	1981
Mean	21.5	71.95	88.91	16.12	1.380	13.789	-
Median	22.8	71.50	100.00	16.50	1.595	11.040	-

Table 2
Industry characteristics

This table reports statistics for the 25 manufacturing industries included in the study. The value reported for R&D- and Cap formation-to-value added (columns (3) and (4)) is the industry average across all countries in the sample. The industry characteristics in columns (5)-(11) are constructed from US firm-level data. All variables and data sources are explained in Table A.1.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
ISIC code	**Industry**	***R&D-to-value added***	***Cap formation-to-value added***	***External finance***	***R&D intensity***	***External finance 1980s***	***External equity***	***RZ dependence***	***Cash flow intensity***	***R&D share of investment***
15	Food products	0.011	0.190	0.026	0.000	0.011	0.002	0.110	0.063	0.000
16	Tobacco	0.013	0.095	-0.009	0.004	-0.002	0.000	-0.450	0.162	0.087
17	Textiles	0.015	0.137	0.008	0.000	0.013	0.000	0.155	0.062	0.000
18	Apparel	0.008	0.075	0.028	0.000	0.007	0.013	0.030	0.037	0.000
19	Leather	0.012	0.096	-0.004	0.000	0.009	0.004	-0.110	0.088	0.000
20	Wood	0.006	0.175	0.004	0.000	0.006	0.000	0.280	0.060	0.000
21	Paper	0.014	0.237	0.010	0.000	0.018	0.000	0.165	0.077	0.000
22	Publishing	0.004	0.135	0.019	0.000	0.017	0.002	0.200	0.064	0.000
23	Petroleum	0.030	0.311	0.014	0.000	0.000	0.000	0.185	0.084	0.000
24	Chemicals	0.060	0.206	0.027	0.011	0.028	0.005	0.210	0.059	0.203
25	Rubber	0.027	0.203	0.020	0.002	0.012	0.001	0.685	0.055	0.047
26	Non-metallic minerals	0.015	0.187	0.016	0.000	0.014	0.001	0.147	0.073	0.000
27	Basic metals	0.023	0.217	0.015	0.000	0.006	0.005	0.050	0.050	0.000
28	Metal products	0.012	0.141	0.012	0.002	0.013	0.000	0.240	0.068	0.044
29	Machinery and equip	0.049	0.121	0.027	0.013	0.020	0.015	0.450	0.065	0.254
30	Office and computing	0.197	0.233	0.096	0.091	0.104	0.078	1.060	0.087	0.597
31	Electrical machinery	0.067	0.140	0.019	0.015	0.028	0.008	0.770	0.065	0.257
32	Radio and tv	0.247	0.246	0.076	0.048	0.059	0.058	1.040	0.080	0.436
33	Scientific instruments	0.113	0.127	0.093	0.065	0.073	0.079	0.960	0.073	0.532
34	Motor vehicles	0.082	0.232	0.027	0.007	0.017	0.009	0.390	0.072	0.183
35	Other transport	0.066	0.139	0.049	0.006	0.035	0.050	0.310	0.043	0.208
36	Furniture	0.013	0.122	0.026	0.001	0.021	0.010	0.355	0.048	0.025
351	Ships	0.027	0.127	0.005	0.000	0.005	0.000	0.460	0.063	0.000
353	Air/spacecraft	0.210	0.168	0.016	0.014	0.009	0.003	0.310	0.067	0.256
2423	Drugs	0.197	0.152	0.354	0.231	0.193	0.312	1.490	-0.018	0.664

Table 3
Transparency and R&D Investment: Differential effects across sectors based on use of external finance

Table 3 reports OLS regressions with industry R&D-to-value added$_{i,j}$ 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 finance* with respect to an industry at the 25th percentile level when it is located in a country at the 75th percentile of either *Transparency*, *Disclosure intensity*, *Financial disclosure* or *Earnings transparency* rather than in a country at the 25th percentile. Fixed country and industry effects are included in all regressions. Standard errors are clustered in the country dimension. The data is from OECD's STAN database and cover 25 manufacturing industries in 20 countries during 1990-2006. All variables are defined in Table A.I.

	(1)	(2)	(3)	(4)
	Industry *External finance* interacted with country			
	Trans-parency	*Disclosure intensity*	*Financial disclosure*	*Earnings transparency*
Transparency × *External finance*	0.053 (0.007)***			
Disclosure intensity × *External finance*		0.032 (0.008)***		
Financial disclosure × *External finance*			0.013 (0.004)***	
Earnings transparency × *External finance*				0.021 (0.010)**
Constant	-0.202 (0.060)***	0.027 (0.008)***	0.034 (0.007)***	0.331 (0.065)***
Observations	433	456	456	431
R-squared	0.724	0.703	0.693	0.713
R&D differential (% of mean)	0.132	0.070	0.067	0.092

Table 4
Transparency and R&D Investment: Accounting for alternative channels

Table 4 reports OLS regressions with industry R&D-to-value added$_{i,j}$ 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 finance* with respect to an industry at the 25th percentile level when it is located in a country at the 75th percentile of the disclosure measure rather than in a country at the 25th percentile. All disclosure measures are orthogonalized with respect to country GDP-per-capita and legal origin. Fixed country and industry effects are included in all regressions. Standard errors are clustered in the country dimension. The data is from OECD's STAN database and cover 25 manufacturing industries in 20 countries during 1990-2006. All variables are defined in Table A.I.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Orthogonalized measures w.r.t. fundamental institutions				Residual *Transparency* with additional interactions		
	Trans-parency	*Disclosure intensity*	*Financial Disclosure*	*Earnings transparency*	Human capital	Human captial & IP protection	Human captial, IP protection, & Fin development
Transparency × *External finance*	0.044 (0.015)***				0.043 (0.014)***	0.030 (0.012)**	0.031 (0.011)***
Disclosure intensity × *External finance*		0.028 (0.010)**					
Financial disclosure × *External finance*			0.010 (0.005)**				
Earnings transparency × *External finance*				0.035 (0.012)***			
Schooling × *External finance*					1.002 (0.440)**	0.494 (0.439)	0.498 (0.439)
Patent protection × *External finance*						1.216 (0.470)**	1.248 (0.586)**
Financial development × *External finance*							-0.032 (0.198)
Constant	0.032 (0.009)***	0.019 (0.011)	0.032 (0.007)***	0.030 (0.007)***	0.006 (0.013)	-0.027 (0.012)**	-0.028 (0.016)*
Observations	433	456	456	431	433	433	433
R-squared	0.693	0.688	0.682	0.710	0.710	0.719	0.719
R&D differential (% of mean)	0.073	0.064	0.043	0.050	0.071	0.049	0.051

Table 5
Transparency and R&D Investment: Differential effects across sectors based on R&D intensity

Table 5 reports OLS regressions with industry R&D-to-value added$_{i,j}$ 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 *R&D intensity* with respect to an industry at the 25th percentile level when it is located in a country at the 75th percentile of the disclosure measure rather than in a country at the 25th percentile. All disclosure measures are orthogonalized with respect to country GDP-per-capita and legal origin. Fixed country and industry effects are included in all regressions. Standard errors are clustered in the country dimension. The data is from OECD's STAN database and cover 25 manufacturing industries in 20 countries during 1990-2006. All variables are defined in Table A.I.

	(1)	(2)	(3)	(4)	(5)
	Industry *R&D intensity* interacted with country residual				
	Trans-parency	*Disclosure intensity*	*Financial disclosure*	*Earnings transparency*	*Trans-parency*
Transparency × *R&D intensity*	0.067 (0.023)***				0.043 (0.015)**
Disclosure intensity × *R&D intensity*		0.039 (0.015)**			
Financial disclosure × *R&D intensity*			0.016 (0.007)**		
Earnings transparency × *R&D intensity*				0.052 (0.017)***	
Schooling × *R&D intensity*					0.671 (0.599)
Patent protection × *R&D intensity*					1.949 (0.799)**
Financial development × *R&D intensity*					0.027 (0.286)
Constant	0.032 (0.008)***	0.022 (0.011)**	0.032 (0.008)***	0.031 (0.007)***	0.030 (0.007)***
Observations	433	456	456	431	433
R-squared	0.695	0.688	0.683	0.711	0.725
R&D differential (% of mean)	0.097	0.078	0.060	0.066	0.062

Table 6
Transparency and R&D Investment: Alternative sample periods and industry characteristics

Table 6 reports OLS regressions with industry R&D-to-value added$_{i,j}$ 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. *Transparency* is orthogonalized with respect to country GDP-per-capita and legal origin. Fixed country and industry effects are included in all regressions. Standard errors are clustered in the country dimension. The data is from OECD's STAN database and cover 25 manufacturing industries in 20 countries during 1990-2006. All variables are defined in Table A.I.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Alternative sample periods		Alternative industry measures				
	1990-2000	1996-2006	External finance 1980s	External equity	RZ dependence	Cash flow intensity	R&D share of investment
Transparency × *External finance*	0.044 (0.017)**	0.049 (0.015)***					
Transparency × *External finance 1980s*			0.074 (0.028)**				
Transparency × *External equity*				0.048 (0.017)**			
Transparency × *RZ dependence*					0.007 (0.003)**		
Transparency × *Cash flow intensity*						-0.064 (0.023)**	
Transparency × *R&D share*							0.016 (0.007)**
Constant	0.023 (0.008)***	0.037 (0.009)***	0.031 (0.008)***	0.032 (0.008)***	0.043 (0.009)***	-0.048 (0.012)***	0.035 (0.007)***
Observations	429	428	433	433	433	433	433
R-squared	0.656	0.683	0.692	0.692	0.688	0.681	0.694
R&D differential (% of mean)	0.073	0.081	0.156	0.067	0.229	-0.100	0.435

Table 7
Transparency and R&D Investment: Sample splits based on enforcement

Table 7 reports OLS regressions with industry R&D-to-value added$_{i,j}$ as the dependent variable. Countries are sorted into the 'High' *Rule of law* and *Regulatory staff* sub-samples if they are above the sample median, and into the 'Low' sub-samples otherwise. 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 finance* or *R&D intensity* 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. *Transparency* is orthogonalized with respect to country GDP-per-capita and legal origin. Fixed country and industry effects are included in all regressions. Standard errors are clustered in the country dimension. The data is from OECD's STAN database and cover 25 manufacturing industries in 20 countries during 1990-2006. All variables are defined in Table A.I.

	(1)	(2)	(3)	(4)	(5)	(6)
	High rule of law	Low rule of law	*p-value*	High reg staff	Low reg staff	*p-value*
			Panel A: Interaction with industry *External finance*			
Transparency × *External finance*	0.048 (0.011)***	0.028 (0.029)	*0.477*	0.075 (0.015)***	0.016 (0.025)	*0.025*
Constant	0.006 (0.003)	-0.006 (0.010)		0.025 (0.007)***	0.018 (0.013)	
Observations	219	214		201	232	
R-squared	0.756	0.675		0.696	0.756	
R&D differential (% of mean)	0.079	0.046		0.124	0.026	
			Panel B: Interaction with industry *R&D intensity*			
Transparency × *R&D intensity*	0.069 (0.016)***	0.046 (0.044)	*0.575*	0.109 (0.022)***	0.030 (0.037)	*0.042*
Constant	0.005 (0.009)	-0.016 (0.008)*		0.021 (0.009)*	0.021 (0.012)	
Observations	219	214		201	232	
R-squared	0.756	0.677		0.697	0.757	
R&D differential (% of mean)	0.100	0.066		0.157	0.043	

Table 8
Time series changes in the disclosure environment: Evidence from insider trading enforcement

Table 8 reports OLS regressions with industry R&D-to-value added$_{i,j,t}$ as the dependent variable. The investment differential 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-year with insider trading enforcement rather than in a country-year with no insider trading enforcement. *Transparency* is orthogonalized with respect to country GDP-per-capita and legal origin. Fixed country, industry, and country-year fixed effects are included in all regressions. Standard errors are clustered in the country dimension. The data is from OECD's STAN database and cover 25 manufacturing industries in 20 countries during 1990-2006. All variables are defined in Table A.I.

	(1)	(2)	(3)	(4)
	Baseline	Add *Transparency* interaction	End sample in 2000	Sort industries by *R&D intensity*
Insider enforcement × *External finance*	0.467 (0.100)***	0.366 (0.119)***	0.340 (0.115)***	
Transparency × *External finance*		0.038 (0.013)***	0.038 (0.015)**	
Insider enforcement × *R&D intensity*				0.569 (0.188)***
Transparency × *R&D intensity*				0.056 (0.018)***
Constant	0.004 (0.008)	0.049 (0.007)***	0.047 (0.008)***	0.042 (0.006)***
Observations	6,664	6,300	3,826	6,300
R-squared	0.622	0.634	0.628	0.637
R&D differential (% of mean)	0.114	0.089	0.083	0.122

Table A1
Variable descriptions

Variable name	Description	Source
Industry-level variables		
R&D-to-value added	Industry research and development expenditures per dollar of value added. Average over 1990-2006 for each industry-country pair.	OECD
External finance	The ratio of net external financing-to-assets for the median US firm in a given industry, where net external financing is the sum of net stock issues and net long-term debt issues. Both net external financing and assets are summed over the period 1990-2006 prior to computing the ratio.	Compustat
R&D intensity	The ratio of R&D-to-sales for the median US firm in a given industry.	Compustat
External finance 1980s	The ratio of net external financing-to-assets for the median US firm in a given industry computed over the period 1980-1990.	Compustat
RZ dependence	The share of capital spending not financed with operating cash flow for the median US firm in a given industry, computed by Rajan and Zingales (1998) over the period 1980-1989.	Rajan and Zingales (1998)
Cash flow intensity	The ratio of gross cash flow-to-assets for the median US firm in a given industry, where gross cash flow is measured as income before extraordinary expenses plus depreciation plus R&D.	Compustat
R&D share of investment	The ratio of R&D-to-total investment for the median US firm in a given industry, where total investment is measured as capital expenditures plus R&D.	Compustat
Country-level variables		
Transparency	A comprehensive measure of the information environment constructed by Francis et al. (2009). Based on each country's relative ranking across a number of disclosure and transparency measures, including accounting disclosures, auditing activity, analyst coverage, insider trading enforcement, and media coverage.	Francis et al. (2009)
Disclosure intensity	An index of the comprehensiveness of corporate annual reports created by The Center for International Financial Analysis and Research (CIFAR). Based on the average number of 90 different items disclosed by a sample of firms in each country.	CIFAR and Levine (1999)
Financial disclosure	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" constructed by Bushman, Piotroski, and Smith (2004).	Bushman, Piotroski, and Smith (2004)
Earnings transparency	The country aggregate measure of earnings management constructed by Leuz, Nanda, and Wysocki (2003), multiplied by minus one so that higher values indicate less earnings management and more corporate transparency.	Leuz, Nanda, and Wysocki (2003)