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Board Reforms and Innovation

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Abstract

We study the effect of board reforms on firms' research and development (R&D) investments utilizing a sample of 40 countries. Using a difference-in-differences analysis, we find that firms invest more in R&D following corporate governance reforms. Of these, two reforms–having an independent audit committee and board independence–have a greater impact on R&D investment. Additionally, we show that reforms have the largest impact on R&D investment in hi-tech industries and the health sector.

Keywords: Corporate Governance, Board Reforms, Innovation, Research and Development
JEL: classifications G3, O30, O32

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1. Introduction

The importance of research and development (R&D) investment and good governance for firms is well documented in the literature (see Mairesse and Sassenou (1991) and Milosevic et al. (2015) for a literature survey on R&D and corporate governance, respectively). Innovation can vastly improve the welfare of consumers and firms, and thus, benefit the economy. Meanwhile, good corporate governance generally benefits the development of firms, markets, and countries. Unsurprisingly, existing empirical literature from the United States (US) generally shows positive effects of improved governance on firm's innovation intensity (e.g. Becker-Blease (2011), O'Connor and Rafferty (2012)). Given the benefits of good governance as well a number of corporate governance scandals in the last two decades, a significant number of countries voluntarily reformed their governance systems. Here, we use these legal changes to investigate their effect on firm's R&D expenses. That is, we look at whether broad improvement in corporate governance in a country affects firms' innovation in the long term. Moreover, we try to establish which components of the governance reforms are more likely to affect R&D investment.

This study builds on the recent research trends by investigating the potential impact of corporate governance on a firm's R&D orientation. We exploit Fauver et al. (2017) dataset of major board reforms in 41 countries for the period from 1992 to 2012. Using a sample of 78,272 firm-year observations extracted from these data , we employ a difference-in-differences (DID) analysis of the changes in R&D investment following board reforms enforcement. We use regressions that control for time-varying industry- and country-specific characteristics, as well as firm and year fixed effects. We find a significant increase in R&D investment following the board reforms. Among these reforms, having an independent audit committee and board independence have a greater impact on R&D investment. Moreover, we document that the reforms have the largest impact on R&D investment in hi-tech industries and health sector. Our results are robust to using alternative R&D investment measures and samples. Additionally, to gain a higher degree of certainty regarding the correctness of our interpretation of the firm-level results, we address causality and endogeneity concerns by performing two tests. First, we introduce a dynamic model where we control for the effects before and after the reform using several dummies. We observe that only the dummies after the reform are significant. Moreover, we see that while the first effects are already visible one year after the reform, the coefficients are stronger for two and more years after the reforms. Second, if our results are accidental or driven by factors that are unaccounted for, a placebo test would falsify our findings. To examine this possibility, we re-estimate the firm-level models based on random assignments of the board reforms over time. We establish that neither of our conclusions is falsified by this placebo test as the randomly assigned coefficients are insignificant. Consequently, the results of the placebo test are consistent with the view that the board reforms and R&D investment have a causal relationship.

Our study contributes to the existing literature on corporate governance and R&D investment in two ways. First, using a larger set of countries and firms than prior studies, we provide novel evidence on the important link between board reforms and corporate innovation measured by R&D expenses. Our findings contrast prior studies showing that large governance reforms have a detrimental effect on innovation-related activities of public firms in the United States (US; Bargeron et al. (2010)) and the United Kingdom (UK; Driver and Guedes (2012)).

Second, we supplement Fauver et al. (2017)'s study (2017) who provide cross-country evidence that board reforms are related to higher corporate value. However, questions remain about the channels through which board reforms may matter for corporate value. One potentially important channel is R&D financing, a critical input to firm innovation. Bhagat and Welch (1995) report a positive relationship between R&D expenditures and lagged stock returns. The authors argue that higher future growth opportunities (proxied by high stock returns) induce firms to actually increase their R&D investments to realize those opportunities. Furthermore, Pakes (1985) and Hall and Ziedonis (2001) confirm a positive relation between corporate innovation and firm value. In our opinion, board effects mitigate agency conflict, as shown by Chen et al. (2020). In turn, this has a positive impact on R&D investment, and consequently, firm value in the long run.

This study is organized as follows. Section 2 presents the literature review on the link between R&D investment intensity and a firm's corporate governance. In Section 3, we document the variables and methods. Sections 4 and 5 describe the results and robustness tests, respectively. Finally, Section 6 presents the conclusions of this study.

2. Literature review

In the last two decades, we have witnessed increased academic interest on the relationship between a firm's innovation policy and its corporate governance. This is rooted in agency theory as a firm's R&D strategy and decisions are prone to conflicts of interests between managers and shareholders. The problem arises because of the divergence between managers' and shareholders' objectives in terms of the risk related to the firm's corporate R&D investments Baysinger et al. (1991). High R&D investment is generally a high risk strategy that may be attractive to shareholders as they expect a high payoff in the future. Moreover, shareholders can minimize their risk by diversifying their portfolio. However, innovative projects have high failure rates. Therefore, managers are likely to be reluctant to increase R&D expenses. Hence, they are more likely to invest in less risky and innovative R&D projects. This choice may differ from shareholders' preferences. However, McDermott and O'connor (2002) show that effectively developing radical innovation is critical for the long-term survival of firms. They document that firms dominated by a single product generation often fail to maintain leadership when there is a shift to new technology. Therefore, it is important to introduce corporate governance mechanisms that may alleviate the agency problems related to R&D.

Baysinger et al. (1991) analyze the combined effects of board composition and ownership on corporate R&D spending. They find that both the proportion of inside directors serving on the board and the presence of institutional investors as shareholders positively affect corporate R&D investments of large US firms. Kor (2006) further analyzes the effect of management and board outsider compositions on R&D investment. The results suggest that managers are more likely to be reluctant to undertake R&D investments when they become more powerful, as these investments are associated with high risk. Furthermore, Kor (2006) also finds that separating the chief executive officer (CEO) and board chairperson duties is positively associated with R&D investment intensity. However, he provided no evidence on a positive relationship between the ratio of outsiders on the board and firms' R&D investments. Meanwhile,Balsmeier et al. (2017) show that firms whose boards become independent are more likely to file patents and claims. However, this increase comes mainly in areas where the firm has previous patents. Thus, managers in those firms are more likely to exert effort toward maximizing the return of innovation on previously proven trajectories, but may invest less in exploitative types of innovation. That is, they demonstrate that independent boards result in greater, but less creative patenting.

Recent studies have further investigated the effect of internal governance on innovation, particularly focusing on what affects firms' R&D intensity levels. Ederer and Manso (2013) investigated the role of compensation schemes of top management on innovation. investigate the role of compensation schemes of top management on innovation. They find that correctly structured performance-based financial incentives can motivate innovation, while regulations that restrict their use may adversely affect innovation. Barker III and Mueller (2002) document that CEO characteristics explain a significant proportion of the sample variance in firm R&D spending. They show that firms with younger CEOs who have greater wealth invested in the firm's stock and significant career experience in marketing and/or engineering spend more on R&D. Hirshleifer et al. (2012) show that overconfident CEOs invest more in innovation, obtain more patents and patent citations, and achieve greater innovative success for given R&D expenditures. Griffin et al. (2021) report that diverse boards are related to more failure-tolerant and long-term CEOs. These are incentive characteristics that are conducive to improved innovative performance. They show that gender diverse boards have more patents, overall, more novel patents, and a higher innovative efficiency. Moreover, empirical evidence shows that other internal governance mechanics, such as the power separation between managers and board members (Driver and Guedes, 2012) or annual shareholders' meeting rules (Lhuillery, 2011), may determine the incentives of innovation investment. Overall, the literature shows that internal governance plays a key role in explaining firm's R&D expenditures.

Additionally, several studies have further investigated the effect of external governance on innovation, particularity focusing on the relationship between R&D intensity and the degree of ownership concentration or owner identity (Munari et al., 2010; Block, 2012). Francis and Smith (1995) argue that corporate innovation is positively related to ownership concentration as a more concentrated ownership structure will reduce agency cost by effectively disciplining managers. In contrast, Ortega-Argiles et al. (2005) argue that dispersed ownership makes corporate innovation more productive because it offers managers' more flexibility and specialization. Meanwhile, Lee (2005) presents that the effects of ownership concentration on innovation are likely to be nonlinear and depend on the country. Hence, the existing empirical studies present ambiguous results on the effect of ownership on corporate innovation.

Nevertheless, most studies present a positive impact of good governance on firm's R&D investment intensity. However, this relationship is once again less clear between innovation and broader corporate governance reforms in a country. For example, Shadab (2007) investigates the impact of the corporate governance changes brought in the US by the Sarbanes–Oxley Act (SOX). SOX was enacted in response to several corporate failures in 2001. It increased the role of outside monitoring and introduced more internal control over financial reporting. Shadab (2007) finds that corporate governance changes due to objective monitoring by outsiders. However, restricting subjective decision making by insiders may have had a detrimental effect on innovation-related activities of public US firms. However, the empirical results present ambiguous support for this claim.

Bargeron et al. (2010) showed that risk-taking by public US firms decreased after the adoption of SOX, with significantly reduced R&D expenditures compared to their non-US counterparts. In a similar vein, Driver and Guedes (2012) use a corporate governance index and a sample of UK listed firms to provide evidence that more governance tends to depress R&D activity. However, they show that the individual components of the index may have particular effects that are positive for R&D expenditures, even if the overall corporate governance index is negatively related to firm innovation. In summary, these studies show that the adoption of corporate governance provisions aimed at strengthening and protecting shareholders' rights may have some unintended consequences in the form of a reduction in R&D and innovation investments.

In contrast, Gu and Zhang (2017) show that the passage of SOX increased corporate innovation, as measured by the number of patents and the number of citations per patent. They argue that SOX implementation enhanced monitoring from independent directors. This mitigated the agency problem by urging the risk-averse managers to pursue more innovation projects. It shows that the SOX effect is stronger for firms with more entrenched CEOs, as proxied by a longer tenure, and firms with low institutional ownership. Similarly, Honoré et al. (2015) find a positive relationship between corporate governance practice, measured using a governance ratings, and R&D activities of European firms. Their results suggest that governance practices that are designed to respond to the short-term expectations of financial markets may prove to be detrimental to long-term R&D investments.

Meanwhile, a growing steam of research has assessed the effect of internal governance on innovation. This study finds a positive relationship between the two. The results remain the same using either governance changes or indexes. We aim to contribute to the existing literature by providing some new evidence using a large cross-country sample.

3. Data and methodology

We collect a sample of firms from 41 economies that passed major board reforms during 1990-2012. We obtain this data from Fauver et al. (2017), who provide a detailed description of the reforms for each economy in their Appendix A. The countries in the sample consist of developed and developing countries, and represent close to 95% of the total market capitalization worldwide. In our sample, the UK is the first country to adopt major reforms in 1998, while Indonesia is the last country to adopt major reforms in 2008. We follow Fauver et al. (2017) and restrict our sample period to the 11-year window around a reform [-5;5] to alleviate concerns about confounding events. Therefore, our sample period starts from 1993 and ends in 2013. We retrieve the financial data for the firms listed on the stock exchanges in the sample countries from Thomson Financial DataStream for the years 1992-2013. We exclude firms in financial industries (Standard Industry Classification Codes: 6000 to 6999). Furthermore, we exclude firms with missing data and those for which the database reports negative values for R&D, total assets, and sales. We require that all firms have observation in both pre- and post-reform periods. Our final sample consists of 78,272 firms-years observation, where the sample size and period varies by country due to data availability. The country-level variables are retrieved from the World Bank WDI database. Table A1 presents all variables used in our study with their descriptive statistics.

Table A1 here

3.1. Variables

3.1.1. Measure of corporate innovation

Firms make investments in innovation either internally through R&D spending or externally by making acquisitions of innovative targets. The firms' internal investment decision is the focus of this study. Our dependent variable is R&D intensity and is defined as the ratio of R&D expenditures to total sales, as in Mukherjee et al. (2017) and Opler et al. (1999). R&D is a critical element of innovation and measures the firms engagement in development of new products or refinements. R&D efforts can be undertaken relatively quickly, and therefore, can be easily linked to specific events such as board reforms. Moreover, the generally accepted accounting principles require that most R&D costs be expensed in the current period. Hence, using R&D allows us to analyze the causal link between firms' innovation efforts and countries' board reforms.

Following Faleye et al. (2014), we set the ratio to zero when DataStream reports R&D expenses as missing. The R&D to sales ratio controls for the size effect and heteroscedasticity. However, as a robustness check, we also use a ratio where we scale the R&D investment by net assets (calculated as total assets minus cash).

3.1.2. Board governance reforms

Our main variable captures the effect of board governance reforms on R&D activity, which may vary by country. However, the common objective is to strengthen investor rights by changing the practices pertaining to board governance. Fauver et al. (2017) identify the years in which major board reforms became effective as well the three components of the reforms: (1) board independence, (2) audit committee and auditor independence, and (3) requirements of separating the CEO and chairman positions.

We use this set to define the variable *Post* that takes a value of one beginning in the year a major board reform becomes effective in the country and the following four years, and zero otherwise. In other words, we examine each firm and country from the t = -5 to t = 5 year window, where t = 0 in the year of major board reform. In the sensitivity analysis, we examine the effects of the different components on firms R&D activity. In the robustness tests, we relax the sample restrictions.

3.1.3. Control variables

We control for firm and country characteristics using variables that the existing literature suggests may affect firms' R&D investment. We control for firm size (*Size*), measured as the natural log of total assets.Hall and Ziedonis (2001) argue that larger firms innovate more because they enjoy information advantages, economies of scale, and scope in R&D. Additionally, we use the ratio of fixed assets to total assets (*Tangibility*) as a proxy for the size of the past investments in innovative activities.

Singh and Faircloth (2005) document a negative relationship between the firms' financial leverage and R&D investments. Moreover, their results indicate that higher leverage leads to lower R&D expenses. Faleye (2011) argues that financial leverage constrains innovation by increasing managerial risk aversion and diminishing resources available for risky long-term projects. To measure leverage, we use the variable *Leverage*, measured as the ratio of the book value of total debt to the sum of the market value of the equity and book value of debt

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We control for firm performance since better performing firms have easier access to the external capital markets, and thus, can raise funds at a lower cost. We control for operating profitability, as in Faleye et al. (2014), and use the ratio of income before extraordinary items to total assets (*ROA*). We also include proxies for growth opportunities using the market to book ratio (*MtB*). MtB is calculated as the book value of total assets minus the book value of equity plus the market value of equity, divided by the book value of total assets.

Moreover, we control for a country's economic development using GDP per capita (*GDPpc*) and economic growth (*GDP growth*). Griffin et al. (2021) show that in countries with higher GDP per capita, the average level of board gender diversity is higher, which in turn has a positive effect on firm innovation. Moreover, on average, more developed countries have better institutional structure for R&D, while GDP growth should encourage investments. Henceforth, we may expect that both variables will be positively related to firms' R&D investment.

3.2. Methodology

We use board reforms as an exogenous shock to identify the effects of changes in board structure on firms R&D activity. Specifically, we use a DID design and estimate the following regression model:

$$RD = \alpha + \beta_1 Post_{i,t} + \beta_2 F_{i,t} + \beta_3 C_{i,t} + \eta_t + \delta_i + +\epsilon_{i,t} \quad (1)$$

where RD represents the R&D investments for firm i at time t; F and C are vectors of firm- and country-level control variables, respectively; η, and δ are industry x year, and firm fixed effects, respectively; $Post$ is a binary variable that indicates the post-reform period; and ϵ is an error term. This methodology implicitly takes all firms from countries without reforms as the control group at time t.

To control for potential time-invariant firm and industry level factors in our main specification, we include firm and industry x year fixed effects in all regressions. Industries are defined following Fama and French (1997) 48 industry classification. Our industry x year fixed effects control for aggregate fluctuation within an industry and a year. Controlling for time-varying covariates in the regression can ease the effect of possible non-parallel trends. Time-invariant differences between the treatment and control groups can be captured by firm fixed effects, including the pre-treatment condition and any common time trend unrelated to the treatment (Atanasov and Black, 2016). The effect of board reform is captured by β_1. A positive (negative) coefficient indicates an increase (decrease) in the firms R&D investments. We follow Griffin et al. (2021) and use robust standard errors that are clustered at the firm level. [1]

4. Results

Table 2 presents the results of the average effect of corporate board reforms on firm R&D investments. Columns (1)-(3) present our baseline results where the dependent variable is R&D investments to sales. Columns (4)-(6) present the results where we employ our alternative variable of R&D investments to net assets. In columns (1) and (4), we do not

[1] In a robustness test, we cluster standard errors at the country level and our results remain unchanged.

include the firm fixed effects and include the country fixed effects. In columns (2) and (5), we add the firm fixed effects, and do not interact the industry with year and add them separately. We estimate our main specifications in column (3) and (6), where we include industry x year and firm fixed effects. We find that the coefficient on Post is significantly positive in all specifications, suggesting that firms spend more on R&D in the post-reform period. The effect is also economically significant. The results in column (3) indicate that R&D investments increases by 2.13 percentage points following the reforms. This translates into an increase of 14% from our sample average of 16%.

The coefficients for the control variables are generally consistent with prior studies. In all specifications, we find that the coefficient for growth opportunities is positively related to R&D spending and significant at the 1% level. Meanwhile, we find that R&D investment is negatively related to leverage and highly significant. This result is in line with Singh and Faircloth (2005). findings. Moreover, the coefficient for profitability and tangibility is also negatively related to R&D. The coefficient for size is negative and significant only when we use our alternative variable. Still, in columns (1)-(3), the coefficient for size is indeed positive, but insignificant. However, in a robustness test, when we cluster the standard errors at country level, the coefficient for size is weakly statistically significant. In conclusion, the results related to size remain ambiguous.

The results for the country-level control variables in Table2 are as expected. The proxy variable for economic development is positive and significantly related to R&D spending, as reported by Griffin et al. (2021). In contrast, the coefficient for economic growth is negative and statistically significant at the 1% level in all specifications. One explanation for the results is that on average, higher GDP growth is in observed low-income countries. These countries have lower R&D spending in comparison to developed countries.

Table 2 here

4.1. Sensitivity

Here, we further analyze our results by two sensitivity tests. First, we investigate how the three major components of board reforms affect the firm's R&D investments. The three major components are as follows: 1) board independence, 2) audit committee and auditor independence, and 3) separation of the chairman and CEO positions. We re-estimate our model. However, now the dummy variable Post equals one starting in the year when the reform involving the individual component becomes effective. Columns (1)-(3) of Table 3 report the results for major reforms that involve board independence, audit committee and auditor independence, and chairman and CEO separation, respectively. We find that the coefficient on Post is significantly positive in countries with reforms involving board independence and audit committee and auditor independence. In contrast, we do not find a positive effect of reforms involving chairman and CEO separation.

In other words, our results indicate that reforms involving more representation from outsiders, but not those on separating the chairman and CEO positions, lead to greater increases in R&D investments. These results are in line with Balsmeier et al. (2017) , who show a positive and economically large effect of board independence on firm's innovation. They document that one year after the transition to an independent board, the number of patents increases between 20% and 30%, and the number of citations between 40% and 60%. Moreover, our results complement the findings of Fauver et al. (2017), who find that the two reforms involving board independence and audit committee and auditor independence lead to higher firm value. Our results suggest that these channels increase R&D intensity, which in turn further augments technological innovations.

Table 3 here

Second, we further examine the generality of our finding on the relation between board reforms and corporate innovation, particularly between innovative and noninnovative industries. Hirshleifer et al. (2012) show that the effect of CEOs achieving greater innovative success for given R&D expenditures happens but only in innovative industries. Hence, we expect that the effect of board reforms on R&D intensity will be larger for industries where more opportunities exist for innovation.

Therefore, we split the sample using the Fama and French (1997) industry classification and create five subsamples consisting of firms from the following sectors: consumer (Cnsmr), manufacturing (Manuf), high-tech (HiTec), health care (Hlth), and others (Other). Table 4 presents the results across the five subsamples.

We find that the coefficient for the variable identifying board reforms is positive for four subsamples. However, it is only statistically significant for the subsamples representing high-tech and health care sectors. Our results are not surprising as these two sectors are technologically intensive, where investments in R&D have been the primary source of product innovation and superior returns (Kor, 2006). In these sectors, R&D investment intensity constitutes an important input for the development of differentiation and product innovation. Product innovation is important for the firm's survival in the long term. Our results are in line with Gu and Zhang (2017), who find that effect of corporate reforms (SOX), in the form of corporate innovation output, was stronger for firms operating in innovative industries.

Thus, our results provide evidence that improved governance through board reforms has a positive impact on R&D expenses of technologically intensive firms. Further, we find that the control variables for the high-tech and health care subsamples are in line with the results presented in Table 2.

Table 4 here

4.2. Robustness

We check the robustness of our findings using several methods. First, we follow Fauver et al. (2017) and use robust standard errors that are clustered by country as board reforms are a country-level decision. Table A1 in the Appendix show the results and they do not differ from our main results presented in Table 2.

Second, we alternate our sample and the results using alternative samples shown in Table 5. In column (1), we relax our assumption about the sample and include those firms that have at least one year in the pre- and post-periods. Then, the sample size increases from 78,272 to 170,363 firm-year observations. However, the results remain qualitatively similar to the results in Table 2. Next, to assess whether the results are not driven by the countries having the largest representation in our sample, we exclude them. Columns (2)-(4) present our analyses after excluding the US, UK, and Japanese firms from the sample, respectively. We find that alternating the sample does not change our main results. In all specifications, the coefficients have the same sign and significance as in Table 2.

Table 5 here

Third, we further examine whether our results are sensitive to sample construction. To address this concern, we use propensity score matching procedures, based on observable firm characteristics, to match observations subject to board reforms with observations not subject to such reforms. That is, we match each board reform firm to a non–board reform firm using all firm-level control variables. The results of the matching procedures are presented in Panel A in Table 6. The univariate statistics support our approach as we find that, on average, the matched firms in the treated group differed significantly from the control group. However, after the matching procedure, the firms in those two samples do not differ significantly. Next, we re-estimate our basic model using the matched sample. Panel B in Table 6 shows that the effect of board reform on R&D investments is significantly positive. In particular, we continue to find that the coefficient on Post is positive and significant at the 1% level. Thus, our results are not determined by sampling bias.

Table 6 here

Fourth, we assess whether the identified association between board reforms and corporate innovation is likely to be causal. We follow Fauver et al. (2017) and replace the Post indicator with indicator variables that track the effect of the reforms before and after they become effective. In columns (1) and (2) in Table 7, we include new dummy variables that are positive prior or after the reforms becomes effective. The variables *Years 1 and 2 before*, *Year 2 before*, and *Year 1 before* equal one for year two and/or one before the reform becomes effective, respectively, and zero otherwise. The variable *Year of Reform* equals one for the year the reform becomes effective, and zero otherwise. Lastly, the variables *Year after* and *Year 2 to max* after equal one for the year, and one for year 2 and the subsequent years after the board reform becomes effective, respectively, and zero otherwise.

If the board reforms are passed as an answer to changes in the countries' economic or political conditions, one can expect an effect on R&D investments prior to the reform. However, in columns (1) and (2), we find that the coefficients for the variables identifying the years prior to the board reforms and the year of the board reform are insignificant. This means that firms did not increase R&D investments prior to the board reform and in the year the board reform is effective. In contrast, we find a significant coefficient for indicators year one after, and year two and more after the board reform. In other words, the results show an increase in R&D investments at least one year after the board reform is effective in the firm's country. We find that the results are stronger for the indicator showing year two and more after the reform. We attribute this result to the fact that innovation is not a process that can be started immediately. Our results support the findings of Balsmeier et al. (2017), who show that the effects of board independence on innovation are visible only one year after an increase in board independence.

In summary, the results provide evidence on the casual relationship between board reforms and firm's R&D investment. To mitigate concerns that our results may be attributable to confounding events, we conduct a placebo (falsification) test using pseudo board reform years. Specifically, we assign each firm a random board reform year as the pseudo year and repeat the analysis in our baseline DID analysis. The results are reported in columns (3) and (4) in Table 7. We find no evidence of changes in R&D investments after the pseudo board reform years, as indicated by the insignificant coefficient on Post. This finding allows us to reject the hypothesis that the increase in R&D investments following board reforms is due to confounding effects.

Table 7 here

5. Conclusions

In the last two decades, several countries have conducted significant corporate governance reforms, starting with the adoption of corporate code mandated on a comply-or-explain basis to wide-ranging and extensive passages of laws applying to public firms. The initial idea behind these reforms is that good governance enhances the development of firms', markets, and thus, economies in the long run.

Corporate governance is also likely to influence R&D expenditure (Chung et al., 2003). However, there is no consensus in the literature regarding the expected nature and strength of any effects. Surprisingly, general executive managers and shareholders consider innovation a top strategic priority, and plan on sustaining or even increasing the high levels of assets allocated to innovation activities . Unlike corporate investment in physical assets, investment in innovation is highly risky and is characterized by a high degree of uncertainty. Generally, however, managers are more risk averse than shareholders as the latter can diversify risk by owning shares in other firms. In contrast, managers tend to have a more short-term focus than shareholders since the former generally do not own shares. However, the literature argues that existing agency conflicts can be mitigated through good internal governance in firms (Shleifer and Vishny, 1997).

In this paper, we present large-sample evidence on the effect of reforms on firm's innovation around the world. We find that across the 45 countries in our sample, changes in the governance of public firms resulted in increased R&D spending following the reforms. We further find that the corporate board reforms seem to have the strongest effect on the increase in innovation, as measured by R&D expenditures. Moreover, we find that the effect is much stronger for innovative industries.

We conducted numerous robustness checks on our main findings, including using alternative measures of innovation, alternative samples, focusing on specific industries, and controlling for other dimensions. To address the reverse causality concern, we employ a change-on-change specification to assess how the board reform-corporate innovation relation unfolds over time. We find that after two or more years, board reforms are followed by an improvement in innovative performance. This shows that reverse causality is unlikely to drive our results. Furthermore, we re-estimate the firm-level models based on the random assignment of the board reforms over time and find that the random coefficient is insignificant. In summary, the results of the placebo test are consistent with the view that the board reforms and R&D investment have a causal relationship.

We conclude that our results provide strong support for the hypothesis that good governance influences corporate innovation, particularly through board reforms. In our opinion, the results are policy relevant as they show that improved governance not only positively influences firms and markets development, but also firm innovation. In turn, this has a positive effect on the countries' economic growth.

References

Atanasov, V. A. and Black, B. S. (2016), 'Shock-based causal inference in corporate finance and accounting research', *Critical Finance Review* **5**, 207–304.

Balsmeier, B., Fleming, L. and Manso, G. (2017), 'Independent boards and innovation', *Journal of Financial Economics* **123**(3), 536–557.

Bargeron, L. L., Lehn, K. M. and Zutter, C. J. (2010), 'Sarbanes-oxley and corporate risk-taking', *Journal of Accounting and Economics* **49**(1-2), 34–52.

Barker III, V. L. and Mueller, G. C. (2002), 'Ceo characteristics and firm r&d spending', *Management Science* **48**(6), 782–801.

Baysinger, B. D., Kosnik, R. D. and Turk, T. A. (1991), 'Effects of board and ownership structure on corporate r&d strategy', *Academy of Management Journal* **34**(1), 205–214.

Becker-Blease, J. R. (2011), 'Governance and innovation', *Journal of Corporate Finance* **17**(4), 947–958.

Bhagat, S. and Welch, I. (1995), 'Corporate research & development investments international comparisons', *Journal of Accounting and Economics* **19**(2-3), 443–470.

Block, J. H. (2012), 'R&d investments in family and founder firms: An agency perspective', *Journal of Business Venturing* **27**(2), 248–265.

Chen, R. R., Guedhami, O., Yang, Y. and Zaynutdinova, G. R. (2020), 'Corporate governance and cash holdings: Evidence from worldwide board reforms', *Journal of Corporate Finance* **65**, 101771.

Chung, K. H., Wright, P. and Kedia, B. (2003), 'Corporate governance and market valuation of capital and r&d investments', *Review of Financial Economics* **12**(2), 161–172.

Driver, C. and Guedes, M. J. C. (2012), 'Research and development, cash flow, agency and governance: Uk large companies', *Research Policy* **41**(9), 1565–1577.

Ederer, F. and Manso, G. (2013), 'Is pay for performance detrimental to innovation?', *Management Science* **59**(7), 1496–1513.

Faleye, O. (2011), 'Ceo directors, executive incentives, and corporate strategic initiatives', *Journal of Financial Research* **34**(2), 241–277.

Faleye, O., Kovacs, T. and Venkateswaran, A. (2014), 'Do better-connected ceos innovate more?', *Journal of Financial and Quantitative Analysis* **49**(5-6), 1201–1225.

Fama, E. F. and French, K. R. (1997), 'Industry costs of equity', *Journal of Financial Economics* **43**(2), 153–193.

Fauver, L., Hung, M., Li, X. and Taboada, A. G. (2017), 'Board reforms and firm value: Worldwide evidence', *Journal of Financial Economics* **125**(1), 120–142.

Francis, J. and Smith, A. (1995), 'Agency costs and innovation some empirical evidence', *Journal of Accounting and Economics* **19**(2-3), 383–409.

Griffin, D., Li, K. and Xu, T. (2021), 'Board gender diversity and corporate innovation: International evidence', *Journal of Financial and Quantitative Analysis* **56**(1), 123–154.

Gu, Y. and Zhang, L. (2017), 'The impact of the sarbanes-oxley act on corporate innovation', *Journal of Economics and Business* **90**, 17–30.

Hall, B. H. and Ziedonis, R. H. (2001), 'The patent paradox revisited: an empirical study of patenting in the us semiconductor industry, 1979-1995', *rand Journal of Economics* pp. 101–128.

Hirshleifer, D., Low, A. and Teoh, S. H. (2012), 'Are overconfident ceos better innovators?', *The journal of finance* **67**(4), 1457–1498.

Honoré, F., Munari, F. and de La Potterie, B. v. P. (2015), 'Corporate governance practices and companies' r&d intensity: Evidence from european countries', *Research Policy* **44**(2), 533–543.

Kor, Y. Y. (2006), 'Direct and interaction effects of top management team and board compositions on r&d investment strategy', *Strategic Management Journal* **27**(11), 1081–1099.

Lee, P. M. (2005), 'A comparison of ownership structures and innovations of us and japanese firms', *Managerial and Decision Economics* **26**(1), 39–50.

Lhuillery, S. (2011), 'The impact of corporate governance practices on r&d efforts: a look at shareholders' rights, cross-listing, and control pyramid', *Industrial and Corporate Change* **20**(5), 1475–1513.

Mairesse, J. and Sassenou, M. (1991), 'R&d productivity: A survey of econometric studies at the firm level', *NBER working paper* (w3666).

McDermott, C. M. and O'connor, G. C. (2002), 'Managing radical innovation: an overview of emergent strategy issues', *Journal of Product Innovation Management* **19**(6), 424–438.

Milosevic, D., Andrei, S. and Vishny, R. W. (2015), 'A survey of corporate governance', *Journal of Finance* **52**, 737–783.

Mukherjee, A., Singh, M. and Žaldokas, A. (2017), 'Do corporate taxes hinder innovation?', *Journal of Financial Economics* **124**(1), 195–221.

Munari, F., Oriani, R. and Sobrero, M. (2010), 'The effects of owner identity and external governance systems on r&d investments: A study of western european firms', *Research Policy* **39**(8), 1093–1104.

O'Connor, M. and Rafferty, M. (2012), 'Corporate governance and innovation', *Journal of Financial and Quantitative Analysis* **47**(2), 397–413.

Opler, T., Pinkowitz, L., Stulz, R. and Williamson, R. (1999), 'The determinants and implications of corporate cash holdings', *Journal of Financial Economics* **52**(1), 3–46.

Ortega-Argiles, R., Moreno, R. and Caralt, J. S. (2005), 'Ownership structure and innovation: is there a real link?', *The Annals of Regional Science* **39**(4), 637–662.

Pakes, A. (1985), 'On patents, r & d, and the stock market rate of return', *Journal of Political Economy* **93**(2), 390–409.

Shadab, H. B. (2007), 'Innovation and corporate governance: The impact of sarbanes-oxley', *University of Pennsylvania Journal of Business and Employment Law* **10**, 955.

Shleifer, A. and Vishny, R. W. (1997), 'A survey of corporate governance', *Journal of Finance* **52**(2), 737–783.

Singh, M. and Faircloth, S. (2005), 'The impact of corporate debt on long term investment and firm performance', *Applied Economics* **37**(8), 875–883.

Table 1: Summary statistics

The table provides means, standard deviations, and the 25th, 50th, and 75th percentiles for the variables used in this study. The sample consists of 78,272 firm-year observations in 41 countries for the years 1990–2012. R&D is the ratio of research and development expenditures to total assets. Posts is a dummy variable that takes value of for the years following the board reforms. Size is the log of total assets in millions of dollars. Leverage is the ratio of total debt to total assets. Tangibility is the ratio of fixed assets to total assets. ROA is the ratio of pretax income to total assets. MtB is the ratio of market value to book value. GDP growth is the countries economic growth. GDP per capita is the countries' GDP per capita.

Variable	Mean	Std Dev.	25th	Median	75th.
R&D	16.137	51.116	0.112	1.529	7.526
Post	0.570	0.495	0.000	1.000	1.000
Size	18.919	2.435	17.457	18.949	20.434
Leverage	69.107	145.666	1.411	17.212	62.917
Tangibility	26.004	19.532	9.630	22.254	37.978
ROA	-7.327	33.475	-5.418	2.900	7.778
MTB	2.664	4.211	0.811	1.623	3.203
GDP growth	2.847	2.211	1.663	2.726	3.868
GDP pc	10.242	0.845	10.321	10.492	10.589

Table 2: Effect of board reforms on R&D intensity

The table shows the results of DID regressions of board reforms on R&D investments using the [-5,+ 5] sample. The dependent variable in columns (1)-(3) and (4)-(6) are the ratio of R&D expenses to sales and to net assets, respectively. The variable of interest is Post that equals one starting the year in which the board reform becomes effective in the country, and zero otherwise. Variable definitions are provided in Table . Standard errors are adjusted for heteroskedasticity and clustered on firm-level. t-statistics are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Post	4.152***	4.118***	2.131***	0.521**	0.673***	0.389**
	0.000	0.000	0.000	0.023	0.006	0.037
Size	0.187	0.170	0.467	-0.303***	-0.323***	-1.150***
	0.153	0.196	0.397	0.000	0.000	0.000
Leverage	-0.014***	-0.015***	-0.004***	-0.009***	-0.009***	-0.002***
	0.000	0.000	0.000	0.000	0.000	0.003
Tangibility	-0.312***	-0.309***	-0.136***	-0.199***	-0.198***	-0.046***
	0.000	0.000	0.000	0.000	0.000	0.000
ROA	-0.565***	-0.559***	-0.102***	-0.264***	-0.259***	-0.068***
	0.000	0.000	0.000	0.000	0.000	0.000
MTB	0.879***	0.860***	0.027	0.369***	0.372***	-0.065**
	0.000	0.000	0.648	0.000	0.000	0.020
GDP growth	-0.335***	-0.373***	-0.175***	-0.132***	-0.170***	-0.098***
	0.000	0.000	0.001	0.000	0.000	0.000
GDPpc	4.975***	5.136***	1.785	1.326	1.538*	1.791**
	0.008	0.009	0.278	0.108	0.074	0.017
Year FE	Yes			Yes		
Industry FE	Yes			Yes		
Country FE	Yes	Yes		Yes	Yes	
Industry x Year FE		Yes	Yes		Yes	Yes
Firm FE			Yes			Yes
Adj. R^2	0.282	0.287	0.774	0.323	0.326	0.807
F-Statistic	166.5	162.3	11.95	205.8	199.4	22.93
Countries	41	41	41	41	41	41
Observations	78,272	78,272	78,272	78,169	78,169	78,169

Table 3: Analysis of the effect of components of board reforms on R&D intensity

The table shows the results of DID regressions of the components of board reforms on R&D investments. The variable Post identifies in: column (1) the reforms of board independence; column (2) the reforms of audit committee and auditor independence; and column (3) the reforms of chairman and CEO separation. The dependent variable is R&D to Sales and the variables of interest are Post. Variable definitions are provided in Table . Standard errors are adjusted for heteroskedasticity and clustered on firm-level. t-statistics are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	(1)	(2)	(3)
Post	0.922**	2.067***	1.396
	0.034	0.000	0.123
Size	0.457	0.474	0.456
	0.407	0.389	0.408
Leverage	-0.004***	-0.004***	-0.004***
	0.000	0.000	0.000
Tangibility	-0.136***	-0.136***	-0.136***
	0.000	0.000	0.000
ROA	-0.102***	-0.102***	-0.101***
	0.000	0.000	0.000
MTB	0.029	0.027	0.029
	0.630	0.653	0.625
GDP growth	-0.122**	-0.161***	-0.120**
	0.018	0.003	0.020
GDP pc	0.910	1.999	0.536
	0.589	0.229	0.669
Industry x Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Adj R^2	0.281	0.287	0.774
F-Statistic	173.5	168.6	11.95
Countries	41	41	41
Observations	79,861	79,780	78,272

Table 4: Effect of board reforms on R&D intensity by industry

The table shows the results of DID regressions of board reforms on R&D investments. In the columns we present the results for the subsamples consisting of firms from consumer (Cnsmr) sector, manufacturing (Manuf), high-tech (HiTec), health care (Hlth) and other sectors (Other). The dependent variable is R&D to Sales and the variables of interest are Post. Variable definitions are provided in Table . Standard errors are adjusted for heteroskedasticity and clustered on firm-level. t-statistics are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	Cnsmr	Manuf	HiTec	Hlth	Other
Post	0.246	0.625	2.826***	7.690***	-0.489
	0.509	0.261	0.002	0.001	0.613
Size	-1.545	-0.248	1.676*	-1.414	0.142
	0.217	0.848	0.061	0.452	0.869
Leverage	0.000	-0.001	-0.013***	-0.006	-0.001
	0.766	0.349	0.001	0.393	0.415
Tangibility	-0.046	-0.101	-0.161***	-0.345***	-0.066*
	0.182	0.111	0.010	0.005	0.098
ROA	-0.002	-0.050	-0.121***	-0.196***	-0.042*
	0.944	0.105	0.000	0.000	0.088
MTB	-0.119	0.489***	0.021	-0.076	0.005
	0.199	0.001	0.796	0.703	0.975
GDP growth	0.121**	-0.009	-0.411***	-0.934***	-0.001
	0.021	0.879	0.009	0.009	0.995
GDP pc	-2.423	0.325	5.754	8.573	-4.697
	0.112	0.897	0.172	0.423	0.149
Year FE	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Adj R^2	0.707	0.698	0.725	0.791	0.675
F-Statistic	1.904	2.371	6.405	6.144	0.946
Countries	41	41	41	41	41
Observations	15,911	20,757	23,406	8,615	9,676

Table 5: Robustness test of the effect of board reforms on R&D intensity

The table shows the results of DID regressions of board reforms on R&D investments. In Column 1, the assumption about the sample are relaxed. In Columns (2)-(4) we exclude US, UK and Japanese firms from the sample, respectively. The dependent variable is R&D and the variables of interest are Post. Variable definitions are provided in Table . Standard errors are adjusted for heteroskedasticity and clustered on firm-level. t-statistics are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	(1)	(2)	(3)	(4)
Post	0.725*	1.561***	1.430***	2.189***
	0.086	0.003	0.008	0.000
Size	0.954***	0.286	0.448	0.457
	0.001	0.721	0.432	0.422
Leverage	-0.005***	-0.002*	-0.005***	-0.004***
	0.000	0.093	0.000	0.000
Tangibility	-0.088***	-0.130***	-0.146***	-0.137***
	0.000	0.000	0.000	0.000
ROA	-0.146***	-0.058***	-0.103***	-0.104***
	0.000	0.005	0.000	0.000
MTB	0.120**	0.064	0.033	0.024
	0.013	0.465	0.602	0.704
GDP Growth	-0.060**	-0.132**	-0.177***	-0.180***
	0.031	0.028	0.006	0.001
GDP pc	1.724**	2.759*	2.156	1.726
	0.014	0.088	0.381	0.312
Industry x Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Adj. R^2	0.741	0.789	0.767	0.773
F-Statistic	30.29	4.088	10.66	11.58
Countries	41	40	40	40
Observations	170,363	46,919	61,882	74,063

Table 6: Matched sample

The table shows the results of DID of board reforms on R&D investments. Panel A presents pairwise comparisons of the variables on which the matching is performed both before and after the matching using one-to-one propensity-score-matching algorithm based on a firm's level control variables. Panel B present the results of the OLS regression where the dependent variable is R&D to Sales. The variables of interest are Post and variable definitions are provided in Table . Standard errors are adjusted for heteroskedasticity and clustered on firm-level. t-statistics are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Panel A: Comparison of means across matched sample

	before matching			after matching		
	Treated	Control	t-stat	Treated	Control	t-stat
Size	18.880	18.940	-3.36	18.880	18.870	0.24
Leverage	59.980	80.870	-10.72	59.980	61.390	-1.07
Tangibility	25.370	26.870	-10.72	25.370	25.530	-0.86
ROA	-6.968	-8.001	4.32	-6.971	-7.249	0.89
MTB	2.514	2.872	-11.87	2.515	2.472	1.13

Panel B: Board reforms

	(1)	(2)
Post	4.229***	2.243***
	0.000	0.000
Size	0.193	0.726
	0.186	0.219
Leverage	-0.016***	-0.004***
	0.000	0.001
Tangibility	-0.324***	-0.122***
	0.000	0.000
ROA	-0.591***	-0.095***
	0.000	0.000
MTB	1.016***	0.040
	0.000	0.595
GDP growth	-0.301***	-0.170**
	0.001	0.011
GDP pc	4.574**	1.939
	0.035	0.283
Country FE	Yes	
Industry x Year FE	Yes	Yes
Firm FE		Yes
Adj R^2	0.29	0.787
F-Statistic	141	9.284
Countries	41	41
Observations	64,903	64,903

Table 7: Board reform timing and placebo tests

The table shows the results of DID regressions of board reforms on RD investments. The dependent variable is R&D to Sales and the variables of interest are Post. In columns (1)-(2) we identify the periods before and after the board reforms. In columns (3)-(4) the variable Post is assigned randomly. Variable definitions are provided in Table . Standard errors are adjusted for heteroskedasticity and clustered on firm-level. t-statistics are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	(1)	(2)	(3)	(4)
Post			0.077	-0.040
			0.804	0.836
Year 1 and 2 before	0.020			
	0.970			
Year 2 before		0.262		
		0.611		
Year 1 before		-1.072		
		0.116		
Year of Reform	0.312	-0.541		
	0.650	0.511		
Year after	2.222**	1.252		
	0.012	0.223		
Year 2 to max after	3.983***	2.759**		
	0.000	0.032		
Size	0.461	0.458	0.114	0.433
	0.403	0.406	0.387	0.428
Leverage	-0.004***	-0.004***	-0.015***	-0.004***
	0.000	0.000	0.000	0.000
Tangibility	-0.136***	-0.136***	-0.310***	-0.136***
	0.000	0.000	0.000	0.000
ROA	-0.102***	-0.102***	-0.561***	-0.101***
	0.000	0.000	0.000	0.000
MTB	0.028	0.030	0.872***	0.032
	0.635	0.613	0.000	0.590
GDP growth	-0.201***	-0.190***	-0.264***	-0.110**
	0.000	0.001	0.000	0.028
GDP pc	1.806	2.100	5.176***	1.674
	0.266	0.193	0.009	0.308
Country FE			Yes	
Industry x Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes		Yes
Adj. R^2	0.774	0.774	0.288	0.775
F-Statistic	9.736	9.534	162.5	10.51
Countries	41	41	41	41
Observations	78,272	78,272	78,169	78,169

Table A1: Robustness analysis of the main results

The table shows the results of DID regressions of board reforms on R&D investments. The dependent variable in columns (1)-(3) and (4)-(6) is R&D to sales and to net assets, respectively. The variables of interest are Post. Variable definitions are provided in Table . Standard errors are adjusted for heteroskedasticity and clustered on firm-level. t-statistics are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	(1)	(2)	(3)
Post	4.152***	4.118***	2.131***
	0.000	0.000	0.001
Size	0.187	0.170	0.467***
	0.571	0.596	0.005
Leverage	-0.014***	-0.015***	-0.004**
	0.003	0.004	0.020
Tangibility	-0.312***	-0.309***	-0.136***
	0.000	0.000	0.000
ROA	-0.565***	-0.559***	-0.102***
	0.000	0.000	0.000
MTB	0.879***	0.860***	0.027
	0.000	0.000	0.249
GDP growth	-0.335***	-0.373***	-0.175***
	0.002	0.004	0.001
GDP pc	4.975	5.136	1.785
	0.303	0.315	0.350
Year FE	Yes		
Industry FE	Yes		
Country FE	Yes	Yes	
Industry x Year FE		Yes	Yes
Firm FE			Yes
Adj. R^2	0.282	0.287	0.774
F-Statistic	120.4	125.3	101.5
Countries	41	41	41
Observations	78,272	78,272	78,272