Saving Long-term Investment From Short-Termism:

the Surprising Role of Short Selling

Massimo Massa[*], Fei Wu[†], Bohui Zhang[‡], Hong Zhang[§],

Abstract

We propose that a more effective short selling market can help mitigate managerial short-termism. Based on a sample of 11,969 firms across 33 countries over the 2003-2009 period, we observe that the threat of short selling increases long-term (i.e., R&D) investment while reducing short-term (i.e., capital expenditure) investment. Tests based on regulatory experiments and instrumental variable support a causal interpretation. We further find that short selling promotes long-term investment through improved price efficiency, an enhanced disciplining effect, and a more positive feedback effect, and that its impact is beneficial in that it reduces under-investment rather than inducing over-investment and that it enhances a firm's future performance and innovation output.

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[*] INSEAD, Boulevard de Constance, 77305 Fontainebleau Cedex, France; E-mail: massimo.massa@insead.edu.
[†] SAIF, Shanghai Jiao Tong University, 211 West Huaihai Road, Shanghai, China, 200030; Email: fwu@saif.sjtu.edu.cn.
[‡] University of New South Wales, Sydney, NSW, Australia, 2052; Email: bohui.zhang@unsw.edu.au.
[§] PBC School of Finance, Tsinghua University, 43 Chengfu Road, Haidian District, Beijing, PR China 100083, Email: zhangh@pbcsf.tsinghua.edu.cn.

Harvard University Professor Michael Porter, the world's leading academic strategist, noted recently, "Capital markets can be toxic to strategy." ... The Aspen Institute echoes this sentiment. It recently issued a clarion call for "Overcoming Short-termism" that was endorsed by 28 national leaders.

– The Wall Street Journal, October 30, 2009.

Introduction

The last few decades have witnessed heated debate over short-term managerial focus in investment ("short-termism"). One major contention has been that short-term investors induce managers to focus on short-term goals. Michael Porter, for instance, wrote: "the U.S. system first and foremost advances the goals of shareholders interested in near-term appreciation of their shares - even at the expense of the long-term performance of American companies," which could produce disadvantages for U.S. firms vis-à-vis their foreign competitors (Porter 1992). Two decades later, books have been published with glaring titles such as "Saving Capitalism From Short-Termism: How to Build Long-Term Value and Take Back Our Financial Future" (Rappaport 2011). Such books document that many executives adopt a short-term orientation because investors' horizons are short. Hence, the common wisdom is that *short-term investors impose short-term goals*; in other words, short-term shareholders doom companies to short-term investment and a lack of focus on the future.[1]

However, the above argument ignores an important question: do some short-term investors know more about managers' actions than the general public, and if so, does their superior information help overcome short-termism? Our novel view is that some short-term investors may possess better information than the market and are thus able to reduce the asymmetry of information between managers and the market. In so doing, they may shift the incentives of managers toward the long run. In other words, in contrast to the traditional wisdom, the presence of more informed short-term investors may actually *reduce* managerial short-termism.

In general, short-termism is linked to the asymmetry of information between managers and the market by two channels. First, when the market cannot observe the full spectrum of managerial actions, moral hazard will induce managers to steer their investment choices

[1] This may, for instance, lead firms to forego valuable long-term investment projects to meet short-term earnings goals (Graham, Harvey, and Rajgopal 2005).

toward short-term objectives (e.g., Narayanan 1985; Stein 1989; Benmelech, Kandel, and Veronesi 2010). Second, in the presence of asymmetric information, even well-meaning long-term managers will find it difficult to convey the promising prospects of long-term projects to the market. Therefore, bad firms have incentives to mimic the investment decisions of good firms, which creates a lemon problem (Myers and Majluf 1984; Trueman 1986): good firms either over-invest as a form of signaling behavior (Bebchuk and Stole 1993) or under-invest in keeping with market preferences (Brandenburger and Polak 1996). A common feature of the two channels is that asymmetric information distorts managerial incentives, which leads to managerial short-termism and myopic investment.

Better-informed (with respect to the market) short-term investors can mitigate the issue of myopic investment that arises through either channel. Indeed, they help reduce information asymmetry and signal the quality of long-term investment projects through their action/inaction – e.g., by selling the stocks of firms engaging in value-destroying projects and holding the stocks of firms engaging in value-increasing projects. Even the sell side alone, which is the focus of our paper, can reduce information asymmetry between firms and the market. That is, given that short-term investors in general sell firms that make value-destroying investment decisions, the market will interpret their decision not to sell as a vote of confidence in managers' investment decisions. In other words, informed short-term investors play the role of "the dog that did not bark", sending a signal to the market through their trading or lack thereof.

These considerations suggest that the presence of informed short-term investors in the market may incentivize firms to engage in more value-creating long-term projects than short-term projects. We refer to this notion as the "*watch-dog hypothesis*", which is in contrast to the alternative "*myopic (short-term) investor hypothesis*" that better reflects the traditional wisdom. In particular, the watch-dog hypothesis differs from the myopic investor hypothesis in predicting that informed short-term investors overcome—rather than encourage—firm short-termism, making firm investment both more long-term oriented and more value-creating.

We further hypothesize that the positive link between short-term investors and long-term investment should be stronger when moral hazard is more severe or when it is more difficult for managers to convey private information about long-term projects to the market. Indeed, the watch-dog effect reduces managers' incentives to boost short-term cash flows/stock prices at the expense of future long-term cash flows (i.e., moral hazard). These incentives are greater when other mechanisms (e.g., governance) fail to mitigate moral hazard or when increased information asymmetry creates a “lemon problem”, making it less appealing for managers to invest in superior long-term projects. In contrast, according to the myopic investor hypothesis, the combination of more myopic short-term investors and a more severe moral hazard/lemon problem only persuades managers to adopt a more short-term focus. In addition to the traditional issues of moral hazard and the lemon problem, short-term investors can also affect investment through the more recently documented “feedback effect” (Durnev, Morck, Yeung 2004; Chen, Goldstein, and Jiang 2007). By increasing the informativeness of the stock price, the presence of informed short-term investors will also increase managers’ incentives to respond to the stock price, enhancing the sensitivity of long-term investment to a firm’s stock price. In contrast, myopic short-term investors will reduce the informativeness of the stock price and thus the sensitivity of long-term investment to it.

To test the above hypotheses, we focus on a specific set of short-term investors known to be informed (relative to the public): short sellers. Short sellers can contribute to the informational efficiency of global equity markets (e.g., Bris, Goetzmann, and Zhu 2007; Boehmer, Jones, and Zhang 2008; Boehmer and Wu 2013; Saffi and Sigurdsson 2011). They are also capable of attacking misbehaving firms (e.g., Hirshleifer, Teoh, and Yu 2011; Karpoff and Lu 2010) and providing a disciplining device for managers (e.g., Massa, Zhang, and Zhang 2015; Fang, Huang, and Karpoff 2015). The behavior of such traders provides an ideal testing ground to assess the link between the short horizons of investors and the long-term investment of firms.

Accordingly, we use worldwide short-selling data that spans 12,114 firms across 33 countries for the period 2003-2009, and focus on the *ex ante* effect related to the presence of investors ready to short-sell (hereafter “short-selling potential”) on long-term investment, as opposed to *ex post* actions taken by short sellers. Short-selling potential is proxied by the total supply of shares available to be lent for short sale, *Lendable*, which is known to increase price efficiency in the global market (Saffi and Sigurdsson 2011). We argue that the potential presence of short sellers by itself generates either an *ex ante* screening and information effect, as posited by the watch-dog hypothesis, or more short-termism distortion, as posited by the myopic hypothesis.

Long-term investment is proxied by R&D investment. Compared with other types of investment, such as purchases of fixed assets that may generate cash flows in the near future (which are usually included in a firm's capital expenditure), R&D investment is typically of longer duration and generally entails considerable uncertainty with respect to (successful) completion. Consequently, firms that spend more on R&D experience greater difficulty in persuading the market of the worthiness of such long-term investment.

We begin by documenting a strong positive correlation between *Lendable* and R&D investment (scaled by total assets). A one-standard-deviation increase in *Lendable* is associated with a 9.7% increase in R&D investment. This relationship is robust to various sub-samples, including the sample with positive *Lendable* and the sample with positive R&D. Additionally, our results hold for the sample that excludes the recent global financial crisis, and they are robust to the use of alternative measures of R&D (e.g., scaled by sales or by total investment, defined as capital expenditure plus R&D). These findings lend initial support to the watch-dog hypothesis as opposed to the myopic investor hypothesis. Interestingly, we also find that *Lendable* is negatively associated with capital expenditures, which is consistent with Grullon, Michenaud, and Weston's (2015) finding that increases in short-selling activity cause firms to reduce this type of investment. Together, these findings suggest that short selling may have different effects on different types of investment: the watch-dog effect should mainly apply to long-term (R&D) investment—and firms appear to achieve this goal by reducing other types of investment that generate cash flow in the near future, such as purchases of fixed assets.[2] In other words, short selling activities are positively associated with firm incentives to substitute long-term R&D investment for short-term capital expenditure, thereby mitigating short-termism.

Next, we design three tests to address issues of endogeneity and spurious correlation due to the omission of potentially important variables. First, following Aggarwal et al. (2011), we perform Granger causality tests to provide initial evidence regarding the issue of reverse causality. We also use alternative specifications based on either firm-fixed effects or supply-side changes to explore the issue of spurious correlation related to unobservable firm-specific characteristics. We find that an increase in *Lendable* incentivizes firms to simultaneously reduce short-term capital expenditures and increase long-term R&D investment in the near

[2] Because firms typically spend less on long-term (R&D) investment than on capital expenditures, total investment (Capex plus R&D) can still be reduced by short selling, as indicated by Grullon, Michenaud, and Weston's (2015). The important point here, however, is that short selling could shift firms' incentives from short-term investment to long-term investment. Because the negative impact of short selling on capital expenditure is exhaustively examined in Grullon, Michenaud, and Weston (2015), the remainder of our analysis focuses on the contrary effect that short selling has on long-term investment.

future. By contrast, there is little evidence that reverse causality and spurious correlation play a crucial role in this initial setup.

Our second endogeneity test formally employs an event-based approach to explore a series of cross-sectional policy restrictions that have exogenous effects on the ability to short sell. Specifically, we consider the short-selling ban imposed in 2007-2009 and two regulatory "experiments" on short selling: SEC Regulation SHO in the U.S. and the gradual introduction of (regulated) short selling on the Hong Kong Stock Exchange. (a) During the period 2007-2009, regulators worldwide reacted to the global financial crisis by imposing shortselling bans (Beber and Pagano 2013). (b) In Hong Kong, short selling was prohibited until 1994, when the Hong Kong Stock Exchange introduced a pilot scheme in which short selling of 17 stocks was permitted. The number of stocks eligible for short selling varied considerably, ranging from the initial 17 stocks to 325 in March 1998 to 150 in February 2002 (e.g., Chang, Cheng, and Yu 2007). (c) The U.S. experiment began in 2005 and lasted until 2007. The SEC established a pilot program exempting a randomly selected one-third of the stocks contained in the Russell 3000 Index from price restrictions related to short selling (e.g., Grullon, Michenaud, and Weston 2015). In all the three experiments, we find that firms for which short selling is allowed (banned) experience an increase (reduction) in R&D investment. Since the regulatory events are exogenous if not randomized in spirit, these results strongly support a causal interpretation between short selling potential and R&D investment.

In our last endogeneity test, we extend the intuition of Hirshleifer, Teoh, and Yu (2011) and apply an instrumental variable specification based on the ownership of passive institutional investors. We know that, on the one hand, a large portion of lendable shares are made available by passive institutional investors such as Exchange Traded Funds (ETFs) that fully replicate benchmarks. Their willingness to lend out shares (and thus outsource their monitoring roles) to the short selling market significantly affects the supply of *Lendable*. On the other hand, unlike hedge funds or other active institutional investors, these ETFs typically do not monitor firms. Nor does *the time-series variation* of their ownership convey stock-specific information, because these ETFs aim only to fully replicate indexes. After a proper control of index membership and liquidity conditions, therefore, the ownership of such ETFs provides a reasonable instrument that is correlated neither with direct monitoring nor with private information. Indeed, our diagnostic tests suggest that ETFs do not directly affect R&D policies except through the indirect channel of short selling. Consistent with *watch-dog* *hypothesis,* in this IV approach we find that the instrumented *Lendable* significantly increases R&D. Hence, this test not only provides additional support for the aforementioned impact of short selling, but its normative implication – that the engagement of long-term and passive investors who are willing to "outsource" monitoring to short sellers provides an effective way to establish this impact – also complements the policy lessons that we can learn from the second test.

Combined, our endogeneity tests suggest that regulations and market designs that encourage short selling activities may causally affect firms' investment decisions. We also provide a robustness check to see whether this policy implication can apply to a wider range of regulations and market practices that affect the legality and feasibility of short selling in different countries (e.g., Charoenrook and Daouk 2005; Bris, Goetzmann, and Zhu 2007; Beber and Pagano 2013), which we refer to as market-wide *short-selling potential*. Indeed we find that market-wide short-selling potential is also positively associated with R&D. For instance, R&D is 25% (20.1%) higher in countries in which short selling is legal (feasible) than in those where short selling is banned (unfeasible).

After establishing causality, we explore three economic channels through which the threat of short selling affects long-term investment, as hypothesized. We use firm-level internal governance and country-level governance (i.e., an anti-self-dealing index and legal origin) as proxies for the severity of moral hazard, and we use age, news coverage, disclosure regulations, and analyst forecasting errors as proxies for the difficulty of releasing/interpreting managers' private information. We find that short-selling potential affects R&D investment through both channels. Specifically, short selling enhances R&D more for firms that have poor internal governance, are located in countries with weaker investor protections, are younger, and are subject to less news coverage and more analyst forecasting errors. Additionally, following Chen, Goldstein, and Jiang's (2007) approach, we provide evidence of a positive feedback effect: the presence of short sellers in the market increases the sensitivity of investment to a firm's stock price.

One remaining issue is about firm value. While our previous analysis supports the working hypothesis that short selling mitigates investment short-termism, more long-term investment does not necessarily benefit firms – the latter may, on the contrary, imply over-investment that destroys firm value. It is therefore important to examine whether R&D investment induced by short-selling potential leads to value-creation or the opposite direction.

Our final step of the analysis aims to achieve this goal by linking short selling to under- or over-investment and future performance. We find that short-selling potential generally reduces the probability that firms under-invest compared with industry peers, but does not cause firms to over-invest. Furthermore, the interaction between R&D and *Lendable* significantly boosts future growth, performance, and innovation output. Both findings are in favor of the interpretation that short selling is value-enhancing and that short selling affects long-term investment by mitigating market frictions which otherwise reduce its efficiency.

Overall, these results offer evidence of a beneficial effect of the short-selling market on the long-term investment of a firm. This has important normative implications for the determinants of corporate investment and contributes to several strands of the literature. First, our paper builds on and extends the literature on short-termism and myopic corporate behavior. In a survey of financial executives, Graham, Harvey, and Rajgopal (2005) find that the majority of managers would forgo valuable projects to avoid missing concurrent consensus earnings forecasts. Perhaps not surprisingly, short-termism is especially harmful for long-term investment related to growth opportunities (Skinner and Sloan 2002) and corporate innovation (Manso 2011). Additionally, the literature has proposed that such myopic investment decisions may emerge due to two types of information asymmetry: hidden managerial actions, which may occasion moral hazard (Narayanan 1985; Stein 1989; Benmelech, Kandel, and Veronesi 2010), and hidden private information, which may lead to a lemon problem or adverse selection (Myers and Majluf 1984; Trueman 1986; Bebchuk and Stole 1993; Brandenburger and Polak 1996) in investment decisions.

While it is widely assumed that the short horizon of investors causes or at least greatly exacerbates short-termism and myopic investment (e.g., Porter 1992; Rappaport 2011), we show that informed short-term investors, such as short sellers, mitigate myopic behavior because they help firms address moral hazard and adverse selection problems and potentially incentivize managers to respond more strongly to stock prices. This intuition is consistent with Edmans (2009), who argues that the existence of multiple blockholders – which, in the traditional view, shortens the investment horizon of blockholders – helps reduce myopic corporate behavior. The difference is that we focus on short sellers, who arguably have the shortest investment horizon among all investors and do not directly monitor managers. This provides a very powerful test of the impact of horizon on investment.

In so doing, we are – to the best of our knowledge – the first to investigate the effect of the short-selling market on long-term (R&D) investment. While the standard short-selling literature links short sellers' activities to stock returns (Senchack and Starks 1993; Asquith and Meulbroek 1995; Aitken et al.1998) and establishes that short selling is generally informed and can help improve price efficiency (Cohen, Diether, and Malloy 2007; Bris, Goetzmann, and Zhu 2007; Boehmer, Jones, and Zhang 2008; Boehmer and Wu 2010; Saffi and Sigurdsson 2011), there are also concerns about the adverse impact of short selling, as with speculation (Khanna and Mathews 2012) and predatory trading (Brunnermeier and Oehmke 2013). We document that the threat of short selling appears to dominate its adverse impact by helping firms achieve their optimal investment policies. These results also extend the emerging literature on the real impact of short selling (e.g., Massa, Zhang, and Zhang 2015; Fang, Huang, and Karpoff 2015; Grullon, Michenaud, and Weston, 2015; Li and Zhang 2015). Notably, consistent with Massa, Zhang, and Zhang (2015) and Fang, Huang, and Karpoff (2015), we show that governance is an important channel through which short selling may affect firm activities. We also compliment Grullon, Michenaud, and Weston (2015) in demonstrating that short selling may have different effects on different types of investment. Indeed, it is striking to observe that the presence of short sellers, who are associated with shorter horizons than normal shareholders, shifts firm incentives from short-term investment to long-term investment.

Finally, our results also contribute to the literature that relates shareholder composition to firm performance (e.g., Morck, Shleifer, and Vishny 1988; Himmelberg, Hubbard, and Palia 1999; Holderness, Kroszner, and Sheenan 1999; Franks and Mayer 2001; Franks, Mayer and Renneboog 2001) and international governance (e.g., Claessens, Djankov, and Lang 2000; La Porta, Lopez-de-Silanes, and Shleifer 2006; Claessens and Laeven, 2003; Aggarwal et al. 2011; Laeven and Levine 2008; Doidge, Karolyi, and Stulz 2007). Although the literature primarily focuses on large/controlling shareholders with positive stakes, we are the first to show a positive role for investors with negative positions – short sellers. We show the investors traditionally considered to have a very short-term orientation – short sellers – may actually help improve long-term investment.

II. Data, Variable Construction and Preliminary Evidence

We now describe the sources of our data and the construction of our main variables and provide some preliminary evidence.

A. Data Sample and Sources

The sample covers the period between 2003 and 2009. We begin with all publicly listed companies worldwide for which we have accounting and stock market information from Datastream/WorldScope. This sample is then matched with short-selling information data from Data Explorers and with data on institutional investors' stock holdings from FactSet/LionShares.

In particular, we obtain equity lending data from Data Explorers, a research company that collects equity- and bond-lending data directly from the securities lending desks of the world's leading financial institutions. Information detailed at the stock level is available from May 2002 to December 2009. The dataset provides unique information on the values of shares on loan to short sellers and the values of shares available to be lent to short sellers; both sets of information are important for the purposes of this paper. A more detailed description of the data can be found in Saffi and Sigurdsson (2011) and Jain et al. (2012).

The data on institutional investor ownership are from the FactSet/LionShares database, which provides portfolio holdings of institutional investors worldwide. Because institutional ownership represented over 40% of the total world stock market capitalization during our sample period, we control for it in all our regressions to highlight the effects of short selling. We also obtain ETF ownership of stocks from this database, which we use later as an instrument to explain lending supply in the short-selling market.

We combine the Datastream/WorldScope data with the short selling and institutional holdings data, using SEDOL and ISIN codes for non-U.S. firms. We use CUSIP to merge short-selling data with U.S. security data from Datastream/WorldScope. The initial sample from the matched datasets of Datastream/WorldScope and Data Explorers covers 13,909 firms over the period 2003-2009. After the match with Factset/Lionshare, the sample was reduced to 12,800 firms over the period. We further require that stocks have non-missing financial information on R&D expenditures, firm size, book-to-market ratio, age, financial leverage, cash holdings, sales growth, annual stock return, and stock return volatility. This reduces the number of stocks to 11,969 in 33 countries, a number comparable to the sample of

12,621 stocks in 26 countries in Saffi and Sigurdsson (2011). In terms of market capitalization, the sample includes more than 90% of global stocks.

Our sample selection differs from that of Saffi and Sigurdsson (2011) in two respects: 1) we restrict our sample to non-financial and non-utility firms; and 2) we use a relatively extended period, 2003-2009, while Saffi and Sigurdsson (2011) focus on the period 2005-2008. Appendix B reports sample firm distributions across countries and over time. The sample includes 2,696 non-U.S. firms and 889 U.S. firms in the year 2003. The number grows to 6,326 for non-U.S. firms and 2,416 for U.S. firms in December 2009.

B. Main Variables

In line with the literature, we use R&D as the main proxy for long-term investment (e.g., Brown, Martinsson and Petersen 2013). The R&D variables include R&D scaled by total assets (*RD/TA*), R&D scaled by sales (*RD/Sales*), and R&D scaled by total investment (*RD/CapExRD*). In addition, we use more general measures, such as total investment scaled by total assets (*CapExRD/TA*) and capital expenditures scaled by total assets (*CapEx/TA*).

We define our main measure of short-selling potential as *Lendable*. This is the annual average fraction of shares of a firm that are available (to be lent) to short sellers. We follow Equation (4) of Saffi and Sigurdsson (2011) to compute the ratios of the values of shares supplied to the short-selling market to the market capitalizations of stocks. We then define the average of the monthly ratios as the annual *Lendable* ratio. In addition, we define an alternative proxy for short-selling potential based on shares lent (*On Loan*), which is the annual average fraction of shares of a firm lent out (or short interest). We also use country-level short-selling potential variables, following Charoenrook and Daouk (2005), including the legality of short selling (*Legality*), the feasibility of short selling (*Feasibility*), put option trading (*Put Option*), and the feasibility of put option trading (*F or P*). These country-level variables are defined in Appendix A.

Our control variables are firm size (*Size*), book-to-market ratio (*BM*), age (*Age*), financial leverage (*Leverage*), cash holdings (*Cash*), sales growth (*SalesG*), annual stock return (*Return*), stock return volatility (*STD*), American Depository Receipts (*ADR*), MSCI country index membership (*MSCI*), and institutional ownership (*IO*). Institutional ownership is the aggregate equity holdings of domestic and foreign institutional investors as a percentage of the total number of outstanding shares. Similarly, we construct ETF ownership (*ETF*), which is defined as the percentage of the total number of outstanding shares that are invested by ETFs. A detailed definition of all these variables is provided in Appendix A.

Table 1 presents the summary statistics for the main variables. In Panel A, we report the number of observations (N), the means, medians, and standard deviations (STD) of the variables, and the decile (90% and 10%) and quartile (75% and 25%) distributions of the variables. In Panel B, we report the correlation coefficients among the variables, where the highlighted upper-right part (bottom-left part) of the table refers to the Spearman (Pearson) correlation matrix.

We observe that both our R&D variables and the short-selling variables exhibit reasonable variation. For example, the mean of *RD/TA* in our sample is 0.024, which is comparable to the R&D mean of 0.053 in Brown, Martinsson, and Petersen (2013) in a sample of 32 countries over the 1990-2007 period. The slight difference in *RD/TA* is due to both the use of different sample periods and different sample selection criteria. Brown, Martinsson, and Petersen (2013) exclude firms without at least three non-missing R&D observations and firms with no information on employment. The mean (5.8%) of *Lendable* is also close to the mean (8.0%) of the lending supply variable in Saffi and Sigurdsson (2011). The remaining difference arises from the requirement that firms must have valid R&D variables and control variables to be included in our sample. Our results are robust to whether we include or exclude firms with zero (missing) R&D or firms where no shares are available to be sold short (i.e., zero lendable).

The statistics for the control variables are also similar to those reported in the literature. For example, in Ferreira and Matos' (2008) sample of 11,224 non-U.S. firms for the period 2000-2005 from 27 countries, the average logarithm of firm size, the average logarithm of the book-to-market ratio, average financial leverage, and average cash holdings are 11.96, -0.17, 0.25, and 0.13, respectively, compared with 13.2, -0.64, 0.20, and 0.17 in our sample. Aggarwal at al. (2011) report that the average total institutional ownership across 23 countries (including the U.S.), also from FactSet/LionShares, ranges from 16.38% to 26.46%, which is very close to the 24.8% in our sample.

As predicted by our hypothesis, the three R&D investment measures (*RD/TA, RD/Sales, RD/CapExRD*) are positively correlated with our two proxies for short selling, *Lendable* and *On Loan*. For example, the correlation coefficients between *RD/TA, RD/Sales, RD/CapExRD* and *Lendable* are 0.020, 0.045, 0.022 (0.048, 0.055, 0.025), respectively, in the Spearman

(Pearson) correlation matrix. Interestingly, the proxy for fixed investment, *CapEx/TA*, is negatively correlated with short-selling measures, which provides some preliminary evidence that short selling may have different effects on different types of investment. In both correlation matrices, *RD/TA* is negatively correlated with *Size*, *BM*, *Leverage*, *SalesG*, *Return*, while it is positively correlated with *Cash*, *STD*, *ADR*, and *IO*.

III. Short-Selling Potential and Long-Term Investment

We begin with some preliminary analysis of the link between short selling and investment in R&D. We regress the firm's R&D investment alternatively on the firm's lendable shares (*Lendable*) or shares on loan (*On Loan*) and the set of firm-level control variables (*X*). The control variables include: firm size (*Size*), book-to-market ratio (*BM*), age (*Age*), financial leverage (*Leverage*), cash holdings (*Cash*), sales growth (*SalesG*), institutional ownership (*IO*), log of annual stock returns (*Return*), stock return volatility (*STD*), MSCI country index membership (*MSCI*), and American Depository Receipts (*ADR*). We estimate a panel specification with industry-, country-, and year-fixed effects (ICY). Standard errors are adjusted for heteroskedasticity and firm-level clustering.

We report the results in Table 2. In columns (1) to (5), long-term (R&D) investment is defined as *RD/TA(t+1).* The main independent variable for these columns is *Lendable*, except for column (2), where we replace *Lendable* with the actual amount of historical short selling (*On Loan*) as a robustness check. Column (3) only includes firm-year observations with positive *Lendable*, and column (4) includes firm-year observations with positive R&D (e.g., *RD/TA*). Column (5) (Ex.GFC) excludes the global financial crisis period from 2007 to 2008.

The results display a strong positive correlation between *Lendable* and investment in R&D. The results are strongly significant and robust across the different specifications. They are also economically significant. A one-standard-deviation increase in *Lendable* is associated with a 9.7% increase in R&D investment (relative to the mean).[3] This relationship is robust across various sub-samples, including the sample with positive *Lendable* and the sample with positive R&D. Additionally, our results hold in the sample that excludes the recent global

[3] The economic magnitude of the regression $y = \beta \times x$ is computed as $\beta \times \sigma_x / \bar{y}$, where y and x are the dependent and independent variables, respectively, β is the regression coefficient, σ_x is the standard deviation of x, and $\bar{y}$ is the mean of y. For instance, the standard deviation of horizontal *Lendable* is 0.08, the regression coefficient in column (1) is 0.029, and the average RD/TA is 0.024. From these numbers, we compute the economic magnitude as 0.029×0.08/0.024=9.7%, which implies a 9.7% increase in R&D investment. We use this interpretation to determine the impact of short selling on average R&D. Using the standard deviation of RD/TA (0.049 from Table 1), the impact is approximately 5%.

financial crisis. As a robustness check, we also redefine R&D investment as *RD/Sales* in column (6). The effect of *Lendable* on R&D is even stronger: the coefficient (*t*-statistic) becomes 0.041 (6.01). Columns (7) and (8) examine the role of investment associated with cash flows over shorter horizons. In particular, because fixed assets can generate cash flows faster than R&D, we replace R&D investment with total capital expenditures (*CapEx/TA*) in column (7).

Consistent with Grullon, Michenaud, and Weston (2015), we find that high *Lendable* is typically associated with low capital expenditures, which is the opposite of the relationship between *Lendable* and R&D investment. This opposing pattern suggests that short selling may drastically change the incentives of firms to undertake different types of investment: short selling appears to promote long-term investment while discouraging short-term expenditures. Indeed, it is very likely that firms shift capital from short-term projects to long-term investment when they face more efficient short selling.

If it is true that short selling encourages firms to shift capital from short-term investment to long-term investment, we should expect *Lendable* to affect the fraction of long-term investment of a firm even more significantly than it affects long-term investment (*RD/TA*) itself. Column (8) tests this conjecture by focusing on the ratio of long-term investment to total investment (*RD/CapExRD*, or the ratio of R&D to the summation of R&D and capital expenditure). We observe that, consistent with the conjecture, the coefficient and its *t*-statistic in this case are 0.225 and 8.28, respectively, which implies a higher significance level than in column (1).

The results in Table 2 also show that firms with greater age, smaller size, a lower book-to-market ratio, and more cash tend to spend more on R&D investment. The evidence of more intensive R&D in small firms than in large firms is consistent with a Schumpeterian view of creative destruction, whereby new entrants use innovation to challenge established incumbents (e.g., Aghion and Howitt 1992; Brown, Martinsson and Petersen 2013). Compared with their counterparts, firms that cross-list in the U.S. invest more in R&D.

Surprisingly, we find that overall (i.e., both domestic and foreign) institutional ownership is negatively correlated with a firm's R&D investment. This is inconsistent with Aghion, Van Reenen, and Zingales (2013), who find that institutional ownership is positively associated with innovation (measured by citation-weighted patents). However, our analysis differs from theirs in that the dependent variable is R&D investment rather than R&D output. Moreover, as we will see in the next section, institutional ownership becomes insignificant in the presence of firm-fixed effects (or specifications based on changes). In Section VI, consistent with Aghion, Van Reenen, and Zingales (2013), we find that institutional ownership significantly increases a firm's future patent outputs.

IV. Endogeneity Issues

One concern is that short-selling potential may be higher for firms that invest more in R&D. To properly address this and other potential endogeneity issues, we follow the literature to provide three endogeneity tests. First, we follow Aggarwal et al. (2011) to examine the issue of spurious correlation resulting from the omission of relevant firm-specific information. Second, in spirit of Grullon, Michenaud, and Weston (2015), we focus on several regulatory events in which short selling flexibility is exogenously determined. Third, we employ an instrumental variable approach following Hirshleifer, Teoh, and Yu (2011). In addition to these tests, we examine the impact of market-wide *short selling potential* to check the robustness of the policy implication.

A. Alternative Specifications

We begin with three alternative ways to initially explore the concern that short-selling potential may be spuriously related to unobservable firm-specific characteristics: the use of firm-fixed effects, Granger causality analysis, and difference-in-difference tests.

Specifically, in Model (1) of Table 3, we estimate the baseline specification with firm-fixed effects included to control for spurious correlations between *Lendable* and R&D that may be generated by time-invariant firm characteristics. In Models (2) and (3), we perform Granger causality tests. Model (2) regresses R&D scaled by total assets (*RD/TA*) on lendable shares (*Lendable*) with lagged *RD/TA* as a control, while model (3) regresses *Lendable* on *RD/TA*. Finally, in Model (4), we report the results of the difference-in-difference specification. We regress the change in R&D scaled by total assets on the change in lendable shares. In all specifications, standard errors are adjusted for heteroskedasticity and firm-level clustering.

The results of the baseline regression with firm-fixed effects confirm the previous results and display a strong positive correlation between R&D and *Lendable*. A one-standard-deviation increase in *Lendable* is associated with a 3.7% increase in R&D. Although in the interest of brevity, we focus only on the overall sample, unreported results for the sub-samples in Table 2 are similar both qualitatively and quantitatively. The Granger causality test shows that *Lendable* increases R&D, in line with our prediction. In the reverse direction, R&D is not related to *Lendable*, in line with our intuition that short sellers are not attracted by R&D. This suggests that *Lendable* is exogenous to firms' R&D.

Model (4) focuses on the effects of changes in *Lendable* on changes in *RD/TA* (Diff-in-diff specification), with changes in other firm-level variables used as controls. The results clearly show that a one-standard-deviation increase in *Lendable* from the previous period is associated with a 5.7% increase in R&D from the previous period.[4] The difference-in-difference specification allows us to further explore how changes in lendable shares affect firm incentives to shift capital from short-term investment to long-term investment, thereby leading firms to substitute long-term investment for short-term investment. To capture such incentives, we define a dummy variable that takes a value of one when a firm simultaneously increases *RD/TA* and reduces *CapEx/TA* in a given year and zero otherwise. This dummy variable, which we refer to as *D_Substitute(t+1)*, is then regressed on the change in lendable shares. The regression results, tabulated in Model (5), clearly show that enhanced short selling increases this substitution effect—a one-standard-deviation increase in *Lendable* from the previous period is associated with a 9.7% increase in the substitution effect.[5] Jointly, Models (4) and (5) support the notion that short selling has different effects on different types of investment in ways consistent with the *watch-dog hypothesis*. Because the impact of short selling on capital expenditure is well explored in the literature (e.g., Grullon, Michenaud, and Weston 2015), in the remainder of the analysis, we mainly focus on its impact on long-term (R&D) investment.

It is important to note that the effects of institutional ownership on R&D are insignificant in both the fixed-effect and the difference-in-difference specifications. Similar results can be found if we do not include *Lendable* in the regression. Thus, *Lendable* more powerfully influences R&D in these tests than does institutional ownership, which suggests that the impact of *Lendable* is unlikely to derive from the latter. These findings appear to eliminate

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[4] The economic magnitude of the difference-in-difference regression of $\Delta y = \beta \times \Delta x$ is computed as $\frac{\Delta y}{\bar{y}} = \beta \times \sigma_x / \bar{y}$, where y and x are the dependent and independent variables, respectively, β is the regression coefficient, σ_x is the standard deviation of x, and $\bar{y}$ is the mean of y. For instance, the standard deviation of horizontal *Lendable* is 0.08, the regression coefficient in Model (4) is 0.017, and the average RD/TA is 0.024. From these numbers, we compute the economic magnitude as $0.017 \times 0.08/0.024 = 5.7\%$, which implies a relative change of 5.7% in R&D investment.

[5] Similar conclusions can be drawn from Probit regressions. The Probit regression coefficient on changes in *Lendable* is 1.36, with a *p-value* below 0.001, which is highly significant.

concern that *Lendable* spuriously represents the power of certain shareholders – such as institutional investors – who both monitor managers and supply lendable shares to short sellers.

In fact, the institutional design of the short-selling market makes it implausible for shareholders who actively monitor managers to supply lendable shares to short sellers on a large scale because the voting rights and the effective ownership of lendable shares will be transferred away from the lender during the short-selling period, which undermines both the incentive and the ability of the lender to act as an effective monitor. Our tests are fully consistent with this institutional feature. The remaining question is whether there are shareholders who do not monitor managers but are willing to lend shares to short sellers who subsequently boost long-term investment. We will assess this possibility shortly in an instrumental specification.

B. An Event-based Approach

But before we move on, it is worthwhile to first employ an event-based approach to explore policy "events" that exogenously affect the ability to short sell: the short-selling ban imposed in 2007-2009, the gradual introduction of (regulated) short selling in the Hong Kong Stock Exchange, and SEC Regulation SHO in the U.S. The advantage of this approach is that these policy events created shocks and variations in short-selling costs that are orthogonal to firm-specific spurious correlation and endogeneity. Our working hypothesis is that policies that impose a higher (lower) short-selling cost will generally decrease (increase) the effectiveness of short selling.

We begin with the short-selling ban, under which regulators worldwide imposed regulatory restrictions on short selling in reaction to the global financial crisis from 2007 to 2008 (Beber and Pagano 2013). Models (1) and (2) in Table 4 report the regression results for the sub-samples with and without the short-selling ban. In the presence of the ban (Model (1)), the significant link between *Lendable* and R&D disappears, while for firms that did not face the short-selling ban (Model (2)), the relationship between *Lendable* and R&D remains positive.

Next, we focus on the introduction of regulated short selling into the Hong Kong Stock Exchange (1994-2005). The Hong Kong Stock Exchange provides a different experiment in which short selling was gradually introduced into the market (e.g., Chang, Cheng, and Yu

2007). The most interesting feature of this experiment is that the list of firms eligible for short selling changes over time, which creates both time-series and cross-sectional variations in the short-selling restrictions applicable to firms listed in Hong Kong. Stocks were added at the discretion of the regulator as a function of "changing market conditions". After February 12, 2001, stocks were added on a quarterly basis according to a set of criteria, such as market capitalization, turnover, index membership, and having derivative contracts written on shares. The selection remains unlikely to create spurious correlation because we explicitly control for all relevant variables. To explain R&D, we create an annualized dummy variable, Hong Kong short-selling eligibility (*HKSS*), to capture a stock's eligibility for short selling in Hong Kong. We report the results in Panel B. While Model (3) covers the full sample, Model (4) covers only the sub-sample period from 2002 to 2005 to approximate the analysis of a similar time-frame in our baseline analysis. The results show that firms for which short selling is allowed experience an increase in R&D of 12.5% relative to the full sample (Model (3)) and 29% relative to the sub-sample (Model (4)). [6]

In the U.S. experiment, the SEC established a pilot program exempting a third of stocks in the Russell 3000 Index from uptick rules and other price restrictions (see Grullon, Michenaud, and Weston 2015). The choice of stocks was purely random. As described in SEC Release No. 50104, the regulator "sorted the securities into three groups – AMEX, NASDAQ NNM and NYSE – and ranked the securities in each group by average daily dollar volume over the one year prior to the issuance of this order from highest to lowest for the period. In each group, we then selected every third stock from the remaining stocks." In doing so, the SEC effectively generated a randomized experiment that we can use to assess whether a relaxation of short-sale restrictions exogenously enhances long-term investment. We therefore relate R&D investment to an indicator of whether the restrictions have been lifted for the specific stock. The Regulation SHO experiment began in 2005 and lasted until 2007. The announcement year (2004) is removed from the sample.

The impact of the SHO experiment is presented in Panel C of Table 4. *Pilot* refers to the dummy variable that takes a value of one if a stock is selected as an SHO pilot firm and zero otherwise; *SHOTest* is a dummy variable that takes a value of one if time *t* is within 2005-2007 and zero otherwise; and *SHOTest*×*Pilot* is the interaction term. We expect that the interaction term captures incremental increases in R&D of SHO pilot firms within the *SHO*

[6] The magnitude is computed as the coefficient of HK SS scaled by the average R&D in the sample.

testing periods. Models (5) and (6) report results for the full sample of stocks, while Models (7) and (8) report results only for Russell 3000 stocks. Models (5) and (7) report results for the testing period from 1999 to 2009 (5 years prior vs. 5 years after the event), while Models (6) and (8) report results for the testing period from 2001 to 2007 (3 years prior vs. 3 years after the event). In both Models (6) and (8), the announcement year of Regulation SHO, 2004, is removed from the sample. The results clearly show that the lifting of restrictions – i.e., Regulation SHO – is associated with a higher level of R&D. In terms of economic significance, exemption from the restrictions is related to a 20%-37% higher level of R&D.[7]

C. An Instrumental Variable Approach

We now consider an instrumental specification based on the ownership of passive investors in spirit of Hirshleifer, Teoh, and Yu (2011). Following Massa, Zhang, and Zhang (2015), we consider ETF ownership to be used as an instrument to clarify the role of *Lendable*. Indeed, on the one hand, ETFs are among the main contributors to the short-selling market, making shares available that can then be used by short sellers.[8] On the other hand, ETFs are not typically concerned with the active control of firm managers, as ETFs are typically passive investors unconcerned with activism or firm information. Moreover, because ETF investment typically follows indices rather than individual stocks, *the time-series variation* of ETF ownership can only be attributed to index-level investor flows rather than stock specific information.

These features make the fraction of stock ownership by ETFs a nice instrument because it reasonably meets both the exclusion restriction (it is unrelated to R&D except through the short-selling channel) and the inclusion restriction (ETFs make shares available to short sellers). Moreover, the exogenous high growth rate of the ETF industry over the past decade suggests that the instrument is likely to be powerful.

[7] The magnitude for a given model is computed as the coefficient of $SHOTest \times Pilot$ scaled by the average R&D in the sample. It is also worth mentioning that the negative impact of short selling on capital expenditure is confirmed in this and other endogenous tests. Because the conclusion is similar to that of Grullon, Michenaud, and Weston (2015), we do not tabulate the results here. One can further infer from the opposing results on R&D and Capex that enhanced short selling introduced by SHO should also increase firm incentives to substitute long-term (R&D) investment for short-term (capital expenditure). Our empirical tests based on *D_Substitute* confirm this prediction. However, because the results can be inferred from our existing tests as well as those of Grullon, Michenaud, and Weston (2015), we do not tabulate them here.

[8] ETFs are bound by rules related to securities lending similar to those governing traditional mutual funds. For instance, in Europe, ETF providers can lend up to 80% of their basket of securities to third parties to generate revenues. Interested readers may refer to the 2011 IMF "Global Financial Stability Report" for more information on how ETFs may contribute to the short-selling market.

Thus, we regress R&D on ETF ownership (*ETF*)-instrumented *Lendable* and firm-level control variables (*X*) and industry-, country-, and year-fixed effects:

$$The\ 1st\ stage: Lendable_{i,t} = \alpha + \beta_1 ETF_{i,t} + \beta_2 X_{i,t} + \varepsilon_{i,t}; \quad (1)$$

$$The\ 2nd\ stage: RD/TA_{i,t+1} = \alpha + \beta_1 Predicted\ Lendable\ on\ ETF_{i,t} + \beta_2 X_{i,t} + \varepsilon_{i,t+1}, \quad (2)$$

where $X_{i,t}$ includes the list of standard control variables. Models (1) and (3) regress *Lendable* shares on ETF ownership (*ETF*) or the residuals of ETF ownership (*ETF-R*), which is obtained by regressing ETF on the Amihud illiquidity measure (*Amihud*) and on analyst coverage (*Analyst*) and news coverage (*NewsCoverage*) variables. Models (2) and (4) regress R&D scaled by total assets on predicted lendable shares (*Lendable-P*, *Lendable-PR*). The standard errors are adjusted for heteroskedasticity and firm-level clustering.

We report the results in Table 5. Panel A shows the results of the aforementioned specifications, while Panel B provides diagnostic analyses of the impact of ETF ownership (*ETF*) on *RD/TA* for the subsample of stocks for which short selling is either prohibited due to regulation (Models 6 and 7) or low – when very few shares could be or actually were lent out (Models 8 to 9). Model (10) explores the reverse constraint by regressing *RD/TA* on *Lendable* for the sample of stocks with low ETF ownership.

If we focus on the first-stage regression, we observe that short-selling potential is strongly and positively related to the fraction of ETF ownership, with a *t*-statistic always above 4. This translates into an *F*-statistic above 10, which is well above the threshold for weak exogeneity proposed by Staiger and Stock (1997). The effect is also economically significant. A one-standard-deviation increase in ETF ownership is related to a 29.8% increase in lendable shares, suggesting that ETFs are indeed a major supplier to the short-selling market.[9]

The second-stage regression shows a strong positive correlation between instrumented short-selling potential and R&D. A one-standard-deviation increase in instrumented *Lendable* is correlated with a 19.2% increase in R&D.[10] Note that in all the regressions, we control for the institutional ownership of firms. Thus, we also exclude the possibility of spurious

[9] The standard deviation of ETF ownership is 0.019, the regression coefficient in column (1) is 0.909, and the average value of *Lendable* is 0.058. From these numbers, we compute the economic magnitude as $0.909 \times 0.019/0.058 = 0.298$, which implies a 29.8% increase in lendable shares.

[10] The standard deviation of instrumented *Lendable* is 0.073, the regression coefficient in column (2) is 0.063, and the average RD/TA is 0.024. From these numbers, we compute the economic magnitude as $0.063 \times 0.073/0.024 = 0.192$, which implies a 19.2% increase in R&D investment.

correlation, which might arise when ETF ownership proxies for the monitoring role that institutional investors often play. This further confirms our findings in the previous table. In tests of the residuals of ETF ownership, the results are unchanged.

It is not surprising that the tests in which ETF ownership is used as an instrument are robust. As we have argued, the features of the ETF industry (e.g., low cost, passive, index tracker) imply that ETFs do not directly affect managerial behavior. If supplying lendable shares to the short-selling market is the *only* channel through which ETFs can indirectly affect mangers, we should expect ETF ownership (*ETF*) to have an insignificant effect on R&D when short selling is constrained. In contrast, if ETFs can affect mangers directly or indirectly through some *other* channels that are independent of short selling, then such an impact should be observed regardless of how low the level of *Lendable* may be. Therefore, in Model (5), we show that the effect of ETF on R&D is positive. However, if we examine the effect of ETF ownership (*ETF*) on R&D in the subsamples of stocks for which short selling is prohibited (Model (6)), *Lendable* is not feasible (Model (7)), *Lendable* is not supplied (Model (8)), or *Lendable* is very small (Model (9)), the impact of ETF on R&D is either negative (Model (6)) or not significant (Models (7)-(9)).

To complete our diagnostics, we also investigate whether the impact of *Lendable* diminishes when ETF ownership is limited. Thus, we regress R&D on *Lendable*, which follows the main specification of the previous table conditioned on low ETF ownership. We observe that the effect of *Lendable* is slightly attenuated but remains marginally significant. This suggests that short selling is a necessary condition for ETFs to impact R&D, although ETFs are not a necessary condition for *Lendable* to affect R&D. The latter result is reasonable because other (passive) institutional investors, such as pension funds and insurance companies, may also be willing to lend shares to short sellers. However, the important point is that ETFs provide “ammunition”, not initially related to R&D, that short sellers can use in trading.

D. Robustness Checks on Policy Implications

The last two tests essentially suggest that regulations (such as Regulation SHO) or market designs (such as the development of passive investors who are willing to outsource monitoring to short sellers) that encourage short selling may causally affect firms’ investment decisions. To the extent that different countries typically adopt different policies, it will be fruitful to provide a robustness check to examine whether this policy implication applies to a wider scope of regulations and market designs. More explicitly, we want to examine how market-wide short-selling potential as implied by a broader range of regulation environment and the market practices of a country increases R&D. The main intuition is that short-sale potential at the country level also affects the informational efficiency of the market. For instance, Bris, Goetzmann, and Zhu (2007) document that in markets that allow short selling, negative information may be more effectively incorporated into prices. Beber and Pagano (2013) further note that short-selling bans were detrimental to liquidity and failed to support prices. Based on these observations, we expect country-level short-selling potential to play a role similar to that of firm-level short-selling potential – i.e., it will enhance R&D. Moreover, because country-level short-selling potential is largely exogenous to individual firms, tests of the relationship between market-wide short-selling potential and R&D are less subject to concerns of spurious correlation and potential endogeneity that may arise in firm-level tests.

We therefore regress firm R&D scaled by total assets (*RD/TA*) on market-wide short-selling regulation variables (*Regulatory SS*), firm-level control variables (*X*), and country-level control variables (*C*) as well as industry- and year-fixed effects (IY):

$$RD/TA_{i,t+1} = \alpha + \beta_1 Regulatory\ SS_{i,t} + \beta_2 C_{i,t} + \beta_3 X_{i,t} + \varepsilon_{i,t+1}, \quad (3)$$

where $Regulatory\ SS_{i,t}$ includes the legality of short selling (*Legality*), the feasibility of short selling (*Feasibility*), put option trading (*Put*), and the feasibility of put option (*F or P*). The *Legality*, *Feasibility*, and *Put Option* variables are constructed following Charoenrook and Daouk (2005); we also refer to Bris, Goetzmann, and Zhu (2007) and Beber and Pagano (2013) for more recent periods. The difference between legality and feasibility is that the latter requires that trading be both legal and feasible, i.e., there must be an existing institutional infrastructure supporting short selling, a low cost of short selling, and the availability of market makers willing to trade on short positions. $C_{i,t}$ stacks the list of market-level control variables, including the market cap-to-GDP ratio (*MV/GDP*), the credit-to-GDP ratio (*Credit/GDP*), GDP growth (*GDPG*), and the FDI-to-GDP ratio (*FDI/GDP*). $X_{i,t}$ includes the same list of firm control variables as above.

We report the results in Panel A of Table 6. Models (1) to (4) provide regression results when only firm control variables are used. Models (5) to (8) tabulate regression results when country-level control variables are also included. Panel B repeats the same regressions at the country-industry level.

We find a strong positive correlation between market-level short-selling potential and R&D. This correlation holds across all specifications and is economically significant. For example, in the fully fledged specifications, in countries in which short selling is legal (feasible), R&D is 25% (20.1%) higher than in countries in which it is banned (unfeasible). Additionally, in countries in which put options, an indirect way of short selling, are permitted, R&D investment is 17% higher than in the countries in which put options are unavailable. The feasibility of either a direct short sale or an indirect short sale through put options yields a 25% increase in R&D. These results provide further support for the policy implication of our working hypothesis.

V. Economic Channels

We now investigate the mechanisms by which *Lendable* exerts its effects by focusing on the three channels: managerial moral hazard, the “lemon” problem, and the positive feedback effect. We begin with an investigation of whether short selling promotes investment to a greater extent in the presence of a high degree of moral hazard and high cost of information. The tests provide us with a better understanding of the first two potential channels through which short-selling potential affects under-investment.

We use corporate governance as a proxy for the severity of moral hazard. The corporate governance measures include the firm-level (internal) corporate governance index (*ISS*), which is taken from Risk Metrics' composite corporate governance index based on 41 firm-level governance attributes (Aggarwal et al. 2011); the country-level (external) anti-self-dealing index (*Antsel*), which measures the strength of laws protecting investors from self-dealing transactions by insiders (Djankov et al. 2008); and legal origin (*CommLaw*), a dummy variable that equals one if a country’s legal system has a common law origin and zero otherwise (La Porta et al. 1998). Higher values of the variables are associated with a better (internal/external) corporate governance system.

To measure the cost of information, we use the firm-level variables of age (*Age*), news coverage (*NewsCoverage*), and analyst forecasting errors (*AnalystErrors*), as well as a country-level variable of the disclosure requirements index (*DisReq*), an index reflecting disclosure rules aimed at reducing information asymmetry (Hail and Leuz 2006). These variables capture the difficulty of releasing managers’ private information. Higher (lower) values of *Age*, *NewsCoverage*, and *DisReq* (*AnalystErrors*) are associated with a lower (higher) cost of information. The regression model is:

$$RD/TA_{i,t+1} = \alpha + \beta_1 Lendable_{i,t} + \beta_2 InfAsy_{i,t} + \beta_3 Lendable_{i,t} \times InfAsy_{i,t} + \beta_4 Lendable_{i,t} \times CGov_{i,t} + \beta_5 X_{i,t} + \varepsilon_{i,t+1}, \quad (4)$$

where $X_{i,t}$ includes the same list of firm control variables as above, $InfAsy_{i,t}$ refers to a set of information cost variables, and $CGov_{i,t}$ refers to a set of corporate governance variables.

The results are reported in Table 7. We find that short-selling potential affects under-investment through both channels, although the evidence appears to more strongly support the corporate governance channel. For example, interactions between *Lendable* and the corporate governance variables are all negative and significant, even in regressions that include information cost variables. Short selling enhances investment more significantly for firms with poor corporate governance (i.e., low *ISS*) and for firms operating in countries with poor corporate governance (e.g., countries where anti-self-dealing laws are weak or in which the legal system did not originate from common law). This result may suggest the substitution of the short-selling threat as a disciplining mechanism in the absence of effective internal and external corporate governance mechanisms. The impact of *Lendable* is also stronger for firms that are younger, receive less news coverage, are subject to more analyst forecasting errors, and are located in countries with less stringent disclosure requirements. However, these inferences are evident only when we separate the effects of the cost of information from the effects of corporate governance. The evidence on the information cost channel becomes less clear if both information cost and corporate governance variables are included in the same specification.

Finally, we test whether lower information asymmetry may create a positive feedback effect. In this case, we would expect *Lendable* to be positively related to the sensitivity of investment to a firm's stock price (as per Durnev, Morck, Yeung 2004; Chen, Goldstein, and Jiang 2007). To test this hypothesis, we investigate how the relationship between *Lendable* and R&D is affected by firm stock price. Using a specification similar to that of Chen, Goldstein, and Jiang (2007), we regress firm R&D scaled by total assets (*RD/TA*) on lendable shares (*Lendable*), its interaction with Tobin's Q (*Q*), and firm-level control variables (*X*). We also control for industry-, country-, and year-fixed effects (ICY). We estimate:

$$RD/TA_{i,t+1} = \alpha + \beta_1 Lendable_{i,t} + \beta_2 Lendable_{i,t} \times Q_{i,t}$$
$$+ \beta_3 Lendable_{i,t} \times CashFlows_{i,t+1}$$
$$+\beta_4 Q_{i,t} + \beta_5 CashFlows_{i,t+1} + \beta_6 1/TA_{i,t+1} + \beta_6 Return_{i,t+2,t+4} + \varepsilon_{i,t+1}, \quad (5)$$

where $1/TA_{i,t+1}$ is the inverse of total assets, $Return_{i,t+2,t+4}$ denotes future abnormal returns,[11] and $CashFlows_{i,t+1}$ is cash flows scaled by total assets. The results, reported in Table 8, show that the link between R&D and Tobin's Q is stronger in the case of higher *Lendable*. These results are in line with the of Chen, Goldstein, and Jiang (2007), implying that managers may have greater incentives to rely on stock price in making long-term investment decisions if the stock price becomes more efficient through the efforts of short sellers.

VI. The Real Effects of Lendable on R&D Investment

Our results confirm a causal interpretation of the positive relationship between short-selling potential and long-term investment and provide the economic channels through which short-selling potential affects long-term investment. More investment, however, does not necessarily imply optimality, as it may also imply over-investment, which reduces efficiency and firm value. To address this issue, we design a set of tests to explore the real impact of short selling in terms of firm value.

A. *Lendable* and Under- or Over-investment

In this section, we investigate whether *Lendable* induces the firm to achieve an optimal R&D path. Specifically, we directly examine the impact of short selling on the long-term investment decisions of firms that exhibit relative under- or over-investment compared with industry peers.

We follow Biddle, Hilary, and Verdi's (2009) methodology. For each firm, we create an R&D under-investment dummy (*Under-investment*) and an over-investment dummy (*Over-investment*). These are constructed by preliminarily regressing, for each industry (and each country), firms' R&D investment on a set of firm characteristics:

[11] We include firms' future returns to control for managers' market timing of investment, as it has been argued that firms invest more when their stocks are overvalued (i.e., when expected future returns are lower (see, Baker and Wurgler (2002), and Baker, Stein, and Wurgler (2003)).

$$RD/TA_{i,t+1} = \alpha + \beta_1 TA_{i,t} + \beta_2 Age_{i,t} + \beta_3 SalesG_{i,t} + \beta_4 Leverage_{i,t} + \beta_5 BM_{i,t} + \beta_6 Cash_{i,t} + \theta_{i,t+1}. \quad (6)$$

The residual $\theta_{i,t+1}$ represents the degree of over-investment (under-investment). We then sort firms yearly in each industry into quintiles based on $\theta_{i,t+1}$. Firms in the bottom quintile (i.e., the most negative residuals) are in the under-investment group, firms in the top quintile (i.e., the most positive residuals) are in the over-investment group, and the normal investment group is in the middle.

Next, we estimate a multi-nominal logistic regression (using the normal investment group as a reference) that predicts the likelihood that a firm will be in one of the extreme quintiles as opposed to the middle quintiles as:

$$Prob(Under\text{-}investment_{i,t+1}, Over\text{-}investment_{i,t+1}\ vs.\ Normal\text{-}investment_{i,t+1}) = \alpha + \beta_1 Lendable_{i,t} + \beta_2 X_{i,t} + \varepsilon_{i,t+1}, \quad (7)$$

where $X_{i,t}$ includes institutional ownership (*IO*), the log of annual stock returns (*Return*), stock return volatility (*STD*), MSCI country index membership (*MSCI*), and American Depository Receipts (*ADR*). Additionally, we control for industry-, country-, and year-fixed effects (ICY). *P*-values, based on standard errors adjusted for heteroskedasticity and firm-level clustering, are presented in parentheses below coefficients.

This specification considers simultaneously, but separately, the likelihood of over- and under-investment. We report the results in Table 9. Models (1) and (2) report the results for the under-investment and over-investment groups sorted by industry, while Models (3) and (4) report the results for under-investment and over-investment groups sorted by both country and industry (i.e., we sort firms yearly in each country-industry into quintiles based on $\theta_{i,t+1}$).

The coefficients associated with *Lendable* have the predicted signs. Models (1)-(4) show that the coefficients for *Lendable* in the under-investment equations are negative and statistically significant (with *p*-values well below 0.001), whereas the coefficients for *Lendable* in the over-investment equations are insignificant. These results suggest that firms with high short-selling potential are less likely to exhibit under-investment behavior. For example, holding all other factors in Model (1) constant, a one-standard-deviation increase in *Lendable* reduces the odds of a firm under-investing relative to its peers by 11%, which is again highly significant in both statistical and economic terms.[12] The conclusion holds regardless of whether we compare a firm to its industry peers around the world or in the same country.

B. *Lendable* and the Impact of R&D on Firm Value

Next, we investigate whether *Lendable* affects firm value by optimizing R&D. We proceed in two steps. First, we ask whether, if *Lendable* affects subsequent R&D investment, such *Lendable*-related R&D has positive implications for a firm's future performance. We therefore regress the firm's average future growth and performance (productivity growth (*PG*), value added growth (*VAG*)[13], return-on-assets ratio (*ROA*), annual stock returns (*Return*)) over the next three years on one-year lagged lendable shares (*Lendable*), its interaction with R&D scaled by total assets (*RD/TA*), and firm-level control variables (*X*). We also control for industry-, country-, and year-fixed effects (ICY). Thus, we estimate:

$$PG_{i,t+1,t+3}\left(VAG_{i,t+1,t+3}, ROA_{i,t+1,t+3}, Return_{i,t+1,t+3}\right)$$
$$= \alpha + \beta_1 Lendable_{i,t-1} + \beta_2 Lendable_{i,t-1} \times RD/TA_{i,t} + \beta_3 RD/TA_{i,t}$$
$$+ \beta_4 X_{i,t} + \varepsilon_{i,t+1}, (8)$$

where $X_{i,t}$ includes the same list of firm control variables as above.

We report the results in Table 9. Models (1) and (2) display the results for future growth, while models (3) and (4) display the results for future performance. The results show that, while R&D and *Lendable* are not always directly related to future performance, the interaction between R&D and *Lendable* is always positive and significant. The effect is stronger in the case of performance. The interaction between R&D and *Lendable* significantly boosts firm-level growth and performance, suggesting that R&D investment induced by short-selling potential is indeed "optimal".

In the second step, we examine whether *Lendable*-related R&D has positive implications for a firm's future innovation outputs. This helps determine whether *Lendable* affects firm performance by optimizing R&D. We measure innovation outputs, using the number of

[12] The impact is computed as exp(-1.451×0.08)-1.

[13] We follow Brown, Martinsson and Petersen (2013) in defining the two measures of a firm's future growth. Value added growth is measured as the log change in the sum of operating income plus labor expense. Productivity growth is computed as revenue growth - 0.3*growth in fixed assets – 0.7*growth in labor inputs (employees).

patents granted by national/regional patent offices applied for by a firm in a given year (*Patent*). Patent data are from BVD Orbis. The Orbis patent database provides comprehensive coverage of more than 83 million patent applications worldwide from the 1850s through 2013. These patents are filed by public and private firms, individuals, governments, and other organizations such as universities through 94 national, regional, and international patent offices. We then estimate the following specification:

$$Patent_{i,t+1,t+3}\left(Patent_{i,t+1}, Patent_{i,t+2}, Patent_{i,t+3}\right)$$
$$= \alpha + \beta_1 Lendable_{i,t-1} + \beta_2 Lendable_{i,t-1} \times RD/TA_{i,t} + \beta_3 RD/TA_{i,t}$$
$$+ \beta_4 X_{i,t} + \varepsilon_{i,t+1}, (9)$$

where $Patent_{i,t+1,t+3}$ is the logarithm of a firm's average future patent counts over the next three years; $Patent_{i,t+1}, Patent_{i,t+2}, Patent_{i,t+3}$ are the logarithm of a firm's patent counts in year *t*+1, *t*+2 and *t*+3, respectively.

The results are reported in Models (5)-(8) in Table 9. Several interesting findings emerge. First, a higher level of R&D investment leads to increased patent output. Second, *Lendable* is positively related to the future patent counts of firms. Finally, and most interestingly, the interactions between *Lendable* and *RD/TA* are positive and statistically significant in all four models. The findings suggest that short-selling potential has real effects on R&D efficiency – in the presence of short selling, a fixed proportion of R&D inputs leads to a higher degree of R&D output. This also explains why short-selling potential is positively related to future patent output. That is, *Lendable* enhances R&D efficiency, resulting in increased innovation.

Overall, our results confirm the beneficial effects of short selling on R&D investment and its effects on the value of the firm.

Conclusion

We examine the link between short-term investors and R&D investment. We argue that short-term investors can foster the market to assess firms' decisions to invest in R&D. We focus on a specific set of short-term investors: short sellers. Such investors are clearly short-term, informed, and, unlike most other short-term investors, display an intensity of attack that can increase with the severity of misconduct. We expect a positive correlation between the presence of short sellers and R&D investment.

We test these hypotheses using a worldwide short-selling dataset that spans 12,114 firms across 33 countries for the 2003-2009 period. We find a strong positive correlation between the number of shares of a firm available to be lent and the amount of investment a firm undertakes in R&D. An instrumental variable approach and several exogenous events (cross-sectional and time-series regulatory and market restrictions) enable us to detect a causal link between the two. We further explore three possible channels through which short selling fosters R&D. The evidence shows that short sellers increase R&D by improving price efficiency, disciplining myopic managers, and guiding managers in making investment decisions. We also find that the threat of short selling strengthens the positive relationship between R&D and future performance, growth, and innovation output.

Overall, our results suggest a beneficial effect of short-selling on long-term investment and innovation by firms. This research therefore provides a basis for a re-assessment of short selling as a positive externality.

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Appendix A: Variable definitions

Variable	Acronym	Definition	Data Source
A. Firm-level variable			
A1. Short selling variables			
Lendable shares	*Lendable*	Annual average fraction of shares of a firm available to lend	Dataexplorers
Shares on loan	*On Loan*	Annual average fraction of shares of a firm lended out	Dataexplorers
ETF ownership	*ETF*	Annual average holdings by ETF as a percentage of total number of outstanding shares	FactSet
A2. Investment variables			
R&D scaled by total assets	*RD/TA*	Ratio of research and development expenses to total assets	Worldscope
R&D scaled by sales	RD/Sales	Ratio of research and development expenses to sales	Worldscope
R&D scaled by total investment	RD/CapExRD	Ratio of research and development expenses to capital expenditures plus research and development expenses	Worldscope
Total investment	*CapExRD/TA*	Ratio of capital expenditures plus research and development expenses scaled by total assets	Worldscope
Capital expenditures	*CapEx/TA*	Ratio of capital expenditures scaled by total assets	
A3. Control variables			
Firm size	*Size*	Log of total assets in U.S. $.	Datastream
Book-to-market ratio	*BM*	Log of book-to-market equity ratio	Datastream
Age	*Age*	Log of number of years from the listed date to current date	Datastream
Financial leverage	*Leverage*	Ratio of total debt to total assets	Worldscope
Cash holdings	*Cash*	Cash and cash equivalents scaled by total assets	Worldscope
Sales growth	*SalesG*	Log of changes in net sales	Wordscope
Institutional ownership	*IO*	Aggregate equity holdings by institutional investors scaled by total number of outstanding shares	FactSet
Annual stock return	*Return*	Log of annual stock return	Datastream
Stock return volatility	*STD*	Annualized standard deviation of monthly stock returns	Datastream
MSCI country index membership	*MSCI*	Dummy variable equals one if the firm is included in an MSCI country index and zero otherwise	Datastream
American Depository Receipts	*ADR*	Dummy variable equals one if the firm was cross-listed on a U.S. stock exchange	Multiple sources**

Appendix A: Variable definitions - Continued

Variable	Acronym	Definition	Data Source
A4. Other variables			
Amihud's (2002) illiquidity	*Amihud*	Log of the average of daily absolute value of stock return divided by dollar trading volume	Datastream
News coverage	*NewsCoverage*	Log of one plus number of news releases recorded in Dow Jones Newswire	RavenPack
Number of analysts following	*Analyst*	Number of financial analysts following a firm	IBES
Analyst forecast errors	*AnalystErrors*	Analyst forecast errors scaled by stock price	IBES
Corporate governance index	*ISS*	RiskMetrics's composite corporate governance index based on 41 firm-level governance attributes	Aggarwal et al. (2011)
Return-on-asset ratio	*ROA*	Ratio of net income before extraordinary items plus interest expenses to total assets	Worldscope
Tobin's Q	*Q*	Total assets plus market equity capitalization minus book equity value scaled by total assets	Worldscope
Cash flows	*CashFlows*	Cash flows scaled by total assets	Worldscope
Productivity growth	*PG*	Revenue growth - 0.3*growth in fixed assets – 0.7*growth in labor inputs (employees)	Worldscope
Value added growth	*VAG*	Log change in the sum of operating income	Worldscope
Number of patents	*Patent*	Number of granted patents applied for by a firm in a year to national/regional patent offices	BVD Orbis
B.Country-level variable			
Legality of short selling	*Legality*	Dummy variable equals one if short selling is legally allowed in a country	Charoenrook and Daouk (2005)
Feasibility of short selling	*Feasibility*	Dummy variable equals one if short selling is feasible in a country	Charoenrook and Daouk (2005)
Put option trading	*Put*	Dummy variable equals one if put option trading is feasible in a country	Charoenrook and Daouk (2005)
Feasibility or put option	*F or P*	Dummy variable equals one if either short selling or put option is feasible in a country	Charoenrook and Daouk (2005)
Market cap-to-GDP ratio	*MV/GDP*	Ratio of stock market capitalization to GDP	World Development Indicators
Credit-to-GDP ratio	*Credit/GDP*	Ratio of banking credit to GDP	World Development Indicators
GDP growth	*GDPG*	Annual GDP growth	World Development Indicators
FDI-to-GDP ratio	*FDI/GDP*	Ratio of the sum of absolute values of FDI inflows and outflows to GDP	World Development Indicators
Disclosure requirements index	*DisReq*	An index which reflects disclosure rules aimed at reducing information asymmetry problem	Hail and Leuz (2006)
Anti-self-dealing index	*Antsel*	An index which measures the strength of laws in protecting investors against self-dealing transactions by insiders	Djankov et al. (2008)
Legal origin	*CommLaw*	A dummy variable which equals one if a country has a common law origin, and zero otherwise.	La Porta et al. (1998)

Appendix B: Number of Stocks by Country and Year

This table summarizes the number of our sample stocks for each country over the 2003 to 2009 sample period.

	N	2003	2004	2005	2006	2007	2008	2009
Australia	563	105	167	217	245	310	398	385
Austria	39	12	18	18	21	26	33	33
Belgium	76	15	24	35	44	53	62	63
Brazil	55				1	8	33	48
Canada	671	115	154	220	376	425	485	448
Denmark	72	17	22	31	42	59	60	58
Finland	40	14	19	19	21	24	27	29
France	90	25	37	55	59	76	82	80
Germany	440	149	185	202	241	298	357	337
Greece	452	101	134	198	279	286	339	317
Hong Kong	38	1	14	1	1	19	22	26
Indonesia	361	57	81	114	140	186	281	293
Ireland	29	8	6	9	14	17	14	18
Israel	36		8	12	14	13	26	30
Italy	202	58	77	90	124	138	153	167
Japan	2,285	1,197	1,351	1,536	1,703	1,858	1,954	1,946
Korea	391	23	53	88	119	276	351	352
Mexico	59	16	28	30	35	39	49	51
Netherlands	100	40	52	57	75	78	78	75
New Zealand	132	24	35	46	60	76	91	98
Norway	40	10	16	21	22	21	28	24
Philliphines	12				5	6	1	9
Poland	29	7	10	12	20	23	23	25
Portugal	10	1	4	4	4	2	7	6
Singapore	124	36	45	48	68	92	97	93
South Africa	220	35	47	67	77	95	161	174
Spain	97	40	47	59	64	72	77	80
Sweden	213	45	74	99	111	150	169	166
Swizerland	166	58	88	108	121	126	139	138
Taiwan	58	2	3	5	15	25	44	52
Turkey	127	13	18	37	47	44	61	118
United Kingdom	1,024	472	519	497	570	604	602	587
United States	3,718	889	2,376	2,542	2,714	2,664	2,397	2,416
All	11,969	3,585	5,712	6,477	7,452	8,189	8,701	8,742

Table 1: Summary Statistics

This table presents the summary statistics and Spearman (Pearson) correlation coefficients of main variables used in this study. The variables are R&D scaled by total assets (*RD/TA*), R&D scaled by sales (*RD/Sales*), R&D scaled by total investment (*RD/CapExRD*), total investment (*CapExRD/TA*), capital expenditures (*CapEx/TA*), lendable shares (*Lendable*), shares on loan (*On loan*), firm size (*Size*), book-to-market ratio (*BM*), age (*Age*), financial leverage (*Leverage*), cash holdings (Cash), sales growth (*SalesG*), institutional ownership (*IO*), log of annual stock return (*Return*), stock return volatility (*STD*), MSCI country index membership (*MSCI*), American Depository Receipts (*ADR*). Panel A reports the number of observations (N), mean, median, standard deviation (STD), and the deciles (90% and 10%) and quartiles (75% and 25%) distribution of the variables. Panel B reports the correlation coefficients among the variables above, where the highlighted upper-right part (bottom-left part) of the table refers to the Spearman (Pearson) correlation matrix. The sample is between 2003 and 2009. All the variables are defined in Appendix A.

Panel A: Summary Statistics

Variable	N	Mean	STD	P90	Q3	Median	Q1	P10
RD/TA(t+1)	48,858	0.024	0.049	0.079	0.023	0.000	0.000	0.000
RD/Sales(t+1)	48,858	0.030	0.076	0.092	0.023	0.000	0.000	0.000
RD/CapExRD(t+1)	48,858	0.225	0.309	0.781	0.424	0.000	0.000	0.000
CapExRD/TA(t+1)	48,858	0.076	0.074	0.166	0.101	0.055	0.026	0.010
CapEx/TA(t+1)	48,858	0.052	0.062	0.114	0.065	0.034	0.016	0.007
Lendable(t)	48,858	0.058	0.080	0.185	0.079	0.021	0.004	0.000
On Loan(t)	48,858	0.016	0.032	0.045	0.016	0.004	0.001	0.000
Size(t)	48,858	13.219	1.809	15.614	14.368	13.119	11.995	10.964
BM(t)	48,858	-0.638	0.865	0.380	-0.096	-0.614	-1.138	-1.660
Age(t)	48,858	2.548	0.775	3.497	3.178	2.639	2.079	1.386
Leverage(t)	48,858	0.199	0.175	0.442	0.316	0.175	0.034	0.000
Cash(t)	48,858	0.173	0.178	0.424	0.234	0.112	0.047	0.018
SalesG(t)	48,858	0.151	0.399	0.417	0.234	0.116	0.019	-0.078
IO(t)	48,858	0.248	0.287	0.757	0.373	0.125	0.028	0.000
Return(t)	48,858	-0.027	0.618	0.598	0.329	0.060	-0.294	-0.806
STD(t)	48,858	0.412	0.261	0.698	0.505	0.350	0.248	0.185
MSCI	48,858	0.680	0.467	1.000	1.000	1.000	0.000	0.000
ADR(t)	48,858	0.038	0.192	0.000	0.000	0.000	0.000	0.000

Table 1: Summary Statistics – Continued

Panel B: Correlation Coefficients (Spearman for the upper-right part, highlighted; Pearson for the bottom-left part)

Variable	*RD/TA(t+1)*	*RD/Sales(t+1)*	*RD/CapExRD(t+1)*	*CapExRD/TA(t+1)*	*CapEx/TA(t+1)*	*Lendable(t)*	*On Loan(t)*	*Size(t)*	*BM(t)*	*Age(t)*	*Leverage(t)*	*Cash(t)*	*SalesG(t)*	*IO(t)*	*Return(t)*	*STD(t)*	*MSCI*	*ADR(t)*
RD/TA(t+1)	-	0.937	0.976	0.469	-0.136	0.048	0.086	-0.091	-0.069	0.058	-0.225	0.323	-0.082	0.056	-0.055	0.094	0.025	0.028
RD/Sales(t+1)	0.592	-	0.920	0.396	-0.117	0.055	0.081	-0.034	-0.029	0.087	-0.193	0.275	-0.080	0.053	-0.043	0.054	0.050	0.030
RD/CapExRD(t+1)	0.690	0.632	-	0.359	-0.281	0.025	0.068	-0.104	-0.042	0.057	-0.232	0.331	-0.100	0.038	-0.060	0.096	0.013	0.016
CapExRD/TA(t+1)	0.717	0.393	0.374	-	0.674	0.120	0.125	-0.039	-0.219	-0.065	-0.102	0.154	0.104	0.131	0.013	0.102	0.053	0.092
CapEx/TA(t+1)	-0.116	-0.118	-0.253	0.602	-	0.103	0.071	0.179	-0.111	0.031	0.144	-0.178	0.152	0.080	0.091	-0.077	0.115	0.079
Lendable(t)	0.020	0.045	0.022	0.021	0.007	-	0.575	0.405	-0.171	0.134	0.009	-0.069	0.045	0.551	-0.031	-0.126	0.334	0.096
On Loan(t)	0.081	0.096	0.076	0.070	0.008	0.393	-	0.327	-0.187	0.056	0.084	0.003	0.048	0.393	-0.035	0.029	0.331	0.088
Size(t)	-0.232	-0.157	-0.182	-0.151	0.050	0.255	0.155	-	0.065	0.345	0.376	-0.298	-0.024	0.250	0.060	-0.354	0.541	0.175
BM(t)	-0.183	-0.126	-0.098	-0.212	-0.093	-0.103	-0.107	0.092	-	0.179	0.077	-0.179	-0.250	-0.226	-0.203	-0.070	-0.111	-0.047
Age(t)	-0.112	-0.094	-0.014	-0.131	-0.060	0.122	0.008	0.325	0.171	-	0.140	-0.186	-0.225	0.049	0.053	-0.264	0.182	0.024
Leverage(t)	-0.211	-0.190	-0.256	-0.115	0.077	0.006	0.071	0.330	0.019	0.094	-	-0.511	-0.008	-0.030	0.009	-0.075	0.102	0.038
Cash(t)	0.463	0.391	0.418	0.285	-0.124	-0.049	0.054	-0.345	-0.238	-0.233	-0.422	-	-0.007	-0.017	-0.015	0.202	-0.036	-0.009
SalesG(t)	-0.021	-0.009	-0.062	0.067	0.121	-0.009	0.002	-0.031	-0.129	-0.164	-0.002	-0.007	-	0.050	0.174	0.080	0.004	0.025
IO(t)	0.075	0.106	0.079	0.077	0.023	0.448	0.357	0.219	-0.207	0.031	-0.014	0.040	-0.013	-	0.009	-0.045	0.280	0.008
Return(t)	-0.099	-0.093	-0.085	-0.016	0.085	-0.027	-0.067	0.058	-0.204	0.067	-0.008	-0.040	0.083	-0.012	-	-0.047	0.083	0.008
STD(t)	0.191	0.147	0.129	0.161	0.011	-0.108	0.050	-0.332	-0.088	-0.220	-0.043	0.221	0.044	-0.054	0.015	-	-0.141	-0.032
MSCI	-0.058	-0.013	-0.030	-0.019	0.041	0.230	0.192	0.514	-0.093	0.175	0.088	-0.067	-0.013	0.265	0.087	-0.147	-	0.074
ADR(t)	0.031	0.031	0.008	0.066	0.059	0.077	0.057	0.212	-0.040	0.026	0.028	-0.013	0.012	-0.043	0.005	-0.027	0.074	-

Table 2: Short Selling and R&D Investment

This table presents panel regression of a firm's investment measures (*RD/TA, RD/Sales, CapEx/TA*, *RD/CapExRD*) on lendable shares (*Lendable*) or its shares on loan (*On Loan*), and firm-level control variables (*X*) as well as unreported industry-, country-, and year-fixed effects (ICY) on the full samples and different subsamples. The regression model is $RD/TA_{i,t+1} = \alpha + \beta_1 Lendable_{i,t} + \beta_2 X_{i,t} + \varepsilon_{i,t+1}$, where $X_{i,t}$ includes firm size (*Size*), book-to-market ratio (*BM*), age (*Age*), financial leverage (*Leverage*), cash holdings (*Cash*), sales growth (*SalesG*), institutional ownership (*IO*), log of annual stock return (*Return*), stock return volatility (*STD*), MSCI country index membership (*MSCI*), American Depository Receipts (*ADR*). The construction of these variables is detailed in Appendix A. Ex.GFC excludes the global financial crisis period from 2007 to 2008. Key results are highlighted in bold. *t*-statistics shown in parentheses are based on standard errors adjusted for heteroskedasticity and firm-level clustering. Obs denotes the number of firm-year observations, and AdjRsq is adjusted R^2. The sample period is from 2003 to 2009.

	RD/TA(t+1)					*RD/Sales*	*CapEx/TA*	*RD/CapExRD*
			Lendable(t)≠0	*RD/TA(t+1)≠0*	Ex.Crisis	(t+1)	(t+1)	(t+1)
Variable	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)	Model (8)
Lendable(t)	**0.029**		**0.031**	**0.031**	**0.028**	**0.041**	**-0.012**	**0.225**
	(6.71)		**(6.98)**	**(4.16)**	**(6.48)**	**(6.01)**	**(-1.88)**	**(8.28)**
On Loan(t)		**0.058**						
		(4.93)						
Size(t)	-0.001	-0.001	-0.001	-0.004	-0.001	0.000	-0.001	-0.001
	(-3.35)	(-2.61)	(-4.32)	(-9.13)	(-3.72)	(0.10)	(-2.04)	(-0.31)
BM(t)	-0.003	-0.003	-0.004	-0.007	-0.003	0.000	-0.005	-0.009
	(-6.03)	(-5.97)	(-7.24)	(-8.31)	(-6.43)	(-0.49)	(-7.13)	(-3.08)
Age(t)	0.003	0.003	0.003	0.003	0.003	0.003	-0.003	0.031
	(6.82)	(7.15)	(6.37)	(4.02)	(6.87)	(4.26)	(-4.75)	(10.40)
Leverage(t)	-0.007	-0.008	-0.007	-0.012	-0.005	-0.002	0.006	-0.117
	(-3.82)	(-4.45)	(-3.60)	(-3.61)	(-2.83)	(-0.53)	(1.73)	(-9.13)
Cash(t)	0.072	0.071	0.074	0.093	0.068	0.113	-0.025	0.355
	(21.16)	(21.07)	(20.94)	(20.53)	(19.76)	(18.93)	(-8.71)	(20.26)
SalesG(t)	-0.001	-0.001	-0.001	-0.005	0.000	0.002	0.008	-0.013
	(-1.53)	(-1.77)	(-1.67)	(-3.05)	(-0.20)	(1.18)	(7.16)	(-4.00)
IO(t)	-0.006	-0.004	-0.007	-0.007	-0.004	-0.005	0.005	-0.023
	(-2.58)	(-1.95)	(-3.09)	(-2.08)	(-1.70)	(-1.37)	(1.93)	(-1.73)
Return(t)	-0.005	-0.005	-0.006	-0.010	-0.006	-0.007	0.005	-0.027
	(-11.37)	(-10.95)	(-12.20)	(-12.15)	(-11.11)	(-8.71)	(7.51)	(-10.32)
STD(t)	0.006	0.006	0.008	0.014	0.007	0.009	0.005	0.020
	(5.31)	(4.89)	(6.42)	(6.13)	(5.81)	(4.16)	(2.77)	(2.93)
MSCI	0.003	0.003	0.002	0.004	0.003	0.006	0.005	0.016
	(3.42)	(3.30)	(2.06)	(2.61)	(2.90)	(4.16)	(3.87)	(2.46)
ADR(t)	0.013	0.013	0.013	0.016	0.014	0.016	0.007	0.062
	(6.53)	(6.40)	(6.70)	(5.44)	(6.52)	(5.14)	(2.41)	(5.43)
Fixed Effects	ICY	ICY	ICY	ICY	ICY	ICY	ICY	ICY
Obs	48858	48858	46014	24509	33397	48858	48858	48858
AdjRsq	35.5%	35.5%	36.8%	44.8%	36.5%	28.6%	18.5%	38.8%

Table 3: Short Selling and R&D Investment: Alternative Specifications

This table addresses the endogeneity problem and presents tests with firm-fixed effects in Model (1), Granger causality tests in Models (2) and (3), and difference-in-difference specifications in Model (4). Model (1) presents results of the baseline regression, with firm-fixed effects as a control. Model (2) regresses R&D scaled by total assets (*RD/TA*) on lendable shares (*Lendable*), with lagged *RD/TA* as a control. Model (2) regresses *Lendable* on *RD/TA*. Model (4) regresses the change in R&D scaled by total assets on the change in lendable shares. In Model (5), *D_Substitute(t+1)* is a dummy variable that takes a value of one if a firm simultaneously increases RD/TA and reduces CapEx/TA and zero otherwise. This dummy variable is regressed on the change in lendable shares. Key results are highlighted in bold; *t*-statistics, shown in parentheses, are based on standard errors adjusted for heteroskedasticity and firm-level clustering. Obs denotes the number of firm-year observations, and AdjRsq is adjusted R^2. The sample period is from 2003 to 2009.

	Firm-fixed Effects	Granger Causality Tests			Diff-in-diff Tests	
	RD/TA(t+1)	*RD/TA(t+1)*	*Lendable(t+1)*		*ΔRD/TA(t+1)*	*D_Substitute(t+1)*
Variable	Model (1)	Model (2)	Model (3)		Model (4)	Model (5)
Lendable(t)	**0.011**	**0.012**		*ΔLendable(t)*	**0.017**	**0.229**
	(3.58)	**(5.32)**			**(3.68)**	**(3.95)**
RD/TA(t)		0.718	**0.012**			
		(42.34)	**(1.69)**			
Size(t)	-0.003	0.000	0.009	*ΔSize(t)*	0.010	-0.015
	(-3.97)	(3.46)	(26.95)		(7.99)	(-2.25)
BM(t)	0.001	0.001	0.003	*ΔBM(t)*	0.002	0.033
	(2.58)	(2.82)	(6.36)		(4.39)	(8.57)
Age(t)	0.004	0.000	0.003	*ΔAge(t)*	0.001	0.011
	(2.78)	(2.43)	(5.49)		(4.41)	(3.99)
Leverage(t)	-0.001	-0.002	-0.011	*ΔLeverage(t)*	-0.007	0.121
	(-0.28)	(-2.93)	(-4.91)		(-2.73)	(5.48)
Cash(t)	-0.001	0.017	0.005	*ΔCash(t)*	0.004	-0.067
	(-0.32)	(10.60)	(1.95)		(1.28)	(-3.24)
SalesG(t)	0.000	0.001	-0.001	*ΔSalesG(t)*	0.000	-0.002
	(0.38)	(1.44)	(-2.06)		(-0.12)	(-0.55)
IO(t)	-0.007	-0.001	0.161	*ΔIO(t)*	-0.004	-0.020
	(-2.59)	(-1.55)	(59.60)		(-1.60)	(-0.77)
Return(t)	-0.001	-0.001	0.012	*ΔReturn(t)*	0.001	0.001
	(-1.75)	(-3.26)	(22.31)		(2.47)	(0.38)
STD(t)	-0.002	0.001	-0.007	*ΔSTD(t)*	0.000	-0.016
	(-2.18)	(1.39)	(-5.92)		(-0.29)	(-2.13)
MSCI		0.000	0.024	*MSCI*	0.000	0.011
		(0.33)	(21.99)		(0.81)	(2.59)
ADR(t)	0.007	0.003	0.012	*ADR(t)*	0.000	0.021
	(1.89)	(4.48)	(5.54)		(-0.46)	(2.13)
Fixed Effects	FY	ICY	ICY		ICY	ICY
Obs	48,858	48853	46717		36711	36711
AdjRsq	88.8%	78.1%	65.7%		1.9%	4.5%

Table 4: Short Selling and R&D Investment: Short-selling Ban, Hong Kong's Experiment, and US's Regulation SHO

This table explores three experiments with changes in short-selling regulation. Panel A examines short-selling ban, in which regulators around the world imposed regulatory restrictions on short selling in reaction to the global financial crisis period from 2007 to 2008. Models (1) and (2) report the regression results on the sub-samples with or without short-selling ban imposed. Panel B explores the unique regulatory setting in the Hong Kong market in which the regulator changes the list of stocks eligible to short selling based on a quarterly frequency from 1994 to 2005, proxied by an annual dummy variable, Hong Kong short-selling eligibility (*HK SS*). Modes (3) reports results based on a testing period from 1994 to 2005, and Modes (4) reports results based on a testing period from 2002 to 2005. Panel C examines Regulation SHO in the U.S., in which the SEC randomly selects a sample of pilot firms announced in 2004 and formally removes their uptick restrictions in 2005. The SHO pilot program lasts three years from 2005 to 2007. *Pilot* refers to the dummy variable which takes the value of 1 if the stock is selected as a SHO pilot firm; and *SHOTest* refers to the dummy variable which takes the value of 1 if time *t* is within 2005-2007; and *SHOTest×Pilot* is the interaction term. Models (5) and (6) report results based on entire sample, while Models (7) and (8) report results based on only Russell 3000 stocks. Models (5) and (7) report results based on a testing period from 1999 to 2009, while Models (6) and (8) report results based on a testing period from 2001 to 2007, in both of which the announcement year 2004 of Regulation SHO is removed from the sample. Key results are highlighted in bold. *t*-statistics shown in parentheses are based on standard errors adjusted for heteroskedasticity and firm-level clustering. Obs denotes the number of firm-year observations, and AdjRsq is adjusted R^2.

	A. Short Selling Ban (GFC)		**B. Regulatory Short Selling (Hong Kong)**	
	RD/TA(t+1)		*RD/TA(t+1)*	
	With	Without	1994-2005	2002-2005
Variable	Model (1)	Model (2)	Model (3)	Model (4)
Lendable(t)	**0.026**	**0.028**		
	(1.27)	**(6.27)**		
HK SS(t)			**0.003**	**0.007**
			(2.97)	**(3.33)**
Size(t)	0.001	-0.001	-0.001	-0.002
	(1.71)	(-3.67)	(-2.91)	(-2.90)
BM(t)	-0.003	-0.003	0.000	0.000
	(-3.40)	(-6.13)	(-0.41)	(0.40)
Age(t)	0.004	0.003	-0.001	-0.001
	(4.80)	(6.27)	(-1.45)	(-1.68)
Leverage(t)	-0.011	-0.007	-0.005	-0.005
	(-3.73)	(-3.58)	(-2.41)	(-1.81)
Cash(t)	0.023	0.074	0.005	0.007
	(3.32)	(21.07)	(1.34)	(1.63)
SalesG(t)	0.000	-0.001	0.000	0.000
	(0.03)	(-1.61)	(-0.16)	(-0.20)
IO(t)	0.000	-0.005	0.018	0.016
	(-0.01)	(-2.24)	(1.91)	(1.60)
Return(t)	-0.003	-0.006	-0.001	-0.002
	(-1.90)	(-11.66)	(-1.58)	(-1.50)
STD(t)	0.001	0.007	-0.001	000
	(0.17)	(5.64)	(-1.23)	(0.01)
MSCI	0.001	0.003	0.000	0.000
	(1.03)	(3.19)	(0.35)	(-0.19)
ADR(t)	0.011	0.013	-0.005	-0.003
	(2.12)	(6.57)	(-1.23)	(-0.83)
Fixed Effects	ICY	ICY	ICY	ICY
Obs	2,955	45,903	3,466	2,059
AdjRsq	21.8\%	36.1\%	13.2%	14.1%

	C. Regulatory Short Selling (US SHO Pilot Prgram)			
	All sample stocks		*Russell 3000 stocks*	
	RD/TA(t+1)		*RD/TA(t+1)*	
	1999-2009	2001-2007	1999-2009	2001-2007
Variable	Model (5)	Model (6)	Model (7)	Model (8)
SHOTest ×Pilot	**0.007**	**0.009**	**0.005**	**0.006**
	(4.38)	**(5.20)**	**(2.69)**	**(2.94)**
Pilot	0.001	-0.001	0.001	0.000
	(0.69)	(-0.65)	(0.58)	(-0.19)
SHOTest	-0.002	0.000	0.005	0.007
	(-1.07)	(0.21)	(2.43)	(3.17)
Size(t)	-0.002	-0.002	-0.003	-0.003
	(-5.21)	(-4.29)	(-5.02)	(-4.52)
BM(t)	-0.006	-0.006	-0.008	-0.008
	(-6.60)	(-6.66)	(-7.04)	(-6.83)
Age(t)	0.002	0.002	0.006	0.007
	(2.32)	(2.14)	(4.50)	(4.80)
Leverage(t)	-0.018	-0.015	-0.009	-0.007
	(-5.52)	(-4.07)	(-2.04)	(-1.30)
Cash(t)	0.067	0.065	0.073	0.070
	(13.98)	(12.49)	(10.56)	(10.07)
SalesG(t)	-0.001	0.001	0.002	0.005
	(-0.96)	(0.34)	(1.00)	(2.01)
IO(t)	0.001	0.001	-0.003	-0.002
	(0.52)	(0.30)	(-1.05)	(-0.61)
Return(t)	-0.011	-0.012	-0.013	-0.014
	(-12.83)	(-12.35)	(-11.39)	(-9.52)
STD(t)	0.011	0.013	0.015	0.021
	(6.89)	(6.79)	(5.75)	(6.21)
MSCI	0.002	0.001	-0.005	-0.007
	(1.11)	(0.62)	(-1.49)	(-1.76)
Fixed Effects	ICY	ICY	ICY	ICY
Obs	27,358	17,049	13,291	8,843
AdjRsq	38.3%	39.3%	43.6%	45.1%

Table 5: Short Selling and R&D Investment: Instrument with ETF ownership

Panel A addresses the endogeneity problem using ETF ownership (*ETF*) as an instrument variable and presents panel regression of a firm's R&D scaled by total assets (*RD/TA*) on predicted lendable shares (*Lendable*), and firm-level control variables (*X*) as well as unreported industry-, country-, and year-fixed effects (ICY) on the variation of the following models

$$The\ 1st\ stage: Lendable_{i,t} = \alpha + \beta_1 ETF_{i,t} + \beta_2 X_{i,t} + \varepsilon_{i,t};$$

$$The\ 2nd\ stage: RD/TA_{i,t+1} = \alpha + \beta_1 Predicted\ Lendable\ on\ ETF_{i,t} + \beta_2 X_{i,t} + \varepsilon_{i,t+1},$$

where $X_{i,t}$ includes the list of standard control variables. Models (1) and (3) regress lendable shares on ETF ownership (*ETF*) or the residuals of ETF ownership (*ETF-R*), which is obtained by regressing ETF on Amihud's illiquidity (*Amihud*), analyst coverage (*Analyst*), and news coverage (*NewsCoverage*) variables. Models (2) and (4) regress R&D scaled by total assets on predicted lendable shares (*Lendable-P, Lendable-PR*). Panel B provides the diagnostic analyses on the impact of ETF ownership (*ETF*) on *RD/TA* on the subsample of the stocks for which short selling is either prohibited due to regulation (Models 6 and 7) or low – when very little shares could be or actually be lent out (Models 8 to 9). Model (10) explores the reverse constraint by regressing *RD/TA* on *Lendable* on the sample of stocks whose ETF ownership is low. Key results are highlighted in bold. *t*-statistics shown in parentheses are based on standard errors adjusted for heteroskedasticity and firm-level clustering. Obs denotes the number of firm-year observations, and AdjRsq is adjusted R^2. The sample period is from 2003 to 2009.

	A. ETF Ownership as an Instrumental Variable				B.Diagnostic Analyses on the Impact of ETF Ownership					
	Lendable(t)	*RD/TA(t+1)*	*Lendable(t)*	*RD/TA(t+1)*	*RD/TA(t+1)*					
	(1st stage)	(2nd stage)	(1st stage)	(2nd stage)	Full	*Legality=0*	*Feasibility=0*	*Lendable=0*	*0<=Lendable<1%*	*ETF=0*
Variable	Model	Model	Model	Model	Model	Model	Model	Model	Model	Model
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ETF(t)	**0.909**				**0.071**	**-0.783**	**-0.003**	**-0.001**	**0.007**	
	(5.01)				**(3.21)**	**(-2.51)**	**(-0.31)**	**(-0.16)**	**(1.30)**	
ETF-R(t)			**0.855**							
			(5.26)							
Lendable-P(t)		**0.063**								
		(3.14)								
Lendable-PR(t)				**0.035**						
				(2.19)						
Lendable(t)										**0.029**
										(3.22)
Size(t)	0.008	-0.001	0.009	-0.001	-0.001	000	-0.002	-0.001	-0.002	-0.002
	(28.62)	(-3.75)	(22.37)	(-3.00)	(-2.61)	(0.39)	(-2.09)	(-1.55)	(-3.15)	(-4.65)
BM(t)	0.002	-0.003	0.001	-0.003	-0.003	0.000	-0.003	0.000	0.000	-0.001
	(4.07)	(-6.22)	(1.13)	(-5.97)	(-5.95)	(0.12)	(-2.23)	(0.06)	(-0.59)	(-1.02)
Age(t)	0.004	0.003	0.003	0.003	0.003	0.000	0.000	0.001	0.003	0.001
	(6.80)	(6.22)	(6.00)	(6.82)	(6.88)	(-0.18)	(0.14)	(1.55)	(4.18)	(1.88)
Leverage(t)	-0.010	-0.007	-0.014	-0.007	-0.007	-0.021	-0.001	-0.004	-0.004	-0.009
	(-5.23)	(-3.56)	(-6.81)	(-3.67)	(-3.95)	(-2.45)	(-0.14)	(-1.18)	(-1.47)	(-3.25)
Cash(t)	-0.001	0.072	-0.001	0.073	0.072	0.020	0.066	0.040	0.056	0.065
	(-0.68)	(21.21)	(-0.67)	(21.14)	(21.19)	(1.82)	(3.36)	(5.73)	(10.11)	(14.55)
SalesG(t)	-0.005	-0.001	-0.005	-0.001	-0.001	-0.003	0.001	0.001	-0.003	-0.001
	(-10.20)	(-1.20)	(-9.81)	(-1.41)	(-1.69)	(-0.83)	(0.46)	(0.38)	(-2.48)	(-1.03)
IO(t)	0.116	-0.011	0.119	-0.007	-0.004	0.052	0.017	0.009	-0.002	-0.004
	(17.61)	(-3.11)	(20.96)	(-2.26)	(-1.83)	(2.47)	(1.03)	(0.96)	(-0.47)	(-1.25)
Return(t)	-0.001	-0.005	-0.001	-0.005	-0.005	-0.004	-0.004	-0.002	-0.002	-0.004
	(-2.47)	(-11.21)	(-3.11)	(-11.27)	(-11.38)	(-2.42)	(-2.92)	(-1.45)	(-2.07)	(-6.04)
STD(t)	-0.001	0.006	-0.001	0.006	0.006	0.007	0.005	0.001	0.006	0.004
	(-0.89)	(5.31)	(-1.40)	(5.44)	(5.30)	(1.20)	(1.59)	(0.28)	(3.47)	(2.93)
MSCI	0.018	0.003	0.018	0.003	0.004	-0.002	0.005	0.002	0.005	0.004
	(17.04)	(2.44)	(18.61)	(3.16)	(3.75)	(-0.50)	(1.18)	(0.79)	(3.42)	(2.74)
ADR(t)	0.008	0.013	0.008	0.013	0.013	0.035	0.013	0.013	0.012	0.016
	(4.26)	(6.33)	(4.19)	(6.38)	(6.61)	(3.85)	(2.73)	(1.20)	(2.52)	(4.22)
Fixed Effects					ICY	ICY	ICY	ICY	ICY	ICY
Obs	48858	48858	47323	47323	48858	845	2669	3233	14240	19318
AdjRsq	64.5%	35.5%	63.8%	35.3%	35.5%	60.1%	42.8%	17.4%	30.3%	33.3%

Table 6: Short Selling and R&D Investment: Market-wide Short-selling Regulations

Panel A presents a panel regression of a firm's R&D scaled by total assets (*RD/TA*) on market-wide short-selling regulation variables (*Regulatory SS*), firm-level control variables (*X*), and country-level control variables (*C*) as well as unreported industry- and year-fixed effects (IY) on the variation in the following model:

$$RD/TA_{i,t+1} = \alpha + \beta_1 Regulatory\ SS_{i,t} + \beta_2 C_{i,t} + \beta_3 X_{i,t} + \varepsilon_{i,t+1},$$

where $Regulatory\ SS_{i,t}$ includes the legality of short selling (*Legality*), the feasibility of short selling (*Feasibility*), put options trading (*Put*), and the feasibility of put options (*F or P*). $C_{i,t}$ stacks the list of market-level control variables, including the market cap-to-GDP ratio (*MV/GDP*), the credit-to-GDP ratio (*Credit/GDP*), GDP growth (*GDPG*), and the FDI-to-GDP ratio (*FDI/GDP*). $X_{i,t}$ includes the same list of firm control variables as above. Models 1-4 report regression results when only firm control variables are used. Models 5-8 tabulate the results when country-level control variables are also included. Panel B repeats the same regressions at the country-industry level. Key results are highlighted in bold; *t*-statistics, shown in parentheses, are based on standard errors adjusted for heteroskedasticity and firm-level clustering. Obs denotes the number of firm-year observations, and AdjRsq is adjusted R^2. The sample period is from 1990 to 2009.

	A. Market-wide Short-selling Regulations at the Firm-level Analysis								**B. Market-wide Short-selling Regulations at the Industry-level Analysis**							
	RD/TA(t+1)								*RD/TA(t+1)*							
	Legality	*Feasibility*	*Put*	*F or P*	*Legality*	*Feasibility*	*Put*	*F or P*	*Legality*	*Feasibility*	*Put*	*F or P*	*Legality*	*Feasibility*	*Put*	*F or P*
Variable	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)	Model (8)	Model (9)	Model (10)	Model (11)	Model (12)	Model (13)	Model (14)	Model (15)	Model (16)
Regulatory SS(t)	**0.008**	**0.005**	**0.004**	**0.007**	**0.006**	**0.005**	**0.004**	**0.006**	**0.007**	**0.009**	**0.006**	**0.008**	**0.006**	**0.010**	**0.007**	**0.009**
	(15.29)	**(11.82)**	**(10.42)**	**(13.52)**	**(10.85)**	**(10.38)**	**(9.19)**	**(11.52)**	**(2.40)**	**(2.36)**	**(3.30)**	**(2.76)**	**(2.56)**	**(2.28)**	**(2.94)**	**(2.63)**
MV/GDP(t)					0.001	0.001	0.001	0.001					0.000	-0.002	-0.001	-0.001
					(4.17)	(2.42)	(4.10)	(4.02)					(-0.21)	(-1.30)	(-0.83)	(-1.00)
Credit/GDP(t)					0.001	0.000	0.001	0.001					-0.001	0.001	-0.001	-0.001
					(4.10)	(1.80)	(3.85)	(4.78)					(-2.13)	(1.61)	(-2.00)	(-1.43)
GDPG(t)					0.014	0.018	0.008	0.007					-0.018	-0.005	-0.020	-0.023
					(2.82)	(3.57)	(1.67)	(1.41)					(-1.34)	(-0.61)	(-1.40)	(-1.60)
FDI/GDP(t)					-0.026	-0.030	-0.029	-0.028					-0.003	0.007	-0.003	-0.002
					(-13.22)	(-14.61)	(-14.19)	(-13.80)					(-1.88)	(1.83)	(-1.92)	(-1.33)
Firm Controls(t)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects	IY	IY	IY	IY	IY	IY	IY	IY	IY	IY	IY	IY	IY	IY	IY	IY
Obs	195,603	195,603	195,603	195,603	193,061	193,061	193,061	193,061	4,964	4,964	4,964	4,964	4,778	4,778	4,778	4,778
AdjRsq	28.0%	28.0%	27.9%	27.9%	28.4%	28.4%	28.4%	28.4%	28.3%	29.6%	28.4%	28.3%	28.1%	29.6%	28.4%	28.4%

Table 7: Short Selling, R&D Investment, Information Asymmetry, and Corporate Governance

This table presents panel regressions of a firm's R&D scaled by total assets (*RD/TA*) on lendable shares (*Lendable*), its interaction with information asymmetry variables (*InfAsy*), corporate governance (*CGov*), and firm-level control variables (*X*) (with unreported industry-, country-, and year-fixed effects, ICY). The regression model is:

$RD/TA_{i,t+1} = \alpha + \beta_1 Lendable_{i,t} + \beta_2 InfAsy_{i,t} + \beta_3 Lendable_{i,t} \times InfAsy_{i,t} + \beta_4 Lendable_{i,t} \times CGov_{i,t} + \beta_5 X_{i,t} + \varepsilon_{i,t+1}$,

where $X_{i,t}$ includes the same list of firm control variables as above, $InfAsy_{i,t}$ refers to firm-level and country-level information asymmetry variables, including age (*Age*), news coverage (*NewsCoverage*), analyst forecast errors (*AnalystErrors*), and the disclosure requirements index (*DisReq*). $CGov_{i,t}$ refers to firm-level and country-level corporate governance variables, including the corporate governance index (*ISS*), the anti-self-dealing index (*Antsel*), and legal origin (*CommLaw*). The construction of these variables is detailed in Appendix A; *t*-statistics, shown in parentheses, are based on standard errors adjusted for heteroskedasticity and firm-level clustering. Obs denotes the number of firm-year observations, and AdjRsq is adjusted R^2. The sample period is from 2003 to 2009. For brevity, firm control variables are excluded from the table.

A. Separate Test: Information Asymmetry and Corporate Governance

	RD/TA(t+1)						
	InfAsy				*CG*		
	Age	*AnalystErrors*	*NewsCoverage*	*DisReq*	*ISS*	*Antsel*	*CommLaw*
Variable	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)
Lendable(t)	0.081	0.022	0.049	0.116	0.081	0.112	0.100
	(6.44)	(4.68)	(4.44)	(4.89)	(2.37)	(7.07)	(8.94)
Lendable(t) × InfAsy(t)	**-0.019**	**0.012**	**-0.006**	**-0.092**			
	(-4.73)	**(2.84)**	**(-2.57)**	**(-3.78)**			
InfAsy(t)	0.004	000	0.003	0.069			
	(8.61)	(1.15)	(8.55)	(6.60)			
Lendable(t) ×CG(t)					**-0.099**	**-0.124**	**-0.076**
					(-2.00)	**(-5.48)**	**(-7.18)**
CG(t)					0.022	-0.021	0.018
					(2.07)	(-3.39)	(5.24)
Firm Controls(t)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects	ICF	ICF	ICF	ICF	ICF	ICF	ICF
Obs	48858	38044	48839	48837	14412	48858	48858
AdjRsq	35.64%	38.2%	35.8%	35.6%	40.2%	35.7%	35.7%

Table 7: Short Selling, R&D Investment, Information Asymmetry, and Corporate Governance – Continued

B. Joint Test: Information Asymmetry and Corporate Governance												
	RD/TA(t+1)											
	InfoAsy=Age			*InfoAsy=AnalystErrors*			*InfoAsy=NewsCoverage*			*InfoAsy=DisReq*		
CG=	*ISS*	*Antsel*	*CommLaw*	*ISS*	*Antsel*	*CommLaw*	*ISS*	*Antsel*	*CommLaw*	*ISS*	*Antsel*	*CommLaw*
Variable	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)	Model (8)	Model (9)	Model (10)	Model (11)	Model (12)
Lendable(t)	0.066	0.154	0.149	0.033	0.083	0.079	0.051	0.128	0.091	0.054	0.145	0.004
	(1.67)	(8.03)	(9.03)	(0.95)	(4.98)	(6.55)	(1.45)	(6.85)	(6.69)	(1.11)	(5.88)	(0.16)
Lendable(t) × InfAsy(t)	**0.007**	**-0.018**	**-0.019**	**0.005**	**0.011**	**0.011**	**0.012**	**-0.006**	**-0.002**	**0.039**	**-0.047**	**0.153**
	(0.98)	**(-4.36)**	**(-4.62)**	**(0.74)**	**(2.66)**	**(2.55)**	**(2.24)**	**(-2.38)**	**(-0.73)**	**(0.74)**	**(-1.75)**	**(3.86)**
InfAsy(t)	0.001	0.004	0.004	0.002	000	000	0.001	0.003	0.002	0.031	0.067	0.045
	(1.12)	(8.49)	(8.47)	(1.86)	(1.21)	(1.35)	(0.98)	(8.47)	(7.55)	(1.16)	(5.51)	(4.01)
Lendable(t) ×CG(t)	**-0.104**	**-0.116**	**-0.075**	**-0.026**	**-0.090**	**-0.060**	**-0.132**	**-0.120**	**-0.063**	**-0.114**	**-0.107**	**-0.128**
	(-2.10)	**(-5.16)**	**(-7.09)**	**(-0.52)**	**(-3.85)**	**(-5.45)**	**(-2.42)**	**(-5.35)**	**(-5.83)**	**(-2.05)**	**(-4.34)**	**(-7.46)**
CG(t)	0.022	-0.022	0.018	0.005	-0.028	0.020	0.024	-0.010	0.016	0.024	0.012	0.007
	(2.10)	(-3.46)	(5.19)	(0.44)	(-4.22)	(5.51)	(2.22)	(-1.48)	(4.69)	(2.14)	(1.48)	(1.69)
Firm Controls(t)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects	ICF	ICF	ICF	ICF	ICF	ICF	ICF	ICF	ICF	ICF	ICF	ICF
Obs	14412	48858	48858	12819	38044	38044	14412	48839	48839	14412	48837	48837
AdjRsq	40.3%	35.7%	35.8%	42.5%	38.3%	38.3%	40.4%	35.9%	35.9%	40.3%	35.7%	35.7%

Table 8: Short Selling and Sensitivity of R&D Investment to Price

This table presents a panel regression of a firm's R&D scaled by total assets (*RD/TA*) on lendable shares (*Lendable*), its interaction with Tobin's Q (*Q*) or cash flows (*CashFlows*), and firm-level control variables (*X*), as well as unreported industry-, country-, and year-fixed effects (ICY). The regression model is:

$$RD/TA_{i,t+1} = \alpha + \beta_1 Lendable_{i,t} + \beta_2 Lendable_{i,t} \times Q_{i,t} + \beta_3 Lendable_{i,t} \times CashFlows_{i,t+1}$$
$$+\beta_4 Q_{i,t} + \beta_5 CashFlows_{i,t+1} + \beta_6 1/TA_{i,t+1} + \beta_6 Return_{i,t+2,t+4} + \beta_7 X_{i,t} + \varepsilon_{i,t+1},$$

where $1/TA_{i,t+1}$is the inverse of total assets, $Return_{i,t+2,t+4}$ denotes future abnormal returns, and $X_{i,t}$ includes the same list of firm control variables as above. The construction of these variables is detailed in Appendix A; *t*-statistics, shown in parentheses, are based on standard errors adjusted for heteroskedasticity and firm-level clustering. Obs denotes the number of firm-year observations, and AdjRsq is adjusted R^2. The sample period is from 2003 to 2009.

	RD/TA(t+1)			
Variable	Model (1)	Model (2)	Model (3)	Model (4)
Lendable(t) × Q(t)	**0.027**	**0.018**	**0.016**	**0.008**
	(5.75)	**(3.86)**	**(4.15)**	**(2.04)**
Q(t)	0.001	0.001	-0.001	-0.001
	(4.95)	(4.53)	(-1.60)	(-1.43)
Lendable(t) × Cash Flows(t+1)		0.213		0.181
		(4.25)		(4.11)
Cash Flows(t+1)		0.006		0.007
		(1.63)		(1.66)
Lendable(t)	-0.013	-0.017	0.009	0.005
	(-1.33)	(-1.82)	(1.15)	(0.64)
1/Asset(t+1)	0.306	0.347		
	(7.29)	(8.05)		
Return (t+2,t+4)	0.001	0.001		
	(1.60)	(1.39)		
Firm Controls(t)	No	No	Yes	Yes
Fixed Effects	ICY	ICY	ICY	ICY
Obs	39,011	39,011	48,786	48,786
AdjRsq	29.1%	29.6%	34.1%	34.6%

Table 9: Short Selling, R&D Under-investment, and R&D Over-investment

This table presents panel regression of a firm's R&D under-investment dummy (*Under-investment*) and over-investment dummy (*Over-investment*) on lendable shares (*Lendable*), firm-level control variables (*X*), and unreported industry-, country-, and year-fixed effects (ICY). We first follow Biddle, Hilary, and Verdi (2009) in constructing under/over-investment as follows. For each industry (and each country), a firm's R&D investment is regressed on a set of firm characteristics:

$$RD/TA_{i,t+1} = \alpha + \beta_1 TA_{i,t} + \beta_2 Age_{i,t} + \beta_3 SalesG_{i,t} + \beta_4 Leverage_{i,t} + \beta_5 BM_{i,t} + \beta_6 Cash_{i,t} + \theta_{i,t+1},$$

$\theta_{i,t+1}$ is the over-investment (under-investment) term, and we sort firms into quintiles based on $\theta_{i,t+1}$. Firms in the top quintile are in over-investment group, firms in the bottom quintile are in under-investment group, and the normal investment group is in the middle. We then conduct multi-nominal logistic regression (using the normal investment group as a reference) as follows:

$$Prob(Under\text{-}investment_{i,t+1}, Over\text{-}investment_{i,t+1}\ vs.\ Normal\text{-}investment_{i,t+1}) = \alpha + \beta_1 Lendable_{i,t} + \beta_2 X_{i,t} + \varepsilon_{i,t+1},$$

where $X_{i,t}$ includes institutional ownership (*IO*), the log of annual stock return (*Return*), stock return volatility (*STD*), MSCI country index membership (*MSCI*), and American Depository Receipts (*ADR*). The construction of these variables is detailed in Appendix A; *t*-statistics, shown in parentheses, are based on standard errors adjusted for heteroskedasticity and firm-level clustering. Obs denotes the number of firm-year observations, and AdjRsq is adjusted R^2. The sample period is from 2003 to 2009.

	By Industry		By Country and Industry	
	Prob (*Under-investment(t+1)*)	Prob (*Over-investment(t+1)*)	Prob (*Under-investment(t+1)*)	Prob (*Over-investment(t+1)*)
Variable	Model	Model	Model	Model
	(1)	(2)	(3)	(4)
Lendable(t)	**-1.451**	**0.362**	**-1.687**	**0.068**
	[<.001]	**[0.148]**	**[<.001]**	**[0.797]**
IO(t)	0.129	-0.166	0.239	-0.075
	[0.116]	[0.035]	[0.003]	[0.369]
Return(t)	0.394	-0.065	0.411	-0.006
	[<.001]	[0.016]	[<.001]	[0.830]
STD(t)	0.044	0.355	0.213	0.459
	[0.437]	[<.001]	[<.001]	[<.001]
MSCI(t)	0.190	0.283	0.139	0.264
	[<.001]	[<.001]	[<.001]	[<.001]
ADR(t)	0.202	1.017	0.081	0.96
	[0.009]	[<.001]	[0.282]	[<.001]
Fixed Effects	ICY		ICY	
Obs	48,858		48,858	
AdjRsq	36.18%		35.58%	

Table 10: Short Selling, R&D Investment, and Firm Performance

This table presents a panel regression of a firm's future growth, performance, and innovation outputs on lagged lendable shares (*Lendable*), its interaction with R&D scaled by total assets (*RD/TA*), and firm-level control variables (*X*) as well as unreported industry-, country-, and year-fixed effects (*ICY*). Panel A reports results of a firm's average future growth (productivity growth, *PG*, Value added growth, *VAG*) over the next three years. Panel B presents results of a firm's average future performance – the return-on-asset ratio (*ROA*) and annual stock returns over the next three years (*Return*). The regression model is:

$$PG_{i,t+1,t+3}(VAG_{i,t+1,t+3}, ROA_{i,t+1,t+3}, Return_{i,t+1,t+3}) = \alpha + \beta_1 Lendable_{i,t-1} + \beta_2 Lendable_{i,t-1} \times RD/TA_{i,t} + \beta_3 RD/TA_{i,t} + \beta_4 X_{i,t} \, .$$

Panel C presents results for a firm's future innovation outputs (patent counts, *Patent*) in one of next three years and of a firm's average future innovation outputs over the next three years. The regression model is:

$$Patent_{i,t+1,t+3}(Patent_{i,t+1}, Patent_{i,t+2}, Patent_{i,t+3}) = \alpha + \beta_1 Lendable_{i,t-1} + \beta_2 Lendable_{i,t-1} \times RD/TA_{i,t} + \beta_3 RD/TA_{i,t} + \beta_4 X_{i,t} \, .$$

The construction of these variables is detailed in Appendix A. Key results are highlighted in bold; t-statistics, shown in parentheses, are based on standard errors adjusted for heteroskedasticity and firm-level clustering. Obs denotes the number of firm-year observations, and AdjRsq is adjusted R2. The sample period is from 2003 to 2009.

	A. Future Growth		**B. Future Performance**		**C. Patent Outputs**			
	PG(t+1,t+3)	*VAG(t+1,t+3)*	*ROA(t+1,t+3)*	*Return(t+1,t+3)*	*Patent(t+1)*	*Patent(t+2)*	*Patent(t+3)*	*Patent(t+1,t+3)*
Variable	Model	Model	Model	Model	Model	Model	Model	Model
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Lendable(t −1)×RD/TA(t)	**9.853**	**9.374**	**0.634**	**4.194**	**6.765**	**8.858**	**13.389**	**12.368**
	(3.83)	**(3.77)**	**(2.18)**	**(3.60)**	**(2.45)**	**(2.25)**	**(2.13)**	**(4.24)**
Lendable(t −1)	-0.393	-0.603	-0.013	0.110	1.144	1.499	1.440	0.878
	(-2.62)	(-4.06)	(-0.85)	(1.10)	(3.68)	(3.72)	(2.36)	(2.57)
RD/TA(t)	0.130	-0.259	-0.429	-0.113	5.008	5.346	5.082	5.523
	(0.37)	(-0.77)	(-9.97)	(-0.65)	(11.01)	(10.04)	(8.36)	(10.79)
Size(t)	-0.033	-0.039	0.005	0.018	0.432	0.431	0.438	0.454
	(-5.31)	(-6.28)	(6.47)	(4.50)	(21.05)	(19.91)	(18.60)	(20.96)
BM(t)	0.025	0.004	-0.037	0.048	-0.159	-0.171	-0.209	-0.169
	(2.14)	(0.34)	(-22.81)	(6.21)	(-6.17)	(-5.88)	(-6.26)	(-6.01)
Age(t)	-0.008	-0.045	0.003	0.008	0.005	-0.007	0.002	0.008
	(-0.65)	(-3.70)	(2.29)	(0.94)	(0.15)	(-0.19)	(0.05)	(0.20)
Leverage(t)	0.341	0.310	-0.057	-0.242	-0.661	-0.672	-0.637	-0.774
	(6.65)	(6.33)	(-11.58)	(-6.82)	(-5.14)	(-4.79)	(-4.09)	(-5.49)
Cash(t)	-0.053	0.159	-0.063	-0.031	0.036	0.106	0.112	0.034
	(-0.80)	(2.57)	(-7.08)	(-0.79)	(0.30)	(0.80)	(0.73)	(0.25)
SalesG(t)	-0.236	-0.032	0.001	-0.053	-0.030	0.034	0.037	-0.005
	(-5.44)	(-0.91)	(0.26)	(-3.53)	(-0.75)	(0.73)	(0.61)	(-0.11)
IO(t)	0.017	0.078	0.016	-0.168	0.283	0.317	0.367	0.593
	(0.40)	(1.85)	(2.99)	(-5.03)	(3.03)	(2.98)	(2.87)	(5.67)
Return(t)	0.246	0.277	0.042	-0.132	-0.090	-0.057	-0.056	-0.065
	(14.17)	(17.14)	(22.35)	(-13.50)	(-3.66)	(-1.82)	(-1.40)	(-2.43)
STD(t)	0.101	0.116	-0.089	-0.293	0.078	-0.038	-0.055	0.051
	(2.16)	(2.87)	(-16.41)	(-11.35)	(1.15)	(-0.42)	(-0.53)	(0.68)
MSCI	0.123	0.164	0.013	0.221	-0.134	-0.159	-0.177	-0.073
	(5.02)	(6.91)	(4.95)	(13.55)	(-2.64)	(-2.86)	(-2.85)	(-1.25)
ADR(t)	-0.036	-0.025	-0.016	-0.022	0.384	0.316	0.290	0.381
	(-0.92)	(-0.66)	(-3.82)	(-0.81)	(2.77)	(2.21)	(1.96)	(2.64)
Fixed Effects	ICY	ICY	ICY	ICY	ICY	ICY	ICY	ICY
Obs	26821	28499	37828	37999	11,531	8,917	6,619	11,531
AdjRsq	9.8%	12.0%	25.0%	26.7%	41.4%	42.0%	43.3%	45.4%