Corporate R&D and Stock Returns: International Evidence

Kewei Hou* Po-Hsuan Hsu† Akiko Watanabe‡ Yan Xu§

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Abstract

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*Fisher College of Business, The Ohio State University, 2100 Neil Avenue, Columbus, OH 43210, USA; phone: +1 614 292 0552; fax: +1 614 292 7062; email: hou.28@osu.edu.

†Faculty of Business and Economics, University of Hong Kong; Pokfulam Road, Hong Kong; phone: +852 2859 1049; fax: +852 2548 1152; email: paulhsu@hku.hk.

‡Department of Finance and Statistical Analysis, University of Alberta School of Business; Edmonton, Alberta, Canada T6G 2R6; phone: +1 780 492 0385; fax: +1 780 492 3325; email: akiko.watanabe@ualberta.ca.

§Faculty of Business and Economics, University of Hong Kong; Pokfulam Road, Hong Kong; phone: +852 2859 7037; fax: +852 2548 1152; email: yanxuj@hku.hk.

Abstract

Firms with higher R&D intensity subsequently experience higher stock returns in international stock markets, which is consistent with the U.S. evidence and suggests a fundamentally important role of intangible investments in international asset pricing. We find that this positive effect of R&D intensity on stock returns is stronger in countries with higher market value to growth options, but is unrelated to country characteristics representing market sentiment and limits-of-arbitrage. Moreover, we find that R&D-intensive firms are associated with higher market-to-book ratios, higher future return volatility, and higher future profitability. Our evidence suggests that the cross-sectional relation between R&D intensity and stock return is more likely attributable to growth option risk than to mispricing or market frictions.

JEL Classification: G12, G15, O32

keyword: R&D; Cross-section of stock returns; Innovation

1 Introduction

> Research and development is the major driver of technological change—hence the central role of R&D in economic growth and welfare improvement. The impact of R&D and technological change on economic growth has long been recognized by proponents of free market economies such as Adam Smith, Marshall, Keynes, and Solow. Even two of the most ardent critics of capitalist societies, Marx and Engels, argued in the Communist Manifesto that capitalism depends for its very existence on the constant introduction of new products and processes.
>
> – Baruch Lev (1999)

Research and development (R&D) is one of a firm's key business activities in today's knowledge economy and, to a great extent, determines the growth and uncertainty of a firm's long-term value. Since the 1970s, U.S. public firms have significantly raised their R&D investments; in fact, their R&D investments increased faster than capital expenditures (Jensen, 1993; Skinner, 2008). These heavy investments in R&D are perceived as value-relevant for stock investors as prior studies based on U.S. data have shown that R&D-intensive firms are associated with higher market value (Griliches, 1981; Hall, 1993; Sougiannis, 1994) and higher subsequent stock returns (Lev and Sougiannis, 1996; Lev, 1999; Chan, Lakonishok, and Sougiannis, 2001). Although such a positive R&D-return relation has been confirmed by subsequent studies, whether such a relation is driven by risk premium, market frictions, or behavioral biases remains an important issue under debate and calling for further analyses.

R&D spending also rose globally. Non-U.S. firms have become more aggressive in engaging in R&D activities. In fact, nine of top 20 global R&D spenders in 2014 are not based in the U.S.[1] In the Worldscope database, total R&D expenditures reported by non-U.S. public firms have increased 10.45% annually from 1980 to 2008, in comparison with an annual increase rate of 7.89% from U.S.

[1] According to PwC's Strategy& (http://www.strategyand.pwc.com/global/home/what-we-think/innovation1000/top-innovators-spenders), these nine non-U.S. companies include (ranks in parentheses): Volkswagen (1), Samsung (2), Roche (5), Novartis (6), Toyota (7), Daimler (12), Sanofi-Aventis (16), Honda (17), and GlaxoSmithKline (19).

firms. All these observations suggest a global phenomenon of intensive R&D activities, and motivate us to analyze asset pricing implications of R&D from an international perspective.

In this paper, we examine the cross-sectional return predictability of R&D in international equity markets.[2] Our investigation contributes to the understandings of the role of intangible assets and technological innovation in asset pricing, from three angles: first, the heterogeneity in institutional environments across countries enables us to analyze whether the R&D effect can be explained by particular country characteristics. Second, the cross-section of stock returns spanned by all countries in the Datastream database not only allows us to conduct an out-of-sample test for the R&D-return relation reported in U.S. stock markets, but also enables us to better understand the causes of the R&D effect. Third, there are only few studies of the R&D effect in non-U.S. countries (Canada, France, and U.K. for example),[3] and there is a lack of asset pricing tests in a cross-country setting. Our investigation thus fills in this gap in the finance literature.

Lev and Sougiannis (1996) could be among the first in reporting that U.S. public firms' R&D intensity predicts these firms' subsequent stock returns and profitability with controlling for size, book-to-market ratio, and survivorship bias. They conclude that R&D investments are value-relevant and suggest future studies to examine whether such an R&D effect results from investors' under-reaction to R&D information or extra systematic risk related to R&D investments. Subsequent studies on the R&D effect, mostly based on U.S. data, collectively suggest three possible explanations: risk premium, behavioral biases, or market frictions.[4] On one hand, R&D investments can be

[2]Using international data to reexamine specific patterns found in U.S. markets helps us guard data mining bias and provides new insights on the causes and consequences of these patterns. For example, Fama and French (1998) present international evidence for the value premium based on 13 countries. Rouwenhorst (1998) shows that the momentum effect exists in 12 European markets. McLean, Pontiff, and Watanabe (2009) report negative subsequent stock returns associated with share-issuance in 41 non-U.S. markets. Watanabe et al. (2013) show that firms with higher asset growth subsequently experience lower stock returns in 51 stock markets. In addition, Eisdorfer, Goyal, and Zhdanov (2014) explore the distress anomaly using 34 countries.

[3]For example, the relation between R&D intensity and subsequent stock returns has been studied using Canadian data by Callimaci and Landry (2004), using French data by Cazavan-Jeny and Jeanjean (2006), and using U.K. data by Oswald and Zarowin (2007).

[4]Chan, Lakonishok, and Sougiannis (2001) confirm the finding of Lev and Sougiannis (1996) after taking more systematic risk factors and prior stock performance into account, and advocate the behavioral biases explanation by arguing that investors tend to be over-pessimistic about R&D activities. This viewpoint is further supported by Eberhart, Maxwell, and Siddique (2004, 2008), which report higher abnormal stock returns and higher abnormal operating performance after substantial R&D increases. Market frictions explanation suggests that investors under-react to R&D news because of information lags or limited risk-bearing due to financial constraints (see Penman and Zhang, 2002; Lev, Sarath, and Sougiannis, 2005; Ciftci, Lev, and Radhakrishnan, 2011). Lastly, some studies support

regarded as creating growth options and may increase firms' exposure to unspecified systematic risk. On the other hand, investors may be pessimistic in assessing the value of R&D activities and thus tend to over-discount future cash flows associated with innovations. Moreover, given the existence of market frictions in information flows and financial constraints, some investors may have information advantages or have the capacity to bear higher risk and thus can exploit this specific market inefficiency.

This paper proceeds in two stages. In the first stage, we test whether R&D-intensive firms also provide higher subsequent stock returns using both sorted portfolios and Fama-MacBeth regressions. We also examine the relationship between firms' R&D intensity and profitability, return volatility, and market valuations of options. In the second stage, we study if the R&D effect can be explained by country-specific institutional factors related to risk premiums, market frictions, or behavioral biases by examining which factors explain the high-minus-low return spreads and Fama-MacBeth regression slopes.

Using an unbalanced panel of public firms listed in 21 countries with stock returns from 1981 July to 2012 June in the Datastream and Worldscope databases,[5] we find that R&D-intensive firms are associated with higher subsequent stock returns. Our primary proxy for R&D intensity is defined as a firm's annual R&D expenditures divided by its book equity (Sougiannis, 1994; Lev and Sougiannis, 1996; Kothari, Laguerre, and Leone, 2002). We do not use market equity to scale R&D expenditures because it may bias the explanatory power of R&D for two reasons: first, market equity may have changed immediately following the announcements of R&D increases; and second, market equity is known to predict stock returns as the size effect. Nevertheless, in robustness checks, we also consider alternative proxies by using R&D capital defined as Chan, Lakonishok, and Sougiannis (2001) as the numerator and using market equity or change in book equity as the denominator.

We use U.S. dollar returns in all our analyses so our empirical results can naturally have practical investment implications for an U.S. individual who invests globally. In one-way portfolio analyses, we

the risk premium explanation as R&D activities may create growth options or may increase systematic risk exposure (e.g., Kothari, Laguerre, and Leone, 2002; Chambers, Jennings, and Thompson, 2002; Berk, Green, and Naik, 2004; Li, 2011; Lin, 2012).

[5] Many countries are excluded because they do not have enough number of firms with non-missing and non-zero R&D records in the cross section.

sort all stocks reporting R&D expenditures from fiscal year t-1 into quintile portfolios by their R&D intensity, and then track the equal- and value-weighted portfolio returns for the 12 months starting from July of year t to June of year t+1. We consider both global sorting and country-neutral sorting. In the global sorting, the top quintile portfolio outperforms the bottom one by 0.76% (0.23%) per month in equal-weighted (value-weighted) returns. When we conduct country-neutral sorting by sorting all stocks reporting R&D expenditures within each country into quintile portfolios then combine,[6] we find that the top quintile portfolio outperforms the bottom one by 0.54% (0.17%) per month in equal-weighted (value-weighted) returns. Similar results are found when we exclude U.S. firms from the sample. Furthermore, we find that these top-minus-bottom return spreads generally cannot be explained by international return factors of Hou, Karolyi, and Kho (2011).

We are concerned that the positive return spreads associated with R&D intensity may be driven by large firms because they have higher incentive to invest in R&D due to economies of scale in learning, financial stability, and diversified product lines (e.g., Cohen, Levin, and Mowery, 1987; Acs and Audretsch, 1987), or by small firms that are riskier in spending on big projects (Li, 2011). Thus, we conduct two-way portfolio sorts by sorting all stocks first by market capitalization then by R&D intensity into 5×5 quintiles. We find that the R&D effect is more pronounced in smaller firms than in larger firms. Controlling for size, however, does not erode the R&D effect: the equal- and value-weighted average returns of the five portfolios in the high R&D intensity quintile still significantly outperform the average returns of the five portfolios in the low R&D intensity quintile by 0.70% and 0.61% per month.

Fama-MacBeth regression results including country and industry fixed effects suggest that the return-predictive power of R&D intensity remains significant after controlling for size, book-to-market, momentum, profitability, and asset growth. When U.S. firms are included (excluded), the slopes on R&D intensity range from 0.013 to 0.020 (0.007 to 0.014) per month using equal-weighted regressions. We obtain similar results when we use market equity to weigh the Fama-MacBeth regressions, and the slopes on R&D intensity range from 0.015 to 0.026 (0.009 to 0.016) per month. Our analyses suggest that the R&D effect exists in international equity market and cannot be attributed to exposure to

[6]The country-neutral sorting approach mitigates the influence of large firms from developed countries and also appropriately controls for different accounting standards and tax credits for R&D.

common risk factors and firm characteristics. It is noteworthy that our results based on country-neutral sorting and Fama-MacBeth regressions including country fixed effects eliminate the influence of country-specific factors, such as currency risk and political and economic uncertainty, on the level of stock returns.

We then examine the relation between R&D investments and market-to-book ratio, future profitability, and future return volatility because growth options are valuable yet entail higher systematic risk, and the exercise of growth options leads to changes in operations (Chambers, Jennings, and Thompson, 2002; Bloom and van Reenen, 2002). Our Fama-MacBeth regression results indicate that R&D investments are associated with higher market-to-book ratio, higher future profitability, and higher future return volatility; all these results collectively support that R&D investments are closely related to growth options.

We then focus on the role of country-specific variables in the R&D effect (i.e., the sensitivity of stock returns to R&D intensity). The idea is to quantify the magnitude of R&D effect in each country in a month, and then to examine if the effect can be explained by country-level proxies that reflect various possible mechanisms for the return predictability (Watanabe et al., 2013; Eisdorfer, Goyal, and Zhdanov, 2014). Corresponding to the three explanations based on risk premium, market frictions, and behavioral biases, we construct three sets of country-level proxies for dispersion in growth option value, limits-to-arbitrage, and sentiments, respectively.

Four measures to quantify the R&D effect are constructed for each country in a month: top-minus-bottom R&D spreads (both equal- and value-weighted) and the slopes on R&D intensity from cross-sectional regressions (both equal- and value-weighted). For each country in every month, we sort all stocks reporting R&D expenditures into quintile portfolios based on R&D intensity and then track the equal- and value-weighted returns of the top-minus-bottom portfolio to form country-specific R&D spreads. To form country-specific R&D slopes, we conduct cross-sectional regressions to calculate the slope of stock returns on R&D intensity across all firms in one country in one month using equal- and value-weighted least squares. These four measures present substantial variation of R&D effects across countries to be explained.

The first set of country-level proxies for dispersion in growth option value consists of dispersion in two common measures of growth options: price dividend ratios, and the present value of growth options (Long, Wald, and Zhang, 2005; Cao, Simin, and Zhao, 2008). The theory argues that technological innovation generates growth options and thus commands risk premium in the cross section (Garleanu, Panageas, and Yu (2012), Carlson, Fisher, and Giammarino (2004), and Li and Kumar (2016)). Therefore, following this argument, we expect that large dispersion in growth option value indicates that the risk premium of growth options are more likely to be priced. If the R&D effect is driven by risk generated from growth options, we expect it to be more pronounced in countries with larger dispersions.[7]

The second set of country variables proxies for limits-to-arbitrage. We consider short-sale permission (Bris, Goetzmann, and Zhu, 2007; McLean, Pontiff, and Watanabe, 2009), idiosyncratic volatility (Li and Zhang, 2010), and dollar trading turnover (Watanabe et al., 2013). Limits-to-arbitrage impose higher costs and risks on investors with information advantages and thus weaken the R&D effect that is driven by market frictions. If the R&D effect is hard to be timely exploited, then it should be more pronounced in those countries with stronger limits-to-arbitrage.

The third set of country variables proxies for sentiments. We consider the number of newly listed firms and volatility premium, both proposed by Baker, Wurgler, and Yuan (2012). If the R&D effect is driven by investors' behavioral biases (mainly "high-tech fad"), it is expected to be correlated with these sentiment proxies.

After constructing country-month panels of R&D spreads and slopes, we regress these R&D effect measures on country-specific variables for growth option value, limits-to-arbitrage, or sentiments. We find that R&D spreads and slopes can be significantly explained by growth option proxies but not by the proxies for limits-to-arbitrage or sentiments. These results indicate that, in markets with higher value to growth options, stock returns are more sensitive to R&D activities as these markets more likely recognize the value of growth options driven by R&D investments. Thus, our country-level analyses also support that the R&D effect could be attributed to risk premiums rather than market frictions or behavioral bias.

[7]There is a long literature arguing that growth options are riskier and thus lead to higher risk premium (e.g., Berk, Green, and Naik, 1999; Carlson, Fisher, and Giammarino, 2004; Kogan and Papanikolaou, 2014).

This paper contributes to the finance literature as follows. First, we find a cross-country pattern that R&D-intensive firms are associated with higher subsequent stock returns, which serves as out-of-sample evidence for prior findings in the U.S. Thus, our study further extends the studies of asset pricing anomalies to an international setting, following Griffin (2002), McLean, Pontiff, and Watanabe (2009), Hou, Karolyi, and Kho (2011), and Watanabe et al. (2013).

Second, we present both country- and firm-level evidence supporting a risk-based explanation for our findings: R&D investments increase firms' growth options and thus lead to higher expected stock returns as growth options are risky. Our test results from specifying the risk channel corroborate the implications of previous theoretical models of Berk, Green, and Naik (1999), Carlson, Fisher, and Giammarino (2004), Zhang (2005), Garleanu, Panageas, and Yu (2012), Ai and Kiku (2013), and Kogan and Papanikolaou (2014).

The rest of the paper is organized as follows. Section II describes the data sources and variable construction. Section III presents our portfolio and regression analyses for the R&D-return relation. Section IV examines if country-specific variables explain the R&D effect. Section V concludes.

2 Data

We obtain the data on stock market variables and company accounting items for all international firms from Thomson-Reuters Datastream and Worldscope databases. Our sample coverage is largely the same as those used in Watanabe et al. (2013) and we end up with 21 countries for which stock returns and non-missing R&D data are available. These countries are, Australia, Canada, China, Finland, France, Germany, Greece, Hong Kong, India, Israel, Italy, Japan, Malaysia, Singapore, South Korea, Sweden, Switzerland, Taiwan, Turkey, U.K., and U.S. We consider only firms listed in the largest stock exchange in most countries except China (Shanghai and Shenzhen), Japan (Tokyo and Osaka), and the U.S. (NYSE, Amex, and Nasdaq). Since data errors are common in international data, we impose the standard filters suggested by Ince and Porter (2006) to ensure the quality of the data from the Datastream database.[8] We also follow McLean, Pontiff, and Watanabe (2009) to

[8] If r_t and r_{t-1} are the gross returns in month t and $t-1$, we set r_t and r_{t-1} to missing if r_t or r_{t-1} is greater than 300% and $(1+r_t)(1+r_{t-1})-1 < 50\%$. We also eliminate all monthly observations for delisted stocks from the end of

winsorize all variables from the Worldscope database at the top and bottom one percentiles of their distributions within each country. We take a U.S. investor's perspective and report all results on returns denominated in U.S. dollars. Firms in financial industries with Datastream industry codes (INDM) corresponding to the four-digit SIC (Standard Industrial Classification) codes between 6000 and 6999 are removed from our sample.

Our primary measure for R&D intensity for firm i in year t is defined as firm i's annual R&D expenditure (Worldscope item 01201) reported in fiscal year t divided by the firm's book equity (BE) at the end of fiscal year t. BE is defined as stockholders' equity minus value of preferred stock (item 03451) plus deferred taxes and investment tax credit (item 04101), following Davis, Fama, and French (2000) and Hou, Xue, and Zhang (2014). It is worth noting that on average 69.95% of our whole sample report either missing or zero R&D expense, although this portion varies by country over time. Following the literature (Chan, Lakonishok, and Sougiannis, 2001), we only include firm-year observations with positive R&D expenditures in the sample.

Several issues regarding our definition of R&D intensity are worth discussions. Unlike prior studies using market equity (e.g., Chan, Lakonishok, and Sougiannis, 2001), we use book equity as the deflating factor for R&D investments following Sougiannis (1994), Lev and Sougiannis (1996), and Kothari, Laguerre, and Leone (2002). Market equity itself is found to predict stock returns (i.e., the size effect), and increases with reported R&D expenditures (Griliches, 1981; Hall, 1993; Sougiannis, 1994). Another possible deflator for R&D expenditure is sales (e.g., Lev and Sougiannis, 1996; Chan, Lakonishok, and Sougiannis), which is not used in this study because sales records are volatile in international data. The choices of denominator and R&D capital as numerator, however, are of minimal effect to our final results. We obtain consistent results using alternative proxies by using R&D capital (i.e., accumulated five-year R&D expenditures with a 20% obsolescence rate) defined as Chan, Lakonishok, and Sougiannis (2001) or using the simple average of past five-year R&D expenditures as the numerator and using market capitalization or change in book equity as the denominator.

All these procedures result in a sample consisting of 319,259 firm-year observations when the U.S. is

the sample period to the first nonzero return date since Datastream keeps padding the last available return after the delisting date.

included and 233,773 observations when the U.S. is excluded. The country-level summary statistics for the sample including the U.S. is reported in Table 1. It is noted that the data for most developed countries are available in the early 1980s, while the data coverage for emerging countries is more limited. Most developed countries enter into our sample in July 1981, while Greece Turkey, and China are the latest entrants (December 1987, December 1987, and December 1990, respectively). U.S. firms account for 26.78% of the total firm-year observations and 45.74% of the total market capitalization. In Table 1, we list the median and standard deviation of R&D intensity. We find that firms in Canada lead the world in terms of R&D intensity. We also observe considerable cross-country variation in these statistics, with the median R&D intensity ranging between 0.79% (Malaysia) and 21.57% (Canada) and the standard deviation of R&D intensity ranging between 1.41% (Malaysia) and 40.79% (Canada).

Our sample coverage of 21 countries may look narrower compared to the literature. For example, both McLean, Pontiff, and Watanabe (2009) and Watanabe et al. (2013) include 41 countries in their studies on international capital markets. Karolyi, Lee, and van Dijk (2012) study a sample of 40 countries. The sample used in Hou, Karolyi, and Kho (2011) broadly includes 49 countries. We have to exclude many countries from emerging markets as our cross-country analysis requires a reliable estimate of the country-level R&D effect, which in turn requires a sizeable cross-section of stocks with positive R&D expenditure within each market at a given year, to mitigate the concern that our estimate may be driven by only a few firms. Nevertheless, our sample consists of both the developed countries and emerging markets, instead of concentrating on only a specific region. We explain our data requirement with more details in the next section.

Table 1 about here.

3 Empirical Analysis

3.1 Returns

3.1.1 Portfolios analysis

We consider three different one-way sorted portfolios to examine the R&D effect. To ensure that our portfolios do not include micro-caps which are hard to trade, we exclude the bottom 10% market value firms for each country. In addition, we require each country-month cross-section to have at least 50 firms to be sorted. Our first approach is global sorting, in which we rank all sample firms by their R&D intensity measures in year t-1 and then sort them into five equal-sized quintile portfolios in the beginning of July in year t. The low quintile contains the 20% of firms with the lowest R&D intensity, while the high quintile consists of the 20% with the highest R&D intensity. For each month from July in year t to June in year t+1, we calculate the equal-weighted returns of each portfolio using the simple average of the monthly returns of all stocks in each quintile, and the value-weighted returns of each portfolio using the weighted average of the monthly returns of all stocks weighted by lagged U.S. dollar-denominated market capitalization in each quintile. As reported in Table 2, the five quintile portfolios (from low to high) provide equal-weighted returns of 1.23%, 1.19%, 1.27%, 1.43%, and 1.99% per month. The return spread between the high and low quintiles is 0.76% per month with a t-statistic of 3.01. The value-weighed returns of the five quintile portfolios (from low to high) are 0.91%, 0.89%, 0.89%, 1.04%, and 1.14% per month. The return spread between the high and low quintiles is 0.23% per month with a t-statistic of 1.35.[9] Our finding that the equal-weighted spread is more significant than the value-weighted one is consistent with Chan, Lakonishok, and Sougiannis (2001) and Eberhart, Maxwell, and Siddique (2004 and 2007), and suggests that substantially higher subsequent returns for more intensive R&D investments are more pronounced among firms that are not giants. Given that insignificant results in the value-weighted spread due to the dominating role of large firms, we resort to two-way sorted portfolios to further control for the size effect in the next subsection.

[9] Nevertheless, as we will show later, the value-weighted spread becomes significant after we control for global factors of Hou, Karolyi, and Kho (2011).

Our second approach is country-neutral sorting, in which we rank all sample firms in one country by their R&D intensity measures in year t-1 and then sort them into five equal-sized quintile portfolios in the beginning of July in year t. We first compute the quintile equal- or value-weighted returns within each countries then average to arrive at the country-neutral portfolio returns. In comparison with the global portfolio, country-neutral portfolio not only avoids that some quintiles are loaded with firms from specific countries but also appropriately control for different accounting standards and tax credits for R&D. The averages of the equal-weighted returns of the high and low portfolio are 1.82% and 1.28%, respectively; in addition, the averages of the value-weighted returns of the high and low portfolio are 1.31% and 1.14%, respectively. The return spread between the high and low quintiles based on equal-weighted returns is a statistically significant 0.54% (t=3.29), while return spread based on value-weighted returns is again a statistically insignificant 0.17% (t=0.91).

To better examine if the R&D effect still holds in international capital markets other than the U.S., our third approach then is country-neutral sorting without U.S. firms. The same procedure as the second approach is implemented except that we do not include U.S. firms in each quintile. The return spread based on equal-weighted returns is a statistically significant 0.45% (t=2.52), while the return spread based on value-weighted returns is again a statistically insignificant 0.07% (t=0.31). We find a similar pattern in all three sorting approaches, suggesting that the R&D-return relation is a global phenomenon and serving as out-of-sample evidence for the R&D effect reported in U.S.-based analyses.

Table 2 about here.

The results presented in Table 2 suggest that the R&D effect is more pronounced in equal-weighted portfolios than in value-weighted portfolios around the world, which is similar to prior studies using U.S. data (Chan, Lakonishok, and Sougiannis, 2001; Eberhart, Maxwell, and Siddique, 2004 and 2007). To further understand such a phenomenon and to separate the R&D effect from the size effect, we conduct two-way portfolio sorting based on market capitalization and R&D intensity. We rely on the global sorting to ensure a proper number of firms in each group. Specifically, all sample firms are ranked by U.S. dollar-denominated market capitalization at the end of year t-1 and then sorted into five size quintile portfolios in the beginning of July in year t. Subsequently, all sample firms within each size quintiles are ranked by their R&D intensity in year t-1 and then sorted into five R&D quintile portfolios in the beginning of July in year t. This two-way sorting procedure results in 25 portfolios, and the equal- and value-weighted returns of these portfolios are tracked from July in year t to June in year t+1.

Table 3 shows that the R&D effects within all the size groups for both equal- and value-weighted portfolios (Panels A and B, respectively). We calculate the high-minus-low spread for the high and low R&D intensity portfolios within each size quintile. The spread and t-statistics are presented in the rightmost columns of two panels. In Panel A, the high-minus-low spreads of the five size quintile portfolios (from small to big) are 1.45%, 0.85%, 0.46%, 0.49%, and 0.27% per month with t-statistics of 4.06, 2.58, 1.54, 2.07, and 1.44, respectively. In addition, a size-neutral high-minus-low spread is calculated by averaging the high-minus-low spreads across size quintiles following Fama and French (1993), and appears to be substantial (the average is 0.70% with a t-statistic of 2.44), which is close to the one-way equal-weighted spread from global sorting in Table 2 (0.76%). This number is reported at the bottom of the high-minus-low R&D-return spread in the rightmost column of panel A.

Similar results are reported in Panel B based on value-weighted portfolios. The high-minus-low spreads of the five size quintile portfolios (from small to big) are 1.14%, 0.81%, 0.50%, 0.48%, and 0.14% per month with t-statistics of 3.20, 2.44, 1.68, 2.06, and 0.76, respectively. In addition, the size-neutral high-minus-low spread, reported at the bottom of the high-minus-low R&D-return spread in the rightmost column, is similar to that of panel A, at 0.61% with a t-statistic of 2.13.

These results confirm the global existence of the R&D effect. In comparison with Table 2, we find a sharper contrast in the returns between high and low R&D-intensity portfolios along the size groups. Overall, we conclude although smaller firms are associated with more pronounced R&D effects, it still exists in firms in the middle and mid-large size quintiles.

Table 3 about here.

The return patterns presented in Table 2 may be attributed to higher risk exposure to international risk factors related to R&D investments. Thus, we regress all high-minus-low spreads on the three factors proposed by Hou, Karolyi, and Kho (2011) that include a global market factor (Rm_rf), a global cash-to-price factor ($F_{C/P}$), and a global momentum factor (F_{MOM}). In Table 4, we find that the alphas from the three-factor model are in fact higher than return spreads. For example, the equal-weighted alpha from global sorting is 0.73% (t=2.33), which is close to the equal-weighted high-minus-low spread of 0.76%. More importantly, we find that the value-weighted alpha is a positive 0.30% with a t-statistic of 1.69. These results suggest that the R&D effect cannot be explained by return factors that explain common variation in global stock returns. In addition, we also find that the R&D spreads are positively loaded on the global market factor and negatively loaded on the global cash-to-price factor. Such a pattern is reasonable as R&D investments naturally increase a firm's market risk while lower a firm's cash positions.

Table 4 about here.

Overall, all results reported in Tables 2 to 4 based on various sorted portfolios and different linear risk factor models provide strong support to an R&D effect on subsequent stock returns in international stock markets.

3.1.2 Fama-MacBeth regressions

Lev, Sarath, and Sougiannis (2005) and subsequent studies employ Fama-MacBeth regressions to examine whether the U.S. R&D effect is robust to the control of return-predictive power of many firm characteristics including size, book-to-market ratio, and earnings. In this section, we employ the same approach to examine an international R&D effect and include more control variables including momentum, return on equity (ROE), asset growth, industry dummies, and country dummies.

In each month from July of year t to June of year t+1, we conduct a cross-sectional regression in which we regress the stock returns of all sample stocks from all countries on corresponding R&D intensity (R&D expenditure over book equity), size (ME), book-to-market ratio (BM), momentum (MOM), return on equity (ROE), asset growth (AG), industry dummies, and country dummies. ME is defined as the natural logarithm of market capitalization of the prior month. BM is defined as the natural logarithm of the book value in fiscal year t-1 scaled by market capitalization of the prior month. MOM is defined as past 12 months to 2 months ago cumulative returns. ROE is defined as net income minus preferred dividends over common equity in fiscal year t-1, and asset growth is defined as the change of total assets over lagged total assets in fiscal year t-1. It is necessary for us to control for industry dummies because there is substantial cross-industry variation in R&D expenditures and intensity due to different natures of industries (e.g., Chan, Lakonishok, and Sougiannis, 2001) and the expected costs of capital also vary across industries (Fama and French, 1997). More importantly, we also include country dummies because there may exist country-level attributes such as currency risk and political instability that may affect the level of stock returns in a particular period.

Table 5 reports the time-series averages and associated t-statistics of the estimated coefficients from the cross-sectional regressions. We proceed first with the simple regression such that the R&D intensity is the only return predictor. Then we add more controls, starting from country fixed effects, then both country and industry fixed effects, then ME, BM, MOM, and finally also ROE and AG, each group one at a time. For brevity, we do not report the average coefficients on industry and country fixed effects.

Based on equal-weighted Fama-MacBeth regressions, Panel A presents the results using all 21 countries and Panel B presents the results excluding U.S. firms. In Panel A, we find that the average coefficients of R&D intensity range from 0.013 to 0.020 per month with t-statistics all at least above 2.6. When we only control for industry and country fixed effects, the average coefficient of R&D intensity is 0.014 per month. This estimate changes to 0.020 per month when three commonly used firm characteristics (ME, BM, and MOM) are added to the regression. When we further control for ROE and AG, the average coefficient of R&D intensity becomes 0.017 which is still highly significant (t=7.40). We find similar yet weaker results in Panel B, in which the average coefficient of R&D intensity is 0.013 per month after controlling for all characteristics.

Table 5 about here.

We report in Panel C the results of value-weighted Fama-MacBeth regressions in which the weight is firms' market value denominated in U.S. dollars at the June of year t. We find that the average coefficients of R&D intensity range from 0.015 to 0.026 per month with t-statistics ranging from 2.05 to 3.38. When we only control for industry and country fixed effects, the average coefficient of R&D intensity is 0.016 per month. This value changes to 0.022 per month when ME, BM, and MOM are controlled. When we further include ROE and AG, the average coefficient of R&D intensity becomes 0.015 (t=2.86). Again, we find similar yet weaker results in Panel D where we exclude U.S. stocks, in which the average coefficient of R&D intensity is 0.012 (t=2.05) per month after controlling for all fixed effects and firm characteristics.

Overall, the predictive regression results strongly support the existence of R&D effect in the international capital markets, and further suggest that the R&D effect is not driven by common firm characteristics.

3.2 Profitability, return volatility, and options

The risk-based explanation of the R&D-return relationship mainly relies on the argument that R&D investment generates options, which are riskier than the underlying asset because of the implicit leverage of the options. Indeed, R&D investment is generally riskier and less flexible, and generates more uncertain business prospects than does the regular capital investment. In the model of Garleanu, Panageas, and Yu (2012), growth options are priced in all the securities and tend to increase the volatility of equity prices and the risk premia in the economy in the early stage of the technological cycle. The risk premium decreases as the growth options are converted into assets in place. Berk, Green, and Naik (2004) argue that although idiosyncratic uncertainty on R&D investment does not command risk premium, the resolution of idiosyncratic uncertainty can dramatically alter the risk premium earned on the R&D. Their model shows that indeed the required risk premium for the R&D is higher. Li and Kumar (2016) further argue that even the capital investment, as long as it is option generating, can increase the likelihood of future growth options that will potentially put a firm at risk in developing them, and expected stock returns may increase instead of decreasing as documented in the literature. Although not particularly testing an option explanation of the R&D effect, Chambers, Jennings, and Thompson (2002) find that the standard deviation of excess returns for high-R&D firms is much larger than that for either non-R&D firms or for low-R&D firms.

Therefore, before moving to cross-country analysis, we first examine whether the option-based rational explanation can be compatible with empirical patterns when we also conduct Fama-MacBeth regressions on profitability, return volatility, and market evaluation of options. Specifically, we examine if R&D indeed generates growth options and whether more R&D-intensive firms are more profitable, associated with higher market-to-book ratio,[10] and their returns generate higher volatility. These tests are motivated by the above argument from the literature, along with the observations that more growth options lead to higher future cash flows, higher market valuation, and higher volatility in payoffs.

We use the Fama-MacBeth regression to analyze the effect of R&D intensity on future profitability. We first conduct cross-sectional regression, in which the dependent variable is operating profitability in year t+1 ($\mathrm{PF}_{\mathrm{t+1}}$) and the independent variables include R&D intensity, lagged operating profitability (PF_t), ME, BM, and MOM in year t. Industry dummies and country dummies are also included. Operating profitability is defined as revenue minus cost of goods sold (COGS), interest expenses, and selling, general and administrative expenses (SG&A) scaled by book equity. Then, we report the time-series averages and t-statistics in Table 6. We find that R&D intensity is associated with significantly higher operating profitability in the future. For example, in Panel A for all countries, the coefficient of R&D intensity is 0.123 with a t-statistic of 4.65 in the first column. In terms of economic magnitude, a one-standard-deviation increase in R&D intensity (20%) increases future operating profitability by 2.46%. When we only control for lagged operating profitability, industry dummies, and country dummies, the coefficient of R&D intensity is 0.156 with a t-statistic of 6.23. When we include ME, BM, and MOM in the regression, the coefficient of R&D intensity is 0.100 with a t-statistic of 4.74. Consistent results are presented in Panel B when U.S. firms are excluded from the sample. We note that in the last model, the estimates for R&D intensity are much weaker, possibly due to the fact that PF and ROE may be highly correlated. Overall, Table 6 supports that higher R&D intensity leads to higher future profitability as increased growth options.

Table 6 about here.

[10] The market value of the firm is forward looking and contains the option value with payoff coming afterwards. Therefore, we do not conduct predictive regression on market-to-book ratios. This regression is reminiscent of Bloom and van Reenen (2002) based on British firms, except that they did not have enough R&D data so the technology is proxied by patents and citations.

The analysis on the effect of R&D intensity on market-to-book ratios is reported in Table 7. In the cross-section of all firms in year t, we regress the market-to-book ratio in year t on current R&D intensity, controlling for the next period operating profitability (PF) or its absolute value (absPF), and the next period stock return (ret). Table 7 presents the time-series averages and t-statistics of coefficients, for all the countries in Panel A and Non-U.S. in Panel B. The results show that R&D intensity is associated with significantly higher market valuation relative to book equity. For example, in Panel A for all countries, after controlling for country and industry dummies, the coefficient of R&D intensity is 6.995 (5.613) with a t-statistic of 12.55 (9.95) when we control for PF (absPF). The results in panel B is only slightly weaker after we exclude U.S., and after controlling for country and industry dummies, the coefficient of R&D intensity is 6.802 (5.355) with a t-statistic of 6.69 (6.41) when we control for PF (absPF).

Table 7 about here.

To alleviate the concern that there might be a mechanical relationship between the market-to-book ratio and current R&D intensity, which also contains book value as the scaler, we also repeat this analysis by replacing the book value with the change in the book value as the scaler in the construction of R&D intensity. The results are reported in Panel B. For all countries, the coefficient of R&D scaled by change of book value is 0.003 with a t-statistic of 1.78 in the first model. In terms of economic magnitude, a one-standard-deviation increase in R&D over change of book equity (367%) increases market-to-book ratio by 1.10%. When we examine the coefficients of control variables we find they are largely similar in terms of magnitude or statistical significance. Thus this additional analysis further confirms the finding that R&D intensity indeed is positively correlated with market-to-book ratio, which is consistent with the notion that R&D investment is associated with growth options, proxied by the market-to-book ratio.

We also analyze the effect of R&D intensity on future return volatility. We first conduct cross-sectional regression, in which the dependent variable is monthly return volatility between July of year t and June of year $t+1$ (σ_{t+1}) and the independent variables include R&D intensity, lagged return volatility (σ_t), ME, BM, MOM, ROE, and AG observed in June of year t. Industry dummies and country dummies are also included. The time-series averages and t-statistics of coefficients reported in Table 8 suggest that R&D intensity is associated with significantly higher return volatility in the future. For example, in the first model in Panel A for all countries, the coefficient of R&D intensity is 0.053 with a t-statistic of 8.59. A one-standard-deviation increase in R&D intensity increases future return volatility by 1.06%. Moreover, adding conventional controls does not seem to weaken the effect of R&D intensity. These results are also consistent with the findings of Chambers, Jennings, and Thompson (2002) that the R&D investments lead to more volatile returns in the future.

Table 8 about here.

Overall, Tables 6 to 8 provide evidence that R&D-intensive firms are associated with higher future profitability, higher market valuation, and higher return volatility. These results are consistent with the notion that R&D investments create growth options for the firm.

4 Cross-country Analysis

To better understand the source of return predictability and to identify the explanations for the R&D effect, we turn to country-level analysis in this section. Specifically, we aim to distinguish the risk-based explanation, i.e., there is risk premium associated with R&D investment due to its generation of risky growth options, from mispricing explanations. In the spirit of Li and Zhang (2010), Watanabe, Xu, Yao, and Yu (2013), Lam and Wei (2011), we examine whether the R&D effect is more pronounced in countries where growth options more likely command risk premium, or in countries where the behavioral bias and limits-to-arbitrage are more severe. We run horse-races to test these competing hypotheses.

Our empirical strategy is as follows. By treating each country as an individual unit of analysis, we examine which country characteristics explain the magnitude of the R&D effect across different countries, following Watanabe et al. (2013) and Eisdorfer, Goyal, and Zhdanov (2014). Our strategy is to quantify the magnitude of the R&D effect (i.e., the sensitivity of stock returns to R&D intensity) in each country in a month, and then to examine if this effect can be explained by country-specific variables that reflect various possible reasons for the return predictability. We quantify the R&D effect for each country in a month using four measures: top-minus-bottom R&D spreads (i.e., the difference in returns of the high and low portfolios, both equal- and value-weighted) and R&D slopes from the cross-sectional regressions (both equal- and value-weighted). We again require all the investment strategies to have at least 50 firms within each cross section to sort within each country every year, and then track the equal- and value-weighted returns of the top-minus-bottom portfolio to calculate the monthly R&D spread from July of year t to June of year t+1. We use the same sample to calculate R&D slopes as follows. For each month from July of year t to June of year t+1, we conduct cross-sectional regressions by regressing monthly stock returns on R&D intensity in year t-1 to calculate the monthly R&D slope using equal- and value-weighted least squares.

For the explanations of the R&D effect, we construct three sets of country-specific variables as proxies for dispersion in growth option value, limits-to-arbitrage, and sentiments that correspond to the explanations based on option risk premium, market frictions, and behavioral biases, respectively.

We first construct variables that are related to growth option-induced risks. When firms in a country exhibit significant heterogeneity in growth option values, growth option is more likely to be priced in the cross section. And if the R&D effect (in returns) is related to growth options, we expect it to be more pronounced in countries with higher dispersion in growth option values. On the other hand, in countries where firms have homogeneous growth option values, we expect the R&D effect to be weaker.

To measure country-level dispersion in growth option values, we construct two variables. Our dispersion measure is the difference between the 75th percentile and 25th percentile of each variables.[11] We consider the dispersion in price-dividend ratios, the value of which is shown to predict future economic growth (Bekaert, Harvey, Lundblad, and Siegel, 2007). We also consider the dispersion in the present value of growth options (Long, Wald, and Zhang, 2005; Cao, Simin, and Zhao, 2008).[12] Higher values in these variables suggest that the risk of growth options is more likely to be priced in the cross section.

[11] The cutoff points are not critical to our empirical results. We obtain similar results when we use 80th vs. 20th percentiles, or 90th vs. 10th percentiles.

[12] The details of constructing all the country-level variables are provided in the appendix.

In the second set of proxies for limits-to-arbitrage, we consider short-sale permission, idiosyncratic risk, and dollar trading volume (Watanabe et al., 2013). Short-sale permission (SHORT) is a dummy variable equal to one if short-selling is allowed and zero otherwise. We obtain this information from Bris, Goetzmann, and Zhu (2007). In addition, if short-selling was legal prior to 1990, we assume that short-selling was allowed in each of the years before 1990 following McLean, Pontiff, and Watanabe (2009). Idiosyncratic risk (IRISK) is the annual value-weighted average of idiosyncratic volatility of all stocks in a country. For each stock, its idiosyncratic risk is the standard deviation of the residuals from regressing daily stock returns on the value-weighted market returns from July 1st of year t-1 to June 30th of year t following Li and Zhang (2010). Dollar trading volume (DVOL) is the annual value-weighted average of dollar trading volume for all stocks in a country scaled by total market capitalization in the country. Each stock's dollar trading volume is the product of share volume and daily closing price, summed from July of year t-1 to June of year t (Watanabe et al., 2013). Since limits-to-arbitrage impose higher costs and risks on investors with information advantages, it is expected to weaken the R&D effect driven by market frictions.

In the third set of proxies for sentiments, we consider the number of newly listed firms and volatility premium (Baker, Wurgler, and Yuan, 2012). The number of newly listed firms (NIPO) is the number of firms that first appear in Datastream, approximating the number of IPOs within each country's capital market. We then scale it with the total number of firms in that country in that year. The volatility premium (PVOL) is the log of the ratio of the value-weighted average market-to-book ratio of high volatility stocks to that of low volatility stocks at year end. High (low) volatility stocks are those in the top (bottom) three deciles of the variance of the previous year's monthly returns, where decile break points are determined in each country every year. If the R&D effect is driven by investors' behavioral biases related to R&D (mainly "high-tech fad"), it is expected to be correlated with these sentiment proxies.

After constructing country-month panels of R&D spreads and slopes as well as country-specific variables, we present the time-series averages of all these variables for 21 countries in Table 9. While all the R&D effect (spreads and slopes) are measured monthly, the rest variables are measured annually.

The first four variables reported following the country names are measures of R&D effect, all in percentage points. Of all the counries, the U.S. and Canada have the largest equal-weighted return spread (EWSPRD), 1.185% and 1.095%, respectively. Although most of the countries exhibit a positive R&D-return relationship, there are also countries like Israel presenting a monthly return of -1.334%. The next column reports the value-weighted return spread (VWSPRD), and generally its magnitude is less than the counterpart under EWSPRD, consistent with our previous observation that the R&D effect does not exist in giant firms. The next two columns report the equal-weighted regression slope (EWSLOPE) and value-weighted regression slope (VWSLOPE). There also exists a large dispersion in the magnitude of the slopes across countries, which allows us to conduct our subsequent analysis. For example, the EWSLOPE ranges from -16.377% (Malaysia) to 2.638% (Finland), and the VWSLOPE ranges from -13.264% (Turkey) to 6.579% (Finland).

Table 9 about here.

In Table 10, we report the pooling correlations among all these variables. We first find that the correlation between the equal- and value-weighted R&D spreads (EWSPRD and VWSPRD) is 0.32, and the correlation between the equal- and value-weighted R&D slopes (EWSLOPE and VWSLOPE) is 0.78 with statistical significance. Within the dispersions in growth options set, PE and PVGO are correlated at 0.164. Within in the limits-to-arbitrage set, IRISK is negatively correlated with SHORT and DVOL (-0.12 and -0.17), and SHORT and DVOL is positively correlated (0.39). These correlations are insignificant. Within the sentiment set, the correlation coefficient between NIPO and PVOL is 0.44, which is statistically significant.

Table 10 about here.

We next present cross-country regression results in Tables 11 to 14, where the dependent variables are either spreads or slopes covering July of year t to June of year t+1, while the independent variables are country-specific variables at the end of June of year t (or in the year end of year t-1). We report the pooling regression results with yearly fixed effects, and cluster the standard errors both along countries and along time. The regression analysis thus also delivers asset allocation implications for investment strategies. For convenience, we express the spreads and slopes in percentage points.

Table 11 reports the estimation results from regressing the four measures for the R&D effect on country-specific variables for dispersions in growth options. We find that R&D spreads and slopes can be significantly explained by growth option dispersions. For example, in the left part of Panel A for equally-weighted spreads, the coefficients of dispersion in PVGO and PE are 0.094 and 0.024 with t-statistics of 1.82 and 2.57, respectively, when only each of these variables exists in regressions (Models 1 to 2). In terms of economic significance, when dispersions in PVGO and PE increase by one standard deviation, the return spread increases by 0.11% and 0.10% per month, respectively. When we include both variables in the same regression (Model 3), the coefficients on dispersions in PE and PVGO are similar in both economic and statistical significance. In the right half of Panel A for value-weighted spreads, the coefficients of dispersions in PVGO and PE are 0.056 and 0.022 with t-statistics of 1.72 and 2.60, respectively, in Models 1 and 2. When dispersions in PVGO and PE increase by one standard deviation, the return spread increases by 2.60% and 4.14% per month, respectively. When we move to the equal- and value-weighted slopes, the results are albeit weaker but still largely consistent. These results thus support a risk-based explanation for the international R&D effect: if the effect is associated with growth option risk, it is expected to be more pronounced in countries with larger dispersion in growth option value because R&D-induced growth options are more likely priced in these countries.

Table 11 about here.

Table 12 presents the estimation results from regressing the R&D effect measures on limits-to-arbitrage proxies and suggests that R&D spreads and slopes cannot be explained by market frictions. For example, in Panel A for equal-weighted spreads, the coefficients of SHORT, IRISK, and DVOL are 0.294, 0.139, and 0.047 with t-statistics of 1.32, 0.98, and 1.13, respectively, in Models 1 to 3. For value-weighted spreads, the coefficients of SHORT, IRISK, and DVOL are -0.138, 0.234, and -0.017 with t-statistics of -1.22, 2.35, and -0.44, respectively, in Models 1 to 3. We note that the value-weighted slope is strongly positively related to the IRISK, consistent with the findings in Watanabe et al. (2013). When we include all three variables in a regression (Model 4), we find similar results that these country-specific variables for market frictions generally cannot explain the international R&D effect. Particularly, for equal-weighted spreads in the multiple regression (Model (4)), the coefficient on the SHORT tends to be positive, suggesting that countries allowing short sell actually have stronger RD effects. The statistical significance of SHORT coefficient can also be detected when we use either equal- or value-weighted slopes as the dependent variable in panel B. These results do not support the argument that the R&D effect exists due to market frictions.

Table 12 about here.

Next in Table 13, we regress the R&D effect measures on two sentiment proxies and find that R&D spreads and slopes cannot be attributed to these variables. For example, in Panel A for equal-weighted spreads, the coefficients of NIPO and PVOL are -0.141 and -0.011 with *t*-statistics of -0.09 and -0.10, respectively, when only one variable exists in regressions. Similarly, we find insignificant coefficients in Model 3 that includes both variables for market sentiment. Moreover, we do not detect any significant results when we vary the dependent variables, indicating the lack of explanatory power of these measures for the international R&D effect.

Table 13 about here.

The sharp contrast between the explanatory power of growth option dispersions and that of the limits-to-arbitrage and sentiments allows us to validate these different hypotheses in an international setting. Still, examining the joint effects of these country-characteristics should allow us to further differentiate these hypotheses. Therefore, we continue to rely on the above empirical framework and run multiple regression analysis. We follow Watanabe et al. (2013) and conduct a joint estimation examining the role of either proxy of dispersions in growth option value, after controlling all proxies of limits-to-arbitrage and sentiments.

In Table 14 we re-examine the explanatory power of dispersions in PVGO controlling for the other variables, namely, SHORT, IRISK, DVOL, NIPO, and PVOL. We include one variable under alternative hypotheses (i.e., market frictions and behavioral biases) in the regression, then all of these variables jointly. We still run pooling regression with time fixed effects, and the standard errors are clustered at both the time and country level. Again, we have four dependent variables, and Panels A to D report each set of results. We find that the explanatory power of dispersions in PVGO is fairly robust, and does not weaken in most of the models. For example, in Table 11 where the dependent variable is value-weighted spread, the coefficient of PVGO is 0.056 in the simple regression. Controlling for all the other variables, we still observe the coefficient of PVGO ranging between 0.051 and 0.066, especially with an estimate of 0.066 controlling for all the 5 variables (SHORT, IRISK, DVOL, NIPO and PVOL) as proxies for other explanations, and still with a t-value of 2.40. We also find that in all the multiple regressions, the coefficient for PVGO remains statistically significant when the dependent variable is value-weighted spread (Panel B) and value-weighted slope (Panel D), suggesting that the growth option story still has the strongest explanatory power. This pattern, however, does not appear when the dependent variable is equal-weighted slope (Panel C), which is perhaps less surprising, as the dispersion in PVGO does not explain the R&D effect by itself in the simple regression, as reflected in the left half of Panel B of Table 11.

Table 14 about here.

In Table 15 we similarly re-examine the explanatory power of dispersions in PE controlling for the other variables. Again, we have four dependent variables, and Panels A to D report each set of results. Overall, we find that the explanatory power of dispersions in PE is very robust, and does not weaken in any of the models. For example, in Panel A where the dependent variable is equally-weighted spread, the coefficient of dispersion in PE ranges between 0.020 and 0.029, with t-value from 2.144 to 3.271. This pattern is also true in Panel B where the dependent variable is value-weighted spread, and largely remains in Panel C where the dependent variable is equally-weighted slope. Finally, this pattern becomes weaker in statistical significance when the dependent variable is value-weighted slope.

Table 15 about here.

Overall, Tables 11 to 15 collectively suggest that the country-level R&D effect can be explained by dispersions in growth option measures but not by limits-to-arbitrage or sentiment measures. Our empirical evidence from cross-country analysis indicates that the international R&D-return

relation is more likely driven by risk premiums associated with growth options increasing with R&D investments.

5 Conclusion

In this paper, we document that in international equity markets, firms with higher R&D intensity subsequently experience higher stock returns. This finding, combined with the U.S. evidence in the literature (Lev and Sougiannis, 1996; Lev, 1999; Chan, Lakonishok, and Sougiannis, 2001), suggests a fundamentally important role of intangible investments in asset pricing. While existing literature provides several explanations to the positive relation between R&D intensity and subsequent stock returns, whether these explanations hold internationally remains unexplored.

We conduct cross-country analysis and provide further insights into the debate regarding the sources of the R&D effect. We find that the R&D effect is stronger in countries where the growth options are more likely to be priced, but is unrelated to country characteristics representing market sentiment and limits-of-arbitrage. Combined with the fact that R&D-intensive firms are also associated with higher market-to-book ratios, higher future return volatility, and higher future profitability, our test results suggest that the predictive ability of R&D intensity for stock return is more likely attributable to risk associated with innovation than to mispricing or market frictions.

References

Acs, Z. J. and D. B. Audretsch (1987). Innovation, market structure, and firm size. *The Review of Economics and Statistics 69*(4), pp. 567–574.

Ai, H. and D. Kiku (2013). Growth to value: Option exercise and the cross section of equity returns. *Journal of Financial Economics 107*(2), 325 – 349.

Almeida, H. and M. Campello (2007). Financial constraints, asset tangibility, and corporate investment. *The Review of Financial Studies 20*(5), 1429–1460.

Anderson, C. W. and L. Garcia-Feijoo (2006). Empirical evidence on capital investment, growth options, and security returns. *Journal of Finance 61*(1), 171–194.

Baker, M., J. Wurgler, and Y. Yuan (2012). Global, local, and contagious investor sentiment. *Journal of Financial Economics 104*(2), 272 – 287.

Bekaert, G., R. Harvey, Campbell, C. Lundblad, and S. Siegel (2007). Global growth opportunities and market integration. *Journal of Finance 62*(3), 1081–1137.

Berk, J. B., R. C. Green, and V. Naik (1999). Optimal investment, growth options, and security returns. *Journal of Finance 54*(5), 1553–1607.

Berk, J. B., R. C. Green, and V. Naik (2004). Valuation and return dynamics of new ventures. *Review of Financial Studies 17*(1), 1 – 35.

Bloom, N. and J. van Reenen (2002). Patents, real options and firm performance. *The Economic Journal 112*(478), C97–C116.

Bris, A., W. N. Goetzmann, and N. Zhu (2007). Efficiency and the bear: Short sales and markets around the world. *Journal of Finance 62*(3), 1029–1079.

Callimaci, A. and S. Landry (2004). Market valuation of research and development spending under canadian gaap. *Canadian Accounting Perspectives 3*(1), 33–53.

Cao, C., T. Simin, and J. Zhao (2008). Can growth options explain the trend in idiosyncratic risk? *The Review of Financial Studies 21*(6), 2599–2633.

Carlson, M., A. Fisher, and R. Giammarino (2004). Corporate investment and asset price dynamics: Implications for the cross-section of returns. *Journal of Finance 59*(6), 2577–2603.

Cazavan-Jeny, A. and T. Jeanjean (2006, May). The negative impact of r&d capitalization: A value relevance approach. *European Accounting Review 15*(1), 37–61.

Chambers, D., R. Jennings, and I. Thompson, RobertB. (2002). Excess returns to r&d-intensive firms. *Review of Accounting Studies 7*(2-3), 133–158.

Chan, L. K. C., J. Lakonishok, and T. Sougiannis (2001). The stock market valuation of research and development expenditures. *The Journal of Finance 56*(6), pp. 2431–2456.

Ciftci, M., B. Lev, and S. Radhakrishnan (2011). Is research and development mispriced or properly risk adjusted? *Journal of Accounting, Auditing & Finance 26*(1), 81–116.

Cochrane, J. H. (1991). Production-based asset pricing and the link between stock returns and economic fluctuations. *Journal of Finance 46*(1), 209–237.

Cohen, L., K. Diether, and C. Malloy (2012). Misvaluing innovation. Harvard University Working Paper.

Cohen, W. M., R. C. Levin, and D. C. Mowery (1987). Firm size and r & d intensity: A reexamination. *The Journal of Industrial Economics 35*(4), pp. 543–565.

Cooper, M., H. Gulen, and M. Schill (2008). Asset growth and the cross-section of stock returns. *Journal of Finance 63*(4), 1609–1651.

Davis, J. L., E. F. Fama, and K. R. French (2000). Characteristics, covariances, and average returns: 1929 to 1997. *Journal of Finance 55*(1), 389–406.

Eberhart, A., W. Maxwell, and A. Siddique (2008). A reexamination of the tradeoff between the future benefit and riskiness of r&d increases. *Journal of Accounting Research 46*(1), pp. 27–52.

Eberhart, A. C., W. F. Maxwell, and A. R. Siddique (2004). An examination of long-term abnormal stock returns and operating performance following r&d increases. *The Journal of Finance 59*(2), pp. 623–650.

Eisdorfer, A., A. Goyal, and A. Zhdanov (2014). Distress anomaly and shareholder risk: International evidence. University of Connecticut, Working paper.

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

Fama, E. F. and K. R. French (1998). Value versus growth: The international evidence. *Journal of Finance 53*(6), 1975–1999.

Garleanu, N., S. Panageas, and J. Yu (2012). Technological growth and asset pricing. *The Journal of Finance 67*(4), 1265–1292.

Griffin, J. M. (2002). Are the fama and french factors global or country specific? *The Review of Financial Studies 15*(3), pp. 783–803.

Griliches, Z. (1981). Market value, r&d, and patents. *Economics Letters 7*(2), 183 – 187.

Griliches, Z., A. Pakes, and B. H. Hall (1987). In *Economic Policy and Technical Performance* (Eds. P. Dasgupta and P. Stoneman ed.)., Chapter The Value of Patents as Indicators of Inventive Activity, pp. 97 – 124. Cambridge: Cambridge University Press.

Hall, B. H. (1993). The stock market's valuation of r&d investment during the 1980's. *The American Economic Review 83*(2), pp. 259–264.

Hirshleifer, D., P.-H. Hsu, and D. Li (2012). Innovative diversity and stock returns. Hong Kong University Working Paper.

Hou, K., G. A. Karolyi, and B.-C. Kho (2011). What Factors Drive Global Stock Returns? *Review of Financial Studies 2*(3), 173–197.

Hou, K., C. Xue, and L. Zhang (2015). Digesting anomalies: An investment approach. *Review of Financial Studies 28*(3), 650–705.

Hsu, P.-H. (2009). Technological innovations and aggregate risk premiums. *Journal of Financial Economics 94*(2), 264 – 279.

Ince, O. and R. Porter (2006). Individual equity return data from thomson datastream: Handle with care! *Journal of Financial Research 29*, 463–479.

Jensen, M. C. (1993). The modern industrial revolution, exit, and the failure of internal control systems. *The Journal of Finance 48*(3), pp. 831–880.

Karolyi, G. A., K.-H. Lee, and M. A. van Dijk (2012). Understanding commonality in liquidity around the world. *Journal of Financial Economics, forthcoming*.

Kogan, L. and D. Papanikolaou (2014). Growth opportunities, technology shocks, and asset prices. *The Journal of Finance 69*(2), 675–718.

Kothari, S., T. Laguerre, and A. Leone (2002). Capitalization versus Expensing: Evidence on the Uncertainty of Future Earnings from Capital Expenditures versus R&d Outlays. *Review of Accounting Studies 7*, 355–382.

Lam, F. E. C. and K. J. Wei (2011). Limits-to-arbitrage, investment frictions, and the asset growth anomaly. *Journal of Financial Economics 102*(1), 127–149.

Lev, B. (1999). R&d and capital markets. *Journal of Applied Corporate Finance 11*(4), 21–35.

Lev, B., B. Sarath, and T. Sougiannis (2005). R&d reporting biases and their consequences. *Contemporary Accounting Research 22*, 977–1026.

Lev, B. and T. Sougiannis (1996). The capitalization, amortization, and value-relevance of r&d. *Journal of Accounting and Economics 21*(1), 107 – 138.

Li, D. (2011). Financial constraints, r&d investments, and stock returns. *Review of Financial Studies*, 2974–3007.

Li, D. and P. Kumar (2016). Capital investment, innovative capacity and stock returns. *Journal of Finance*. forthcoming.

Li, D. and L. Zhang (2010). Does q-theory with investment frictions explain anomalies in the cross section of returns? *Journal of Financial Economics 98*(2), 297–314.

Li, E. X. N., D. Livdan, and L. Zhang (2009). Anomalies. *Review of Financial Studies 22*(11), 4301–4334.

Lin, X. (2012). Endogenous technological progress and the cross-section of stock returns. *Journal of Financial Economics 103*(2), 411 – 427.

Lipson, M. L., S. Mortal, and M. J. Schill (2011). On the scope and drivers of the asset growth effect. *Journal of Financial and Quantitative Analysis 46*(06), 1651–1682.

Long, M., J. Wald, and J. Zhang (2005). A cross-sectional analysis of firm growth options. In L. Trigeorgis (Ed.), *Innovation, Organization, and Strategy: New Developments and Applications in Real Options*. New York: Oxford University Press.

McLean, R. D., J. Pontiff, and A. Watanabe (2009). Share issuance and cross-sectional returns: International evidence. *Journal of Financial Economics 94*(1), 1–17.

Oswald, D. R. and P. Zarowin (2007). Capitalization of r&d and the informativeness of stock prices. *European Accounting Review 16*(4), 703–726.

Penman, S. H. and X.-J. Zhang (2002). Accounting conservatism, the quality of earnings, and stock returns. *The Accounting Review 77*(2), pp. 237–264.

Rouwenhorst, K. G. (1998). International momentum strategies. *Journal of Finance 53*(1), 267–284.

Skinner, D. (2008). Accounting for intangibles – a critical review of policy recommendations. *Accounting and Business Research 38*(3), 191–204.

Sougiannis, T. (1994). The accounting based valuation of corporate r&d. *The Accounting Review 69*(1), pp. 44–68.

Watanabe, A., Y. Xu, T. Yao, and T. Yu (2013). The asset growth effect: Insights from international stock markets. *Journal of Financial Economics 108*, 529–563.

Zhang, L. (2005). The value premium. *Journal of Finance 60*(1), 67–103.

Appendix. Country characteristic variables

- Dispersion in price-dividend ratios (PE): the difference between the 75th percentile and 25th percentile of the price-dividend ratio distributions of each country every year. The data are from Datastream.
- Dispersion in the present value of growth options (PVGO): The present value of growth options is calculated following Long, Wald, and Zhang (2005) and Cao, Simin, and Zhao (2008). First, for each firm, we use previous four years' ROE to compute a weighted average ROE for year t with declining weights of 0.4, 0.3, 0.2 and 0.1 for years t, t-1, t-2 and t-3. We then obtain the projected earning by multiplying this average ROE by the end-of-period book value of long-term liability not including debt. Second, we estimate the value of asset-in-place, defined as the discounted projected-cash-flows. We follow Cao, Simin, and Zhao (2008) to assume a market beta of one for all, then aggregate all firm-level returns to calculate a country-year's average market returns. Finally, we obtain the PVGO, the total market value of equity minus the value of asset-in-place divided by the total market value of equity. Next, the dispersion is computed as the difference between the 75th percentile and 25th percentile of the PVGO distributions of each country every year. The data are from Datastream.
- Idiosyncratic risk (IRISK): the annual value-weighted average of idiosyncratic volatility of all stocks in a country. We follow Li and Zhang (2010) and estimate idiosyncratic volatility for an individual stock every year by regressing daily stock returns on the value-weighted market return from July 1st of year $t-1$ to June 30th of year t. A stock's idiosyncratic risk is the standard deviation of the regression residuals. The data are from Datastream.
- Dollar trading volume (DVOL): the annual value-weighted average of dollar trading volume over market capitalization for all stocks in a country. Dollar trading volume is the product of share volume and daily closing price, summed from July of year $t-1$ to June of year t. The data are from Datastream.
- Short-sale permission (SHORT): a dummy variable equal to one if short-selling is allowed and zero otherwise. We obtain this information from Bris, Goetzmann, and Zhu (2007). Following McLean, Pontiff, and Watanabe (2009), if short-selling was legal prior to 1990, we assume that short-selling was allowed in each of the years prior to 1990.
- The number of newly listed firms (NIPO): the number of firms that first appear in Datastream in a year, approximating the number of IPOs within each country's capital market. We then scale it with the total number of firms in that country in that year. The data are from Datastream.

- The volatility premium (PVOL): the log of the ratio of the value-weighted average market-to-book ratio of high volatility stocks to that of low volatility stocks at year end. High (low) volatility stocks are those in the top (bottom) three deciles of the variance of the previous year's monthly returns, where decile break points are determined in each country every year. The data are from Datastream.

Table 1: Descriptive statistics

Country	Start date	End date	Firm-year obs	% of total obs	No. of firms per year	% of total firm	Total mkt value (USD$M)	% of total mkt value	RD/BE median (%)	RD/BE stdev (%)
Australia	198107	201206	15,377	4.82%	496	4.54%	240,532	1.72%	17.18%	34.33%
Canada	198107	201206	14,986	4.69%	483	4.42%	402,454	2.87%	21.57%	40.49%
China	199012	201206	14,672	4.60%	699	6.40%	503,427	3.59%	2.46%	4.41%
Finland	198612	201206	2,304	0.72%	92	0.84%	111,775	0.80%	10.04%	12.88%
France	198107	201206	13,004	4.07%	419	3.84%	677,292	4.83%	15.70%	23.90%
Germany	198107	201206	11,175	3.50%	360	3.30%	509,062	3.63%	18.11%	23.45%
Greece	198712	201206	4,348	1.36%	181	1.66%	42,715	0.30%	2.33%	3.63%
Hong Kong	198107	201206	10,339	3.24%	334	3.05%	272,086	1.94%	4.13%	6.72%
India	198107	201206	8,236	2.58%	374	3.43%	279,052	1.99%	1.79%	3.24%
Israel	198601	201206	2,413	0.76%	127	1.16%	51,511	0.37%	17.83%	31.60%
Italy	198107	201206	5,391	1.69%	174	1.59%	218,868	1.56%	9.51%	9.99%
Japan	198107	201206	49,542	15.52%	1598	14.62%	2,172,391	15.50%	5.50%	6.55%
Malaysia	198107	201206	9,782	3.06%	316	2.89%	86,996	0.62%	0.79%	1.41%
Singapore	198107	201206	5,355	1.68%	173	1.58%	123,156	0.88%	3.90%	7.86%
South Korea	198107	201206	14,271	4.47%	529	4.84%	237,252	1.69%	2.37%	3.83%
Sweden	198107	201206	5,777	1.81%	193	1.76%	153,544	1.10%	15.00%	20.10%
Switzerland	198107	201206	4,455	1.40%	144	1.31%	84,649	0.60%	15.12%	18.84%
Taiwan	198709	201206	7,900	2.47%	343	3.14%	248,441	1.77%	4.33%	4.70%
Turkey	198712	201206	2,708	0.85%	113	1.03%	38,172	0.27%	2.27%	4.56%
U.K.	198107	201206	31,738	9.94%	1024	9.37%	1,150,889	8.21%	15.21%	30.31%
U.S.	198107	201206	85,486	26.78%	2758	25.23%	6,410,444	45.74%	17.64%	28.03%
All			319,259	100.00%	10,930	100.00%	14,014,710	100.00%	11.43%	20.27%
All excluding U.S.			233,773	73.22%	8,172	74.77%	7,604,266	54.26%	8.61%	17.37%

This table provides the summary statistics for the 21 markets from the Datastream-Worldscope sample. Columns 2 and 3 report the beginning and end dates during which each country is included in our sample. Each country's total number of firm-year observations, the average number of firms per year, and the average annual total market capitalization in millions of U.S. dollars are provided in columns 4, 6, and 8, respectively. The values of these statistics represented as percentages of the corresponding total across all countries are given in columns 5, 7, and 9, respectively. The last two columns report the medians and standard deviations of the R&D intensity (RD/BE), which is defined as annual R&D expenses scaled by book equity, for each market.

Table 2: One-way sorted portfolio returns

	Global		Country-neutral		Country-neutral (Non-U.S.)	
Weighting	Equal	Value	Equal	Value	Equal	Value
Low RD/BE	1.229	0.911	1.279	1.144	1.407	1.321
	(4.37)	(3.64)	(4.62)	(4.25)	(4.54)	(4.24)
	1.194	0.892	1.323	1.108	1.384	1.145
	(4.53)	(3.79)	(4.78)	(4.09)	(4.61)	(3.83)
	1.269	0.887	1.363	1.117	1.441	1.197
	(4.64)	(3.30)	(4.66)	(3.81)	(4.54)	(3.71)
	1.432	1.044	1.453	1.087	1.464	1.110
	(4.79)	(3.95)	(4.86)	(3.70)	(4.67)	(3.41)
High RD/BE	1.986	1.139	1.817	1.309	1.860	1.391
	(5.37)	(4.07)	(5.45)	(4.08)	(5.43)	(3.94)
High−Low	0.758***	0.228	0.539***	0.166	0.453***	0.070
t-stat	(3.01)	(1.35)	(3.29)	(0.91)	(2.52)	(0.31)

This table reports the monthly returns (in percentage) on R&D intensity (RD/BE) sorted portfolios. At the end of June of each year, we sort stocks into five R&D intensity quintiles by their R&D intensity in year t-1 in three approaches: global sorting, country-neutral, and country-neutral excluding the U.S. For country-neutral sorting, we rank all sample firms in one country by their R&D intensity measures in year t-1. We first compute the quintile equal- or value-weighted returns within each countries then average to arrive at the country-neutral portfolio returns. We then compute the equal-weighted and value-weighted returns on the resulting 5 portfolios and the return spreads between the top and bottom RD/BE quintiles (High - Low). Equal- and value-weighted returns are computed from July of year t to June of year $t + 1$. The sample period is from July of 1981 to June of 2012. The rows labeled "t-stat" show t-statistics for the High - Low return spreads. Statistical significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *, respectively.

Table 3: Two-way sorted portfolio returns: controlling for size

Panel A: Equal-weighted portfolios						
	Low RD/BE	2	3	4	High RD/BE	High−Low
Small	2.001	2.265	2.289	2.509	3.452	1.451
	(6.28)	(7.54)	(7.61)	(7.13)	(7.63)	(4.06)
	1.182	1.090	1.295	1.615	2.036	0.854
	(3.72)	(3.84)	(4.49)	(4.70)	(4.82)	(2.58)
	0.976	0.972	1.067	1.090	1.432	0.456
	(3.28)	(3.34)	(3.75)	(3.31)	(3.67)	(1.54)
	0.892	0.817	0.994	1.114	1.386	0.494
	(3.11)	(2.86)	(3.41)	(3.61)	(3.83)	(2.07)
Large	0.973	0.862	0.973	1.026	1.239	0.266
	(3.85)	(3.39)	(3.59)	(3.73)	(4.06)	(1.44)
						0.704
						(2.44)

Panel B: Value-weighted portfolios						
	Low RD/BE	2	3	4	High RD/BE	High−Low
Small	1.767	1.930	2.032	2.187	2.905	1.138
	(5.49)	(6.46)	(6.89)	(6.37)	(6.47)	(3.20)
	1.187	1.076	1.256	1.616	2.001	0.814
	(3.74)	(3.82)	(4.32)	(4.70)	(4.75)	(2.44)
	0.949	0.950	1.062	1.086	1.450	0.501
	(3.20)	(3.26)	(3.72)	(3.28)	(3.70)	(1.68)
	0.896	0.865	0.954	1.137	1.371	0.475
	(3.16)	(3.02)	(3.25)	(3.68)	(3.84)	(2.06)
Large	0.865	0.703	0.863	0.963	1.002	0.137
	(3.50)	(2.98)	(3.15)	(3.62)	(3.81)	(0.76)
						0.613
						(2.13)

This table reports the monthly returns (in percentage) on two-way sorted portfolios, which measure the R&D effect after controlling for firm size. At the end of June of each year, we sort all stocks independently into RD/BE quintiles and firm size quintiles. We then compute the equal-weighted (Panel A) and value-weighted (Panel B) returns on the resulting 25 portfolios and the return spreads between the top and bottom R&D/BE quintiles
(High - Low) within each size groups. Finally, we average these return spreads and report this average and associated t-statistics in the last column. Returns are computed from July of year t to June of year $t+1$. The sample period is from July of 1981 to June of 2012. t-statistics are reported in parentheses. Statistical significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *, respectively.

Table 4: Time series regression with the factors of Hou, Karolyi and Kho (2011)

	Global		Country-neutral		Country-neutral (Non-U.S.)	
Weighting	Equal	Value	Equal	Value	Equal	Value
Alpha	0.733**	0.301*	0.610***	0.228	0.522**	0.122
	(2.327)	(1.687)	(2.936)	(1.143)	(2.415)	(0.518)
Rm_rf	0.172***	0.070	0.109***	0.121***	0.080*	0.112*
	(3.033)	(1.479)	(2.753)	(2.665)	(1.801)	(1.885)
F_{MOM}	0.118	0.059	0.002	-0.041	-0.026	-0.100
	(0.949)	(1.021)	(0.031)	(-0.547)	(-0.328)	(-1.109)
$F_{C/P}$	-0.163	-0.253***	-0.168*	-0.138*	-0.119	-0.064
	(-1.183)	(-3.476)	(-1.899)	(-1.712)	(-1.291)	(-0.668)
Obs	354	354	354	354	354	354

This table examines the risk-based models' explanatory ability of R&D intensity for portfolio returns. We conduct factor regressions of equal- and value-weighted return spreads separately, and use the Hou, Karolyi and Kho (2011) factor pricing models. These return spreads are High-Low from Table 2 are constructed by global sorting, country-neutral sorting, and country-neutral sorting excluding U.S. firms. Returns are computed from July of year t to June of year $t+1$. The model of Hou, Karolyi and Kho (2011) includes a global market factor (Rm_rf), a global cash-to-price factor ($F_{C/P}$), and a global momentum factor (F_{MOM}). The sample period is from July of 1981 to June of 2012. The t-statistics based on Newey-West (1987) adjusted for time-series autocorrelation are reported in parentheses. Statistical significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *, respectively.

Table 5: Fama-MacBeth regressions

	Panel A: Equally-weighted Fama-MacBeth regressions – All countries				
RD/BE	0.015***	0.013***	0.014***	0.020***	0.017***
	(2.867)	(2.617)	(4.288)	(6.469)	(7.404)
ME				-0.001***	-0.001***
				(-3.058)	(-3.183)
BM				0.005***	0.005***
				(6.709)	(6.537)
MOM				0.007***	0.006***
				(5.245)	(4.785)
ROE					0.000
					(0.327)
AG					-0.003***
					(-3.504)
Cty		Y	Y	Y	Y
Ind			Y	Y	Y
Obs	1247022	1247022	1230632	1141788	1060385
R^2	0.006	0.103	0.125	0.139	0.143
	Panel B: Equally-weighted Fama-MacBeth regressions – Non-U.S.				
RD/BE	0.007	0.006*	0.008**	0.014***	0.013***
	(1.331)	(1.681)	(2.279)	(3.771)	(3.991)
ME				-0.001**	-0.001**
				(-2.200)	(-2.540)
BM				0.004***	0.004***
				(6.578)	(6.894)
MOM				0.006***	0.006***
				(3.228)	(3.009)
ROE					0.002
					(0.710)
AG					-0.008***
					(-4.306)
Cty		Y	Y	Y	Y
Ind			Y	Y	Y
Obs	797512	797512	787840	725526	672623
R^2	0.006	0.157	0.190	0.207	0.208
	Panel C: Value-weighted Fama-MacBeth regressions – All countries				
RD/BE	0.026**	0.023**	0.016**	0.022***	0.015***
	(2.260)	(2.049)	(2.584)	(3.382)	(2.858)
ME				-0.004***	-0.004***
				(-5.146)	(-5.045)

Continued on next page

BM				0.005***	0.005***
				(4.875)	(4.137)
MOM				0.005**	0.003
				(2.570)	(1.299)
ROE					-0.001
					(-0.467)
AG					-0.004***
					(-2.777)
Cty		Y	Y	Y	Y
Ind			Y	Y	Y
Obs	1237176	1237176	1220826	1141601	1060242
R^2	0.008	0.083	0.169	0.190	0.205
Panel D: Value-weighted Fama-MacBeth regressions – Non-U.S.					
RD/BE	0.016*	0.013*	0.009	0.009	0.012**
	(1.780)	(1.689)	(1.403)	(1.466)	(2.045)
ME				-0.004***	-0.003***
				(-4.518)	(-4.075)
BM				0.003***	0.004***
				(2.807)	(3.373)
MOM				0.003	0.003
				(1.025)	(0.958)
ROE					0.009*
					(1.681)
AG					-0.013***
					(-3.629)
Cty		Y	Y	Y	Y
Ind			Y	Y	Y
Obs	792273	792273	782627	725374	672504
R^2	0.016	0.178	0.325	0.351	0.369

This table reports the time series averages and t-statistics of the coefficients from cross-sectional regressions of individual stock returns on R&D intensity, control variables, and country and industry fixed effects. Panel A reports the equal-weighted regression results for all countries, Panel B reports the equal-weighted regression results for all countries excluding the U.S., Panel C reports the value-weighted regression results for all countries, and Panel D reports the value-weighted regression results for all countries excluding the U.S. The dependent variable, stock return, is measured at the first year holding horizon after June of year t. The control variables include ME (the natural logarithm of June-end market value of year t), BM (the natural logarithm of the year $t-1$ fiscal year-end book-to-market ratio), MOM (the year t January-to-May returns), ROE (return on equity), and AG (asset growth in year t). The country/industry dummies are suppressed to save space. The Newey-West t-statistics are adjusted for time-series autocorrelation and reported in the parentheses and significance at the 1%, 5%, and 10% level is indicated by ***, **, and *, respectively.

Table 6: R&D intensity and future profitability

Panel A: All countries					
RD/BE	0.123***	0.114***	0.156***	0.100***	0.019
	(4.645)	(4.796)	(6.228)	(4.743)	(0.779)
PF_t	0.555***	0.543***	0.528***	0.501***	0.571***
	(35.643)	(39.025)	(36.232)	(28.178)	(24.245)
ME				0.019***	0.020***
				(16.312)	(18.491)
BM				-0.053***	-0.053***
				(-5.192)	(-5.090)
MOM				0.125***	0.121***
				(8.519)	(8.937)
ROE					-0.108***
					(-5.660)
AG					-0.011*
					(-1.766)
Cty		Y	Y	Y	Y
Ind			Y	Y	Y
Obs	70938	70938	70938	70346	67387
R^2	0.290	0.297	0.312	0.347	0.365
Panel B: Non-U.S.					
RD/BE	0.157***	0.154***	0.147***	0.114***	0.062*
	(4.285)	(3.929)	(3.922)	(3.867)	(2.043)
PF_t	0.604***	0.584***	0.570***	0.562***	0.633***
	(27.477)	(24.043)	(23.325)	(20.638)	(17.021)
ME				0.012***	0.013***
				(5.541)	(5.828)
BM				-0.044***	-0.040***
				(-3.678)	(-3.551)
MOM				0.088***	0.081***
				(7.880)	(5.698)
ROE					-0.114***
					(-3.170)
AG					0.000
					(0.020)
Cty		Y	Y	Y	Y
Ind			Y	Y	Y
Obs	43938	43938	43938	43499	41150
R^2	0.370	0.387	0.416	0.441	0.456

This table reports the time series averages and t-statistics of coefficients from cross-sectional regressions of individual firms' operating profitability in year t+1 on R&D intensity in year t, operating profitability in year t+1, control variables in year t, and country and industry fixed effects. Operating performance is defined as revenue minus cost of goods sold (COGS), interest expenses, and selling, general and administrative expenses (SG&A) scaled by book equity. Panel A reports the regression results for the whole sample, and Panel B for all countries excluding the U.S. The control variables include ME (the natural logarithm of June-end market value of year t), BM (the natural logarithm of the year $t-1$ fiscal year-end book-to-market ratio), MOM (the year t January-to-May), ROE, and AG (asset growth). The country/industry dummies are suppressed to save space. The t-statistics are adjusted for time-series autocorrelation and reported in the parentheses and significance at the 1%, 5%, and 10% level is indicated by ***, **, and *, respectively.

Table 7: R&D intensity and market-to-book ratio

	Panel A1: All countries				Panel A2: Non-U.S.			
RD/BE	7.422***	6.995***	6.165***	5.613***	6.788***	6.802***	5.332***	5.355***
	(9.384)	(12.544)	(8.350)	(9.946)	(6.563)	(6.691)	(6.475)	(6.413)
PF_{t+1}	0.985***	1.101***			0.559***	0.809***		
	(11.059)	(14.037)			(3.664)	(7.023)		
ret_{t+1}	-0.608**	-0.441**	-0.533*	-0.386**	-1.467***	-1.143***	-1.357**	-1.085***
	(-2.169)	(-2.327)	(-1.985)	(-2.158)	(-2.898)	(-3.754)	(-2.569)	(-3.335)
$absPF_{t+1}$			2.199***	2.168***			2.145***	2.350***
			(11.125)	(10.289)			(7.735)	(7.944)
Cty		Y		Y		Y		Y
Ind		Y		Y		Y		Y
Obs	93219	93219	93219	93219	50262	50262	50262	50262
R^2	0.156	0.262	0.195	0.293	0.134	0.253	0.184	0.304

	Panel B1: All countries				Panel B2: Non-U.S.			
RD/ΔBE	0.003*	-0.001	0.005***	0.001	0.003	0.002	0.004*	0.003*
	(1.779)	(-0.660)	(2.829)	(0.886)	(1.394)	(1.052)	(2.040)	(1.666)
PF_{t+1}	0.857***	1.072***			0.894***	1.228***		
	(5.543)	(8.466)			(4.044)	(4.979)		
ret_{t+1}	-0.821**	-0.525**	-0.659**	-0.420**	-2.111***	-1.543***	-1.825***	-1.294***
	(-2.531)	(-2.412)	(-2.230)	(-2.058)	(-4.320)	(-3.700)	(-3.563)	(-2.950)
$absPF_{t+1}$			2.800***	2.724***			2.954***	3.139***
			(7.997)	(9.355)			(8.221)	(11.956)
Cty		Y		Y		Y		Y
Ind		Y		Y		Y		Y
Obs	78901	78901	78901	78901	42320	42320	42320	42320
R^2	0.026	0.180	0.116	0.248	0.029	0.208	0.133	0.288

This table reports the time series averages and t-statistics of coefficients from cross-sectional regressions of individual firms' market-to-book ratios in year t on R&D intensity in year t, control variables in year t, and country and industry fixed effects. Panel A reports the regression results with RD/BE as independent variable, and Panel B reports the regression results with RD/ΔBE as independent variable. ΔBE denotes the change in book equity. The dependent variable, stock return, is measured at the first year holding horizon after June of year t. The control variables include operating profitability (PF), stock return (ret), and absolute value of operating profitability (absPF). The country/industry dummies are suppressed to save space. The t-statistics are adjusted for time-series autocorrelation and reported in the parentheses and significance at the 1%, 5%, and 10% level is indicated by ***, **, and *, respectively.

Table 8: R&D intensity and future return volatility

			Panel A: All countries		
RD/BE	0.053***	0.061***	0.051***	0.051***	0.031***
	(8.591)	(10.479)	(8.744)	(8.603)	(4.864)
σ_t	0.415***	0.382***	0.357***	0.307***	0.291***
	(21.227)	(17.804)	(17.679)	(17.798)	(17.478)
ME				-0.008***	-0.007***
				(-12.956)	(-12.984)
BM				0.002	0.002*
				(1.440)	(1.904)
MOM				-0.025***	-0.024***
				(-6.864)	(-7.097)
ROE					-0.022***
					(-6.481)
AG					0.009***
					(12.648)
Cty		Y	Y	Y	Y
Ind			Y	Y	Y
Obs	98475	98475	98475	97776	93986
R^2	0.197	0.252	0.271	0.318	0.332
			Panel B: Non-U.S.		
RD/BE	0.026***	0.041***	0.035***	0.030***	0.014**
	(2.840)	(4.939)	(4.065)	(3.848)	(2.199)
σ_t	0.381***	0.314***	0.298***	0.265***	0.243***
	(13.363)	(15.703)	(15.251)	(11.629)	(11.185)
ME				-0.007***	-0.007***
				(-13.012)	(-14.064)
BM				-0.000	-0.001
				(-0.526)	(-0.765)
MOM				-0.022***	-0.020***
				(-3.950)	(-3.766)
ROE					-0.025***
					(-5.248)
AG					0.006**
					(2.334)
Cty		Y	Y	Y	Y
Ind			Y	Y	Y
Obs	63922	63922	63922	63431	60419
R^2	0.146	0.236	0.263	0.301	0.317

This table reports the time series averages and t-statistics of coefficients from cross-sectional regressions of individual firms' stock return volatility in year t+1 on R&D intensity in year t, return volatility (σ) in year t, control variables in year t, and country and industry fixed effects. Panel A reports the results for all countries, and Panel B reports the results for all countries excluding the U.S. The dependent variable, monthly stock return volatility, is measured at the first year holding horizon after June of year t. The control variables include ME (the natural logarithm of June-end market value of year t), BM (the natural logarithm of the year $t-1$ fiscal year-end book-to-market ratio), MOM (the year t January-to-May), ROE (return on equity in year t), and AG (asset growth in year t). The country/industry (Cty/Ind) dummies are suppressed to save space. The Newey-West t-statistics are adjusted for time-series autocorrelation and reported in the parentheses and significance at the 1%, 5%, and 10% level is indicated by ***, **, and *, respectively.

Table 9: Country characteristics

COUNTRY	EWSPRD	VWSPRD	EWSLOPE	VWSLOPE	PE	PVGO	SHORT	IRISK	DVOL	NIPO	PVOL
Australia	0.461%	-0.061%	1.203%	-0.329%	17.72	0.88	1.00	4.67	-1.15	0.14	0.44
Canada	1.095%	0.616%	1.132%	0.813%	29.78	1.17	1.00	5.13	-0.92	0.08	0.22
China	-0.330%	-1.073%	-4.391%	-1.680%	40.44	0.43					
Finland	0.799%	-0.923%	2.638%	6.579%	16.08	0.32	1.00	1.84	-0.81	0.02	-0.28
France	0.410%	0.629%	-0.454%	2.293%	18.54	2.59	1.00	3.22	-0.53	0.08	0.00
Germany	0.645%	0.715%	1.042%	-0.232%	19.54	2.02	1.00	3.57	-1.83	0.07	0.44
Greece	-0.959%	-0.384%	-11.218%	-6.765%	21.76	2.51	0.00	2.69	1.16	0.02	-0.95
Hong Kong	0.381%	0.904%	-0.469%	-0.758%	14.69	1.71	1.00	3.60	-2.04	0.13	0.90
India	0.369%	0.537%	-0.007%	-5.897%	19.67	1.06	0.00	4.35	-4.76	0.16	-0.54
Israel	-1.334%	-0.852%	-1.536%	-1.337%	14.58	0.46					0.01
Italy	0.283%	0.175%	2.159%	1.525%	11.74	0.98	1.00	2.07	-0.82	0.06	-0.41
Japan	0.257%	0.131%	0.410%	0.688%	27.86	1.35	1.00	2.39	-6.57	0.09	0.65
Malaysia	-0.518%	-1.287%	-16.377%	3.388%	13.87	0.65	0.00	2.80	-4.23	0.01	-0.84
Singapore	0.550%	-0.250%	-1.732%	-6.770%	11.94	1.46	0.00	3.24	-2.78	0.04	-0.02
South Korea	0.455%	0.483%	-0.983%	-1.483%	17.94	1.65	0.00	3.98	-6.02	0.14	0.24
Sweden	-0.959%	-0.587%	-0.123%	0.178%	14.83	0.51	1.00	4.07	-2.42	0.07	0.29
Switzerland	0.023%	-0.286%	-1.736%	-4.831%	16.73	0.65	1.00	2.44	-2.19	0.03	-0.07
Taiwan	0.556%	-0.182%	-0.296%	-1.502%	14.30	0.39	1.00	2.76	-1.24	0.14	-0.23
Turkey	0.756%	0.700%	-4.915%	-13.264%	15.55	1.72	1.00	2.47	-0.39	0.09	0.33
UK	0.292%	-0.308%	0.590%	2.856%	14.35	1.28	1.00	2.42	0.03	0.09	0.44
US	1.185%	0.467%	0.566%	0.860%	19.15	1.36	1.00	3.68	-1.29	0.09	0.25

This table reports the four measures of the R&D effect and country-specific variables used in the cross-country analysis. The four measures of the R&D effect include equal-weighted spreads (EWSPRD), value-weighted spreads (VWSPRD), equal-weighted slopes (EWSLOPE), and value-weighted slopes (VWSLOPE). The country-specific variables include proxies for dispersion in growth options, limits-to-arbitrage, and investor sentiment. The proxies for the dispersion in growth option value include dispersion in PE (price-dividend) and PVGO (present value of growth options). The limits-to-arbitrage proxies include the average idiosyncratic stock return volatility IRISK(in percentage points), the average annual dollar trading volume DVOL (in millions), and the indicator for equity short-sale permission SHORT. The proxies for investor sentiment include the number of newly listed equities (NIPO) and volatility premium (PVOL). We report the averages of these variables for each country. The sample period is from July of 1981 to June of 2012.

Table 10: Correlations of country-specific variables

	EWSPRD	VWSPRD	EWSLOPE	VWSLOPE	PE	PVGO	SHORT	IRISK	DVOL	NIPO	PVOL
EWSPRD	1.000										
VWSPRD	0.324	1.000									
	(0.16)										
EWSLOPE	0.559	0.266	1.000								
	(0.01)	(0.26)									
VWSLOPE	0.385	0.037	0.784	1.000							
	(0.09)	(0.88)	(0.00)								
PE	0.270	0.284	0.097	-0.039	1.000						
	(0.25)	(0.22)	(0.68)	(0.87)							
PVGO	-0.155	0.418	-0.314	-0.243	0.164	1.000					
	(0.51)	(0.07)	(0.18)	(0.30)	(0.49)						
SHORT	0.426	0.156	0.453	0.387	0.078	-0.148	1.000				
	(0.07)	(0.52)	(0.05)	(0.10)	(0.75)	(0.55)					
IRISK	0.490	0.380	0.214	-0.024	0.385	0.072	-0.121	1.000			
	(0.03)	(0.11)	(0.38)	(0.92)	(0.10)	(0.77)	(0.62)				
DVOL	0.034	-0.044	-0.045	-0.047	-0.196	0.191	0.386	-0.173	1.000		
	(0.89)	(0.86)	(0.86)	(0.85)	(0.42)	(0.43)	(0.10)	(0.48)			
NIPO	0.411	0.617	0.274	-0.032	0.113	0.115	0.114	0.535	-0.289	1.000	
	(0.07)	(0.00)	(0.24)	(0.89)	(0.64)	(0.63)	(0.64)	(0.02)	(0.23)		
PVOL	0.458	0.335	0.391	0.321	0.166	0.152	0.570	0.290	-0.173	0.444	1.000
	(0.04)	(0.15)	(0.09)	(0.17)	(0.49)	(0.52)	(0.01)	(0.23)	(0.48)	(0.05)	

This table reports the correlations among the measures of the R&D effect and country-specific variables used in the cross-country analysis. The four measures of the R&D effect include equal-weighted spreads (EWSPRD), value-weighted spreads (VWSPRD), equal-weighted slopes (EWSLOPE), and value-weighted slopes (VWSLOPE). The country-specific variables include proxies for dispersion in growth options, limits-to-arbitrage, and investor sentiment. The proxies for the dispersion in growth option value include dispersion in PE (price-dividend) and PVGO (present value of growth options). The limits-to-arbitrage proxies include the average idiosyncratic stock return volatility IRISK (in percentage points), the average annual dollar trading volume scaled by total market capitalization (DVOL), and the indicator for equity short-sale permission SHORT. The proxies for investor sentiment include the number of newly listed equities (NIPO) and volatility premium (PVOL). The sample period is from July of 1981 to June of 2012.

Table 11: R&D effect and growth options

Panel A: SPREAD as dependent variable						
	Equal-weighted SPREAD			Value-weighted SPREAD		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
PVGO	0.094*		0.099**	0.056*		0.060*
	(1.819)		(2.019)	(1.724)		(1.904)
PE		0.024**	0.025***		0.022***	0.023***
		(2.572)	(2.823)		(2.597)	(2.705)
Intercept	-0.936***	-1.333***	-1.418***	-0.656	-0.674	-0.726
	(-3.966)	(-4.989)	(-5.475)	(.)	(.)	(.)
Obs	3282	3271	3271	3282	3271	3271
R^2	0.055	0.055	0.056	0.050	0.050	0.051

Panel B: SLOPE as dependent variable						
	Equal-weighted SLOPE			Value-weighted SLOPE		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
PVGO	0.162		0.178	0.442**		0.439**
	(1.149)		(1.274)	(2.077)		(2.083)
PE		0.062*	0.064*		-0.024	-0.019
		(1.740)	(1.814)		(-0.366)	(-0.285)
Intercept	-0.847	-3.808***	-3.952***	-1.049	5.254*	4.884*
	(-1.491)	(-2.695)	(-2.825)	(-0.774)	(1.804)	(1.703)
Obs	3218	3207	3207	3218	3208	3208
R^2	0.028	0.028	0.029	0.006	0.005	0.006

This table reports the results of panel regressions which examine the relation between the dispersoin in growth option value and the R&D effect on stock returns. The dependent variables are the monthly equal- and value-weighted spread (SPREAD) and slope (SLOPE). SPREAD is the equal-weighted or value-weighted average of the monthly return difference between the top and bottom RD/BE (High–Low), where their returns are cumulated from July of year t to June of year $t+1$. The value-weighting of SPREAD is based on firms' market capitalizations in June of year t. SLOPE is given by regressing buy-and-hold stock returns from July of year t to June of year $t+1$ on the RD/BE measured over year $t-1$. The regressions are either equal-weighted or value-weighted. The value-weighted version of SLOPE is based on weighted-least-squares regressions, where the weights are proportional to market capitalizations in June of year t. Panel A reports the regression results where the equal- or value-weighted SPREAD is used as the dependent variable. Panel B presents the regression results where the equal- or value-weighted SLOPE is used as the dependent variable. The explanatory variables are the proxies of the dispersion in growth option value, including PE (price-dividend ratio) and PVGO (present value of growth options). The t-statistics reported in parentheses are computed using two-way clustered standard errors by country and year. Year fixed effects are included. Statistical significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *, respectively.

Table 12: R&D effect and limits-to-arbitrage

	Panel A: *SPREAD as dependent variable*							
	Equal-weighted SPREAD				Value-weighted SPREAD			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
SHORT	0.294			0.447*	-0.138			0.081
	(1.322)			(1.727)	(-1.217)			(0.455)
IRISK		0.139		0.169		0.234**		0.226**
		(0.975)		(1.294)		(2.345)		(2.172)
DVOL			0.047	0.020			-0.017	-0.017
			(1.134)	(0.574)			(-0.443)	(-0.388)
Intercept	-0.850	-1.754	3.339	-0.884	0.207	-1.094***	0.303***	-1.214**
	(-1.156)	(.)	(.)	(-1.363)	(0.223)	(-3.955)	(4.085)	(-2.208)
Obs	2872	2478	2369	2299	2872	2480	2367	2300
R^2	0.056	0.059	0.061	0.061	0.052	0.060	0.059	0.060
	Panel B: *SLOPE as dependent variable*							
	Equal-weighted SLOPE				Value-weighted SLOPE			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
SHORT	2.562*			3.778**	3.299*			3.888***
	(1.923)			(2.443)	(1.872)			(3.156)
IRISK		0.258		0.507**		-0.647		-0.395
		(0.803)		(1.985)		(-0.702)		(-0.574)
DVOL			0.139	-0.105			0.439	0.175
			(0.706)	(-0.597)			(1.327)	(0.761)
Intercept	-3.020**	-6.023	3.039***	-4.534**	-3.283	-1.358	7.200***	6.119
	(-2.011)	(.)	(12.080)	(-2.240)	(-1.049)	(-0.608)	(22.795)	(1.295)
Obs	2813	2427	2323	2253	2813	2427	2321	2250
R^2	0.031	0.029	0.032	0.036	0.007	0.006	0.007	0.009

This table reports the results of panel regressions which examine the relation between limits-to-arbitrage and the R&D effect on stock returns. The dependent variables are the monthly equal- and value-weighted spread (SPREAD) and slope (SLOPE). SPREAD is the equal-weighted or value-weighted average of the monthly return difference between the top and bottom RD/BE quintile, where their returns are cumulated from July of year t to June of year $t+1$. The value-weighting of SPREAD is based on firms' market capitalizations in June of year t. SLOPE is given by regressing buy-and-hold stock returns from July of year t to June of year $t+1$ on the RD/BE measured over year $t-1$. The regressions are either equal-weighted or value-weighted. The value-weighted version of SLOPE is based on weighted-least-squares regressions, where the weights are proportional to market capitalizations in June of year t. Panel A reports the regression results where the equal- or value-weighted SPREAD is used as the dependent variable. Panel B presents the regression results where the equal- or value-weighted SLOPE is used as the dependent variable. The explanatory variables are the limits-to-arbitrage proxies, including idiosyncratic stock return volatility (IRISK), dollar trading volume scaled by total market capitalization (DVOL), and permission for equity short-sale (SHORT). The t-statistics reported in parentheses are computed using two-way clustered standard errors by country and year. Year fixed effects are included. Statistical significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *, respectively.

Table 13: R&D effect and sentiments

Panel A: SPREAD as dependent variable						
	Equal-weighted SPREAD			Value-weighted SPREAD		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
NIPO	-0.141		-0.007	0.320		0.535
	(-0.087)		(-0.004)	(0.304)		(0.495)
PVOL		-0.011	-0.138		0.069	0.000
		(-0.099)	(-1.067)		(0.393)	(0.002)
Intercept	0.890	-0.528***	0.799	-0.707	-0.524***	-0.529***
	(0.670)	(-10.060)	(0.586)	(-0.865)	(-6.920)	(-4.777)
Obs	2737	3088	2622	2731	3083	2615
R^2	0.058	0.050	0.053	0.056	0.049	0.055

Panel B: SLOPE as dependent variable						
	Equal-weighted SLOPE			Value-weighted SLOPE		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
NIPO	4.128		4.347	-9.813		-9.479
	(0.609)		(0.621)	(-1.175)		(-1.141)
PVOL		0.308	0.196		0.111	0.132
		(0.500)	(0.309)		(0.125)	(0.129)
Intercept	-0.933	8.097***	-1.141	5.271	4.996*	1.406**
	(-0.169)	(3.642)	(-0.200)	(0.479)	(1.764)	(2.512)
Obs	2682	3016	2566	2685	3016	2569
R^2	0.030	0.029	0.030	0.007	0.006	0.007

This table reports the results of panel regressions which examine the relation between investor sentiment and the R&D effect on stock returns. The dependent variables are the monthly equal- and value-weighted spread (SPREAD) and slope (SLOPE). SPREAD is the equal-weighted or value-weighted average of the monthly return difference between the top and bottom RD/BE quintile, where their returns are cumulated from July of year t to June of year $t+1$. The value-weighting of SPREAD is based on firms' market capitalizations in June of year t. SLOPE is given by regressing buy-and-hold stock returns from July of year t to June of year $t+1$ on the RD/BE measured over year $t-1$. The regressions are either equal-weighted or value-weighted. The value-weighted version of SLOPE is based on weighted-least-squares regressions, where the weights are proportional to market capitalizations in June of year t. Panel A reports the regression results where the equal- or value-weighted SPREAD is used as the dependent variable. Panel B presents the regression results where the equal- or value-weighted SLOPE is used as the dependent variable. The explanatory variables include the number of newly listed equities (NIPO) and volatility premium (PVOL). The t-statistics reported in parentheses are computed using two-way clustered standard errors by country and year. Year fixed effects are included. Statistical significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *, respectively.

Table 14: PVGO vs. limits-to-arbitrage and sentiments

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Panel A: EWSPREAD as dependent variable						
PVGO	0.095*	0.079	0.078	0.092*	0.097*	0.090*
	(1.807)	(1.494)	(1.434)	(1.739)	(1.939)	(1.713)
SHORT	0.309					0.666**
	(1.402)					(2.085)
IRISK		0.136				0.173
		(0.917)				(1.219)
DVOL			0.049			0.004
			(1.175)			(0.130)
NIPO				-0.061		-0.606
				(-0.037)		(-0.256)
PVOL					-0.017	-0.207
					(-0.156)	(-1.343)
Intercept	-1.248***	-0.924***	-0.378	-0.151	-0.591***	-0.682
	(-6.277)	(-2.605)	(.)	(-0.219)	(-8.667)	(-1.223)
Obs	2850	2467	2369	2715	3042	2171
R^2	0.058	0.060	0.062	0.059	0.052	0.058
Panel B: VWSPREAD as dependent variable						
PVGO	0.054*	0.052*	0.051*	0.055*	0.056*	0.066**
	(1.652)	(1.783)	(1.761)	(1.691)	(1.685)	(2.398)
SHORT	-0.129					0.356
	(-1.196)					(1.360)
IRISK		0.232**				0.236**
		(2.440)				(2.299)
DVOL			-0.016			-0.014
			(-0.413)			(-0.315)
NIPO				0.370		1.620
				(0.362)		(0.933)
PVOL					0.071	-0.034
					(0.406)	(-0.177)
Intercept	-0.523	0.589**	0.610***	-0.247	-0.563***	-1.177
	(-0.566)	(2.289)	(4.954)	(-0.685)	(-7.548)	(-1.410)
Obs	2850	2470	2367	2709	3038	2169
R^2	0.053	0.061	0.060	0.057	0.050	0.061
Panel C: EWSLOPE as dependent variable						
PVGO	0.168	0.181	0.161	0.173	0.161	0.201
	(1.194)	(1.241)	(1.100)	(1.137)	(1.093)	(1.248)
SHORT	2.581*					4.988***
	(1.899)					(2.897)
IRISK		0.261				0.521**
		(0.788)				(2.126)

DVOL			0.141			-0.172
			(0.699)			(-0.846)
NIPO				4.253		0.815
				(0.616)		(0.128)
PVOL					0.290	-0.613
					(0.467)	(-1.015)
Intercept	-2.569*	-2.409***	2.974***	-0.908	-1.969***	-5.507
	(-1.712)	(-2.967)	(10.840)	(-0.558)	(-8.142)	(-1.507)
Obs	2791	2417	2323	2660	2970	2121
R^2	0.032	0.030	0.032	0.030	0.029	0.039
Panel D: VWSLOPE as dependent variable						
PVGO	0.458**	0.482**	0.450**	0.436**	0.461**	0.533**
	(2.205)	(2.235)	(2.060)	(2.133)	(2.104)	(2.277)
SHORT	3.369**					5.079***
	(1.981)					(3.279)
IRISK		-0.648				-0.367
		(-0.688)				(-0.502)
DVOL			0.446			0.130
			(1.333)			(0.459)
NIPO				-9.507		3.715
				(-1.140)		(0.501)
PVOL					0.091	-0.697
					(0.103)	(-0.676)
Intercept	-3.613*	-1.771	6.780***	4.952*	0.608*	-3.835
	(-1.924)	(-0.791)	(20.538)	(1.760)	(1.654)	(-1.094)
Obs	2791	2416	2321	2663	2971	2118
R^2	0.007	0.007	0.008	0.007	0.006	0.011

This table reports the results of panel regressions which examine the relation between the dispersion in growth option value and the R&D effect on stock returns, after controlling for limist-to-arbitrage and investor sentiment. The dependent variables are the monthly equal- and value-weighted spread (SPREAD) and slope (SLOPE). SPREAD is the equal-weighted or value-weighted average of the monthly return difference between the top and bottom RD/BE quintile, where their returns are cumulated from July of year t to June of year t+1. The value-weighting of SPREAD is based on firms' market capitalizations in June of year t. SLOPE is given by regressing buy-and-hold stock returns from July of year t to June of year $t+1$ on the RD/BE measured over year $t-1$. The regressions are either equal-weighted or value-weighted. The value-weighted version of SLOPE is based on weighted-least-squares regressions, where the weights are proportional to market capitalizations in June of year t. Panel A reports the regression results where the equal- or value-weighted SPREAD is used as the dependent variable. Panel B presents the regression results where the equal- or value-weighted SLOPE is used as the dependent variable. The explanatory variable is the dispersion in present value of growth options (PVGO), and the control variables include the idiosyncratic stock return volatility (IRISK), dollar trading volume scaled by total market capitalization (DVOL), and permission for equity short-sale (SHORT), number of newly listed equities (NIPO) and volatility premium (PVOL). The t-statistics reported in parentheses are computed using two-way clustered standard errors by country and year. Year fixed effects are included. Statistical significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *, respectively.

Table 15: PE vs. limits-to-arbitrage and sentiments

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Panel A: EWSPREAD as dependent variable						
PE	0.025**	0.020**	0.028***	0.025**	0.029***	0.025**
	(2.404)	(2.144)	(3.271)	(2.550)	(2.760)	(2.258)
SHORT	0.240					0.496
	(1.080)					(1.346)
IRISK		0.132				0.155
		(0.933)				(1.106)
DVOL			0.062			0.026
			(1.526)			(0.671)
NIPO				-0.017		-0.508
				(-0.012)		(-0.226)
PVOL					-0.058	-0.221
					(-0.494)	(-1.397)
Intercept	1.765**	0.463	-1.266***	-0.521	-0.928***	-0.596
	(2.149)	(1.316)	(-12.447)	(-0.826)	(-6.456)	(-1.039)
Obs	2839	2456	2358	2704	3031	2160
R^2	0.058	0.060	0.063	0.060	0.052	0.058
Panel B: VWSPREAD as dependent variable						
PE	0.023**	0.024**	0.027**	0.022**	0.028***	0.032**
	(2.397)	(2.239)	(2.091)	(2.362)	(2.641)	(2.200)
SHORT	-0.185*					0.150
	(-1.654)					(0.529)
IRISK		0.209**				0.191
		(2.195)				(1.630)
DVOL			-0.003			0.014
			(-0.076)			(0.334)
NIPO				0.420		1.866
				(0.419)		(1.081)
PVOL					0.034	-0.053
					(0.192)	(-0.286)
Intercept	1.551***	-0.148	-0.331	-0.577	-0.916***	-1.071
	(2.754)	(.)	(-1.614)	(-1.205)	(-6.103)	(-1.295)
Obs	2839	2459	2356	2698	3027	2158
R^2	0.054	0.061	0.061	0.057	0.051	0.062
Panel C: EWSLOPE as dependent variable						
PE	0.061	0.054	0.081	0.072*	0.074*	0.055
	(1.535)	(1.134)	(1.513)	(1.863)	(1.808)	(0.853)
SHORT	2.454*					4.708**
	(1.803)					(2.362)
IRISK		0.316				0.576*
		(0.885)				(1.868)

DVOL			0.194			-0.117
			(0.994)			(-0.464)
NIPO				4.501		0.889
				(0.712)		(0.147)
PVOL					0.167	-0.670
					(0.272)	(-1.166)
Intercept	4.992	-6.948***	1.945***	-1.966	-2.891***	-4.902***
	(.)	(-8.908)	(3.194)	(-1.226)	(-4.755)	(-3.687)
Obs	2780	2406	2312	2649	2959	2110
R^2	0.032	0.030	0.034	0.031	0.030	0.039
Panel D: VWSLOPE as dependent variable						
PE	-0.057	-0.014	-0.004	-0.055	-0.033	-0.018
	(-0.776)	(-0.230)	(-0.065)	(-0.788)	(-0.410)	(-0.242)
SHORT	3.394*					4.876***
	(1.887)					(3.411)
IRISK		-0.680				-0.389
		(-0.729)				(-0.550)
DVOL			0.436			0.112
			(1.367)			(0.417)
NIPO				-10.096		2.679
				(-1.224)		(0.385)
PVOL					0.140	-0.643
					(0.151)	(-0.612)
Intercept	-4.477	-1.068	-0.604	-0.645	1.379	-2.929
	(-1.186)	(-0.377)	(-0.183)	(-0.202)	(1.293)	(-0.417)
Obs	2781	2406	2311	2653	2961	2108
R^2	0.007	0.006	0.007	0.007	0.005	0.010

This table reports the results of panel regressions which examine the relation between the dispersion in growth option value and the R&D effect on stock returns, after controlling for limist-to-arbitrage and investor sentiment. The dependent variables are the monthly equal- and value-weighted spread (SPREAD) and slope (SLOPE). SPREAD is the equal-weighted or value-weighted average of the monthly return difference between the top and bottom RD/BE quintile, where their returns are cumulated from July of year t to June of year $t+1$. The value-weighting of SPREAD is based on firms' market capitalizations in June of year t. SLOPE is given by regressing buy-and-hold stock returns from July of year t to June of year $t+1$ on the RD/BE measured over year $t-1$. The regressions are either equal-weighted or value-weighted. The value-weighted version of SLOPE is based on weighted-least-squares regressions, where the weights are proportional to market capitalizations in June of year t. Panel A reports the regression results where the equal- or value-weighted SPREAD is used as the dependent variable. Panel B presents the regression results where the equal- or value-weighted SLOPE is used as the dependent variable. The explanatory variable is the dispersion in price-to-dividend ratios (PE), and the control variables include the idiosyncratic stock return volatility (IRISK), dollar trading volume scaled by total market capitalization (DVOL), and permission for equity short-sale (SHORT), number of newly listed equities (NIPO) and volatility premium (PVOL). The t-statistics reported in parentheses are computed using two-way clustered standard errors by country and year. Year fixed effects are included. Statistical significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *, respectively.