Corporate Cash Holdings in the Cross–Section of Stock Returns: The Role of Corporate Innovation

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Abstract

This paper studies how innovation affects the positive relation between cash holdings and cross–sectional returns. In doing so, we provide new insights into the link between firms' spending on Research and Development (R&D) and stock returns. Both cash–rich and innovative firms have higher productivity and enjoy lower cost of capital. The cash spread is almost exclusively present amongst firms which incur R&D spending. Both the cash and R&D spreads have strengthened since 1996 as the cash holdings level has been soaring, and innovation has become more sophisticated. Of several cash holding determinants, R&D is the only one that renders the relation between cash holdings and stock returns insignificant. We provide early evidence on how several contemporary production–based theories struggle to explain both the cash and R&D spreads. Both appear to be attributable to mispricing due to investors failing to appreciate the future benefits of corporate innovation.

Keywords: Cash holdings, Research and Development (R&D), mispricing, risk factor
JEL classification: G11, G12, G14

1. Introduction

Optimum corporate cash holdings facilitate several functions, such as giving firms the flexibility needed to face with uncertainty in their environment and avoiding inefficient liquidation of their assets. Several factors have been documented to affect the cross–sectional differences in corporate cash holdings. Examples include research and development (R&D) expenditures (Brown and Petersen, 2011), default risk (Acharya, Davydenko, and Strebulaev, 2012), product market competition (Haushalter, Klasa, and Maxwell, 2007), and refinancing risk (Harford, Klasa, and Maxwell, 2014). [1] Also, the cash holdings level have increased over

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[1]Fritz Foley, Hartzell, Titman, and Twite (2007) argue that corporate cash holdings reflect firms' decision to avoid paying repatriation tax on their profits from overseas operations. However, Pinkowitz, Stulz, and

the past decades. Bates, Kahle, and Stulz (2009) report that the cash–to–asset ratio of U.S. firms more than double between 1980 and 2006.

Of several cash holdings determinants, R&D intensity appears to be a critical one given its ability to account for both the cross–sectional and the time–series patterns of cash holdings. Bates et al. (2009) show that firms with higher R&D expenditures hold more cash due to their riskier cash flows.[2] There is also evidence that corporate cash holdings are concentrated in industries with high R&D intensity. Booth and Zhou (2013) document that the increase in cash holdings is not pervasive across the economy but concentrated in the high–tech firms. Deloitte's global survey (Macmillan, Prakash, and Shoult, 2014) finds that 81% of corporate cash holdings are held by 32% of firms around the world, and this concentration happens within the R&D intensive sectors (i.e. technologies, media, and telecommunications). Begenau and Palazzo (2016) suggest that the sharp increase in U.S. corporate cash holdings is due to the increasing number of R&D intensive firms with high cash holdings gradually replacing traditional public firms.

While the trend and motives of corporate cash holdings are well documented, there is an emerging line of research on the impact of corporate cash holdings on cross–sectional stock returns. Palazzo (2012) documents that the stocks of cash–rich firms are traded at a premium. He attributes the positive spread between the stock returns of cash–rich and cash–poor firms to their systematic risk differential. Specifically, as a precautionary measure, risky firms choose to hold more cash to finance the exercise of their growth options; hence, investors require higher returns to hold their stocks. Along these lines, Simutin (2010) finds that firms holding excess cash are riskier as they have a higher market beta, perform worse during market downturns, and possess risky growth options.

Motivated by the role of R&D to corporate cash holdings, this paper investigates whether and how R&D intensity could explain the positive cash spread (hereinafter interchangeably

Williamson (2012) show that the tax treatment of profit repatriation is not accountable for the high corporate cash holdings among the U.S. firms.

[2] On the basis that R&D intensive firms have risky cash flows, the association between R&D intensity and cash holdings is also consistent with the finding in Opler, Pinkowitz, Stulz, and Williamson (1999) that firms with riskier cash flows choose to hold more cash.

referred to as the cash puzzle) documented in Palazzo (2012). Our analysis taps into the line of research on the positive relation between R&D and stock returns (*i.e.* the R&D puzzle).[3] We show that R&D is crucial to the cash puzzle in a sample of non–financial, non–utilities firms listed on the three main U.S. stock exchanges (NYSE, AMEX, and NASDAQ) between 1975 and 2012. R&D active firms (*i.e.* those incurring R&D spending) account for about a half of our sample. While the cash spread is positive and significant in the subsample of R&D active firms, it is almost nonexistent in the R&D inactive subsample. Both the cash and R&D spreads have become more pronounced since July 1996 compared to the earlier period. In bivariate portfolio sorting analysis, the R&D spread subsumes the cash spread. In Fama and MacBeth (1973) cross–sectional regressions of excess stock returns on firm characteristics, R&D eliminates the significance of cash holdings whereas the other cash holding determinants (*i.e.* default risk, predator risk and refinancing risk) fail to do so.

Despite the proliferation of several risk-based contemporary models aiming at explaining the R&D puzzle, we find no support for how they could resolve either the cash or the R&D puzzle. The results are consistent with the mispricing channel in which investors underestimate the future benefits of corporate innovation. Both the cash and R&D spreads are significantly more pronounced amongst firms which are underpriced relative to the average industry valuation. Quasi–index investor ownership, which unambiguously indicates more transparent information relevant to firms' long–run performance (Bushee and Noe, 2000, D'Souza, Ramesh, and Shen, 2010), weakens the positive relation with stock returns of both cash holdings and R&D. Cash–rich and innovative firms enjoy greater productivity and lower implied cost of equity capital. The pattern is consistent with the view in Imrohoroglu and Tuzel (2014) whereby productivity provides a hedge against aggregate productivity shocks. Our mispricing channel suggests that as investors fail to account for future benefits of the innovation process fully, their earnings forecasts might be underestimated. The stock valuation of cash–rich innovative firms would be too small, leading to subsequent positive returns even when the correct discount rate is applied.

[3] The R&D puzzle implies a positive R&D spread between the stock returns of firms with high and low R&D spending (see, for example, Chan, Lakonishok, and Sougiannis (2001)).

Our study contributes to the literature in three different ways. First, we propose and test a new explanation based on corporate R&D spending for the cash puzzle. Second, our analysis provides early evidence on how several contemporary production–based theories aiming at explaining the R&D puzzle struggle to explain both the cash and R&D puzzles. Finally, we highlight the interrelation amongst cash holdings, R&D, productivity, risks, and cross-sectional stock returns. We offer an explanation for the apparently puzzling pattern where despite having high productivity which lowers their systematic risks and cost of capital, cash–rich and innovative firms generate higher subsequent stock returns.

2. Hypothesiss Development

The literature has long acknowledged the difficulties faced by R&D intensive firms in securing external financing due to (i) high agency costs and moral hazard as a result of information asymmetry surrounding R&D activities, (ii) the inherent uncertainty in their cash flows, and (iii) a lack of collateral capacity.[4] Furthermore, the benefits (if any) from corporate innovation in the more distant future are likely to accrue to shareholders due to their long–term view and the asymmetric payoffs between debtholders and shareholders. Hence, R&D tends to be financed by shareholders using internally generated cash flows and equity issuance. As share issuance is costly and time-consuming, those firms involving in innovative activities might end up hoarding a significant amount of cash for precaution.

Academic studies (Bates et al., 2009, Booth and Zhou, 2013) as well as professional surveys (Macmillan et al., 2014) document that R&D intensive firms hold more cash than others. The accumulated cash holdings may allow them to smooth their R&D activities (Brown and Petersen, 2011). Falato, Kadyrzhanova, and Sim (2014) advocate that the increasing reliance on intangible capital and the difficulty in using intangible capital as collateral in debt financing drive the recent rise in U.S. corporate cash holdings. Begenau and Palazzo (2016) further suggest that this trend is attributable to the increasing number of R&D active firms with high cash holdings entering the stock market.

[4]Several authors including Myers (1984); Hall (1992, 2002), Lerner and Hall (2010) have studied the financial frictions faced by R&D intensive firms.

Given that R&D is a crucial factor in determining the corporate cash holdings level in both the cross–section and time–series, corporate innovation could provide new insights into the positive relation between cash holdings and future stock returns. R&D intensity itself has been found to be positively associated with future cross-sectional stock returns.[5] This phenomenon may manifest itself into the relation between cash holdings and stock returns documented in Palazzo (2012) if firms build their cash reserves to participate in the innovation process. Hence, our first hypothesis (H_1) maintains that *"Corporate R&D spending drives the positive relation between corporate cash holdings and future stock returns."*

Conditional on hypothesis H_1, the cash puzzle may reflect the nature of the R&D puzzle. As such, several models in production–based asset pricing aiming at explaining the R&D puzzle could potentially account for both puzzles. First, the Schumpeterian view suggests that the corporate innovation process, of which R&D spending is the primary input, fuels growth through improving the productivity and quality of the intermediate goods used in producing final goods (Aghion, Akcigit, and Howitt, 2013). Imrohoroglu and Tuzel (2014) document a negative relation between firm-level productivity and future stock returns, courtesy of the ability to shelter aggregate shocks of firms with high productivity. Firms involving in R&D and enjoying higher productivity may also be protected, implying a negative relation between R&D and future returns. Alternatively, Kung and Schmid (2015) find that corporate innovation drives a small but persistent component of productivity that generates long-run uncertainty about future economic growth. Fearing that a prolonged downturn in economic growth may occur at the time of low asset valuations, investors exposed to the risks arising from long-run economic growth uncertainty may require a premium.[6] To this end, higher R&D implies greater long–run productivity risks and triggers investors' demand for lower equity prices and higher equity risk premium.

Lin (2012) suggests another view on how the relation between R&D and systematic risks could arise endogenously. As R&D increases the marginal benefit of physical investment while also decreases its marginal cost, R&D positively covaries with expected physical investment

[5] See, for example, Lev and Sougiannis (1996), Chan et al. (2001), Eberhart, Maxwell, and Siddique (2004).

[6] Kung and Schmid (2015) argue that the long-run productivity risks consist of both long-run consumption risks in the spirit of Bansal and Yaron (2004) and long-run cash flow risks.

returns. Physical capital often dominates R&D in output production. Hence, physical investment returns outweigh R&D investment returns in affecting expected stock returns, making R&D investment positively covary with expected stock returns. Lin's model further suggests that when the innovation process is less devoted to new product innovation and more to productivity improvement, which is embodied in new physical capital investment, the positive association between R&D and future stock returns is more pronounced.

Different from Kung and Schmid (2015) and Lin (2012), other contemporary theories allow technology to arrive exogenously. Motivated by the concept of creative destruction in the Schumpeterian view on growth, Kogan and Papanikolaou (2014) show that firms undertaking innovation expose themselves to the investment-specific technology (IST) shock embodied in the new capital.[7] They further document that, among other characteristics, firms with higher exposure to IST shocks hold more cash and invest more in both physical capital and R&D. Kogan and Papanikolaou (2014) document a negative IST premium, implies that cash–rich and R&D intensive firms should trade at a discount. However, Garlappi and Song (2016) show that, depending on the IST proxy and the period, the IST premium could be positive. Hence, whether exposure to the IST shock could account for both the cash and R&D spreads is an empirical question.

Another view is that R&D generates not only current but future growth options. Recent studies show that R&D success has become more path-dependent. Kumar and Li (2016) also suggest that R&D activities create not only the growth options readily exercisable, but also the innovative capacity to develop future innovation. Hence, when firms hoard cash to finance their R&D, their market performance risk profile is affected by both current and future growth options. According to Cooper and Priestley (2011), a firm's riskiness is higher right before the exercise of current growth options and lower right after. This tendency suggests that the higher risks and returns of cash-rich firms could be due to the higher concentration of their risky growth options waiting to be exercised. This view is in line with Simutin (2010) on cash financing of growth options in explaining the positive relation between excess cash holdings and future stock returns.

[7] Creative destruction refers to the replacement of old technologies due to innovation (Aghion et al., 2013).

Collectively, several contemporary production-based theories suggest that the R&D puzzle may arise through a risk-based channel, which is attributable to several features of the corporate innovation process, including the exposure to long-run productivity risks and investment-specific technological shocks, productivity improvement, and the accumulation of growth options. Hence, conditional on hypothesis H_1, we expect these factors to also explain the cash puzzle, leading to our second hypothesis (H_2) that *"The positive relation between corporate cash holdings and future stock returns is driven by the higher productivity of R&D intensive firms, their accumulation of growth options, and the exposure to innovation-induced risks."*

As an alternative to a risk-based channel, R&D activities are uncertain by nature and could be potentially mispriced. The difficulty in valuing the distant growth options generated from current R&D may result in mispricing.[8] Chan et al. (2001) suggest that relative to physical investments, R&D investments are harder to value, and underpricing may arise if investors use the standard valuation multiples without fully accounting for the long-term benefits of these investments. Evidenced for investor underreaction, Huberman and Regev (2001) report a case-study where investors are excessively slow in incorporating news about R&D findings into the stock price. Investors are also found to fail to account for information about innovation efficiency into the stock price (Cohen, Diether, and Malloy, 2013).

Underpricing of R&D implies a positive relation between R&D and future stock returns as market correction occurs. As such, underpricing could potentially explain the cash puzzle given that firms tend to hoard cash for R&D spending. We argue that the magnitude of the cash spread depends on the extent to which investors are ignorant of the future benefits of R&D, *ceteris paribus*.[9] We hypothesize our final proposition (H_3) that *"The positive relation between corporate cash holdings and future stock returns is driven by the underpricing of R&D intensive firms."*

[8]The lack of uniform accounting practices in the reporting of R&D also introduces substantial information asymmetry, providing grounds for incorrect valuation of R&D.

[9]As mispricing may depend on several other factors, we do not require firms to be underpriced in absolute term. The proposition here is whether investors miss out the future benefits of R&D in their valuation model, making firms relatively underpriced.

3. Variables and Data

3.1. Measurement of Variables

Following Palazzo (2012), we measure cash holdings ($CASH$) as the ratio of cash and cash-equivalent (*i.e.* short term investments) to total assets. We measure R&D by the ratio of annual research and development expenditures to sales. This variable (RD) reflects both the intensity of the R&D activities (*i.e.* the size adjusted annual R&D spending) and to a certain extent, the efficiency of these activities (*i.e.* how much firms spend on R&D to generate $1 of sales). Firms with no data on R&D spending for a particular year are assumed to incur no such expenditure in that year.[10] Productivity, an important ultimate output of the corporate innovation process, is measured by the firm-level productivity variable (TFP) constructed in Imrohoroglu and Tuzel (2014).[11]

Apart from RD, we also report several other sources and uses of cash holdings. Physical investment is measured by (a) WC, *i.e.* the ratio of working capital (net of cash and cash-equivalent) to total assets, and (b) CPX, *i.e.* the ratio of capital expenditure scaled by total assets. Internally generated cash is measured by GPA, which is the ratio of gross profitability to total assets. We use the composite share issuance measure (SEO) from Daniel and Titman (2006), calculated as the difference between the annual growth rate in market capitalization and the annual stock return. SEO captures any action that trades firm ownership for cash (*i.e.* actual equity issuance or share repurchases) or services (*i.e.* the exercise of employee stock options). Finally, dividend distribution ($PAYOUT$) is measured by the ratio of common and preferred dividends to operating income before depreciation.

Other than RD, several other cash holding determinants may affect cross–sectional returns and hence may compete against R&D in explaining the cash puzzle. Acharya et al. (2012) document a positive relation between corporate cash holdings and loan prices and suggest that this association is due to firms with high default risk holding more cash to avoid

[10]While several studies use patents–related variables (*i.e.* the output of the innovation process), our RD measure is focused on the inputs to the corporate innovation process given that cash reserves are used to finance R&D spending necessary for the process to occur.

[11]Our proxy TFP is the antilogarithm of the productivity variable available from Selela Tuzel's website at http://www-bcf.usc.edu/ tuzel/. We thank Selale Tuzel for making this data available.

the costs associated with going bankrupt. Vassalou and Xing (2004) document that distance-to-default (DD), a forward-looking default proxy estimated from Merton (1974) real–option model, is positively related to cross-sectional returns and hence a likely contender to explain the cash puzzle. DD describes how many standard deviations the logarithm of this measure deviates from its mean before default occurs.

Predator risk is also a potential contender capable of explaining the cash puzzle. Firms facing predator risk tend to hold more cash for precaution (Haushalter et al., 2007). Moreover, Hou and Robinson (2006) document a positive relation between a predator risk proxy, *i.e.* the Herfindahl index constructed from Compustat, and cross-sectional returns. To give predator risk the highest chance against R&D in explaining the cash puzzle, we use the Herfindahl index (HHI) from Hou and Robinson (2006). A small value of HHI indicates that the firm operates in a competitive industry and faces high predator risk.

Finally, Harford et al. (2014) suggest that firms facing greater refinancing risk might choose to build their cash reserves. To the extent that refinancing risk may not allow firms to invest in all their desirable investment projects, this risk could represent an aspect of financial constraints.[12] However, Denis and Sibilkov (2010) highlight that financially constrained firms do not necessarily hold more cash.[13] Hence, although Li (2011) suggests that financial constraints might drive the R&D puzzle, we employ the refinancing risk proxy (REF) from Harford et al. (2014). REF is measured by the sum of long-term debts due in the second and third year to total long-term debt (including the portion due within one year).

Information about firms' long-term growth and mispricing is extracted from Market-to-Book ratio (MB). We measure MB as the sum of the book value of common equity and balance sheet deferred tax scaled by market capitalization (MV) measured at fiscal year

[12]Financial constraints are defined as "... frictions that prevent the firm from funding all desirable investment. This inability to fund investment might be due to credit constraints or inability to borrow, inability to issue equity, dependence on bank loans, or illiquidity of assets."(Lamont, Polk, and Sa-Requejo, 2001, p.529). In comparison, Froot, Scharfstein, and Stein (1993) define refinancing risk as the risk of facing higher interest rates due to changes in market conditions or capital market frictions when firms need to refinance their debts.

[13]While financially constrained firms tend to hold more cash, some maintain a modest level of cash holdings due to their spending on physical investments while failing to raise sufficient external finance.

end. We then decompose MB to obtain its growth and mispricing components following the method introduced by RhodesKropf, Robinson, and Viswanathan (2005) (hereinafter referred to as RKRV) as in equation 1:

$$m - b = (m - v) + (v - b) \tag{1}$$

where m, b, and v are the natural logarithm of market value, book value, and fundamental value, respectively. The market value m and book value b are both observable. The fundamental value v of firm i in industry j in year t is unobservable and is estimated using a function of firm-specific accounting information $\theta_{i,t}$, a vector of industry average contemporaneous accounting variables $\alpha_{j,t}$, and a vector of long-run industry average accounting variables α_j. The decomposition of MB in equation 1 could then be expressed as follows:

$$m_{i,t} - b_{i,t} = [m_{i,t} - v(\theta_{i,t}, \alpha_{j,t})] + [v(\theta_{i,t}, \alpha_{j,t}) - v(\theta_{i,t}, \alpha_j)] + [v(\theta_{i,t}, \alpha_j) - b_{i,t}] \tag{2}$$

Following RhodesKropf et al. (2005), firm-level mispricing ($FMIS$) is measured by the first term $[m_{i,t} - v(\theta_{i,t}, \alpha_{j,t})]$, *i.e.* the difference in the market value and the intrinsic value implied by the firm- and industry-specific information at time t. Industry-level mispricing ($IMIS$) is measured by the second term $[v(\theta_{i,t}, \alpha_{j,t})] - [v(\theta_{i,t}, \alpha_j)]$, *i.e.* the difference between the firm-level intrinsic value at time t and the valuation implied by industry-specific information that does not vary over time. The third term $[v(\theta_{i,t}, \alpha_j) - b_{i,t}]$ is the difference between the intrinsic value implied by the long-run industry average multiples and book value, which reflects the growth component ($GROWTH$) of MB.

The RKRV approach outlined in their equation 15 (p.577) is employed to estimate the values of $v(\theta_{i,t}, \alpha_{j,t})$ and $v(\theta_{i,t}, \alpha_j)$. In doing so, we estimate equation 3 for each year in the sample separately for the 12 industry groups categorized by Fama and French (1996).[14]

$$m_{i,t} = \alpha_{0j,t} + \alpha_{1j,t} b_{i,t} + \alpha_{2j,t} ln(NI)^+_{i,t} + \alpha_{3j,t} I_{(<0)} ln(NI)^+_{i,t} + \alpha_{4j,t} LEV_{i,t} + \epsilon_{i,t} \tag{3}$$

where $NI^+_{i,t}$ is the absolute value of the net income of firm i during year t. $I_{(<0)}$ is the indicator when the net income is negative. $LEV_{i,t}$ is the financial leverage ratio of firm i

[14] We thank Kenneth French for making the industry classification available at http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data library.html

in year t, measured as $1 - \frac{Book\ Value\ of\ Equity}{Total\ Assets}$. The fitted value from the regression equation 3 measures the estimate of $v(\theta_{i,t}), \alpha_{j,t})$, which is the time varying firm-level intrinsic value. Hence, firm-level mispricing (*FMIS*) is the error term from the regression equation 3. The estimate of $v(\theta_{i,t}, \alpha_j)$ is the "fitted value" from the cross-sectional regression equation 3 using the time series average of the estimated coefficients. Subtracting the book value from this "fitted value" results in the deviation of the book value from the long-term intrinsic value, which is the proxy for firm growth ($GROWTH$). The industry-level mispricing ($IMIS$) is the final component of the natural logarithm of MB after subtracting firm-level mispricing ($FMIS$) and firm growth ($GROWTH$).

3.2. Data and Summary Statistics

The sample includes NYSE, AMEX, NASDAQ listed firms in the merged CRSP and annual Compustat database. We exclude financial (SIC code 6000-6999) and utilities (SIC code 4900-4999) firms.[15] Only firms with ordinary common equity (securities type 10 and 11 in CRSP) are included. Firm–year observations are required to have non–negative book value of equity, non–negative cash balances, positive sales, and a stock price of $5 and above. The sample starts from 1975 as the new accounting treatment of R&D spending (Financial Accounting Standard Board Statement No. 2) came into effect in that year. We map the accounting data at the end of fiscal year $t-1$ with stock market data from July year t to June year $t+1$. The accounting data end in the fiscal year 2011, although we use the accounting data from the fiscal year 1973 until the fiscal year 2014 to investigate physical investment of the firms in our sample up to three years before and after the portfolio formation date (see Figure 1). The monthly stock returns from CRSP are from July 1976 to December 2012. Overall, our sample covers 977,054 firm–month observations and 10,275 firms.

Table 1 Panel A reports the summary statistics of the key variables in our sample. An average firm holds 15.6% of its assets in cash. The standard deviation of 18% suggests a high variation in the cash holdings level amongst firms. About half of the firms in the sample are R&D active (*i.e.* defined as those with non–zero *RD*), resulting in the median *RD* of

[15]Financial firms are excluded as they have different asset structures. Utilities firms are excluded as several aspects of their firms, including investment and financing, are closely regulated.

close to zero.[16] The market capitalization is on average about 2.7 times the book value of equity. While MB and its mispricing components ($FMIS$ and $IMIS$) are relatively skewed, the growth components ($GROWTH$) does not exhibit much skewness. An average firm invests 14% of its total assets on working capital and 7% on capital expenditure. Its annual gross profit amounts to 40% of total assets while less than 10% of its operating profit before depreciation is distributed in the form of dividends. Each year, about 1.8% of its outstanding shares net of repurchases and exercised employee stock options are newly issued. Firm-level productivity (TFP), distance–to–default (DD) and industry concentration (HHI) are relatively symmetrically distributed. About nearly a quarter of long–term debts is due in the next two to three years, suggesting that firms tend to have low refinancing risk.

Table 1 about here

Given our focus on the role of R&D and the relatively even split between R&D active and inactive firms in the sample, we report the correlation matrices of the firm characteristics separately for these two subsets of firms. Table 1 Panel B (C) indicates the time-series average of the cross-sectional Spearman correlations of the key firm–level variables in the subsample of R&D active (inactive) firms. In Panel B, $CASH$ has the highest correlation with RD (0.41), followed by MB (0.28). The correlation with RD is consistent with the view that firms build their cash reserves to finance their R&D. The comovement between $CASH$ and MB is attributable to the former's correlation with the growth component ($GROWTH$) and the firm-level mispricing component ($FMIS$). Industry-level mispricing ($IMIS$) barely correlates with $CASH$, suggesting that the hot–cold industry cycle is independent of corporate cash holding policies. In the absence of R&D (Panel C), MB has the highest correlation with $CASH$, and this correlation is also attributable to $GROWTH$ and $FMIS$.

Unlike R&D, physical investment (both WC and CPX) are negatively correlated with $CASH$ in both Panels B and C. This association might be owing to the capacity of physical investment as collateral in financing contracts, reducing the firm's need to build its cash reserves. Denis and Sibilkov (2010) also suggest that certain financially constrained firms may have a modest level of cash as they deplete their cash reserve in physical investment while

[16] Out of 977,054 firm–month observations, 477,843 observations have non–zero R&D expenditures.

failing to sufficiently raise cash from external sources.[17] Profitability positively correlates with RD in Panel B and with $CASH$ in both Panels B and C. Seasoned equity issuance only marginally varies with the cash reserves in the R&D active firms while playing a negligible role when firms are not R&D active. The dividend distribution behaviors of R&D active and inactive firms are in stark contrast. The correlation between $PAYOUT$ and $CASH$ is negative (-0.21) in Panel B while it is economically negligible in Panel C. $PAYOUT$ is also negatively related to RD in Panel B, suggesting that R&D active firms choose to retain their cash reserves over distribution.

Being an important output of the innovation process, not surprisingly productivity is positively correlated with both $CASH$ and RD in R&D active firms while its correlation with $CASH$ is much lower in R&D inactive firms. Predator risk appears to be important to innovative firms' cash holdings, given the relatively high correlation of HHI with both $CASH$ and RD in Panel B and a negligible correlation with $CASH$ in Panel C. Default risk and refinancing risks do not exhibit any economically meaningful relationship with $CASH$ and RD in both Panels B and C. Overall, out of several determinants of corporate cash holdings, R&D spending appears to be the most influential factor. R&D also affects how firms invest and finance their investments, consistent with the classic views in the corporate finance literature.

4. Characteristics of and Returns to the *CASH* sorted Portfolios

4.1. Characteristics of the CASH sorted Portfolios

As a precursor to our main analysis, we investigate how the characteristics of $CASH$ sorted portfolios of R&D active firms differ from those in R&D inactive firms. Within each subsample, stocks are first ranked into deciles by $CASH$ measured at fiscal year end of year $t-1$ starting from the fiscal year 1975. Equally weighted portfolios are held from July year t to June year $t+1$. A hedge portfolio $(H-L)$ that goes long in the top $CASH$ decile and short in the bottom $CASH$ decile is also formed. This process continues until December 2012 is the last holding month, and 2011 is the last fiscal year when accounting data are used

[17] We further investigate the behavior of cash-rich and cash-poor firms in Table 2

to construct $CASH$ and form the $CASH$ deciles. Table 2 reports the time series average of the cross-sectional mean value of several firm characteristics of the $CASH$ deciles formed in each set of firms.

By construction, $CASH$ increases from the bottom decile to the top decile in both Panels A and B. R&D active firms tend to hold more cash than R&D inactive firms. In the top $CASH$ decile, R&D active (inactive) firms on average hold 64% (43%) of their total assets in cash and cash-equivalent and drive the cash holdings gap between the extreme $CASH$ deciles. This gap is 1.5 times higher amongst the R&D inactive firms than amongst the R&D inactive firms. In the R&D active firms, this gap translates into an even bigger gap in R&D spending. The top $CASH$ decile firms spend on average twice their annual sales on R&D. This level of R&D expenditure is seven times higher than that of firms residing in the bottom $CASH$ decile.

Table 2 about here

On average, R&D active firms have higher MB than the R&D inactive firms. Furthermore, cash–rich firms tend to have higher MB than cash–poor firms. The MB gap between firms residing in the extreme $CASH$ deciles is bigger amongst the R&D active firms. Further, in both panels, cash–rich firms tend to spend less on physical investment. This trend persists during a window of three years around the portfolio formation year in the full sample (Figure 1). While GPA monotonically increases with $CASH$ amongst the R&D inactive firms, it follows a U-shape amongst the R&D active firms. Hence, profitability only helps R&D inactive firms to build their cash reserves.

Figure 1 about here

Equity issuance and dividend policy play a critical role in the accumulation of cash holdings of R&D active firms. Firms residing in the top (bottom) $CASH$ decile in Table 2 Panel A issue new shares worth about 6.7% (less than 1%) of their market capitalization each year. In comparison, cash–rich firms in Panel B issue less than their cash–poor counterparts. In the R&D inactive subsample, the payout ratio of firms in the top $CASH$ decile is nearly 7% higher than those in the bottom $CASH$ decile. This payout gap is about negative 3% in the R&D active subsample. Consistent with the correlation pattern documented in Table 1, R&D active firms rely on equity issuance and restraining dividend distribution to build their cash reserves. By contrast, R&D inactive firms accumulate cash through profitability, which allows them to issue less equity and distribute more dividends.

Cash reserves appear to provide a reliable financial health indicator for R&D inactive firms as the more cash an average R&D inactive firm holds, the more distant the firm is from the default triggering point. By contrast, amongst the R&D active firms, those residing in the top $CASH$ decile are the most likely to default. The cash–rich firms in this subsample might hoard cash partially for precaution against their heightened default risk, consistent with Acharya et al. (2012). R&D active firms might also build their cash reserves and be involved in the innovation activities in response to predator risk. In Table 2 Panel A, the HHI index in the top $CASH$ decile is about 0.07, 30% lower than that in the bottom $CASH$ decile. No such deviation is present in Panel B. We also observe that cash–rich firms in the R&D active subsample appear to face a slightly higher risk of refinancing, whereas no such difference prevails amongst the R&D inactive firms.

To sum up, the results from Table 2 suggest that the R&D active and inactive firms are austerely different in the way firms accumulate and spend their cash (*i.e.* the overall corporate liquidity management policy). Default risk, predator risk, and refinancing risk appear to influence the cash-hoarding behavior of R&D active firms.

4.2. Returns to the $CASH$ Sorted Portfolios

Table 3 delineates the average monthly returns to the equally weighted $CASH$ deciles and the hedge portfolio ($H - L$). In the full sample (Panel A), the average raw return to the $CASH$ sorted deciles increases from the bottom to the top $CASH$ decile. The hedge portfolio generates an average monthly raw return (*i.e.* the cash spread) of 0.62% (t=1.88). The characteristics–adjusted cash spread following Daniel, Grinblatt, Titman, and Wermers (1997) (hereinafter referred to as DGTW returns) becomes 0.74% per month (t=3.18). Using the Carhart (1997) factor model to adjust returns for risks, the Carhart alpha of the long–short portfolio is 0.88% (t=4.03).

Figure 1 illustrates that cash–poor (rich) firms consistently invest more (less) heavily on physical capital during a window of seven years centered around the portfolio formation year. Hence, the low cash holdings in cash-poor firms might be the consequence of their excessive investment over a prolonged period. Given the persistently excessive investment by cash-poor firms, the negative relation between different types of firms' physical investment and stock returns (see, for example, Cooper, Gulen, and Schill (2008)) may manifest itself into a positive association between corporate cash holdings and stock returns. Hence, we use the contemporary investment-based factor model of Fama and French (2016) (hereinafter referred to as FF5 alpha). Interestingly, the FF5 alpha of the hedge portfolio ($H-L$) is nearly 1.40% per month(t=6.56), almost double the magnitude of the characteristics-adjusted return and the Carhart alpha.

Table 3 about here

Since R&D active and inactive firms differ in several aspects central to the overall corporate liquidity management policy (sections 3.2 and 4.1), we report the cash spread separately for R&D active and inactive firms in Table 3 Panels B and C, respectively. We split the sample into R&D active and inactive subsamples before repeating the univariate sorting procedure within each subsample. Amongst the R&D inactive firms (Panel C), the monthly cash spread in raw returns, DGTW returns, and Carhart alpha is insignificant. By contrast, the spread is positive, economically meaningful and statistically significant amongst the innovative firms (Panel B). In raw returns (DGTW returns) (Carhart alpha), the average monthly cash spread is 0.66% (0.81%) (0.90%) with the t-statistics of 1.82 (3.06) (3.58). In FF5 alpha, the cash spread is statistically significant amongst the R&D inactive firms (0.30%, t=2.27), but its magnitude is about a fifth of the spread amongst the R&D active firms (1.51%, t=6.11).

In summary, we document a positive cash spread exists in our sample. In other words, the stocks of cash–rich firms are traded at a premium, consistent with Palazzo (2012). Moreover, the cash spread exists almost exclusively amongst firms actively involved in the innovation process. Section 4.2 below further investigates how R&D and corporate cash holdings intertwine in cross–sectional returns.

5. The Intertwine of *RD* and *CASH* in Cross–Sectional Returns

This section investigates the intertwining of the well–documented R&D puzzle and the recently documented cash puzzle. Our attempt to draw the connection between these two phenomena is motivated by the dual role of R&D to be (i) a key determinant of corporate cash holdings in corporate finance and (b) associated with stock returns in the cross–section in asset pricing. Other firm characteristics, including default risk, predator risk, and refinancing risk, also potentially satisfy both of these conditions and hence are the competing candidates to R&D in explaining the cash puzzle. The choice and construction of these variables are detailed in section 3.1.

We run a "horse-race" amongst R&D spending, default risk, predator risk and refinancing risk by employing Fama and MacBeth (1973) cross-sectional regressions at month t as described in equation 4 below:

$$R_{j,t} - r_{f,t} = \alpha_{0,t} + \alpha_{1,t} CASH_{j,t-1} + \alpha_{2,t} Firm_{j,t-1} + \sum_{i=1}^{5} \beta_{i,t} Controls_{i,j,t-1} + \epsilon_{j,t} \quad (4)$$

where $R_{j,t}$ is the month t return on stock j and $r_{f,t}$ is the risk–free rate in month t. All independent variables use data readily observable in month $t-1$. $CASH_{j,t-1}$ is the $CASH$ ratio calculated using the accounting data from the most recently available financial statements. For example, July-1976 risk–adjusted stock returns are regressed against variables available by June-1976. As it takes some time for accounting data to be verified and released to the public, $CASH$ is calculated using cash and cash–equivalent and total assets reported in the 1975 financials. This value is used as the independent variable $CASH_{j,t-1}$ in the monthly regressions until (and including) June-1977. The process is repeated for the regressions from July-1977 to June-1978 using the 1976 financials. $Firm_{j,t-1}$ represents the four firm characteristics (R&D, default risk, predator risk and refinancing risk) potential for explaining the cash puzzle. Due to the highly skewed distribution of RD in the full sample, we use the logarithmic transformation of RD (*i.e.* taking the natural logarithm of one plus RD, denoted as $logRD$).[18] $lnRD$, HHI and REF are measured at the same time with $CASH$ whereas DD is measured at month $t-1$.

Several firm characteristics are included as the control variables $Controls_{i,j,t-1}$ in equation 4. To control for the value/growth effect (Fama and French, 1996), we include $lnMB_{j,t-1}$, the natural logarithm of MB of firm j calculated using the accounting data from the most recently available financial statements.[19] The first $lnMB$ is constructed using book value

[18] Revisiting Table 1, RD has a mean of 0.17 and a median of 0.00

[19] The natural logarithm of MB is used due to its high degree of skewness documented in Table 1.

from the 1975 financials, scaled by the market value at 1975 fiscal year end. $lnMV_{j,t-1}$, the natural logarithm of market capitalization at the end of month $t-1$, help to control for the size effect (Banz, 1981). The previous one–month return ($REV_{j,t-1}$) and the cumulative return during the period of 11 months with at least 6 months' return data, ended in month $t-1$ ($MOM_{j,t-1}$) are employed to control for the short–term reversal (Jegadeesh, 1990) and medium–term momentum (Carhart, 1997), respectively. To control for the asset growth effect (Cooper et al., 2008), our final control variable is AG, *i.e.* total asset growth orthogonalized with $lnMB$ over the sample period.[20]

We restrict our full sample to the observations with sufficient data to construct all the variables in equation 4 and report the results in Table 4. In model A where only $CASH$ is included with the control variables (*i.e.* $\alpha_2 = 0$) in equation 4, $CASH$ is positively and significantly related to future returns ($1.01, t = 2.25$), evident for the cash puzzle in our sample. Models B to E impose $\alpha_1 = 0$ and include one of the characteristics $logRD$, DD, HHI or REF in equation 4. In model B, the $lnRD$ coefficient is positive and significant ($2.84, t = 2.76$), consistent with the R&D puzzle documented in several studies, including Lev and Sougiannis (1996), Chan et al. (2001), Cohen et al. (2013). In model C, the DD coefficient is negative and significant ($-0.05, t = -3.17$), suggesting a positive relation between default risk and stock returns as previously documented in Vassalou and Xing (2004). In both models D and E, the HHI and REF coefficients are both positive but insignificant, making them the less likely contenders to drive the cash puzzle.

In models F to I, both $CASH$ and each of the four firm characteristics are present in equation 4. Only in the presence of $logRD$ in model F does the $CASH$ coefficient becomes insignificant, suggesting that the positive association between stock returns and R&D subsumes that and cash holdings. Default risk does not drive the positive $CASH$ coefficient as it remains significant in model G. Since HHI and REF on their own are not significantly associated with stock returns, not surprisingly they are unable to eliminate the positive $CASH$ coefficient in models H and I. Finally, model J includes $CASH$ and all the four firm char-

[20] Orthogonalization is necessary given that both asset growth and MB share some overlapping information on firm growth.

acteristics. The insignificant $CASH$ coefficient is most likely to be attributable to $logRD$, given its patterns in models F to I. Hence, the key takeaway from Table 4 is that of the four characteristics are ex-ante potential contenders to explain the cash puzzle, R&D is the only factor that could consistently do so.

Table 4 about here

In untabulated results (available upon request), when R&D active stocks are independently sorted into quintiles by $CASH$ and RD measured at fiscal year end of year $t-1$ and held from July of year t to June of year $t+1$, the RD spread remains significant within each $CASH$ quintile. By contrast, in most cases, the $CASH$ spread becomes statistically or economically much less significant within each RD quintile. In comparing the time–series behavior of the cash and R&D spreads, we use the fiscal year 1995 as the cutoff point and split the sample into (a) July 1976 to June 1996 and (b) July 1996 to December 2012.[21] Our results (untabulated) show that the monthly average cash spread in the latter period dominates that in the former period.[22] Interestingly, the R&D spread also becomes more prominent in the post–1996 period, coinciding with the strengthening of the cash spread during the time of soaring cash holdings and more sophisticated innovation.[23] Overall, the results support hypothesis H_1 on the role of R&D in driving the positive relation between cash holdings and stock returns.

6. The Cash and R&D Puzzles - a Tale of Two Tales

The overwhelming evidence on the tight–knit relation between the R&D spending and cash holdings in their relation with stock returns in the cross–section documented in sections 4.2 and 5 suggests that innovative activities are central to both the R&D and cash puzzles. It

[21] Bates et al. (2009) document that the average U.S. corporate cash holdings level is higher in the 2000s than in the 1990s. Sanchez and Yurdagul (2013) report a soar in the level of corporate cash holdings around 1995 over the period from 1979–2011.

[22] For example, the monthly characteristics-adjusted $CASH$ spread is 1.06% (t=2.30) in the latter period while it is 0.48% (t=2.70) in the former period.

[23] In characteristics–adjusted returns, the R&D spreads in the pre- and post–1996 period are 0.90% (t=2.69) and 1.93% (t=2.83), respectively.

follows that the channels which could explain one puzzle could also explain the other. Tapping into the literature on the R&D puzzle, we examine various contemporary theories which may give rise to a risk-based explanation to both puzzles in section 6.1 before proceeding to a mispricing explanation in 6.2.

6.1. The Risk-Based Tale

6.1.1. Productivity and Innovation

We embark our analysis with verifying how productivity varies with corporate cash holdings given the Schumpeterian view that innovation improves productivity. Table 5 Panel A depicts the average firm–level productivity (TFP) of the $CASH$ sorted deciles. In the full sample (Panel A.1), TFP increases across the $CASH$ decile, which is entirely driven by R&D active firms. In the R&D active subsample (Panel A.2), the average TFP of the top $CASH$ decile is about 35% higher than that of the bottom $CASH$ decile. In comparison, there is no considerable variation in the average TFP of the $CASH$ deciles amongst the R&D inactive firms (Panel A.3). In Panel C, R&D active stocks are sorted into RD deciles in the same way that the $CASH$ deciles are formed. Not surprisingly, TFP shows an upward trend across the first nine RD deciles accompanied with a slight drop in the top RD decile.

Table 5 about here

In untabulated results, we also examine the average industry–level productivity ($iTFP$) of firms in the $CASH$ and RD sorted deciles.[24] Similar to the TFP pattern, $iTFP$ increases across the first nine $CASH$ and RD deciles amongst R&D active firms. The slight decrease in the productivity level in the top $CASH$ and RD deciles might be attributable to the focus on product innovation amongst the most innovative firms, which is unobservable from the data. Our result on the productivity pattern is consistent with the notion that cash–rich firms are actively involved in innovation, which fuels growth through improving the productivity and quality of the intermediate goods (Aghion et al., 2013).

Kung and Schmid (2015) suggest that a small and persistent component of productivity endogenously arising from innovative activities may expose firms to long–run productivity

[24] Data on industry-level productivity is available for manufacturing firms only and is accessed from http://www.nber.org/nberces/

risks which carry a positive premium. It follows that cash–rich firms might be exposed to long–run productivity risks, which explains for the premium at which their stocks are traded. To avoid the specification of the exact risk factors, we use the firm–level implied cost of capital backed out from stock prices prevailing at the end of June in year t and earnings forecasts using accounting data up to the fiscal year $t-1$.[25] We assign this average implied cost of capital to stocks from July of year t to June of year $t+1$ before updating it at the end of June of year $t+1$.

Table 5 Panel B reports the average implied cost of capital of firms in the $CASH$ sorted deciles. In the full sample, the annual implied cost of capital decreases monotonically from the bottom $CASH$ decile (11.15%) to the top $CASH$ decile (9.38%) and the difference of 1.77% p.a. is significant at 1% level. Although this trend is mirrored in both the R&D active and inactive subsamples, R&D active firms witness a bigger gap in the annual cost of capital of the top and bottom $CASH$ decile (2.00%) compared to that in the R&D inactive firms (1.22%). In Panel C, the implied cost of capital also decreases, although not monotonically, from the bottom to the top RD decile. On average, compared to firms in the bottom RD decile, those in the top RD decile enjoy 1.34% (t = -1.70) lower annual cost of capital.

On the basis that the implied cost of capital reflects stocks' riskiness, the findings from Table 5 imply that both cash–rich and innovative firms are less risky than their cash–poor and less innovative counterparts, which is inconsistent with the view in Kung and Schmid (2015) that innovative firms are more exposed to long–run productivity risks. However, given that cash–rich and innovative firms are more productive, their lower cost of capital is consistent with the view in Imrohoroglu and Tuzel (2014) that productive firms are less risky as they

[25] Following Li and Mohanram (2014), the firm–level cost of capital as the average of twelve value of implied cost of capital for each firm–year observation using three earnings forecast models and four valuation models. Earnings forecasts are obtained using (a) the HVZ model in Hou, van Dijk, and Zhang (2012), (b) the EP model which employs past earnings, and the RI model in Feltham and Ohlson (1996). The implied cost of capital is then backed out from setting the prevailing price at the end of June each year to be equal to the valuation from four valuation models, *i.e.* Claus and Thomas (2001), Gebhardt, Lee, and Swaminathan (2001), Ohlson and Juettner-Nauroth (2005) using the assumptions in Gode and Mohanram (2003), and a simplified version of the Ohlson and Juettner-Nauroth (2005) model using the Price-Earnings-Growth ratio.

are sheltered from aggregate productivity shocks. If investors use the correct discount rate (which we back out from the prevailing stock price), the positive relation with realized future returns of cash and R&D should only be attributable to their underestimation of future cash flows. This estimation error would result in the current underpricing and subsequent positive returns. We will explore the underpricing channel in section 6.2.

In another contemporary model by Lin (2012) where technology also arrives endogenously, when productivity outweighs product innovation in the output of the innovation process, the positive relation between R&D and future stock returns arises simultaneously with the negative relation between physical investment and future stock returns. Lin argues that his conjecture is consistent with the less pronounced R&D spread in industries with less product innovation documented in Lev and Sougiannis (1999). Due to the difficulty in directly quantifying the relativity of R&D spending on process *versus* product innovation, we focus on ex-post productivity as the proxy for firms' priority on process innovation. We independently sort R&D active stocks into 25 portfolios by TFP and either $CASH$ or RD and report how the risk-adjusted cash and R&D spreads vary with TFP in Table 6.

In Table 6 Panel A, the $CASH$ spread is always positive and significant and does not follow any pattern across the TFP quintile. Hence, firm-level productivity does not exhibit any systematic impact on the cash effect.[26] In Panel B, the R&D spread is positive and significant in all the five TFP quintile and monotonically decreases with TFP. The R&D spread in the bottom TFP quintile is almost twice the magnitude of that in the top TFP quintile and the difference of 0.76% is statistically significant. The results suggest that TFP affects the cash and R&D spreads differently and hence, the two effects are not entirely the manifestation of each other. More importantly, the R&D spread is less pronounced amongst more productive firms, inconsistent with the conjecture from Lin (2012). In untabulated results, using industry-level productivity ($iTFP$), we also observe that both the cash and R&D spreads remain significant in each $iTFP$ quintile and do not exhibit any pattern. Hence, we do not find evidence for more pronounced cash and R&D spreads when firms devote more

[26] Consistent with Imrohoroglu and Tuzel (2014), the top TFP quintiles underperform the bottom TFP quintile, resulting in the negative return to the long–short quintiles by TFP within all the $CASH$ quintiles.

of their innovative effort into productivity improvement in the spirit of Lin (2012).

Table 6 about here

6.1.2. Investment Specific Technological Shocks

The Schumpeterian view maintains that corporate innovation activities may cause creative destruction by rendering existing technology redundant and established firms vulnerable. According to Kogan and Papanikolaou (2014), innovative firms may expose themselves to investment-specific technology shocks which carries a negative IST premium, implying a counter-factual negative R&D spread. In the case of a positive IST premium, which Garlappi and Song (2016) suggest is possible depending on the time period and the IST proxies, IST may account for the positive R&D spread and potentially the cash spread.

Table 7 shows the factor loadings of $CASH$ and RD sorted deciles on the IST shock proxied by $gIMC$ and $Ishock$. $gIMC$ measures the spread in the growth rates of aggregate investment and consumption (Kogan and Papanikolaou, 2014). $Ishock$ reflects shocks in the costs that firms face in investing in new capital and is constructed using the relative quality–adjusted price of capital goods and consumption goods (Greenwood, Hercowitz, and Krusell, 1997).[27] Garlappi and Song (2016) find that (a) $gIMC$ and $Ishock$ are strongly correlated with aggregate consumption and investment, and (b) their loadings could explain a large part of the value and momentum effects. These findings motivate our choice of $gIMC$ and $Ishock$ as IST proxies.

When IST is proxied by $gIMC$, the $CASH$ sorted deciles in the full sample (Panel A.1) as well as the subsamples by R&D involvement (Panels A.2 and A.3) do not differ in their IST loadings. Similarly, there is not much variation in the loadings of the RD sorted deciles in the R&D active subsample (Panel B). Using $Ishock$ to proxy for IST in the full sample (Panel A.1), the IST loading of the top $CASH$ decile is less negative than the loading of the bottom $CASH$ decile and the loading differential is significant at 10% level. With a positive $Ishock$ premium during the period 1964-2012 (Garlappi and Song, 2016), the exposure to

[27]We follow Garlappi and Song (2016) to construct $gIMC$ and $Ishock$ using data from the National Income and Product Accounts (NIPA) tables and the quality–adjusted price of investment from Israelsen (2010). We are grateful to Israelsen for sharing the annual and quarterly series of quality–adjusted prices.

$Ishock$ could potentially explain the cash puzzle.

Table 7 about here

However, a granulated look into the $Ishock$ loadings in the subsamples by R&D involvement shows a different story. In the R&D active subsample (Panel A.2) where most of the cash spread resides, there is no significant difference in the exposure to $Ishock$ of the $CASH$ sorted deciles. In Panel B, the RD deciles also do not significantly differ in their exposure to $Ishock$. Furthermore, although the cash spread is barely significant in the R&D inactive subsample (Panel A.3), cash-poor firms tend to be more negatively exposed to $Ishock$ than their cash–rich counterpart and the difference in the $Ishock$ loadings of the extreme $CASH$ deciles is significant at 1% level. The results cautiously suggest that IST could not explain both the cash and R&D puzzles. These two puzzles join the battery of the stock market anomalies which IST struggles to explain. Garlappi and Song (2016) attribute the poor performance of IST to the difficulty in empirically measuring IST shocks.

6.1.3. Risky Growth Options

In our last investigation of the risk–based channel, we study whether the accumulation of risky growth options may give rise to both the R&D and the cash puzzles. Firms might increase their cash reserves, spend on R&D and generate more growth options. Cash–rich firms might have accumulated more growth options given their modest physical investment during three years surrounding the portfolio formation year (Figure 1). As firms' riskiness is higher before the exercise of growth options (Cooper and Priestley, 2011), the accumulation of growth options may exacerbate the risk differential between cash–rich and cash–poor firms.

As Market-to-Book ratio (MB) is commonly used as the proxy for firm growth, we first investigate how MB affects the cash and R&D spreads using bivariate portfolio sorting. Table 8 Panel A(B) reports the Fama and French 5 factor alpha of the 25 independently sorted portfolios by MB and $CASH$ (RD) in the R&D active subsample.[28] Both the cash and R&D spreads decrease with MB. Looking down column F(L) of Panel A(B), the cash

[28] Consistent with the value premium (Fama and French, 1996), the risk-adjusted returns to the long–short portfolios by MB are negative and significant in each of the five $CASH$ (RD) sorted sorted quintiles.

(R&D) spread residing in the bottom MB quintile is 1.24% (1.05%) per month higher than that located in the top MB quintile, and the difference is significant at 1% level.[29]

Table 8 Panels A and B delineate that both the cash and R&D spreads exhibit the pattern contrary to our expectation (*i.e.* decreasing instead of increasing with MB). One possible explanation is that MB is a noisy measure of firm growth. Several studies such as Lakonishok, Shleifer, and Vishny (1994) advocate that an important part of MB reflects stock mispricing. To isolate mispricing from firm growth in MB, we follow RhodesKropf et al. (2005) and decompose MB into three components, *i.e.* long–term growth and two mispricing components at firm– and industry–levels.[30]

Table 8 about here

Table 8 Panel C reports the Fama and French five–factor alpha of the 25 independently sorted portfolios by $GROWTH$ and $CASH$ in the R&D active subsample. Within three out of five $CASH$ quintiles (*i.e.* looking down columns A, B, and E), returns tend to increase with $GROWTH$. This pattern is in line with the view in Cooper and Priestley (2011) that firms with more growth options waiting to be exercised are riskier. The absence of this trend in two out of five $CASH$ quintiles (*i.e.* columns C and D) suggests that part of the information about the accumulation of growth options might also be captured in corporate cash holdings.

Looking across each row in Panel C, the cash spread is always positive and significant within each of the five $GROWTH$ quintiles. Looking down column F, the cash spread remains significant when controlling for $GROWTH$ and does not follow any prominent trend across the $GROWTH$ quintiles. In Panel D where stocks are independently sorted into quintiles by $GROWTH$ and RD, the R&D spread is also significant in each $GROWTH$ quintile. Although the R&D spread is significantly higher amongst firms residing in the top $GROWTH$ quintile than in the bottom $GROWTH$ quintile, this spread does not show a monotonic relation with $GROWTH$.

[29]In untabulated results, in the R&D inactive subsample, the cash spread does not appear to vary with MB in any way, and the difference between the cash spread residing in the top and bottom MB quintiles is insignificant.

[30]The decomposition is described in section 3.

To better control for several firm characteristics affecting cross–sectional returns, within the R&D active subsample, we report the Fama and MacBeth (1973) cross-sectional regressions of excess returns on the interaction term between $CASH$ ($logRD$) and $logMB$ or its growth component ($GROWTH$) as described in equation 5 below in Table 9:

$$R_{j,t} - r_{f,t} = \alpha_{0,t} + \alpha_{1,t} Main_{j,t-1} + \alpha_{2,t} Main_{j,t-1} Firm_{j,t-1} + \alpha_{3,t} Firm_{j,t-1} + \sum_{i=1}^{4} \beta_{i,t} Controls_{i,j,t-1} + \epsilon_{j,t} \tag{5}$$

where the primary firm characteristic, $Main_{j,t-1}$, is either $CASH$ (Panel A) or $logRD$ (Panel B). $Firm_{j,t-1}$ refers to $logMB$ or its components ($GROWTH$, $FMIS$, $IMIS$). As Market-to-Book ratio already enters the regression, the control variables $Controls_{i,j,t-1}$ only include four variables to control for the size, short–term reversal, medium–term momentum, and asset growth effects. All the variables are defined in equation 4.

In Table 9 Panel A, the interaction term $CASH \times logMB$ is negative and significant $(-0.58, t = -2.09)$, suggesting that $CASH$ is more positively related to cross–sectional returns as $logMB$ decreases. The interaction term $logRD \times logMB$ in Table Table 9 Panel B is also negative, although not statistically significant $(-0.96, t = -1.21)$. These results are broadly in line with the bivariate portfolio sorting results from Table 8 where both the cash and R&D spreads decrease with MB. The interaction term $CASH \times GROWTH$ in column B of Table 9 Panel A is positive and significant while there is no relation between the cash spread and $GROWTH$ in the portfolio sorting in Table 8 Panel C. Column F of Table 9 Panel B shows an insignificant coefficient attached to the interaction term $logRD \times GROWTH$, which reflects a lack of a monotonic relation between the R&D spread and $GROWTH$ in Table 8 Panel D. In general, neither MB nor its growth component affects the cash and R&D spreads in the way the accumulation of growth options would do.

Table 9 about here

To sum up, while there is a strong relation between the cash spread and corporate innovation activities, we provide early evidence on generally a lack of empirical support for hypothesis H_2 motivated by several contemporary theories of corporate innovation, growth, and productivity. The theories tested in this section deserve further testing with better empirical proxies for theoretical concepts, which we leave for future research.[31] We explore the mispricing channel to both the cash and R&D puzzles in section 6.2 below.

6.2. The Mispricing Tale

6.2.1. Firm– and Industry–Level Mispricing

The underpricing of future benefits of R&D could reconcile (a) the positive relation with future realized returns of both $CASH$ and RD, (b) the higher productivity of cash–rich and innovative firms, and (c) the risk-based association between productivity and cost of capital as per Imrohoroglu and Tuzel (2014). As the implied cost of capital is backed out from a valuation model using earnings forecasts, if investors underestimate future earnings, the present value (*i.e.* the value at which investors assign as a stock's intrinsic value) would be too low even when they use the correct discount rate.

Broadly defined as the difference between the prevailing market price and intrinsic value, mispricing could be extracted from the procedure introduced by RhodesKropf et al. (2005).[32] Table 10 Panel A reports (a) how firm–level mispricing ($FMIS$) affects the cash spread amongst R&D active firms and (b) the average mispricing of the stocks residing in the $CASH$ sorted portfolios. In Panel B, to draw the link between the impact of mispricing on the cash spread and innovation activities, we also report the magnitude of mispricing and its impact on the R&D spread.

Table 10 about here

In Table 10 Panel A, R&D active stocks are independently sorted into quintiles by $CASH$ and $FMIS$ measured at the end of fiscal year t-1. The resulting 25 portfolios are held from July of year t to June of year t+1. Panel A.1 reports the Fama and French five–factor alpha of the portfolios while Panel A.2 delineates their average $FMIS$. Within each $CASH$ quintile in Panel A.1 (*i.e.* looking down columns A to E), the portfolio returns decrease with $FMIS$

[31] This is also the view in Garlappi and Song (2016) from testing whether IST could explain several stock market anomalies.

[32] The contrasting relations with stock returns and MB *versus* $GROWTH$ documented in section 6.1.3 also suggests the need to isolate growth and mispricing from MB. The decomposition procedure is explained in section 3.1.

and the average monthly $FMIS$ spread (varying between -0.83% to -2.53%) is economically and statistically significant. This result merely reflects underpriced stocks outperforming overpriced stocks given that $FMIS$ measures the firm–level misvaluation relative to the industry average. Since $GROWTH$ is positively related to returns (see Table 8 in section 6.1.3), $FMIS$ appears to drive the negative relation between MB and returns, *i.e.* the value premium (Fama and French, 1996).

Our main interest is the variation of the cash and R&D spreads across different $FMIS$ quintiles. Table 10 Panel A column F delineates that in the bottom $FMIS$ quintile where stocks are about 60% to 70% relative to the industry valuation, the average monthly cash spread is 2.39%. It monotonically decreases as the firm–level valuation increases. In the third $FMIS$ quintile where stocks have approximately the same valuation as the industry average, the average cash spread is 2.06% per month. Moving to the top $FMIS$ quintile where stocks become 100% overvalued relative to the industry valuation, the cash spread (1.15% per month) loses more than half of the magnitude compared to the spread in the bottom $FMIS$ quintile. The difference (1.24% per month) in the cash spread residing in the extreme $FMIS$ quintiles is significant at 1% level. In Table 10 Panel B, R&D active stocks are independently sorted by $FMIS$ and RD. Looking down columns A to E, the $FMIS$ spread is significant within each RD quintile. Across each row, the R&D spread is positive and significant within all the five $FMIS$ quintile. In column F, the R&D spread decreases as the firm–level valuation increases from about 65 to 70% underpriced to 100% overpriced relative to the industry valuation. The difference in the R&D spread located in the extreme $FMIS$ quintiles is also statistically significant $(-1.05\%, t = -2.67)$.

We revisit Table 9 to examine the interaction with $FMIS$ of both $CASH$ and $logRD$ in the context of the Fama–MacBeth cross–sectional regressions to control for several other factors affecting stock returns. In column C of Table 9 Panel A, the interaction term $CASH \times FMIS$ is negative and significant $(-1.28, t = -3.65)$, suggesting that the more underpriced stocks are relative to the industry average, the more positive the relation between $CASH$ and stock returns becomes. The interaction term $logRD \times FMIS$ in column G of Table 9 Panel B is also negative and significant $(-1.66, t = -1.78)$, evidenced for a stronger positive relation between $logRD$ and stock returns when firms are more underpriced at firm–level.

The results from the Fama–MacBeth regressions lend further supports to the findings from Table 10 using bivariate portfolio sorts.

In untabulated results (available upon request), industry–level mispricing ($IMIS$) has no systematic impact on both the cash and R&D spreads when R&D active stocks are independently sorted by $IMIS$ and either $CASH$ or RD. Consistently, the interaction terms with $IMIS$ of both $CASH$ and $logRD$ in Table 9 are both insignificant. Hence, the firm–level rather than industry–level underpricing of innovative activities is an important driver to both the cash and RD puzzles.

Overall, our results support hypothesis H_3 on the underpricing of stocks due to investors' failure to fully value the future benefits of the innovation process. We further investigate the nature of the stock mispricing underlying the cash and R&D puzzles in the light of the heterogeneity of institutional investors in section 6.2.2 below.

6.2.2. Agency Problems versus Information Opacity

Taking advantage of the roles played by different types of institutional investors using the Bushee (1998) classification, our last endeavor investigates how their presence affects the cash and R&D puzzles to shed further light on the mispricing that potentially drives both puzzles.[33] Quasi–index investors are known for both demanding for faster information dissemination and navigating towards stocks with more information disclosure (Bushee and Noe, 2000, D'Souza et al., 2010). If the cash puzzle is driven by investors underestimating the future benefits of the innovation process(hypothesis H_3), both the cash and R&D puzzles should become more pronounced in the presence of these investors. Given their ability to directly monitor and better access private information courtesy of their close ties with investee firms (D'Souza et al., 2010), dedicated investors are likely to affect the cash and R&D puzzles through better monitoring. In comparison, the presence of transient investors may weaken

[33] Bushee (1998) categorize institutional investors into three types based on their trading behaviors. Quasi–index investors are those with diversified portfolios with low turnover. Transient investors are characterized as those with diversified portfolios with low turnover and short investment horizons. Dedicated investors are construed as having close ties with a small number of investee firms, low portfolio turnover and long investment horizons.

the cash puzzle through not only the information channel (as in the case of quasi–index investors) but also the agency channel (similar to dedicated investors).[34]

To gauge the impact of institutional investor heterogeneity on the cash (R&D) puzzle, in the R&D active subsample, we run the Fama and MacBeth (1973) cross-sectional regressions of excess returns on the interaction term between $CASH$ ($logRD$) and the ownership percentage of institutional investors. The regressions are described using equation 5 in which the primary firm characteristic, $Main_{j,t-1}$, remains either $CASH$ (Panel A) or $logRD$ (Panel B). $Firm_{j,t-1}$ refers to QIX, TRA, or DED, being the percentage ownership of quasi–index, transient or dedicated investors, respectively.[35] The control variables $Controls_{i,j,t-1}$ include five variables to control for the value, size, short–term reversal, medium–term momentum and asset growth effects. All the variables are defined in equation 4.

Table 11 about here

In Table 11 Panel A (B), the $CASH$ ($logRD$) coefficient is positive and significant in all the model specification. In column A (D) of Panel A (B), the negative and significant interaction term between $CASH$ ($logRD$) and QIX indicates that the presence of quasi–index investors reduces the positive relation between $CASH$ ($logRD$) and stock returns. The results suggest that both the cash and R&D puzzles are driven by the lack of transparent information environment, which quasi–index investors have the motivation to improve. Column C (F) of Panel A (B) shows that the interaction term with DED of $CASH$ ($logRD$) is insignificant. Hence, both the cash and R&D puzzles are unlikely to arise through the agency channel given the unambiguous role of dedicated investors in guarding against agency problems. As such, any influence by transient investors is potentially attributable to the information channel. The interaction terms with TRA in columns B of Panel A and E of Panel

[34] Although their trading are not driven by fundamental information, transient investors might favor stocks with faster information dissemination as these stocks tend to be more liquid, which facilitates the implementation of short–run trading strategies (Bushee and Noe, 2000). Transient investors might also reduce the agency problems thanks to their exit options (Edmans, 2009).

[35] Institutional ownership data is from Thomson Reuters 13F database available through Wharton Research Data Services. Bushee's categorization of institutional investors is available from 1981. The ownership variables measured at the same time with $CASH$ and $logRD$.

B show that while the presence of transient investors weakens the cash puzzle, the R&D puzzle remains unaffected. Although transient investors might navigate towards stocks with more transparent information, the information may be unrelated to corporate innovation, making transient investor ownership irrelevant to the R&D puzzle. In comparison, quasi–index investors might push for and navigate towards more transparent information on firms' long–run prospects, given their longer investment horizons.

Overall, both the cash and R&D puzzles are likely to arise due to the lack of information on firms' long–run perspectives, which is consistent with hypothesis H_3 on investors' failure to fully appreciate the distant benefits of corporate innovation. The results do not rule out the possibility that the cash puzzle might also be driven by opaque information on short–run firm performance, which would be a potential deviation between the two puzzles.

7. Conclusion

Recently, the literature has documented (a) a sharp rise in corporate cash holdings in corporate finance and (b) the positive relation between cash holdings and cross–sectional stock returns (*i.e.* the cash puzzle) in asset pricing. Existing justifications for the cash puzzle have been built around the riskiness of firms in possession of risky growth options and holding cash for precaution (Palazzo, 2012, Simutin, 2010). This paper makes several important contributions surrounding the role of corporate innovation and the cash puzzle.

First, we document several links between the cash puzzle and corporate innovation in a sample of non–financial, non–utilities firms listed on the three main U.S. stock exchanges (NYSE, AMEX, and NASDAQ) between 1975 and 2012. The cash spread is much more pronounced amongst the R&D active firms. Both the cash and R&D spreads have strengthened since 1996 as corporate cash holdings have been soaring, and innovation becomes increasingly sophisticated and critical to the economy. The R&D spread subsumes the cash spread in bivariate portfolio sorting analysis. Of the four firm characteristics (R&D, default risk, predator risk and refinancing risk) which are both (a) cash holding determinants and (b) affect cross–sectional returns, R&D is the only factor that renders the relation between cash and stock returns insignificant.

Second, we identify several contemporary theories on corporate innovation to explain the

R&D puzzle and empirically test how these theories could explain both the cash and R&D puzzles. Both cash-rich and innovative firms have higher productivity, which is central to the Schumpeterian view on corporate innovation and growth. These firms also face lower implied cost of capital, making it difficult to reconcile with a risk-based explanation such as Kung and Schmid (2015). Productivity does not systematically affect both the cash and R&D spreads, inconsistent with Lin (2012). There is no difference in the exposure to Investment Specific Technological shocks between the extreme portfolios by cash holdings and R&D spending. Hence, exposures to IST do not account for both the cash and R&D puzzles, similar to the findings from Garlappi and Song (2016) in testing several other stock market anomalies. Finally, the accumulation of risky growth options could not explain for the cash and R&D puzzles since firm growth does not significantly influence the cash and R&D spreads. Our early evidence suggests that future testing of these theories may benefit from better empirical proxies for the key theoretical concepts.

Third, our study finds supports for the mispricing channel whereby investors underestimate the future benefits of corporate innovation. In the data, both the cash and R&D spreads are significantly more pronounced amongst firms which are underpriced relative to the average industry valuation. Of the three categories of institutional investors (*i.e.* quasi–index, transient and dedicated, the presence of quasi–index investors unambiguously indicates more transparent information relevant to firms' long–run performance to effectively monitor firms in their portfolios (Bushee and Noe, 2000, D'Souza et al., 2010). We find that quasi–index ownership weakens the positive relation with stock returns of both cash holdings and R&D, consistent with our mispricing argument. The mispricing channel could also explain the relation amongst productivity, risk, and innovation. Cash-rich and innovative firms enjoy greater productivity, lower implied cost of capital, and generate higher subsequent realized stock returns. This trend happens when the implied cost of capital is backed out from a valuation model using earnings forecasts which are underestimated. The "fair" stock value to investors would be too small, resulting in higher subsequent realized stock returns, even when the correct discount rate is applied. Meanwhile, greater productivity shelters cash-rich and innovative firms from aggregate productivity shocks, allowing them to enjoy lower cost of capital in the spirit of Imrohoroglu and Tuzel (2014).

Our results also have interesting implications for investors interested in developing trading strategies based on corporate cash holdings. A long–short strategy investing in the stocks of R&D active firms captures the entire profitability potential of this strategy. Further, if investors pursue their trading strategy within the universe of stocks with limited presence of quasi–index investors or underpriced relative to the industry valuation (although identifying stocks to satisfy the second condition might be practically challenging), the profitability of their long-short strategy based on both cash and R&D could be even further enhanced.

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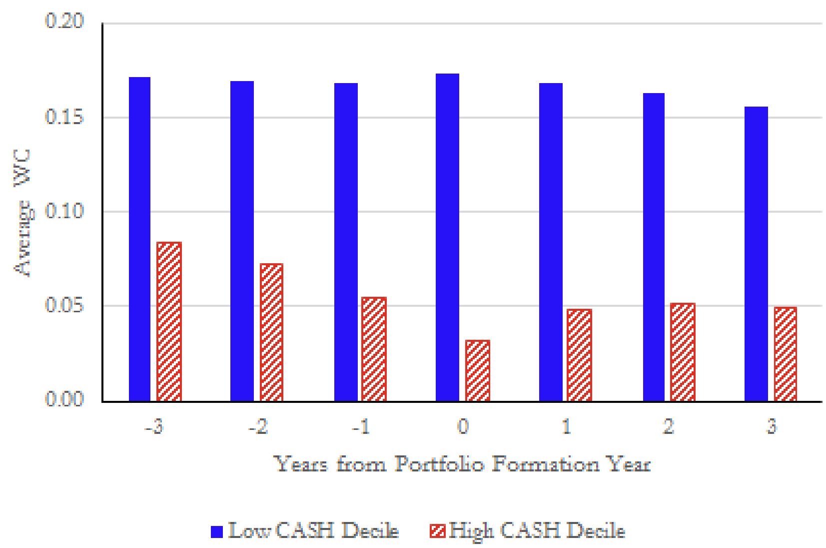
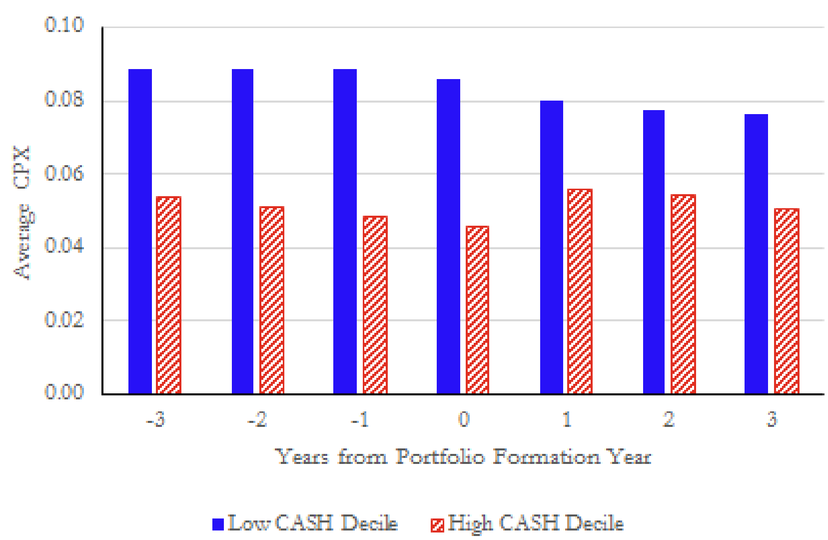
Figure 1: Physical Investment of Top and Bottom $CASH$ Deciles

This figure depicts the time–series average of the cross–sectional mean ratios of WC and CPX measured at the end of fiscal year $t-1$ of the decile portfolios formed at the beginning of July of year t using $CASH$ measured at the end of fiscal year $t-1$, and held until June of year $t+1$. The leads and lags of WC and CPX up to three years around the fiscal year end $t-1$ are also reported. The sample covers non–financial, non–utilities firms listed on NYSE, AMEX, and NASDAQ from July 1976 to December 2012. The accounting data used to construct the leads and lags of WC and CPX run from the fiscal year 1972 to 2014. Firms are required to have non-negative cash balances, positive sales, and a stock price of $5 and above. The variable construction is described in section 3.1.



(a) WC of Top and Bottom $CASH$ Deciles



(b) CPX of Top and Bottom $CASH$ Deciles

Table 1: Descriptive Statistics

This table presents descriptive statistics of the sample of non–financial, non–utilities firms listed on NYSE, AMEX, and NASDAQ from July 1976 to December 2012. Firms are required to have non-negative cash balances, positive sales, and a stock price of $5 and above. Panel A reports the time–series average of the cross–sectional statistics of firm–level variables in the sample at fiscal year–ends. Panel B (C) reports the time–series average of the annual Spearman cross–sectional correlations amongst these variables in the R&D active (inactive) subsample. The variable construction is described in section 3.1.

	CASH	*RD*	*MB*	*FMIS*	*IMIS*	*GROWTH*	*WC*	*CPX*	*GPA*	*SEO*	*PAYOUT*	*TFP*	*DD*	*HHI*	*REF*
							Panel A: Summary Statistics								
Min	0.001	0.000	0.212	−2.939	−0.932	−1.970	−0.694	0.000	−0.745	−0.809	0.000	0.074	1.311	0.030	0.000
25^{th}	0.028	0.000	1.103	−0.306	−0.099	0.248	0.019	0.030	0.229	−0.096	0.010	0.653	7.404	0.053	0.034
50^{th}	0.084	0.001	1.768	0.065	0.015	0.488	0.134	0.052	0.367	−0.001	0.036	0.779	10.595	0.075	0.158
75^{th}	0.223	0.044	3.046	0.473	0.150	0.718	0.254	0.089	0.536	0.110	0.118	0.943	14.793	0.116	0.358
Max	0.827	14.054	32.094	3.426	1.152	2.560	0.612	0.478	1.494	1.228	1.970	5.719	34.808	0.501	0.978
Mean	0.156	0.166	2.755	0.098	0.027	0.460	0.139	0.072	0.401	0.018	0.094	0.847	11.673	0.101	0.231
S.D.	0.177	1.111	3.503	0.650	0.214	0.430	0.172	0.068	0.267	0.210	0.190	0.378	5.952	0.080	0.237
							Panel B: Correlation Matrix in R&D Active Subsample								
CASH	1.000														
RD	0.411	1.000													
MB	0.277	0.288	1.000												
FMIS	0.176	0.195	0.758	1.000											
IMIS	0.014	−0.017	0.172	−0.045	1.000										
GROWTH	0.216	0.238	0.558	0.049	−0.056	1.000									
WC	−0.203	−0.066	−0.165	−0.161	−0.025	−0.065	1.000								
CPX	−0.143	−0.011	0.113	0.106	0.011	0.048	−0.110	1.000							
GPA	0.183	0.256	0.377	0.184	−0.006	0.409	0.176	0.061	1.000						
SEO	0.039	0.085	0.117	0.120	0.034	0.010	0.015	−0.015	−0.003	1.000					
PAYOUT	−0.213	−0.294	−0.112	−0.040	0.009	−0.137	−0.069	0.011	−0.107	−0.166	1.000				
TFP	0.209	0.162	0.441	0.266	−0.024	0.426	−0.216	0.080	0.172	−0.008	−0.024	1.000			
DD	0.025	−0.060	0.152	0.118	−0.014	0.088	−0.105	0.051	0.112	−0.101	0.390	0.232	1.000		
HHI	−0.121	−0.191	−0.101	−0.014	−0.013	−0.156	0.026	0.061	−0.129	0.000	0.004	−0.032	−0.058	1.000	
REF	−0.044	−0.023	−0.037	−0.036	−0.015	−0.015	0.095	−0.015	0.066	0.015	−0.056	−0.104	−0.056	0.023	1.000
							Panel C: Correlation Matrix in R&D Inactive Subsample								
CASH	1.000														
MB	0.209		1.000												
FMIS	0.130		0.784	1.000											
IMIS	−0.012		0.124	−0.080	1.000										
GROWTH	0.198		0.555	0.082	−0.057	1.000									
WC	−0.151		−0.130	−0.130	0.000	−0.050	1.000								
CPX	−0.085		0.131	0.118	0.014	0.034	−0.352	1.000							
GPA	0.115		0.248	0.137	−0.016	0.284	0.373	−0.043	1.000						
SEO	−0.008		0.095	0.117	0.038	−0.031	−0.024	0.016	−0.056	1.000					
PAYOUT	0.005		−0.024	0.016	−0.014	−0.046	0.023	−0.070	−0.010	−0.143	1.000				
TFP	0.069		0.355	0.228	−0.026	0.343	−0.106	0.097	0.076	0.003	−0.001	1.000			
DD	0.089		0.178	0.140	−0.027	0.116	0.031	−0.001	0.140	−0.090	0.331	0.155	1.000		
HHI	0.016		−0.019	0.006	−0.033	−0.025	−0.201	0.165	−0.125	0.005	−0.012	0.003	−0.023	1.000	
REF	−0.011		−0.037	−0.042	−0.014	−0.005	0.024	0.011	0.064	0.011	−0.071	−0.109	−0.040	−0.008	1.000

Table 2: Univariate Portfolio Sorts on $CASH$

This table presents descriptive statistics of the sample of non-financial, non-utilities firms listed on NYSE, AMEX, and NASDAQ from July 1976 to December 2012. Firms are required to have non-negative cash balances, positive sales, and a stock price of $5 and above. Panel A (B) reports the average firm characteristics measured at fiscal year–ends of the decile portfolios formed in the R&D active (inactive) subsample at the beginning of July of year t using $CASH$ measured at the end of fiscal year $t-1$, and held until June of year $t+1$. The number of firm-month observations are reported in square brackets. The variable construction is described in section 3.1.

	Low $CASH$	2	3	4	5	6	7	8	9	High $CASH$	H–L	Obs.
Panel A: Firm Characteristics of CASH Sorted Deciles in R&D Active Subsample												
$CASH$	0.009	0.024	0.043	0.071	0.109	0.160	0.226	0.310	0.429	0.640	0.631	[477,843]
RD	0.033	0.035	0.045	0.052	0.076	0.102	0.130	0.256	0.487	2.051	2.019	[477,843]
MB	2.207	2.274	2.363	2.444	2.792	2.910	3.367	3.862	4.511	5.331	3.124	[470,008]
$FMIS$	0.016	0.010	0.037	0.035	0.077	0.111	0.173	0.256	0.362	0.435	0.419	[469,977]
$IMIS$	0.020	0.019	0.027	0.028	0.020	0.023	0.022	0.028	0.045	0.067	0.047	[469,977]
$GROWTH$	0.410	0.440	0.435	0.460	0.501	0.528	0.581	0.607	0.642	0.721	0.311	[469,977]
WC	0.200	0.202	0.204	0.194	0.184	0.178	0.164	0.135	0.096	0.025	−0.175	[472,553]
CPX	0.067	0.063	0.063	0.064	0.065	0.066	0.062	0.061	0.054	0.042	−0.025	[473,460]
GPA	0.380	0.389	0.409	0.425	0.444	0.460	0.467	0.459	0.406	0.202	−0.178	[477,703]
SEO	0.007	0.007	0.007	0.013	0.006	0.018	0.018	0.025	0.034	0.067	0.060	[447,339]
$PAYOUT$	0.101	0.103	0.106	0.106	0.107	0.104	0.093	0.084	0.079	0.070	−0.031	[408,759]
TFP	0.784	0.781	0.796	0.797	0.820	0.846	0.865	0.887	0.959	1.053	0.269	[362,531]
DD	12.130	12.347	12.500	12.714	12.706	12.803	12.651	12.450	12.087	10.921	−1.209	[362,455]
HHI	0.099	0.091	0.088	0.086	0.083	0.080	0.079	0.076	0.073	0.068	−0.031	[476,640]
REF	0.236	0.225	0.219	0.224	0.225	0.226	0.234	0.222	0.227	0.257	0.021	[383,986]
Panel B: Firm Characteristics of CASH Sorted Deciles in R&D Inactive Subsample												
$CASH$	0.004	0.012	0.021	0.032	0.047	0.069	0.101	0.147	0.223	0.428	0.424	[499,921]
MB	1.866	1.791	1.913	1.944	2.030	2.216	2.343	2.541	2.803	3.311	1.446	[488,898]
$FMIS$	−0.054	−0.066	−0.037	−0.030	−0.031	0.015	0.037	0.085	0.154	0.232	0.286	[488,898]
$IMIS$	0.021	0.017	0.024	0.014	0.016	0.010	0.010	0.024	0.024	0.032	0.012	[488,898]
$GROWTH$	0.313	0.315	0.328	0.346	0.367	0.389	0.410	0.445	0.480	0.522	0.209	[488,898]
WC	0.161	0.164	0.156	0.142	0.131	0.116	0.110	0.104	0.094	0.048	−0.113	[477,439]
CPX	0.094	0.086	0.086	0.087	0.086	0.084	0.084	0.080	0.080	0.059	−0.035	[493,925]
GPA	0.355	0.367	0.380	0.380	0.396	0.401	0.416	0.423	0.473	0.431	0.076	[499,067]
SEO	0.019	0.013	0.012	0.014	0.021	0.017	0.023	0.017	0.020	0.007	−0.011	[465,088]
$PAYOUT$	0.075	0.083	0.075	0.086	0.084	0.085	0.086	0.104	0.110	0.141	0.066	[474,984]
TFP	0.849	0.812	0.809	0.830	0.816	0.827	0.824	0.838	0.857	0.888	0.038	[361,575]
DD	10.928	11.020	10.975	11.028	11.138	11.368	11.671	11.859	12.098	12.599	1.671	[406,576]
HHI	0.119	0.113	0.117	0.121	0.123	0.121	0.121	0.120	0.116	0.118	0.000	[497,312]
REF	0.240	0.241	0.240	0.238	0.230	0.227	0.229	0.224	0.221	0.233	−0.008	[432,397]

Table 3: Returns of Univariate $CASH$ Sorted Portfolios

This table presents returns to the $CASH$ sorted deciles of the stocks of non-financial, non-utilities firms listed on NYSE, AMEX, and NASDAQ from July 1976 to December 2012. Firms are required to have non-negative cash balances, positive sales, and a stock price of $5 and above. The equally–weighted portfolios are formed at the beginning of July of year t using CASH measured at the end of fiscal year $t-1$, and held until June of year $t+1$. Panel A reports the average raw return (% per month), the return adjusted for firm characteristics following Daniel et al. (1997) (DGTW return), and the alpha from the multi-factor models of Carhart (1997) (Carhart alpha) and Fama and French (2016) (FF5 alpha) of the $CASH$ sorted portfolios. Panel B(C) delineates the same set of returns for the $CASH$ sorted portfolios formed in the subsample of R&D active (inactive) firms, i.e. firms with non-zero (zero) R&D. Newey and West (1987) corrected t–statistics are reported in parentheses. ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively, of the $CASH$ spread reported in column H–L. The number of firm-month observations are reported in square brackets. The variable construction is described in section 3.1.

	Low $CASH$	2	3	4	5	6	7	8	9	High $CASH$	H–L	Obs.
					Panel A: CASH Sorted Portfolio Returns in Full Sample							
Raw return	1.84	1.89	1.92	1.98	1.97	1.94	2.04	2.05	2.08	2.46	0.62*	[977, 054]
	(6.69)	(6.68)	(6.53)	(6.93)	(6.78)	(6.77)	(6.90)	(6.43)	(5.93)	(5.93)	(1.88)	
DGTW return	0.54	0.54	0.58	0.59	0.61	0.64	0.74	0.75	0.89	1.28	0.74***	[947, 906]
	(6.85)	(7.35)	(7.75)	(9.89)	(9.39)	(11.13)	(9.64)	(7.97)	(6.29)	(6.33)	(3.18)	
Carhart alpha	0.65	0.65	0.68	0.74	0.78	0.77	0.91	1.02	1.11	1.53	0.88***	[977, 054]
	(6.15)	(5.60)	(5.56)	(7.22)	(7.61)	(8.29)	(8.78)	(8.53)	(7.32)	(7.90)	(4.03)	
FF5 alpha	0.44	0.41	0.41	0.55	0.56	0.64	0.81	1.07	1.25	1.83	1.39***	[977, 054]
	(4.12)	(4.37)	(3.98)	(6.39)	(6.46)	(7.53)	(8.69)	(8.70)	(8.61)	(9.77)	(6.56)	
					Panel B: CASH Sorted Portfolio Returns in R&D Active Subsample							
Raw Return	1.89	1.79	1.93	1.92	1.96	2.06	2.21	2.16	2.36	2.55	0.66*	[477, 843]
	(6.63)	(6.48)	(6.54)	(6.56)	(6.22)	(6.17)	(6.15)	(5.41)	(5.64)	(5.48)	(1.82)	
DGTW Return	0.57	0.49	0.55	0.59	0.63	0.83	0.93	0.89	1.20	1.38	0.81***	[465, 126]
	(6.89)	(6.05)	(7.36)	(7.76)	(6.30)	(5.59)	(6.45)	(4.53)	(5.70)	(5.48)	(3.06)	
Carhart Alpha	0.73	0.59	0.74	0.76	0.84	1.03	1.20	1.21	1.49	1.63	0.90***	[477, 843]
	(5.91)	(5.37)	(6.26)	(8.10)	(6.95)	(6.46)	(7.70)	(5.82)	(7.19)	(7.25)	(3.58)	
FF5 Alpha	0.47	0.34	0.54	0.64	0.81	1.10	1.34	1.43	1.72	1.98	1.51***	[477, 843]
	(4.11)	(3.21)	(4.88)	(7.26)	(6.82)	(7.25)	(8.66)	(7.16)	(8.83)	(8.87)	(6.11)	
					Panel C: CASH Sorted Portfolio Returns in R&D Inactive Subsample							
Raw Return	1.88	1.89	1.92	2.05	2.00	2.02	1.97	2.01	1.93	1.89	0.01	[499, 211]
	(6.87)	(6.62)	(6.36)	(6.70)	(6.80)	(6.83)	(6.74)	(7.00)	(6.90)	(6.49)	(0.05)	
DGTW Return	0.55	0.51	0.57	0.69	0.62	0.64	0.64	0.68	0.63	0.72	0.17	[482, 780]
	(5.48)	(6.24)	(6.77)	(7.57)	(7.42)	(7.30)	(7.45)	(7.81)	(7.30)	(7.53)	(1.30)	
Carhart Alpha	0.66	0.65	0.64	0.79	0.75	0.79	0.73	0.82	0.84	0.84	0.18	[499, 211]
	(5.39)	(5.69)	(4.84)	(5.28)	(6.30)	(6.64)	(6.00)	(7.17)	(7.45)	(6.57)	(1.42)	
FF5 Alpha	0.48	0.43	0.39	0.52	0.53	0.55	0.51	0.65	0.65	0.78	0.30**	[499, 211]
	(4.01)	(3.81)	(3.75)	(4.41)	(4.97)	(5.16)	(4.35)	(5.97)	(5.88)	(5.98)	(2.27)	

Table 4: Explaining the Cash Effect with Corporate R&D, Default Risk, Predator Risk, and Refinancing Risk

This table presents the time series average of the coefficients from the following monthly Fama and MacBeth (1973) cross–sectional regression equation 4 in the sample of non–financial, non–utilities firms listed on NYSE, AMEX, and NASDAQ from July 1976 to December 2012. Firms are required to have non-negative cash balances, positive sales, and a stock price of $5 and above.

$$R_{j,t} - r_{f,t} = \alpha_{0,t} + \alpha_{1,t}CASH_{j,t-1} + \alpha_{2,t}Firm_{j,t-1} + \sum_{i=1}^{5}\beta_{i,t}Controls_{i,j,t-1} + \epsilon_{j,t} \quad (4)$$

where $R_{j,t}$ is the month t return on stock j and $r_{f,t}$ is the risk–free rate in month t. All independent variables use data readily observable in month $t-1$. $CASH_{j,t-1}$ is the $CASH$ ratio calculated using the accounting data from the most recently available financial statements. For example, July-1976 risk–adjusted stock returns are regressed against variables available by June-1976. As it takes some time for accounting data to be verified and released to the public, $CASH$ is calculated using cash and cash–equivalent and total assets reported in the 1975 financials. This value is used as the independent variable $CASH_{j,t-1}$ in the monthly regressions until (and including) June-1977. The process is repeated for the regressions from July-1977 to June-1978 using the 1976 financials. $Firm_{j,t-1}$ represents the four firm characteristics (R&D, default risk, predator risk and refinancing risk) potential for explaining the cash puzzle. Due to the highly skewed distribution of RD in the full sample, we use the logarithmic transformation of RD (*i.e.* taking the natural logarithm of one plus RD, denoted as $logRD$). The control variables are $lnMB_{j,t-1}$ (the natural logarithm of MB), $lnMV_{j,t-1}$ (the natural logarithm of market capitalization at the end of month $t-1$), $REV_{j,t-1}$ (the previous one–month return), $MOM_{j,t-1}$ (the cumulative return during the period of 11 months with at least 6 months' return data, ended in month $t-1$), and AG (total asset growth orthogonalized with $lnMB$ over the sample period). Newey and West (1987) corrected t-statistics are reported in parentheses. ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively. All variables in equation 4 are required to be available. The variable construction is described in section 3.1.

	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
$CASH$	1.01**					0.28	1.04**	1.01**	1.12**	0.63
	(2.25)					(0.77)	(2.31)	(2.26)	(2.30)	(1.30)
$logRD$		2.84***				2.59***				2.83***
		(2.76)				(2.61)				(2.96)
DD			−0.05***				−0.05***			−0.05***
			(−3.17)				(−3.25)			(−3.27)
HHI				−0.34				−0.15		−0.03
				(−0.93)				(−0.71)		(−0.08)
REF					−0.11				0.10	0.53
					(−1.02)				(0.50)	(0.90)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Intercept	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 5: Implied Cost of Capital and Productivity of Univariate Portfolio Sorted by $CASH$ and RD

This table presents the average firm–level productivity (TFP) and cost of capital of the $CASH$ sorted deciles of the stocks of non–financial, non–utilities firms listed on NYSE, AMEX, and NASDAQ from July 1976 to December 2012. Firms are required to have non-negative cash balances, positive sales, and a stock price of $5 and above. The equally–weighted portfolios are formed at the beginning of July of year t using CASH measured at the end of fiscal year $t-1$, and held until June of year $t+1$. Panel A reports the average TFP of the $CASH$ sorted deciles in the full sample and in both the R&D active and inactive subsamples. Panel B delineates the average cost of capital of these $CASH$ sorted deciles. Panel C details both the average productivity and cost of capital of the RD sorted deciles in the R&D active subsample. Newey and West (1987) corrected t–statistics are reported in parentheses. ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively, of the difference in the statistics of the top and bottom $CASH$ and RD sorted deciles reported in column H–L. The number of firm-month observations are reported in square brackets. The construction of cost of capital is described in section sec:5a1. Other variables are described in section 3.1.

	Low $CASH$	2	3	4	5	6	7	8	9	High $CASH$	H–L	Obs.
Panel A: Average Productivity of CASH Sorted Deciles												
A1: Productivity in Full Sample												
TFP	0.821	0.796	0.810	0.811	0.805	0.828	0.841	0.860	0.901	0.995	0.174	[724, 106]
A2: Productivity in R&D Active Subsample												
TFP	0.784	0.781	0.796	0.797	0.820	0.846	0.865	0.887	0.959	1.053	0.269	[362, 531]
A3: Productivity in R&D Inactive Subsample												
TFP	0.849	0.812	0.809	0.830	0.816	0.827	0.824	0.838	0.857	0.888	0.038	[361, 575]
Panel B: Implied Cost of Capital (k_e) of CASH Sorted Deciles												
k_e, Full Sample	11.15	11.09	11.03	10.71	10.62	10.30	10.04	9.91	9.48	9.38	-1.77^{***}	[917, 760]
	(9.22)	(8.98)	(9.60)	(9.92)	(10.40)	(10.42)	(10.47)	(9.54)	(8.72)	(8.99)	(−7.17)	
k_e, R&D Active	11.17	10.96	10.41	10.41	10.06	9.85	9.57	9.38	9.22	9.18	-2.00^{***}	[446, 655]
	(7.82)	(8.24)	(9.64)	(10.39)	(10.04)	(9.61)	(9.81)	(8.97)	(9.00)	(10.36)	(−3.37)	
k_e, R&D Inactive	10.96	11.21	11.24	11.25	10.82	10.85	10.59	10.39	10.13	9.74	-1.22^{***}	[471, 105]
	(10.18)	(9.99)	(8.58)	(9.77)	(10.39)	(11.09)	(10.93)	(9.89)	(9.63)	(8.48)	(−5.12)	

Panel C: Average Firm-Level Productivity and Implied Cost of Capital of RD Sorted Deciles in R&D Active Subsample

	Low RD	2	3	4	5	6	7	8	9	High RD	H–L	Obs.
TFP	0.797	0.805	0.808	0.810	0.841	0.864	0.896	0.952	0.940	0.877	0.080	[362, 531]
k_e	10.83	10.47	10.61	10.25	10.30	9.97	10.12	9.19	8.99	9.49	-1.34^{*}	[446, 655]
	(9.34)	(10.29)	(10.01)	(8.97)	(8.20)	(7.67)	(6.60)	(8.64)	(9.94)	(21.01)	(−1.70)	

Table 6: Productivity and the $CASH$ and RD Spreads in the R&D Active Subsample

This table presents the returns to the independently sorted portfolios by firm–level productivity TFP and either $CASH$ or RD in the sample of non–financial, non–utilities firms listed on NYSE, AMEX, and NASDAQ from July 1976 to December 2012. Firms are required to have non–negative cash balances, positive sales, and a stock price of $5 and above. In Panel A(B), equally–weighted quintiles are independently formed in the R&D active subsample using $CASH$ (RD) and TFP measured at the end of the fiscal year $t-1$, and the resulting 25 portfolios are held from July of year t to June of year $t+1$. Newey and West (1987) corrected t–statistics are reported in parentheses. ***, **, and * denote significance at 1%, 5%, and 10% levels of the spread between the returns to the top and bottom TFP, $CASH$, and RD portfolios. The variable construction is described in section 3.1.

	(A)	*(B)*	*(C)*	*(D)*	*(E)*	*(F)*
			Panel A: TFP and $CASH$			
	Low $CASH$	2	3	4	High $CASH$	H–L
Low TFP	1.17	1.24	1.65	1.86	2.03	0.86***
	(6.64)	(7.04)	(9.40)	(7.48)	(8.48)	(3.24)
2	0.39	0.52	0.47	0.93	1.44	1.05***
	(3.11)	(4.26)	(3.94)	(5.15)	(5.55)	(3.69)
3	0.12	0.33	0.42	0.74	0.97	0.85***
	(0.98)	(3.11)	(3.81)	(4.94)	(5.61)	(4.56)
4	0.06	−0.18	0.17	0.48	1.01	0.95***
	(0.43)	(−1.60)	(1.44)	(3.39)	(5.80)	(4.38)
High TFP	−0.30	−0.03	0.14	0.53	0.62	0.92***
	(−2.11)	(−0.22)	(1.16)	(3.82)	(3.54)	(4.06)
H–L	−1.47***	−1.26***	−1.51***	−1.33***	−1.41***	0.06
	(−7.38)	(−6.39)	(−8.02)	(−5.82)	(−6.73)	(0.26)
			Panel B: TFP and RD			
	Low RD	2	3	4	High RD	H–L
Low TFP	0.82	1.06	1.24	1.90	2.38	1.56***
	(5.01)	(5.94)	(6.20)	(8.37)	(9.64)	(5.32)
2	0.19	0.33	0.65	1.26	1.60	1.41***
	(1.78)	(2.62)	(5.29)	(6.67)	(6.27)	(5.15)
3	0.02	0.08	0.35	1.07	1.12	1.10***
	(0.12)	(0.77)	(2.95)	(6.70)	(5.64)	(4.74)
4	0.13	−0.11	0.09	0.54	1.00	0.87***
	(1.28)	(−1.04)	(0.71)	(4.41)	(4.38)	(3.55)
High TFP	−0.17	−0.06	0.18	0.45	0.63	0.80***
	(−1.20)	(−0.50)	(1.55)	(2.89)	(3.47)	(3.44)
H–L	−0.99***	−1.12***	−1.05***	−1.45***	−1.75***	−0.76***
	(−5.35)	(−5.40)	(−5.48)	(−7.56)	(−7.78)	(−2.72)

Table 7: IST Factor Loadings of $CASH$ and RD Sorted Portfolios

This table presents the IST factor loadings of the $CASH$ and RD sorted deciles of stocks in the sample of non–financial, non–utilities firms listed on NYSE, AMEX, and NASDAQ from July 1976 to December 2012. Firms are required to have non–negative cash balances, positive sales, and a stock price of $5 and above. The portfolios are formed at the beginning of July of year t using $CASH$ or RD measured at the end of fiscal year $t-1$, and held until June of year $t+1$. The factor loadings are estimated by running the regression of monthly portfolio returns in excess of the risk–free rate on a constant and an IST proxy (*i.e.* $gICM$ or $Ishock$) over the whole sample period. The construction of $gICM$ and $Ishock$ is described in section 6.1.2. Other variables are described in section 3.1.

Panel A: IST Factor Loadings of CASH Sorted Deciles											
	Low $CASH$	2	3	4	5	6	7	8	9	High $CASH$	H–L
A1: IST Factor Loadings of CASH Sorted Deciles in Full Sample											
$gICM$ Beta	−0.37	−0.32	−0.32	−0.29	−0.35	−0.33	−0.31	−0.33	−0.34	−0.34	0.03
	(−2.62)	(−2.03)	(−1.95)	(−1.81)	(−2.22)	(−2.21)	(−1.95)	(−2.10)	(−2.11)	(−1.80)	(0.30)
$Ishock$ Beta	−0.39	−0.35	−0.36	−0.36	−0.40	−0.36	−0.33	−0.36	−0.30	−0.18	0.21*
	(−1.58)	(−1.39)	(−1.40)	(−1.47)	(−1.62)	(−1.44)	(−1.41)	(−1.63)	(−1.31)	(−0.79)	(1.69)
A2: IST Factor Loadings of CASH Sorted Deciles in R&D Active Subsample											
$gICM$ Beta	−0.36	−0.26	−0.28	−0.25	−0.31	−0.32	−0.30	−0.40	−0.36	−0.32	0.04
	(−2.43)	(−1.62)	(−1.63)	(−1.59)	(−1.90)	(−1.99)	(−1.76)	(−2.25)	(−1.93)	(−1.50)	(0.32)
$Ishock$ Beta	−0.38	−0.38	−0.41	−0.40	−0.44	−0.32	−0.43	−0.34	−0.32	−0.17	0.22
	(−1.56)	(−1.56)	(−1.57)	(−1.50)	(−1.77)	(−1.38)	(−1.81)	(−1.40)	(−1.32)	(−0.67)	(1.51)
A3: IST Factor Loadings of CASH Sorted Deciles in R&D Inactive Subsample											
$gICM$ Beta	−0.42	−0.29	−0.37	−0.37	−0.34	−0.35	−0.31	−0.37	−0.33	−0.33	0.09
	(−2.99)	(−1.86)	(−2.29)	(−2.09)	(−2.10)	(−2.26)	(−2.01)	(−2.51)	(−2.08)	(−2.25)	(1.37)
$Ishock$ Beta	−0.44	−0.29	−0.33	−0.43	−0.31	−0.39	−0.31	−0.33	−0.28	−0.15	0.29***
	(−1.75)	(−1.17)	(−1.21)	(−1.67)	(−1.26)	(−1.51)	(−1.28)	(−1.39)	(−1.29)	(−0.70)	(3.36)
Panel B: IST Factor Loadings of RD Sorted Deciles in R&D Active Subsample											
	Low RD	2	3	4	5	6	7	8	9	High RD	H–L
$gICM$ Beta	−0.31	−0.30	−0.26	−0.23	−0.26	−0.30	−0.38	−0.40	−0.37	−0.37	−0.05
	(−2.10)	(−1.96)	(−1.77)	(−1.54)	(−1.70)	(−1.89)	(−2.13)	(−2.19)	(−1.80)	(−1.45)	(−0.29)
$Ishock$ Beta	−0.32	−0.37	−0.35	−0.32	−0.40	−0.40	−0.39	−0.44	−0.33	−0.24	0.08
	(−1.35)	(−1.50)	(−1.31)	(−1.15)	(−1.70)	(−1.68)	(−1.73)	(−1.82)	(−1.37)	(−0.84)	(0.41)

Table 8: Firm Growth and the Cash and R&D Spreads in the R&D Active Subsample

This table presents the returns to the portfolios sorted by $CASH$ or RD and a proxy for growth (either MB or $GROWTH$) in the subsample of R&D active non–financial, non–utilities firms listed on NYSE, AMEX, and NASDAQ from July 1976 to December 2012. Firms are required to have non–negative cash balances, positive sales, and a stock price of $5 and above. In Panel A(B), equally–weighted quintiles are independently formed using $CASH$ (RD) and MB. In Panel C(D), stocks are independently formed using $CASH$ (RD) and the growth component (*i.e.* $GROWTH$) of MB. All the sorting characteristics are measured at the end of fiscal year $t-1$, and the resulting portfolios are held from July of year t to June of year $t+1$. Newey and West (1987) corrected t–statistics are reported in parentheses. ***, **, and * respectively denote significance at 1%, 5%, and 10% levels of the spread between the returns to the top and bottom $CASH$, RD, MB and $GROWTH$. The variable construction is described in section 3.1.

	(A)	*(B)*	*(C)*	*(D)*	*(E)*	*(F)*	*(G)*	*(H)*	*(I)*	*(J)*	*(K)*	*(L)*
	Panel A: MB and $CASH$						*Panel B: MB and RD*					
	Low $CASH$	2	3	4	High $CASH$	H–L	Low RD	2	3	4	High RD	H-L
Low MB	0.88	1.04	1.58	2.08	3.17	2.29***	0.72	0.91	1.68	2.22	3.63	2.91***
	(6.48)	(6.77)	(7.76)	(7.81)	(7.66)	(5.89)	(6.04)	(6.29)	(8.18)	(7.12)	(8.77)	(6.88)
2	0.36	0.48	0.99	1.61	2.30	1.94***	0.30	0.35	0.85	1.80	2.50	2.20***
	(2.91)	(4.98)	(5.99)	(6.83)	(6.82)	(5.14)	(3.10)	(3.52)	(5.83)	(7.68)	(6.50)	(5.42)
3	0.15	0.29	0.66	1.28	2.16	2.01***	0.03	0.12	0.75	1.23	2.42	2.39***
	(1.17)	(2.40)	(5.50)	(7.33)	(8.39)	(6.50)	(0.24)	(1.10)	(5.91)	(6.48)	(7.56)	(6.26)
4	−0.08	0.44	0.60	0.97	1.73	1.81***	0.01	0.04	0.57	1.07	1.82	1.81***
	(−0.57)	(3.29)	(3.94)	(5.27)	(8.06)	(7.00)	(0.06)	(0.32)	(3.67)	(5.98)	(7.25)	(5.73)
High MB	0.14	0.31	0.64	1.10	1.19	1.05***	−0.29	0.19	0.56	0.82	1.57	1.86***
	(0.71)	(2.19)	(4.10)	(6.39)	(6.61)	(3.97)	(−1.51)	(1.11)	(3.40)	(4.38)	(8.31)	(6.79)
H–L	−0.74***	−0.73***	−0.94***	−0.98***	−1.98***	−1.24***	−1.01***	−0.72***	−1.12***	−1.40***	−2.06***	−1.05***
	(−3.60)	(−3.98)	(−4.34)	(−4.35)	(−4.98)	(−2.97)	(−5.11)	(−3.70)	(−4.85)	(−4.68)	(−6.06)	(−2.67)
	Panel C: $GROWTH$ and $CASH$						*Panel D: $GROWTH$ and RD*					
	Low $CASH$	2	3	4	High $CASH$	H–L	Low RD	2	3	4	High RD	H-L
Low $GROWTH$	0.22	0.51	1.01	1.48	1.39	1.17***	0.29	0.43	0.95	1.24	1.50	1.21***
	(1.42)	(3.85)	(6.03)	(6.69)	(5.94)	(4.14)	(2.28)	(2.99)	(5.19)	(5.88)	(7.79)	(5.21)
2	0.28	0.37	0.72	1.31	1.73	1.45***	0.16	0.29	0.86	1.54	1.88	1.72***
	(2.30)	(3.35)	(4.73)	(7.23)	(7.29)	(5.45)	(1.30)	(2.70)	(5.46)	(6.28)	(8.14)	(6.16)
3	0.27	0.43	0.81	1.29	1.63	1.36***	0.32	0.16	0.90	1.56	1.80	1.48***
	(2.14)	(3.98)	(5.82)	(7.13)	(8.00)	(5.23)	(2.98)	(1.58)	(5.66)	(7.68)	(7.28)	(5.16)
4	0.39	0.59	0.77	1.10	1.55	1.16***	0.36	0.36	0.84	1.11	1.77	1.41***
	(2.96)	(4.03)	(4.41)	(5.25)	(8.61)	(5.77)	(2.67)	(3.08)	(5.62)	(5.68)	(7.25)	(5.07)
High $GROWTH$	1.03	1.00	1.26	1.59	2.38	1.35***	0.21	0.81	0.93	1.47	2.85	2.64***
	(5.26)	(6.22)	(6.31)	(7.60)	(7.32)	(4.29)	(1.02)	(4.96)	(5.88)	(7.75)	(7.68)	(7.10)
H–L	0.81***	0.49***	0.25	0.11	0.99***	0.18	−0.08	0.38**	−0.02	0.23	1.35***	1.43***
	(3.49)	(2.62)	(1.09)	(0.52)	(2.77)	(0.50)	(−0.38)	(2.11)	(−0.10)	(1.04)	(3.77)	(4.14)

Table 9: The Interaction with Market-to-Book Components of $CASH$ and RD in Cross–Sectional Returns

This table presents the time series average of the coefficients from the following monthly Fama and MacBeth (1973) cross–sectional regression equation 5 in the subsample of R&D active non–financial, non–utilities firms listed on NYSE, AMEX, and NASDAQ from July 1976 to December 2012. Firms are required to have non–negative cash balances, positive sales, and a stock price of $5 and above.

$$R_{j,t} - r_{f,t} = \alpha_{0,t} + \alpha_{1,t} Main_{j,t-1} + \alpha_{2,t} Main_{j,t-1} Firm_{j,t-1} + \alpha_{3,t} Firm_{j,t-1} + \sum_{i=1}^{4} \beta_{i,t} Controls_{i,j,t-1} + \epsilon_{j,t} \quad (5)$$

where $R_{j,t}$ is the month t return on stock j and $r_{f,t}$ is the risk–free rate in month t. The primary firm characteristic, $Main_{j,t-1}$, is either $CASH$ (Panel A) or $logRD$ (Panel B). $Firm_{j,t-1}$ refers to $logMB$ or its components ($GROWTH$, $FMIS$, $IMIS$). As Market-to-Book ratio already enters the regression, the control variables $Controls_{i,j,t-1}$ only include $lnMV$, REV, MOM, and AG to control for the size, short–term reversal, medium–term momentum, and asset growth effects, respectively. Newey and West (1987) corrected t-statistics are reported in parentheses. ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively. All variables in equation 5 are required to be available. The variable construction is described in section 3.1 and in equation 4.

Panel A: CASH and MB Components				
	(A)	*(B)*	*(C)*	*(D)*
$CASH$	1.48***	−0.10	1.12***	0.60
	(2.66)	(−0.19)	(2.67)	(1.06)
$logMB$	0.01			
	(0.05)			
$CASH \times logMB$	−0.58**			
	(−2.09)			
$GROWTH$		0.35**	0.68***	0.66***
		(2.39)	(5.25)	(5.18)
$CASH \times GROWTH$		1.45***		
		(3.11)		
$FMIS$		−0.40***	−0.07	−0.39***
		(−4.81)	(−0.63)	(−4.65)
$CASH \times FMIS$			−1.28***	
			(−3.65)	
$IMIS$		−0.24	−0.16	0.12
		(−0.64)	(−0.43)	(0.28)
$CASH \times IMIS$				−1.42
				(−1.26)
Controls	Yes	Yes	Yes	Yes
Intercept	Yes	Yes	Yes	Yes

Panel B: RD and MB Components				
	(E)	*(F)*	*(G)*	*(H)*
$logRD$	4.71***	3.13**	3.97***	2.52
	(3.50)	(2.13)	(3.18)	(1.22)
$logMB$	−0.15			
	(−1.39)			
$logRD \times logMB$	−0.96			
	(−1.21)			
$GROWTH$		0.45***	0.53***	0.48***
		(2.96)	(4.07)	(3.83)
$logRD \times GROWTH$		−0.45		
		(−0.29)		
$FMIS$		−0.47***	−0.26**	−0.47***
		(−5.31)	(−2.31)	(−5.55)
$logRD \times FMIS$			−1.66*	
			(−1.78)	
$IMIS$		−0.30	−0.25	−0.37
		(−0.74)	(−0.60)	(−0.98)
$logRD \times IMIS$				−0.42
				(−0.14)
Controls	Yes	Yes	Yes	Yes
Intercept	Yes	Yes	Yes	Yes

Table 10: Firm–Level Mispricing and the Cash and R&D Spreads in the R&D Active Subsample

This table presents the returns to the portfolios sorted by $CASH$ or RD and $FMIS$ in the subsample of R&D active non–financial, non–utilities firms listed on NYSE, AMEX, and NASDAQ from July 1976 to December 2012. Firms are required to have non–negative cash balances, positive sales, and a stock price of $5 and above. In Panel A (B), equally–weighted quintiles are independently formed using $CASH$ (RD) and $FMIS$ measured at the end of fiscal year $t-1$, and the resulting portfolios are held from July of year t to June of year $t+1$. Panel A1 (B1) reports the average returns to the double–sorted portfolios whereas Panel A2 (B2) delineates the time–series average of the cross–sectional average $FMIS$ of these portfolios. Newey and West (1987) corrected t–statistics are reported in parentheses. ***, **, and * respectively denote significance at 1%, 5%, and 10% levels of the spreads between the returns to the top and bottom $CASH$, RD, and $FMIS$. The variable construction is described in section 3.1.

	(A)	*(B)*	*(C)*	*(D)*	*(E)*	*(F)*	*(G)*	*(H)*	*(I)*	*(J)*	*(K)*
	Panel A: Firm–Level Mispricing and the Cash Spread in the R&D Active Subsample										
	A1: FF5 Alpha to the $CASH \times FMIS$ Sorted Portfolios						A2: Average $FMIS$ of the $CASH \times FMIS$ Sorted Portfolios				
	Low $CASH$	2	3	4	High $CASH$	H–L	Low $CASH$	2	3	4	High $CASH$
Low $FMIS$	1.26	1.06	1.67	2.23	3.65	2.39***	−0.69	−0.71	−0.68	−0.65	−0.64
	(8.15)	(7.33)	(8.59)	(8.71)	(8.69)	(6.20)					
2	0.26	0.58	0.85	1.43	2.36	2.10***	−0.17	−0.18	−0.17	−0.17	−0.17
	(2.12)	(5.89)	(5.79)	(7.43)	(7.00)	(5.60)					
3	0.14	0.45	0.82	1.23	2.20	2.06***	0.11	0.12	0.12	0.12	0.12
	(1.18)	(4.01)	(5.58)	(6.88)	(8.69)	(6.97)					
4	−0.03	0.27	0.50	0.92	1.20	1.23***	0.43	0.43	0.43	0.44	0.45
	(−0.20)	(2.46)	(3.78)	(5.75)	(6.51)	(5.18)					
High $FMIS$	−0.03	0.23	0.66	0.96	1.12	1.15***	1.02	1.04	1.04	1.09	1.12
	(−0.16)	(1.75)	(4.27)	(5.20)	(5.98)	(4.74)					
H–L	−1.29***	−0.83***	−1.01***	−1.27***	−2.53***	−1.24***					
	(−6.12)	(−5.98)	(−5.24)	(−6.34)	(−6.51)	(−3.23)					
	Panel B: Firm–Level Mispricing and the R&D Spread in the R&D Active Subsample										
	B1: FF5 Alpha to the $RD \times FMIS$ Sorted Portfolios						*B2: Average $FMIS$ of the $RD \times FMIS$ Sorted Portfolios*				
	Low RD	2	3	4	High RD	H–L	Low RD	2	3	4	High RD
Low $FMIS$	0.92	1.02	1.51	2.45	4.42	3.50***	−0.69	−0.69	−0.68	−0.66	−0.65
	(7.03)	(7.11)	(8.58)	(8.99)	(9.24)	(7.59)					
2	0.29	0.30	0.92	1.49	2.41	2.12***	−0.17	−0.17	−0.18	−0.17	−0.17
	(2.91)	(2.85)	(5.96)	(7.87)	(6.63)	(5.27)					
3	0.09	0.16	1.03	1.28	2.25	2.16***	0.12	0.11	0.12	0.12	0.12
	(0.80)	(1.78)	(7.15)	(6.62)	(7.48)	(6.21)					
4	−0.06	0.14	0.42	0.91	1.46	1.52***	0.43	0.43	0.43	0.44	0.45
	(−0.44)	(1.25)	(3.73)	(5.31)	(7.45)	(6.09)					
High $FMIS$	−0.16	0.01	0.47	0.84	1.41	1.57***	1.03	1.01	1.06	1.06	1.15
	(−1.17)	(0.04)	(2.54)	(4.06)	(7.49)	(6.40)					
H–L	−1.08***	−1.01***	−1.04***	−1.61***	−3.01***	−1.93***					
	(−6.46)	(−6.31)	(−5.33)	(−6.31)	(−7.88)	(−5.22)					

Table 11: The Cash and R&D Puzzles and Institutional Ownership

This table presents the time series average of the coefficients from the following monthly Fama and MacBeth (1973) cross–sectional regression equation 5 in the subsample of R&D active non–financial, non–utilities firms listed on NYSE, AMEX, and NASDAQ from July 1976 to December 2012. Firms are required to have non–negative cash balances, positive sales, and a stock price of $5 and above.

$$R_{j,t} - r_{f,t} = \alpha_{0,t} + \alpha_{1,t} Main_{j,t-1} + \alpha_{2,t} Main_{j,t-1} Firm_{j,t-1} + \alpha_{3,t} Firm_{j,t-1} + \sum_{i=1}^{4} \beta_{i,t} Controls_{i,j,t-1} + \epsilon_{j,t} \quad (5)$$

where $R_{j,t}$ is the month t return on stock j and $r_{f,t}$ is the risk–free rate in month t. The primary firm characteristic, $Main_{j,t-1}$, is either $CASH$ (Panel A) or $logRD$ (Panel B). $Firm_{j,t-1}$ refers to QIX, TRA, or DED, being the percentage ownership of quasi–index, transient or dedicated investors, respectively. The control variables $Controls_{i,j,t-1}$ include $lnMV$, $lnMV$, REV, MOM, and AG to control for the value, size, short–term reversal, medium–term momentum, and asset growth effects, respectively. Newey and West (1987) corrected t-statistics are reported in parentheses. ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively. All variables in equation 5 are required to be available. The construction of the institutional investor ownership variables is described in section 6.1.3. Other variables are described in section 3.1 and in equation 4.

Panel A: CASH and Institutional Ownership				*Panel B: RD and Institutional Ownership*			
	(A)	*(B)*	*(C)*		*(D)*	*(E)*	*(F)*
$CASH$	2.60***	1.75***	1.10**	$logRD$	3.26***	2.74***	2.40***
	(5.38)	(3.68)	(2.03)		(4.13)	(5.50)	(3.69)
QIX	0.29			QIX	−0.75*		
	(0.73)				(−1.75)		
$CASH \times QIX$	−7.64***			$logRD \times QIX$	−6.97**		
	(−5.23)				(−2.43)		
TRA		−0.58		TRA		−0.95*	
		(−0.95)				(−1.91)	
$CASH \times TRA$		−4.24**		$logRD \times TRA$		−0.04	
		(−2.04)				(−0.01)	
DED			−1.01*	DED			−0.69
			(−1.77)				(−1.47)
$CASH \times DED$			−0.31	$logRD \times DED$			7.28
			(−0.13)				(1.30)
Controls	Yes	Yes	Yes	Controls	Yes	Yes	Yes
Intercept	Yes	Yes	Yes	Intercept	Yes	Yes	Yes
Obs.	332,239	314,193	255,746	Obs.	332,239	314,193	255,746