Increase in Cash Holdings: Pervasive or Sector-Specific?

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Abstract

We examine the difference in cash holdings between high-tech and non-high-tech firms from 1974 to 2007. The average cash-to-assets ratio of non-high-tech firms remained stable throughout the period. In contrast, the average cash ratio of high-tech firms more than tripled from 1980 to 2007. This difference in cash trends can be explained by the difference in changing firm characteristics in these two sectors. This is a consequence of high-tech new listings, whose changing nature and increasing proportion in the sector over the past three decades have caused the population characteristics in the high-tech sector to tilt toward those typical of firms that hold more cash. These empirical results are consistent with theoretical results that indicate that high-tech firms should hold more cash and companion research that shows that the marginal value of a dollar of cash is higher for high-tech than non-high-tech firms and has increased since 1990.

Key Words: cash holdings; new listings; high-tech
JEL Classification: G30, G32

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1 - Introduction

Cash holdings of U.S. firms have grown significantly over time. In a paper, 'Why Do U.S. Firms Hold So Much More Cash than They Used To?', Bates, Kahle, and Stulz (2009) document a large increase in the average cash-to-assets ratio for publicly listed industrial firms over the period 1980-2006. Their analysis indicates that this upward trend in cash holdings is driven by changing firm characteristics and is pervasive. However, we re-examine this increase and find that it is not pervasive. Instead the increase in cash holdings is concentrated in the high-tech sector. The reason for this is twofold.

First, the high-tech sector has predominantly been in the growth stage of the industry life-cycle over this period; this is reflected in a large influx of young firms into the capital market during the 1980s and 1990s. This development was driven by capital market changes that allowed more immature firms to go public (Fama and French, 2004; Hall and Lerner, 2010). Besides increasing the weight of the high-tech sector in the universe of publicly listed firms, these new listings contributed to more significant changes in the population characteristics of the high-tech sector as compared to the non-high-tech sector.

Second and more important, the distinguishing characteristic of high-tech firms, compared to non-high-tech ones, is the importance of research and development (R&D), which is necessary for them to survive competition and gain market power. The availability of financial slack, including cash as a vital part, is important for high-tech firms, especially junior ones since they are more exposed to capital market frictions. This is due to the high information asymmetry concerning their growth opportunities, as well as their lack of collateral for secured, particularly bank, financing (Myers, 1984; Hall, 2002).

The importance of cash holdings to R&D-based competition has been examined by several recent papers. Schroth and Szalay (2010) show that large cash balances increase the likelihood of winning patent races in the pharmaceutical industry. Brown and Petersen (2010) document that young firms rely more heavily on cash reserves to smooth their R&D expenditures. Lyandres and Palazzo (2012) show that R&D intensive firms hold cash strategically to win R&D competition. Hence, the difference in new listings and the importance of cash reserves for R&D investment should imply a potential difference in the temporal development of cash holdings across the

two sectors.[1] [2] Note that what is important is the *combination* of these two effects.

We investigate this trend by examining the annual average cash-to-assets ratio (cash ratio) over time. Like Bates, Kahle, and Stulz (2009), we find that "on average" U.S. firms have increased their cash ratio since 1980. However, after splitting the sample into high-tech and non-high-tech sectors, we find that the average cash ratio has increasingly diverged across the two sectors since 1980. The average cash ratio for the high-tech sector has more than tripled; increasing from 11.2% in 1980 to 39.1% by 2007. In contrast, over the same period, the average cash ratio of non-high-tech firms has remained relatively constant at around 11%; similar to their level during the 1970s.

What has caused this divergence over time? The literature on corporate cash holdings shows that the level of a firm's cash holdings is a function of fundamental characteristics related to the costs and benefits of holding cash (Kim, Mauer, and Sherman, 1998; Opler, Pinkowitz, Stulz, and Williamson, 1999). Although there are several theoretical reasons that justify higher cash holdings for high tech firms based on their sequential need for financing in a world of information asymmetries and frictions, the growing difference in the cash ratio between these two sectors is at first puzzling. A clue to deciphering this puzzle is the "new listings phenomenon (Fama and French, 2004) as equity markets have developed to allow firms with weaker fundamentals to go public in the 1980s and 1990s

We find that the nature and impact of new listings are significantly different between the high-tech and non-high-tech sectors. The high-tech sector has experienced a rapid expansion due to new listings in the 1980s and 1990s. Moreover, these new listings were different from firms listed earlier. The combined effect of these two aspects has led the population of public firms in the high-tech sector to shift gradually toward the characteristics that, according to the literature on corporate cash holdings, are typical of firms that hold more cash. On the other hand, the population characteristics of the non-high-tech sector were not materially affected by new listings, since the new firms were broadly similar to existing firms.

[1] This type of financing is often described as "bunny financing" as success begets success and is often associated with warrant financing as well as significant pre-financing through "excess" cash balances.

[2] In parallel work we show that the marginal value of a dollar of cash is higher in the high-tech sector indicating that the observed cash holdings are not sub optimal.

To test whether the difference in changing firm characteristics can explain the difference in the cash ratio over time, we follow the framework proposed by Fama and French (2001). After estimating a regression model of corporate cash holdings using the first ten years of available data, we calculate out-of-sample forecasts using the observed firm characteristics and the estimates from the regression model. As emphasized by the literature on R&D financing recently reviewed by Hall (2002), the nature of investment and operation of firms in the high-tech sector is distinct from that in the non-high-tech sector, so it is to be expected that the impact of various firm characteristics on corporate cash holdings may differ between these two sectors. To address this potential difference, the cash holding model is estimated separately for high-tech and non-high-tech sectors during the estimation period. The out-of-sample forecasts on average justify the observed difference in the cash ratio over time between these two sectors.

This paper contributes to several strands of recent research. First, it contributes to a growing body of research on corporate cash holdings. It is linked to Bates, et al. (2009), however, we show that the trend towards increasing cash holdings is *not* pervasive, but is in fact specific to the high-tech sector. In part this is due Bates et al following Laughren and Ritter (2004) who classify the pharmaceutical industry as non high-tech, despite the fact that much of the theoretical work dealing with the impact of R&D is based on the pharmaceutical industry. In contrast, we use the Department of Commerce definitions and for robustness checks also use both the Fama-French industry and the Global Industry Classification Standard (GICS).

Further, the literature has highlighted various benefits and costs associated with holding cash and empirically tested them by linking to significant firm characteristics.[3] Using variance decomposition, we find that a set of five characteristics (including leverage, R&D, size, net working capital, and equity issuance) account for more than 80% of the total explanatory power of the empirical model. These core variables provide good guidance as we examine the impact of changing firm characteristics on the difference in cash trends across these two sectors.

The paper also contributes to the new listings literature by examining the impact on average cash holdings as weaker firms have become listed. Recent research has used new listings data to explain the increasing

[3] An incomplete list of papers includes Kim, Mauer, and Sherman (1998), Opler, Pinkowitz, Stulz, and Williamson (1999), Dittmar, Mahrt-Smith, and Servaes (2003), Pinkowitz, Stulz, and Williamson (2006), Foley, Hartzell, Titman, and Twite (2007), Harford, Mansi, and Maxwell (2008), and Bates, Kahle, and Stulz (2009).

idiosyncratic risk puzzle (Brown and Kapadia, 2007), disappearing dividend puzzle (Fama and French, 2001), and rising cash holdings puzzle (Bates, Kahle, and Stulz, 2009). However, existing research invariably uses the total universe of public firms, which implicitly understates the cross-industry differences that we document. This paper contributes to this literature by emphasizing the significant difference between high-tech and non-high-tech new listings. It is an open question whether these other puzzles are robust to the high-tech versus non-high tech classification.

Finally, this paper contributes to the literature on R&D financing. It is widely accepted that the central feature of high-tech firms is their intensive investment in R&D. The literature finds that R&D-intensive firms, particularly immature ones, are more likely to suffer from capital market frictions, since their intangible assets can rarely be used as collateral and R&D projects tend to have severe information asymmetry (Bradley, Jarrell, and Kim, 1984; Hall, 2002; Brown, Fazzari, and Petersen, 2009). Brown and Petersen (2011) and Passov (2003) both find that R&D-intense firms, particularly financially-constrained ones, tend to use their cash reserves to smooth and/or hedge their R&D investment. Both perspectives indicate that the demand to hold cash is different between high-tech and non-high-tech firms. We address this by running separate regressions for the two sectors and the out-of-sample forecasts show that acknowledging the difference in coefficient estimates increases the explanatory power of a cash holding model.

The remainder of the paper is organized as follows. Section 2 provides the evidence on the difference in cash trends between the high-tech and non-high-tech sectors. Section 3 provides the explanation for this difference, and Section 4 concludes.

2 - Time trends in corporate cash holdings

2.1 Sample

The base sample of this study contains all U.S. publicly traded firms in the CRSP-Compustat merged database (Fundamental Annual) over the period from 1974 to 2007. The sample starts in 1974 because CRSP expanded to include NASDAQ firms in 1973 and the U.S. GAAP was changed in 1974 to require firms to immediately expense their R&D expenditures (Statement of Financial Accounting Standards, SFAS, No. 2, 1974). The sample ends in 2007 to avoid the noise introduced by the financial crisis that began in August 2007. Financial firms (SIC codes 6000-6999) are excluded since they hold cash in order to meet statutory capital requirements.

Table 1 The distribution of sample

	Whole Sample	High-Tech		Non-High-Tech	
Year	**Number**	**Number**	**Percent**	**Number**	**Percent**
1974	3400	434	12.8%	2966	87.2%
1975	3337	434	13.0%	2903	87.0%
1976	3328	442	13.3%	2886	86.7%
1977	3255	438	13.5%	2817	86.5%
1978	3202	447	14.0%	2755	86.0%
1979	3286	501	15.2%	2785	84.8%
1980	3318	526	15.9%	2792	84.1%
1981	3558	613	17.2%	2945	82.8%
1982	3668	677	18.5%	2991	81.5%
1983	3883	816	21.0%	3067	79.0%
1984	4127	960	23.3%	3167	76.7%
1985	4055	972	24.0%	3083	76.0%
1986	4116	1038	25.2%	3078	74.8%
1987	4301	1128	26.2%	3173	73.8%
1988	4211	1111	26.4%	3100	73.6%
1989	4043	1087	26.9%	2956	73.1%
1990	3998	1075	26.9%	2923	73.1%
1991	4025	1104	27.4%	2921	72.6%
1992	4216	1193	28.3%	3023	71.7%
1993	4586	1309	28.5%	3277	71.5%
1994	4888	1356	27.7%	3532	72.3%
1995	5097	1495	29.3%	3602	70.7%
1996	5535	1742	31.5%	3793	68.5%
1997	5614	1857	33.1%	3757	66.9%
1998	5304	1789	33.7%	3515	66.3%
1999	5036	1785	35.4%	3251	64.6%
2000	4874	1855	38.1%	3019	61.9%
2001	4328	1661	38.4%	2667	61.6%
2002	3954	1508	38.1%	2446	61.9%
2003	3655	1342	36.7%	2313	63.3%
2004	3628	1356	37.4%	2272	62.6%
2005	3548	1322	37.3%	2226	62.7%
2006	3455	1266	36.6%	2189	63.4%
2007	3364	1230	36.6%	2134	63.4%
	138193	37869		100324	

This table reports the number of firms in the whole sample and in the high-tech and non-high-tech sectors separately each year during the period from 1974 to 2007. The sample includes U.S.

firms documented on the Compustat-CRSP merged database (fundamental annual) that have positive total assets and sales and nonnegative cash and marketable securities, and have common shares traded on the NYSE, AMEX, or Nasdaq. Financial firms (SIC code 6000-6999) and utility firms (SIC codes 4900-4999) are excluded from the sample, leaving an unbalanced panel of 138,193 observations for 14,948 unique firms. The high-tech and non-high-tech sectors are defined according to the U.S. Department of Commerce. The proportions (in percentage) of the high-tech and non-high-tech sectors in annual sample are reported respectively.

Utility firms (SIC codes 4900-4999) are excluded as their cash policy can be a by-product of regulation. For a firm to be included in the sample in a given year, it must have equity traded on the NYSE, AMEX, or NASDAQ with a share code of 10 or 11 (ordinary common shares). Furthermore, firms in a given year are excluded if their assets or sales were non-positive or if their cash and marketable securities were negative. The screening leaves an unbalanced panel of 138,193 observations for 14,948 unique firms during the period from 1974 to 2007.

Table 1 reports the annual number of firms in the whole sample, as well as in the high-tech and non-high-tech sectors respectively. We follow Brown, Fazzari, and Petersen (2009) to use the official definition of high-tech industries offered by the United States Department of Commerce. The high-tech sector consists of firms from the following seven industries defined by 3-digit SIC codes: drugs (SIC 283), office and computing equipment (SIC 357), communications equipment (SIC 366), electronic components (SIC 367), scientific instruments (SIC 382), medical instruments (SIC 384), and software (SIC 737). The remaining firms in the sample are classified as non-high-tech. Table 1 shows the growth of the high-tech sector during the 1980s and 1990s. The proportion of public firms belonging to the high-tech sector increased from 12.82% in 1974 to 38.1% in 2000, and remained around this level henceforth. Clearly, the high-tech sector has become increasingly important in the universe of publicly listed US firms over time.

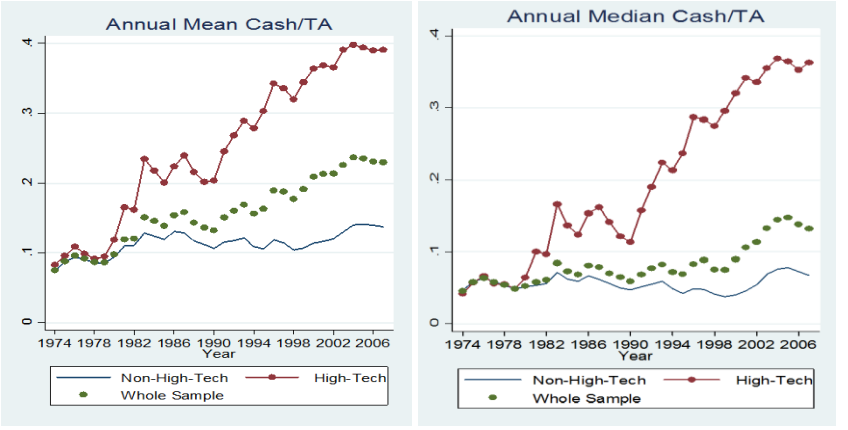
2.2 Cash trends

Figure 1 tracks the time trends in the cash-to-assets ratio of the whole sample, as well as for the high-tech and non-high-tech sectors respectively, measured by the annual mean and median. The trend in cash holdings for the whole sample, plotted as scatter points in Figure 1, is consistent with Bates et al. (2009), i.e. corporate cash reserves on average have more than doubled over these three decades. Furthermore, we identify a more interesting finding by examining the cash trends in the high-tech and non-high-tech sectors

respectively. The cash holdings of these two sectors are very similar in the 1970s. However, the average cash ratio in the high-tech sector started to increase since 1980; between 1980 and 2007, it has more than tripled, from 11.2% to 39.1% (all in annual mean). In contrast, the average cash ratio of non-high-tech firms remained stable at a level similar to that of the 1970s and increased only slightly in the 2000s.

Figure 1 Trends in cash holdings: 1974-2007

Panel A: Annual mean **Panel B: Annual median**



These figures depict the annual mean and median in the cash ratio of the whole sample and of the high-tech and non-high-tech sectors over the period 1974 to 2007. The sample includes 138,193 observations for 14,948 unique firms. The high-tech and non-high-tech sectors are defined according to the U.S. Department of Commerce. The cash-to-assets ratio (Cash/TA) is measured as cash plus marketable securities (CHE), divided by book value of total assets (AT). Figures in Panel A (B) depict the annual mean (median) of cash ratio of firms in two sectors separately.

To show that the difference in the cash trends for these two sectors is not driven by the high-tech sector definition provided by the U.S. Department of Commerce, we use two alternative definitions: the Fama-French industry classification and the Global Industry Classification Standard (GICS).[4] More specifically, the whole sample is split into different industry groups according to these two criteria respectively. After calculating the mean and median cash ratio for each industry group every year from 1980 to 2007, we investigate the significance of the time trend in the average cash ratios for each industry by

[4] The data for the GICS, developed by Standard & Poor's and Morgan Stanley, can be retrieved from the CRSP-Compustat merged database. The Fama-French industries are defined on Ken French's Data Library.

applying a linear trend model, i.e. regressing the average cash ratio on a constant and a time index measured in years. We find that the upward trend in cash holdings is economically and statistically more significant for those industries in the high-tech sector (see Table B.1 in Appendix B for the details).

The above analysis uses the book value of total assets as the denominator of cash ratio. A potential concern for this approach is that the upward trend in the high-tech sector might be artificial due to the existing accounting rule, which requires firms to immediately expense their R&D spending (SFAS No. 2, 1974). Since R&D is an important investment for high-tech firms, especially the young ones, this accounting rule can lead to a severe underestimate of assets and a consequent overestimate of cash-to-assets ratios for high-tech firms. For robustness check, we follow Chan, Lakonishok, and Sougiannis (2001) to capitalize R&D Expenses by using 5-year period uniform amortization and add it to total assets.[5] We plot the trends in the cash ratio that uses the R&D-adjusted book assets as the denominator. The upward trend in cash holdings still holds for the high-tech sector after this adjustment, although the slope is slightly less steep. Hence, it is not entirely driven by the existing accounting standard (see Figure B.1 in Appendix B for the details).

In sum, the above analysis shows that the increase in corporate cash holdings is a phenomenon specific to the high-tech sector. This finding is robust to industry classifications and the capitalization of R&D expense.

3 - Explaining the different trends in corporate cash holdings

Why are the trends in cash holdings so different between the high-tech and non-high-tech sectors over these three decades? Considering the setting of such a long time period, we need to explore fundamental changes that have transformed the population characteristics of these two sectors differently. One vital change is associated with those firms that went public during this period. In this section, we first examine the determinants of the cash holdings. Subsequently, we investigate the differences in the evolution of the firm characteristics in high-tech and non-high-tech sectors, as well as the impact of new listings. Finally, we directly test, using the basic framework proposed in Fama and French (2001), whether the difference in the changing

[5] The R&D asset (RDA) for firm i in year t is calculated as the weighted sum of its R&D expense over the past five years assuming an annual amortization rate of 20%: $RDA_{it} = RD_{it} + 0.8 \cdot RD_{it-1} + 0.6 \cdot RD_{it-2} + 0.4 \cdot RD_{it-3} + 0.2 \cdot RD_{it-4}$. The R&D-adjusted book value is calculated by adding this R&D asset to the reported book value.

firm characteristics can provide an adequate explanation for the observed difference in the cash trends.

3.1 The determinants of corporate cash holdings

Following existing empirical studies on corporate cash holdings, initiated by Opler, Pinkowitz, Stulz, and Williamson (1999), we use the following regression model (details on variable construction in Appendix A).

$$\frac{Cash_{it}}{TA_{it}} = \beta_0 + \beta_1 \times Size_{it} + \beta_2 \times \frac{NWC_{it}}{TA_{it}} + \beta_3 \times IndustrySigma_{it} + \beta_4 \times \frac{CF_{it}}{TA_{it}} + \beta_5 \times MB_{it} + \beta_6 \times \frac{CAPEX_{it}}{TA_{it}}$$
$$+ \beta_7 \times \frac{R\&D_{it}}{Sales_{it}} + \beta_8 \times Leverage_{it} + \beta_9 \times DivDummy_{it} + \beta_{10} \times \frac{ACQN_{it}}{TA_{it}}$$
$$+ \beta_{11} \times NetDiss_{it} + \beta_{12} \times NetEiss_{it} + \beta_{13} \times TbillYield_t + \beta_{14} \times DefaultSpread_t + \varepsilon_{it}$$

Based on the costs and benefits of holding cash reserves, this model attempts to explain a firm's cash holdings with a set of important determinants, including firm size, profitability, growth opportunities (as measured by market-to-book ratio, capital expenditure, and R&D expense), risk (as measured by industry cash flow volatility), etc. Net equity issuance (NetEiss) and net debt issuance (NetDiss) are included to control for the impact of external financing on cash holdings, since firms tend to save the proceeds from their external financing as cash reserves (McLean, 2011). We include the T-bill yield and the default spread to control macroeconomic conditions. The T-bill yield is used as a proxy for the risk-free rate. The default spread is the yield difference between Baa and Aaa rated long-term corporate bonds.

Table 2 documents the descriptive statistics of firm characteristics for high-tech and non-high-tech firms. Z-statistics from the Wilcoxon rank-sum test reject the null that high-tech and non-high-tech firms are from populations with the same distribution. Tests for equal means are reported by t-statistics. Overall, firms from two sectors are different in all aspects. Compared to non-high-tech firms, high-tech firms on average are smaller and less profitable; have higher cash ratio, less net working capital, more business risk, higher market-to-book ratios, lower leverage and less likely to be dividend payer; invest more on R&D but less on capital expenditure; issue less debt but more equity.

Table 2 Descriptive statistics

	Non-High-Tech Sector						High-Tech Sector							
Variable	N	Mean	Median	Standard Deviation	25th Percentile	75th Percentile	N	Mean	Median	Standard Deviation	25th Percentile	75th Percentile	t - statistic	z - statistic
Cash/TA	100324	0.113	0.054	0.149	0.020	0.142	37869	0.288	0.216	0.255	0.064	0.462	-125.9	-127.9
Size	100322	5.086	5.036	2.070	3.663	6.459	37869	3.904	3.698	1.974	2.528	5.053	98.0	96.7
NWC/TA	97017	0.127	0.120	0.206	-0.008	0.270	37507	0.116	0.118	0.213	-0.020	0.266	8.3	6.3
Industry Sigma	100293	0.061	0.055	0.029	0.039	0.079	37869	0.101	0.103	0.032	0.085	0.123	-207.9	-184.6
CF/TA	100142	0.044	0.074	0.160	0.026	0.116	37748	-0.054	0.052	0.287	-0.115	0.115	62.6	45.7
MB	98809	1.625	1.226	1.326	0.959	1.756	37515	2.688	1.886	2.260	1.244	3.208	-85.6	-110.2
Capex/TA	99171	0.078	0.053	0.081	0.026	0.099	37421	0.058	0.040	0.060	0.020	0.073	51.5	46.0
RD/Sales	100324	0.038	0.000	0.339	0.000	0.006	37869	0.450	0.088	1.201	0.032	0.201	-65.8	-233.4
Leverage	100042	0.269	0.247	0.206	0.103	0.393	37742	0.158	0.086	0.192	0.003	0.252	93.6	101.8
DivDummy	100324	0.426	0.000	0.494	0.000	1.000	37869	0.155	0.000	0.362	0.000	0.000	111.7	94.2
ACQN/TA	94893	0.020	0.000	0.056	0.000	0.003	35399	0.017	0.000	0.052	0.000	0.000	7.6	13.1
NetDiss	96535	0.014	0.000	0.102	-0.020	0.039	36580	0.009	0.000	0.094	-0.012	0.004	7.8	8.3
NetEiss	97993	0.044	0.000	0.159	0.000	0.008	36969	0.131	0.009	0.270	0.000	0.099	-58.4	-89.4

These tables present descriptive statistics of firm characteristics for high-tech firms and non-high-tech firms respectively. The sample includes 138,193 observations for 14,948 U.S. firms. The high-tech and non-high-tech sectors are defined according to the U.S. Department of Commerce. Size is the logarithm of net assets. NWC is net working capital, equal to current assets minus current liabilities minus cash. IndustrySigma is the mean of cash flow standard deviations of firms in the same industry. CF is operating income before depreciation, less interest and taxes. M/B is market value of equity plus total assets minus book value of equity, and then divided by total assets. CAPEX is capital expenditure. R&D/Sales is R&D expenditure to sales. Leverage is the ratio of long-term debt plus debt in current liabilities to total assets. DivDummy is dividend dummy, set to one if common dividend is positive. ACQN is acquisition expenditures. NetDiss is equal to long-term debt issuance minus long-term debt reduction, scaled by total assets. NetEiss is equal to the sale of common and preferred stock minus the purchase of common and preferred stock, scaled by total assets. The *t*-statistics are tests for equal means across two sectors. The z-statistics are from the Wilcoxon rank-sum test, which tests whether high-tech firms and non-high-tech firms are from populations with the same distribution.

Table 3 Determinants of corporate cash holdings: 1974-2007

Panel A:

	All Firms				HT	NHT	Diff
	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Size	-0.018***	-0.019***	-0.019***	-0.020***	-0.022***	-0.017***	0.000
	(-30.12)	(-30.56)	(-30.86)	(-31.56)	(-17.01)	(-26.75)	
NWC/TA	-0.287***	-0.310***	-0.286***	-0.307***	-0.450***	-0.224***	0.000
	(-53.60)	(-51.23)	(-53.23)	(-50.91)	(-38.52)	(-37.77)	
Industry Sigma	0.674***	0.565***	0.704***	0.624***	0.580***	0.161***	0.000
	(20.48)	(14.62)	(18.72)	(12.39)	(6.69)	(4.85)	
CF/TA	0.127***	0.133***	0.131***	0.137***	0.191***	0.089***	0.000
	(24.13)	(25.11)	(24.90)	(25.87)	(23.94)	(12.83)	
MB	0.009***	0.008***	0.009***	0.008***	0.006***	0.008***	0.174
	(14.60)	(13.28)	(14.47)	(13.17)	(7.71)	(9.26)	
Capex/TA	-0.548***	-0.498***	-0.542***	-0.492***	-0.644***	-0.427***	0.000
	(-50.15)	(-44.84)	(-49.25)	(-43.98)	(-25.90)	(-35.52)	
RD/Sales	0.059***	0.057***	0.058***	0.056***	0.051***	0.059***	0.113
	(37.43)	(34.72)	(37.09)	(34.43)	(29.64)	(13.15)	
Leverage	-0.354***	-0.355***	-0.348***	-0.350***	-0.484***	-0.279***	0.000
	(-65.92)	(-64.97)	(-64.51)	(-63.69)	(-37.00)	(-48.10)	
DivDummy	-0.008***	-0.009***	-0.008***	-0.008***	-0.022***	0.002	0.000
	(-4.18)	(-4.29)	(-3.97)	(-4.01)	(-3.85)	(1.15)	
ACQN/TA	-0.444***	-0.431***	-0.446***	-0.433***	-0.617***	-0.346***	0.000
	(-48.58)	(-47.28)	(-48.14)	(-46.99)	(-30.03)	(-37.24)	
NetDiss	0.315***	0.309***	0.308***	0.303***	0.392***	0.253***	0.000
	(48.44)	(48.03)	(47.48)	(47.16)	(25.94)	(36.72)	
NetEiss	0.205***	0.205***	0.209***	0.208***	0.184***	0.212***	0.000
	(53.25)	(53.12)	(53.88)	(53.75)	(32.99)	(39.27)	
TbillYield	-0.132***	-0.143***			-0.305***	-0.091***	0.001
	(-6.03)	(-6.97)			(-5.13)	(-4.16)	
Default Spread	1.893***	1.816***			2.069***	1.305***	0.043
	(15.01)	(14.26)			(5.79)	(10.87)	
Constant	0.311***	0.297***	0.344***	0.328***	0.436***	0.291***	0.000
	(52.37)	(20.67)	(51.22)	(21.80)	(29.64)	(44.34)	
Observations	117240	117240	117240	117240	32583	84657	
Adj. R-squared	0.558	0.566	0.562	0.569	0.586	0.423	
Year FE	No	No	Yes	Yes			
Industry FE	No	Yes	No	Yes			
F-test for two sectors							
F(15, 117210)							538.26
Prob > F							0.0000

Panel B:

	Absolute Values			Standardized Values		
	All Firms	High-Tech	Non-High-Tech	All Firms	High-Tech	Non-High-Tech
Leverage	15.50%	15.50%	14.00%	27.70%	26.40%	33.10%
RD/Sales	10.00%	10.50%	2.80%	17.90%	17.90%	6.60%
NetEiss	6.80%	5.60%	6.50%	12.10%	9.50%	15.30%
NWC/TA	6.60%	15.50%	5.40%	11.90%	26.40%	12.70%
Size	6.40%	3.40%	7.90%	11.50%	5.80%	18.60%
Industry Sigma	3.80%	1.40%	0.10%	6.80%	2.30%	0.20%
Capex/TA	2.20%	2.10%	2.00%	4.00%	3.60%	4.80%
MB	1.50%	0.50%	1.00%	2.60%	0.90%	2.40%
NetDiss	1.10%	1.20%	1.10%	1.90%	2.00%	2.70%
CF/TA	1.00%	1.60%	0.60%	1.80%	2.70%	1.30%
ACQN/TA	0.80%	1.20%	0.90%	1.50%	2.00%	2.00%
Default Spread	0.10%	0.10%	0.10%	0.20%	0.10%	0.20%
DivDummy	0.10%	0.10%	0.00%	0.10%	0.20%	0.00%
TbillYield	0.00%	0.10%	0.00%	0.10%	0.20%	0.00%
Total Variation	55.80%	58.70%	42.30%	100%	100%	100%
By 5 Core Variables	45.30%	50.40%	36.50%	81.10%	85.90%	86.30%
By R&D and NWC	16.60%	26.00%	8.20%	29.70%	44.30%	19.30%

This table analyzes the impact of firm characteristics on firms' cash holdings over the period from 1974 to 2007. In Panel A, Column (1)-(4) are based on all firms. Column (5) and (6) are separate regressions for the high-tech and non-high-tech sectors. Column (7) tests whether the coefficients estimates for the high-tech sector are different from the non-high-tech sector. P-values are reported. The standard errors are adjusted for clustering on firms. t-statistics are reported in the parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. 'F-test' indicates the joint test that all coefficients are equal between two sectors. Panel B reports the relative importance of the explanatory variables in the regression with the pooled sample, as well as the regressions with high-tech and non-high-tech firms respectively. For each determinant two values are reported: the percentage of the variation of the dependant variable that it explains (absolute value) and the percentage of the variation explained within the regression model (standardized value).

Panel A of Table 3 presents the results of regression estimated over the entire sample period. The standard errors are adjusted for firm-level clustering, assuming errors are independent across firms but not over time (Petersen, 2009). The first column reports the ordinary least squares (OLS) estimates. The results are consistent with previous studies. Small firms with high growth opportunities and low net working capital in industries with high cash flow volatility tend to hold more cash; while stable firms, such as those with dividend payments or higher leverage, usually hold less cash. Moreover, higher levels of capital expenditures and acquisitions are associated with lower cash holdings. The coefficients on net equity issuance and net debt issuance are positive and statistically significant, consistent with the argument that firms keep some of the proceeds from external financing in the form of cash. The coefficients on the T-bill yield and the default spread have correct signs, that is, they are negative and positive respectively. When macroeconomic conditions deteriorate, the default spread widens due to higher default risk and the central bank cuts interest rates to stimulate the economy. Meanwhile, firms usually increase their cash reserves due to stronger precautionary motives. The adjusted R-squared is 55.8%, indicating that the regression provides a good explanation of the variation in cash holding.

We take several robustness checks. To address the potential industry fixed effects, in column [2] we add industry indicator variables in the regression. The results are almost identical to the OLS estimation. To examine whether the T-bill yield and the default spread properly capture the common trend related to macroeconomic events, we replace these two variables with year dummies. The coefficient estimates reported in column [3] are almost the same as those in column [1], and the adjusted R-squared increases only by 0.4%. Therefore, using the T-bill yield and the default spread gives results that are similar to those year dummy variables. Results are similar if the model is estimated with year and industry fixed effects (Column [4]).

Since the business environment is different for firms in the high-tech versus non-high-tech sectors, it is highly possible that the impacts of firm characteristics on corporate cash holdings are different between these two sectors. We estimate the cash model for these two sectors separately over the sample period, the results of which are reported in columns [5] and [6]. The adjusted R-squared is 58.6% for the high-tech sector, almost 40% higher than that of the non-high-tech sector (42.3%), indicating that the cash model provides a much better fit for high-tech firms. Column [7] tests whether the coefficient estimates are statistically different across two sectors. Although all the coefficients, except dividend dummy, have the same signs across these

two sectors, there are statistically significant differences in almost all the explanatory variables between high-tech and non-high-tech firms, except for the market-to-book ratio and the R&D-to-sales ratio. Furthermore, the F-test rejects the hypotheses that all the coefficients are jointly equal across these two sectors. Overall, there exists preliminary evidence in support of estimating the cash model for the two sectors separately.

Although the signs and statistical significance of the coefficients from the above regressions are consistent with expectations, the results do not provide clear guidance on which ones, among fourteen explanatory variables in the regression, are relatively more important in explaining corporate cash holdings. To reveal the economic importance of the factors, we apply a variance decomposition analysis designed by Grömping (2006, 2007), which provides estimates of the proportion of the variation of the dependant variable explained by the variation of each of the explanatory variables.[6] Two values are reported for each determinant: the percentage of the variation in the dependant variable that it explains (absolute value) and the percentage of the variation explained within the regression model that it contributes (standardized value). A higher absolute or standardized value indicates a more important variable.

The results based on the OLS regressions of the modified cash model for the whole sample and for the high-tech and non-high-tech sectors respectively are reported in Panel B of Table 3. According to the standardized values, the top five contributors to the overall variation in corporate cash holdings, for the pooled sample as well as for two separate sectors, are leverage, R&D intensity, net working capital, size, and net equity issuance. In total, they contribute to more than 80% of the total explanatory power of the model, irrespective of whether it is for the whole sample or for the two separate sectors. However, the explanatory power of R&D and net working capital is much stronger for high-tech than for non-high-tech firms. They jointly contribute to 44.3% of the total explanatory power of the model for the high-tech sector, but only 19.3% for the non-high-tech sector. Overall, the cash model explains 58.7% of the variation in the cash holdings of high-tech

[6] Several recent studies discussed the relative importance of explanatory variables, such as Bekaert, Harvey, Lundblad, and Siegel (2011) on equity market segmentation, Frank and Goyal (2009) on capital structure decisions, and Lemmon, Roberts, and Zender (2008) on persistence in capital structures. Grömping (2006, 2007) method is preferable as it takes into account the pair-wise correlation among the independent variables.

firms, but just 42.3% for non-high-tech firms. Hence, the absolute explanatory power of R&D and net working capital is even higher in the high-tech sector.[7]

3.2 Difference in changing firm characteristics across two sectors

Fama and French (2004) find that stock markets experienced surges of new listings in the 1980s and 1990 and their characteristics, such as profitability and growth opportunities, are different from those that went public earlier. The shift in the population characteristics of public firms, driven by these new listings, has been used to explain the puzzling phenomena of disappearing dividends, increasing idiosyncratic risk, and increasing cash holdings (Fama and French, 2001; Brown and Kapadia, 2007; Bates, Kahle, and Stulz, 2009). However, less is known about the differences in the impact of new listings in the high-tech versus non-high-tech sectors. Previous section identifies a set of firm characteristics that are related to corporate cash holdings. In this section, we investigate whether these cash-related characteristics have changed over time and how these changes are different between high-tech firms and non-high-tech sectors. Moreover, we also examine to what extent the new listings have contributed to these changes.

Panel A of Table 4 reports equally-weighted averages of each characteristics for two sectors during each decade. This provides a general picture of the evolution of a typical firm's characteristics in each sector over time. Since the difference in cash trends started in early 1980s, we use the 1970s characteristics as the benchmark for comparison, and thus focus on changes in subsequent decades.

During 1980-2007, both sectors experienced an increase in R&D intensity, firm size, business risk, and market-to-book; and a decrease in leverage, net working capital, and capital expenditure. Based on the findings described in the previous section that the cash ratio rises with business risk and R&D intensity, and decreases with net working capital, capital expenditure, size and leverage, changes in these firm characteristics, except firm size, overall point to the direction of increasing cash holdings.

[7] The contribution from the industry-level cash flow volatility (IndustrySigma) is relatively small, just around 4% of the total variation for the whole sample and even smaller for the two separate sectors. This does not necessarily shake its role as a key proxy for the precautionary motive to hold cash, as this industry-level measure, by design, has less cross-sectional variation than those firm-level variables.

Table 4 Changes in firm characteristics

Panel A: Sub-Periods

Sector	Sub-Period	Obs	Cash	Leverage	R&D	NetEiss	NWC	Size	Industry Sigma	Capex	MB	NetDiss	CF	ACQN	Div Dummy
Non-High-Tech	[1974, 1979]	17112	0.086	0.267	0.009	0.004	0.204	5.220	0.034	0.079	1.072	0.014	0.078	0.007	0.658
	[1980, 1989]	30352	0.118	0.277	0.034	0.051	0.133	4.667	0.056	0.09	1.615	0.017	0.029	0.017	0.466
	[1990, 2000]	36613	0.112	0.273	0.045	0.064	0.107	5.025	0.070	0.076	1.788	0.015	0.036	0.026	0.323
	[2001, 2007]	16247	0.132	0.247	0.059	0.025	0.076	5.867	0.077	0.061	1.813	0.007	0.051	0.024	0.339
	Time trend														
	[1980, 2007]		0.001	-0.001	0.001	-0.001	-0.003	0.053	0.001	-0.001	0.013	0.000	0.001	0.001	
	p-value		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.129	<.0001	<.0001	
High-Tech	[1974, 1979]	2696	0.096	0.250	0.050	0.023	0.291	4.262	0.043	0.08	1.497	0.017	0.079	0.005	0.414
	[1980, 1989]	8928	0.205	0.199	0.238	0.117	0.198	3.591	0.074	0.078	2.382	0.013	-0.031	0.011	0.220
	[1990, 2000]	16560	0.308	0.141	0.502	0.172	0.103	3.765	0.106	0.056	3.029	0.007	-0.064	0.018	0.115
	[2001, 2007]	9685	0.384	0.124	0.668	0.104	0.015	4.332	0.131	0.035	2.683	0.008	-0.097	0.024	0.091
	Time trend														
	[1980, 2007]		0.010	-0.004	0.024	0.000	-0.010	0.038	0.003	-0.002	0.027	0.000	-0.004	0.001	
	p-value		<.0001	<.0001	<.0001	0.119	<.0001	<.0001	<.0001	<.0001	<.0001	0.676	<.0001	<.0001	

This table compares the characteristics of firms over the period from 1974 to 2007. In Panel A, the total sample is split into four sub-periods for two sectors. Obs is the total number of observations of a given sector in the indicated sub-period. The results for each period are simple averages over all firm-year observations locating in a given sub-sample. Firm characteristic of high-tech firms and non-high-tech firms over 1980-2007 are regressed separately on a constant and a year index. Estimates of the slope coefficient are reported in the row titled Time Trends [1980, 2007]. P-values are also reported. In Panel B, the observations in each sub-period are further divided according to listing cohorts. Based on the year of going public, firms are sorted into the following cohorts: pre-1980 IPO (listed before 1980), 1980s IPO (listed from 1980 to 1989), 1990s IPO (listed from 1990 to 2000), and 2000s IPO (listed from 2001 to 2006). The results for each period are simple averages over all firm-year observations locating in a given sub-sample defined according to listing cohort and sub-period.

Panel B: Listing Cohorts in Each Sub-Period

Sector	IPO Cohort	Obs	Cash	Leverage	R&D	NetEiss	NWC	Size	Capex	MB	NetDiss	CF	ACQN	DivDummy
		Sub-Period: [1980, 1989]												
Non-High-Tech	Overall	30352	0.118	0.277	0.034	0.051	0.133	4.667	0.09	1.615	0.017	0.029	0.017	0.466
	Pre-1980 IPO	20059	0.098	0.271	0.012	0.011	0.164	5.287	0.079	1.361	0.012	0.057	0.014	0.622
	1980s IPO	10293	0.157	0.287	0.079	0.128	0.073	3.459	0.113	2.111	0.027	-0.026	0.022	0.161
High-Tech	Overall	8928	0.205	0.199	0.238	0.117	0.198	3.591	0.078	2.382	0.013	-0.031	0.011	0.220
	Pre-1980 IPO	4099	0.133	0.217	0.072	0.036	0.245	4.488	0.077	1.875	0.012	0.047	0.010	0.402
	1980s IPO	4829	0.267	0.183	0.379	0.188	0.159	2.829	0.078	2.812	0.013	-0.097	0.011	0.065
		Sub-Period: [1990, 2000]												
Non-High-Tech	Overall	36613	0.112	0.273	0.045	0.064	0.107	5.025	0.076	1.788	0.015	0.036	0.026	0.323
	Pre-1980 IPO	11143	0.083	0.260	0.011	0.000	0.137	6.031	0.065	1.514	0.007	0.075	0.019	0.627
	1980s IPO	10708	0.109	0.280	0.039	0.036	0.109	4.505	0.074	1.731	0.012	0.034	0.019	0.256
	1990s IPO	14762	0.137	0.278	0.075	0.133	0.082	4.642	0.086	2.038	0.023	0.008	0.036	0.142
High-Tech	Overall	16560	0.308	0.141	0.502	0.172	0.103	3.765	0.056	3.029	0.007	-0.064	0.018	0.115
	Pre-1980 IPO	2626	0.135	0.196	0.080	0.017	0.193	5.183	0.055	1.974	0.004	0.067	0.019	0.383
	1980s IPO	5535	0.248	0.16	0.348	0.084	0.133	3.640	0.055	2.738	0.008	-0.026	0.015	0.106
	1990s IPO	8399	0.402	0.112	0.735	0.276	0.055	3.404	0.058	3.551	0.008	-0.129	0.02	0.036
		Sub-Period: [2001, 2007]												
Non-High-Tech	Overall	16247	0.132	0.247	0.059	0.025	0.076	5.867	0.061	1.813	0.007	0.051	0.024	0.339
	Pre-1980 IPO	4001	0.093	0.241	0.014	-0.005	0.108	6.753	0.053	1.605	0.001	0.085	0.022	0.664
	1980s IPO	2586	0.122	0.234	0.039	0.010	0.115	5.548	0.058	1.725	0.005	0.060	0.020	0.383
	1990s IPO	7627	0.146	0.251	0.083	0.022	0.060	5.562	0.061	1.814	0.009	0.037	0.024	0.190
	2000s IPO	2033	0.164	0.259	0.086	0.112	0.027	5.669	0.079	2.329	0.012	0.026	0.036	0.207
High-Tech	Overall	9685	0.384	0.124	0.668	0.104	0.015	4.332	0.035	2.683	0.008	-0.097	0.024	0.091
	Pre-1980 IPO	903	0.227	0.145	0.120	0.003	0.129	6.116	0.036	2.040	0.006	0.067	0.024	0.430
	1980s IPO	1646	0.316	0.133	0.382	0.051	0.076	4.542	0.034	2.491	0.004	-0.027	0.023	0.140
	1990s IPO	5971	0.407	0.125	0.744	0.098	-0.014	4.102	0.035	2.691	0.010	-0.129	0.023	0.038
	2000s IPO	1165	0.484	0.093	1.108	0.281	-0.010	3.829	0.035	3.415	0.006	-0.161	0.028	0.035

More importantly, the extent of changes is quite different across two sectors. High-tech sector has gone through more significant changes relative to non-high-tech sector. To facilitate the comparison, we follow Brown and Kapadia (2007) to directly test the time trends in the firm characteristics of these two sectors over 1980-2007, by regressing each firm characteristic on a constant and a time index measured in years. We compare the estimates of the slope coefficient between the high-tech and non-high-tech sectors, with a focus on five core characteristics.

The *Leverage* of high-tech firms declined much faster, at a rate of 0.4% per year (compared to 0.1% per year for non-high-tech firms). The average leverage of high-tech firms in the 2000s is 12.4%, only half of the level during the 1970s benchmark period. Compared with the 1970s, *R&D intensity* has increased considerably in both sectors, but with a remarkable difference in their rates. R&D/Sales of non-high-tech firms followed an upward trend with a slope equal to 0.1%, but the time trend is much steeper in the high-tech sector, increasing from 23.8% in 1980s to 66.8% in 2000s with an annual rate of 2.4%. The ratio of *net working capital to assets* has decreased in both sectors. Starting with a higher level of 29.1% (compared to 20.4% in non-high-tech), NWC/TA of the high-tech firms, on average, ends up at a much lower level of 1.5% in the 2000s (compared to 7.6% for the non-high-tech sector) since the rate of decrease in the high-tech sector is three times faster than that in the non-high-tech sector. For both sectors, *net equity issuance* has become more common after the 1970s and experienced an inverted-U shape change with its peak in the 1990s. However, high-tech firms generally use much more equity financing than firms in the non-high-tech sector and are more dependent on equity financing than on debt financing. This is consistent with the findings of previous studies on the R&D financing literature (Hall, 2002). Finally, compared to 1970s, the average **size** of firms in both sectors has dropped in the 1980s and 1990s due to new listings. Over the entire period from 1980 to 2007, the average size has increased gradually, but high-tech firms are usually much smaller than non-high-tech firms.

Panel A also shows that growth opportunities, as measured by the market-to-book ratio, are much higher in the high-tech sector. Furthermore, a difference deserving more attention is that the growth opportunities in the high-tech sector are based on R&D expenditures, while the non-high-tech sector's growth is built mostly on capital expenditure. This difference is important since capital expenditures help build tangible assets, which can be used as collaterals and hence facilitate external financing. In contrast, growth opportunities based on R&D are more uncertain, and hence trigger a stronger precautionary motive for holding cash.

Panel A provides evidence that the high-tech sector has shifted more significantly towards a set of firms with characteristics consistent with higher and increasing cash holdings. In Panel B, we decompose the firms in each sub-period according to the year they went IPO and investigate whether the changes are driven by new listings.[8]

When compared to the non-high-tech sector, the high-tech sector has been progressively dominated by new listings. During the 1980s, the 1980 IPO cohort constitutes 54% of the observations in the high-tech sector, compared to 34% in the non-high-tech sector. During the 1990s, the 1980 and 1990 cohorts jointly contribute to 84% of the sample observations in the high-tech sector, while the ratio is 70% for the non-high-tech sector. Even after the burst of the Internet bubble, 79% of the observations in the 2000s are from the 1980s and 1990s cohorts in the high-tech sector, whereas the ratio is 63% in the non-high-tech sector.

Moreover, firms in the later cohorts are different from those in the earlier cohorts, and these differences are more significant in the high-tech as compared to the non-high-tech sector. In the high-tech sector, although the firms that survived in each cohort have on average decreased their leverage over time, a more important phenomenon is that the leverage of firms from the later cohorts is always lower than that in an earlier cohort. A similar pattern is not obvious in the non-high-tech sector. In both sectors, later cohorts have higher R&D intensity, but the increase takes place much faster in the high-tech sector. The R&D-to-sales ratio of the Pre-1980 IPO cohorts is around 10% in all the sub-periods, while the R&D-to-sales ratio of the 1980s cohort is between 35% and 38% over time, and the ratio of the 1990s cohort is even higher at 74%. Hence, the higher R&D intensity of new listings has contributed to the increase in the average R&D intensity in the high-tech sector. A similar analysis can be applied to other characteristics, for example net working capital and net equity issuance.

In sum, the results tabulated in Table 4 show that when compared to the non-high-tech sector, the population of publicly traded firms in the high-tech sector has tilted more towards characteristics typical of firms that hold more cash. The source of this tilt is new listings: they dominate the high-tech sector by number and they differ significantly from more senior firms.

[8] Industry Sigma is excluded from this table since it is an industry measure and hence impossible to decompose the contribution of each IPO cohort.

3.3 Can difference in changing characteristics explain different cash trends?

To test whether the difference in changing firm characteristics can explain the difference in the observed cash trends across high-tech and non-high-tech sectors, we follow the basic empirical strategy proposed in Fama and French (2001). First, we estimate the modified regression model of corporate cash holdings over the period from 1974 to 1983 (estimation period). This provides a model of how cash holdings depend on firm characteristics identified earlier.[9] We then use this estimated model of corporate cash holdings to predict the cash that firms should hold over the 1984-2007 period. By fixing the coefficients based on the 1974-1983 period but allowing for changes in firm characteristics, the predictions capture the change in cash holdings explained by changing firm characteristics.

Table 5 reports coefficient estimates of the modified model of cash holdings during the estimation and forecast periods, for the pooled sample (all firms) and for the high-tech and non-high-tech sectors respectively. Setting aside the dividend dummy, estimated slopes in both estimation and forecast periods confirm the inferences drawn from regressions with the entire sample period. In the pooled regression and separate regressions for high-tech and non-high-tech firms, F-tests reject the hypothesis that all coefficients are jointly equal between estimation and forecast periods. However, when the t-statistics of the estimates are considered, a smaller number of variables is found to differ in the cases of the regressions conducted separately for high-tech and non-high-tech firms, thus pointing to a lower extent of discrepancy.

Given these parameter estimates from the estimation period, we can assess the cash-to-assets ratio that a firm in the high-tech (non-high-tech) sector would have maintained had the firm chosen its cash holdings in the same way as during the estimation period. More specifically, the expected cash ratios are computed by applying the coefficient estimates from the estimation period to the values of the explanatory variables for each firm-year observation during the forecast period of 1984-2007. The finding that the actual cash ratio stays above the expected value, in the spirit of Fama and French (2001), indicates that a firm is more inclined to hold cash than in the forecast period.

[9] Although the difference in the cash trends starts around 1980, we expand the estimation period to 1983 to increase the number of available observations for estimating the model coefficients. Moreover, since this estimation period covers the recessions in the early 1980s and the subsequent hot IPO markets, it contains adequate variations in external financing variables and macroeconomic variables to ensure a proper estimate of their impacts on cash policy.

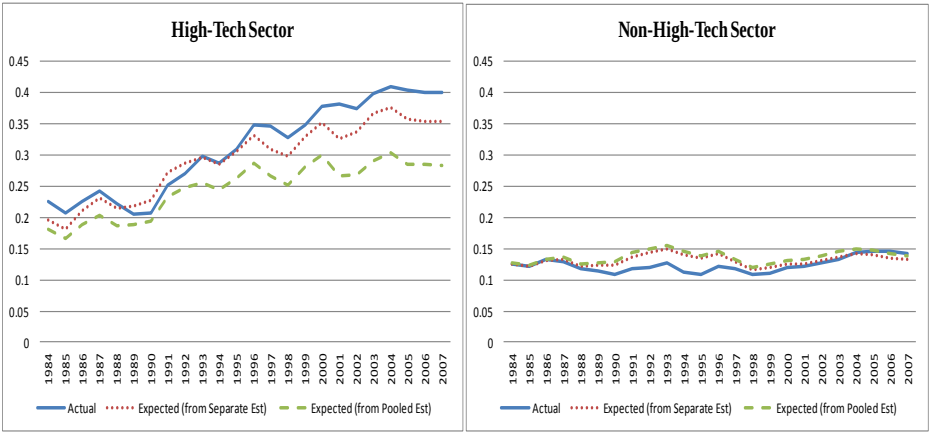
Table 5 Determinants of corporate cash holdings: estimation vs. forecast periods

	All Firms			High-Tech			Non-High-Tech		
	1974-1983	1984-2007		1974-1983	1984-2007		1974-1983	1984-2007	
	(1)	(2)		(3)	(4)		(5)	(6)	
Size	-0.016***	-0.019***	###	-0.014***	-0.024***	###	-0.016***	-0.017***	
	(-21.58)	(-26.41)		(-7.12)	(-16.64)		(-20.75)	(-22.30)	
NWC/TA	-0.258***	-0.294***	###	-0.441***	-0.451***		-0.234***	-0.221***	
	(-32.04)	(-47.68)		(-20.18)	(-35.59)		(-26.93)	(-32.06)	
Industry Sigma	0.371***	0.709***	###	0.612**	0.598***		0.288***	0.178***	
	(4.30)	(18.96)		(2.03)	(5.43)		(3.18)	(4.60)	
CF/TA	0.129***	0.131***		0.217***	0.193***		0.094***	0.090***	
	(10.12)	(23.10)		(9.46)	(22.88)		(6.26)	(11.71)	
MB	0.005***	0.010***	###	0.003	0.007***		0.005***	0.009***	##
	(3.88)	(15.36)		(1.34)	(8.36)		(3.13)	(9.30)	
Capex/TA	-0.445***	-0.574***	###	-0.607***	-0.649***		-0.404***	-0.439***	
	(-26.03)	(-44.57)		(-14.60)	(-22.48)		(-21.47)	(-30.98)	
RD/Sales	0.043***	0.058***	##	0.036***	0.051***	#	0.051***	0.059***	
	(6.27)	(36.21)		(4.16)	(28.57)		(5.10)	(12.50)	
Leverage	-0.270***	-0.370***	###	-0.355***	-0.498***	###	-0.258***	-0.284***	###
	(-33.62)	(-59.96)		(-15.71)	(-34.47)		(-30.17)	(-42.54)	
DivDummy	0.009***	-0.017***	###	-0.001	-0.030***	###	0.011***	-0.002	###
	(3.65)	(-6.78)		(-0.10)	(-4.33)		(4.47)	(-0.88)	
ACQN/TA	-0.382***	-0.437***	##	-0.553***	-0.607***		-0.350***	-0.343***	
	(-17.69)	(-44.28)		(-9.27)	(-28.33)		(-15.40)	(-33.89)	
NetDiss	0.245***	0.324***	###	0.346***	0.398***	#	0.227***	0.259***	##
	(21.49)	(43.81)		(12.70)	(23.83)		(18.07)	(32.73)	
NetEiss	0.279***	0.197***	###	0.290***	0.175***	###	0.261***	0.204***	###
	(26.78)	(47.55)		(16.99)	(30.20)		(19.87)	(34.42)	
TbillYield	-0.093***	-0.230***	###	-0.142**	-0.351***	##	-0.081***	-0.143***	
	(-4.83)	(-6.26)		(-2.46)	(-4.09)		(-3.98)	(-3.83)	
Default Spread	0.420***	2.994***	###	1.020***	2.809***	###	0.284***	2.623***	###
	(4.35)	(12.44)		(3.78)	(5.17)		(2.79)	(10.78)	
Constant	0.295***	0.311***		0.360***	0.437***	###	0.288***	0.282***	
	(39.77)	(42.58)		(15.72)	(23.80)		(36.44)	(34.00)	
Observations	29004	88236		4492	28091		24512	60145	
Adj. R-squared	0.466	0.558		0.596	0.561		0.424	0.421	
F-test		36.36			9.19			10.49	
p-value		0.00			0.00			0.00	

This table presents the results of coefficient estimates for the high-tech and non-high-tech sectors, jointly and separately, during the estimation period from 1974 to 1983 and the forecast period from 1984 to 2007. The sample contains 138,193 observations, 34,235 in estimation period and 103,958 in forecast period. Results from OLS regressions are reported for the pooled sample (Column (1)-(2)), the high-tech sector (Column (3)-(4)), and the non-high-tech sector (Column (5)-(6)). The standard errors are adjusted for clustering on firms. t-statistics are

reported in the parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. #, ##, and ### indicate statistical significance at the 10%, 5%, and1% levels, respectively, for a t-test that tests whether the coefficients are equal between the two sub-periods. 'F-test' indicates the joint test that all coefficients are equal between estimation and forecast periods.

Figure 2 Actual and expected cash holdings: forecast period



These plots show the expected cash holdings based on pooled estimation and separate estimation, as well as the actual cash holdings, in the high-tech sector and in the non-high-tech sector during the forecast period from 1984 to 2007. The sample includes 103,958 observations during the period from 1984 to 2007, including 32,541 observations in the high-tech sector and 71,417 observations in the non-high-tech sector. Due to missing explanatory values, we can calculate expected cash holdings for 28,091 observations in the high-tech sector and 60,145 observations in the non-high-tech sector. Expected cash holdings are calculated for each firm-year observation by fitting the firm characteristics in forecasting period into the cash holding model estimated in the estimating period. In the plot about the high-tech sector, coefficients estimates during the estimation period come from the separate regression on high-tech firms and from the pooled regression with all firms. In the plot about the non-high-tech sector, coefficients estimates during the estimation period come from the separate regression on non-high-tech firms and from the pooled regression with all firms.

Figure 2 reports the annual mean of actual and expected cash holdings in high-tech and non-high-tech sectors, with the coefficients being estimated respectively from the pooled regression and the separate regressions during the estimation period. For non-high-tech firms, the actual value of cash holdings in the forecast period is closely tracked by the expected value, no

matter based on coefficient estimates from pooled regression or separate regression in the estimation period. However, the story is quite different for high-tech firms. Overall, expected cash holdings are lower than the actual level in high-tech sector, indicating that on average high-tech firms tend to hold more cash than needed in the forecast period. More importantly, although expected cash holdings in the high-tech sector on average track the upward trend, the results based on the coefficient estimates from separate regression are much better, as evidenced from a smaller deviation from the annual means of actual values. More specifically, if we ignore the difference between two sectors by applying coefficients estimates from the pooled regression in the estimation period, the inference on the out-of-sample forecast would be that high-tech firms on average hold much more cash than needed for most years and the excess cash increases faster over time, staying above 10% in the 2000s. Since the expected level of cash holdings already takes into account the various motives of holding cash, persistently holding excess cash at such a high level would be considered as a puzzle. Nevertheless, the results based on the coefficients from the separate regression for the high-tech sector tells a different story: high-tech firms on average seem to hold more cash than needed over the past decade, but on average the excess cash is always below 5% of assets.

Overall, the analysis in this section shows that the difference in changing cash-related firm characteristics can help explain the difference in cash trends across the high-tech and non-high-tech sectors. Moreover, the distinct results in the high-tech sector when using coefficient estimates from separate versus the pooled regressions imply that future studies should properly account for the potential difference across these two sectors before concluding that high-tech firms on average hold too much excess cash.

4 - Conclusion

Cash holdings of U.S. firms have grown gradually over time. A recent paper by Bates et al (2009) shows that the average cash-to-assets ratio has more than doubled from 1980 to 2006. In this study, we find that this upward trend in corporate cash holdings is not pervasive across all industries; instead, it is a phenomenon specific to the high-tech sector. In contrast to the average cash ratio of non-high-tech firms that remained stable around 11%, which is similar to its level during the 1970s, the average cash ratio in the high-tech sector has increased significantly, rising gradually from 11.2% in 1980 to 39.1% in 2007.

The identified difference in the cash trends of these two sectors coincides with a growing difference in the cash-relevant firm characteristics. When compared to the non-high-tech sector, the population of public firms in the high-tech sector has tilted toward attaining the characteristics typical of firms that hold more cash. This tilt is caused by the new listings: the high-tech sector has expanded considerably by the new listings in the 1980s and 1990s, whose nature differ notably from existing firms. In contrast, the new listings in the non-high-tech sector are similar to existing ones and thus less change is seen in the characteristics of its population.

In order to test whether the differences in changing firm characteristics provide an adequate explanation for the observed difference in the cash trends across these two sectors, we employ the basic framework proposed in Fama and French (2001). The out-of-sample forecasts, based on coefficients estimated separately for the two sectors in the early sub-period and changing firm characteristics in the forecast period, on average, adequately justify the observed difference in cash trends across the high-tech and non-high-tech sectors over time. Furthermore, for the high-tech sector, the average excess cash holdings is reduced to only around 5% of the total assets when the coefficients from the separate estimation per sector are used compared to an average of above 10% of the total assets, when the coefficients from a pooled estimation are used. This result should generate some skepticism towards a "one-size-for-all" cash holding model, as it may generate false claims that the high-tech sector holds too much cash.

Over the past three decades, the high-tech sector has become more important among the publicly listed US firms due to the disproportional influx of new listings into this sector. Moreover, high-tech firms are different from traditional firms in terms of operation, investment, and financial policies. The results in this paper document this difference and highlight the importance of developing theoretical and empirical models in future studies to examine the high-tech sector in particular, instead of relying on a generic model for all industries.

Appendix A: Variable construction

All names in parentheses refer to the Compustat (XPF version, Fundamental Annual) item names.

- **Cash-to-assets ratio (Cash/TA)** is measured as cash plus marketable securities (CHE), divided by book value of total assets (AT).
- **Industry cash flow volatility (IndustrySigma)**: For each firm-year, we compute the standard deviation of cash flow over assets for the previous

10 years if there are at least 3 observations. Industry sigma is calculated as the mean of cash flow standard deviations of firms in the same industry, defined by 2-digit SIC code.

- **Market-to-Book (MB)** is the ratio of market value of assets to book value of assets. The market value of assets is equal to total assets (AT) minus book value of common equity (CEQ) plus the market value of common equity (fiscal year end price (PRCC_F) times shares outstanding (CSHO)).
- **Size** is measured with the logarithm of net assets (AT-CHE) that is converted to 2006 dollars using the Consumer Price Index.
- **Cash flow over assets (CF/TA)** is defined as operating income before depreciation (OIBDP), less interest (XINT) and taxes (TXT), and then divided by total assets.
- **Net working Capital over assets (NWC/TA)** is the ratio of working capital (ACT-LCT) minus cash and marketable securities (CHE) to total assets.
- **Capital expenditures (Capex/TA)** is the ratio of Capital expenditures (CAPX) to total assets.
- **Leverage** is long-term debt (DLTT) plus debt in current liabilities (DLC), divided by total assets.
- **R&D/Sales** is the ratio of R&D expenditure (XRD) to Sales (SALE). It is set to zero if R&D expenditure (XRD) is missing.
- **Dividend payer (DivDummy)** is set to one if common dividend (DVC) is positive; else equal to zero.
- **Acquisition (ACQN/ TA)** is the ratio of Acquisitions (AQC) to total assets.
- **Net debt issuance (NetDiss)** is equal to long-term debt issuance (DLTIS) minus long-term debt reduction (DLTR), scaled by total assets.
- **Net equity issuance (NetEiss)** is equal to the sale of common and preferred stock (SSTK) minus the purchase of common and preferred stock (PRSTKC), scaled by total assets.
- **T-bill yield** is the average annual three-month rates published by the Federal Reserve.
- **Default spread** is the average yield on Baa less Aaa Moody's rated corporate bonds with maturity of approximately 20-25 years. Data are from http://research.stlouisfed.org/fred2/.
- **IPO date**: Jay Ritter's proprietary database of IPO dates is used. If the IPO date of a stock is unavailable from Ritter, the first trading date on the CRSP is identified as the IPO date.

Appendix B: Robustness checks

Table B.1 Trends in cash holdings: Fama-French industries and GICS economic sectors

Panel A: the Fama-French 12 industry groups

	Cash/TA_Mean			Cash/TA_Median			Cash/TA_VW		
Description (FF 12 industries)	**Slope**	**P-value**	**R-Sq**	**Slope**	**P-value**	**R-Sq**	**Slope**	**P-value**	**R-Sq**
BusEq	**0.85%**	**<.0001**	**0.88**	**1.03%**	**<.0001**	**0.88**	**0.72%**	**<.0001**	**0.86**
Chems	0.06%	0.144	0.08	-0.04%	0.191	0.06	0.03%	0.298	0.04
Durbl	0.05%	0.218	0.06	0.03%	0.502	0.02	0.00%	0.992	0.00
Enrgy	-0.23%	<.0001	0.57	-0.13%	0.000	0.42	-0.03%	0.453	0.02
Hlth	**0.92%**	**<.0001**	**0.88**	**1.11%**	**<.0001**	**0.86**	**0.29%**	**<.0001**	**0.53**
Manuf	0.09%	0.002	0.31	0.04%	0.233	0.05	0.03%	0.313	0.04
NoDur	-0.01%	0.842	0.00	-0.02%	0.362	0.03	-0.05%	0.031	0.17
Shops	0.03%	0.356	0.03	-0.02%	0.506	0.02	0.08%	0.020	0.19
Telcm	**0.20%**	**<.0001**	**0.45**	**0.15%**	**<.0001**	**0.57**	**0.09%**	**<.0001**	**0.51**
other	0.15%	0.000	0.44	0.07%	0.027	0.17	0.01%	0.876	0.00

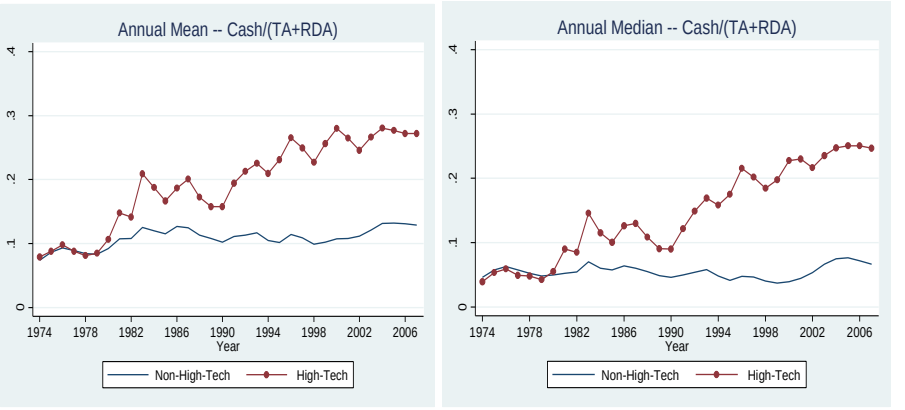
Panel B: the GICS Economic Sectors

	Cash/TA_Mean			Cash/TA_Median			Cash/TA_VW		
Description (GICS Economic Sectors)	**Slope**	**P-value**	**R-sq**	**Slope**	**P-value**	**R-sq**	**Slope**	**P-value**	**R-sq**
Energy (10)	-0.18%	0.000	0.42	-0.10%	0.005	0.26	-0.02%	0.648	0.01
Materials (15)	-0.09%	0.004	0.28	-0.06%	0.016	0.20	0.03%	0.286	0.04
Industrial (20)	0.02%	0.573	0.01	-0.01%	0.739	0.00	-0.09%	0.002	0.31
Consumer discretionary(25)	0.08%	0.006	0.26	0.04%	0.181	0.07	-0.01%	0.830	0.00
Consumer staples (30)	-0.06%	0.071	0.12	-0.06%	0.011	0.23	-0.08%	0.005	0.26
Health care (35)	**0.82%**	**<.0001**	**0.85**	**0.92%**	**<.0001**	**0.86**	**0.25%**	**<.0001**	**0.52**
Financials (40)	0.04%	0.648	0.01	0.24%	0.006	0.25	-0.57%	0.118	0.09
Information technology(45)	**0.86%**	**<.0001**	**0.89**	**1.05%**	**<.0001**	**0.90**	**0.80%**	**<.0001**	**0.89**
Telecommunications (50)	**0.40%**	**<.0001**	**0.72**	**0.31%**	**<.0001**	**0.75**	**0.13%**	**<.0001**	**0.51**
Utilities (55)	-0.07%	0.575	0.01	-0.09%	0.439	0.02	0.13%	0.150	0.08

This table reports the trends in cash holdings of industry groups defined by the Fama-French 12 industry classification (Panel A) and the Global Industry Classification Standard (GICS) (Panel B) over the period from 1980 to 2007. The cash-to-assets ratio (Cash/TA) is measured as cash plus marketable securities (CHE), divided by book value of total assets (AT). The annual mean, median, and value-weighted average (based on annual book assets) of Cash/TA in each subsample are regressed separately on a constant and a year index. Estimates of the slope coefficient, p-value, and R-squared are reported for each industry group separately.

Figure B.1 Trends in cash holdings – R&D adjusted assets as the denominator

Panel A: Annual Mean **Panel B: Annual Median**



These figures depict the annual mean and median of the cash ratio of the whole sample and of the high-tech and non-high-tech sectors over the period 1974 to 2007. The sample includes U.S. firms documented on the Compustat-CRSP merged database (fundamental annual) that have positive total assets and sales and nonnegative cash and marketable securities, and have common shares traded on the NYSE, AMEX, or Nasdaq. Financial firms (SIC code 6000-6999) and utility firms (SIC codes 4900-4999) are excluded from the sample, leaving an unbalanced panel of 138,193 observations for 14,948 unique firms. The high-tech and non-high-tech sectors are defined according to the U.S. Department of Commerce. The cash-to-R&D adjusted assets ratio is measured as cash plus marketable securities (CHE), divided by the R&D-adjusted book assets (the sum of book assets (TA) and R&D asset). The R&D asset (RDA) is defined as the weighted sum of its R&D expense over the past five years assuming an annual amortization rate of 20% ($RDA_{it} = RD_{it} + 0.8 \cdot RD_{it-1} + 0.6 \cdot RD_{it-2} + 0.4 \cdot RD_{it-3} + 0.2 \cdot RD_{it-4}$). Figures in Panel A (B) depict the annual mean (median) of the cash-to-R&D adjusted assets ratio for firms in two sectors separately.

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