Firm Selection and Corporate Cash Holdings*

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Abstract

We show that a change in the composition of firms at IPO is responsible for the secular increase in the cash holdings of public U.S. firms. While the typical public U.S. firm experiences a decline in the cash-to-asset ratio over time, firms go public with progressively higher cash balances. This selection effect, mostly driven by R&D-intensive firms, reverses the negative within-firm time trend. We use a firm industry model with endogenous entry in the stock market to explore a set of competing selection mechanisms: 1) a structural change in the composition of firms in the U.S. economy and 2) better IPO conditions for R&D-intensive firms. A combination of both can explain 60% of the secular increase in cash holdings between 1979 and 2013.

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1 Introduction

Over the last thirty years, cash holdings of the average U.S. public company have more than doubled.\(^1\) Most explanations in the literature draw on changes within firms. That is, a change in the business environment caused existing public firms to increase their cash–to–asset ratio over time. We show that the main driver of the secular increase in cash holdings is an increasing share of R&D–intensive firms that become public with progressively higher cash balances.

Figure 1: Industry Composition of U.S. Public Firms (1959-2013)

The left panel of this figure presents the share of R&D–intensive firms in Compustat. The middle panel shows the share of R&D–intensive entrants. The right panel shows the average cash-to-assets ratio at entry R&D–intensive and non–R&D–intensive firms. A R&D intensive firm belongs to an industry whose average R&D investment amounts to at least 2% of assets over the sample period. We group firms into cohorts of five years starting from 1959. We define as *entrant* a firm that reports a fiscal year-end value of the stock price for the first time (item *PRCC_{F}*).

Figure 1 presents the basic story. Starting at the end of the 1970s, the fraction of R&D–intensive\(^2\) publicly traded firms has steadily increased (left panel), driven by a steady

\(^1\)We show the evolution of the average cash–to–asset ratio of U.S. listed firms during the period 1958–2014 in appendix A.

\(^2\)A R&D–intensive firm belongs to an industry whose average R&D investment amounts to at least 2% of assets over the sample period. We choose 2% as the cut-off level because this is the minimum R&D to asset ratio of the top quintile industries in terms of R&D to asset. Industries are calculated at the three-digit SIC level.
increase in the fraction of R&D–intensive entrants (middle panel). At the same time, R&D–
intensive firms have gone public with progressively higher cash balances (right panel). In
the 1970s, R&D–intensive firms went public (entered the Compustat sample) with about
the same average cash–to–asset ratio as non–R&D–intensive entrants (0.09). After 35 years
however, this number more than quadrupled for R&D–intensive entrants (0.54 for the 2009–
2013 cohort), while it has remained very close to the 1970s values for non–R&D–intensive
entrants (0.12 for the 2009-2013 cohort). In this paper, we show that the secular increase
in cash holdings is driven by a gradual replacement of non–R&D–intensive firms by R&D–
intensive firms (i.e., selection) and their higher cash holdings at entry.

We first quantify the effect of selection by simply decomposing the change in the average
cash–to–asset ratio into the change due to incumbent firms and the change due to net entry
(i.e., non–incumbent firms). The former component measures the within-firm change, while
the latter component measures the overall contribution of selection. We find the contribution
of incumbent firms to be negative. Over the period 1979–2012, incumbent firms decrease
their cash–to–assets ratio by 0.005 per year, a cumulative change of -0.17 over 34 years. Why
do we observe a secular increase in cash holdings? It is because the contribution of selection is
large enough to reverse the negative trend due to incumbent firms. Non-incumbent firms are
responsible for an average increase in the cash–to–assets ratio of 0.010 per year, a cumulative
change of 0.34 over 34 years. R&D–intensive firms account for the bulk of the selection effect.

Second, we also estimate the contribution of selection using linear regression techniques.
We first run pooled OLS regressions to estimate the cumulative change in cash, which is equal
to 0.15. Then, we estimate the cumulative change in the cash ratio of incumbents by running
regressions with a firm-specific intercept and a firm-specific slope. The estimated cumulative
change is -0.17. In contrast, the estimated contribution of selection is 0.32, consistent with
our simple decomposition. Thus, entrants’ increase in their cash-to-asset ratio occurs at a
faster rate than incumbents’ depletion of cash over time. This generates a positive time
trend in the average cash–to–ratio.

Focusing on changes within firms misses a key feature of the data: the compositional
change of publicly traded U.S. companies over the last 35 years. We build a firm industry
model with endogenous entry to investigate two potential reasons for an increase in the cash–to–asset ratio that is driven by selection. Our model allows us to test the quantitative importance of different selection mechanisms and to analyze their interaction. First, we study the effects of a structural change in the composition of the overall U.S. economy that makes IPOs of R&D–intensive firms more likely. Second, in the spirit of Fama and French (2004) we explore whether an increased supply of equity capital for risky investments such as R&D–intensive firms can generate a secular increase in the cash ratio\textsuperscript{3}. We model the improvement in funding conditions as a reduction in the stock exchange entry cost for R&D–intensive firms that increases their likelihood of going public. We discipline these exercises using the observed data.\textsuperscript{4} Third, we study the interaction of these two potential mechanisms.

We start by studying the effects of a compositional change in isolation and show that the model generates a negligible increase in average cash holdings. This is entirely due to the increase in the proportion of young R&D–intensive firms. Then, we separately study the effect of a reduction in the entry cost for R&D–intensive firms. In this case, the model–generated selection effect is able to explain around one third of the change in cash holdings over the period 1979–2013. The model’s performance is dramatically improved when a compositional change coincides with a reduction in the entry cost for R&D–intensive firms. In this case, the model explains around 60% of the change in cash holdings. The key for the model’s success is in the increased proportion of young R&D–intensive firms (driven by the compositional change) that amplifies the effect of higher cash balances at entry (driven by the reduction in the entry cost). This is important as firms on a firm by firm basis deplete cash over time. Without the influx of young firms with higher cash balances at IPO, the model fails to account for the secular increase in cash holdings.

\textit{Related Literature}

\textsuperscript{3}Michelacci and Suarez (2004) propose a model where technological spillovers and market externalities reduce the costs for start-ups to go public. This mechanism could explain the observed rise in the number of young firms going public in the U.S. equity markets.

\textsuperscript{4}We calibrate (i) the change in the composition of potential entrants to replicate the observed change in composition of publicly traded firms over the period 1979–2013 and (ii) the change of the entry cost for R&D–intensive firms to replicate the observed dynamics of average cash holdings upon entry for R&D–intensive firms over the period 1979–2013.
The causes of the increase in cash-to-asset ratios of public U.S. corporations has been studied in numerous papers. However, most papers attribute the change in firms’ average cash-holdings to changes within firms or the business environment. Instead, we propose a novel explanation in which the secular increase in cash-holdings is due to a dramatic shift in the composition of firms.

In theory, there are several reasons for firms to hold cash. A classic motive are transaction costs (e.g. Baumol (1952), Tobin (1956), and Miller and Orr (1966)). For example, taxes levied on repatriated profits can be interpreted as transaction costs. This argument has been advanced by Foley, Hartzell, Titman, and Twite (2007). A precautionary savings motive entices firms to accumulate cash when external financing frictions make it harder to take advantage of attractive investment opportunities (Froot, Scharfstein, and Stein (1993)). Jensen (1986) proposed an agency motive that explains excess cash holdings.

The recent empirical literature has explained the increase in average cash-holdings both with a tax-based explanation (Foley, Hartzell, Titman, and Twite (2007)), and a precautionary savings motive due to higher cash-flow volatilities (e.g. Bates, Kahle, and Stulz (2009) and McLean (2011)). Azar, Kagy, and Schmalz (2015) attribute changes in corporate cash-holdings to changes in the cost of carrying cash. Similarly, Curtis, Garin, and Mehkari (2015) draw on changes in the real value of carrying cash when they argue that corporate cash holdings are negatively correlated with inflation. Graham and Leary (2015) use data ranging back to the 1920s. They find mixed evidence for precautionary saving motives in their panel and some support for a tax-based explanation for the secular increase in cash holdings.

Bates, Kahle, and Stulz (2009) also show that recently listed firms have successively higher cash ratios relative to seasoned firms. Excluding the first five years of newly listed firms, the authors estimate a positive time trend after IPO. They also find that R&D-intensive (high-tech) firms hold more cash compared to non-R&D-intensive firms and document a positive time trend for both groups. For this reason, they conclude that the change

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5When interest rates are high and firms' are restricted to hold cash in non-interest bearing accounts, the opportunity cost of carrying cash is high leading to low cash balances and vice-versa.
in the composition of public firms is not alone responsible for the secular increase. Our goal is to find what quantitatively drives up the average cash–to–asset ratio over time. Therefore we include all observations of incumbents as well as the first year of newly listed firms. R&D–intensive entrants enter with higher and higher cash ratios over time while the cash ratio of non–R&D intensive entrants remains relatively stable. After IPO, firms deplete cash over the first five years and then keep a steady ratio (see section 2.3).

Opler and Titman (1994) show that R&D expenditures are particularly informationally sensitive investments. Consistent with this view, Opler, Pinkowitz, Stulz, and Williamson (1999) find that cash rich firms invest more in R&D. Since Opler, Pinkowitz, Stulz, and Williamson (1999) more papers have provided evidence that high R&D investment is related to more cash holdings at the firm level, for example Brown and Petersen (2011), Falato and Sim (2014), He and Wintoki (2014), and Lyandres and Palazzo (2015) among others. Falato, Kadyrzhanova, and Sim (2013) show how a shift within firms towards intangible capital investment increases average cash holdings.6

Only a few papers hint at the notion that the increase in average cash–to–asset ratios is driven by a subset of firms. He and Wintoki (2014) find evidence for the view that the increase can be explained with an increased sensitivity of cash to R&D among R&D–intensive firms. Moreover, they find that financial constraints and cash flow volatility are more relevant for R&D–intensive firms than for non-R&D–intensive firms. Booth and Zhou (2013) present evidence that the increase in the average cash–to–assets ratio is due to changing firm characteristics of high-tech firms that went public after 1980. We focus on firms’ cash-holdings at entry and evaluate the separate contributions to the secular increase in cash of selection and within-firm changes.

Thakor and Lo (2015) develop a theory to explain that under competitive pressure firms have incentives to increase R&D investment and therefore their cash–to–asset ratio. The data suggests that R&D–intensive firms and non-R&D–intensive firms coexist. We further show that conditional on firms’ type financial policies do not change much over time. This

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6In the model of Falato, Kadyrzhanova, and Sim (2013), firms with intangible capital cannot collateralize the capital stock, therefore requiring more internal funds for investment.
relates to the literature on persistence in the corporate capital structure (e.g. Lemmon, Roberts, and Zender (2008)). To our knowledge, we are the first paper to link the secular increase in cash–to–asset ratios to the increased cash balances at entry of firms of a new type: R&D–intensive firms that invest in the production of ideas.\footnote{Fama and French (2004) also document the compositional shift of U.S. public companies over the last thirty years, however they do link this phenomenon to a change in corporate financing policies.}

We study different hypotheses that may have caused the increase in the composition of firms in a firm industry model that builds on Hopenhayn (1992). A key feature of our model is the entry decision of firms, where we follow Clementi and Palazzo (2015). There are two types of firms in the model: R&D–intensive firms and non-R&D–intensive firms. We model the non-R&D–intensive firms similarly to Begenau and Salomao (2015) who study the business cycle dynamics of financial policies in a firm industry model with aggregate shocks and entry and exit. Debt is preferred over equity because of a tax-advantage. The non-R&D–intensive firms invest in tangible capital and pledge tangible capital as collateral to access debt financing. We model R&D–intensive firms similar to Riddick and Whited (2009). These firms build a stock of intangible capital that cannot be collateralized via R&D spending. Therefore, they can only finance themselves with equity or with internal funds.

The paper is organized as follows. The next section documents that the increase in average cash holdings of U.S. public firms can be explained with a shift in the composition of firms. Section 3 presents the model. Section 4 explores which of the two hypotheses can account for the increase in R&D–intensive firms in Compustat. Section 5 concludes.

\section{Facts}

We show that the secular increase in the cash–to–asset ratio has been driven by a change in the type of firms that decided to go public, rather than being driven by a change of cash holding policies within the firm.\footnote{We rule out firm exit as a driver of the secular increase in the cash–to–asset ratio (see figure 13 in the appendix). We find that the average cash–to–asset ratio at exit is close to the cross-sectional average of the cash–to–asset ratio. This is consistent with exit being i.i.d.} R&D–intensive firms have entered in increasing number, relative to non-R&D–intensive firms, and with higher and higher cash balances, thus driving...
up the cash holdings of the typical U.S. public company.

We also show that R&D–intensive and non-R&D–intensive firms can be considered as two different types of firms, both in their production process and in their financial structure. R&D–intensive firms are characterized by high R&D-to-asset ratios, low tangibility, high cash holdings, and a low level of long-term debt relative to assets. Non-R&D–intensive firms have smaller cash balances, higher tangibility, do not show an increase in R&D activities or cash balances over the sample period, and have a higher level of leverage. These differences in production and financing activities are persistent, i.e., the two types of firms do not become more similar over time.

2.1 R&D–intensive Firms: Data and Definitions

We use accounting data from the annual Compustat database over the period 1959-2013. We exclude financial firms (SIC codes 6000 to 6999) and utilities (SIC codes 4000 to 4999) and we only consider firms incorporated in the United States and traded on the three major exchanges: NYSE, AMEX, and NASDAQ.

We define R&D–intensive firms as firms belonging to an industry (using the three-level digit SIC code) that has an average R&D investment-to-asset ratio of at least 2% over the period 1959-2013. We choose 2% as the cut-off level because this it is the minimum R&D to asset ratio of the top quintile industries in terms of R&D to asset. Our results do not depend on the specific choice of the cut-off. We obtain very similar results if we narrow down our definition using the seven specific industries that account for the bulk of R&D–intensive entrants. These industries are: Computer and Data Processing Services (SIC 737, 26% of total entrants), Drugs (SIC 283, 15%), Medical Instruments and Supplies (SIC 384, 9%), Electronic Components and Accessories (SIC 367, 8%), Computer and Office Equipment (SIC 357, 7%), Measuring and Controlling Devices (SIC 382, 5%), and Communications Equipment (SIC 366, 5%)\textsuperscript{9}.

In order to follow the dynamics of an entering cohort, we sort firms into eleven cohorts by

\textsuperscript{9}Brown and Petersen (2009) use the same seven SIC codes to identify high–tech industries.
considering non-overlapping periods of 5 years starting with the window 1959-1963. Having a 5-year cohort is fairly standard in the firm dynamics literature. We define as \textit{entrant} firms that reports a fiscal year-end value of the stock price for the first time (item $PRCC_F$).\footnote{To validate our definition of entry in a stock exchange, we compare our entry year with the IPO year reported by Jay Ritter over the period 1975-2014. We find that 98\% of the matched companies’ entry year is the same or one year older than the reported IPO year in Ritter’s dataset. The latter can be found at http://bear.warrington.ufl.edu/ritter/ipodata.htm}

### 2.2 Aggregate Contribution of Selection

In this section, we argue that changes in the investment and financing decisions within firms (i.e., a firm decides to do more R&D and hold more cash over time) play a minor role for the change in average cash-holdings relative to the selection effect due to entry.

To this end, we decompose the change in the average cash–to–assets ratio into the change within incumbent firms and the change due to new firms (entrants) and show that the aggregate shift in the average cash–to–assets ratio is indeed driven by the change in the composition of firms at entry.

More precisely, consider the change in average cash holdings between time $t$ and time $t - 1$: $\Delta CH_t = CH_t - CH_{t-1}$. Let $N^I_t$ be the firms publicly traded at time $t - 1$ and $t$ (the incumbents) and $N^X_{t-1}$ the firms that exit between time $t - 1$ and $t$. Then, the average cash holdings at time $t - 1$ is $\frac{N^I_t}{N_{t-1}} CH^I_{t-1} + \frac{N^X_{t-1}}{N_{t-1}} CH^X_{t-1}$, where $N_{t-1} = N^I_t + N^X_{t-1}$, $CH^I_{t-1}$ is the average cash holdings of incumbents at time $t - 1$, and $CH^X_{t-1}$ is the average cash holdings at time $t - 1$ of firms that exit between time $t - 1$ and $t$.

Let $N^E_t$ be the firms that enter into Compustat at time $t$. Then, the average cash holdings at time $t$ is $\frac{N^I_t}{N_t} CH^I_t + \frac{N^E_t}{N_t} CH^E_t$, where $N_t = N^I_t + N^E_t$, $CH^I_t$ is the average cash holdings of incumbents at time $t$, and $CH^E_t$ is the average cash holdings at time $t$ of firms that enter at time $t$.

It follows that the change in average cash holdings between time $t - 1$ and $t$ can be
Figure 2: Cash Change Decomposition

This figure reports the cumulative change in average cash holdings over the sample period (solid-dotted black line) together with its three components: the cumulative change due to incumbents (dashed blue line), the cumulative change due R&D–intensive entrants (solid red line), and the cumulative change due non-R&D–intensive entrants (dashed-dotted blue line).

written as

\[
\Delta CH_t = \frac{N_t^I}{N_t} CH_t^I + \frac{N_t^E}{N_t} CH_t^E - \left( \frac{N_t^I}{N_{t-1}} CH_{t-1}^I + \frac{N_t^X}{N_{t-1}} CH_{t-1}^X \right)
\]

\[
= \left( \frac{N_t^I}{N_t} CH_t^I - \frac{N_t^I}{N_{t-1}} CH_{t-1}^I \right) + \left( \frac{N_t^E}{N_t} CH_t^E - \frac{N_t^X}{N_{t-1}} CH_{t-1}^X \right)
\]

The first term is the change in average cash holdings due to incumbents (within change). The second term is change in average cash holdings due to the selection effect. The latter effect can be further split between the selection effect generated by R&D–intensive firms and the selection effect generated by non-R&D–intensive firms, that is

\[
\Delta CH_t = \left( \frac{N_t^I}{N_t} CH_t^I - \frac{N_t^I}{N_{t-1}} CH_{t-1}^I \right) + \sum_{i \in \{R&D,non\,R&D\}} \left( \frac{N_t^{E_i}}{N_t} CH_t^{E_i} - \frac{N_{t-1}^{X_i}}{N_{t-1}} CH_{t-1}^{X_i} \right).
\]

Figure 2 reports the cumulative change in average cash holdings over our sample period. The selection effect due to R&D–intensive firms accounts for the lion share in determining the
secular increase in cash holdings. In other words, the increase is predominantly driven by an increase in the cash–to–asset ratio of high R&D firms at entry. The contribution of the *within change* is actually negative. Table 4 in the Appendix A reports the quantities. The average cash holdings equals 0.083 in 1979 and 0.238 in 2012, an increase of 0.155. The latter number can be decomposed in the contribution of the *within change* and the contribution of the selection effect. The *within change* contribution is -0.178. The overall contribution of the selection effect is 0.329 which is dominated by the entry of R&D intensive firms. They account for 81% of the selection effect.

### 2.3 Cross-sectional Analysis

Cross-sectional averages sometimes mask the underlying drivers of secular trends.\(^\text{11}\) Table 1 analyzes the hypothesis whether selection matters for generating a higher average cash–to–asset ratio over time. Column I presents the results for the OLS regression of the cash–to–asset ratio on a time trend using the entire sample of firms. The resulting trend is positive: cash holdings have increased by 0.146 over the 35 years that cover 1979 to 2013. Given the evidence in Table 5, we include a dummy variable in Column II that takes a value of zero if a firm is non-R&D–intensive and 1 otherwise. The difference between the estimated trend for non-R&D–intensive and R&D–intensive firms is striking.

Column III and Column IV report the results for firms that entered Compustat within the last 5 years and for firms that entered Compustat more than 5 years ago, respectively. The results show that there has been a substantial increase in cash balances among R&D–intensive firms that have entered Compustat within the last 5 years. In contrast, the average cash holdings of new non–R&D–intensive firms have been constant over the 35-year period.

We find a very similar difference in the cash holdings trends when we focus on firms that have been in Compustat for more than 5 years. In this case, R&D–intensive firms witness a

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\(^{11}\)In the appendix, Table 5 presents cross-sectional averages for the cash–to–asset ratio sorting firms according to their IPO date (within the last 5 years or more than 5 years ago) and according to the R&D intensity of the industry in which firms operate. R&D–intensive firms had the largest increase in their cash–to–asset ratio over our sample period, while non-R&D intensive firms experienced virtually no secular increase.
Table 1: Estimating the Time Trend within Firm

<table>
<thead>
<tr>
<th></th>
<th>Pooled OLS</th>
<th>FE</th>
<th>Firm-by-firm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All I</td>
<td>All II</td>
<td>IPO III</td>
</tr>
<tr>
<td>Trend</td>
<td>0.0042</td>
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<tr>
<td></td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.1150</td>
</tr>
<tr>
<td>Trend * R&amp;D intensity</td>
<td>0.0060</td>
<td>0.0078</td>
<td>0.0070</td>
</tr>
<tr>
<td></td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>R&amp;D intensity Dummy</td>
<td>0.0462</td>
<td>0.0911</td>
<td>-0.0124</td>
</tr>
<tr>
<td></td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>Constant</td>
<td>0.1066</td>
<td>0.0936</td>
<td>0.1294</td>
</tr>
<tr>
<td></td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>Observations</td>
<td>86,029</td>
<td>86,029</td>
<td>23,657</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.0349</td>
<td>0.1838</td>
<td>0.2284</td>
</tr>
</tbody>
</table>

We estimate the following baseline linear equation:

$$CH_{i,t} = \alpha + \beta t + \varepsilon_{i,t}$$

The dependent variable is the cash–to–assets ratio defined as che/at. The sample includes U.S. incorporated Compustat firm-year observations from 1979-2013 with at least 5 years of observations, positive values for assets and sales, excluding utilities and financial firms. A firm’s IPO year is the first year for which a stock price (prcc, t) is observed. This IPO assignment is consistent with Jay Ritter’s dataset. We also sort firms into R&D versus non-R&D sector, where R&D sectors are those with more than 2% of R&D expenditures relative to assets. In columns I to V we normalize the year 1979 to zero. In columns VI and VII we run a linear regression for each firm in our sample and set t equal to zero the first year the firm appears in the sample. We report p-values based on robust standard error. The reported number of observations for the firm-by-firm regressions is the average number of observations for each equation. The reported $R^2$ for the fixed effect regression is the overall $R^2$. The reported $R^2$ for the firm-by-firm regressions is the average $R^2$ across all the regressions. In the last column, we compare the estimated slopes and constants across the two industries.

A significant increase in the cash–to–assets ratio because R&D–intensive firms that enter with higher cash balances and survive more than 5 years have, on average, larger cash balances. On the other hand, the cash–to–asset ratio of non–R&D–intensive firms is relatively flat until 2002 and shows a modest increase starting from 2003\textsuperscript{12}.

Pooled OLS regressions allow us to identify R&D–intensive firms as the driver of the

\textsuperscript{12}During the first half of the 2000s, there have been two events that had a significant impact on corporate cash holdings: the Sarbanes–Oxley Act and the 2003 dividend tax cut. Bargeron et al. (2010) document a significant increase in cash holdings following the introduction of the Sarbanes–Oxley Act. Officer (2011) documents a large increase in cash holdings in anticipation of the dividend tax cut.
secular increase in cash holdings. However, the cash–to–asset ratio is fairly persistent (see also Figure 7 and Lemmon et al. (2008)), and pooled OLS regressions are not conclusive with regard to each firm’s individual cash–to–assets evolution. In fact, one could make the case that incumbent R&D–intensive firms indeed increased their cash–to–asset ratio over time. To address the persistence issue, we first include a firm fixed effect in our linear specification (Column V). Here the time trend has a negative sign and it is not significant. The inclusion of a firm specific intercept is enough to make the secular increase in cash holdings disappear.

In the last two columns of Table 1, we perform firm–by–firm regressions and report average values of the estimated coefficients. We assign a value of zero to the first year a firm appears in the sample, in this way we control for the cash holding at entry at the firm-level. In this case, the results strongly point toward a negative change in average cash holdings for incumbents. The estimated change (within change) in average cash over 35 years implied by Column VI is -0.174. The contribution of selection to the secular increase in cash holdings can be calculated as the difference between the estimated change using pooled OLS (0.146) and the one using firm–by–firm regressions (-0.174). The resulting quantity is 0.320, very similar to the one in section 2.2. Column VII shows that R&D–intensive firms start with much larger cash balances than non-R&D–intensive firms and deplete cash faster compared to non-R&D–intensive firms.

If firms actually decrease their cash balances over time, what explains the gradual increase in the cash–to–asset ratio of incumbent R&D intensive firms? In the next section we show that R&D–intensive firms enter progressively with higher cash balances. As long as incumbents deplete cash at a lower rate\textsuperscript{13} than entrants increase cash-balance at IPO, the overall change in the cash–to–asset ratio will be positive. The next section provides evidence that underscore the importance of entry for the secular increase.

Table 2 focusses just on mature firms, i.e. firms that are listed for more than 5 years. The negative time trend in the firm–by–firm regressions is insignificant (column IV and V). This means that mature firms neither dramatically increase nor decrease their cash-ratios

\textsuperscript{13}Column VII of Table 1 estimates an average initial cash balance of 0.323 that decreases on average by 0.007 per year.
Table 2: Estimating the Time Trend within Firm for Mature Firms

<table>
<thead>
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<th>Pooled OLS</th>
<th>FE</th>
<th>Firm-by-firm</th>
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<tbody>
<tr>
<td></td>
<td>All I</td>
<td>All II</td>
<td>All III</td>
</tr>
<tr>
<td>Trend</td>
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<td>0.0009</td>
<td>0.0010</td>
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<td></td>
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</tr>
<tr>
<td>Trend X R&amp;D intensity</td>
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<td></td>
<td>0.0000</td>
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<tr>
<td>R&amp;D intensity Dummy</td>
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<td>0.0000</td>
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<tr>
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<td>0.0936</td>
<td>0.1438</td>
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<td>0.0800</td>
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<tr>
<td></td>
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<tr>
<td>Observations</td>
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<tr>
<td>Adjusted $R^2$</td>
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<td>0.0349</td>
</tr>
<tr>
<td></td>
<td>0.2898</td>
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<td></td>
</tr>
</tbody>
</table>

We estimate the following baseline linear equation:

$$ CH_{i,t} = \alpha + \beta t + \varepsilon_{i,t} $$

The dependent variable is the cash–to–assets ratio defined as che/at. The sample includes U.S. incorporated Compustat firm-year observations from 1979-2013 that have been public for more than 5 years and with at least 5 years of observations, positive values for assets and sales, excluding utilities and financial firms. A firm’s IPO year is the first year for which a stock price (prcc$_{i,f}$) is observed. This IPO assignment is consistent with Jay Ritter’s dataset. We also sort firms into R&D versus non-R&D sector, where R&D sectors are those with more than 2% of R&D expenditures relative to assets. In columns I to III we normalize the year 1979 to zero. In columns IV and V we run a linear regression for each firm in our sample and set $t$ equal to zero the first year the firm appears in the sample. We report p-values based on robust standard error. The reported number of observations for the firm-by-firm regressions is the average number of observations for each equation. The reported $R^2$ for the fixed effect regression is the overall $R^2$. The reported $R^2$ for the firm-by-firm regressions is the average $R^2$ across all the regressions. In the last column, we compare the estimated slopes and constants across the two industries.

over time. Moreover, we can conclude that most of the action in the secular increase in the cash–to–asset ratio is driven by the first few years of newly listed firms.

2.4 Entry

We present key facts on firm-level characteristics at IPO to highlight the changing nature of new public firms. We start with cash. New firms enter with higher cash balances relative to assets over time, as can be seen from Figure 3 that presents the evolution of the cash–to–asset ratio at the cohort level starting with the 1959-1963 cohort. The red dot marks the
average cash holdings at entry for each cohort. The straight blue line links the initial average cash holdings upon entry to the average cash holdings of the cohort in 2013. A negative (positive) slope means that the average cash holdings at the cohort level declines (increases). The first observations is the average cash holdings of incumbent firms in 1958. Three facts emerge. First, there is an increase in initial cash holdings over time, new cohorts enter with higher and higher cash balances. Second, the majority of cohorts (9 out of 12) deplete cash: at the cohort level there is hardly a secular increase. Third, there is a clear break in the data that separates the first five cohorts from the subsequent ones. Cohorts of firms that entered before 1979 have similar cash balances upon entry, while subsequent cohorts show an increasing trend.

Figure 3: Average Cash Holdings at Entry (1959-2013)

The figure reports the evolution of the cash–to–asset ratio for U.S. public companies for eleven 5-year cohorts over the period 1959-2013. The red dot denotes the average cash holdings at entry for each cohort. The first observations is the average cash holdings of incumbent firms in 1958. The straight line connects the initial average cash-holdings to the average holding in 2013 for each cohort.

From Figure 1 we know that the proportion of R&D–intensive firms has increased from around 35% in the beginning of the 1980s to 55% in 2013 and that, starting in the mid-1980s, the majority of firms entering into the Compustat sample (IPO) are R&D–intensive firms. When we compare average cash holdings at entry by cohort and industry (see Figure
The figure reports the average cash–to–asset ratio for U.S. public companies at entry for eleven 5-year cohorts over the period 1959-2013. The red line refers to non-R&D–intensive firms (old economy), while the blue line to R&D–intensive firms (new economy). The straight dashed line is the linear trend.

we observe that R&D–intensive firms have entered with higher and higher cash balances over time, while non-R&D–intensive firms have not increased their cash balance upon entry during the last thirty years. This fact highlights the importance of entry dynamics and composition effects that have so far received little attention in the literature.

Figure 5 shows an almost identical pattern for the R&D-to-asset ratio at entry by cohort and industry. The literature has established a strong correlation between R&D investment and cash holdings and it has been suggested that an increase in R&D activities of firms could be responsible for the secular increase in cash-holdings. Figure 5 presents evidence for a different story. R&D–intensive firms invest more in R&D already at entry while, not surprisingly, there seems to be no evidence for a change in R&D activities for non-R&D–intensive firms over the past 30 years.

High R&D–intensive and low R&D–intensive entrants do not only differ in their cash balance and R&D activity. Figure 6 reports tangibility and net leverage at entry by cohort, highlighting that the differences in production (high vs low tangibility) and financing (debt vs cash) models are already in place at the time of the IPO. While high R&D firms tangibility
The figure reports the average R&D-to-asset ratio for U.S. public companies at entry for eleven 5-year cohorts over the period 1959-2013. The red line refers to non-R&D–intensive firms (old economy), while the blue line to R&D–intensive firms (new economy). The straight dashed line is the linear trend.

ratios as well as net leverage have been decreasing over time, no such stark change has occurred for non-R&D–intensive firms. The average tangibility (left panel), measured as the ratio of gross property, plant and equipment over total assets, was around 50% for R&D–intensive entrants at the beginning of the 1960s, a value close to 60%, the average tangibility of non-R&D–intensive entrants. After 50 years, R&D–intensive entrants have a tangibility slightly larger than 15% of total assets, while for non-R&D–intensive firms this value is around 55%. Net leverage at entry (right panel of figure 6) started to diverge at the beginning of the 1980s, when the cash–to–asset ratio also began to diverge. Low R&D–intensive firms slightly increased their net leverage upon entry, while high R&D firms decreased their net leverage mainly because of the sharp increase in their cash holdings. By the 1990s, the typical R&D–intensive entrant had negative net leverage.

2.5 Post-Entry Dynamics

The previous section has shown that R&D–intensive firms enter with higher and higher cash–to–assets ratios. What happens to their cash holdings in the subsequent years after
entry? Figure 7 shows that the differences in basic firm characteristics at entry (cash, R&D, tangibility, and net leverage) persist over time. That is, high R&D firms’ characteristics do not converge to the levels held by low R&D firms.

The figure shows cash holdings for entrants from the entry year (year 0) up to five years after entry (year 5) together with other key firm-level characteristics. Both high R&D–intensive and low-R&D–intensive firms deplete their cash holdings after the entry year. R&D–intensive firms experience a change in cash holdings over the five year period equal to 0.13, while non-R&D–intensive firms decrease them by 0.05. The difference in average cash holdings between the two set of firms decreases during the first two years after entry and then stays constant around 0.18. The R&D activity for R&D–intensive firms stays constant during the five years after entry and fluctuates around 0.11, while low-R&D firms’ post entry R&D investment fluctuates around 0.5% of total assets.
The figure reports the average value from entry (year 0) up to five years after entry (year 5) of the following firm-level characteristics: cash holdings, R&D expenditure, long-term debt, tangibility, leverage, and net leverage. The red line refers to non-R&D–intensive firms, while the blue line to R&D–intensive firms.

Both categories of firms show an increase in their post entry values for tangibility and net leverage. However, these values are highly persistent and the difference at the entry stage remains stable for the entire post-entry period. In short, R&D–intensive and non-R&D–intensive firms do not converge in terms of key firm characteristics linked to production and financing structure.

3 Model

In this section, we use a firm industry model with endogenous entry to explore qualitatively and quantitatively the importance of different selection mechanisms.

In our model economy, firms are one of two types: old economy firms (i.e., non-R&D–intensive firms) and new economy firms (i.e., R&D–intensive firms). Since our focus is on the dynamics of the cash–to–assets ratio’s cross-sectional average, we simplify the setup...
assuming that old economy firms produce using physical capital and new economy firms produce using intangible capital. Only the former can be pledged as collateral to issue debt. We assume the existence of a time-invariant mass of potential firms that can become public (potential entrants in the stock market) by paying a fixed IPO cost. The potential entrants are heterogeneous because they can be either new economy or old economy firms. In the benchmark economy, the proportion of potential entrants of the new economy type is kept constant.

3.1 Incumbent problem

3.1.1 Technology

We assume that both types of firms share the same functional form for the production function:

\[ y_t = e^{z_{t+1} k_{j,t}^\alpha} \]

where \( j \) indicates if the firm uses tangible \((j = o)\) or intangible capital \((j = n)\) and \( z_t \) is an idiosyncratic productivity shock that evolves according to

\[ z_{t+1} = \rho z_t + \sigma \epsilon_{t+1}, \]

where \( \epsilon_{t+1} \sim N(0, 1) \). The law of motion for the capital stock is

\[ k_{j,t+1} = (1 - \delta_g)k_{j,t} + x_{j,t}, \]

where \( \delta_j \) is the depreciation rate and \( x_{j,t} \) is the capital investment at time \( t \). We assume \( \delta_n > \delta_o \).\(^{14}\) We also assume the presence of quadratic investment adjustment costs

\[ \phi(k_{j,t+1}, k_{j,t}) = \eta \left( \frac{k_{j,t+1} - (1 - \delta_j)k_{j,t}}{k_{j,t}} \right)^2 k_{j,t}. \]

\(^{14}\)Investment of high R&D firms in the model parallels R&D investment in the data. This also justifies the higher depreciation rate for high R&D firms’ capital stock. Hall (2007) provides evidence for a larger depreciation rate for the R&D capital stock.
3.1.2 Financing

Firms can finance their operations internally by transferring cash from one period to the next at an accumulation rate $\hat{R}$. For the time being, we assume that $\hat{R} < R$, namely internal accumulation of cash delivers a return lower than the risk-free rate. At the same time, firms can raise external resources by issuing equity or debt. Equity financing is costly: raising equity (that is, having a negative dividend $d_t < 0$) requires the payment of $H(d_t)$, where

$$H(d_t) = -\kappa_1 \text{abs}(d_t).$$

Debt financing is attractive because there is a tax advantage: interest paid on corporate debt is tax deductible. The amount of debt issuance is limited by a collateral constraint that depends on the next period depreciated capital level, that is $(1 - \delta_o)k_{o,t+1}$. Moreover, raising debt in the amount of $b_{t+1}$ costs the firm

$$J(b_{t+1}) = -\gamma \frac{b_{t+1}}{\hat{R}}.$$

Since new economy firms have only intangible capital that cannot be collateralized, they can only use cash and equity.

3.1.3 Old economy incumbent’s problem

At time $t$, the firm’s budget constraint is

$$d_t = w_t + b_{t+1} - \frac{s_{t+1}}{R_o} - x_{o,t+1} - \phi(k_{o,t+1}, k_{o,t}).$$

The firm can use the total resources available to distribute dividends ($d_t$), invest in tangible capital ($x_{o,t+1}$) and pay the adjustment cost ($\phi(k_{o,t+1}, k_{o,t})$), or to accumulate cash internally $s_{t+1}/\hat{R}_o$. If the initial net worth $w_t$ is negative, then the firm raises external funds to repay pre-existing liabilities. Given that there is a tax advantage of debt, the firm will first issue debt $b_{t+1}$ and then use the more expensive equity. The maximum amount of debt that the firm can repay at time $t+1$ equals $(1 - \delta_o)k_{o,t+1}$. If $d_t$ is negative (i.e. the firm has exhausted
its debt capacity and uses equity to finance the initial time $t$ liabilities), the equity issuance cost is $\kappa_1 d_t$. In what follows, $1_{[d_t \leq 0]}$ is an indicator function that takes value 1 only if the firm needs to issue equity at time $t$.

The firm’s $t + 1$ net worth is

$$w_{t+1} = s_{t+1} + (1 - \tau)e^{z_{t+1}}k_{a,t+1}^{\alpha} - (R - \tau(R - 1)) b_{t+1}$$

$$= s_{t+1} + (1 - \tau)e^{z_{t+1}}k_{a,t+1}^{\alpha} - l^*_t. \quad (2)$$

The interest paid on corporate debt is tax deductible, so the net repayment is equal to the promised repayment, $Rb_{t+1}$, net of the reduction in corporate taxes, $\tau(Rb_{t+1} - b_{t+1})$. If the realized earnings are negative, the firm does not pay corporate taxes but still benefits from the tax advantage of debt. To simplify the set-up, we assume that for old economy firms $\widehat{R}_o = R - \tau(R - 1)$. To simplify the notation, we introduce a new variable, $l^*_t$, that is equal to the repayment to the bondholders net of the tax deduction. Notice that by construction $b_{t+1}$ equals $\frac{l^*_{t+1}}{R_o}$. It follows that we can summarize cash and debt in a single variable $l_{t+1} = s_{t+1} - l^*_t$, the net leverage of the firm. Each period, the firm faces an exogenous exit probability, $\lambda$. Upon exit, the firm recovers its net worth and depreciated capital stock. The time $t$ value of an old economy firms solves the following functional equation

$$V^o(k_{a,t}, l_{t+1}, z_t) \equiv \max_{l_{t+1}, x_{a,t+1}} d_t + H(d_t)1_{[d_t \leq 0]} + J(l_{t+1})1_{[l_{t+1} \leq 0]}$$

$$+ \frac{1 - \lambda}{R} E_t[V_{t+1}(k_{a,t+1}, l_{t+1}, z_{t+1})] + \frac{\lambda}{R} E_t[w_{t+1} + (1 - \delta_o)k_{a,t+1}] \quad (3)$$

---

15 This assumption is innocuous in the context of our exercise. Figure 13 in the appendix shows that the average cash holding for exiting firms is very close to the average cash holdings of incumbent firms. This feature of the data can be replicated by an i.i.d. exit process. In the data as well as in the model, we allow exit to be defined in a broader sense that includes firms disappearing from the data or the model due to acquisition and mergers, bankruptcy, or going private.
subject to

\[ d_t = w_t - \frac{l_{t+1} - x_{o,t+1} - \phi(k_{o,t+1}, k_{o,t})}{R_o}, \quad (4) \]
\[ k_{o,t+1} = (1 - \delta_o)k_{o,t} + x_{o,t+1}, \quad (5) \]
\[ w_{t+1} = (1 - \tau)e^{zt+1}k^0_{o,t+1} + l_{t+1}, \quad (6) \]
\[ -l_{t+1} \leq (1 - \delta_o)k_{o,t+1}, \quad (7) \]

where \( \lambda \) is the exit probability between time \( t \) and \( t + 1 \).

### 3.1.4 New economy incumbent’s problem

A new economy firm cannot rely on external debt given the lack of collateral. Thus, the only difference with the functional equation of an old economy firm is in having \( l_t = s_t \). It follows that the time \( t \) value of a new economy firms solves the functional equation below

\[
V^n(k_{n,t}, l_t, z_t) \equiv \max_{l_{t+1}, x_{n,t+1}} d_t + H(d_t)1_{|d_t|\leq 0} + \frac{1 - \lambda}{R} E_t[V_{t+1}(k_{n,t+1}, l_{t+1}, z_{t+1})] \\
... + \frac{\lambda}{R} E_t[w_{t+1} + (1 - \delta_n)k_{n,t+1}] \\
(8)
\]

subject to

\[ d_t = w_t - \frac{l_{t+1} - x_{n,t+1} - \phi(k_{n,t+1}, k_{n,t})}{R_n}, \quad (9) \]
\[ k_{n,t+1} = (1 - \delta_n)k_{n,t} + x_{n,t+1}, \quad (10) \]
\[ w_{t+1} = (1 - \tau)e^{zt+1}k^\alpha_{n,t+1} + l_{t+1}, \quad (11) \]
\[ l_{t+1} \geq 0, \quad (12) \]

where \( \lambda \) is the exit probability between time \( t \) and \( t + 1 \). Choosing cash holdings \( (s_{t+1} = l_{t+1}) \) and investment \( (x_{n,t+1}) \) determines the next period net worth \( (w_{t+1}) \). We assume that the internal accumulation rate for a new economy firm is \( \hat{R}_n = \nu R \), where \( \nu \in (0, 1) \).
3.2 Entry

Every period there is a constant mass \( M > 0 \) of firms that decide to go public. \( M \) is the sum of \( M_n > 0 \), the mass of new economy firms that are private, and \( M_o > 0 \), the mass of old economy firms that are private. We define \( \omega \) as the fraction \( M_o/M \). Firms that decide to go public are randomly drawn from the stationary distribution of private firms. The model focuses thus on the entry margin by private firms as opposed to the life of private firms before they decide whether or not they go public.

Following [?], we assume that each potential entrant in the stock market receives a signal \( q \) about its future productivity, where the signal follows a Pareto distribution \( q \sim Q(q) \). Conditional on entry, the distribution of the idiosyncratic shocks in the first period of operation is \( F(z'|q) \), strictly decreasing in \( q \). Firms that decide to go public pay an IPO cost \( c_e \). The value function for an old economy entrant is

\[
V^{E,o}(q_t) = \max_{l_{t+1},x_{o,t+1}} \left\{ -x_{o,t+1} - \frac{l_{t+1}}{R_o} + \frac{1}{R} E[V^o(k_{o,t+1},l_{t+1},z_{t+1})|q_t] \right\}, \tag{13}
\]

while the value function for a new economy entrant is

\[
V^{E,n}(q_t) = \max_{l_{t+1},x_{n,t+1}} \left\{ -x_{n,t+1} - \frac{l_{t+1}}{R_n} + \frac{1}{R} E[V^n(k_{n,t+1},l_{t+1},z_{t+1})|q_t] \right\}. \tag{14}
\]

A firm will go public if and only if

\[ V^{E,i} \geq c_{e,i} \quad \forall i \in \{o, n\}. \]

3.3 Firm industry equilibrium

Denote \( \omega \) as the fraction of old economy firms. Given \( \omega \) and the riskless rate \( R \), a recursive competitive equilibrium consists of (i) value functions \( V^i(k_i,l_i,z) \) and \( V^{E,i}(q) \), (ii) policy functions \( l'_i(k_i,l_i,z) \) and \( x'_i(k_i,l_i,z) \) and (iii) bounded sequences of incumbents’ measure \( \{\Gamma_i\}_{t=1}^{\infty} \) and entrants’ measures \( \{\varepsilon_i\}_{t=0}^{\infty} \) \( \forall i \in \{o, n\} \) such that

1. \( V^i(k_i,l_i,z), l'_i(k_i,l_i,z) \) and \( x'_i(k_i,l_i,z) \) solve the incumbents problem \( \forall i \in \{o, n\} \)
2. $V^{E,i}(q), l'_i(q)$ and $x'_i(q)$ solve the entrants problem $\forall i \in \{o, n\}$

3. For all Borel sets $Z \times K \times L \times X \times R$ and $\forall t \geq 0$ and $W = K \times L$

$$
\varepsilon^i_{t+1}(W) = M_i \int_Z \int_{B^E_i(W)} dQ(q) d(F(z^*|q))
$$

where $B^E_i(W) = \{(l'_i(q), x'_i(q)) \text{ s.t. } l'_i(q) \in L, x'_i(q) \in X \text{ and } V^{E,i} \geq c_{e,i}\}$ denotes the policy functions of entrants.

4. For all Borel sets $Z \times K \times L \times X \times R$ and $\forall t \geq 0$ and $W = K \times L$

$$
\Gamma^i_{t+1}(W') = (1 - \phi) \int_Z \int_{B^i(W)} d\Gamma^i_t(W) dF(z'|z) + \varepsilon^i_{t+1}(W)
$$

where $B^i(W)$ denotes the policy functions of incumbents and $\omega = \Gamma^o_{t+1}(W')/(\Gamma^o_{t+1}(W') + \Gamma^n_{t+1}(W'))$.

The firm distribution evolves in the following way. A mass of entrants receives a signal and some decide to enter. The signal $q$ determines the productivity level of the following period. Firms choose debt or savings and investment in their capital type (intangible or tangible). This determines the net worth for the following period. Conditional on not exiting, incumbent firms pick period’s investment, internal or external funds. The shocks follow a Markov distribution.

### 4 Parametrization

We parametrize the model at an annual frequency using parameter values taken from other studies together with a set of calibrated values. Table 3 reports the parameter values. Following Hennessy and Whited (2007), we set $\alpha = 0.62$ and $\delta_o = 0.15$. The annual risk-free interest rate is set to 4%, the same value used in Riddick and Whited (2009). The corporate tax rate is 35%. We set the value of $\delta_o$ equal to 0.205, a number consistent with depreciation rates for R&D capital reported by the Bureau of Economic Analysis (e.g., Li (2012)).
Since we are interested in the evolution of corporate cash holdings during the period 1980-2013, we calibrate the remaining parameters to match some key moments using data from the period 1959-1979. The proportion of potential entrants of type old ($\omega$) is set to 0.668. This value allows us to replicate the composition of publicly traded firms during the period 1959-1979. The persistence and conditional standard deviation of the idiosyncratic shock are set to match the average cross-sectional standard deviation and the average firm-level autocorrelation of the sales growth rate.

Then we calibrate a set of parameters to replicate some key cash holdings moments for R&D-intensive firms in 1979. First, we calibrate the cost of carrying cash inside the firm ($\nu$) to match the average cash-to-asset ratio. Second, we pick a value for the the entry cost for R&D-intensive firms to match the average cash-to-asset at entry. The proportional equity issuance cost ($\kappa_1$) is set to match the average equity-to-asset ratio of R&D-intensive firms over the period 1959-1979.

In our model, it is key to generate the correct persistence of cash holdings. The reason being that having cash holdings that counterfactually revert quickly to the mean will impair the model’s ability to generate the observed secular increase. We choose to generate persistent cash holdings policies using the investment adjustment cost parameter. We choose a value for the latter parameter to replicate the first order autocorrelation of cash holdings for R&D-intensive firms over the period 1959-1979.

The value of the proportional debt issuance cost is calibrated to match the average net debt-to-asset ratio of non-R&D-intensive firms. The entry cost for the old type firm is picked to match the size of old type entrants relative to the size of old type incumbents of age 5. The parameter that governs the shape of the Pareto distribution over the set of signals is chosen to match the the size of entrants relative to the size of incumbents of age 5. Panel B of Table 3 reports the simulated moments together with their empirical counterpart.

To conclude, we set the exogenous exit rate ($\lambda$) to 7%, a value that delivers an age (i.e., years from entry) distribution close to the one observed in Compustat over the period 1980-2013 (Panel C of Table 3).\textsuperscript{16}

\textsuperscript{16}In our model, younger firms have a larger cash-to-asset ratio. An age distribution tilted toward young...
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Function</th>
<th>Origin/Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha = 0.62$</td>
<td>Decreasing returns to scale</td>
<td>Hennessy and Whited (2007)</td>
</tr>
<tr>
<td>$\delta_o = 0.15$</td>
<td>Depreciation old firms</td>
<td>Hennessy and Whited (2007)</td>
</tr>
<tr>
<td>$\delta_n = 0.205$</td>
<td>Depreciation new firms</td>
<td>Li (2012)</td>
</tr>
<tr>
<td>$\tau_c = 0.35$</td>
<td>Corporate tax rate</td>
<td>subject to experimentation</td>
</tr>
<tr>
<td>$r = 0.04$</td>
<td>Risk-less rate</td>
<td>Riddick and Whited (2009)</td>
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**Panel B: Calibrated parameters**

<table>
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<tr>
<th>Parameter</th>
<th>Moment</th>
<th>Data</th>
<th>Model</th>
</tr>
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<tbody>
<tr>
<td>$\omega = 0.668$</td>
<td>Proportion of new firms</td>
<td>0.332</td>
<td>0.332</td>
</tr>
<tr>
<td>$\rho = 0.90$</td>
<td>Autocorrelation sales’ growth rate</td>
<td>0.221</td>
<td>0.238</td>
</tr>
<tr>
<td>$\sigma = 0.121$</td>
<td>Volatility sales’ growth rate</td>
<td>0.234</td>
<td>0.252</td>
</tr>
<tr>
<td>$\nu = 0.99592$</td>
<td>Cash holdings new firms</td>
<td>0.083</td>
<td>0.083</td>
</tr>
<tr>
<td>$c_{e,n} = 0.0105$</td>
<td>Cash holdings new firms at entry</td>
<td>0.138</td>
<td>0.133</td>
</tr>
<tr>
<td>$\kappa_1 = 0.14$</td>
<td>Equity-to-asset ratio new firms</td>
<td>0.056</td>
<td>0.053</td>
</tr>
<tr>
<td>$\eta = 0.015$</td>
<td>Autocorrelation cash holdings new firms</td>
<td>0.727</td>
<td>0.668</td>
</tr>
<tr>
<td>$\gamma = 0.0161$</td>
<td>Net Debt-to-asset ratio old firms</td>
<td>0.143</td>
<td>0.139</td>
</tr>
<tr>
<td>$c_{e,o} = 0.0143$</td>
<td>Relative size old type entrant</td>
<td>0.707</td>
<td>0.712</td>
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<tr>
<td>$\epsilon = 16$</td>
<td>Relative size entrant</td>
<td>0.663</td>
<td>0.718</td>
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**Panel C: Age distribution with $\lambda=0.07$**

<table>
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<tr>
<th>Age Bins</th>
<th>1-5</th>
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<th>16-20</th>
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<td>0.211</td>
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5 Experiments

In this section we investigate to what extent different selection mechanisms can account for the increase in average cash holdings of U.S. public firms and other features of the data. In all the experiments we assume a constant cash holdings value of 0.08 for non-R&D-intensive firms. These firms have an indeterminate financial policy (only net leverage matters) and firms will greatly help the model to reproduce the increase in the cash-to-asset ratio during the 1980-2013 period. At the same time, an age distribution tilted toward old firms will negatively affect the ability of the model to reproduce the secular increase in cash holdings. For this reason, we choose an exit rate that delivers an age distribution as close to the data as possible.
we pick a value that reflects the average cash holdings of non–R&D–intensive firms in 1979. We do this for two reasons. First, we completely shut down the effect of non–R&D–intensive firms on the secular increase in cash. Second, it will be easier to compare the model generated results with the data.

5.1 Composition outside (private sector) has changed

The first experiment that we run is designed to explore the effect of a structural change in the composition of firms within the U.S. economy on the change in average cash holdings of U.S. publicly traded firms. To this end, we assume that the fraction of potential entrants of type old \( \omega \) changes over a time span of 35 years in a way to generate a compositional change for publicly traded firms similar to the one observed in the data (see left panel of Figure 1).\(^{17}\)

Figure 8 presents the results. The top left (right) panel reports the evolution of average cash holdings (the fraction of new firms) over 35 years. The bottom left panel reports the average cash holdings of new economy firms only. The bottom right panel reports new economy firms that have done an IPO in the last 5 years (young firms) as a fraction of the total number of new economy firms.

A structural change in the composition of entrants is unable to generate a secular increase in the average cash holdings of publicly traded firms. Over 35 years, the average value of the cash–to–asset ratio goes from a steady state value of 0.081 to a value of 0.083. The initial increase in average cash holdings is due to the increase in the proportion of young new economy firms. These firms have on average larger cash balances relative to their more mature counterparts. However, as the fraction of young new economy firms reverts to its mean, the value of average cash holdings starts to decrease. Without a change of the characteristics at entry of new economy firms the model cannot generate the sizable increase in average cash holdings found in the data.

\(^{17}\)To be precise, we assume that the fraction of potential entrants of type old evolves over time according to \( \omega_t = (\omega - a_1) + a_1 t^{-a_2} \) where \( t = 1, ..., 35 \). We pick \( a_1 \) and \( a_2 \) to minimize the distance between the compositional change generated by the model and the one observed in the data. The calibrated values of \( a_1 \) and \( a_2 \) deliver a fraction of potential entrants of type old equal to 40% after 35 years.
This figure reports the effect of an increase in the share of new economy firms on average cash holdings.

5.2 Entry costs have fallen for new economy firms

In this section, we study the model’s response to a reduction in the IPO cost for new economy firms. We can model this scenario through a reduction in the entry cost for new economy firms $c_{e,n}$. We assume a reduction in entry cost over 35 years to mimic the cash holdings’ evolution at entry of R&D–intensive firms.$^{18}$

Figure 9 presents the results. The top left (right) panel reports the evolution of average cash holdings (average cash holdings at entry of new economy firms) over 35 years. As in the previous section, the bottom left panel reports the average cash holdings of new economy firms only, while the bottom right panel reports new economy firms that have done an IPO in the last 5 years (young firms) as a fraction of the total number of new economy firms.

The reduction of the entry cost for new economy firms causes progressively smaller firms

---

$^{18}$We assume that the entry cost for entrants of type new evolves over time according to $c_t = (c_{e,n} - a_1) + a_1 t^{-a_2}$ where $t = 1, ..., 35$. We pick $a_1$ and $a_2$ to minimize the distance between the average cash holdings at entry for new economy firms generated by the model and the one observed in the data. The calibrated values of $a_1$ and $a_2$ imply an entry cost which is 44% of the initial one after 35 years.
This figure reports the effect of a decrease in the entry cost for new economy firms on average cash holdings. To become public. That is, new economy firms enter with a progressively smaller productivity shock. Since the shocks are mean reverting, lower productivity firms anticipate future higher productivity shocks, which increases their investment needs today. In order to avoid being constrained from raising funds to invest in capital at times when productivity is high, they raise more cash relative to their asset at the IPO stage. The lower the entry cost, the lower the productivity threshold of entry of new economy firms and the higher the average cash holdings at entry.

Figure 9 shows how the average cash holdings increases when we abstract from a change in the composition of firms. This increase is driven by new firms entering with higher and higher cash balances (top right panel) meanwhile the distribution of new firms’ age stays constant (bottom right panel). Over 35 years, the average cash holdings goes from its steady state value of 0.081 to a value of 0.130, a 62% increase.
This figure reports the effect of a reduction in the entry cost for new economy firm entrants and an increase in the share of new economy firms in the economy. The solid blue line depicts the simulated data, the dashed red line depicts the empirical counterpart.

5.3 Reduction in entry cost and increase in share of new-economy firms

The results from the previous two sections suggest that a change in the composition of private firms alone cannot generate an increase in average cash holdings over time, while a reduction in the entry cost for new economy firms is able to generate a modest increase. In this section, we combine both features and show how a change in the composition of private firms amplifies the effect of a reduction in the entry cost for new economy firms thus allowing the model to get much closer to the data.

Figure 10 presents the results. We report both the model generated data (solid blue line) and their empirical counterpart (dashed red line). To make the data comparable to the model’s results, we calculated the average cash holdings assigning a constant value of 0.08 to old economy firms. The top left (right) panel reports the evolution of average cash holdings
(the fraction of new firms) over 35 years. The bottom left (right) panel reports the average cash holdings (the average cash holdings at entry) of new economy firms.

As we can see, adding a change in composition on top of a reduction in the entry cost for new economy firms helps the model along two dimensions. First, the model can generate both a secular increase in cash holdings for new economy firms at entry and a shift in composition toward R&D-intensive companies. Second, the secular increase in average cash holdings becomes steeper, thus bringing the model closer to the data.

Over 35 years, the average cash holdings goes from its steady state value of 0.081 to a value of 0.172, a 113% increase. In the data, the average cash holdings goes from value of 0.081 in 1979 to a value of 0.235, a 190% increase. Our model is thus able to generate 60% of the increase in average cash holdings witnessed between 1979 and 2013.19

Figure 11: Model Generated Average Cash Holdings at Entry (1979-2013)

The secular increase in cash holdings is entirely driven by a selection effect. Figure 11 is the model counterpart of Figure 3. As in the data, firms enter with progressively higher cash holdings and younger cohorts, on average, deplete cash faster after entry. The slope of

19The value of average cash holdings in 2013 without assuming a constant value of 0.08 for old economy firms is 0.249, an increase of 207%. In this case, our model would be able to explain 55% of the increase in average cash holdings.
the line that links the initial average cash holdings upon entry to the average cash holdings of the cohort in 2013 is negative for all cohorts: the within-firm change in cash holdings contributes negatively to the secular increase.

Conclusion

In this paper we highlight the importance of entry and shifts in the composition of firms to explain the cash dynamics for the typical U.S. public company during the last thirty years. Our results suggest a new direction in the debate about the causes of the secular increase in corporate cash-to-asset ratios. Instead of focusing on factors that influence incumbents’ financial decisions, we argue for a shift of research efforts towards understanding why more R&D-intensive firms go public and why they do so with higher cash-to-asset ratios over time.
REFERENCES


A Supplemental Graphs and Tables

Figure 12: Average cash–to–asset ratio of U.S. listed firms

This figure reports the average cash–to–asset ratio of publicly traded U.S. companies over the period 1958-2014.

Figure 13: Average cash–to–asset ratio at entry and at exit of U.S. listed firms

This figure reports the average cash–to–asset ratio at entry (solid-dotted red line) versus at exit (dashed-dotted blue line) as well as the average cash–to–asset ratio of the sample (solid black line). We group firms into cohorts of five years starting with the cohort 1964-1968 and ending with the cohort 2009-2013.
<table>
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<tr>
<th>Year</th>
<th>Within</th>
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<th>Non-R&amp;D</th>
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<th>Average</th>
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Table 5: Average Cash Ratios

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<td>32.77%</td>
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</tr>
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Difference 1979-2013 22.20% 0.61% 22.02% 3.53%

The sample includes U.S. incorporated Compustat firm-year observations from 1979-2013 with at least 5 years of observations, positive values for assets and sales, excluding utilities and financial firms. A firm’s IPO year is the first year for which a stock price (prce.f) is observed. This IPO assignment is consistent with Jay Ritter’s dataset. We also sort firms into R&D versus non-R&D sector, where R&D sectors are those with more than 2% of R&D expenditures relative to assets.