Firm Selection and Corporate Cash Holdings*

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Abstract

The gradual replacement of traditional U.S. public companies by more R&D-intensive firms is key to understanding the secular trend in average cash-holdings. Over the last 35 years, an increasing share of R&D—intensive firms has entered the stock market with progressively higher cash-balances. This positive entry-effect dominates the negative within-firm effect post IPO. We build a firm industry model with endogenous entry to quantify the importance of two competing selection mechanisms: an increasing share of R&D–intensive firms in the overall economy and more favorable IPO conditions. Only the combination of both mechanisms successfully generates a sizable secular increase.

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1 Introduction

Over the last thirty years, key characteristics of the *average* U.S. public company have substantially changed. The disappearance of dividends (Fama and French (2001)), the decline in profitability (Fama and French (2004)), the increase in cash holdings (Bates et al. (2009)) and cash flow volatility (Davis et al. (2007)) are phenomena of this period. One might think that changes in the business environment caused incumbent public firms to alter their investment and financing behaviors. In this paper, we focus on the *secular increase* in the cash–to–asset ratio[1] to highlight the importance of selection (i.e., the gradual replacement of incumbent firms by new entrants in the stock market) as an engine of these phenomena. In particular, we show that the main driver for higher average cash–holdings is an increasing share of R&D–intensive firms that become public with progressively higher cash balances (selection effect), while the within–firm effect (change of incumbents' cash–holdings) is mostly negative or second order. Our results stress the importance of accounting for selection when inference is based on cross–sectional comparisons over time, because many of the observed changes in investment and financing practices could equivalently be viewed as symptoms of the changing composition of U.S. public firms.

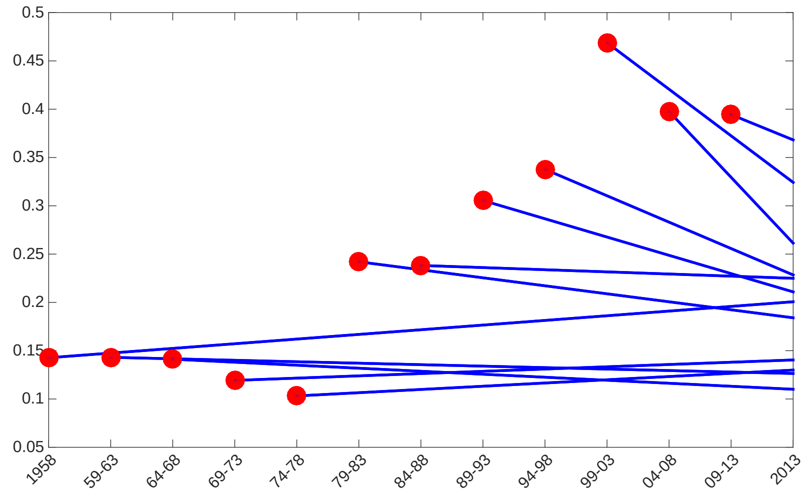
Figure 1 illustrates our key finding. Each dot in the graph represents the average cash–to–asset ratio of a cohort at entry into the U.S. stock market over time. The blue line connects each cohorts' ratio at entry to the average cash–to–asset ratio of the surviving firms in the cohort in 2013. This graph suggests that the increase in the cross-sectional average cash–to–asset ratio is a by–product of a change of cash holdings at entry rather than due to an increase in cash balances of incumbent firms.

The following two panels of Figure 2 provide more color to our selection story. Starting at the end of the 1970s, the fraction of R&D–intensive[2] publicly traded firms has steadily increased, driven by a steady increase in the fraction of R&D–intensive entrants. At the

[1] We report the evolution of the average cash–to–asset ratio of U.S. listed firms during the period 1958–2014 in Appendix A.

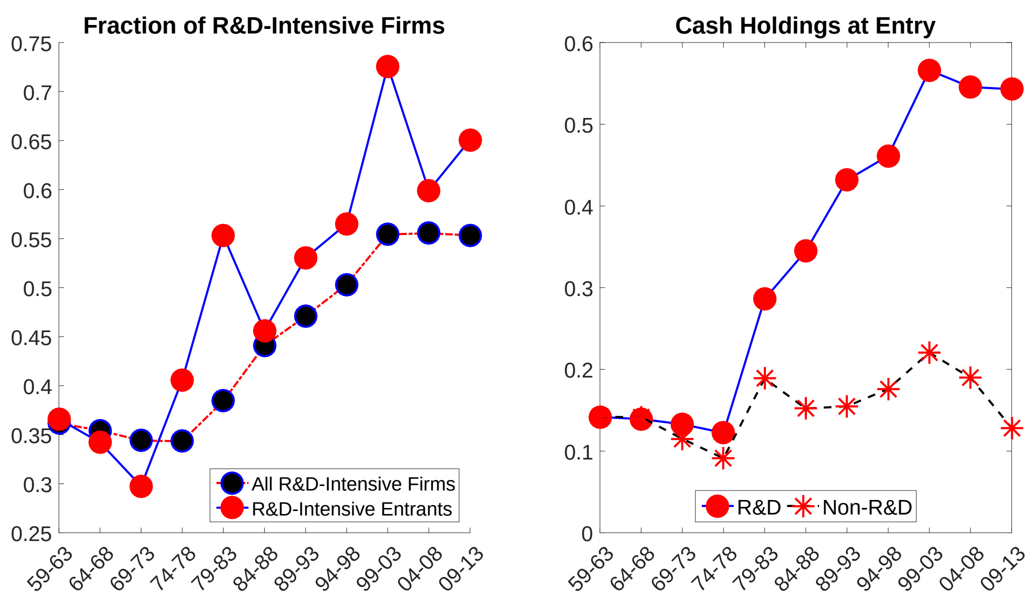
[2] A R&D–intensive firm belongs to an industry whose average R&D investment amounts to at least 2% of assets over the sample period. We choose 2% as the cut-off level because this it is the minimum R&D to asset ratio of the top quintile industries in terms of R&D to asset. Industries are calculated at the three-digit SIC level.

Figure 1: 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 observation denotes 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.

Figure 2: 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 (in darker color with a dashed line) and the share of R&D–intensive entrants (in red with a solid line). The right panel shows the average cash–to–assets ratio at entry of R&D–intensive and non–R&D–intensive firms. A R&D–intensive firm belongs to an industry (three-level digit SIC code) 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 firms that reports a fiscal year-end value of the stock price for the first time (item $PRCC\_F$).

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 (i.e., entered the Compustat sample) with about the same average cash–to–asset ratio as non–R&D–intensive entrants. After 35 years however, this number more than quadrupled for R&D–intensive entrants, while it has remained very close to the 1970s values for non–R&D–intensive entrants. The overall pattern is robust to using the market value for assets, value weighting the data, or defining entry based on the IPO dates provided by Jay Ritter.[3]

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 then observe a secular increase in cash holdings? 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, a value consistent with our decomposition result. To put it simply, the increase in the cash–to–asset ratio at entry overcompensates for the depletion of incumbents' cash holdings, resulting in the secular increase. Thus, 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.

These facts leave open the question which selection mechanism caused the secular increase: a structural shift in the composition of the overall U.S. economy towards R&D–

[3] http://bear.warrington.ufl.edu/ritter/ipodata.htm.

intensive firms, or – in the spirit of Fama and French (2004) – favorable IPO conditions for R&D–intensive firms (e.g. an increased supply of equity capital for risky investments such as R&D–intensive firms).[4] We build a firm industry model with endogenous entry to study this question. The interaction of these two selection mechanisms leads to an amplification effect on cash holdings. As a result, the model can explain a substantial fraction of the increase in average cash–holdings in the data and account for the empirical restrictions presented in Figure 1.[5]

The model highlights that both a shift in the composition towards R&D–intensive firms as well as improved entry conditions are necessary to quantitatively account for the increase in cash–holdings in the data. The compositional change in isolation generates only a small increase in average cash holdings, which is entirely due to the increase in the proportion of young R&D–intensive firms. These firms have typically higher investment and precautionary savings needs. But this effect is neither large enough nor does it generate higher cash–holdings at entry over time as in the data.

The second mechanism we investigate, favorable IPO conditions for R&D–intensive firms proxied by a reduction in the value of staying private, leads to a reduction in the average productivity level of entering firms, as the entry hurdle has been effectively lowered. With adjustment costs and mean-reverting productivity shocks, R&D–intensive firms choose higher cash balances at entry to fund their growth over time and avoid paying equity issuance costs. However, a reduction in the entry cost alone only generates a modest increase in average cash holdings as the composition of public firms has remained constant.

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

[4]We model the structural shift in the composition of firms as an increasing fraction of R&D–intensive private firms. We model the improvement in funding conditions as a reduction in the value of staying private for R&D–intensive firms. This assumption is analogous to the one in Michelacci and Suarez (2004), who propose a model where technological spillovers and market externalities reduce the costs for start-ups to go public. This mechanism could explain the observed reduction in the profitability of U.S. public firms in the data.

[5]We discipline the exercise using the observed data. 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.

explains around 60% of the change in cash holdings. The key for the model's success is 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 because corporations 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.

We also show that the selection mechanism is at least qualitatively consistent with other phenomena, such as the disappearance of dividends, higher cash flow volatility, and the decline in profitability.

Related Literature

The causes of the increase in the average cash–to–asset ratios of public U.S. corporations have 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 selection effect.

A classic motive for cash holdings is transaction costs (e.g. Baumol (1952), Tobin (1956), and Miller and Orr (1966)). Other motives include taxes (e.g. Foley, Hartzell, Titman, and Twite (2007)), precautionary savings (e.g. Froot, Scharfstein, and Stein (1993)), and agency costs (e.g. Jensen (1986) and Nikolov and Whited (2014)). The literature has found evidence for a tax-based explanation (Foley, Hartzell, Titman, and Twite (2007)), a precautionary savings motive (e.g. Bates, Kahle, and Stulz (2009)[6], McLean (2011), and Zhao (2015)), operative changes (Falato, Kadyrzhanova, and Sim (2013) and Gao (2015)), as well as changes in the cost of carrying cash (e.g. Azar, Kagy, and Schmalz (2015) and

[6]Bates, Kahle, and Stulz (2009) also show that non-dividend payers and recently listed firms have successively higher cash ratios relative to seasoned or dividend paying firms. Excluding the first five years (Figure 3 in Bates, Kahle, and Stulz (2009)) of newly listed firms, the authors find 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 but document a positive time trend for both groups. For this reason, they conclude that the change 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).

Curtis, Garin, and Mehkari (2015)).

Using data ranging back to the 1920s, Graham and Leary (2016) note in concurrent work that average cash holdings began to rise in about 1980 even though within-firm cash balances decline over this period, while aggregate cash balances did not rise until about 2000. They attribute the post-1980 rise in average cash balances to changes in sample composition due to Nasdaq firms, and health and tech firms, going public with large cash balances. The post-2000 aggregate increase is consistent with increases in cash trapped due to tax repatriation issues (Faulkender and Petersen (2012)). Falato, Kadyrzhanova, and Sim (2013) propose a dynamic model that links the secular increase in cash holdings to a shift towards intangible capital investment. We show that the shift towards intangible capital of the average firm in Compustat is driven by R&D–intensive firms that go public with progressively less tangible capital relative to assets while non R&D–intensive firms keep their tangibility ratios relatively stable over time. He and Wintoki (2014) find evidence for the view that higher average cash-holdings 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.[7]

Our contribution is to *identify* and *quantify* the secular increase in average cash holdings as a symptom of selection of R&D–intensive firms into public markets. With the help of a stylized model, we show that a combination of two selection mechanisms can account for a substantial fraction in the secular change in cash holdings. To our knowledge, we are the first paper to quantify the secular increase in cash–to–asset ratios related to increased cash balances at entry of firms of a specific type (i.e. R&D–intensive firms that invest in the

[7]The positive relationship between cash and R&D expenditures has been investigated among others by Opler and Titman (1994), Opler, Pinkowitz, Stulz, and Williamson (1999), Brown and Petersen (2011), Falato and Sim (2014), He and Wintoki (2014), and Lyandres and Palazzo (2015). 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.

production of ideas) and to study how the selection mechanism *operates*.[8]

The paper is organized as follows. We start in Section 2 by documenting the role of selection in shaping average cash–holdings. Section 3 presents a firm industry model that can accommodate the different selection mechanisms identified by the data. In Section 4, we use the model as a laboratory to study the importance of these different mechanisms in accounting for the secular increase in cash holdings among U.S. public companies.

2 What drives the average cash–to–assets ratio?

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 of individual firms.[9] R&D–intensive firms have entered in increasing numbers, 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 provide evidence based on a simple aggregate decomposition as well as on a panel analysis.

We show that R&D–intensive and non-R&D–intensive firms can be characterized as two different types of firms, both with regard to their production process as well as in their financial structure. R&D–intensive firms have high R&D–to–asset ratios, a low tangibility of assets, high cash holdings, and a low level of (or non) 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 higher levels 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.

[8] Fama and French (2004) also document the compositional shift of U.S. public companies over the last thirty years. They link this phenomenon to a reduction in equity funding costs for new IPOs.

[9] We rule out firm exit as a driver of the secular increase in the cash–to–asset ratio (see figure 14 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.

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 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 a 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%).[10]

In order to follow the dynamics of an entering cohort, we sort firms into eleven cohorts by considering non-overlapping periods of 5 years starting with the window 1959-1963. A cohort definition based on a 5-year window is fairly standard in the firm dynamics literature but not essential to our results. We define as *entrant* a firms that reports a fiscal year-end value of the stock price for the first time (item $PRCC\_F$).[11]

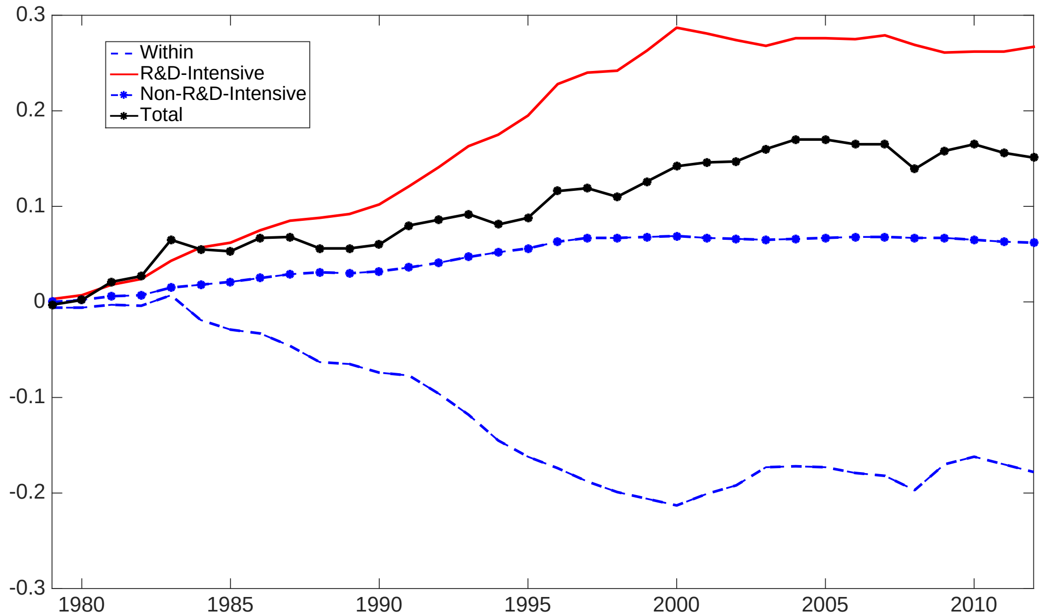
2.2 Decomposition of the cash–to–assets ratio

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

[10] Brown and Petersen (2009) use the same seven SIC codes to identify high–tech industries.

[11] 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.

Figure 3: Cash Change Decomposition



This figure reports the cumulative change in average cash holdings over the sample period together with its three components: the cumulative change due to incumbents (labeled "within"), the cumulative change due R&D–intensive entrants, and the cumulative change due non-R&D–intensive entrants.

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.

The change in the average cash–to–asset ratio ΔCH_t between time $t-1$ and t can be written as

$$\Delta CH_t = \underbrace{\left(\frac{N_t^I}{N_t} CH_t^I - \frac{N_t^I}{N_{t-1}} CH_{t-1}^I\right)}_{\text{within change}} + \underbrace{\left(\frac{N_t^E}{N_t} CH_t^E - \frac{N_{t-1}^X}{N_{t-1}} CH_{t-1}^X\right)}_{\text{selection effect}},$$

where the first term is the change in average cash–holdings due to incumbents (*within change*), while the second term is the change in average cash holdings due to the selection effect. N^j denotes the number of incumbents (I), entrants (E), and exitors (X).[12]

The selection 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

$$\Delta CH_t \;=\; \Big(\frac{N_t^I}{N_t}CH_t^I - \frac{N_t^I}{N_{t-1}}CH_{t-1}^I\Big) + \sum_{i=\{R\&D;nonR\&D\}} \Big(\frac{N_t^{E_i}}{N_t}CH_t^{E_i} - \frac{N_{t-1}^{X_i}}{N_{t-1}}CH_{t-1}^{X_i}\Big).$$

Figure 3 reports the cumulative change in average cash holdings over the 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 equal 0.083 in 1979 and 0.238 in 2012, an increase of 0.155. We can decompose the actual increase in the contribution of the *within change* and the contribution of the *selection effect*. The *within change* contribution is -0.178, while the overall contribution of the *selection effect* is 0.329. The selection effect is driven by the entry of R&D intensive firms, which account for 81% of the selection effect. Table 5 in the Appendix shows that the results are even robust to value-weighted cash-ratios.

2.3 Cross-sectional Analysis

Cross-sectional averages sometimes mask the underlying drivers of secular trends.[13] 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–

[12]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_t^I be the firms publicly traded at time $t-1$ and t (the incumbents) and N_{t-1}^X the firms that exit between time $t-1$ and t. Then, the average cash holdings at time $t-1$ is $\frac{N_t^I}{N_{t-1}}CH_{t-1}^I + \frac{N_{t-1}^X}{N_{t-1}}CH_{t-1}^X$, where $N_{t-1} = N_t^I + N_{t-1}^X$, CH_{t-1}^I is the average cash holdings of incumbents at time $t-1$, and CH_{t-1}^X is the average cash holdings at time $t-1$ of firms that exit between time $t-1$ and t. Let N_t^E be the firms that enter into Compustat at time t. Then, the average cash holdings at time t is $\frac{N_t^I}{N_t}CH_t^I + \frac{N_t^E}{N_t}CH_t^E$, where $N_t = N_t^I + N_t^E$, CH_t^I is the average cash holdings of incumbents at time t, and CH_t^E is the average cash holdings at time t of firms that enter at time t.

[13]Table 6 in the appendix 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.

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 the right panel of Figure 2, we include a dummy variable in Column II that takes a value of zero if a firm is non-R&D–intensive and one otherwise. The difference between the estimated trend for non-R&D–intensive and R&D–intensive firms is striking.

Table 1: Estimating the Time Trend within Firm

	Pooled OLS				FE	Firm-by-firm	
	All I	All II	IPO III	No IPO IV	All V	All VI	All VII
Trend	0.0042	0.0006	-0.0003	0.0009	-0.0002	-0.0050	-0.0027
	0.0000	*0.0000*	*0.1150*	*0.0000*	*0.1290*	*0.0000*	*0.0000*
Trend X R&D intensity		0.0060	0.0078	0.0070			-0.0046
		0.0000	*0.0000*	*0.0000*			*0.0000*
R&D intensity Dummy		0.0462	0.0911	-0.0124			0.2065
		0.0000	*0.0000*	*0.0000*			*0.0000*
Constant	0.1066	0.0936	0.1294	0.0810	0.1856	0.2192	0.1167
	0.0000	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*
Observations	86,029	86,029	23,657	62,372	86,029	16	
Adjusted R^2	0.0349	0.1838	0.2284	0.1923	0.0349	0.2316	

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_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 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.

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 trend of cash–holdings when we focus on firms that have been in Compustat for more than 5 years. Also in this case, the cash-to-asset ratio of R&D–intensive firms has a positive and significant trend. This result is a combination of progressively higher cash holdings at entry and of the persistence in cash holding policies. 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.[14]

Pooled OLS regressions allow us to identify R&D–intensive firms as the driver of the secular increase in cash holdings. However, the cash–to–asset ratio is fairly persistent (see also Figure 15 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 towards 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 value based on our decomposition in section 2.2. Column VII shows that R&D–intensive firms start with much larger cash balances than non-R&D–intensive firms

[14] 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 (see also Table 6 in the Appendix).

Table 2: Estimating the Time Trend for Mature Firms

	Pooled OLS		FE	Firm-by-firm	
	All I	All II	All III	All IV	All V
Trend	0.0048	0.0009	0.0010	-0.0008	-0.0009
	0.0000	*0.0000*	*0.000*	0.0310	*0.1870*
Trend X R&D intensity		0.0067			-0.0003
		0.0000			*0.5470*
R&D intensity Dummy		-0.0062			0.1603
		0.0930			*0.0000*
Constant	0.0670	0.0936	0.1438	0.1820	0.1023
	0.0000	*0.0800*	*0.0000*	*0.0000*	*0.0000*
Observations	55,027	55,027	55,027	15	
Adjusted R^2	0.0408	0.1761	0.0349	0.2898	

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_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.

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. It follows that the rate at which incumbents deplete cash has to be lower than the rate at which entrants increase cash because the overall change in average cash holdings is positive. 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 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 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.

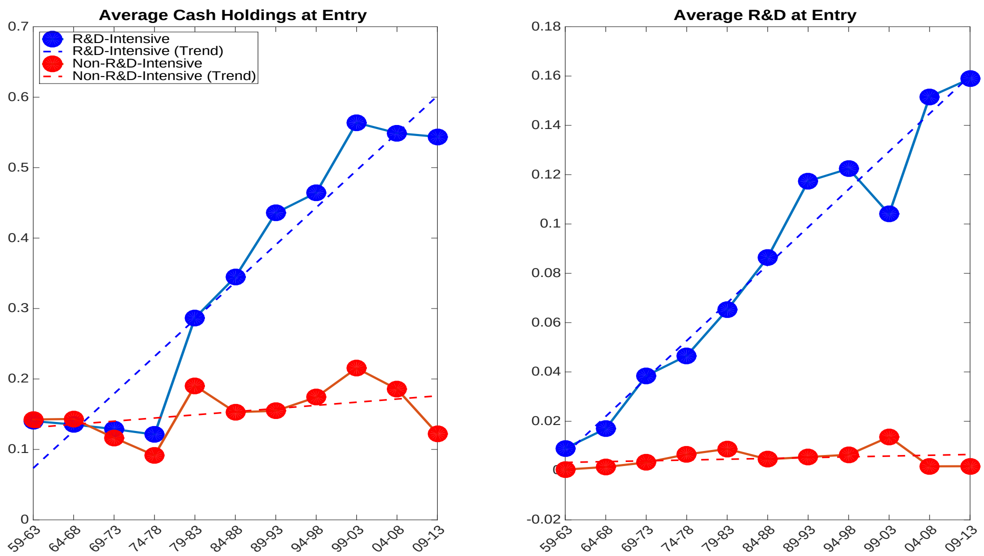
The next section provides evidence that underscores the importance of entry for the secular increase and provides lessons for our firm industry model.

2.4 Lessons from the entry margin

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 1 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 observation is the average cash–to–assets ratio of incumbent firms in 1958. Three facts emerge. First, there is an increase in initial cash holdings over time, , i.e. new cohorts enter with higher and higher cash balances. Second, the majority of cohorts (9 out of 12) deplete cash, i.e. 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 at entry, while subsequent cohorts show an increasing trend.

From Figure 2 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 the left panel of Figure 4), we observe that R&D–intensive firms have entered with higher and

Figure 4: Average Cash Holdings by Cohort at Entry (1959-2013)



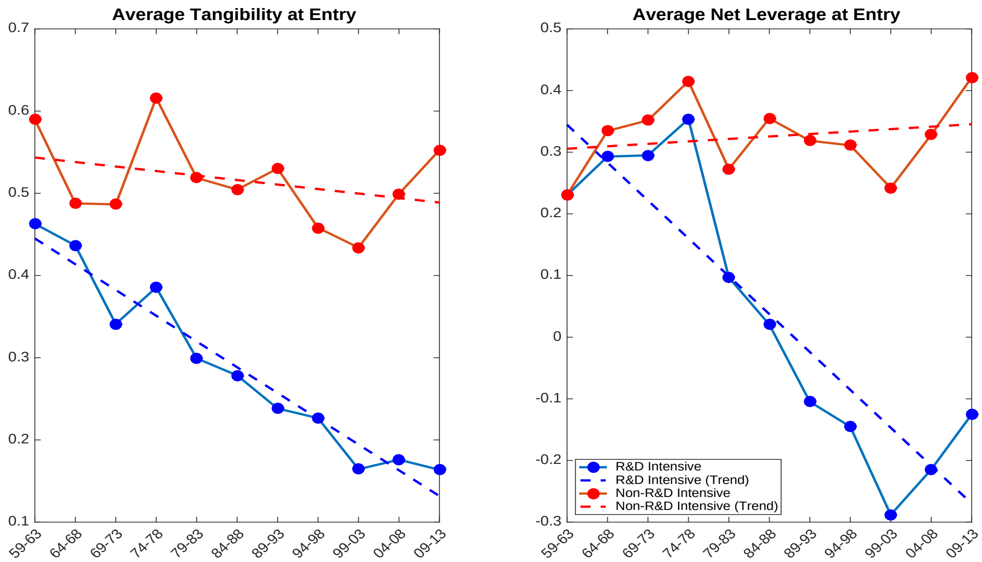
The figure reports the average cash–to–asset ratio (left panel) and the average R&D–to–asset ratio (right panel) for U.S. public companies at entry for eleven 5-year cohorts over the period 1959-2013. The red line refers to non-R&D–intensive firms (old economy), while the blue line to R&D–intensive firms (new economy). The straight dashed line is the linear trend.

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.

The right panel of Figure 4 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 4 presents evidence for a different story. R&D–intensive firms invest more in R&D already at entry while 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 5 reports asset 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'

Figure 5: Other Firm Characteristics by Cohort at Entry (1959-2013)



The figure reports the average tangibility ratio (item $PPEGT$ over item AT) and average net-leverage (item LT net of item CHE over item AT), 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, while the blue line to R&D–intensive firms. The straight dashed line is the linear trend.

tangibility 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–to–assets ratio that is only slightly larger than 15%, while for non-R&D–intensive firms it is around 55%. Net leverage at entry (right panel of Figure 5) 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. Since the mid–1980s, the typical R&D–intensive entrant has had negative net leverage.[15]

The data presented here provide compelling evidence for a major role of selection. How-

[15]We use Compustat data to calculate the cash–to–asset ratio and the R&D–to–asset ratio in the two years prior to the IPO year. We observe a similar trend in cash balances and R&D activity prior to IPO as documented in Figure 4.

ever, it does not shed any light on which selection mechanism caused the secular increase: a structural shift in the composition of the overall U.S. economy towards R&D–intensive firms, or – in the spirit of Fama and French (2004) – favorable IPO conditions for R&D–intensive firms. In section 3 we build a firm industry model with endogenous entry to analyze the effects of these two selection mechanisms and use the stylized facts documented in this section to guide our modeling assumptions and impose a tight discipline on our experiments.

First, we do not model the decision of a firm to become a certain type. We believe that this is justified by the stark and persistent differences between R&D and non-R&D–intensive firms at entry and beyond in the data, suggesting that the decision to be either type is made some time before the decision to become a public firm. Figure 15 in Appendix A describes the post entry dynamics of cash holdings, R&D-to–assets, tangibility, and net-leverage. Second, we simplify our analysis by restricting R&D–intensive firms to hold only non-tangible capital that cannot be financed with debt, as overall suggested by Figure 5.

In order to investigate whether an increasing R&D–intensive firm share in the economy could give raise to the secular increase, we change the fraction of R&D–intensive potential entrants in our experiments to generate a compositional change for publicly traded firms disciplined by the dynamics observed in the left panel of Figure 2. On the other hand, to explore the role of more favorable IPO conditions for R&D–intensive firms, we will make the IPO decision more attractive for R&D–intensive firms in a way to mimic the cash holdings' evolution at entry of R&D–intensive firms documented in the left panel of Figure 4.

3 Model

In this section, we study the interaction between the two selection mechanisms discussed in the empirical part using a heterogeneous firm industry model that builds on Hopenhayn (1992). Key features of our model are an endogenous entry decision, where we follow Clementi and Palazzo (2015), and the presence of two types of firms: R&D–intensive firms labeled as new economy firms and non-R&D–intensive firms labeled as old economy firms. We model old economy firms similarly to Begenau and Salomao (2016) who study the business cycle dynamics of financial policies in a firm industry model with aggregate shocks and endogenous entry and exit. Debt is preferred over equity because of a tax-advantage. Old economy firms invest in tangible capital and pledge tangible capital as collateral to access debt financing. We model new economy 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.

We assume the existence of a time-invariant mass of potential firms that can become public (potential entrants in the stock market). 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

Technology For simplicity, we assume that both types of firms share the same decreasing return to scale production function

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

where j indicates if the firm uses tangible ($j = o$, i.e. old-economy) or intangible capital ($j = n$, i.e. new-economy) and z_{t+1} is an idiosyncratic productivity shock that evolves according to

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

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

$$k_{j,t+1} = (1 - \delta_j) k_{j,t} + x_{j,t},$$

where δ_j is the depreciation rate and $x_{j,t}$ is the capital investment at time t. We assume $\delta_n > \delta_o$.[16] We also assume the presence of quadratic investment adjustment costs

[16]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) and Warusawitharana (2015) provide evidence for a larger depreciation rate for the R&D capital stock.

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

Financing Firms can finance their operations internally by transferring cash from one period to the next at an accumulation rate $\widehat{R}$. We assume that $\widehat{R} < R$, namely internal accumulation of cash delivers a return lower than the risk-free rate. Firms can also 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

$$H(d_t) = -\kappa |d_t|.$$

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

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

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

Old economy incumbent's problem At time t, the firm's budget constraint is

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

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 $\left(s_{t+1}/\widehat{R_o}\right)$. 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 κd_t. In what follows, $\mathbf{1}_{[d_t \leq 0]}$ 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

$$\begin{aligned} w_{t+1} &= s_{t+1} + (1-\tau)e^{z_{t+1}}k_{o,t+1}^{\alpha} - \underbrace{\left(R - \tau(R-1)\right)b_{t+1}}_{\equiv b^*_{t+1}} \\ &= s_{t+1} + (1-\tau)e^{z_{t+1}}k_{o,t+1}^{\alpha} - b^*_{t+1}. \end{aligned} \tag{2}$$

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 save on notation, we introduce a new variable, b^*_{t+1}, that is equal to the repayment to the bondholders net of the tax deduction. Notice that by construction b_{t+1} equals $\frac{b^*_{t+1}}{\widehat{R}_o}$. It follows that we can summarize cash and debt in a single variable $l_{o,t+1} = s_{t+1} - b^*_{t+1}$, the net cash holdings of the firm. Each period, the firm faces an exogenous exit probability, λ.[17] 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

$$\begin{aligned} V^o(k_{o,t}, l_{o,t}, z_t) \quad &\equiv \max_{l_{t+1}, x_{o,t+1}} \quad d_t + H\left(d_t\right)\mathbf{1}_{[d_t \leq 0]} + J\left(l_{o,t+1}\right)\mathbf{1}_{[l_{o,t+1} \leq 0]} \\ \ldots \quad & \quad + \frac{1-\lambda}{R}E_t\left[V_{t+1}\left(k_{o,t+1}, l_{o,t+1} z_{t+1}\right)\right] + \frac{\lambda}{R}E_t\left[w_{t+1} + (1-\delta_o)k_{o,t+1}\right] \end{aligned} \tag{3}$$

[17] This assumption is innocuous in the context of our exercise. Figure 14 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

$$
\begin{aligned}
d_t &= w_t - \frac{l_{o,t+1}}{\widehat{R_o}} - x_{o,t+1} - \phi(k_{o,t+1}, k_{o,t}), && (4)\\
k_{o,t+1} &= (1-\delta_o)k_{o,t} + x_{o,t+1}, && (5)\\
w_{t+1} &\equiv (1-\tau)e^{z_{t+1}}k^{\alpha}_{o,t+1} + l_{o,t+1}, && (6)\\
-l_{o,t+1} &\leq (1-\delta_o)k_{o,t+1}. && (7)
\end{aligned}
$$

New economy incumbent's problem A new economy firm cannot rely on external debt given the lack of collateral. Thus, the only difference to the problem of the old-economy firm is that $l_{n,t} = s_t$. Thus, the time t value of the new-economy firm solves the functional equation below

$$
\begin{aligned}
V^n(k_{n,t}, l_{n,t}, z_t) \quad &\equiv \max_{l_{t+1}, x_{n,t+1}} \quad d_t + H(d_t)\,\mathbf{1}_{[d_t \leq 0]} + \frac{1-\lambda}{R}E_t\left[V_{t+1}\left(k_{n,t+1}, l_{n,t+1,}z_{t+1}\right)\right] \\
&\quad ... + \frac{\lambda}{R}E_t\left[w_{t+1} + (1-\delta_n)k_{n,t+1}\right] \qquad (8)
\end{aligned}
$$

subject to

$$
\begin{aligned}
d_t &= w_t - \frac{l_{t+1}}{\widehat{R_n}} - x_{n,t+1} - \phi(k_{n,t+1}, k_{n,t}), && (9)\\
k_{n,t+1} &= (1-\delta_n)k_{n,t} + x_{n,t+1}, && (10)\\
w_{t+1} &= (1-\tau)e^{z_{t+1}}k^{\alpha}_{n,t+1} + l_{n,t+1,}, && (11)\\
l_{n,t+1,} &\geq 0. && (12)
\end{aligned}
$$

Choosing cash holdings ($s_{t+1} = l_{n,t+1}$) 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 $\widehat{R_n} = \nu R$, 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 ω as the fraction M_o/M. Firms that decide to go public are randomly drawn from the stationary distribution of private firms.

We focus 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 Clementi and Palazzo (2015), we introduce heterogeneity in firms that go public by assuming that each potential entrant in the stock market receives a signal q about its future productivity. This 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 decide to go public if the value of being a publicly traded firm exceeds the value of staying private V_p. The value function for an old economy entrant is

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

while the value function for a new economy entrant is

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

A firm will go public if and only if

$$V^{E,i} \geq V_{p,i} \quad \forall i \in \{o, n\}.$$

3.3 Firm industry equilibrium

Denote ω as the fraction of old economy firms. Given ω 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 $\{\Gamma_t^i\}_{t=1}^{\infty}$ and entrants' measures $\{\varepsilon_t^i\}_{t=0}^{\infty}$ $\forall i \in \{o, n\}$ 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 $Z \times K \times L \times X \times \Re$ 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 $B^{E_i}(W) = \left\{(l'_i(q), x'_i(q)) \text{ s.t. } l'_i(q) \in L,\ x'_i(q) \in X \text{and } V^{E,i} \geq c_{e,i}\right\}$ denotes the policy functions of entrants.

4. For all Borel sets $Z \times K \times L \times X \times \Re$ 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 $\omega = \Gamma^o_{t+1}(W')/(\Gamma^n_{t+1}(W') + \Gamma^o_{t+1}(W'))$.

The distribution of firms 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.

3.4 Parametrization

We parametrize the model at an annual frequency using a combination of parameter values taken from other studies together with a set of parameters that we calibrate. To highlight the role of selection, we calibrate the parameters to match key features of U.S. public companies during the years that precede 1980 and we keep these parameters fixed over the period 1980-2013. Table 3 reports the parameters' 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 δ_n equal to 0.205, a number consistent with depreciation rates for R&D capital reported by the Bureau of Economic Analysis (e.g., Li

Table 3: PARAMETRIZATION

Panel A: Parameters from other studies

Parameter	Function	Origin/Target
$\alpha = 0.62$	Decreasing returns to scale	Hennessy and Whited (2007)
$\delta_o = 0.15$	Depreciation old firms	Hennessy and Whited (2007)
$\delta_n = 0.205$	Depreciation new firms	Li (2012)
$\tau_c = 0.35$	Corporate tax rate	subject to experimentation
$r = 0.04$	Risk-less rate	Riddick and Whited (2009)
$\sigma = 0.121$	Volatility firm-level shock	Riddick and Whited (2009)

Panel B: Calibrated parameters

Parameter	Moment	Data	Model
$\omega = 0.668$	Proportion of new firms	0.332	0.332
$\rho = 0.90$	Volatility sales' growth rate	0.221	0.188
$\nu = 0.99592$	Cash holdings new firms	0.083	0.083
$V_{p,n} = 0.0105$	Cash holdings new firms at entry	0.138	0.133
$\kappa = 0.14$	Equity-to-asset ratio new firms	0.056	0.053
$\eta = 0.015$	Autocorrelation cash holdings new firms	0.727	0.668
$\gamma = 0.0161$	Net Debt-to-asset ratio old firms	0.143	0.139
$V_{p,o} = 0.0143$	Relative size old type entrant	0.707	0.712
$\epsilon = 16$	Relative size entrant	0.663	0.718

Panel C: Age distribution with exit rate $\lambda = 0.07$

Age Bins	1-5	6-10	11-15	16-20	>20
Model	0.302	0.211	0.147	0.102	0.238
Data	0.296	0.206	0.159	0.119	0.221

(2012)).

Since we are interested in the evolution of corporate cash–holdings during the period 1980–2013, we calibrate the remaining parameters to match key moments using data from the period 1959–1979. The proportion of potential entrants of type old (ω) is set to 0.668. This value allows us to replicate the composition of publicly traded firms during the period 1959-1979. The conditional standard deviation of the idiosyncratic shock is the same as in Riddick and Whited (2009), while we set the persistence parameter equal to 0.90 – a value within the estimates provided by Hennessy and Whited (2007) – to match the average cross–sectional standard deviation of the sales growth rate. Following Davis et al. (2007), we define the latter quantity as $\frac{y_t - y_{t-1}}{0.5\times y_t + 0.5\times y_{t-1}}$.

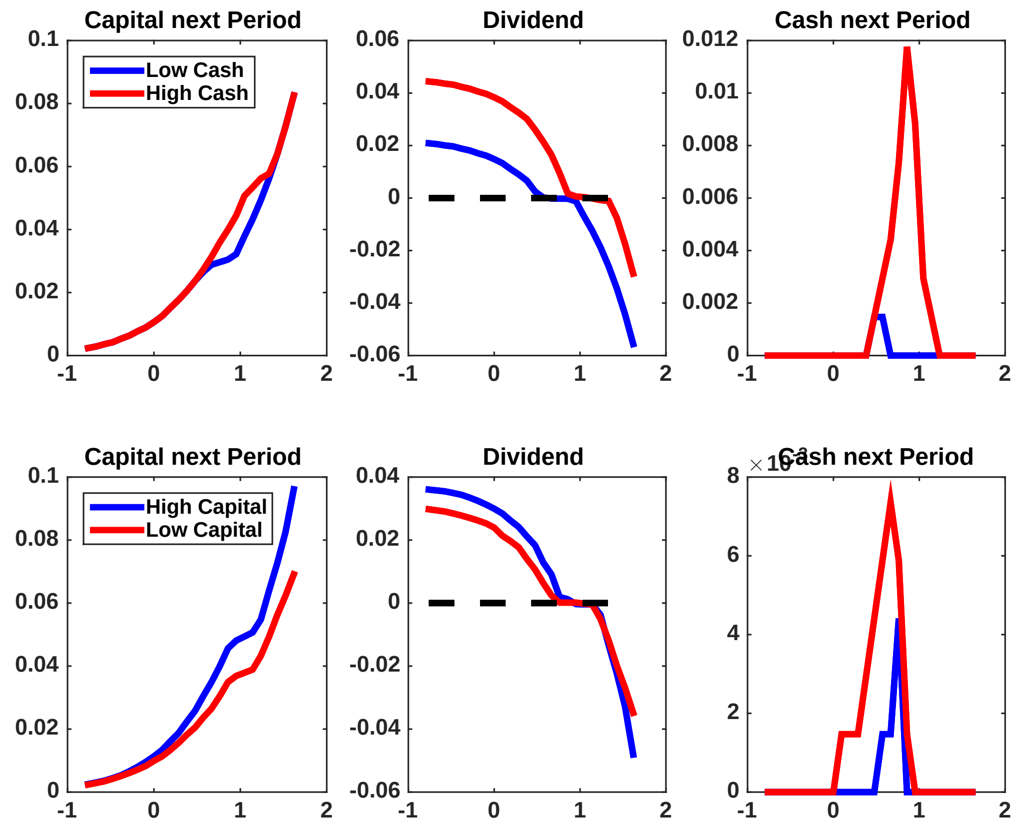
Then we calibrate a set of parameters to replicate some key cash holdings moments for R&D–intensive firms in 1979. First, we calibrate the cost of carrying cash inside the firm, ν, to match the average cash–to–asset ratio. Second, we choose a number for the value of staying private for R&D–intensive firms to match the average cash–to–asset at entry. The proportional equity issuance cost (κ) is set to match the average equity-to-asset ratio of R&D–intensive firms over the period 1959-1979. We define the cash–to–asset ratio as cash holdings divided by the beginning of the period capital plus cash holdings, while the equity-to-asset ratio is equity issuance also divided by the beginning of the period capital plus cash holdings.

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. A quadratic investment adjustment cost introduces persistence in the investment policy that will translate in persistent cash holding policies. 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 net debt-to-asset ratio is $l_{o,t+1}$ divided by the beginning of the period capital plus cash holdings. The value of staying private 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. We measure firm size using total sales (y_t). Panel B of Table 3 reports the simulated moments together with their empirical counterpart.

To conclude, we set the exogenous exit rate (λ) 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). In our model, younger firms have a larger cash–to–asset ratio. An age distribution tilted towards young 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 towards 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.

Figure 6: Policy Functions



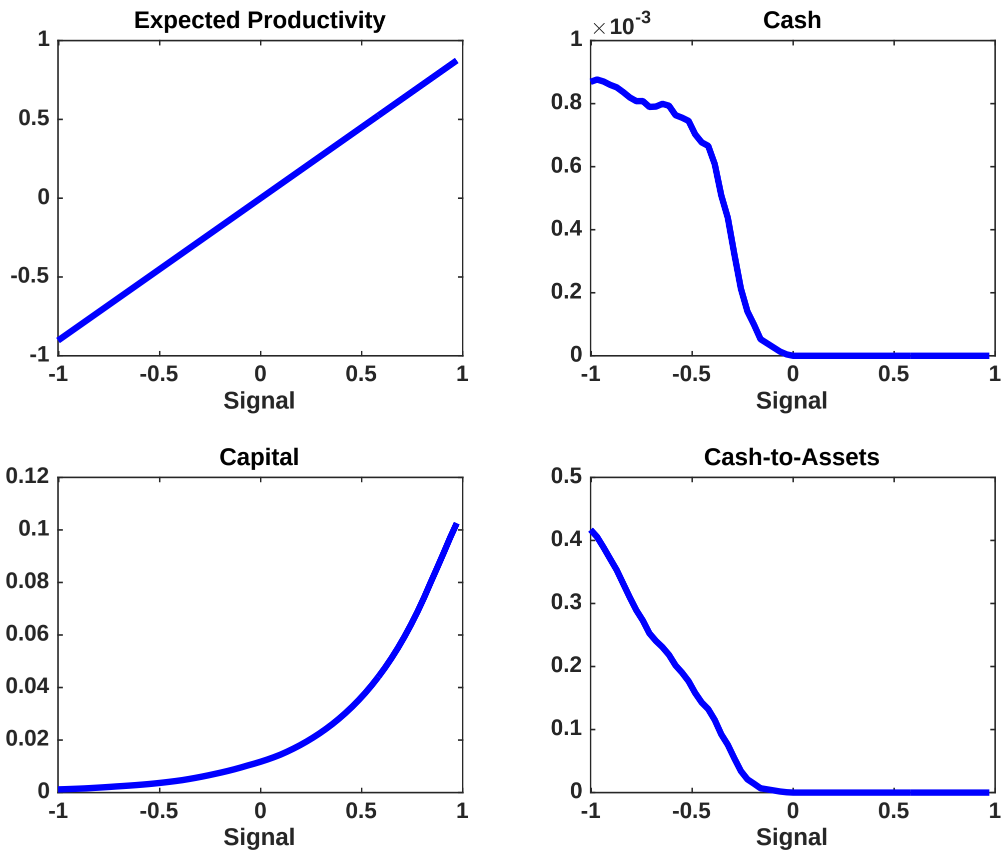
The figure reports the policy functions as a function of the firm-level shock for a new economy firm. The left panels depict the optimal capital choice, the middle panels the distributed dividends, and the right panels the optimal saving policy. The top panels report the policies for a high cash firm (red line) and a low cash firm (blue line), while considering the same level of beginning of the period capital stock. The bottom panels report the policies for a low capital firm (red line) and a high capital firm (blue line), while considering the same level of beginning of the period cash.

3.5 Policy functions

Figure 6 illustrates the policy functions for a new economy type firm as a function of the firm–level shock. For the sake of brevity, we omit the discussion of the policy functions for a old economy type firm, which are not the main focus of the model. The top panels illustrate the policies for two firms that only differ in their beginning of the period cash balances. The left panel shows that these two firms choose the same capital next period if they are both distributing dividends or issuing equity. For small values of the shock, both firms have the same investment and financing policies. In particular, when the shock is very low both firms can rely on small cash flows and decide to retain no cash to finance future growth. As the shock becomes larger, both firms decide to reduce their dividend and to invest more thus taking advantage of the higher productivity. If the shock becomes large enough, they engage in precautionary savings. Given that issuing equity is costly, they decide to save internal resources to avoid equity issues in the near future. If the shock is very large, it becomes optimal to stop saving and issue equity to finance a larger investment. In the latter case, both firms have similar investment policies but the firm with lower cash balances issues more equity than the firm with larger cash balances. The difference in the equity issuance is exactly equal to the cash balance differential multiplied by $1 + \kappa$.

The bottom panels illustrate the policies for two firms that only differ in their beginning of the period capital. The behavior of the investment and financing policies as a function of the productivity shock are very similar to the ones described above. However, given the presence of capital adjustment costs, the installed capital matters for the firm's optimal investment decision. Differently from the previous case, the two firms do not have the same investment policy when they are both financially unconstrained (i.e., for low level of the shock) and when they both issue equity (i.e., for high level of the shock). The investment adjustment cost makes the investment policy more persistent so that large firms tend to stay large and small firm tend to stay small. In addition, firms with larger installed capital can rely on larger internal resources everything else being equal. For this reason, they stop distributing dividends and start issuing equity for a larger level of the idiosyncratic shock

Figure 7: Policy Functions at Entry



The figure reports the characteristics at entry for a new economy firm as a function of the entry signal. The top left panel depicts the expected firm-level productivity, the bottom left panel the capital choice at entry, the top right panel the cash balance, and the bottom right panel the cash balance divided by total assets (i.e., capital plus cash holdings).

relative to firms with smaller beginning of the period capital.

Figure 7 depicts the optimal investment and cash holdings decisions of a new economy type firm as a function of the signal q about its future productivity. The top left panel shows the expected productivity given the signal. As the signal improves, the firm expects a larger productivity and decides to invest more (bottom left panel). At the same time, the firm decides to save some of the IPO proceeds as cash to minimize the future equity issuance cost (top right panel). However, as the signal improves the firm expects larger cash flows and a consequent smaller probability of costly equity issuance, namely the marginal benefit of saving cash out of IPO proceeds decreases. If the signal is sufficiently good, the firm decides not to save any cash. The bottom right panel reports the cash–to–asset ratio of an entering firm. As the signal improves, the firm saves less cash and invests more thus generating a decrease in the cash–to–asset ratio.

4 The effect of selection on average cash holdings

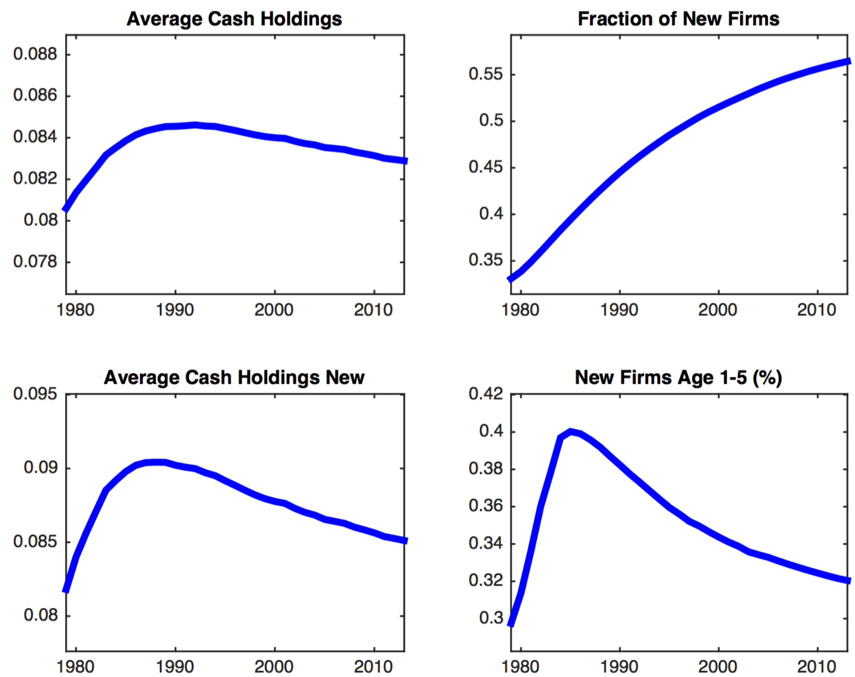
In this section we investigate to what extent different selection mechanisms can account for the increase in average cash holdings of U.S. public firms and other features of the data. In all the experiments we assume a constant cash holdings value of 0.08 for non–R&D–intensive firms. These firms have an indeterminate financial policy (only net leverage matters) and 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.

Private sector composition 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 ω changes over a time span of 35 years so that the model replicates the compositional change for publicly traded firms in the data (see left panel of Figure 2).[18]

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 gone public in the last 5 years (young firms) as a fraction of the total number of new economy firms. This selection mechanism – the compositional shift –

[18]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.

Figure 8: Increase in share of new economy firms



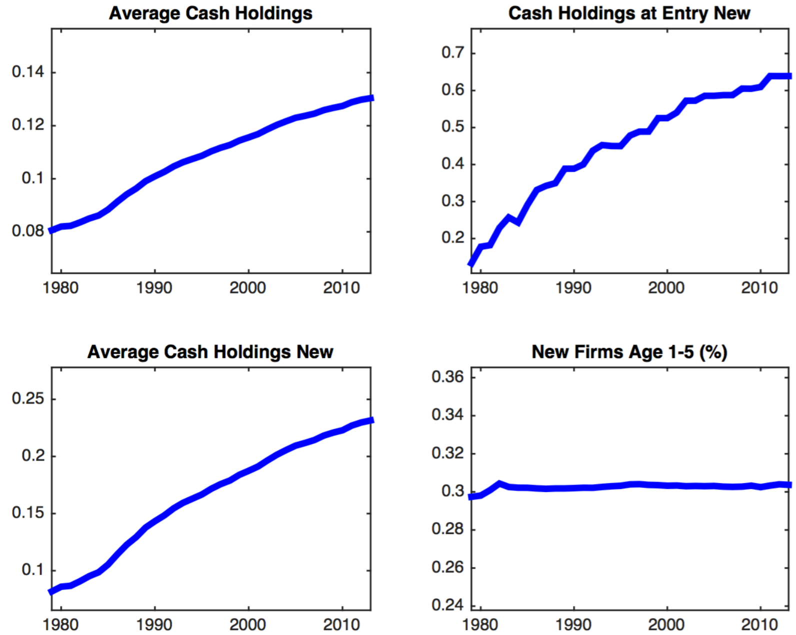
This figure reports the effect of an increase in the share of new economy firms on average cash holdings.

makes the average R&D–intensive firm (new firm type) younger (since going public).

A structural change in the composition of entrants is unable to generate a secular increase in the average cash holdings of publicly traded firms. 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.

The value of staying private changes for new economy firms. In our second experiment, we study the model's response to a reduction in the value of being private for new economy firms. We assume a reduction in $V_{p,n}$ over 35 years to mimic the cash holdings'

Figure 9: Reduction in entry costs for new economy firms



This figure reports the effect of a decrease in the entry cost for new economy firms on average cash holdings.

evolution at entry of R&D–intensive firms.[19]

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 in $V_{p,n}$ for new economy firms makes it even for small, low productivity firms, i.e. young low profitability firms with higher growth potential, optimal to go public. Since the shocks are mean reverting, lower productivity firms anticipate higher productivity shocks in the future, which increases their investment needs today. In order to avoid paying equity issuance costs to raise funds at times when productivity is high, they raise more

[19]We assume that the value of staying private for entrants of type new evolves over time according to $V_{p,n,t} = (V_{p,n} - a_1) + a_1 t^{-a_2}$ 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.

cash relative to their asset at the IPO stage. The lower $V_{p,n}$, the lower the productivity threshold of entry of new economy firms and the higher the average cash holdings at entry. The reduction in firms' profitability and age at IPO particularly for R&D–intensive firms is borne out in the data (see Panel B of Figure 12 on profitability and Table 7 on the age at IPO).

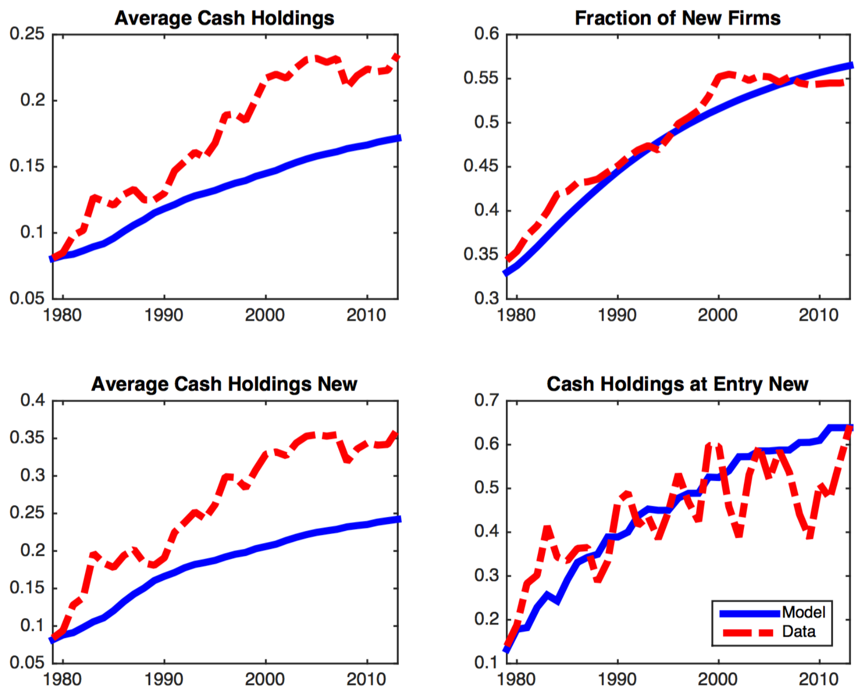
Figure 9 shows how the average cash holdings increases when we abstract from a change in the composition of firms. This increase is driven by new firms entering with higher and higher cash balances (top right panel) meanwhile the distribution of new firms' age stays constant (bottom right panel). Over 35 years, the average cash holdings goes from its steady state value of 0.081 to a value of 0.130 and the model is capable to explain around 30% of the total change in cash holdings documented in the data.

Reduction in $V_{p,n}$ and increase in share of new-economy firms. The results from the previous two experiments 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 $V_{p,n}$ 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 $V_{p,n}$ 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 value of staying private for new economy firms helps the model along two dimensions. First, the model can generate both a secular increase in cash holdings for R&D–intensive at entry and a shift in composition toward R&D–intensive companies. Second, the secular increase in

Figure 10: Combined

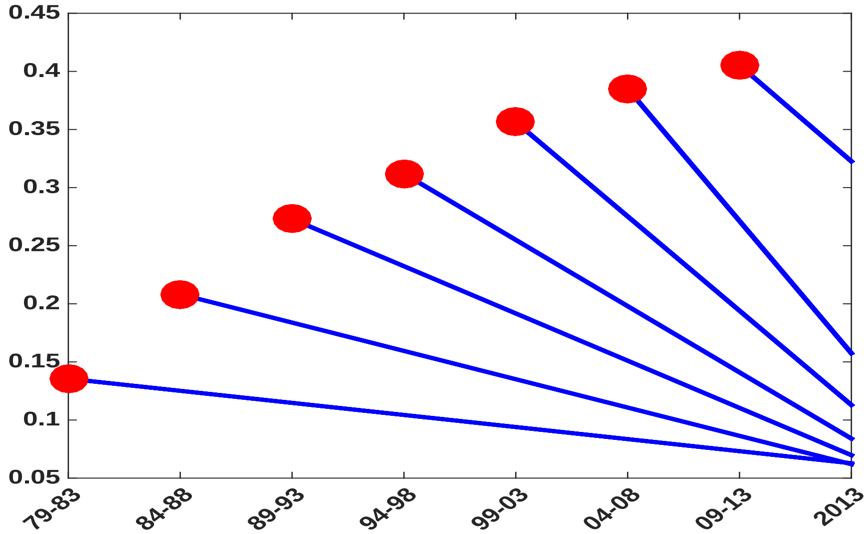


This figure reports the effect of a reduction in the entry cost for new economy firm entrants and an increase in the share of new economy firms in the economy. The solid blue line depicts the simulated data, the dashed red line depicts the empirical counterpart.

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.

The mechanism behind the secular increase in cash holdings in our model is based on a positive selection effect that offsets the contribution of a negative within effect. This can be seen in Figure 11, which is the model counterpart of Figure 1. As in the data, firms enter with progressively higher cash holdings. The tilt towards younger cohorts further implies that firms, on average, deplete cash faster after entry. The slope of 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.

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



The figure reports the evolution of the cash–to–asset ratio for model generated firms using seven 5-year cohorts over the period 1979-2013. The red dot denotes the average cash holdings at entry for each cohort. The straight line connects the initial average cash-holdings to the average holding in 2013 for each cohort.

4.1 The Role of Selection for Other Secular Trends

Selection can also play an important role in explaining other *secular trends* that have been documented among publicly listed U.S. companies. Fama and French (2001) highlight the steady decrease in the number of dividend paying firms over the period 1978–1999. In a follow up paper (Fama and French (2004)), they focus on the average cross–sectional profitability and document a steady decrease in profitability during the 1980–2001 period. Davis et al. (2007) show how, contrary to what happened in the private sector, the cross sectional dispersion of firm growth rates for publicly listed U.S. companies has increased over the period 1978–2004. In this section, we explore the model's ability to reproduce these three empirical findings.

We start with the decline in dividend distribution. The lower propensity to pay dividends documented in Fama and French (2001) is paired with a decline of the average cross–sectional dividend-to-assets ratio (see Panel B in Figure 12). The top left panel in Panel A of Figure 12 reports the evolution of the average cross–sectional dividend–to–assets ratio generated by the model over the period 1979–2013. The dotted black line is the average value including all the firms. As we can see the model is qualitatively consistent with the disappearing dividend phenomenon and produces a decline of more than 20% in the dividend–to–assets ratio over the period of interest.[20]

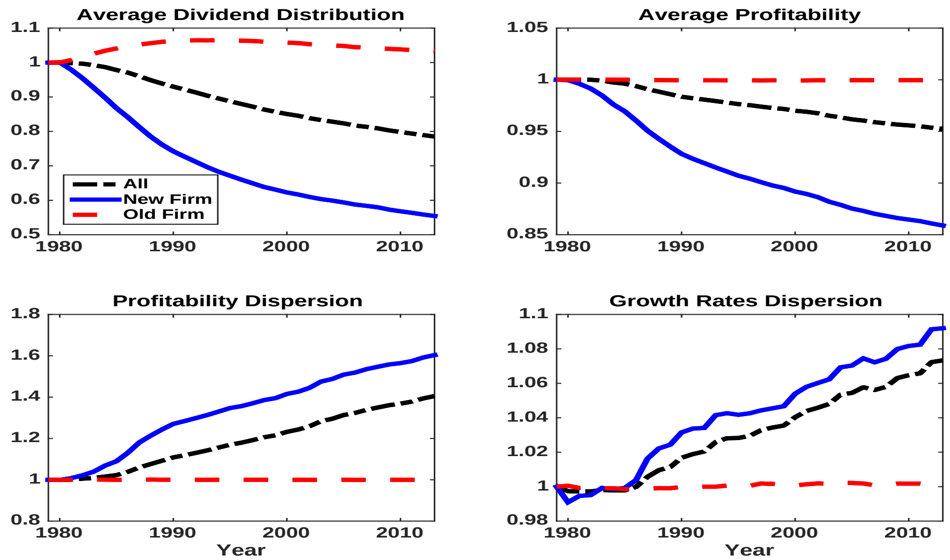
The decline in the dividend-to-asset ratio is connected to the dynamic evolution of the average cross–sectional profitability (top right panel). In our experiment, new economy firms require a progressively lower signal to enter in the equity market. For this reason, they have a lower average productivity that explains the decrease in the average profitability in the cross–section. Given the mean-reverting nature of the firm-level shock, these new entrants will invest a lot relative to their initial size and use all of the internal resources and, potentially, equity to finance their investment needs thus generating a reduction in dividend distribution.

To conclude, we explore the dynamic evolution of the cross-sectional dispersion of profitability and sales growth rates in the bottom panels of Panel A in Figure 12. Consistent with the findings of Davis et al. (2007) and with their empirical counterparts reported in Panel B of Figure 12, the selection mechanism that drives the secular increase in average cash holdings is able to produce an increase in the cross-sectional volatilities over the 1979-2013 period qualitatively consistent with what we observe in the data. As Clementi and Palazzo (2015) point out, this increase happens despite constant parameters of the idiosyncratic productivity, across time and across firms. As time goes by, the selection mechanism allows smaller firms to go public and, because of decreasing returns to scale, these firms will be characterized by higher growth rates relative to incumbents. This feature is responsible for the increase in the cross-sectional standard deviation.

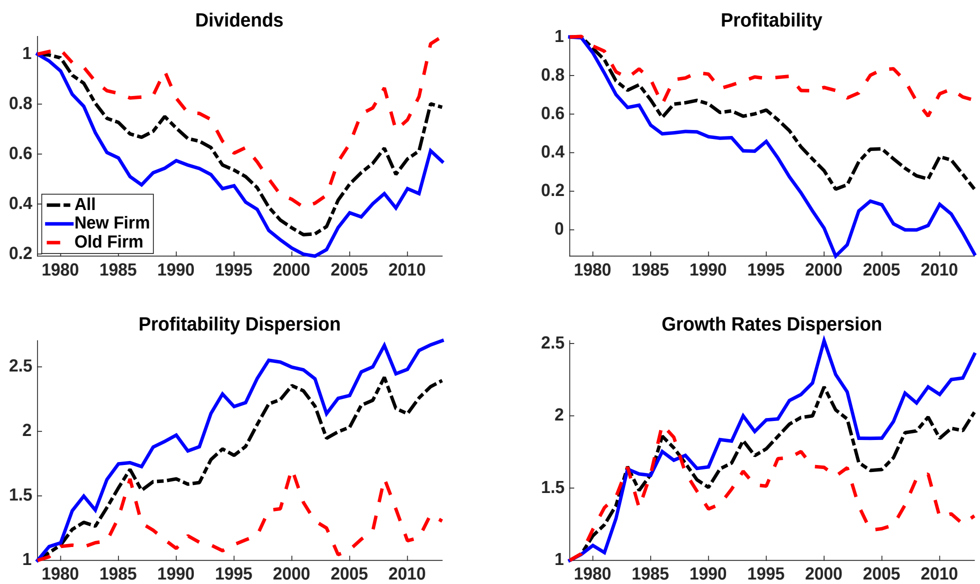
[20]The data also shows a steep decline in the dividend-to-asset ratio for non-R&D-intensive firms that our selection model does not capture. This behavior is likely caused by forces outside our model like catering incentives (e.g., Baker and Wurgler (2004)), market liquidity (e.g., Banerjee et al. (2007)), or risk as measured by stock returns volatility (e.g., Hoberg and Prabhala (2009)).

Figure 12: Additional Predictions

Panel A: Model



Panel B: Data



The top panel reports the dynamic evolution of dividend distribution, profitability and the dispersion of profitability and sales growth rates generated by a reduction in $V_{p,n}$ for new economy firm entrants and an increase in the share of new economy. The bottom figure reports the data counterpart using a 1978-2013 annual Compustat sample. Top left: cross-sectional averages of dividend/assets. The series are normalized with the first observation in 1978 to facilitate comparison. Top right: cross-sectional average ebitda/assets. Bottom left: cross-sectional standard deviation of ebitda/assets. Bottom right: cross-sectional standard deviation of sales growth where sales growth is measured as in Davis et al. (2007). The solid blue line refers to new economy firms, the dashed red line refers to old economy firms, and the dash-dotted black line refers to all the firms in the economy.

5 Conclusion

In this paper we highlight the importance of selection in explaining the increase in the average cash–to–asset ratio for U.S. public companies during the last thirty years. We separate the contribution of incumbent firms (within effect) from the contribution of new entrants in the stock market (selection effect) and show that, while the typical U.S. public company experiences a decrease in the cash–to–asset ratio, the selection effect is powerful enough to reverse the negative within effect and to generate a secular increase. Given the compelling evidence for a major role of selection, we build an industry model with endogenous entry to analyze the effects of two selection mechanisms: an increasing share of R&D-intensive firms and more favorable IPO conditions. Alone, these mechanisms cannot account for the data. Only the combination of both successfully generates a sizable secular increase. Our results suggest a new direction in the debate about the causes of the secular increase in the corporate cash–to–asset ratio and other observed changes in investment and financing practices. Instead of focusing on factors that influence incumbents' investment and financing 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.

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A Supplemental graphs and tables

In this appendix, we provide graphs and tables to supplement the empirical analysis in the main body of the paper.

The secular increase in cash. Figure 13 shows the average cash–to–asset ratio for U.S. public companies over the period 1958–2013. What has been dubbed as *the secular increase* (Bates et al. (2009)) starts in 1979. In the period 1979–2013 the average cash holdings value goes from 0.08 in 1979 to 0.25 in 2013.

Cash decomposition: Selection effect versus within effect. Table 4 reports the contribution of the *selection effect* and of the *within change* on a year–by–year basis for the period 1979–2012. For each year, we report both the change and the cumulative change in average cash–holdings due to incumbents (*within change*) and the change in average cash holdings due to the selection effect. The latter quantity is split between the selection effect generated by R&D–intensive firms and the selection effect generated by non-R&D–intensive firms.

Cash decomposition: Value-weighted results. Table 5 presents the same decomposition exercise as in section 2.2 but with the value-weighted instead of the equally-weighted cash–to–asset ratio. In this case, we decompose the change in the value-weighted cash–to–asset ratio between time $t-1$ and t as

$$\Delta CH_t^{VW} = \underbrace{\sum_{i=1}^{I_t}(w_{i,t}CH_{i,t} - w_{i,t-1}CH_{i,t-1})}_{\text{within change}} + \underbrace{\sum_{j=1}^{E_t} w_{j,t}CH_{j,t} - \sum_{k=1}^{X_{t-1}} w_{k,t-1}CH_{k,t-1}}_{\text{selection effect}},$$

where the first term is the change in average cash–holdings due to incumbents (*within change*), while the second term is the change in average cash holdings due to the selection effect. I_t denotes the number of incumbents in the sample between time $t-1$ and t, E_t denotes the number of entrants in the sample at time t, and X_{t-1} denotes the number of firms that exit the sample at the end of time $t-1$. The weight is given by the value of the firm at time t over the total value of the firms in the sample at time t. We measure the firm's value as the sum of total liabilities (Compustat item LT) and market value of equity, which is calculated as the product of the number of share outstanding (Compustat item $CSHO$) times the price per share (Compustat item $PRCC\_C$) .

As in the equal–weighted case, R&D–intensive entrants play a key role in shaping the time-series evolution of the value-weighted cash–to–asset ratio. However, value weighting sheds a different light on the phenomenon itself. When we consider all the firms in the sample, the within effect and the selection effect due to R&D intensive entrants have roughly the same importance in explaining how the value-weighted cash-to-asset ratio evolves over time. However, it is enough to eliminate the top 1% of the size distribution from the sample firms to make the selection effect due to R&D intensive entrants the most important driving force. When we eliminate firms in the top 5% of the size distribution, we moreover obtain the negative within-effect results, consistent with the equally-weighted approach.

Cash decomposition: R&D-intensive versus non-R&D-intensive firms. Table 6 reports the evolution of the average cash-to-asset ratio for R&D-intensive and non-R&D-intensive firms over the period 1979–2013. For each category of firm, we separate between firms that have entered the Compustat database within 5 years and firms that have been in the Compustat database for more than 5 years.

The exit margin. Figure 14 compares the average cash holding of entering and exiting firm in our sample. The data show that exitors hold almost the same cash ratio as the average firm over time, supporting the assumption of an exogenous and i.i.d. exit process used in the model.

Post-entry dynamics. What happens to cash holdings in the subsequent years after entry? Figure 15 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. 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.

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. This evidence supports our modeling decision of having a fixed type of firms rather than assuming firms that can dynamically change their type.

Age at IPO. Table 7 reports the average and median age at IPO of companies in our sample. We merge the data on founding dates available from Jay Ritter's website with the data on founding dates collected by Jovanovic and Rousseau (2001)[21].

B Computational details

Solution

We solve the incumbent problem by value function iteration. We discretize the firm-level shock with 35 grid-points using the method in Rouwenhorst (1995). We discretize the capital grid using 200 grid-points, the net leverage grid for old economy firms using 100 grid-points, and the cash grid for new economy firms using 100 grid-points. We also scale the revenue function so that the capital choice is between zero and one.

We also solve the entrant problem by value function iteration. We discretize the signal

[21] We are grateful to Boyan Jovanovic and Peter Rousseau for kindly providing their dataset. We are grateful to Jay Ritter for making data on founding dates publicly available on his website:
https://site.warrington.ufl.edu/ritter/ipo-data/

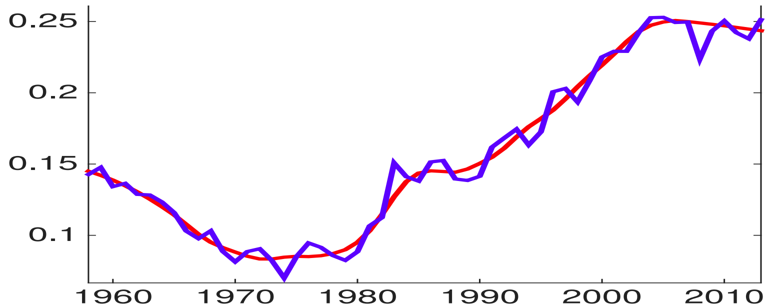
space using 100 grid-points. The lower (upper) bound of the signal grid coincides with the lower (upper) bound of the firm-level shock grid. We use a discrete version of the Pareto distribution to allocate the mass of potential entrants over the signal space.

Simulation

We simulate a panel of 40,000 firms for 300 periods to let the economy settle in the ergodic state. At each time t, a fraction λ of firms exits the economy. These firms are replaced by an equal mass of entrants in each period. We discard the first 100 periods and calibrate the model using the remaining 200.

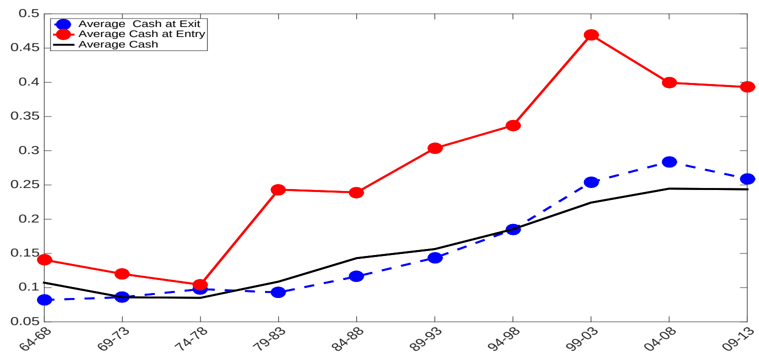
To run our experiments, we start from the stationary distribution and simulate our economy for an additional 35 years. We repeat the simulation 200 times and report average values across the 200 simulations.

Figure 13: Average cash–to–asset ratio of U.S. listed firms



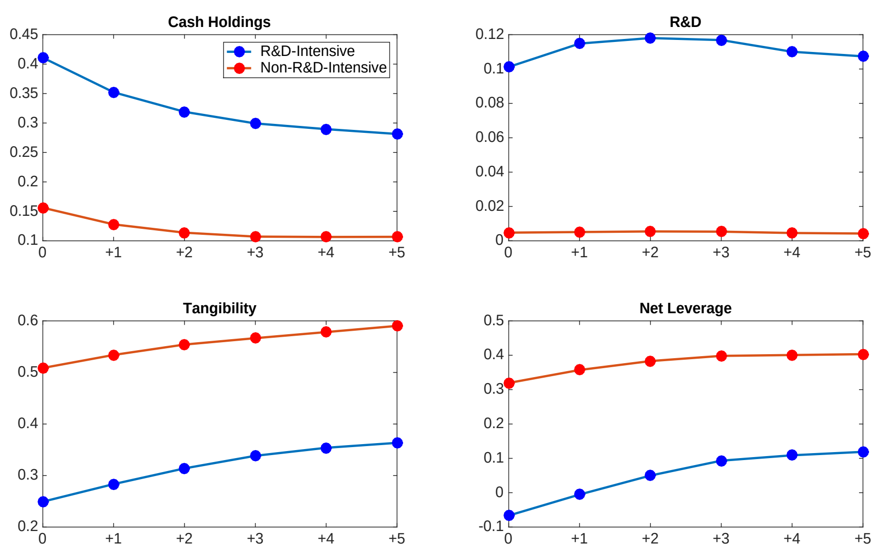
This figure reports the average cash–to–asset ratio of U.S. public companies over the period 1958-2013.

Figure 14: 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.

Figure 15: Dynamic Evolution Post-Entry



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.

Table 4: Cash Change Decomposition

	Change				Cumulative Change				Average
Year	Within	R&D	Non-R&D	Total	Within	R&D	Non-R&D	Total	All firms
1979	-0.006	0.003	0.000	-0.003	-0.006	0.003	0.000	-0.003	0.083
1980	0.000	0.004	0.002	0.006	-0.006	0.007	0.002	0.002	0.088
1981	0.003	0.011	0.004	0.018	-0.003	0.018	0.006	0.021	0.107
1982	-0.002	0.006	0.001	0.006	-0.004	0.024	0.007	0.027	0.112
1983	0.012	0.019	0.008	0.038	0.007	0.043	0.015	0.065	0.151
1984	-0.026	0.014	0.002	-0.010	-0.019	0.057	0.018	0.055	0.141
1985	-0.011	0.005	0.003	-0.003	-0.029	0.062	0.021	0.053	0.138
1986	-0.003	0.013	0.005	0.014	-0.033	0.075	0.025	0.067	0.151
1987	-0.013	0.010	0.004	0.001	-0.046	0.085	0.029	0.068	0.153
1988	-0.018	0.004	0.002	-0.012	-0.063	0.088	0.031	0.056	0.139
1989	-0.002	0.003	-0.001	0.001	-0.065	0.092	0.030	0.056	0.138
1990	-0.009	0.011	0.001	0.003	-0.074	0.102	0.032	0.060	0.141
1991	-0.003	0.019	0.004	0.020	-0.077	0.121	0.036	0.080	0.162
1992	-0.019	0.020	0.005	0.006	-0.096	0.141	0.041	0.086	0.168
1993	-0.021	0.022	0.006	0.006	-0.118	0.163	0.047	0.092	0.174
1994	-0.027	0.012	0.005	-0.011	-0.145	0.175	0.052	0.081	0.163
1995	-0.017	0.020	0.004	0.007	-0.162	0.195	0.056	0.088	0.172
1996	-0.012	0.033	0.007	0.028	-0.174	0.228	0.063	0.116	0.201
1997	-0.014	0.012	0.004	0.003	-0.188	0.240	0.067	0.119	0.203
1998	-0.011	0.002	0.000	-0.009	-0.199	0.242	0.067	0.110	0.193
1999	-0.007	0.022	0.001	0.016	-0.206	0.263	0.068	0.126	0.208
2000	-0.007	0.023	0.000	0.017	-0.213	0.287	0.069	0.142	0.225
2001	0.012	-0.006	-0.002	0.004	-0.201	0.281	0.067	0.146	0.229
2002	0.008	-0.007	-0.001	0.001	-0.192	0.274	0.066	0.147	0.230
2003	0.020	-0.006	-0.001	0.013	-0.173	0.268	0.065	0.160	0.242
2004	0.000	0.008	0.002	0.010	-0.172	0.276	0.066	0.170	0.252
2005	0.000	0.000	0.001	0.000	-0.173	0.276	0.067	0.170	0.253
2006	-0.006	0.000	0.001	-0.005	-0.179	0.275	0.068	0.165	0.249
2007	-0.003	0.004	0.000	0.000	-0.182	0.279	0.068	0.165	0.249
2008	-0.015	-0.010	-0.001	-0.026	-0.197	0.269	0.067	0.139	0.224
2009	0.027	-0.008	0.000	0.019	-0.170	0.261	0.067	0.158	0.243
2010	0.008	0.001	-0.002	0.007	-0.162	0.262	0.065	0.165	0.250
2011	-0.007	0.000	-0.002	-0.009	-0.170	0.262	0.063	0.156	0.242
2012	-0.008	0.005	-0.002	-0.005	-0.178	0.267	0.062	0.151	0.238

This table reports the year-by-year decomposition of the cash-to-assets ratio over the period 1979–2012. We report both the yearly change and the cumulative change. The column *wihin* reports the contribution of incumbent firms. The column *R&D* reports the contribution of R&D–intensive net entrants. The column *Non–R&D* reports the contribution of Non–R&D–intensive net entrants. The last column reports the average cash–to–assets ratio.

Table 5: Value-Weighted Cash Change Decomposition

	All Firms				Excluding Top 1%				Excluding Top 5%			
Year	CH	Within	Select. R&D	Select. No-R&D	CH	Within	Select. R&D	Select. No-R&D	CH	Within	Select. R&D	Select. No-R&D
1979	0.08	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.07	0.00	0.00	0.00
1980	0.07	-0.01	0.00	0.00	0.07	0.00	0.00	0.00	0.07	0.01	0.00	0.00
1981	0.07	-0.01	0.00	0.00	0.07	0.00	0.00	0.00	0.08	0.01	0.00	-0.01
1982	0.07	-0.01	0.00	0.00	0.08	0.01	0.00	0.00	0.08	0.02	0.01	-0.01
1983	0.09	0.01	0.01	0.00	0.11	0.03	0.01	0.00	0.12	0.04	0.02	-0.01
1984	0.08	0.00	0.01	-0.01	0.09	0.01	0.01	-0.01	0.11	0.03	0.02	-0.01
1985	0.08	0.00	0.00	-0.01	0.09	0.01	0.01	-0.01	0.11	0.03	0.02	-0.01
1986	0.09	0.01	0.01	-0.01	0.09	0.02	0.01	-0.01	0.12	0.04	0.02	-0.01
1987	0.09	0.01	0.01	-0.01	0.09	0.02	0.01	-0.01	0.12	0.03	0.03	-0.01
1988	0.07	-0.01	0.01	-0.01	0.08	0.00	0.01	-0.01	0.10	0.02	0.03	-0.01
1989	0.07	-0.01	0.00	-0.01	0.08	0.00	0.00	-0.01	0.10	0.02	0.02	-0.01
1990	0.07	-0.01	0.01	-0.01	0.08	0.00	0.01	-0.01	0.10	0.02	0.02	-0.01
1991	0.08	-0.01	0.01	-0.01	0.10	0.02	0.01	-0.01	0.13	0.04	0.03	-0.01
1992	0.08	0.00	0.01	-0.01	0.10	0.02	0.01	-0.01	0.12	0.03	0.03	-0.01
1993	0.08	-0.01	0.01	0.00	0.10	0.01	0.02	0.00	0.12	0.03	0.04	-0.01
1994	0.08	-0.01	0.01	0.00	0.09	0.01	0.01	0.00	0.11	0.01	0.04	-0.01
1995	0.09	0.00	0.01	0.00	0.10	0.01	0.01	0.00	0.13	0.02	0.05	0.00
1996	0.10	0.00	0.02	0.00	0.10	0.01	0.02	0.00	0.14	0.01	0.06	0.00
1997	0.11	0.01	0.02	0.00	0.10	0.01	0.02	0.00	0.13	0.00	0.06	0.00
1998	0.12	0.02	0.02	0.00	0.11	0.01	0.02	0.00	0.13	0.00	0.06	0.00
1999	0.17	0.05	0.04	0.00	0.19	0.05	0.06	0.00	0.21	0.03	0.11	0.00
2000	0.17	0.04	0.05	0.00	0.17	0.02	0.08	0.00	0.20	-0.01	0.14	0.00
2001	0.16	0.03	0.05	0.00	0.15	0.00	0.08	0.00	0.18	-0.02	0.13	0.00
2002	0.14	0.02	0.05	0.00	0.13	-0.02	0.08	0.00	0.15	-0.05	0.13	0.00
2003	0.16	0.04	0.04	0.00	0.16	0.01	0.08	0.00	0.17	-0.02	0.13	0.00
2004	0.18	0.05	0.05	0.00	0.16	0.01	0.08	0.00	0.17	-0.03	0.13	0.00
2005	0.18	0.05	0.05	0.00	0.16	0.02	0.07	0.00	0.17	-0.03	0.13	0.00
2006	0.16	0.04	0.04	0.00	0.15	0.01	0.07	0.00	0.16	-0.03	0.12	0.00
2007	0.16	0.04	0.04	-0.01	0.14	0.00	0.07	0.00	0.16	-0.03	0.12	0.00
2008	0.14	0.02	0.04	0.00	0.13	-0.01	0.06	0.00	0.14	-0.05	0.12	0.00
2009	0.17	0.05	0.04	0.00	0.15	0.02	0.06	0.00	0.17	-0.02	0.12	0.00
2010	0.17	0.05	0.04	0.00	0.16	0.03	0.06	0.00	0.18	-0.01	0.12	0.00
2011	0.17	0.05	0.04	0.00	0.16	0.03	0.06	0.00	0.17	-0.02	0.12	0.00
2012	0.16	0.04	0.04	0.00	0.15	0.02	0.07	-0.01	0.16	-0.03	0.12	0.00
	0.08	48%	57%	-5%	0.08	20%	87%	-7%	0.09	-29%	131%	-2%

This table reports the year-by-year decomposition of the value-weighted cash-to-assets ratio over the period 1979–2012. We perform the decomposition using (i) all the firms in the sample, (ii) excluding firm in the top 1% of the size distribution, and (iii) excluding firm in the top 5% of the size distribution. For each sample, we report the value-weighted cash-to-asset ratio (Column *CH*), the cumulative change due to incumbent firms (Column *Within*), the cumulative selection effect due to R&D-intensive firms (Column *Select. R&D*), and the cumulative selection effect due to Non-R&D-intensive firms (Column *Select. No-R&D*). The last row reports the cumulative change in the value-weighted cash-to-assets ratio over the period 1979–2012 and the corresponding contribution (in percentage terms) of the within and the selection effects.

Table 6: Average Cash Ratios

	IPO within last 5 years		No IPO within last 5 years	
Year	R&D	Non R&D	R&D	Non R&D
1979	10.56%	9.48%	7.85%	7.86%
1980	14.38%	12.52%	7.96%	7.84%
1981	20.22%	15.05%	9.04%	8.22%
1982	21.62%	13.60%	9.33%	8.89%
1983	30.87%	16.85%	12.23%	10.28%
1984	27.62%	15.19%	11.49%	9.34%
1985	25.67%	13.61%	11.52%	9.54%
1986	27.95%	15.43%	12.67%	9.98%
1987	29.54%	13.43%	13.05%	10.35%
1988	25.72%	12.54%	12.71%	9.23%
1989	24.38%	11.28%	13.33%	9.54%
1990	26.23%	10.37%	14.02%	9.22%
1991	32.73%	11.86%	15.10%	9.70%
1992	34.25%	12.28%	16.70%	9.36%
1993	36.52%	11.79%	17.09%	9.39%
1994	33.63%	9.79%	16.90%	8.25%
1995	35.46%	9.88%	16.94%	7.82%
1996	38.90%	11.73%	18.80%	8.15%
1997	37.66%	11.20%	20.07%	8.58%
1998	36.06%	11.05%	20.00%	8.10%
1999	40.07%	10.88%	20.78%	7.49%
2000	40.76%	11.62%	23.08%	7.21%
2001	41.60%	12.61%	24.82%	8.11%
2002	41.02%	15.06%	27.37%	8.82%
2003	43.64%	17.47%	29.51%	10.15%
2004	45.40%	19.10%	29.78%	11.04%
2005	45.95%	15.38%	30.59%	11.42%
2006	43.77%	13.51%	31.18%	11.40%
2007	42.99%	12.40%	31.05%	10.90%
2008	40.52%	11.25%	27.69%	10.26%
2009	39.66%	12.93%	30.34%	12.65%
2010	38.54%	12.22%	31.18%	13.29%
2011	36.62%	11.86%	30.46%	12.05%
2012	35.65%	9.40%	29.93%	11.40%
2013	32.77%	10.09%	29.87%	11.38%
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 (prcc_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.

Table 7: Age at IPO

	All Firms			Non-R&D-Intensive			R&D-Intensive		
Cohort	Mean	Median	Obs	Mean	Median	Obs	Mean	Median	Obs
1979-1983	23.53	13	279	27.70	16	154	18.39	11	125
1984-1988	22.24	14	488	27.17	18	296	14.63	10	192
1989-1993	19.16	9	594	24.02	12	296	14.34	8	298
1994-1998	16.82	9	1226	21.92	11	572	12.36	8	654
1999-2003	14.93	8	1057	21.67	11	378	11.17	7	679
2004-2008	16.94	8	778	26.10	14	291	11.46	7	487
2009-2013	18.51	9	873	26.29	14	334	13.69	8	539
Total	17.85	9	5295	24.35	13	2321	12.78	8	2974

This table reports the firm age at IPO of the seven entering cohorts over the period 1979-2013.