Firm Selection and Corporate Cash Holdings*

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June 2015

Abstract

This paper proposes a novel explanation for the secular increase in the cash holdings of public U.S. firms. We show that this fact results from a change in the composition of firms. Since the end of the 70s, the proportion of R&D-intensive firms has increased dramatically. These types of firms enter the Compustat sample with progressively more cash holdings. In contrast, non-R&D-intensive firms’ cash holdings have remained stable over time. We use a firm industry model with endogenous entry in the stock market to explore three competing hypothesis: 1) a structural change in the composition of U.S. firms; 2) lower entry costs/better IPO conditions for R&D-intensive firms; 3) institutional reasons such as a change in the tax benefit of R&D activities. We find that in isolation neither a structural change in the composition of firms nor a reduction in the entry cost for R&D-intensive firms can rationalize the features of the data. Only a combination of both can generate a secular increase in corporate cash holdings and R&D-intensive firms that enter with progressively higher cash balances.

∗ Comments are welcome. We are grateful to Andrea Buffa, Gian Luca Clementi, Joan Farre-Mensa, and Evgeny Lyandres, as well seminar attendants at Boston University, Harvard University and SED meeting for their comments and suggestions. All remaining errors are our own responsibility. Correspondence: Juliane Begenau (jbegenau@hbs.edu) and Berardino Palazzo (bpalazzo@bu.edu).
1 Introduction

Over the last thirty years, cash-holdings of the average U.S. public company have doubled. In theory, a firm’s cash policy is determined by transaction-, precautionary savings-, tax-, or agency-driven motives. Several explanations for the dramatic increase in cash holdings have been advanced by the literature: an increase in agency conflicts, a change in firm characteristics and business environments that has led to an increase in precautionary savings motives, or the stronger presence of multinational firms that are able to expatriate their taxes. What these explanations have all in common is that they focus on changes within the firm. In this paper we propose a novel explanation for the increase in average cash holdings. We argue that the secular increase in cash holdings stems from a change in the composition of firms, that is, the gradual replacement of non-R&D-intensive firms by R&D-intensive firms. Rather than being driven by a change of cash holding policies within the firm, this secular increase has been driven by a change in the type of firms that decided to go public.

The left panel of Figure 1 shows that the fraction of R&D-intensive firms has increased, a fact largely explained by an increase in the fraction of R&D-intensive entrants (right panel). Why do R&D-intensive firms carry higher cash balances? We argue that their R&D activities require cash financing. The reasons are the following. First, R&D activities contribute to the increase of a firm’s intangible capital stock, which is difficult to collateralize. Second, firms may also find it optimal to finance their R&D activities with cash. When firms use external financing to fund R&D, they have to disclose sensitive information that could give an edge to competitors. Firms can avoid the disclosure of important information by using cash to finance R&D. When firms use debt, they need to put up collateral. High R&D firms, however, tend to hold more intangible assets that are more difficult to collateralize. Again, the firm can avoid running into financing frictions by using cash instead of external funds.

The emergence of R&D-intensive firms since the 1980s is linked to a shift in the U.S. economy from a goods producing economy to an ideas producing economy (e.g., Buera and

\[ A \text{ R&D-intensive firm belongs to an industry whose average R&D investment amounts to at least 2\% of assets over the sample period. However, we show that seven sectors dominate in the R&D-intensive firm classification.} \]
The left panel of this figure presents the share of R&D-intensive firms in Compustat. The right panel shows the share of R&D-intensive entrants. A R&D intensive firm belongs to an industry whose average R&D investment amounts to at least 2% of assets over the sample period. We group firms into cohorts of five years starting from 1959. We define as entrant a firms that reports a fiscal year-end value of the stock price for the first time (item $PRCC_F$).

It is thus important to recognize this dichotomy in a data sample of U.S. companies. These two firm types differ not only in their business models (production of goods versus ideas), but also in the way how operations are financed. R&D-intensive firms are characterized by high R&D-to-asset ratios, low tangibility, and high cash-to-asset ratios. Their cash-to-asset ratio at entry increases over time. Non-R&D-intensive firms have smaller cash balances, higher tangibility, and do not show an increase in R&D activities or cash balances over the sample period.

This is why it is insufficient to look at changes within the firm to explain the secular increase in cash holdings. Instead, we need to investigate the reasons for the shift in firms’ composition. To this end, we develop a novel quantitative model of firm dynamics and firm financing in which firms are either R&D-intensive firms or non-R&D-intensive firms. We use this model to investigate different explanations for the change in the composition of U.S. public firms. We identify three potential hypotheses. First, a structural change in the overall
U.S. economy that makes IPOs of R&D-intensive firms more likely. Second, a decrease in stock exchanges entry cost for R&D-intensive firms so that they find it relatively cheaper to do an IPO. And finally, we explore institutional reasons as well. In particular, we analyze whether a change in the tax benefit of R&D in 1981 was a driver of the change.

Our results suggest that an increase in the share of R&D-intensive firms alone generates an increase in average cash holdings but not an increase in average cash holdings at entry for R&D-intensive firms. This effect is generated with a reduction in the entry cost for R&D-intensive firms. Only a combination of these two features can account for the stylized facts of the data.

Related Literature

The causes of the increase in cash-to-asset ratios of public U.S. corporations has been studied in numerous papers. However, most papers attribute the change in firms’ average cash-holdings to changes within the firm. We propose a novel explanation in which the secular increase in cash-holdings is due to a dramatic shift in the composition of firms.

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

The recent empirical literature has explained the increase in average cash-holdings both with a tax-based explanation (Foley, Hartzell, Titman, and Twite (2007)) and a precautionary savings motive due to higher cash-flow volatilities (e.g. Bates, Kahle, and Stulz (2009)). When asymmetric information is the cause of external financing frictions, firms whose activities are more informationally sensitive have a stronger precautionary savings motive compared to other firms. Graham and Leary (2015) use data ranging back to the 1920s. They find mixed evidence for precautionary saving motives in their panel and some
support for a tax-based explanation for the secular increase in cash holdings. Opler and Titman (1994) argue that the value of R&D expenditures are particularly informationally sensitive investments. Consistent with this view, Opler, Pinkowitz, Stulz, and Williamson (1999) find that cash rich firms invest more in R&D.

Since Opler, Pinkowitz, Stulz, and Williamson (1999) more papers have provide evidence that high R&D investment is related to more cash holdings at the firm level, for example Brown and Petersen (2011), Falato and Sim (2014), and He and Wintoki (2014), among others.

Only a few papers hint at the notion that the increase in average cash-to-asset ratios is driven by a subset of firms. For example, He and Wintoki (2014) find evidence for the view that the increase can be explained with an increased sensitivity of cash to R&D among R&D-intensive firms. Moreover, they find that financial constraints and cash flow volatility are more relevant for R&D-intensive firms than for non-R&D-intensive firms. Thakor and Lo (2015) argue that standard theory does not capture the financial and business environment of R&D-intensive firms sufficiently well, requiring a new theory. In their model, competitive pressure leads firm to choose more R&D investment and higher cash-to-asset ratios.

Thakor and Lo (2015) provide a rationale for why more firms choose a high R&D-intensive business model, we argue that the data suggest that two types of firms coexist: R&D-intensive firms and non-R&D-intensive firms. We further show that conditional on the firm’s type financial policies do not change much over time. This relates to the literature on persistence in the corporate capital structure (e.g. Lemmon, Roberts, and Zender (2008)). To our knowledge, we are the first paper to link the secular increase in cash-to-asset ratios to the increased entry of firms of a new type: new-economy firms that invest in the production of ideas.\footnote{Fama and French (2004) also document the compositional shift of U.S. public companies over the last thirty years, however they do link this phenomenon to a change in corporate financing policies.}

We study different hypotheses that may have caused the increase in the composition of firms in a firm industry model that builds on Hopenhayn (1992). A key feature of our model is the entry decision of firms, where we follow Clementi and Palazzo (2013). There

\footnote{Fama and French (2004) also document the compositional shift of U.S. public companies over the last thirty years, however they do link this phenomenon to a change in corporate financing policies.}
are two types of firms in the model: R&D-intensive firms and non-R&D-intensive firms. We model the non-R&D-intensive firm type similarly to Begenau and Salomao (2015) who study the business cycle dynamics of financial policies in a firm industry model with aggregate shocks and entry and exit. Debt is preferred over equity because of a tax-advantage. The non-R&D-intensive firms invest in tangible capital and pledge tangible capital as collateral to access debt financing. We model R&D-intensive firms similar to Riddick and Whited (2009). These firms build a stock of intangible capital that cannot be collateralized via R&D spending. Therefore, they can only finance themselves with equity or with internal funds.

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

2 Facts

In this section, we show that the secular increase in the cash-to-asset ratio has been driven by a change in the type of firms that decided to go public, rather than being driven by a change of cash holding policies within the firm. R&D-intensive firms have entered in increasing number, relative to non-R&D-intensive firms, and with higher and higher cash balances, thus driving up the cash holdings of the typical U.S. public company.

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

We use accounting data from the annual Compustat database over the period 1959-2013. We exclude financial firms (SIC codes 6000 to 6999) and utilities (SIC codes 4900 to 4999) and we only consider firms incorporated in the United States and traded on the three major exchanges: NYSE, AMEX, and NASDAQ.

A R&D-intensive firm belongs to an industry (defined using a three-level digit SIC code) whose average R&D investment amounts to at least 2% of assets over the period 1959-2013. 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% entrants), Drugs (SIC 283, 15% entrants), Medical Instruments and Supplies (SIC 384, 9% entrants), Electronic Components and Accessories (SIC 367, 8% entrants), Computer and Office Equipment (SIC 357, 7% entrants), Measuring and Controlling Devices (SIC 382, 5% entrants), and Communications Equipment (SIC 366, 5% entrants).

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. Having a 5-year cohort is fairly standard in the firm dynamics literature. We define as entrant a firm that reports a fiscal year-end value of the stock price for the first time (item PRCC_F)\(^3\).

2.2 Firm Characteristics at Entry

We argue that investment and financing decisions within the firm (i.e., a firm decides to do more R&D and hold more cash over time) play a secondary role in explaining the change in average cash-holdings relative to the selection effect induced by the entry dynamics. New entrants have a larger cash balance upon entry and their increasing number in the cross-section of firms has lifted up the cash-to-asset ratio.

\(^3\)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 are able to merge 56% of our entry companies with the ones in Ritter’s data set. 98% of the matched companies’ entry year is the same or one year larger than the reported IPO year in Ritter’s dataset. The latter can be found at http://bear.warrington.ufl.edu/ritter/ipodata.htm
Figure 1 shows 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.

Figure 2 presents the evolution of the cash-to-asset ratio at the cohort level starting with the 1959-1963 cohort. The red dot is 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 has declined (increased). The first observations is the average cash holdings of incumbent firms in 1958. Two facts emerge. First, there is an increase in initial cash holdings over time, new cohorts enter with higher and higher cash balances. Second, the majority of cohorts deplete cash: at the cohort level there is hardly a secular increase.

Figure 2: Average Cash Holdings at Entry (1959-2013)

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

When we compare the average cash holdings at entry by cohort and industry (see Figure 3), we observe that R&D-intensive firms have entered with higher and higher cash balances...
The figure reports the average cash-to-asset ratio for U.S. public companies at entry for eleven 5-year cohorts over the period 1959-2013. The red line refers to non-R&D-intensive firms, while the blue line to R&D-intensive firms. The straight dashed line is the linear trend.

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

Figure 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 provides evidence for a slightly different story. It shows that R&D-intensive firms exhibit strikingly different R&D activities 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.

R&D-intensive and non-R&D-intensive entrants do not differ only in their cash balance and R&D activity. Figure 5 reports other firm characteristics at entry by cohort that highlight the differences in their business models (production of goods versus ideas) and in their financing sources. The top left panel shows how R&D-intensive firms have entered with less and less tangible assets, while non-R&D-intensive firms have experienced a much less
The figure reports the average R&D-to-asset ratio for U.S. public companies at entry for eleven 5-year cohorts over the period 1959-2013. The red line refers to non-R&D-intensive firms, while the blue line to R&D-intensive firms. The straight dashed line is the linear trend.

dramatic change of tangibility upon entry. The average tangibility, measured as the ratio of gross property, plant and equipment over total assets, was around 50% for R&D-intensive entrants at the beginning of the 1960s, a value close to 60%, the average tangibility of non-R&D-intensive entrants. After 50 years, R&D-intensive entrants have a tangibility slightly larger than 15% of total assets, while for non-R&D-intensive firms this value is around 55%.

The decrease in tangibility for R&D-intensive firms has been coupled with a decrease in the amount of long-term debt outstanding that have witnessed a recovery only in the mid 2000s (top right panel of Figure 5). On the other hand, non-R&D-intensive firms have witnessed an increase in the amount of long-term debt outstanding relative to assets. The typical non-R&D-intensive entrant had a value of long-term debt outstanding equal to 12% of total asset in the early 1960s. This value has more than doubled in 50 years and the typical non-R&D-intensive entrant in the last cohort (2009-2013) had a value of long-term debt outstanding equal to 26% of total asset.

Leverage and net leverage (bottom left and right panels of Figure 5, respectively) are very similar and move in the same fashion for the first four cohort and they start to diverge
Figure 5: Other Firm Characteristics by Cohort at Entry (1959-2013)

The figure reports the average long-term debt to assets ratio (item $DLTT$ over item $AT$), the average tangibility (item $PPEGT$ over item $AT$), the average net-leverage (item $LT$ net of item $CHE$ over item $AT$), and the average leverage (item $LT$ 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.

in opposite directions at the beginning go the 1980s when the cash-to-asset ratio also begins to diverge. Non-R&D-intensive firms experience an increase in the average leverage upon entry coupled with an increase in net leverage. R&D-intensive firms are characterized by a decrease in leverage and a even more dramatic decrease in net leverage driven by the sharp increase in cash holdings. By the beginning of the 1990s, the typical R&D-intensive entrant had a negative net leverage.

2.3 Post-Entry Dynamics

The previous section has shown that R&D-intensive firms enter with higher and higher cash-to-assets ratios. What happens to their cash holdings in the subsequent years after entry? Figure 6 reports the average 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.
The figure reports the average value from entry (year 0) up to five years after entry (year 5) of the following firm-level characteristics: cash holdings, R&D expenditure, long-term debt, tangibility, leverage, and net leverage. The red line refers to non-R&D-intensive firms, while the blue line to R&D-intensive firms.

Both R&D-intensive and non-R&D-intensive firms deplete their cash holdings after the entry year. R&D-intensive firms experience a change in cash holdings over the five year period equal to 0.13, while non-R&D-intensive firms decrease them by 0.05. The difference in average cash holdings between the two set of firms decreases during the first two years after entry and then stays constant around 0.18. The R&D activity for R&D-intensive firms stays constant in the five years after entry and fluctuates around 0.11. At the same time, the R&D activity of non-R&D-intensive firms does not show any increase in the post entry period and fluctuates around 0.5% of total assets.

Both categories of firms show an increase in their post entry values for long-term debt, tangibility, leverage, and net leverage. However, these values are highly persistent and the difference at the entry stage survives for the entire post-entry period. In short, R&D-intensive and non-R&D-intensive firms do not show any sign of convergence in key firm-level characteristics linked to their productive and financing structure.
2.4 Firm Dynamics: Growth Rates, Survival Rates, and Relative Size at Entry

In this section, we explore some key quantities widely used in the firm dynamics literature to further highlight the peculiarities of firms entering in the three major stock exchanges over the period 1959-2013. We will use these quantities as a guidance to calibrate the entry process in our model economy.

We start by comparing the relative size of entering firms with the size of incumbent public firms. Each year, we measure size using two different variables: total employment (item EMP) and sales (item Sale). The relative size of an entrant in a given year $t$ is the average size of entrants in year $t$ divided by the average size in year $t$ of firms that were public in year $t - 1$ and $t$. Table 1 reports the time-series average of the annual values evaluated over the period 1959-2013. We compare entering firms with incumbents that have been public for 5 years (Panel A, Columns I and II) and incumbents that have been public for 10 years (Panel A, Columns III and IV). As we can see, entering firms are on average smaller and their relative size varies between 75%-80% if compared with incumbents of age 5 and 55%-60% if compared with incumbents of age 10.

When we split the sample between R&D-intensive and non-R&D-intensive firms we find that R&D-intensive entrants are on average much smaller than non-R&D-intensive entrants. When we use employment (sales) to measure size, R&D-intensive entrants’ size is on average 48.5% (45.2%) the size of the non-R&D-intensive entrants (results not tabulated). R&D-intensive firms’ relative size is around 66% if compared with R&D-intensive incumbents of age 5 and around 47% if compared with R&D-intensive incumbents of age 10 (Panel B). On the other hand, non-R&D-intensive firms’ relative size is around 90% if compared with non-R&D-intensive incumbents of age 5 and around 72% if compared with non-R&D-intensive incumbents of age 10 (Panel C).

Figure 7 reports the growth rates of employment (top panel) and sales (bottom panel) during the five years after entry for R&D-intensive and non-R&D-intensive firms. It is a well established fact in the firm dynamics literature that a firm’s average growth rate and
Table 1: Relative Size of Entrants

<table>
<thead>
<tr>
<th>Age 5 Incumbents</th>
<th>Age 10 Incumbents</th>
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**Panel A**

<table>
<thead>
<tr>
<th></th>
<th>Employment</th>
<th>Sales</th>
<th>Employment</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Firms</td>
<td>0.756</td>
<td>0.781</td>
<td>0.562</td>
<td>0.598</td>
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</table>

**Panel B**

<table>
<thead>
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<th></th>
<th>Employment</th>
<th>Sales</th>
<th>Employment</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>R&amp;D-Intensive</td>
<td>0.671</td>
<td>0.662</td>
<td>0.465</td>
<td>0.491</td>
</tr>
</tbody>
</table>

**Panel C**

<table>
<thead>
<tr>
<th></th>
<th>Employment</th>
<th>Sales</th>
<th>Employment</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-R&amp;D-Intensive</td>
<td>0.882</td>
<td>0.892</td>
<td>0.716</td>
<td>0.737</td>
</tr>
</tbody>
</table>

its volatility are decreasing in its size and age (Evans (1987)). The figure shows that average growth rates of surviving firms decline over time as their median and volatility, a finding consistent with the available empirical evidence. Even if R&D-intensive firms are smaller than non-R&D-intensive ones, we do not see a stark difference in their average growth rates, as predicted by their relative size. On the other hand, the median and the volatility of the growth rate for R&D-intensive firms are always larger than the corresponding values for non-R&D-intensive firms.

To conclude, we report the exit rates during the first five years in Figure 8. We use a broad definition of exit and assume that a firm exits when it stops reporting a value for total assets in Compustat. As a consequence, a firm can exit the sample because it goes bankrupt, it merges with another firm, it is acquired by another firm, or it goes private. Figure 8 shows that both types of firms witness a decrease in the exit rate as they age. In addition, R&D-intensive firms, being smaller, have a larger exit rate. The difference in exit
rates between the two types of firm almost vanishes after five year.

Figure 7: Growth Rates

This figure reports the average growth rate of employment (top panel) and sales (bottom panel) for new economy entrants (solid blue line) and old economy entrants (solid red line). Data are winsorized at the top and bottom 1% to minimize the impact of extreme observations.

2.5 Off-Shore Tax Havens

In this section, we explore the role of tax arbitrage for explaining the increase in corporate cash holdings as put forward by a recent literature (e.g., Foley, Hartzell, Titman, and Twite (2007)). This concern matters in particular for multinationals whose cash holdings in foreign subsidiaries might be high simply because it is costly to repatriate foreign income (e.g., Hartzell, Titman, and Twite (2005). Moreover, many firms set up tax-residency in foreign tax havens (e.g., Hines and Rice (1994)). This option is particularly important for R&D intensive firms that operate mainly with intangible capital. For this reason, we compute
The average tax payment for new and old economy firms. Since cash holdings of non-R&D-intensive firms significantly differ from the cash holdings of R&D-intensive firms, a tax-based explanation should present with a significant difference in paid taxes. We investigate this possibility in figure 9. This figure shows no difference in the effective tax rate paid by the
two types of firms until the mid 1970s. From then on, R&D-intensive firms paid a lower effective tax rate compared to non-R&D-intensive firms. The ability to expatriate taxes alone, however, is not sufficient to rationalize the difference in cash holdings between high and low R&D firms, see for instance the discussion in Farre-Mensa (2014).

3 Model

In our model economy, firms can be of two types: old economy firms (i.e., non-R&D-intensive firms) and new economy firms (i.e., R&D-intensive firms). Since our focus is on the dynamics of the cash-to-assets ratio’s cross-sectional average, we simplify the setup assuming that firms can either produce using physical capital or intangible capital and that only the former can be pledged as collateral to issue debt.

We assume the existence of a time-invariant mass of potential firms that can become public (potential entrants in the stock market) by paying a fixed IPO cost. The potential entrants are heterogeneous because they can be either new economy or old economy firms. In the benchmark economy, the proportion of potential entrants of the new economy type is kept constant.

3.1 Incumbent problem

3.1.1 Technology

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

\[ y_t = e^{z_t k_{jt}} \]

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

\[ z_{t+1} = \rho z_t + \sigma \epsilon_{t+1}, \]
where $\varepsilon_{t+1} \sim N(0, 1)$. The law of motion for the capital stock is

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

where $\delta_j$ is the depreciation rate and $x_{j,t}$ is the capital investment at time $t$. We assume $\delta_n > \delta_o$.⁴

### 3.1.2 Financing

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

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

Debt financing is attractive because there is a tax advantage: interests paid on corporate debt are tax deductible. There is unlimited liability and thus debt is priced at the riskless rate. However, the amount of debt issuance is limited by a collateral constraint: a firm can borrow up to the present discounted value of next period depreciated capital level $((1 - \delta_o)k_{o,t+1}/R)$. Moreover, raising debt in the amount of $b_{t+1}$ costs the firm

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

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

⁴Hall (2007) provides evidence for a larger depreciation rate for the R&D capital stock.
3.1.3 Old economy incumbent’s problem

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

$$d_t = w_t + b_{t+1} - \frac{s_{t+1}}{\hat{R}_o} - x_{o,t+1}. \quad (1)$$

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

The firm’s $t+1$ net worth is

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

$$= s_{t+1} + (1 - \tau) e^{z_{t+1}} k_{o,t+1}^\alpha - l_{t+1}^e. \quad (2)$$

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

\[ V^o(l_{t+1}, k_{o,t+1}) \equiv \max_{l_{t+1}, k_{o,t+1}} d_t + H(d_t) 1_{[d_t \leq 0]} + J(l_{t+1}) 1_{[l_{t+1} \leq 0]} \]  
\[ ... + \frac{1 - \phi}{R} E_t [V_{t+1}(l_{t+1}, k_{o,t+1}, z_{t+1})] + \frac{\phi}{R} E_t [w_{t+1} + (1 - \delta_o)k_{o,t+1}] \]  

subject to

\[ d_t = w_t - \frac{l_{t+1}}{R_o} - x_{o,t+1}, \]  
\[ k_{o,t+1} = (1 - \delta_o)k_{o,t} + x_{o,t+1}, \]  
\[ w_{t+1} = (1 - \tau) e^{z_{t+1} k_{o,t+1}^a} + l_{t+1}, \]  
\[ -l_{t+1} \leq (1 - \delta_o)k_{o,t+1}, \]  

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

3.1.4 New economy incumbent’s problem

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

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

subject to

\[ d_t = w_t - \frac{l_{t+1}}{R_o} - x_{n,t+1}, \]  
\[ k_{n,t+1} = (1 - \delta_n)k_{n,t} + x_{n,t+1}, \]  
\[ w_{t+1} = (1 - \tau) e^{z_{t+1} k_{o,t+1}^a} + l_{t+1}, \]  
\[ l_{t+1} \geq 0, \]  

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

### 3.2 Entry

Every period there is a constant mass $M > 0$ of firms that decide to go public. $M$ is the sum of $M_n > 0$, the mass of new economy firms that are private, and $M_o > 0$, the mass of old economy firms that are private. Firms that decide to go public are randomly drawn from the stationary distribution of private firms.

Following Clementi and Palazzo (2013), we assume that each potential entrant in the stock market receives a signal $q$ about its future productivity, where the signal follows a Pareto distribution $q \sim Q(q)$. Conditional on entry, the distribution of the idiosyncratic shocks in the first period of operation is $F(z'|q)$, strictly decreasing in $q$. Firms that decide to go public pay an IPO cost $c_e$. The value function for an old economy entrant is

$$V^{E,o}(q) = \max_{x_{i,t+1}} \left\{ -x_{i,t+1} - \frac{l_{t+1}}{R_o} + \frac{1}{R} E_{z^*_i} [V^o(w_{t+1})] \right\},$$

while the value function for a new economy entrant is

$$V^{E,n}(q) = \max_{x_{i,t+1}} \left\{ -x_{i,t+1} - \frac{l_{t+1}}{R_E} + \frac{1}{R} E_{z^*_i} [V^n(w_{t+1})] \right\}.$$

Notice that the internal accumulation rate for a new economy entrant, $\hat{R}_n = \nu^c R$, is different from the one of a new economy incumbent. We add this feature to capture higher cash balances at entry, as it is the case in the data.

A firm will go public if and only if

$$V^{E,i} \geq V^{P,i} + c_e \quad \forall i \in \{o, n\}.$$
3.3 Firm industry equilibrium

Denote $\omega$ as the fraction of new economy firm. Given $\omega$ and the riskless rate $R$, a recursive competitive equilibrium consists of (i) value functions $V^i(w)$ and $V^{E,i}(q)$, (ii) policy functions $l^i(w)$ and $x^i(q)$ and (iii) bounded sequences of incumbents’ measure $\{\Gamma^i_t\}_{t=1}^{\infty}$ and entrants’ measures $\{\varepsilon^i_t\}_{t=0}^{\infty}$ such that

1. $V^i(w)$ and $l^i(w)$ and $x^i(q)$ solve the incumbents problem $\forall i \in \{o, n\}$

2. $V^{E,i}(q)$ and $l^i(w)$ and $x^i(q)$ solve the entrants problem $\forall i \in \{o, n\}$

3. For all Borel sets $Z \times W \times L \times X \times \mathbb{R}$ and $\forall t \geq 0$,

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

where $B^i(W) = \{p^w \text{ and } p^s \text{ s.t. } l^i(q) \in L, x^i(q) \in X \text{ and } V^{E,i} \geq V^{P,i} + c_{e,i}\}$ denotes the policy functions.

4. For all Borel sets $Z \times W \times L \times X \times \mathbb{R}$ and $\forall t \geq 0$,

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

$$B^i(W) = \{w'\} \text{ and } \omega = \Gamma^o_{t+1}(W')/\Gamma^o_{t+1}(W').$$

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

We parametrize the model at an annual frequency using parameter values taken from other studies together with a set of calibrated values. Table 2 reports the parameter values. Following Hennessy and Whited (2007), we set $\alpha = 0.62$ and $\delta_o = 0.15$. As in Clementi and Palazzo (2013), the persistence and conditional standard deviation of the firm-level productivity shock are $\rho = 0.55$ and $\sigma = 0.22$. 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%.

Since we are interested in the evolution of corporate cash holding during the period 1980-2013, we calibrate the remaining parameters to match some key moments over the period 1959-1979. The depreciation rate of new firms is calibrated to match the size of R&D-intensive firms that have been in Compustat exactly 5 years relative to their non-R&D-intensive counterpart. The calibrated value is $\delta_n = 0.215$, a number consistent with depreciation rates for R&D capital reported by the Bureau of Economic Analysis (e.g., Li (2012)). We calibrate the cost of carrying cash inside the firm ($\nu$) and the proportional equity issuance cost ($\kappa_1$) to match the average cash-to-asset ratio and equity-to-asset ratio of R&D-intensive firms. The cost of carrying cash inside the firm for new economy entrants ($\nu^E$) is set to match the average cash-to-asset ratio of R&D-intensive firms upon entry. 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 exogenous exit rate ($\phi$) is 5%, a value that delivers the average disappearance of firms from the Compustat data set. The proportion of potential entrants of old type ($\omega$) is set to 0.65. This value allows us to replicate the composition of public firms observed in the data during the period 1959-1979. To conclude, we calibrate the entry cost for type $i$ firms ($c_{e,i}$) to match the size of type $i$ entrants relative to the size of type $i$ incumbents of age 5. Table 3 reports the simulated moments together with their empirical counterpart.

\footnote{We calibrate relative size quantities using sales data.}
Table 2: Parametrization

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Function</th>
<th>Origin/Target</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>From other studies</td>
<td></td>
</tr>
<tr>
<td>$\alpha = 0.62$</td>
<td>Decreasing returns to scale</td>
<td>Hennessy and Whited (2007)</td>
</tr>
<tr>
<td>$\delta_o = 0.15$</td>
<td>Depreciation old firms</td>
<td>Hennessy and Whited (2007)</td>
</tr>
<tr>
<td>$\tau_c = 0.35$</td>
<td>Corporate tax rate</td>
<td>subject to experimentation</td>
</tr>
<tr>
<td>$r = 0.04$</td>
<td>Riskless rate</td>
<td>Riddick and Whited (2009)</td>
</tr>
<tr>
<td>$\rho = 0.55$</td>
<td>Persistence idiosyncratic shock</td>
<td>Clementi and Palazzo (2013)</td>
</tr>
<tr>
<td>$\sigma = 0.22$</td>
<td>Std. dev. idiosyncratic shock</td>
<td>Clementi and Palazzo (2013)</td>
</tr>
<tr>
<td>$\psi = 0.05$</td>
<td>Exit rate</td>
<td>Disappearance from data</td>
</tr>
<tr>
<td>$\omega = 0.65$</td>
<td>Proportion of old firms to new firms</td>
<td>Proportion of old/new firms</td>
</tr>
</tbody>
</table>

Table 3: Calibrated Moments

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Moment</th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\delta_n = 0.215$</td>
<td>Rel. size new to old incumb.</td>
<td>0.638</td>
<td>0.595</td>
</tr>
<tr>
<td>$\nu = 0.9968$</td>
<td>Cash holdings new firms</td>
<td>0.095</td>
<td>0.094</td>
</tr>
<tr>
<td>$\kappa_1 = 0.984$</td>
<td>Cash holdings new entrants</td>
<td>0.150</td>
<td>0.140</td>
</tr>
<tr>
<td>$\kappa_1 = 0.029$</td>
<td>Equity-to-asset ratio new F</td>
<td>0.056</td>
<td>0.063</td>
</tr>
<tr>
<td>$\gamma = 0.0163$</td>
<td>Net Debt-to-asset ratio old F</td>
<td>0.143</td>
<td>0.138</td>
</tr>
<tr>
<td>$c_{e,o} = 0.129$</td>
<td>Rel. size old type entrant</td>
<td>0.707</td>
<td>0.704</td>
</tr>
<tr>
<td>$c_{e,n} = 0.076$</td>
<td>Rel. size new type entrant</td>
<td>0.484</td>
<td>0.483</td>
</tr>
<tr>
<td>$\epsilon = 0.5$</td>
<td>Rel. size entrant</td>
<td>0.663</td>
<td>0.650</td>
</tr>
</tbody>
</table>

5 Experiments

In this section we investigate to what extent different selection mechanisms can account for the increase in average cash holdings of U.S. public firms and other features of the data.

5.1 Composition outside (private sector) has changed

The first experiment that we run is designed to explore the effect of a structural change in the composition of 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 old firm potential entrants $\omega$ changes (linearly) over a time span of 35 years from the steady state value of 65% to 30%. This assumption allows us to generate a fraction of publicly traded new economy firms around 55% after 35 years, a value similar to the observed fraction of publicly traded...
This figure reports the effect of an increase in the share of new economy firms on average cash holdings and productivity at entry for old and new firms.

R&D-intensive firms in 2013 (Figure 1). Figure 10 presents the results. The top left (right) panel reports the evolution of average cash holdings (the fraction of new firms) over 35 years. The central left (right) panel reports the evolution of average cash holdings at entry of old economy (new economy) firms. The bottom left (right) panel reports the evolution of average productivity at entry of old economy (new economy) firms.

A structural change in the composition of entrants has the potential to generate a secular increase in the average cash holdings of publicly traded firms. Over 35 years, the average cash holdings goes from its steady state value of 0.033 to a value of 0.052, a 58% increase. However, cash holdings at entry of new economy firms are flat, a feature at odd with what we observe in the data. A change in the composition alone is therefore not enough to rationalize
the data, particularly not the fact that cash holdings at entry have been increasing for R&D-intensive firms (Figure 3).

### 5.2 Entry costs have fallen for new economy firms

In this section, we study the model’s response to a reduction in the entry/IPO cost for new economy firms. We can model this scenario through a reduction in $c_{e,n}$. We assume a reduction in entry cost over 35 years to mimic the cash holdings’ evolution at entry of R&D-intensive firms. Figure 11 presents the results. The top left (right) panel reports the evolution of average cash holdings (the fraction of new firms) over 35 years. The central left (right) panel reports the evolution of average cash holdings at entry of old economy (new economy) firms. The bottom left (right) panel reports the evolution of average productivity at entry of old economy (new economy) firms.

The reduction of the entry cost for new economy firms causes progressively smaller firms to become public (i.e., new economy firms enter with a progressively smaller productivity shock, as documented in the bottom right panel of Figure 11). Since the shocks are mean reverting, lower productivity firms anticipate future higher productivity shocks, which increases their investment needs today. In order to avoid being constrained from raising funds to invest in capital at times when productivity is high, they raise more cash relative to their asset at the IPO stage. The lower the entry cost, the lower the productivity threshold of entry of new economy firms and the higher the average cash holdings at entry. Figure 11 however also shows that average cash holdings increases only slightly when we abstract from a change in the composition. Over 35 years, the average cash holdings goes from its steady state value of 0.032 to a value of 0.041, a 28% increase.

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

The results from the previous two sections suggest that neither a reduction in the entry cost nor a change in the composition of private firms alone can account for the features in
Figure 11: Reduction in entry costs for new economy firms

This figure reports the effect of an increase in the share of new economy firms on average cash holdings and productivity at entry for old and new firms.

the data. We therefore combine both features and show that the model rationalizes at least qualitatively the two stylized facts presented in Figure 1 and Figure 3.

Figure 12 presents the results. We normalize the cash holdings at time 0 to 1. The top panels show that the adding a reduction in entry cost for new economy firms on top of a change in composition helps the model along two dimensions. First, the model can generate a secular increase in cash holdings both for incumbent firms and for new economy firms at entry. Second, the secular increase in average cash holdings becomes steeper, thus bringing the model closer to the data. The model with only a change in composition generates average cash holdings after 35 years that are 1.57 times larger. If we add a change in entry cost, the average cash holdings after 35 years are 2.07 times larger, an increase of 32%. 
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.

5.4 Institutional: R&D tax advantage or off-shore tax havens (TBD)

We use the model to explore to what extend a tax advantage could help explain the features we see in the data.

Conclusion

In this paper we highlight the importance of entry to explain the capital structure dynamics for the typical U.S. public company during the last thirty years.
REFERENCES


A Optimality Conditions for Old Firm

A.1 No equity financing cost

\[ V^o(w_t, z_t) \equiv \max_{b_{t+1}, k_{o,t+1}} w_t + b_{t+1} - k_{o,t+1} - \gamma b_{t+1} 1_{[b_{t+1} \geq 0]} + \frac{1 - \phi}{R} E_t [V_{t+1}(w_{t+1}, z_{t+1})] \]

... + \frac{\phi}{R} E_t [w_{t+1} + (1 - \delta_o)k_{o,t+1}]

subject to

\[ w_{t+1} \equiv (1 - \tau)e^{z_{t+1}}k^o_{o,t+1} - \hat{R} b_{t+1} + (1 - \delta_o)k_{o,t+1}, \]

\[ b_{t+1} \leq \frac{(1 - \delta_o)k_{o,t+1}}{\hat{R}} \]

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

The Lagrangian for this problem becomes

\[ \mathcal{L}^o(w_t, z_t, \lambda_t) = V^o(w_t, z_t) + \lambda_t \left( \frac{(1 - \delta_o)k_{o,t+1}}{\hat{R}} - b_{t+1} \right). \]

The solution to the problem satisfies the following conditions

\[ \frac{\partial \mathcal{L}^o(w_t, z_t, \lambda_t)}{\partial k_{o,t+1}} = 0 \]

\[ \frac{\partial \mathcal{L}^o(w_t, z_t, \lambda_t)}{\partial b_{t+1}} = 0 \]

\[ \lambda_t \left( b_{t+1} - \frac{(1 - \delta_o)k_{o,t+1}}{\hat{R}} \right) = 0 \]

\[ \lambda_t \geq 0 \]

\[ b_{t+1} \leq \frac{(1 - \delta_o)k_{o,t+1}}{\hat{R}} \]

We now derive the first order conditions w.r.t. capital and debt choice. We start with
the optimal investment decision:

\[
1 = \frac{1}{\hat{R}} \left( \alpha(1 - \tau)E_t[e^{\zeta_t+1}]K_{o,t+1}^{\alpha-1} + (1 - \delta_o) \left( 1 + \lambda_t \frac{\hat{R}}{R} \right) \right)
\]

The LHS is the marginal cost of adding one extra unit of capital, that is the unit cost of the capital good. The RHS is the marginal benefit of adding one extra unit of capital. There are two components. The first one is the expected marginal product of capital plus the resale value. The second term reflects the benefit of adding an extra unit of capital: the borrowing constraint is relaxed, thus allowing the firm to issue more debt. The benefit is adjusted by the discounted depreciated value of capital per unit of the gross repayment value of the bond. The optimal capital policy will always be greater then the frictionless one because the marginal benefit of investment will also include the effect on the borrowing constraint.

The optimal debt issuing decision is dictated by the F.O.C. w.r.t. debt

\[
\frac{R - \hat{R}}{R} = \gamma 1_{[b_t+1 \geq 0]} + \lambda_t.
\]

The LHS is the marginal benefit of issuing one extra unit of debt, that is net tax-advantage of debt. The RHS is the marginal cost of issuing one extra unit of debt. There are two components. The first term denotes the marginal issuance cost. The second term reflects the fact that issuing an extra unit of debt makes the borrowing constraint tighter.

Given the requirement \( \lambda_t \geq 0 \), the problem has only a solution when \( 1 - \gamma 1_{[b_t+1 \geq 0]} \geq \frac{\hat{R}}{R} \).

By assumption \( \hat{R}/R < 1 \), implying \( b_{t+1} > 0 \). Furthermore, the borrowing constraint is binding when \( 1 - \gamma - \frac{\hat{R}}{R} = \lambda_t > 0 \). We can further derive a restriction for the parameters such that the firm will issue positive debt. Using the definition for \( \hat{R} \) we obtain

\[
\gamma < \frac{\tau (R - 1)}{R}.
\]

That is the cost of debt issuance has to be smaller than the discounted benefit given by the tax-advantage of debt.
A.2 Equity financing cost

\[ V^o(w_t, z_t) \equiv \max_{b_{t+1}, k_{o,t+1}} \left( 1 + \kappa 1_{[d_t<0]} \right) \left( w_t + b_{t+1} - k_{o,t+1} - \gamma b_{t+1} 1_{[b_{t+1} \geq 0]} \right) + \frac{1 - \phi}{R} E_t \left[ V_{t+1} (w_{t+1}, z_{t+1}) \right] \]

\[ \text{subject to} \]

\[ w_{t+1} = (1 - \tau) e^{z_{t+1}} k_{o,t+1} - \bar{R} b_{t+1} + (1 - \delta_o) k_{o,t+1}, \]

\[ b_{t+1} \leq \frac{(1 - \delta_o) k_{o,t+1}}{R} \]

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

It helps to rewrite the value function as:

\[ V^o(w_t, z_t) \equiv \max_{b_{t+1}, k_{o,t+1}} \left\{ \left( 1 + \kappa 1_{[d_t<0]} \right) \left( w_t + b_{t+1} - k_{o,t+1} - \gamma b_{t+1} 1_{[b_{t+1} \geq 0]} \right) \right. \]

\[ + \frac{1 - \phi}{R} E_t \left[ \left( 1 + \kappa 1_{[d_{t+1}<0]} \right) \left( w_{t+1} + b_{t+2} - k_{o,t+2} - \gamma b_{t+2} 1_{[b_{t+2} \geq 0]} \right) \right] \]

\[ + \frac{1 - \phi}{R} E_{t+1} \left[ V_{t+2} (w_{t+2}, z_{t+2}) \right] + \frac{\phi}{R} E_{t+1} \left[ w_{t+2} + (1 - \delta_o) k_{o,t+2} \right] \]

\[ + \frac{\phi}{R} E_t \left[ w_{t+1} + (1 - \delta_o) k_{o,t+1} \right] \}

Similarly to the previous case, the Lagrangian for this problem becomes

\[ L^o(w_t, z_t, \lambda_t) = V^o(w_t, z_t) - \lambda_t \left( b_{t+1} - \frac{(1 - \delta_o) k_{o,t+1}}{R} \right) \]
The solution to the problem satisfies the following conditions

\[
\frac{\partial L^o(w_t, z_t, \lambda_t)}{\partial k_{o,t+1}} = 0
\]

\[
\frac{\partial L^o(w_t, z_t, \lambda_t)}{\partial b_{t+1}} = 0
\]

\[
\lambda_t (b_{t+1} - \frac{(1 - \delta_o) k_{o,t+1}}{\hat{R}}) = 0
\]

\[
\lambda_t \geq 0
\]

\[
b_{t+1} \leq \frac{(1 - \delta_o) k_{o,t+1}}{\hat{R}}
\]

We now derive the first order conditions w.r.t. capital and debt choice. We start with the optimal debt decision:

\[
\left\frac{R - \hat{R}}{R} + \kappa 1_{[d_t < 0]} = (1 + \kappa 1_{[d_t < 0]}) \gamma 1_{[b_{t+1} > 0]} + \lambda_t + \frac{\hat{R}}{R} E_t 1_{[d_{t+1} < 0]} (1 - \phi) \kappa
\]

The LHS is the marginal benefit of issuing one extra unit of debt. There are two components. As before, we have tax benefit of debt. In addition, the firm saves the equity issuance cost if it chooses to finance with debt rather than with equity. The RHS is the marginal cost of issuing one extra unit of debt. There are three components. The first one is marginal debt adjustment costs. The second one takes into account the fact that issuing an extra unit of debt tightens the borrowing constraint. The third term is the marginal cost produced by the increased likelihood of issuing equity given the repayment of the debt outstanding.

We now derive the first order conditions w.r.t. capital:

\[
(1 + \kappa 1_{[d_t < 0]}) = \lambda_t \left(\frac{1 - \delta_o}{\hat{R}}\right) + E_t \left(\left(\frac{1}{\hat{R}} + \frac{1 - \phi}{\hat{R}} \kappa 1_{[d_{t+1} < 0]}\right) \left(\alpha (1 - \tau) e^{\gamma_{t+1} k_{o,t+1}} + (1 - \delta_o)\right)\right).
\]

The LHS is the marginal cost of adding one extra unit of capital, that is the unit cost of the capital good plus the marginal equity issuance cost if the firm has to use equity to invest in capital. The RHS is the marginal benefit of adding one extra unit of capital. There are three components. The first one takes into account the fact that adding an extra unit of capital relaxes the borrowing constraint thus allowing the corporation to issue more debt.
The second is the expected marginal product of capital plus the resale value. The third term captures the reduction in equity issuance cost from having larger expected cash flows and larger installed capital.

We can now derive some restrictions on the parameters linked to the debt issuance decision. The firm will always issue debt up to the limit if the smallest possible marginal benefit (i.e., \(1 - \hat{R}R\)) is larger than the largest possible marginal cost (i.e., \(\gamma + \hat{R}R(1 - \phi)\kappa\)). Let \(\nu = \hat{R}R\), then firms will issue debt up to the debt limit if

\[
\gamma < (1 - \nu) - \nu(1 - \phi)\kappa.
\]

Notice that without equity issuance costs, the above restriction is identical to the one derived in the previous section. We can also derive a restriction for the case in which no firm will ever issue debt. Consider the case in which the firm has to pay an equity issuance cost in the current period. A firm will never issue debt if the smallest possible marginal cost (i.e., \((1 + \kappa)\nu\)) is larger than the largest possible marginal benefit (i.e., \(1 - \nu + \kappa\)), namely when

\[
\gamma > \frac{1 - \nu + \kappa}{1 + \kappa}.
\]

B Optimality Conditions for New Firm

\[
V^n(w_t) \equiv \max_{l_{t+1}x_{n,t+1}} d_t(1 + \kappa 1_{[dt<0]}) + \frac{1 - \phi}{R} E_t \left[ V_{t+1}(w_{t+1}) \right]
\]

\[
\ldots + \frac{\phi}{R} E_t \left[ w_{t+1} + (1 - \delta_n)k_{n,t+1} \right]
\]
subject to

\[ d_t = w_t - \frac{l_{t+1}}{R} - k_{n,t+1}, \quad (17) \]
\[ w_{t+1} = (1 - \tau)e^{\frac{\alpha}{\tau}}k_{n,t+1}^\alpha + l_{t+1} + (1 - \delta_n)k_{n,t+1}, \quad (18) \]
\[ l_{t+1} \geq 0. \quad (19) \]

The Lagrangian is

\[ L^n(w_t, z_t, \lambda_t) = V^n(w_t, z_t) - \lambda_t^n l_{t+1}. \]

The solution to the problem satisfies the following conditions

\[ \frac{\partial L^n(w_t, z_t, \lambda_t)}{\partial k_{n,t+1}} = 0 \]
\[ \frac{\partial L^n(w_t, z_t, \lambda_t)}{\partial l_{t+1}} = 0 \]
\[ \lambda_t^n l_{t+1} = 0 \]
\[ \lambda_t^n \geq 0 \]
\[ l_{t+1} \geq 0 \]

The first order condition with respect to savings is:

\[ \frac{1}{R}(1 + \kappa I_{[d_t<0]}) = \frac{1}{R} + \lambda_t^n + \frac{(1 - \phi)}{R}\kappa E_t I_{[d_{t+1}<0]} \]

If \( l_{t+1} > 0 \) the equation becomes

\[ \frac{1}{R}(1 + \kappa I_{[d_t<0]}) = \frac{1}{R} + \frac{(1 - \phi)}{R}\kappa E_t I_{[d_{t+1}<0]} \]

The LHS is the marginal cost of saving, one over the tax adjusted return. The RHS denotes the marginal benefit, consisting in two terms. The first term denotes the discounted value of one unit of cash saved. The second term represents the marginal benefit produced by the reduced likelihood of issuing equity given the extra unit of available funds.

The FOC with respect to capital is:
\[(1 + \kappa \mathbf{1}_{d_t < 0}) = E_t \left[ \left( \frac{1}{\hat{R}} + \kappa \mathbf{1}_{d_{t+1} < 0} \frac{1 - \phi}{\hat{R}} \right) \left( \alpha(1 - \tau)e^{z_{t+1}}k_{n,t+1}^{\alpha-1} + (1 - \delta_n) \right) \right] \]

The LHS is the marginal cost of adding one extra unit of capital, that is the unit cost of the capital good plus the marginal equity issuance cost if the firm has to use equity to invest in capital. The RHS is the marginal benefit of adding one extra unit of capital. There are two components. The first is the expected marginal product of capital plus the resale value. The second term captures the reduction in equity issuance cost from having larger expected cash flows and larger installed capital.

Let \(\hat{R} = \eta R < R, \eta \in (0, 1)\). We can interpret the parameter \(\eta\) as the cost of carrying cash holdings inside the firm. The restriction for a non-zero savings policy is that the minimum marginal cost in the Euler equation for savings (i.e., \(\frac{1}{\hat{R}}\)) should be less than the maximum marginal benefit (i.e., \(\frac{1 + (1 - \phi)\kappa}{\hat{R}}\)), that is

\[
\frac{R}{\hat{R}} = 1 < 1 + (1 - \phi)\kappa \Rightarrow \eta > \frac{1}{1 + (1 - \phi)\kappa}
\]