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Do corporate policies follow a life-cycle? ☆

Robert Faff [a], Wing Chun Kwok [b], Edward J. Podolski [c,*], George Wong [d]

[a] University of Queensland, Australia
[b] Hang Seng Management College, Hong Kong
[c] Department of Finance, Deakin University, 221 Burwood Hwy, Burwood, Melbourne, VIC 3125, Australia
[d] Hong Kong Polytechnic University, Hong Kong

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ABSTRACT

We examine whether corporate investment, financing, and cash policies are interdependent and follow a predictable pattern in line with the firm life-cycle. We find that investments and equity issuance decrease with firm life-cycle, while debt issuance and cash holdings increase in the introduction and growth stages and decrease in the mature and shake-out/decline stages of the firm's life-cycle. These results are robust after using various proxies for life-cycle and controlling for firm, CEO and board level characteristics. Collectively, our results show that corporate policies follow a firm life-cycle.

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1. Introduction

What determines a firm's investment, financing, and cash policies? Classical models in financial theory tell us that firms make investment decisions which maximize shareholder wealth, capital structure is set in a way which maximizes firm value (Kraus and Litzenberger, 1973; Myers and Majluf, 1984), and surplus cash is returned to shareholders (Jensen, 1986). Although empirical evidence finds mixed support for the classical models, contemporary research in corporate finance identifies two primary determinants of corporate policies: (i) firm characteristics such as leverage, profitability, and working capital (Fazzari et al., 1988); Fazzari and Petersen, 1993; Lang et al., 1996; Kaplan and Zingales, 1997), and (ii) behavioral preferences of managers (Ben-David et al., 2013; Hutton et al., 2014; Chava and Purnanandam, 2010; Cronqvist and Fahlenbrach, 2009). To supplement this literature, we examine whether and to what extent corporate policies develop organically over time as the firm moves through the different phases of its life-cycle. It is well established that firm investment opportunities and cash flows follow a predictable pattern over the different phases of firm maturity (Kimberly and Miles, 1980; Greiner, 1972; Porter, 2004; Miller and Friesen, 1984). Motivated by this observation, we argue that corporate policies are related to the evolution of a firm's investment opportunities and cash flows, and therefore follow a predictable pattern in line with the firm's life-cycle.

Life-cycle theory proposes that firms inevitably evolve and transition from one phase of development to another (Porter, 2004). The theory posits that firms will follow a predictable pattern characterized by different phases of development which cannot be easily reversed (Porter, 2004; Miller and Friesen, 1984). Consistent with life-cycle theory, recent literature has documented that dividend policy (Grullon et al., 2002; DeAngelo et al., 2006), seasoned equity offerings (DeAngelo et al., 2010), takeover activity (Owen and Yawsonm, 2010), and cash flow patterns (Dickinson, 2011) are predictable and related to a firm's life-cycle phase. While this group of papers highlights the important role of life-cycle on limited aspects of corporate policy, in our paper, we propose a holistic

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* Corresponding author. Tel.: +61 392468358.
E-mail address: Edward.podolski@deakin.edu.au (E.J. Podolski).

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explanation of the interdependence of corporate decision making with respect to investment, financing, and cash holdings.

Using a simple model, we illustrate how a firm's investment activity, external finance, and cash policies evolve over various phases of the life-cycle. Our argument is based on the notion that firm's make interdependent corporate decisions which are sensitive to the evolution of the firm's investment opportunities and cash flows over a life-cycle. We show that, due to the decrease in investment opportunities and increase in the agency cost of cash holdings, a firm will invest less and issue less equity as it becomes more mature. We also show that the evolution of a firm's cash holdings and debt issuance are non-monotonic and exhibit a "hump" shape over a life-cycle. For a young firm, due to the improvement in debt servicing ability as it moves from its introduction phase to the mature phase, it will gradually increase its debt issuance. In contrast, mature and shake-out/decline firms will issue less debt due to the diminishing debt servicing ability and investment opportunities. Moreover, due to the increase in cash flow and debt issuance, and decreased investment opportunities as it moves from the introduction phase to the mature phase, a young firm will have more cash to carry forward. On the other hand, mature and shake-out/decline firms will reduce its cash holdings because of the reduction in the internal cash flow and external financing. We argue that the non-monotonicity of debt issuance and cash policies implies that estimation using a linear model can inadvertently lead to misguided analysis and inferences.

We test our predictions on a large sample of US firms over the 1973–2014 period. A challenging part of our analysis is to find a good proxy for firm life-cycle. Recent literature suggests that the maturity of a firm can be reflected by its age (DeAngelo et al., 2010), earned to contributed capital ratio (DeAngelo et al., 2006), assets growth (Grullon et al., 2002), as well as size and cash flows (Porter, 2004). We argue that, while these variables do provide some indication of a firm's maturity, they have limitations and, hence, are unlikely to be reliable proxies for a firm life-cycle on their own. To address this issue, we use a multiclass linear discriminant analysis (*MLDA*) to generate our main life-cycle proxy, as a function of: age, earned to contributed capital ratio, profitability and assets growth.

In line with our predictions, we find that investment and equity issuance decrease as the firm moves towards the latter phases of its life-cycle. Firms issue more debt and hold more cash as they move from the introduction phase to the mature phase, and issue less debt as they are in the mature and shake-out/decline phases. These results hold after controlling for a comprehensive set of firm-level controls. A key takeaway from our results is that life-cycle is an important determinant of corporate policies, and that the effect that life-cycle has on corporate policies is non-monotonic.

We conduct numerous tests to establish the robustness of our results. First, we control for CEO characteristics (age, tenure, overconfidence, and remuneration incentives), board characteristics (anti-takeover provisions, portion of independent board members, and institutional holdings), and cash flow uncertainty, in addition to standard firm-level factors. These additional tests are aimed at ensuring that our results are not driven by CEO characteristics, board characteristics and cash flow uncertainty being jointly correlated with life-cycle and corporate policies. Our findings remain solid.

Further, to ensure that our results are not driven by our specific measure of life-cycle, we employ three additional proxies. First, following DeAngelo et al. (2006), we use the earned to contributed capital ratio (i.e. the ratio of retained earnings to total assets) as a life-cycle proxy. Second, we classify firms into different life-cycle stages using the Dickinson (2011) classification scheme. Finally, we proxy life-cycle stages using industry and size adjusted age. Using these three alternate measures of life-cycle we generate qualitatively consistent results compared to our baseline results. We conclude that our empirical predictions are supported by the data.

So, how does our work contribute to the existing literature on the determinants of corporate policies? We are the first to propose and test a unified theory of how corporate life-cycle affects investment, external financing, and cash policies. Given that earlier papers have limited their attention to the effects of life-cycle on payout policy, seasoned equity offerings, and takeover activity, our paper enhances this literature by looking at a wider spectrum of key corporate policies and examining any non-linearity in the relation. Our paper complements the extant literature by showing that corporate policies, to a large extent, develop organically and in line with the firm's stage in the life-cycle. The implication of our findings is that corporate policies in general follow a highly predictable pattern that is independent of the preferences of corporate managers and other firm characteristics.

The remainder of this paper is structured as follows. We derive our empirical hypotheses in Section 2. Section 3 describes our empirical methodology. We discuss our results in Section 4. Section 5 concludes.

2. Hypothesis development

Based on a simple model, we derive hypotheses on how a firm makes interdependent corporate decisions over its life-cycle. Denote $m \in (0, 1]$ as the measure of a firm's maturity, and m increases as a firm becomes more mature. Consider a firm at stage m has access to a production technology. We denote I as the level of the firm's investment and $\theta(m)F(I)$ as its corresponding value of production. F is an increasing and concave production function (i.e. $F' > 0$ and $F'' < 0$) and θ measures the firm's growth opportunities at stage m. Grullon et al. (2002) argues that a firm's growth opportunities will decrease over its life-cycle, therefore, $\theta'(m) \leqslant 0$ and $\theta'(m) = 0$ for $\bar{m} \leqslant m$, where $\bar{m}$ represents the point beyond which the firm is mature and declining.[1]

The firm also has assets in place which generate cash flows denoted by $c(m)$. We assume that the evolution of $c(m)$ over a firm's life-cycle follows an S-shaped or bell-shaped curve, which implies $c'(m) > 0$ for $m < \bar{m}$ and $c'(m) \leqslant 0$ for $m \geqslant \bar{m}$.[2]

We assume cash flows to be after dividend payments, and we do not include dividends or change in working capital decisions in our model. Our results are unaffected if we assume that dividends are a fixed fraction of cash flows and/or if we assume that the investment in working capital is proportional to capital expenditure (i.e., investment).

[1] We can also view θ as the number of available investment opportunities and F as the value per unit of investment opportunity. The number of available investment opportunities is expected to decrease and vanish as the firm becomes more mature.

[2] The characteristic of an S-shaped life-cycle curve is supported by Roger's theory of diffusion and adoption of new products (Rogers, 1962). Although Rogers's theory is commonly used to describe the evolution of cash flow of an industry or of a new product, it has also been widely applied to describe a firm's life-cycle (see e.g. Kimberly and Miles, 1980; Quinn and Cameron, 1983; Miller and Friesen, 1984). The rationale behind the application of Rogers's theory on a firm's growth life-cycle is that; sales are low in a new firm introduction, because few consumers are aware of the goods (or services) provided by a new firm. With more firm experience, market power and consumer recognitions and acceptance, sales begin to increase at an increasing rate. However, the rate of growth in sales will diminish as more competitors enter the market. Sales will reach a plateau when a firm matures. Finally, sales will eventually taper off as most of the mass market has already purchased the products or new substitutes appear in the market. A firm failing to innovate in this stage will suffer declining sales. It is worth noting that while an S-shaped life-cycle curve is well-documented in the literature, previous studies also document a Bell-shaped life-cycle curve (see e.g., Polli and Cook, 1969; Porter, 2004; Buzzell, 1966; Frederixon, 1969; Headen, 1966).

The firm has access to external financial markets. We denote E and D as the level of equity and debt finance, respectively. The use of external finance involves deadweight costs.[3] We denote $H(E)$ and $G(D, c(m))$ as the deadweight costs of equity and debt finance, respectively, where H and G are increasing and convex with respect to the level of equity and debt (i.e. $H_1 > 0, H_{11} > 0, G_1 > 0$ *and* $G_{11} > 0$).[4]

The influence of a firm's maturity on the deadweight cost of debt is less straightforward. The cost of debt is sensitive to the firm's ability in servicing its debt (Fisher, 1959, Jaffee, 1975; Fung and Rudd, 1986). Since a firm with higher cash flows has stronger debt servicing ability and capacity (Lemmon and Zender, 2010), we assume that the cost and the marginal cost of debt decreases as the level of the firm's cash flows increases (i.e. $G_2 < 0, G_{12} < 0$).

The firm has a precautionary motive to hoard cash out of its cash flow (Almeida et al., 2004). However, carrying a cash balance is costly because it could induce agency problems which reduce firm value (e.g., Jensen and Meckling, 1976; Jensen, 1986). Moreover, the fact that the corporate tax rate is generally higher than the personal tax rate paid on income tax further reduces the value of each unit of cash holding (Faulkender and Wang, 2006). We denote π as the unit cost of cash holding.[5]

The firm's manager who acts in the best interests of existing shareholders makes optimal investment, external financing, and cash holding decisions (I, E, D, C) to maximize the following objective function:

$$\max_{E,C,I}\theta(m)F(I) - H(E) - G(D, c(m)) - \pi C - I \tag{1a}$$

$$\text{s.t. } I + C = c(m) + E + D \tag{1b}$$

The first order conditions (*FOC*s) of problem (1) are:

$$H_1(E) = G_1(D, c(m)) \tag{2}$$

$$-\pi = G_1(D, c(m)) \tag{3}$$

$$\theta(m)F'(I) = 1 + G_1(D, c(m)) \tag{4}$$

Using *FOC*s (2)–(4) and the implicit function theorem, it can be shown that:

$$\frac{dE}{dm} = \frac{\theta' F' + \theta F''}{H_{11}} \tag{5}$$

$$\frac{dD}{dm} = \frac{-G_{12}c'}{G_{11}} \tag{6}$$

$$\frac{dI}{dm} = \frac{-\theta' F'}{\theta F''} \tag{7}$$

and

$$\frac{dC}{dm} = \frac{(G_{11} - G_{12})c'}{G_{11}} + \frac{\theta' F'}{\theta F''} \tag{8}$$

Using Eqs. (5)–(8), we illustrate how a firm makes interdependent corporate decisions over its life-cycle and propose the following hypotheses:

Hypothesis I. Firms will invest less and issue less equity as they become more mature.

Eqs. (5) and (7) suggest that firms will invest less and issue less equity as they become more mature because their investment opportunities are declining over the life-cycle (i.e. $\theta' \leqslant 0$).[6]

Hypothesis II. Firms will increase their debt issuance as they move from the introduction phase to the mature phase. Mature and shake-out/decline firms will issue less debt.

Eq. (6) suggests that the evolution of a firm's debt issuance over its life-cycle is non-monotonic. Specifically, due to the improvement in their debt servicing ability (i.e. $c'(m) > 0$ for $m < \bar{m}$), firms will gradually increase their debt issuance as they move from the introduction phase to the mature phase. In contrast, firms in the mature and shake-out/decline phases will issue less debt due to their diminishing in debt servicing ability (i.e. $c'(m) \leqslant 0$ for $m \geqslant \bar{m}$).[7]

Hypothesis III. Firms will increase their cash holdings as they move from the introduction phase to the mature phase. Mature and shake-out/decline firms will hold less cash.

Eq. (8) suggests that the evolution of a firm's cash holdings over its life-cycle is non-monotonic. For firms in the introduction phase, their internal cash flow and the issuance of debt gradually increases ($c'(m) > 0$ for $m < \bar{m}$) and investment opportunities ($\theta\prime \leqslant 0$) gradually decreases as they move to the mature stage. These increases in the sources of cash and decreases in the uses of cash imply that these firms will have more cash to carry forward. In contrast, mature and shake-out/decline firms will reduce their cash holdings because of the reduction in the internal cash flow and external financing.

It should be noted that studies on the effects of life-cycle on corporate policies often examine only its linear effects. The non-monotonic nature of corporate policies across life-cycle, however, implies that estimation using a linear model is not appropriate and can lead to misinterpretation.[8] Therefore, to study the evolution of corporate policies across the life-cycle dimension in a meaningful way, we need to incorporate the non-linear nature of corporate policies in the empirical model.

[3] See e.g., Myers and Majluf, 1984; Myers, 1984; Greenwald et al., 1984 for the deadweight cost of equity and Myers, 1977 for the deadweight cost of debt.

[4] Following convention, the subscript $i = \{1, 2\}$ of a function $x = \{H, G\}$ represents the partial derivative of x with respect to its ith argument. A convex cost function has been widely used in the literature (e.g. Froot et al., 1993; Stein, 2003). Altinkilic and Hansen (2000) show that debt and equity issuance costs consist of both a fixed costs and a convex variable costs. Leary and Roberts (2005) show that the observed dynamics of leverage ratios is consistent with a cost function of external finance that has a fixed and an increasing and weakly convex component. Note that the deadweight cost of equity may also be a function of the firm's maturity (i.e. $H(E, m)$). Theoretically, firms' investment needs generally exceed internally generated funds in their earlier years; hence, firms issue equity in their earlier years to finance value-enhancing investment. In later years, however, firms' internal funds exceed their investment needs, thus adverse selection problems become more severe (DeAngelo and DeAngelo, 2006; DeAngelo et al., 2006). In other words, mature firms that issue equity, when the market views it unnecessary, send a strong signal of equity overvaluation. Thus, it is natural to assume that the cost and the marginal cost of equity to be higher when the firm becomes more mature i.e.$H_2 > 0, H_{12} > 0$. However, for simplicity, we do not assume H to be directly dependent on m. In an earlier version of this paper, we show that our results also hold under this assumption.

[5] Note that π may also be a function of m. In particular, the agency problem of cash holding is expected to be more severe for a mature firm, but relatively immaterial for firms in their early and growth stages (DeAngelo and DeAngelo, 2006; DeAngelo et al., 2006). However, for simplicity, we do not assume π to be dependent on m. In an earlier version of this paper, we show that our results also hold under this assumption.

[6] Note that if we assume the agency cost of cash holdings is a function of firm's maturity, firms' incentive to invest and issue equity will be further reduced as they become more mature due to the higher agency cost of cash holdings.

[7] Note that if we assume the agency cost of cash holdings is a function of firm's maturity, mature and declining firms will be more reluctant in issuing debt because holding unused cash is more costly for mature and declining firms.

[8] For example, if we try to fit a linear function into a hump shaped curve, the coefficient estimate can either be positive or negative depending on which phases of the life-cycle dominate the others. However, this doesn't mean that corporate policy is increasing or decreasing across life-cycle.

3. Empirical framework

3.1. Data

The data are obtained from *Compustat* and *CRSP*, covering the period 1973 to 2014. Following DeAngelo et al. (2006); Huang and Ritter (2009) and Chang et al. (2014), financial (SIC 6000-6999) and utility (SIC 4900-4949) industries are excluded from the sample because the former have relatively low physical capital investment, while the latter are under government regulation. Consistent with DeAngelo et al., 2006, a firm is included in the sample only if it has *CRSP* share codes 10 or 11 and is incorporated in US (*FIC* = USA).[9] We require firms to provide valid information on their total assets, earnings before extraordinary items, retained earnings, sales growth, market capitalization, changes in cash holdings, investment, cash flow, and external finance. Some additional data exclusions are necessary: firms with market capitalization of equity less than USD 10 million or firms with abnormal assets or sales growth (greater than 1) are also excluded.[10] To control for the effect of outliers, all variables are winsorized at the 1st and 99th percentile. The final sample consists of more than 12,000 firms, producing over 100,000 firm-year observations.

3.2. Classification of Life-cycle Stage

3.2.1. Multiclass linear discriminant analysis (MLDA)

A challenging part of our analysis is to find a good proxy for a firm life-cycle. Recent literature suggests that the maturity of a firm can be indicated by its age (DeAngelo et al., 2010), earned to contributed capital ratio (DeAngelo et al., 2006), assets growth (Grullon et al., 2002), size and cash flow (Porter, 2004). While these variables do provide some indication of firm maturity, they have limitations and thus are unlikely to be a good proxy for a firm's life-cycle on their own.[11]

To address this issue and to utilize the life-cycle information provided by these variables, we use multiclass linear discriminant analysis (*MLDA*) to generate our main life-cycle proxy. Specifically, we first classify firms into four groups (Introduction, Growth, Mature and Shake-out/decline) using the Dickinson (2011) classification scheme (*DCS*). We then perform the following linear discriminant analysis to provide maximal separation between the groups:

$$Group_i = \alpha_0 + \alpha_1 AGE_i + \alpha_2 RETA_i + \alpha_3 EBIT_i + \alpha_4 AGrth_i + \varepsilon_i \tag{9}$$

where *Group* represents the life-cycle group, *AGE* is *CRSP* listed firm age; *RETA* is the ratio of retained earnings to total assets; *EBIT* is a proxy for cash flow; *AGrth* is assets growth.[12]

Based on our discriminant analysis in Eq. (9), we classify our sample into four life-cycle stages and generate our life-cycle proxy LC_x, where x = {Intro, Growth, Mature, Shake-out/decline}, which takes a value of one if a firm is in stage x and zero otherwise.

We argue that classifying firms' life-cycle using discriminant analysis is preferred to *DCS* or other indicative life-cycle proxies for four reasons. First, many indicative life-cycle proxies not only indicate a firm's life-cycle stage but also reflect other firm characteristics. On the other hand, classifying firms using *MLDA* allows us to disentangle and utilize the life-cycle information provided by a range of commonly accepted life-cycle variables. Second, it is verified by statistical procedures. Third, many variables are not good proxies for life-cycle as they do not evolve monotonically across life-cycle stages, classifying firms using *MLDA* helps reduce this problem. Finally, *DCS* relies on cash flow patterns data which are only available for two thirds of the sample. Using *MLDA*, however, allows us to classify all firms in the sample.[13]

3.2.2. Earned to contributed capital ratio

Following DeAngelo et al. (2006), we use earned to contributed capital ratio as one of our life-cycle proxies, i.e. the ratio of retained earnings to total assets (*RETA*).[14] DeAngelo et al. (2006) argue that earned to contributed capital ratio is good proxy for a firm's financial life-cycle stage since the composition of its equity and the extent to which its total assets are financed by earned equity indicate whether a firm is in a self-financing (i.e. firms with high *RETA*) or capital infusion (i.e. firms with low *RETA*) stage.

3.2.3. Cash flow patterns classification scheme (DCS)

Dickinson (2011) provides a life-cycle classification scheme based on the combination of a firm's net operating, investing, and financing cash flow patterns. She shows that the classification of life-cycle using cash flow patterns is consistent with economic theory.[15] We employ *DCS* as another life-cycle proxy. Specifically, based on firms' cash flow patterns, we classify our sample into four life-cycle stages: (1) Introduction, (2) Growth, (3) Mature, and (4) Shake-out/decline. Appendix A provides the details of the classification.

3.2.4. Industry and size adjusted firm age

Finally, we use *CRSP* listed firm age adjusted for industry and size effects ($AdjAGE_i$) as our final life-cycle proxy. As mentioned, the time required for firms to mature varies across industries and firms can exist long before they become listed. To address this problem, we adjust the firm age for the cross-sectional age differences across industries. To the extent that a larger firm tends to exist longer, we also adjust the firm age for size to control for the cross-sectional age differences before listing.

Specifically, we generate industry indicator variables ($InDum_j$) based on 2-digit SIC codes (i.e. $InDum_j$ takes a value of one if firm i is in industry j and zero otherwise). For each industry based on

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[9] Share codes 10 and 11 refer to ordinary common shares with no special status or no special status necessary.

[10] According to Gilchrist and Himmelberg (1995), a linear investment model is inappropriate for small firms. Small firms are dropped also because they tend to have severely limited access to the public market (Acharya et al., 2007). Firms with abnormal growth are also excluded because it implies major corporate events (Almeida et al., 2004; Almeida and Campello, 2007).

[11] Firm age is not a good proxy for life-cycle for several reasons. First, the time required for firms to mature varies across industries. Second, firm age does not necessarily represent maturity. Some firms may linger in a given life-cycle stage longer than others. Indeed, a younger firm might actually be more mature than an older firm. Third, only listed firm age but not actual firm age is available in the dataset. However, before they become a listed company, some firms may exist for a longer (or shorter) time than the other firms, thus listed firm age is a misleading measure of a firm's actual age. More importantly, Dickinson (2011) argues that firm age is not a good proxy for life-cycle as it does not evolve monotonically across life-cycle. It is well-documented in the literature that new firms grow faster but are more likely to fade out (Jovanovic, 1982; Freeman et al., 1983). Therefore, new firms may either enter the growth phase or the shake-out/decline phase. Thus, firm age is expected to adopt an inverted U-shape across life-cycle stages. Similarly, assets growth, size and cash flow are not good proxies for life-cycle since they also reflect other firm characteristics. In addition, similar to firm age, they might not evolve monotonically across life-cycle stages. For example, Dickinson (2011) argues that size is also expected to adopt an inverted U-shape across life-cycle stages. Similarly, firm with low cash flow and assets growth can either be interpreted as in the introduction phase or in the shake-out/decline phase.

[12] Note that we also conduct a discriminant analysis, where life-cycle is a function of size, firm age, earned to contributed capital ratio, profitability and assets growth. All results are consistent. However, as we explicitly control for size in our regression, we do not include size in our discriminant analysis.

[13] Specifically, there are 68,022 firm-year observations using *DCS* versus 100,572 firm-year observations using *MLDA*.

[14] Results (unreported) are qualitatively consistent when we use the ratio of retained earnings to total common equity (*RETE*) as a life-cycle proxy.

[15] For example, she provides summary statistics to show that profitability is maximized and the operational emphasis shifts to cost reduction in mature stage, and sales growth decreases monotonically across life-cycle stages.

Table 1
Sample descriptive features of the multiclass linear discriminant analysis (*MLDA*) classification. Panel A reports the mean values of earned to contributed capital ratio (*RETA*) and firm age (*AGE*) across the life-cycle stages of the *MLDA* classification, and the percentage of overlapping firms sharing the same Dickinson (2011) classification scheme (*DCS*) and *MLDA* life-cycle classification. Panel B lists the five largest firms in each life cycle stage based on *MLDA* classification in 2014. Panel C reports the movement of firm life-cycle stages over the period 2013–2014.

		(1)	(2)	(3)	(4)
Panel A: Relation between life-cycle proxies					
		MLDA Classification			
		INTRO	GROWTH	MATURE	SHADEC
RETA		−1.39	0.03	0.18	−1.01
AGE		10.88	15.41	20.59	15.44
DCS		31.97%	61.36%	66.64%	50.98%
Panel B: The five largest firms in each life-cycle stage					
		INTRO	GROWTH	MATURE	SHADEC
		Vertex Pharmaceuticals Inc	Microsoft Corp	Exxon Mobil Corp	Abbvie Inc
		Biomarin Pharmaceutical Inc	Celgene Corp	Johnson & Johnson	Mondelez International Inc
		Servicenow Inc	Priceline Group Inc	General Electric Co	Delta Air Lines Inc
		Netsuite Inc	Alexion Pharmaceuticals Inc	Pfizer Inc	Kraft Foods Group Inc
		Salix Pharmaceuticals Ltd	Vmware Inc – Cl A	Verizon Communications Inc	Hilton Worldwide Holdings
Panel C: Movement of life-cycle stages over the period 2013–2014					
		Year 2013			
		INTRO	GROWTH	MATURE	SHADEC
INTRO	Year 2014	**57.25%**	2.59%	0.09%	11.69%
GROWTH		5.07%	**41.47%**	11.44%	10.95%
MATURE		1.45%	34.77%	**70.79%**	17.66%
SHADEC		24.64%	11.66%	5.10%	**45.27%**
FAILED		11.59%	9.50%	12.57%	14.43%
		100.00%	100.00%	100.00%	100.00%

Bold values represent the correlation between life-cycle stage in 2014 and 2013.

2-digit SIC codes, we also sort firms into quintiles based on their size and create size indicator variables ($SizeDum_{j,k}$) for each kth quintile (i.e. $SizeDum_{j,k}$ takes a value of one if the firm i is in industry j with size in kth quintile and zero otherwise). We then regress *AGE* on *InDum* and *SizeDum* and use the percentile rank of the residual value ($AdjAGE_i$) from the regression as a proxy for life-cycle.

3.2.5. Verifying the MLDA life-cycle proxy

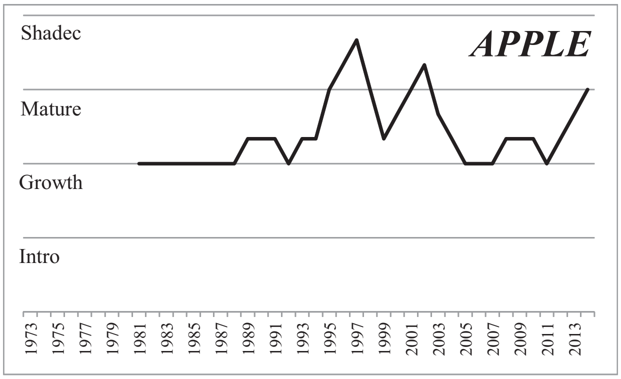
How are our life-cycle proxies related? Does the main life-cycle (*MLDA*) proxy reliably capture firm life-cycle stages? How likely does a firm change from one life-cycle stage to another?

It is well-known that many life-cycle proxies do not evolve monotonically across life-cycle stages. Therefore, estimating the correlation between the non-monotonic life-cycle proxies cannot provide a meaningful sense of how well they are related. Instead, as shown in Panel A of Table 1, we summarize how other life-cycle proxies evolve with the *MLDA* life-cycle stages. The first two rows of Panel A plot the mean values of *RETA* and firm age over various life-cycle stages classified by the *MLDA* life-cycle proxy and the third row indicates the percentage of overlapping firms sharing the same *DCS* and *MLDA* life-cycle classification. Consistent with Jovanovic, 1982; Freeman et al., 1983, firm age exhibits an inverted U-shape over *MLDA* life-cycle classification: i.e., young firms grow faster but they are also more likely to fail and enter into the shake-out and decline stage. Similarly, a firm with low *RETA* is more likely to be either a new firm or a shake-out and decline firm. Moreover, there is also a reasonable overlap between *DCS* and *MLDA* classifications. Overall, we conclude that the *MLDA* classification is able to capture life-cycle stages. In addition, as we will see in Section 4.4 the *MLDA* life-cycle proxy also provides substantial additional explanatory power for the cross-sectional variation of corporate policies compared to other life-cycle proxies.

To provide a sense of what type of companies fall into each life-cycle category, we classify all firms in 2014 into four life-cycle stages based on the *MLDA* classification. Panel B of Table 1 reports the five largest companies for each life-cycle stage. It shows that the introduction and growth stages contain mainly Pharmaceutical and Technological firms, whereas the mature and shakeout and decline stages contain firms like Johnson & Johnson, General Electric Corporation, and Kraft Foods. In short, the *MLDA* classification is consistent with our basic intuition of how the firm life-cycle should be classified.

We further provide the life-cycle classification time series for Apple and Microsoft in Fig. 1.[16] From the figure we see that Apple has gradually transformed from growth to mature and shakeout and decline phases after the departure of Steve Jobs in 1985, and reverted back to a growth phase, after Steve Jobs took over the helm in 1997. As we will see later, it is unusual for a company to revert to earlier stages and, so, Apple is quite a special case. Indeed, market practitioners label the success of Apple as the "Steve Jobs Phenomenon". As such, it is encouraging that the *MLDA* classification captures this unusual change. Turning our focus to Microsoft Corporation, Fig. 1 shows that it was in its growth stage during 1980s and 1990s and it is now moving away from growth towards the mature stage. However, we observe a slight shift back into the growth phase from 2009 onwards, roughly corresponding to the period when it substantially rebranded its products. Again, the life-cycle classification time series of Microsoft strongly accords with expectations.

[16] In order to provide a clear sense of how firms move along their life-cycle over time, we take an average value of firms over three years from time $t-1$ to $t+1$ so that firms can fall in between two groups of life-cycle. Specifically, for each year, we assign 1, 2, 3 and 4 respectively to a firm in introduction, growth, mature, and shakeout and decline stages. The life-cycle stage for a firm in year t is equal to the average value of $t-1$, t, and $t+1$.



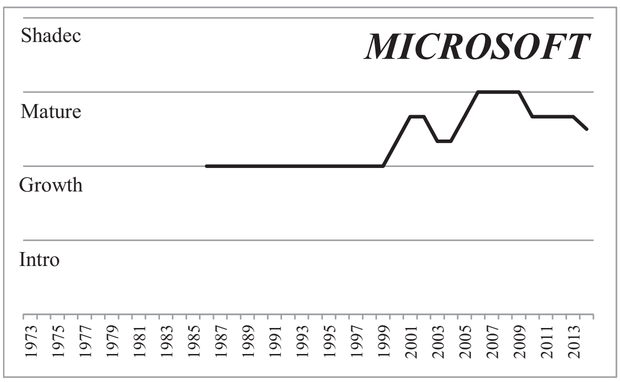


Fig. 1. Multiclass linear discriminant analysis (*MLDA*) classification – time series illustrative examples for Apple and Microsoft. This figure plots the life-cycle of Apple and Microsoft over the period 1973–2014.

Finally, we are interested in how likely a firm transforms from one life-cycle stage to another. Intuition suggests that life-cycle should evolve gradually over time and therefore it should be "sticky" over time, i.e. a firm in a given life-cycle stage is more likely to stay in the same stage in the next year, than to change. Intuitively, it is also unlikely for a firm to revitalize their strategies, i.e. it is unlikely for a company to revert in appearance to the introduction or other earlier stages. Furthermore, economic theories also suggest that firms in the introduction phase have a higher chance of fade out (Jovanovic, 1982; Freeman et al., 1983) and firms in the shakeout and decline phase have a higher chance of failure. Pursuant to these themes, Panel C of Table 1 provides the percentage of firms which change from one life-cycle stage to another from 2013 to 2014. Consistent with our expectations, we see life-cycle stage inertia, introduction stage firms are more likely to fade out (i.e., either shakeout/decline or fail), shakeout and decline firms are more likely to fail, and there is little evidence of stage reversion. Overall, our results suggest that the *MLDA* classification captures, reasonably well, firm life-cycle stage.

3.3. Empirical models

Following DeAngelo et al., 2010, we investigate the impact of life-cycle on corporate policies using OLS estimation with clustered standard errors. Specifically, to capture the non-monotonic association between life-cycle and corporate policies, the following empirical model is employed for non-continuous life-cycle classifications (i.e., *DCS* and *MLDA* classifications):

$$[CP]_{y,i} = \alpha_0 + \alpha_{INTRO}LC_{INTRO,i} + \alpha_{GROWTH}LC_{GROWTH,i} + \alpha_{SHADEC}LC_{SHADEC,i} + \sum_{y}\alpha_y X_{y,i} + \varepsilon_i \tag{10}$$

where LC_x is the life-cycle indicator variable which takes a value of one if a firm is in stage x and zero otherwise, where $x = \{INTRO$ (Introduction), $GROWTH$, $SHADEC$ (Shake-out/decline)$\}$. X_y are the control variables for corporate policy y. $[CP]_y$ is the corporate policy variable for policy y, where

$$[CP]_y \in [Investment, EQUISS, lDISS, \Delta CASH],$$

and *Investment* is capital expenditure; *DISS* and *EQUISS* are long-term (net) debt issuance and (net) equity issuance, respectively; and $\Delta CASH$ is defined as the change in cash and marketable securities. The constant term, α_0, captures the influence of life-cycle on corporate policies for mature firms, while the incremental effect of other life-cycle stage firms (relative to this base case) is captured by each associate α term. In other words, the full impact of other life-cycle stages (x) on corporate policies is captured by $\alpha_0 + \alpha_x$. All variables utilized in this study are defined in Appendix B.

We also employ the following empirical model for continuous life-cycle measures (*RETA* and *AdjAGE*):

$$[CP]_{y,i} = \alpha_0 + \alpha_{LC}LC_i + \alpha_{LI}LC_i * INTRO + \alpha_{LS}LC_i * SHADEC + \sum_{y}\alpha_y X_{y,i} + \varepsilon_i, \tag{11}$$

where, LC_i is the proxy for firm i life-cycle (*RETA* and *AdjAGE*). *INTRO* (*SHADEC*) is an indicator variable which takes a value of one if a firm's relevant life-cycle measure is in the bottom (top) tercile (33%) of distributions, and zero otherwise.

In Eq. (11), the coefficient sum, $\alpha_{LC} + \alpha_{LI}$ captures the influence of life-cycle on corporate policies of firms in the introduction stage, while the coefficient sum, $\alpha_{LC} + \alpha_{LS}$ captures the impact of life-cycle on firms in the shake-out/decline stage. By construction, the coefficient estimate α_{LC} captures the impact of life-cycle on corporate policies in the growth and mature stages.

3.4. Control variables

A wide range of firm-level control variables are included in our regression model to account for time-varying firm factors other than life-cycle which influence corporate policies. Since we employ different dependent variables (corporate policies) in our analysis, and the empirical literature in corporate finance identifies different factors to be relevant for each corporate policy, we employ appropriate alternative sets of control variables in each model dealing with each separate corporate policy. We discuss these control variables below. All control variables are defined in Panel C in Appendix B.

3.4.1. Investment model

Cash flow (*CashFlow*) is controlled for to account for the well-documented evidence of investment-cash flow sensitivity (Fazzari et al., 1988; Kaplan and Zingales, 1997). Tobin's Q (*Q*), which captures investment opportunities, is also included (Tobin, 1988). Firm size (*Size*), defined as the natural logarithm of total assets, is included to control for differences in capital investment policies of differently sized firms. We also include cash holdings (*CashHoldings*) which is defined as the lagged sum of cash and marketable securities scaled by lagged total assets to control for the effect that corporate liquidity has on investment (Myers and Majluf, 1984; Kim et al., 1998). Lang et al. (1996) suggest that it is important to control for financial leverage (*Leverage*), defined as lagged total debt scaled by total assets, because it is negatively related to investment. *Sales* are included to control for the effect of changes in demand which are not captured by Tobin's Q. We control for the change in net working capital (ΔNWC) since working capital and capital investment are two major competing uses of funds (Fazzari and Petersen, 1993).

Table 2
Summary statistics.

Variable	Obs.	Mean	Median	Std. Dev.	Min	Max
Panel A: Core variables						
Investment	100,687	0.079	0.052	0.091	0.000	0.928
EQUISS	100,687	0.026	0.000	0.154	−0.151	4.698
DISS	100,687	0.009	0.000	0.082	−0.351	0.578
ΔCash	100,687	−0.006	−0.001	0.084	−0.436	0.471
Panel B: Proxies for life-cycle stage						
RETA	100,687	−0.096	0.218	1.680	−63.711	0.778
AdjAge	100,687	0.497	0.496	0.290	0.009	0.990
Panel C: Control variables						
Size	100,687	5.401	5.231	1.894	−1.577	10.999
CashFlow	100,687	0.064	0.083	0.166	−3.320	0.539
Q	96,441	1.793	1.291	1.868	0.472	46.283
Inventory	100,013	0.172	0.141	0.157	0.000	0.651
Gross PPE	100,331	0.533	0.462	0.365	0.000	2.187
D/E Ratio	100,473	0.723	0.370	1.672	−8.904	17.134
Leverage	100,425	0.216	0.195	0.183	0.000	0.886
Sales	100,554	1.311	1.181	0.848	0.000	4.981
ΔNWC	98,804	0.020	0.011	0.095	−0.971	0.969
Acquisition	96,638	0.022	0.000	0.070	−0.006	0.670
ΔSTDebt	100,687	0.000	0.000	0.008	−0.224	0.355
CashHoldings	100,687	0.152	0.075	0.187	0.000	0.947

3.4.2. Debt and equity models

Cash flow is included as a control variable because of its negative impact on external financing (Leary and Roberts, 2005). *Q* is included because the attractiveness of investment opportunities should influence financial policy (Almeida and Campello, 2010). Following Almeida and Campello (2010), we also control for *Size*. As suggested by Almeida and Campello (2010), firms might use internal wealth such as cash holdings (*CashHoldings*) and working capital (*Inventory*) to mitigate the impact of cash flow shocks. Thus, we also control for these two variables. Finally, *Gross PPE* and *D/E ratio* are included as control variables because of their impacts on financial policy (Almeida and Campello, 2010).

3.4.3. Cash holdings model

CashFlow is included because of the positive cash-cash flow sensitivity documented by Almeida et al. (2004). All other control variables follow those in Almeida et al. (2004): *Size* is included because of economies of scales in cash management; *Q* is included because cash policy is influenced by future investment opportunities for firms that have restricted access to external finance; *Acquisitions*, *ΔNWC* and *ΔSTDebt* are included as control variables because firms might use their cash balances to finance investment, and working capital and short-term debt can be a substitute for cash holdings.

Descriptive statistics for variables used in our study are summarized in Table 2. In Panel A of Table 2 the summary statistics for the core dependent variables are provided. In Panel B of Table 2 the summary statistics for our continuous life-cycle measures are provided, while Panel C summarizes the control variables. In all cases, quite standard patterns emerge within our sample, giving us confidence to proceed with the analysis.

4. Empirical analysis

4.1. The effect of life-cycle on corporate policies

In this section we discuss the regression results using our main life-cycle proxy, i.e., classifying firms using multiclass discriminant analysis described in Section 3.2.1. Table 3 reports the results of the effect of life-cycle on corporate investment, financing and cash policies. We first discuss the relation between life-cycle and investments as well as equity issuance (Hypothesis I). We then discuss the relation between life-cycle and debt issuance (Hypothesis II) followed by the relation between life-cycle and cash holdings (Hypothesis III).

Table 3
Life-cycle and corporate policies – discriminant analysis proxies. This table reports the outcome of estimating Eq. (10) in the text, using discriminant analysis to create life-cycle measures. The dependent variables are *Investment* (net investment in plant, property & equipment), *DISS* (long term net debt issuance), *EQUISS* (net equity issuance), and *ΔCASH* (the change in cash and marketable securities). All dependent variables are scaled by lagged total assets. All variable definitions are given in Appendix B. The data are obtained from *COMPUSTAT* and *CRSP* for the period 1973–2014. The sample consists of 12,125 US firms. Firms excluded from the final sample: those with less than USD 10 million market capitalization and those with abnormal growth (assets growth or sales growth greater than 1). Coefficients significant at the 10%, 5% and 1% levels are indicated by *, ** and ***, respectively, and the associated *t*-statistics are presented in parentheses.

	(1) *Investment*	(2) *EQUISS*	(3) *DISS*	(4) *ΔCASH*
LC_{INTRO}	0.069***	0.191***	0.046***	0.014***
	(22.4)	(30.8)	(19.6)	(4.9)
LC_{GROWTH}	0.050***	0.036***	0.053***	0.018***
	(43.9)	(40.4)	(73.0)	(26.2)
LC_{SHADEC}	−0.007***	−0.029***	−0.011***	−0.016***
	(−7.9)	(−16.1)	(−12.5)	(−16.6)
CashFlow	0.130***	−0.414***	−0.072***	0.051***
	(21.1)	(−26.7)	(−21.1)	(10.6)
Q	0.002***	0.013***	−0.002***	−0.002***
	(7.5)	(11.8)	(−9.5)	(−5.5)
Size	0.000	−0.003***	0.005***	0.001***
	(0.6)	(−13.6)	(28.7)	(5.8)
Leverage	0.020***			
	(5.8)			
CashHoldings	−0.034***	−0.037***	−0.014***	
	(−10.6)	(−7.6)	(−7.0)	
Sales	−0.012***			
	(−13.5)			
ΔNWC	0.024***			−0.229***
	(4.7)			(−35.1)
Inventory		−0.044***	−0.009***	
		(−13.3)	(−4.4)	
Gross PPE		0.032***	0.007***	
		(19.3)	(7.3)	
D/E ratio		0.001***	−0.003***	
		(2.7)	(−9.8)	
Acquisitions				−0.262***
				(−38.0)
ΔSTDebt				−0.449***
				(−3.9)
Constant	0.063***	0.028***	−0.024***	−0.004***
	(22.3)	(9.5)	(−15.3)	(−3.7)
Observations	94,264	95,215	95,215	90,851
R-squared	0.19	0.45	0.14	0.14

Columns (1) and (2) report the regression results of the effect of life-cycle on investment and equity issuance, respectively. The coefficient estimates of all life-cycle variables are statistically significant at conventional levels (1% level). Consistent with Hypothesis I, both investment and equity issuance decrease monotonically over a firm's life-cycle. The results are economically significant even after controlling for a wide range of firm-level control variables. For example, moving from introduction to growth stage is associated with a decrease in investment and equity issuance of 1.9% and 15.5% of total assets, respectively. The implied decrease in investment and equity issuance are approximately, 6.4% and 43.8% of the net fixed assets and book value of equity of an average firm, respectively.[17] Overall, the results show a negative association between life-cycle and corporate investment and equity issuance.

In Hypothesis II, we predict a non-linear relation between life-cycle and debt issuance, with companies in the growth stage issu-

[17] The calculations are based on the total assets ($1512.1 million), net fixed assets ($451.1 million) and book value of equity ($534.8 million) of an average firm.

ing more debt compared with companies in the introduction or shake-out/decline phases. We report our results on the relation between life-cycle and debt issuance in column (3). The coefficient estimates of all life-cycle variables are statistically significant at conventional levels (1% level). Consistent with Hypothesis II, debt issuance adopts a "hump" shape across life-cycle stages. These results are economically significant even after controlling for a wide range of firm-level control variables. For example, moving from introduction to growth (mature to shake-out/decline) stage is associated with an increase (a decrease) in debt issuance of 0.7% (1.1%) of total assets. The implied increase (decrease) in debt issuance is approximately, 3.6% (5.7%) of book value of long-term debt of an average firm.[18] Overall, the results are consistent with the hypothesized prediction that firms will issue more debt as they move from the introduction phase to the mature phase, and then issue less debt as they are in the mature and shake-out/decline phases.

In Hypothesis III, we also predict that cash holdings will exhibit a "hump" shape across life-cycle stages. Specifically, we expect to observe a positive relation between life-cycle and cash holdings as firms move from the introduction phase to the mature phase and a negative relation as they are in the mature and shake-out/decline phases. The regression results on the relation between life-cycle and cash holdings are shown in column (4). The coefficient estimates of all life-cycle variables are statistically significant at conventional levels (1% level) and, consistent with Hypothesis III, firms increase their cash holdings as they move from the introduction to mature phase and decrease their cash holdings as they are in the mature and shake-out/decline phases. Moving from the introduction to growth (mature to shake-out/decline) stage is associated with an increase (a decrease) in cash holdings of 0.4% (1.6%) of total assets. The implied increase (decrease) in cash holdings is approximately, 3.5% (14.1%) of an average firm total cash holdings.[19] Overall, the results presented in column (4) suggest that when a firm is in the introduction phase, progressing along its life-cycle is associated with an increase in corporate cash holdings. The association becomes negative once the firm enters into the shake-out/decline phase.

4.2. Omitted variable bias

The results presented up to this point show that life-cycle has a strong effect on numerous corporate policies. However, the above-mentioned results are potentially driven by the omitted variables bias. While we have controlled for a broad set of time-varying firm-level factors found to influence a firm's corporate policies, our results may be spurious if our models omit any key variables that affect both firm life-cycle and corporate polices.

It should be noted that some omitted variables concerns have already been addressed in our main results. For example, we have controlled for size and cash flow. Size and cash flow were found in the literature to influence firms' corporate policies (Fazzari et al. (1988); Leary and Roberts (2005); Almeida et al. (2004); Almeida and Campello (2010)) and they are also common proxies for life-cycle (Bhattacharya et al., 2004; Caskey and Hanlon, 2007; Porter, 2004). We perform two additional tests to alleviate concerns over omitted variable bias.

4.2.1. CEO and board characteristics

The life-cycle transitioning of a firm can be influenced by its managerial decisions made along the path of evolution (Porter, 2004), therefore the managerial characteristics (in particular, the characteristics of CEOs and/or the board) can play an important role in the evolution of a firm's life-cycle. If this were the case, then, rather than being a direct consequence of the firm's life-cycle, it is possible that our documented results are really driven (or at least to some degree) by the omitted characteristics of CEOs and/or the board which are jointly correlated with both firm life-cycle and corporate policies. To account for this possibility, in this subsection we control for CEO and board characteristics.[20]

With respect to CEO characteristics, we include controls for CEO age, CEO tenure, CEO overconfidence, and CEO incentives. CEO age and tenure are collected directly from the *ExecuComp* database. To identify overconfidence, Malmendier and Tate (2008) exploit the overexposure of CEOs to the idiosyncratic risk of their firms through their holdings of stock options. More specifically, as in Malmendier and Tate, 2008, we define a CEO as overconfident once he postpones the exercise of vested options that are at least 67% in-the-money (Holder 67). The Holder 67 variable takes the value of one when the CEO is identified as overconfident, and zero otherwise.

Since, we do not have detailed data on the CEO's option holdings and exercise prices for each option grant, we follow Campbell et al. (2011) in calculating an average moneyness of the CEO's option portfolio for each year. First, for each CEO-year, we calculate the average realizable value per option by dividing the total realizable value of the options by the number of options held by the CEO. The strike price is calculated as the fiscal year end stock price minus the average realized value. The average moneyness of the options is then calculated as the stock price divided by the estimated strike price. As we are only interested in options that the CEO can exercise, we include only the vested options held by the CEO.

We control for managerial incentives in line with Chava and Purnanandam (2010) who show that CEO risk-taking incentives are important in setting corporate policy. Motivated by option pricing theory, we capture CEO incentives using CEO delta ($ln(1 + Delta)$) and vega ($ln(1 + Vega)$). Delta is defined as the dollar change in a CEO's stock and option portfolio for a one-percent change in stock price and measures the CEO's incentives to increase the stock price. Vega is the dollar change in a CEO's option holdings for a 0.01 unit change in stock return volatility. Vega measures the risk-taking incentives generated by the CEO's option holdings.

To take account of the role of corporate governance factors in the setting of corporate policy, we control for anti-takeover provisions as captured by the G-Index developed by Gompers et al. (2003). In addition to anti-takeover provisions, which capture managerial entrenchment, we also control for the portion of board directors who are independent (*Independent dir*), and the total portion of a firm's shares outstanding which are held by institutions (*Total IO*).

A significant problem with controlling for CEO and board characteristics is that the data is only available for a sub-set of the entire database. This poses a significant challenge to our empirical setup, given that we are interested in how life-cycle affects corporate policies as the firm progresses through the different stages of life. Limiting the sample to only those firm-year observations which are available from the *ExecuComp* database would largely limit our data to those firms which are in the advanced stages of their life-cycle. To avoid this serious sample selection bias, we replace missing observations for these variables with zero. To account for the potential bias this approach introduces, in all

[18] The long-term debt of an average firm amounts to $291.5 million.

[19] The cash holdings of an average firm amounts to $171.2 million.

[20] The main reason for treating this analysis as a robustness check is based on our judgment of the research design tradeoffs – the cost is high, since (as elaborated earlier) we lose over half our sample due to data omissions on key CEO and board characteristics variables.

Table 4
Life-cycle and corporate policies – discriminant analysis proxies (controlling for CEO and board characteristics). This table reports the outcome of estimating Eq. (10) in the text, using discriminant analysis to create life-cycle measures. The dependent variables are *Investment* (net investment in plant, property & equipment), *DISS* (long term net debt issuance), *EQUISS* (net equity issuance), and *ΔCASH* (the change in cash and marketable securities). All dependent variables are scaled by lagged total assets. CEO characteristics include the natural logarithm of CEO age, the natural logarithm of CEO tenure, the natural logarithm of CEO stock option delta and vega, and an indicator variable (*Holder 67*) equals to one if the CEO is overconfident. Board characteristics include the portion of independent directors, G-index, and total institutional ownership. All variable definitions are given in Appendix B. The data are obtained from *COMPUSTAT* and *CRSP* for the period 1973–2014. The sample consists of 12,125 US firms. Firms excluded from the final sample: those with less than USD 10 million market capitalization and those with abnormal growth (assets growth or sales growth greater than 1). Coefficients significant at the 10%, 5% and 1% levels are indicated by *, ** and ***, respectively, and the associated *t*-statistics are presented in parentheses.

	(1) *Investment*	(2) *EQUISS*	(3) *DISS*	(4) *ΔCASH*
LC_{INTRO}	0.051***	0.178***	0.052***	0.016***
	(13.7)	(23.6)	(16.7)	(4.0)
LC_{GROWTH}	0.033***	0.052***	0.053***	0.024***
	(20.9)	(35.3)	(45.1)	(19.8)
LC_{SHADEC}	−0.011***	−0.035***	−0.008***	−0.013***
	(−9.0)	(−13.0)	(−6.8)	(−9.6)
Independent dir	−0.001	−0.011**	0.001	0.000
	(−0.2)	(−2.4)	(0.4)	(0.1)
Holder 67	0.005***	0.004**	0.001	0.001
	(2.9)	(2.1)	(0.5)	(0.4)
Ln(Ceo age)	−0.021**	−0.006	−0.013***	0.024***
	(−2.4)	(−1.0)	(−2.7)	(5.0)
Ln(CEO tenure)	0.003***	0.001	0.002***	−0.003***
	(2.8)	(1.0)	(2.8)	(−4.2)
G-index	−0.000	−0.000	0.000	0.001***
	(−1.0)	(−1.3)	(0.2)	(4.7)
Total IO	−0.004	0.019***	−0.002	−0.002
	(−1.6)	(6.5)	(−1.5)	(−1.5)
Ln(1 + Delta)	0.000	0.002	−0.006***	0.003**
	(0.0)	(1.2)	(−5.4)	(2.3)
Ln(1 + Vega)	−0.005***	−0.005***	0.006***	−0.005***
	(−2.7)	(−3.0)	(5.6)	(−4.2)
Constant	0.146***	0.058**	0.017	−0.095***
	(4.3)	(2.2)	(0.9)	(−5.0)
Firm level controls	YES	YES	YES	YES
Observations	40,291	40,859	40,859	39,097
R-squared	0.16	0.49	0.14	0.16

regressions we include an indicator variable which is equal to one if a missing observation for a specific variable has been replaced with zero.[21] Although this approach is not perfect, it is necessary given our specific empirical design. Missing values of CEO and board characteristics are only replaced with zero over the years that these data are generally available. Since our CEO/board characteristic data starts from the early 1990s, while our full sample utilized in the baseline specification spans the period 1973–2014, our sample after controlling for CEO/board characteristics decreases relative to the baseline results, even after replacing missing values with zero.[22]

We report our results in Table 4.[23] We find that our results are consistent with our baseline tests reported in Table 3, even after controlling for CEO and board characteristics. The negative associations between life-cycle and investment as well as equity issuance, are evident in columns (1) and (2), respectively. The coefficient estimates of all life-cycle variables are once again found to be statistically significant at 1% level. In terms of the relation between life-cycle and debt issuance, the results documented in column (3) reveal that the association between life-cycle and debt issuance is positive in both the introduction and growth phases, and negative in the shake-out/decline phase. This set of findings is consistent with Hypothesis II. Finally, consistent with Hypothesis III, the results displayed in column (4) show that cash holdings exhibit a "hump" shape across life-cycle stages. Overall, our findings after controlling for CEO and board characteristics are consistent with the main results. Thus, with regard to this important threat to our research design, we have a robust message on the role and importance of the firm's life-cycle.

4.2.2. Cash flow uncertainty

In the prior literature, cash flow uncertainty is found to influence corporate policies (see e.g., Dixit and Pindyck, 1994; Chay and Suh, 2009; Han and Qiu, 2007). On the other hand, Grullon et al. (2002) argue that firms are less risky (with lower discount rate) when they become more mature. If this were the case, then, rather than being a direct consequence of the firm's life-cycle, it is possible that our documented results are really driven by the omitted cash flow uncertainty which is jointly correlated with both firm life-cycle and corporate policies. To account for this possibility, we control for cash flow uncertainty in an extended analysis. To do this, we use the standard deviation of 5-year forward looking *CashFlow* as a proxy for cash flow uncertainty (*CashFlow Uncertainty*).[24]

This analysis reported in Table 5. Our results are consistent with our baseline tests reported in Tables 3 and 4, after controlling for *CashFlow Uncertainty*. The negative associations between life-cycle and investment as well as equity issuance, are evident in columns (1) and (2), respectively. The coefficient estimates of all life-cycle variables are once again statistically significant at the 1% level. Further, the results documented in column (3) reveal that the association between life-cycle and debt issuance is positive in both the introduction and growth phases, and negative in the shake-out/decline phase. Finally, the results displayed in column (4) show that cash holdings exhibit a "hump" shape across life-cycle stages. Thus, with regard to this important threat to our research design, we have a robust message on the role and importance of the firm's life-cycle.

4.3. Alternative measures of life-cycle

In this sub-section we consider alternate proxies for life-cycle to ensure that our results are not spuriously driven by a specific measure of life-cycle. Specifically, we employ three alternative proxies: (1) Earned to contributed capital ratio, (2) *DCS*, and (3) Industry and size adjusted firm age. The computation of these proxies is described in Section 3.2.

Tables 6–8 reports the regression results using alternative life-cycle proxies and controlling for firm characteristics (including CEO and board characteristics) [including *CashFlow Uncertainty*]. For brevity, we do not report the coefficient estimates on control variables. While the results of both tables are generally consistent with our baseline results, we do observe a few variations. For example based on *DCS*, in the case of investment and equity issu-

[21] This is a common treatment used in the literature to avoid the sample selection problem (see e.g., Hirshleifer et al., 2012; Chang et al., 2015). If we exclude all observations with missing CEO and board characteristics, there will only be less than 9000 observations (i.e. less than 10% of the total observations) remaining in the sample. As such, this would very likely be an unrepresentative sample.

[22] We note that the reduced sample biases our results against finding significant results.

[23] To conserve on space, we report only the coefficients of interest. The full results are available from the authors upon request.

[24] Note that for additional robustness, we also use alternative measures of cash flow uncertainty: (1) the standard deviation of 5-year (and 10-year) backward (and forward) looking *CashFlow*, (2) 1-year backward (and forward) looking stock return volatility, (3) the standard deviation of 5-year (and 10-year) backward (and forward) looking *ROA*. Our results (unreported) are highly consistent with the results reported in this section. The full results are available from the authors upon request.

Table 5
Life-cycle and corporate policies – discriminant analysis proxies (controlling for cash flow uncertainty). This table reports the outcome of estimating Eq. (10) in the text, using discriminant analysis to create life-cycle measures. The dependent variables are *Investment* (net investment in plant, property & equipment), *DISS* (long term net debt issuance), *EQUISS* (net equity issuance), and *ΔCASH* (the change in cash and marketable securities). All dependent variables are scaled by lagged total assets. *CashFlow Uncertainty* is the standard deviation of 5-year forward looking *CashFlow*. All variable definitions are given in Appendix B. The data are obtained from *COMPUSTAT* and *CRSP* for the period 1973–2014. The sample consists of 12,125 US firms. Firms excluded from the final sample: those with less than USD 10 million market capitalization and those with abnormal growth (assets growth or sales growth greater than 1). Coefficients significant at the 10%, 5% and 1% levels are indicated by *, ** and ***, respectively, and the associated *t*-statistics are presented in parentheses.

	(1) *Investment*	(2) *EQUISS*	(3) *DISS*	(4) *ΔCASH*
LC_{INTRO}	0.071***	0.210***	0.042***	0.015***
	(18.5)	(25.8)	(14.6)	(4.2)
LC_{GROWTH}	0.051***	0.036***	0.051***	0.018***
	(38.8)	(34.6)	(61.7)	(23.1)
LC_{SHADEC}	−0.008***	−0.027***	−0.011***	−0.017***
	(−6.7)	(−12.6)	(−10.3)	(−14.5)
CashFlow	0.151***	−0.373***	−0.078***	0.053***
	(18.4)	(−20.7)	(−19.1)	(9.7)
Q	0.002***	0.012***	−0.002***	−0.002***
	(5.8)	(9.4)	(−9.1)	(−5.0)
Size	0.001**	−0.003***	0.004***	0.001***
	(2.5)	(−8.1)	(22.8)	(5.5)
Leverage	0.022***			
	(5.3)			
CashHoldings	−0.032***	−0.045***	−0.009***	
	(−8.3)	(−8.0)	(−3.9)	
Sales	−0.012***			
	(−11.7)			
ΔNWC	0.034***			−0.238***
	(5.0)			(−30.6)
CashFlow Uncertainty	0.042***	0.093***	−0.020***	0.035***
	(5.8)	(6.4)	(−3.7)	(4.3)
Inventory		−0.042***	−0.009***	
		(−11.1)	(−3.5)	
Gross PPE		0.031***	0.010***	
		(15.1)	(8.3)	
D/E Ratio		0.001***	−0.003***	
		(3.0)	(−9.4)	
Acquisitions				−0.247***
				(−30.8)
ΔSTDebt				−0.409***
				(−2.9)
Constant	0.055***	0.017***	−0.022***	−0.007***
	(16.7)	(5.1)	(−11.6)	(−4.6)
Observations	66,974	67,701	67,701	64,277
R-squared	0.20	0.43	0.14	0.15

Table 6
Life-cycle and corporate policies – alternate life-cycle proxies. This table reports the outcome of estimating Eqs. (10) and (11) in the text, using *RETA*, Dickinson (2011) classification scheme (*DCS*), and industry and size adjusted age as proxies of life-cycle (*LC*). The dependent variables are *Investment* (net investment in plant, property & equipment), *DISS* (long term net debt issuance), *EQUISS* (net equity issuance), and *ΔCASH* (the change in cash and marketable securities). All dependent variables are scaled by lagged total assets. In Panel A and C, *INTRO* (*SHADEC*) is an indicator variable which takes a value of 1 if a firm's relevant life-cycle measure is in the bottom (top) tercile, 0 otherwise. All variable definitions are given in Appendix B. The data are obtained from *COMPUSTAT* and *CRSP* for the period 1973–2014. The sample consists of 12,125 US firms. Firms excluded from the final sample: those with less than USD 10 million market capitalization and those with abnormal growth (assets growth or sales growth greater than 1). Coefficients significant at the 10%, 5% and 1% levels are indicated by *, ** and ***, respectively, and the associated *t*-statistics are presented in parentheses.

	(1) *Investment*	(2) *EQUISS*	(3) *DISS*	(4) *ΔCASH*
Panel A: RETA				
LC	−0.005	−0.048***	0.029***	0.014***
	(−1.0)	(−9.0)	(8.8)	(5.1)
*LC*INTRO*	0.004	0.047***	−0.026***	−0.015***
	(0.8)	(8.4)	(−7.7)	(−5.4)
*LC*SHADEC*	−0.027***	−0.016***	−0.016***	−0.012***
	(−6.4)	(−5.1)	(−6.3)	(−6.4)
Firm level controls	YES	YES	YES	YES
Observations	94,320	95,288	95,288	90,902
R-squared	0.12	0.40	0.06	0.13
Panel B: DCS				
LC_{INTRO}	0.029***	0.005	0.059***	0.018***
	(15.2)	(1.2)	(36.7)	(8.9)
LC_{GROWTH}	0.046***	0.037***	0.064***	0.028***
	(31.8)	(32.8)	(74.1)	(33.4)
LC_{SHADEC}	−0.008***	−0.075***	−0.011***	0.001
	(−8.2)	(−23.1)	(−9.0)	(0.5)
Constant	0.061***	0.068***	−0.041***	−0.015***
	(19.0)	(16.4)	(−22.4)	(−10.1)
Firm level controls	YES	YES	YES	YES
Observations	63,038	64,062	64,062	61,127
R-squared	0.15	0.44	0.18	0.15
Panel C: Industry and size adjusted age				
LC	−0.019***	−0.021***	−0.012***	0.005***
	(−6.5)	(−7.2)	(−6.0)	(3.1)
*LC*INTRO*	0.041***	0.009	0.016***	−0.023***
	(8.3)	(1.5)	(4.3)	(−6.3)
*LC*SHADEC*	−0.004*	−0.002	−0.003**	−0.001
	(−1.9)	(−1.0)	(−2.4)	(−1.3)
Firm level controls	YES	YES	YES	YES
Observations	94,320	95,288	95,288	90,902
R-squared	0.12	0.38	0.04	0.13

ance policies, monotonicity is weakened. In particular, we see evidence suggesting that growth firms both invest more and have higher use of equity, than their introduction phase counterpart firms. Nevertheless, the *RETA* and *DCS* analyses in Panels A and B confirms the predicted hump shape linkage between debt issuance-life cycle and cash holdings-life cycle. Overall, supplementary results presented in Tables 6–8 suggest that the baseline results regarding the relation between life-cycle and corporate policies are not driven by the choice of life-cycle measure, and instead are qualitatively consistent across alternate proxies. More generally, all of our robustness analyses give us great confidence in the view that firm life-cycle does have an influential role in shaping corporate policy.

4.4. Proportion of life-cycle proxy contribution to R-squared

So far, we find that firm life-cycle has an influential role in shaping corporate policy. In this section, we assess how much more of the cross-sectional variation of corporate policies can be explained by life-cycle proxies compared to traditional firm characteristics. Specifically, we compute the proportion of life-cycle proxy contribution to R-squared for corporate policy i (PCR_i) as follows:

$$PCR_i = \frac{R_i^2(\text{All}) - R_i^2(\text{noLC})}{R_i^2(\text{All})} \tag{12}$$

where $R_i^2(\text{All})$ is the *R*-squared of the regression of policy i with all independent variables and $R_i^2(\text{noLC})$ is the R-squared of the regression of policy i with all independent variables excluding the life-cycle proxy.

PCR of a life-cycle proxy can be interpreted as the proportion of the cross-sectional variation which can be explained by a given life-cycle proxy and $1 - PCR$ represents the proportion of the cross-sectional variation which can be explained by traditional firm characteristics.

Table 9 reports *PCR* for all the life-cycle proxies used in this paper. A number of points are worth noting. First, a significant proportion (ranging from 11% for cash policy to 76% for debt issuance policy) of the cross-sectional variation of corporate policies can be

Table 7

Life-cycle and corporate policies – alternate life-cycle proxies (Controlling for CEO and board characteristics). This table reports the outcome of estimating Eqs. (10) and (11) in the text, using *RETA*, Dickinson (2011) classification scheme (*DCS*), and industry and size adjusted age as proxies of life-cycle (*LC*). The dependent variables are *Investment* (net investment in plant, property & equipment), *DISS* (long term net debt issuance), *EQUISS* (net equity issuance), and *ΔCASH* (the change in cash and marketable securities). All dependent variables are scaled by lagged total assets. CEO characteristics include the natural logarithm of CEO age, the natural logarithm of CEO tenure, the natural logarithm of CEO stock option delta and vega, and an indicator variable (*Holder 67*) equals to one if the CEO is overconfident. Board characteristics include the portion of independent directors, G-index, and total institutional ownership. In Panel A and C, *INTRO* (*SHADEC*) is an indicator variable which takes a value of 1 if a firm's relevant life-cycle measure is in the bottom (top) tercile, 0 otherwise. All variable definitions are given in Appendix B. The data are obtained from *COMPUSTAT* and *CRSP* for the period 1973–2014. The sample consists of 12,125 US firms. Firms excluded from the final sample: those with less than USD 10 million market capitalization and those with abnormal growth (assets growth or sales growth greater than 1). Coefficients significant at the 10%, 5% and 1% levels are indicated by *, ** and ***, respectively, and the associated *t*-statistics are presented in parentheses.

	(1) *Investment*	(2) *EQUISS*	(3) *DISS*	(4) *ΔCASH*
Panel A: RETA				
LC	0.008	−0.022***	0.011**	0.018***
	(1.1)	(−2.8)	(2.4)	(4.1)
*LC*INTRO*	−0.009	0.023***	−0.009*	−0.019***
	(−1.2)	(2.9)	(−1.9)	(−4.4)
*LC*SHADEC*	−0.014**	−0.023***	−0.002	−0.017***
	(−2.3)	(−4.3)	(−0.6)	(−5.1)
Full set of controls	YES	YES	YES	YES
Observations	40,331	40,907	40,907	39,134
R-squared	0.11	0.42	0.06	0.14
Panel B: DCS				
LC_{INTRO}	0.025***	0.007	0.057***	0.014***
	(11.6)	(1.4)	(28.0)	(5.9)
LC_{GROWTH}	0.038***	0.037***	0.065***	0.031***
	(23.4)	(28.0)	(60.8)	(29.6)
LC_{SHADEC}	−0.007***	−0.072***	−0.008***	0.003
	(−6.6)	(−17.8)	(−5.2)	(1.6)
Constant	0.136***	0.087***	0.005	−0.108***
	(4.0)	(3.2)	(0.3)	(−5.8)
Full set of controls	YES	YES	YES	YES
Observations	40,003	40,563	40,563	38,796
R-squared	0.15	0.45	0.18	0.16
Panel C: Industry and size adjusted age				
LC	−0.006	−0.018***	−0.004	0.006**
	(−1.6)	(−3.8)	(−1.4)	(2.2)
*LC*INTRO*	0.026***	0.008	0.009	−0.035***
	(3.7)	(0.8)	(1.5)	(−5.5)
*LC*SHADEC*	−0.004	−0.001	−0.002	0.000
	(−1.3)	(−0.2)	(−1.2)	(0.1)
Full set of controls	YES	YES	YES	YES
Observations	40,331	40,907	40,907	39,134
R-squared	0.11	0.41	0.04	0.14

Table 8

Life-cycle and corporate policies – alternate life-cycle proxies (controlling for cash flow uncertainty). This table reports the outcome of estimating Eqs. (10) and (11) in the text, using *RETA*, Dickinson (2011) classification scheme (*DCS*), and industry and size adjusted age as proxies of life-cycle (*LC*). The dependent variables are *Investment* (net investment in plant, property & equipment), *DISS* (long term net debt issuance), *EQUISS* (net equity issuance), and *ΔCASH* (the change in cash and marketable securities). All dependent variables are scaled by lagged total assets. *CashFlow Uncertainty* is the standard deviation of 5-year forward looking *CashFlow*. In Panel A and C, *INTRO* (*SHADEC*) is an indicator variable which takes a value of 1 if a firm's relevant life-cycle measure is in the bottom (top) tercile, 0 otherwise. All variable definitions are given in Appendix B. The data are obtained from *COMPUSTAT* and *CRSP* for the period 1973–2014. The sample consists of 12,125 US firms. Firms excluded from the final sample: those with less than USD 10 million market capitalization and those with abnormal growth (assets growth or sales growth greater than 1). Coefficients significant at the 10%, 5% and 1% levels are indicated by *, ** and ***, respectively, and the associated *t*-statistics are presented in parentheses.

	(1) *Investment*	(2) *EQUISS*	(3) *DISS*	(4) *ΔCASH*
Panel A: RETA				
LC	−0.006	−0.059***	0.034***	0.012***
	(−0.9)	(−9.2)	(8.6)	(3.7)
*LC*INTRO*	0.005	0.060***	−0.030***	−0.013***
	(0.8)	(9.1)	(−7.6)	(−3.9)
*LC*SHADEC*	−0.031***	−0.015***	−0.019***	−0.010***
	(−6.2)	(−3.9)	(−6.4)	(−4.5)
Firm level controls	YES	YES	YES	YES
Observations	66,999	67,744	67,744	64,300
R-squared	0.13	0.38	0.06	0.13
Panel B: DCS				
LC_{INTRO}	0.028***	0.010*	0.057***	0.020***
	(12.5)	(1.9)	(30.8)	(8.7)
LC_{GROWTH}	0.048***	0.038***	0.062***	0.027***
	(28.5)	(28.3)	(60.4)	(27.8)
LC_{SHADEC}	−0.008***	−0.071***	−0.012***	−0.000
	(−6.4)	(−18.1)	(−8.1)	(−0.2)
Constant	0.052***	0.055***	−0.041***	−0.018***
	(13.7)	(11.3)	(−18.1)	(−8.8)
Firm level controls	YES	YES	YES	YES
Observations	42,442	43,232	43,232	41,049
R-squared	0.17	0.43	0.18	0.15
Panel C: Industry and size adjusted age				
LC	−0.019***	−0.024***	−0.012***	0.003
	(−5.7)	(−7.2)	(−5.3)	(1.5)
*LC*INTRO*	0.046***	0.012*	0.017***	−0.022***
	(7.9)	(1.7)	(4.1)	(−5.4)
*LC*SHADEC*	−0.004	−0.000	−0.003*	−0.000
	(−1.6)	(−0.1)	(−1.9)	(−0.1)
Firm level controls	YES	YES	YES	YES
Observations	66,999	67,744	67,744	64,300
R-squared	0.13	0.36	0.04	0.13

explained by our main life-cycle proxy. Second, in terms of the cross-sectional variation explanatory power, our main and *DCS* proxies are better proxies than *RETA* and *AdjAge*. Third, life-cycle plays an important role in explaining the cross-sectional variation of debt issuance and investment policies. For example, 76% (42%) of the cross-sectional variation of debt issuance (investment) policy can be explained by our main life-cycle proxy with the remaining 24% (58%) explained by the traditional firm characteristics. Overall, life-cycle provides substantial additional explanatory power of the cross-sectional variation of corporate policies and it is an important determinant for which we should control.

5. Conclusion

This study examines the importance of life-cycle theory as a determinant of corporate policies. In particular, we examine whether a firm's life-cycle stage influences the amount of

Table 9

Proportion of life-cycle proxy contribution to *R*-squared. This table reports the proportion of life-cycle proxy contribution to R-squared for corporate policy $i(PCR_i)$. PCR_i is computed as follows: $PCR_i = \frac{R_i^2(\text{All}) - R_i^2(\text{noLC})}{R_i^2(\text{All})}$ where $R_i^2(\text{All})$ is the *R*-squared of the regression of corporate policy *i* with all independent variables and $R_i^2(\text{noLC})$ is the *R*-squared of the regression of corporate policy *i* with all independent variables except the life-cycle proxy.

(1) *Investment*	(2) *EQUISS*	(3) *DISS*	(4) *ΔCASH*
Discriminant analysis classification			
0.42	0.16	0.76	0.11
RETA			
0.10	0.05	0.45	0.01
DCS			
0.28	0.15	0.82	0.13
Industry and size adjusted age			
0.09	0.01	0.11	0.01

resources allocated to each policy. We illustrate how the corporate decision making process is interdependent over the firm's life-cycle. The empirical analysis largely confirms our predications. Based on an extensive sample of US firms over the period 1973 to 2014, we find that life-cycle is negatively associated with investment and equity issuance. In addition, life-cycle is positively associated in the introduction, and growth stages and negatively associated in the mature and shake-out/decline stages, with debt issuance and cash holdings.

Firm life-cycle is important for corporate decision making. Firm characteristics, growth opportunities, corporate culture and organization structure change gradually as firms mature. Because many of these changes are largely irreversible, firms behave differently in various life-cycle stages. Collectively, our results show that corporate policies follow a largely predictable pattern over time.

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Appendix A. Dickinson (2011) cash flow patterns classification scheme (*DCS*)

Following Dickinson (2011), we classify firms into different stages of life-cycle according to their cash flow patterns. Eight cash flow patterns are formed based on the signs of operating (*OCF*), investing (*ICF*) and financing (*FCF*) cash flows. Firms are then classified into four stages as follows:

	1 Introduction	2 Growth	3 Mature	4 Shake-out/ decline	5 Shake-out/ decline	6 Shake-out/ decline	7 Shake-out/ decline	8 Shake-out/ decline
OCF	–	+	+	–	+	+	–	–
ICF	–	–	–	–	+	+	+	+
FCF	+	+	–	–	+	–	+	–

Appendix B. Variable Definitions

Variable	Definition
Panel A: Dependent variables	
Investment	[Cash paid for PPE – Sales of PPE]/Lagged total assets where: PPE is plant, property & equipment
EQUISS	Net equity issuance/Lagged total assets
DISS	Long-term (net) debt issuance/Lagged total assets
ΔCash	ΔCashHoldings, where CashHoldings = [Cash + Marketable securities]/Lagged total assets
Panel B: Proxies for life-cycle stage	
RETA	Retained earnings/Total assets
AdjAge	Industry and size adjusted CRSP firm age
Panel C: Control variables	
Size	ln [Total assets]
CashFlow	Cash flow from operations/Lagged total assets
Q	Market to Book = [Market value of equity – Book value of equity + Book value of total assets]/Book value of total assets
Inventory	Inventory/Total assets
Gross PPE	Gross PPE/Total assets
D/E Ratio	Total debt/Total equity
Leverage	Total debt/Total assets
Sales	Sales/Total assets
ΔNWC	Change in net working capital, where net working capital = [Current assets – Current liabilities]/Lagged total assets
Acquisition	Acquisitions/Lagged total assets
ΔSTDebt	Change in short term debt/Total assets
CashHoldings	[Cash + Marketable securities]/Lagged total assets

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