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Corporate Lifecycle and Default Risk

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ABSTRACT

We find a nonlinear relation between corporate lifecycle and default risk. Default risk is significantly higher for growth and decline firms when compared to mature firms, after controlling for firm specific and macroeconomic factors on default risk. The shorter distance to default for introduction firms vis-a-vis mature firms are, however, mostly explained by known determinants of default risk. Whereas the 2008 financial crisis adversely impacted all firms, the elevation in default risk was intensified among mature firms. Further results show greater default risk is associated with firms that are lifecycle leaders among their industry peers but is lower for laggards.

Keywords: Corporate lifecycle, default risk, financial crisis, industry leaders and laggards.

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I. Introduction

The corporate lifecycle literature documents growing evidence of a nonlinear relation between a firm's life stage and its investment and financing policies. The nonlinear relation aligns with the postulation that firms in their introduction and growth stages are likely to finance their innovative investments for growth mainly with debt. On the other hand, mature firms tend to use equity financing to invest for maintaining their assets in place (Hirsch & Walz, 2011; Hubbard, 1998). For firms that transit beyond the mature stage into the decline stage, they pursue riskier projects that are associated with greater cash flow uncertainties in their efforts to improve their vulnerable financial conditions (Faff *et al.*, 2016; Habib & Hasan, 2017). From the perspectives of stock investors, both systematic and idiosyncratic risks and hence the cost of equity capital are higher for firms in the introduction and decline stages than mature firms (Dickinson, 2011; Hasan & Hossain, 2017; Hasan *et al.*, 2015). The finding of a U-shape relation between life stage and corporate risk taking indicates that the outcomes of investment and financing policies impact the riskiness of the firm and its stock.

Default risk can be considered as an extreme form of firm risk as default is among the most disruptive and costly corporate events. Hence, effective management of default risk is a critical task for managers. For analysts and investors, default risk is the primary risk factor and the key determinant of bond rating and valuation (Collin-Dufresne & Goldstein, 2001; Duffee, 1999). Whereas the literature documents extensive evidence of the roles of financial ratios (Bellovary *et al.*, 2007), non-financial factors (Altman *et al.*, 2016) and market factors (Hernandez-Tinoco & Wilson, 2013) in explaining default risk, there is limited research on how a firm's life stage impacts its default risk. The primary objective of our study is to fill the void in the literature by examining the likelihood of default faced by a firm across its life stages.

With a sample period of 2000 to 2019 with 16,334 firm-year observations, we find support for our hypothesis that there is a nonlinear relation between default risk and a firm's life stage. Our results show that mature firms face the least likelihood of default, whereas firms in both ends of the lifecycle spectrum display shorter distance to default and hence greater default risk. Further, growth firms are associated with the greatest default risk relative to mature firms after controlling for known determinants of default risk. Further results show that while the 2008 financial crisis elevated default risk faced by all sample firms, the adverse impact hit mature firms most relative to firms in other life stages. These findings echo the severity of the 2008 financial crisis that adversely impacted all firms including those that are financially healthy during the normal economic conditions. Besides, we find that default risk is higher for firms that lead their industry peers in the lifecycle but is lower for laggards. The association between a firm's lifecycle and its default risk persists after we control for the effects of industry leaders and laggards on default risk.

Our study contributes to the corporate lifecycle literature by being the first study that provides empirical evidence on the role of a firm's life stage in explaining its default risk in a manner that is not captured by firm specific and macroeconomic determinants of default risk. Our findings indicate that the nonlinear impact of lifecycle on a firm's risk-taking behaviors is also manifested in its default risk, and call for the attention of bond investors to consider the life stage of a firm in assessing their investments. Our study also adds to the industry leaders and laggards literature with evidence that leaders (laggards) face greater (less) default risk than their peers.

II. Literature Review and Hypothesis Development

Over its life, a firm may develop different competitive advantages that impact its performance as the coordination of its resources and capabilities changes along with external environments it experiences across different stages in its life cycle (Helfat & Peteraf, 2003). Consistent with the implications of the dynamic resource-based view of corporate life cycle, the literature documents a nonlinear relation between a firm's life stage and its profitability and riskiness (Dickinson, 2011; Habib & Hasan, 2017; Hasan & Hossain, 2017; Koh *et al.*, 2015), and its corporate policies (Faff et al., 2016). Habib and Hasan (2017) find that firms in the introduction and decline stages display greater risk-taking behaviors leading to greater cash flow uncertainties. Dickinson (2011) and Hasan and Hossain (2017) find greater asset beta and idiosyncratic risk for firms in the introduction and decline stages than growth and mature firms. These studies show that the life stage of a firm plays a significant role in explaining the riskiness of a firm after controlling for known determinants for the riskiness of the firm and its stock.

These findings suggest a possible influence of a firm's life stage in the level of default, which is the primary risk factor of particular interest to professionals and investors in the corporate bond market. There exist extensive studies on determinants of corporate default risk. The early works focus on predictivity of financial ratios on corporate bankruptcy. Since the financial ratios are derived based on financial statements, these kinds of bankruptcy prediction models are called accounting-based models, among which Altman's (1968) Z-score and Ohlson's (1980) O-score are the most popular default risk measures. The following studies introduce non-financial variables in complementing financial variables to improve prediction accuracy. For example, Dakovic *et al.* (2010) find that auditor remarks and company age are effective on top of financial variables to predict bankruptcy. Wilson *et al.* (2013) show that management quality and reliability and payment behavior are additional effective nonfinancial variables. Altman *et al.* (2016) document that industry risk, payment behavior, and board member characteristics can be significant predictors in combination with financial variables. As the accounting-based default risk measures are mainly based on financial statements that are designed to measure past performance and may not be very informative about the future status of a firm, and also the measures fail to incorporate asset volatility that is a crucial variable in default prediction, Hillegeist *et al.* (2004), and Bharath and Shumway (2008) develop market-based default risk measures based on structural models of default risk (e.g. Merton, 1974), while Chava and Jarrow (2004) develop the default risk measure based on Shumway's (2001) dynamic hazard model with industry effects. The main advantages of market-based default risk measures are that they provide guidance about the theoretical determinants of default prediction and extract default-related information from market prices. More importantly, market-based models predict corporate bankruptcy more accurately than accounting-based models, as shown by Hillegeist *et al.* (2004) that compare prediction performance of market-based models versus accounting-based models. Also, Gharghori *et al.* (2006) point out that market-based measures incorporate timely information about the firm, industry and macroeconomy into estimation of bankruptcy probability and hence is more accurate in predicting bankruptcy probability than accounting-based measure such as Altman's Z-Score. In more recent studies, Hsu *et al.* (2015) use the market-based default risk measure proposed by Bharath and Shumway (2008) to show that the quantity, impact, originality, and generality of a firm's patent portfolio have negative impact on its default risk. Ali *et al.* (2018) apply the market-based Merton (1974) distance to default in gauging default risk and demonstrate that a firm with strong corporate governance has a lower-level default risk. Cathcart *et al.* (2020) adopt Shumway's (2001) hazard model to estimate default risk and find that financial leverage has a greater impact on default risk of small and medium sized enterprises than of large corporations.

However, the existing studies have not explored how the life cycle of a firm could affect its default risk. Since the studies in the literature of corporate life cycle suggest that a firm's life cycle has impacts on its investment and financing policies, which impact its likelihood of default and success, we postulate that a firm's life stage offers unique insight on its default risk. Firms in their introduction stage tend to be smaller firms with great growth opportunities that take the form of risky innovative investments (Coad *et al.*, 2016). Consequently, firms in this life stage tend to face greater default risk with much uncertainty in profitability and cash flows (Dickinson, 2011; Habib & Hasan, 2017). At the peak performance in the lifecycle spectrum, mature firms are characterized as larger firms with established histories of success in the markets and communities that offer them competitive advantage in attaining resources (Helfat & Peteraf, 2003). They tend to be profitable with stable cash flows and less aggressive investments, and hence face less default risk. For firms moving beyond their mature stage into the decline stage, they face stagnant growth resulting from shrinking investment opportunities and resource base, and are in financial distress due to declining sales, profits and cash flows. These firms are associated with increasing default risk as they struggle to regain their competitiveness and profitability by pursuing riskier projects (Hasan *et al.*, 2015). In summary, firms in the introduction and decline stages are less profitable and display greater risk-taking behaviors that are associated with greater cash flow uncertainty and likelihood of default, compared to their peers in the mature stage.

We hypothesize that default risk is higher for firms in the introduction and decline stages, compared to mature firms. Duffie and Singleton (2003) and Lizares and Bautista (2021) suggest that during crises periods, the possibilities of financial distress of firms increase significantly. We therefore investigate whether the 2008 financial crisis impacts the relation between life stage and default risk as well. Given the severity and broad nature of the adverse impacts of the 2008 financial crisis on the liquidity crunch and investor confidence in global financial markets, we postulate that there was an across-the-board increase in default risk for all firms with differential impacts on firms in different life stages.

III. Data and Methodology

A. Data and Key Variables

We construct our sample by scanning COMPUSTAT and CRSP for U.S. firms between 2000 and 2019 and exclude financial and utilities firms and firms with negative book values. We follow Koh *et al.* (2015) to categorize firms into four life stages, i.e., introduction, growth, maturity, and decline. According to Dickinson's (2011) cashflow based lifecycle measure, the life stage of the sample firm is constructed according to the predicted combinations of operating (OANCF), investing (IVNCF), and financing (FINCF) cash flows for each fiscal year. Dickinson shows that different cash flow patterns are driven by a firm's profitability, growth, risk performance, and allocation of resources, as predicted in economic theories. The four stages of a firm's life cycle are classified as:

1) Introduction: OANCF < 0, IVNCF < 0, and FINCF > 0.
2) Growth: OANCF > 0, IVNCF < 0, and FINCF > 0.
3) Mature: OANCF > 0, IVNCF < 0, and FINCF < 0.
4) Decline: We combine Dickinson's shake-out and decline stages that cover other combinations of OANCF, IVNCF, and FINCF.

We use Bharath and Shumway's (2008) market-based distance to default to measure default risk due to accuracy and simplicity. Specifically speaking, distance to default measures the difference between the asset value of a firm and the face value of its debt, scaled by the standard deviation of the firm's asset value. The measure combines three key credit factors: asset value of a firm, the firm's business and industry risk, and its leverage. A higher distance to default implies that a firm is farther away from default, i.e., lower default risk. Following Bharath and Shumway (2008), we compute the distance to default as follows:

$$Distance\ to\ Default = \frac{ln\left[\frac{E+F}{F}\right] + (r_{it-1} - 0.5\sigma_V^2)T}{\sigma_V\sqrt{T}}$$

where E is the market value of equity, F is the face value of debt, σ_V is the asset volatility, r_{it-1} is the firm's stock return over the previous year, and T is the time horizon.

B. Methodology

We examine the relation between default risk and lifecycle with the following models and assign the Mature stage as the benchmark in the analysis:

$$DD_{i,t} = \alpha_0 + \beta_1 Intro_{i,t-1} + \beta_2 Growth_{i,t-1} + \beta_3 Decline_{i,t-1} + \varepsilon_{i,t} \quad (1)$$

and

$$DD_{i,t} = \alpha_0 + \beta_1 Intro_{i,t-1} + \beta_2 Growth_{i,t-1} + \beta_3 Decline_{i,t-1} + \beta_4 Liquidity_{i,t-1} + \beta_5 ROA_{i,t-1} + \beta_6 Leverage_{i,t-1} + \beta_7 FirmSize_{i,t-1} + \beta_8 CashFlow_{i,t-1} + \beta_9 MB_{i,t-1} + \beta_{10} MktRet_{t-1} + \varepsilon_{i,t} \quad (2)$$

The dependent variable $DD_{i,t}$ is distance to default for firm i in year t. The main explanatory variables are the binary life stage variables - *Intro*, *Growth*, and *Decline* that take the value of one for the respective life stages and zero otherwise. In all regressions, we include control variables representing firm characteristics such as cash flow, leverage, liquidity, profitability, firm size and valuation, and capital market condition that are known determinants of default risk (Ali *et al.*, 2018; Cathcart *et al.*, 2020; Hsu *et al.*, 2015). The definitions for the control variables - *Liquidity*, *ROA*, *Leverage*, *FirmSize*, *CashFlow*, *MB*, and *MktRet* with the predicted signs are presented in the Appendix. All control variables are computed for the lagged fiscal year t-1 for the default risk in fiscal year t.

As our sample period includes the 2008 financial crisis and recession, we apply the following regression to examine the impact of the 2008 crisis on the relation between lifecycle and default risk.

$$DD_{i,t} = \alpha_0 + \beta_1 Intro_{i,t-1} + \beta_2 Growth_{i,t-1} + \beta_3 Decline_{i,t-1} + \beta_4 Intro_{i,t-1} \times Recession + \beta_5 Growth_{i,t-1} \times Recession + \beta_6 Decline_{i,t-1} \times Recession + \beta_7 Liquidity_{i,t-1} + \beta_8 ROA_{i,t-1} + \beta_9 Leverage_{i,t-1} + \beta_{10} FirmSize_{i,t-1} + \beta_{11} CashFlow_{i,t-1} + \beta_{12} MB_{i,t-1} + \beta_{13} MktRet_{t-1} + \beta_{14} Recession + \varepsilon_{i,t} \quad (3)$$

where Recession takes the value of 1 if year is 2008 or 2009 and 0 otherwise. We include the industry and year fixed effects in all regressions, and cluster standard errors at the firm level to calculate test statistics. All continuous variables are winsorized at the 1st and 99th percentiles.

IV. Results

A. Sample Statistics and Univariate Analysis

Panel A of Table I presents the summary statistics for sample firms that are distributed as 5% in the introduction stage, 30% growth, 53% mature, and 12% decline. The default risk measure, i.e., distance to default (DD), has an overall average of 5.59, suggesting that sample firms are generally in good financial condition. Sample firms have an average ROA of 2% and carry an average debt ratio of 28% in their capital structure. The average firm size measured in total assets is about $2.12 billion with an average market-to-book ratio of 4.03. A closer look at the summary statistics reported in Panel B finds interesting variations across life stages. The key variation is that distance to default (DD) exhibits an inverse U-shape pattern across the four life stages. Since a shorter distance to default, i.e., a lower value of DD, implies that the firm faces a higher likelihood of default, the observed nonlinear pattern in DD means that firms in the two ends of the lifecycle spectrum face greater default risk than mature firms. In summary, default risk is highest for firms in the introduction stage with an average

TABLE I: DESCRIPTIVE STATISTICS

Panel A: Descriptive statistics For all life stages

	Mean	Median	Std. Dev.	Max.	Min.
DD	5.59	5.08	3.72	82.71	-0.81
Introduction	0.05	0.00	0.23	1.00	0.00
Growth	0.30	0.00	0.46	1.00	1.00
Mature	0.53	1.00	0.50	1.00	1.00
Decline	0.12	0.00	0.33	1.00	0.00
Liquidity	2.31	1.82	1.88	28.36	0.43
ROA	0.02	0.04	0.14	0.30	-1.85
Leverage	0.28	0.27	0.18	0.80	0.00
FirmSize	7.66	7.61	1.61	11.87	2.21
CashFlow	0.08	0.09	0.11	0.32	-1.20
MB	4.03	2.41	6.38	96.73	0.15
MktRet	0.09	0.13	0.18	0.33	-0.38
N	16,334				

Panel B: Descriptive statistics by life stag

	Introduction			Growth		
	Mean	Median	Std. Dev.	Mean	Median	Std. Dev.
DD	3.96**	3.15**	4.20	5.22**	4.88**	3.20
Liquidity	3.97**	2.57**	3.80	2.24**	1.79**	1.56
ROA	-0.19**	-0.13**	0.24	0.02**	0.03**	0.08
Leverage	0.30**	0.30**	0.21	0.31**	0.31**	0.18
FirmSize	6.15**	6.09**	1.50	7.56**	7.50**	1.40
CashFlow	-0.13**	-0.06**	0.16	0.09**	0.08**	0.05
MB	5.87**	2.80**	9.98	3.45**	2.29**	4.40
MktRet	0.09	0.13	0.19	0.09	0.13	0.17
N	892			4,883		
	Mature			Decline		
	Mean	Median	Std. Dev.	Mean	Median	Std. Dev.
DD	6.22	5.66	3.85	4.55**	3.86**	3.52
Liquidity	2.02	1.74	1.16	3.05**	2.15**	2.97
ROA	0.05	0.05	0.07	-0.07**	0.00**	0.24
Leverage	0.27	0.25	0.17	0.26**	0.24**	0.19
FirmSize	8.01	7.93	1.54	7.01**	6.92**	1.79
CashFlow	0.12	0.11	0.06	0.00**	0.04**	0.17
MB	4.00	2.48	5.90	4.79**	2.30**	9.48
MktRet	0.10	0.13	0.18	0.08**	0.13	0.19
N	8,596			1,963		

**denotes significance at the 5% level. See Appendix for variable definitions.

DD of 3.96, and lowest for mature firms with an average DD of 6.22, before reversing its course for firms in the decline stage with an average DD of 4.55.

Further statistics reported in Panel B indicate that firm characteristics display similar nonlinear relations across life stages that mirror the U-shape relation for default risk. For instance, financially healthy mature firms that are associated with least default risk are characterized as most profitable (mean ROA of 5%), strongest cash flow position (mean CashFlow of 12%), and largest in firm size (mean FirmSize of 8.01; $3.01 billion). Firms in their introduction stage face most default risk are characterized as smaller (mean FirmSize of 6.15; $0.47 billion), unprofitable (mean ROA of -19%) firms with weak cash flow position (mean CashFlow of -13%). Their average market-to-book (MB) ratio of 5.87 is the highest among all four life stage groups, aligning with the expectation that firms in the introduction stage enjoy most growth opportunities associated with their earlier stage in corporate lifecycle. Consistent with changing firm characteristics across lifecycle, firms in their decline stage fall off from the peak in the spectrum as firms that are smaller with an average firm size of $1.1 billion in total assets, weaker cash flow position and unprofitable with an average ROA of -7%, comparable to the characteristics of firms in the introduction stage.

In addition, we apply the t-test and the Wilcoxon test to the mean and median, respectively, of each variable in the comparison of each life stage with the (benchmark) mature stage. The statistical significance of the univariate test results reported in Panel B of Table I are consistent with the above observations that point to a nonlinear, U-shape relation between default risk faced by sample firms and their life stages. The univariate results raise an interesting question on whether the selected set of determinants of default risk has fully explained the U-shape pattern between default risk faced by a firm and its life stage. In the following multivariate regression analysis, we address this question by examining any remnant impact of life stage on default risk after controlling for firm specific and market characteristics.

B. Multivariate Regression Analysis

We report the baseline regression results in Table II. Model (1) shows a U-shape relation between a firm's life stage and default risk that it faces in the following fiscal year. Echoing the univariate results presented in Panel B of Table I, the distance to default is significantly shorter for firms in the other three stages, when compared to mature firms. The results suggest that default risk is the highest in the introduction stage, followed by the decline and growth stages with mature firms being least risky. With the inclusion of known determinants for default risk, the results presented in Model (2) continue to show a nonlinear relation between life stage and default risk faced by firms. However, the magnitude and statistical significance for the growth binary are larger than those for the other two life stages.

TABLE II: CORPORATE LIFECYCLE, FINANCIAL CRISIS, AND DEFAULT RISK

	Model (1)	Model (2)	Model (3)
$Intercept_t$	6.42***	1.31***	1.99***
	(100.48)	(5.89)	(9.03)
$Intro_{t-1}$	-2.43***	-0.30	-0.43*
	(-14.36)	(-1.45)	(-1.87)
$Growth_{t-1}$	-1.25***	-0.57***	-0.60***
	(-15.41)	(-7.59)	(-7.78)
$Decline_{t-1}$	-1.33***	-0.32***	-0.35***
	(-12.33)	(-3.04)	(-3.18)
$Intro_{t-1}$*recession			1.44***
			(3.54)
$Growth_{t-1}$*recession			0.50***
			(3.18)
$Decline_{t-1}$*recession			0.87***
			(3.67)
$Liquidity_{t-1}$		0.27***	0.25***
		(10.93)	(9.91)
ROA_{t-1}		3.83***	3.85***
		(8.80)	(9.07)
$Leverage_{t-1}$		-5.02***	-5.09***
		(-24.36)	(-25.74)
$FirmSize_{t-1}$		0.55***	0.55***
		(23.25)	(23.86)
$CashFlow_{t-1}$		3.13***	3.38***
		(5.29)	(5.67)
MB_{t-1}		0.14***	0.14***
		(18.03)	(18.02)
$MktRet_{t-1}$		4.48***	1.75***
		(19.87)	(6.49)
Recession			-3.29***
			(-22.05)
Industry Fixed Effect	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes
R-Square	0.04	0.28	0.33

Note. Dependent Variable: DD_t. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively. See Appendix for variable definitions.

And the remnant effect of life stage on default risk for firms in the introduction stage is not statistically significant, despite its negative coefficient. Regardless, our results show that a firm's life stage offers incremental information (beyond known determinants) about default risk in the following fiscal year that helps bond investors in their assessments. Besides, the coefficients of control variables in Model (2) are consistent with those reported in the literature (Ali *et al.,* 2018). Other factors being equal, our results show that larger profitable firms with stronger liquidity and cash flow positions, along with a favorable capital market condition, are associated with longer distance to default, i.e., lower default risk, whereas a higher leverage ratio has the opposite effect.

We further investigate the relation between life stage and default risk of firms by accounting for possible interactive effects of the 2008 financial crisis in Model (3). Whereas the results echo those reported in Model (2) regarding the nonlinear relation between life stage and default risk, Model (3) offers incremental insight. As expected, the highly significant negative coefficient of the Recession variable indicates that DD was greatly shortened for all firms during the crisis, suggesting that firms in general experienced greater default risk during recessions. The results for interactive variables show that the adverse effect of financial crisis on default risk was not evenly distributed across firms in different life stages, but instead was concentrated among mature firms that display least default risk under normal economic conditions. This echoes the breadth and depth of the adverse impacts of the 2008 financial crisis on the financial system and investor sentiment.

V. FURTHER ANALYSIS

Cantrell and Dickinson (2020) develop the conditional life cycle measure that identifies leading and laggard firms in their industries and offers insight on the firm's performance relative to their industry peers and the underlying reasons. Industry leaders are characterized as firms that utilize their superior skills and resources to expand the industry frontier by making advance progress along their lifecycle ahead of their peers. Whereas industry leaders may be benefited by their first-mover advantages, they likely face greater risk of default in their pursuit as they may fail to convert the advantages into sustainable profitability. On the other hand, industry laggards, which are defined as firms that fall behind their industry lifecycle stages, enjoy the benefits of learning from their peers' mistakes that allow them to minimize risk taking and hence face less risk of default.

We conduct further analysis on the relation between corporate lifecycle and default risk by examining the role of industry leaders and laggards in understanding a firm's default risk. We postulate that industry leaders (laggards) face greater (less) default risk and hence predict a negative (positive) impact for leaders (laggards) on the distance to default measure.

TABLE III: CORPORATE LIFECYCLE, DEFAULT RISK, AND INDUSTRY LEADERS AND LAGGARDS

	Model (4)	Model (5)	Model (6)
$Intercept_t$	4.61***	-0.04	0.64***
	(33.54)	(-0.17)	(2.74)
$Intro_{t-1}$	-1.26***	0.86***	0.84***
	(-6.49)	(3.43)	(3.12)
$Mature_{t-1}$	2.09***	1.00***	0.95***
	(13.59)	(6.56)	(6.72)
$Intro_{t-1}$*recession			0.54
			(1.18)
$Mature_{t-1}$*recession			-0.63***
			(-3.92)
$Leader_{t-1}$	-1.10***	-0.52***	-0.42***
	(-7.89)	(-4.05)	(-3.57)
$Laggard_{t-1}$	1.05***	0.63***	0.54***
	(6.32)	(4.14)	(3.95)
$Liquidity_{t-1}$		0.30***	0.29***
		(11.90)	(11.61)
ROA_{t-1}		4.75***	4.91***
		(8.17)	(8.44)
$Leverage_{t-1}$		-4.43***	-4.58***
		(-18.88)	(-20.65)
$FirmSize_{t-1}$		0.55***	0.56***
		(21.48)	(22.71)
$CashFlow_{t-1}$		4.87***	5.05***
		(6.07)	(6.54)
MB_{t-1}		0.15***	0.15***
		(15.49)	(15.69)
$MktRet_{t-1}$		3.98***	1.29***
		(18.06)	(5.19)
Recession			-2.84***
			(-17.12)
Industry Fixed Effect	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes
R-Square	0.05	0.27	0.33

Note. Dependent Variable: DD_t. ***denotes significance at the 1% level. See Appendix for variable definitions.

We follow Cantrell and Dickinson (2020) to construct the conditional life cycle of our sample firms by adapting Dickinson (2011) cashflow based lifecycle stage measure for industries that are classified by the 3-digit SIC codes. The procedures involve first determining the industry's lifecycle stage with aggregate data on financing, investing and operating across all firms in the same industry. Then, the conditional life cycle measure interacts each sample firm's own life stage with its industry's life stage for the same fiscal year. If the sample firm's own lifecycle stage is more advanced than that of its industry, the sample firm is classified as an industry leader for the fiscal year. For firms that have their own lifecycle stage falling behind that of their industry, they are classified as the industry laggards for the fiscal year.

We examine the relation between default risk and conditional lifecycle for the industry leader and laggard effects with the following models as the growth stage is the benchmark:

$$DD_{i,t} = \alpha_0 + \beta_1 Intro_{i,t-1} + \beta_2 Mature_{i,t-1} + \beta_3 Leader_{i,t-1} + \beta_4 Laggard_{i,t-1} + \varepsilon_{i,t} \quad (4)$$

and

$$DD_{i,t} = \alpha_0 + \beta_1 Intro_{i,t-1} + \beta_2 Mature_{i,t-1} + \beta_3 Leader_{i,t-1} + \beta_4 Laggard_{i,t-1} + \beta_5 Liquidity_{i,t-1} + \beta_6 ROA_{i,t-1} + \beta_7 Leverage_{i,t-1} + \beta_8 FirmSize_{i,t-1} + \beta_9 CashFlow_{i,t-1} + \beta_{10} MB_{i,t-1} + \beta_{11} MktRet_{t-1} + \varepsilon_{i,t} \quad (5)$$

and

$$DD_{i,t} = \alpha_0 + \beta_1 Intro_{i,t-1} + \beta_2 Mature_{i,t-1} + \beta_3 Intro_{i,t-1} \times Recession + \beta_4 Mature_{i,t-1} \times Recession + \beta_5 Leader_{i,t-1} + \beta_6 Laggard_{i,t-1} + \beta_7 Liquidity_{i,t-1} + \beta_8 ROA_{i,t-1} + \beta_9 Leverage_{i,t-1} + \beta_{10} FirmSize_{i,t-1} + \beta_{11} CashFlow_{i,t-1} + \beta_{12} MB_{i,t-1} + \beta_{13} MktRet_{t-1} + \beta_{14} Recession + \varepsilon_{i,t} \quad (6)$$

We modify Models (1), (2) and (3) for Models (4), (5) and (6), respectively, with the inclusion of two binary variables, *leader* and *laggard*, where *leader* (*laggard*) takes a value of one for industry leaders (laggards) and zero otherwise. We use the growth stage as the benchmark because we follow Cantrell and Dickinson (2020) that the conditional life cycle measures are constructed only for the introduction, growth, and mature stages.

The results reported in Table III show that default risk is higher (lower) for industry leaders (laggards) across all three models. Besides, with the inclusion of control variables in Models (5) and (6), the results continue to show the U-shape relation between default risk and life stage of sample firms even after we account for the impact of being an industry leader or laggard on default risk. The statistically significant positive coefficients for both the *intro* and *mature* echo the results reported in Table II that the growth stage is associated with shorter distance to default that goes beyond the explanatory ability of known determinants for default risk. The results of Model (6) also show the across-the-board adverse effect of financial crisis on default risk was the strongest among mature firms.

VI. Summary and Conclusion

Default risk is an extreme form of corporate risk and calls great attention to managers for effective risk management and investors for sensible investment choices. Extensive studies have documented that default risk is affected by financial variables, non-financial variables, and market factors. Whether default risk is affected by corporate life cycle that is found to affect corporate risk taking has not been explored in the literature. In this study, we examine the relation between default risk and corporate lifecycle. We find that the firm lifecycle has significant nonlinear impacts on default risk. After controlling for the effects of firm specific and macroeconomic variables on default risk, firms in decline and growth stages face greater default risk than mature firms. We note that the elevated level of default risk during the 2008 financial crisis was intensified among mature firms. Besides, if a firm is a lifecycle leader (laggard) among its industry peers, it has higher (lower) default risk.

Our results contribute to the literature of default risk by showing that corporate lifecycle has significantly incremental impacts on default risk that are not captured by firm specific and macroeconomic factors documented in the literature. Our results add new evidence to the literature of corporate lifecycle by showing that default risk is impacted by the outcomes of a firm's investment and financing policies in a nonlinear manner across its lifecycle.

Appendix

A. *Variable Definitions*

Variable	Definition	Sign
Liquidity	Current assets/Current liabilities.	+
ROA	Net income/Total assets.	+
Leverage	(Debt in current liabilities and long-term debt)/Total assets.	-
FirmSize	Natural logarithm of total assets.	+
CashFlow	Operating cash flow/Total assets.	+
MB	Market-to-book ratio is defined as closing price at the fiscal year end times common shares outstanding divided by book value of equity.	+
MktRet	Return on the CRSP value-weighted market index.	+
Recession	Binary variable that has a value of one for 2008 and 2009, and zero otherwise.	-

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