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The Role of Operational Capabilities in Enhancing New Venture Survival: A Longitudinal Study

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We investigate relationships between operational capabilities and new venture survival. On the basis of operations management and entrepreneurship literature, we develop a contingency framework of operational capabilities especially appropriate at different life phases of a new venture's evolution. We expect that in the first years of a new venture's life, entrepreneurs should emphasize high inventory turnover to preserve working capital, support customer responsiveness, and aid firm adaptability. As new ventures grow, entrepreneurs should emphasize internal working capital generation via larger gross margins to support production ramp-up. Later, new venture entrepreneurs should emphasize employee productivity to buttress sustainable volume production. We analyze a 6-year longitudinal sample of 812 Swedish manufacturing new ventures using a gamma frailty-based Cox regression. The findings show that specific operational capabilities, while always supporting new venture survival, have exceptional influence in specific new venture life phases. The three hypotheses are confirmed, suggesting that higher *inventory turnover*, *gross margin*, and *employee productivity* further increase new venture survival likelihoods, respectively, in the venture's *start-up*, *growth*, and *stability* phases. This suggests a phased-capabilities approach to new venture survival. This study contributes to operations management and entrepreneurship theory and practice, and sets a foundation for future research on operations strategy for new ventures.

Key words: firm survival; working capital; labor productivity; start-ups; longitudinal methods; performance measurement
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1. Introduction

As nearly half of all new ventures fail within 5 years (Small Business Administration (SBA) 2011), a primary concern of entrepreneurs is what actions can increase the likelihood of survival. A large body of research identifies factors contributing to new venture survival including founder and founding team characteristics (Eisenhardt and Schoonhoven 1990), financing (Kirilenko 2001), resource acquisition (Katz and Gartner 1988), and business plan development (Delmar and Shane 2004). Taken together, prior research suggests that strategic decisions and appropriate resource configurations in the early years impact venture survival (Gilbert et al. 2006); however, extant research largely neglects operations-based decisions, resources, and capabilities as potential contributors to venture survival.

Recent entrepreneurship literature emphasizes the need to study resource orchestration across a firm's life cycle (Sirmon et al. 2011), including internal mechanisms impacting firm growth (Gilbert et al. 2006). Shepherd and Patzelt (2011) call for research on the selection and management of operations processes that refine entrepreneurial actions. Kickul et al. (2011) underscore the need for deeper understanding of operations management capabilities to aid venture growth and survival, and Gruber (2007) advocates longitudinal studies, starting from the point of very-early venture creation, to provide richer insights into internal aspects of the firm.

Extant operations management research on firm strategy considers the objectives, configuration, implementation, and improvement of a firm's internal operations and external partner interfaces to design, source, produce, and deliver valued goods to customers (Boyer et al. 2005). This literature primarily addresses established manufacturing firms, providing little guidance on operations strategies for new ventures (Kickul et al. 2011). Scholars call for interdisciplinary approaches (Ireland and Webb 2007, Shane and Ulrich 2004), contingency perspectives (Sousa and Voss 2008), and longitudinal methods (Rosenzweig and Easton 2010) to better understand operations strategy in understudied settings such as new ventures.

This study addresses these research gaps by investigating: Do a new venture's operational capabilities influence its likelihood of survival? Specifically, which operational capabilities should be emphasized in distinct phases of a new venture's evolution? We believe that new ventures can increase survival odds by prioritizing different operational capabilities at distinct new venture life-cycle phases. Integrating operations management and entrepreneurship theory, we posit specific operational capabilities that are especially impactful in respective phases. We test the contingency-based hypotheses using a gamma frailty-based Cox regression analysis of a 6-year longitudinal data set of 812 Swedish manufacturing ventures founded in 2005 and followed through 2010.

2. Conceptual Framework and Hypotheses

2.1. New Venture Context

The venture creation process is fraught with uncertainty and ambiguity (Stinchcombe 1965). New ventures typically lack established routines and resources (Bruderl et al. 1992). A large body of entrepreneurship research describes how new ventures generate capabilities over time by acquiring, combining, and refining resources (Lichtenstein and Brush 2001). Consistent with characterizations in the literature on firm life cycles (Gilbert et al. 2006, Greiner 1972, Hanks et al. 1993), we view new ventures as having three phases, which we term *start-up*, *growth*, and *stability*. Each phase has a unique set of liabilities of newness and smallness (Aldrich and Auster 1986), organizational structure and formalization, customer bases, and operational challenges, as depicted in Table 1.

2.2. Contingency Theory and Operational Capabilities

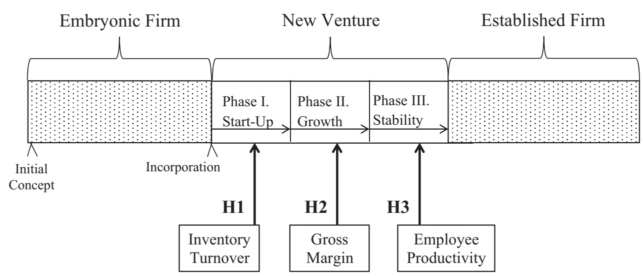
The central tenet of contingency theory is that an organization should match its strategies, structures, and processes to its environment (Lawrence and Lorsch 1967, Thompson 1967). Thus, there is no universal best practice in terms of organization design. The firm-environment alignment, frequently termed "fit," explains many findings in operations and supply chain research (e.g., Flynn and Flynn 1999, Frohlich and Westbrook 2001, Stock and Tatikonda 2008) and entrepreneurship (e.g., Gruber 2007). We consider fit at three venture phases, investigating the model in Figure 1. We expect that higher inventory turnover leads to greater firm survival likelihood through the initial start-up phase. In the subsequent growth phase, ventures with higher gross margins are more likely to survive. Finally, in the stability phase, we expect that higher levels of employee productivity lead to favorable survival outcomes.

We now present conceptual and practical motivations for the three hypotheses. We address the fundamental operational challenge(s) faced by a new venture in each life phase, present entrepreneurship literature-based explanations of firm-level environmental and organizational factors at each phase, and describe the specific operational capability of interest for the respective life phase. Given the limited litera-

Table 1 New Venture Phases

	New Venture Phase		
	Start-Up	Growth	Stability
Liabilities of newness and smallness	Very high	High	Moderate
Organizational structure and formalization	Informal relationships, organic structure	Emerging formalized relationships and control	Moderate formalization, emerging mechanistic structure
Customer base	Small customer base	Increasing customer base	Large, established customer base
Operational challenges	Considerable product design adaptation. High customer responsiveness including rapid delivery. High inventory turns to preserve working capital deployable to product and market development.	Increasing production volume to service greater demand. Obtain internal returns (greater gross margin) to support scale-up.	Large production scale. Reliable and economically sustainable operations. Employee productivity to support greater unit output.

Figure 1 Conceptual Framework of Operational Capabilities and New Venture Survival by Firm Life-Cycle Phases



ture on operational challenges at this level of evolutionary granularity, the presentation below also incorporates learnings from our extensive field experience and interactions with practicing entrepreneurs.

2.3. Inventory Turnover and Venture Start-Up

The key challenges for operations in the start-up phase are achieving *high customer responsiveness* and *supporting the firm's adaptability*. In general, neither product unit cost minimization nor firm-level profitability is an initial objective of start-ups. Rather, a start-up focuses on obtaining initial new customers, growing market share beyond the first customers, and continuing to modify and adapt the core product design (Jacobs and Swink 2011) based on the latest understanding of customer needs, competitor offerings, and internal R&D technological feasibility (Gartner et al. 2004, Jawahar and McLaughlin 2001, Reynolds and Miller 1992). High customer responsiveness can be achieved through product adaptation via changes and improvements to the product design (Erat and Kavadias 2008, Loch et al. 2001, Sommer et al. 2009) and rapid provision of the goods (Chandler and Hanks 1994).

A large body of research identifies the importance of a start-up's ability to adapt and respond to its environment, including customers and competitors (e.g., Terjesen et al. 2011). Manufacturing start-ups must undertake market development and R&D activities, both of which consume scarce resources. Start-ups with higher inventory turnover have less working capital locked into inventory, thus allowing working capital to be deployed to marketing and research activities (Kuratko and Hornsby 2009) including competitor analysis, customer prospecting, and product design and development (Rosenthal 1992, Ulrich and Eppinger 2011). Practicing entrepreneurs value start-up capital, hailing that "cash is king" (Fisher 2011) and further claiming that "inventory is cash" (Brennan 2006). Working capital preservation represents the concept of "unabsorbed slack" where liquidity (usually cash) is not yet assigned to a purpose and can be invested quickly in emerging opportunities (Davies et al. 2009).

Having high inventory turns indicates that the firm is able to successfully meet customer demand while maintaining fast flows of materials through the production system. Producing in small batches is fundamental to this swift throughput (Hyer and Wemmerlöv 2002, Schmenner and Swink 1998). The small batch sizes may even be units of one, and the production approach may be closer to make-to-order than make-to-stock. High-velocity materials flows and smaller batches allow the firm to rapidly and frequently provide the latest product design modifications and variants to the marketplace, incorporating increased understanding of customer, competitor, and R&D product and process knowledge. In contrast, a start-up with a large finished-goods inventory that turns slowly must work through that inventory of obsolete product before offering customers the latest version. Alternatively, the start-up could scrap the obsolete product, but this is wasteful given the significant investment in materials, personnel, and overhead represented in the finished goods.

The above suggests that inventory turnover is an important operational capability for manufacturing ventures in the start-up phase. Inventory turnover is a well-established concept in operations management research (e.g., Chen et al. 2005, Dehning et al. 2007), but is seldom considered in entrepreneurship research. Inventory turnover varies widely across firms, and inventory frequently accounts for a high percentage of firm assets (Gaur et al. 2005). Extant operations management research on inventory turnover investigates *established* firms rather than *new ventures*. We hypothesize:

> H1: During the *start-up phase* of a new venture's life cycle, higher *inventory turnover* is associated with lower likelihood of *venture failure*.

2.4. Gross Margin and Venture Growth

The key challenges for operations in the growth phase are *ramping-up production* and *generating internal returns* to fund this ramp-up. A growth phase venture has a nontrivial set of customers and a relatively firm product design (fewer design modifications per unit time than in the start-up phase). Higher production volumes are needed to meet the increasing demand. In ramping up the operations, entrepreneurs develop new organizational routines and implement operational changes to improve coordination, reduce costs, and increase margins (Bhave 1994, Dodge et al. 1994, Jawahar and McLaughlin 2001). Operations efforts may include manufacturing process design and development, manufacturability-based product design modifications, and new supply chain relationships (Terwiesch and Bohn 2001).

The differential between the rate of growth of sales (revenue) and the rate of growth of the cost of fulfilling that demand (cost of goods sold) reflects these operational improvements (Lévesque et al. 2012) and is the source of operations-based generation of working capital deployable to fund increased production scale. Accordingly, gross margin may be critical to firm survival during the venture growth phase. Gross margin is frequently studied in operations management (e.g., Gaur et al. 2005, Kesavan et al. 2010) and entrepreneurship (e.g., Jarillo 1989, Wiklund 1999), but has not been investigated in growth phase new ventures. We hypothesize:

> H2: During the *growth phase* of a new venture's life cycle, higher *gross margin* is associated with lower likelihood of *venture failure*.

2.5. Employee Productivity and Venture Stability

The key challenge for operations in the stability phase is achieving *sustainable volume production*. The venture now has a much larger, established customer set, higher levels of demand, and a very firm core product (Li and Atuahene-Gima 2001). Entrepreneurs now seek greater scale economies, more routinized and reliable production activity, and further cost reductions, to obtain the notable production volumes now necessary to load distribution channels and support sales demand (Kuratko and Hornsby 2009, Parker 2006). The stability phase venture is more viable than before but is not yet completely established or mature, and firm survival remains uncertain. Stability-phase firms may experience downward pressure on unit sales prices due to competitive factors, a pressure not experienced as sharply in the start-up and growth phases. Stability-phase ventures typically continue to defend sales volume in existing markets, but also seek new growth opportunities in existing and new markets (Gilbert et al. 2006, Greiner 1972).

To attain sustainable larger volume operations, stability-phase ventures grow their employee headcount (Kochan et al. 1986). A new venture is usually founded by a small number of people, commonly one to four individuals, who make nearly all decisions about the venture's direction (Gartner et al. 2004). In contrast, by the stability phase, ventures have many more employees engaged in decision making and implementation activities across functions, levels, and geographies. Thus, managing human resources emerges as a principal concern (Kuratko and Hornsby 2009, Lieberman and Demeester 1999, Ward et al. 1992). For stability-phase new ventures, employee productivity may be more representative of sustainable scale operations than fixed-asset productivity, because ventures in this phase typically have proportionally smaller fixed-asset investments relative to established firms. Appropriate recruitment, selection, and retention routines help identify and secure high-performance personnel. Once employed in the new venture, appropriate training, appraisal, and reward routines can enhance employee productivity (Heneman et al. 2000, Wang and Lee 2009). In all, personnel play a key role in achieving and supporting higher volume, sustainable operations, and employee productivity should contribute to venture survival in the stability phase. We hypothesize:

> H3: During the *stability phase* of a new venture's life cycle, higher *employee productivity* is associated with lower likelihood of *venture failure*.

3. Sample and Measures

3.1. Data Sample and Unit of Analysis

The sample consists of 812 new manufacturing ventures that registered in Sweden during 2005. The failure or continuing survival of each venture is tracked on a monthly basis through the end of 2010. Swedish law requires firms to register with the government prior to initiating formal commercial activity (e.g., renting space, hiring employees) and to file annual reports certified by a chartered accountant. Sweden is one of the few countries where income statement and balance sheet information is available regardless of firm age. Such data are available for publicly traded firms in countries such as the United States; however, it is rarely available for *new* and *young ventures*. Archival data is objective and arguably more reliable than survey-based self-reports. Sweden is considered highly representative of developed-country entrepreneurial activity (Short et al. 2009), and Swedish data have been used in numerous entrepreneurship studies (e.g., Delmar and Shane 2004, 2006, Eckhardt et al. 2006, Steffens et al. 2012). The 6-year time frame for new ventures is consistent with prior research (Zahra et al. 2000). In all, our data set provides a unique opportunity to test hypotheses regarding operational capabilities and firm survival in different new venture phases.

We used the Affarsdata database to identify new ventures. Affarsdata compiles annual reports of Swedish ventures registered as "Aktiebolag" (AB). Similar to "Inc." or "LLC" in the United States and "PLC" in the United Kingdom, an AB firm can be publicly traded or privately held. Per Swedish incorporation rules, a privately held AB must have capital of at least SEK 100,000 (~US$12,500), whereas a publicly traded AB must have at least SEK 500,000 (~US$62,500).

From the Affarsdata database, we identified 21,742 firms that registered for the first time in 2005. We then applied four filters to determine the resultant sample of new ventures to investigate: size (number of employees), resource base (financial capital), timing of initial recorded sales, and industry sector (manufacturing sectors only). First, we removed firms with 250 or more employees in the first year of incorporation. Large size may indicate nontrivial prior history and already highly developed operations. Furthermore, the European Union's definition of a "Small and Medium Enterprise" is any firm with up to 249 employees. Second, we removed ventures with SEK 500,000 or more in capital in Year 1. Such high capitalization suggests these firms could be spin-offs from existing large corporations or subsidiaries of existing firms and therefore have large initial resource bases. Third, we removed ventures that did not report sales in Year 1 (2005). Lack of sales data may indicate firms that are nonexistent, incomplete, or unreliable. Firms with sales reported provide a more valid and reliable assessment of operational capability measures. Fourth, we removed firms in nonmanufacturing sectors. The nature of operational capabilities may be quite different in service sectors. The resulting sample contains 812 new ventures, all registered in 2005, all privately held, representing 72 unique four-digit SIC codes from diverse manufacturing sectors, and averaging 7.7 employees at the end of 2005. The resulting sample is not a random sample, but rather the *complete population* of new ventures meeting the specified characteristics.

3.2. Variables

3.2.1. Dependent Variable. Our data include the month and year of each firm's incorporation and, if applicable, its termination. Using month as the primary time unit, we track survival over 6 years and create 72 time windows during which a venture may fail.[1] If a venture fails during a given year and month, then the dependent variable is coded as 1, otherwise 0. A venture is considered to have failed when it reports to the government that it has discontinued operations (we note in which month and year) or does not provide the required annual report information to the government.[2,3] Over the 6-year period from 2005 to 2010, 521 of the 812 ventures did not survive (6-year survival rate of 35.83%). The vast majority (see Table 2) reported failure in Year 2 (178) and Year 3 (122), with the remaining reporting failure in Year 4 (91), Year 5 (86), or Year 6 (44).[4]

3.2.2. Independent Variables: Time-varying Covariates. *Inventory Turnover* is the ratio of cost of goods sold (COGS) to average inventory level. Given the data available, our operationalization is annual COGS divided by year-end inventory. *Gross Margin* is the ratio of annual operating income (sales less cost of goods sold) to annual sales. *Employee Productivity* is the ratio of annual operating income to the number of employees in the given year.

3.2.3. Control Variables. To control for contemporaneous, idiosyncratic industry-level conditions over the 6-year period, we employ three common control variables, each of which captures a unique and potentially influential environmental attribute: *Environmental Munificence*, *Environmental Dynamism*, and *Environmental Complexity*.[5] For each focal year, we use four-digit SIC code industry data in the current year and four previous years to operationalize each measure (e.g., for 2005, we use industry sector data from 2001 to 2005). Each measure is lagged by 1 year relative to the firm's survival/failure in a given year. Data are from the Swedish Business Register.

Environmental munificence refers to the "scarcity or abundance of critical resources needed by (one or more) firms operating in an environment" (Castrogiovanni 1991, 542). This measure of the environment's "carrying capacity" (Aldrich 1979) is important because greater availability of critical resources allows the firm a broader range of strategic options (Singh et al. 1986) and increases firm survival likelihood (Brittain and Freeman 1980). Environmental munificence is an essential aspect of a new venture's environment given the importance of securing resources for growth (Terjesen et al. 2011). Keats and Hitt (1988) suggest that increasing sales over time signals greater carrying capacity and therefore greater levels of munificence. We follow Dess and Beard (1984) in measuring environmental munificence by averaging the antilogs of regression coefficients of a given industry sector's natural log of net sales and natural log of operating income over a 5-year period.

Table 2 Venture Failures across 6-Year Time Frame

Year	Calendar year	Starting cohort size	Ventures reported failed	Ventures surviving	Cumulative ventures failed	Annual failure rate	Cumulative failure rate
1	2005	812	–	812	–	–	–
2	2006	812	178	634	178	21.9%	21.9%
3	2007	634	122	512	300	19.2%	37.0%
4	2008	512	91	421	391	17.8%	48.2%
5	2009	421	86	335	477	20.4%	58.7%
6	2010	335	44	291	521	13.1%	64.2%

Environmental dynamism refers to the uncertainty posed by a firm's external environment. It has long been considered important for the firm to understand and manage environmental sources of uncertainty (Thompson 1967). Greater environmental dynamism can contribute to firm failure (Terjesen et al. 2011). Environmental dynamism has two principal components: instability (magnitude and frequency of environmental change) and unpredictability (irregular patterns of environmental change) (Miller et al. 2006). Consistent with Dess and Beard (1984), we assess instability and unpredictability through variability in sales and operating income and measure environmental dynamism as the average of the antilog of standard errors of the regression slopes for the natural log of net sales and natural log of operating income regression equations used in calculating industry sector munificence.

Environmental complexity refers to the heterogeneity of factors an organization must contend with in developing strategic responses and reconfiguring internal resources. More complex environments may require the firm to respond with even greater experimentation and learning, which is especially challenging for new ventures given their limited resources and less-established routines. Less-concentrated (more fragmented) industry sectors are more complex (Boyd 1990, Dess and Beard 1984). Particularly complex industry sectors have many large firms, each with a small market share. Per Heeley et al. (2006), we measure environmental complexity by regressing respective terminal-year market shares of the firms in a given industrial sector onto those firms' initial-year market shares. This measure is multiplied by a negative one, so higher values indicate greater complexity. Here, higher complexity (larger regression beta) suggests a highly fragmented industrial sector, while lower complexity (smaller regression beta) indicates greater dominance by a relatively small number of firms, each having large market shares.

For each industry sector, we control for *Industry Entry Rate* (relative number of new firms entering an industry sector each year), *Industry Average Firm Age*, *Industry Average Firm Size* (ln[total employees in the industry]/ln[total number of firms]), and *Industry Sales Growth* ([Industry Net Sales$_t$ − Industry Net Sales$_{t-1}$]/Industry Net Sales$_{t-1}$) from the previous year. New firm failure is more likely to occur in industry sectors with greater firm entry rates (Caves 1998). New firms, due to their liabilities of newness and smallness, are even more likely to fail in sectors having greater proportions of older and larger firms (Aldrich and Auster 1986). In general, greater industry sales growth supports firm survival. We include dummies for each *12-month time window*, respectively, labeled Years 1–6, to capture time-related events that may affect all firms. In addition, we specify gamma frailty to control for industry-level factors.

At the firm level, we control for the *Number of Employees* and *Percentage of Owner Equity* for each of the 6 years. *Number of Employees* proxies firm size and indicates personnel resources. *Percentage of Owner Equity* proxies entrepreneurs' motivation and effort (Chandler and Lyon 2009). Larger firm size and higher owner equity may reduce firm-failure likelihoods. Table 3 presents the correlation matrix. Table 4 presents trends in operational capability values.

4. Data Analysis

4.1. Hazard Effects Modeling Approach with Varying Failure Rates

Proportional hazard models "assume that the hazard functions of all individuals differ only by a factor of proportionality. That is, if one individual's hazard rate is 10 times higher than another's at one point in time, it is 10 times higher at all points in time" (Chung et al. 1991, 71). Our conceptual framework posits that specific operational capabilities of the individual firm have differential effects on the firm's survival likelihood over time. Therefore, the assumption of proportionality in survival analysis may not be applicable. As variable effects could be nonproportional, steps must be taken to model this. Box-Steffensmeier and Zorn (2001) explain that Schoenfeld (1982) residuals must be used to assess whether a variable has a nonzero slope over time. If Schoenfeld residuals are significant, then nonproportionality can be accommodated either through a piecewise-exponential regression or by including a time variable in the Cox regression.

We first conducted the Schoenfeld residual test assessing the nonzero slope of residuals over time to ensure that hazard rates are nonproportional. A nonzero slope indicates violation of the proportional hazard assumption. Table 5 shows that all three independent variables (operational capabilities) and six time-window variables have significant nonzero slopes, indicating that the effects are nonproportional over time. Given the nonproportionality, we employ a Cox regression with time variables. This is consistent with Box-Steffensmeier and Zorn's (2001) specification:

$$h(t) = h_0(t)e^{[X_i\beta+(X_i g(t))+\varepsilon]}, \quad (1)$$

where $h_0(t)$ is the baseline hazard function, X_i are the covariates, and $g(t)$ is the time function. As we focus on changes in effects of covariates over time, we take calendar year windows and specify the time function $g(t)$ as a set of year-wise dummy variables with 2005 as the reference.

Table 3 Correlation Matrix

	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12
1. Inventory Turnover	2.29	1.09	1											
2. Gross Margin	0.16	0.19	0.092	1										
3. Employee Productivity (Ln)	3.32	3.48	0.082	0.083	1									
4. Environmental Munificence	0.55	0.61	0.158	0.111	0.417	1								
5. Environmental Dynamism	1.13	0.79	−0.204	−0.096	−0.191	−0.210	1							
6. Environmental Complexity	0.68	0.27	−0.087	0.072	−0.078	0.156	0.284	1						
7. Industry Entry Rate (Ln)	4.60	8.47	−0.063	−0.076	0.121	0.108	−0.109	−0.216	1					
8. Industry Average Firm Age	11.73	9.36	0.039	0.061	0.087	0.076	−0.172	0.075	−0.065	1				
9. Industry Average Firm Size (Ln)	3.39	2.31	0.085	0.028	0.109	0.121	−0.147	−0.183	−0.288	0.062	1			
10. Industry Sales Growth	0.06	0.57	0.062	0.077	0.111	0.157	−0.105	−0.146	0.127	0.053	0.081	1		
11. Number of Employees	11.86	13.62	0.059	0.036	0.059	0.181	−0.127	0.074	−0.103	0.062	0.022	0.192	1	
12. Percentage of Owner Equity	0.66	0.53	0.026	0.053	0.082	0.282	0.018	0.025	0.055	0.029	0.054	0.013	0.018	1
13. Venture Failure	0.36	–	−0.105	−0.068	−0.080	−0.141	0.267	0.183	0.134	−0.085	−0.072	−0.133	−0.054	−0.066

Correlations $\geq$ |.12| are significant at $p < 0.01$; correlations $\geq$ |.08| are significant at $p < 0.05$; two-tailed tests.

Table 4 Trends in Operational Capability Values

	Inventory Turnover (mean)	Inventory Turnover (st. dev.)	Gross Margin (mean)	Gross Margin (st. dev.)	Employee Productivity (mean)	Employee Productivity (st. dev.)
Year 1	1.938	0.862	0.113	0.207	2.934	3.349
Year 2	2.049	1.017	0.156	0.159	3.053	3.493
Year 3	2.339	1.037	0.166	0.119	3.118	3.548
Year 4	2.439	1.146	0.175	0.254	3.251	3.566
Year 5	2.416	1.215	0.179	0.246	3.639	3.377
Year 6	2.546	1.287	0.180	0.162	3.944	3.513

4.2. Shared Gamma Frailty and Selection Bias

Ventures in a given industry share common factors affecting venture survival odds. As such, ventures "share frailty" based on industry. To accommodate shared survival likelihoods, due to the possibility of correlated errors, we model gamma frailty in the Cox regression model specified in Equation (1).

The sample cohort includes ventures that registered in 2005 and reported sales in 2005. There may be unobserved heterogeneity because we only include ventures that survived the test of making the first sale in year 2005. These ventures may have different (and likely more and better) underlying resources and capabilities than ventures that registered in 2005 but did not have sales in 2005. Ignoring such initial conditions could bias estimations in favor of ventures with sales in 2005. Similarly, ventures that registered in 2005 and had sales *in* 2005 could have resources different from ventures that registered in 2005, but incurred first sales in years *after* 2005. Cader and Leatherman (2011) advocate controlling for selection bias in survival analysis in the small firm setting, and prior new venture survival research controls for self-selection (e.g., Delmar and Shane 2006, Eckhardt et al. 2006). To reduce selection bias, we use Heckman's (1979) two-step self-selection approach. Consistent with standard economic practice, we employ the inverse Mills ratio, based on Heckman's two-step approach, to control for self-selection of (a) ventures that registered in 2005 and had no sales between 2005 and 2010 (5093 ventures), and (b) ventures that registered in 2005 and incurred first sales in respective

Table 5 Schoenfeld Residuals Test for Proportional Hazard Model

	Rho†	Chi-square	df	Prob > Chi-square
Nonproportional effects of Operational Capabilities				
Inventory Turnover	−0.306	5.851	1	0.016
Gross Margin	0.293	6.206	1	0.013
Employee Productivity	0.384	5.300	1	0.021
Global Test††	0.604	16.214	3	0.001
Nonproportional effects of Time Windows				
Year 1	1.406	6.550	1	0.010
Year 2	1.686	4.639	1	0.031
Year 3	1.964	5.283	1	0.022
Year 4	2.481	6.407	1	0.011
Year 5	0.562	5.228	1	0.022
Year 6	0.433	5.218	1	0.022
Global Test†††	6.673	15.987	6	0.014

†Rho is the Pearson product-moment correlation of the scaled Schoenfeld residuals and time. The null hypothesis is that the Pearson product-moment correlation is zero. If the null hypothesis is rejected then residuals are significantly related to time and the assumption of proportionality is rejected. The null hypothesis is tested using the Chi-square significance test.
††Global Test is the joint significance of inventory turnover, gross margin, and employee productivity; based on *stphtest* in Stata 11.
†††Global Test is the joint significance of Years 1–6; based on *stphtest* in Stata 11.

years 2006 (538 ventures), 2007 (472), 2008 (419), 2009 (373), or 2010 (181). These new ventures were subject to the same sample filtering criteria (size, capital, sector) as the main sample except for timing of first (or any) sales. The selection equation for ventures with no sales over 6 years is

$$\lambda_{it,nosales} = \frac{\phi_{it,nosales}[\Phi^{-1}(F_i(t))]}{1 - F_i(t)}. \quad (2)$$

The selection equations for ventures with first sales in years 2006, 2007, 2008, 2009, and 2010 are

$$\lambda_{it,sales} = \frac{\phi_{it}[\Phi^{-1}(F_i(t))]}{1 - F_i(t)}, \quad (3)$$

where $F_i(t)$ is the cumulative hazard function for venture i, at time t; ϕ is the standard normal density function; and Φ^{-1} is the inverse of the standard normal density function.

In the first step, these variables are used to estimate sales (= 1) or no sales (= 0) for each year in a probit regression having these predictor variables: number of patents filed,[6] environmental munificence, environmental dynamism, environmental complexity, capital at registration, and owner equity percentage. Ventures with more patents typically engage in more knowledge-intensive resource recombinations and therefore are likely to realize sales at a slower rate than other firms (Newbert 2005). Environmental munificence addresses resource abundance. Ventures in a more munificent environment are more likely to realize sales than ventures in a less munificent environment (Schoonhoven et al. 1990). Dynamic environments lower the likelihood of realizing sales (Lichtenstein et al. 2006). Complex environments facilitate niche-based competition, which increases the likelihood of realizing sales (Clarysse et al. 2011). Firms starting with greater capital at registration face fewer liabilities of smallness and are more likely to realize sales (Aldrich and Auster 1986). Owner equity percentage may increase owner effort, in turn increasing the likelihood of realizing sales (Downes and Heinkel 1982). In the second step, based on Equations (2) and (3), we include the estimated inverse Mill's ratios as controls.

5. Results

5.1. Hypothesis Tests

Table 6, column (a), shows the results of the shared gamma frailty Cox regression. Because venture failure is coded as 1, positive betas indicate increased likelihood of failure, and negative betas indicate lower likelihood of failure.

The effects of the industry sector control variables are largely as expected. Environmental munificence (reflecting greater resource availability) is associated with lower venture-failure likelihood ($\beta = -0.092$, $p < 0.01$), environmental dynamism (indicating increased environmental instability and unpredictability) is associated with increased venture-failure likelihood ($\beta = 0.346$, $p < 0.01$), and environmental complexity (greater industry fragmentation) is associated with increased likelihood of venture failure ($\beta = 0.129$, $p < 0.01$). A higher industry entry rate is associated with lower venture-survival likelihood ($\beta = 0.147$, $p < 0.01$). Industry average firm age lacks significant association with firm-survival likelihood ($\beta = 0.003$, $p > 0.10$). This is unexpected given that new ventures should face greater liability of newness in an industry dominated by older firms. Average firm size in an industry is associated with greater venture-failure likelihood ($\beta = 0.079$, $p < 0.05$). Industry sales growth is associated with lower venture-failure likelihood ($\beta = -0.084$, $p < 0.05$).

The main effects of the time window controls, Years 2–6, show that the likelihood of failure is high in Year 2 ($\beta = 0.132$, $p < 0.01$) and Year 3 ($\beta = 0.155$, $p < 0.01$). The likelihood of survival is greater in Year 4 ($\beta = -0.246$, $p < 0.01$), Year 5 ($\beta = -0.244$, $p < 0.01$), and Year 6 ($\beta = -0.139$, $p < 0.05$). These findings are consistent with past research, suggesting that ventures are more likely to fail in early years and that failure likelihood declines over time. All six inverse Mills ratios are significant. This validates the need to control for self-selection between ventures with and without sales over the period of observation. Controlling for

Table 6 Shared Gamma Frailty Cox Regression Model for New Venture Failure†

	(a)	(b) Sensitivity Test Under Different Firm Sizes (number of employees)			(c)
	Full Model 812 firms (100.0%)	1–9 575 firms (70.8%)	10–49 146 firms (18.0%)	50–249 91 firms (11.2%)	Discrete Manufacturers†† 544 firms (67.0%)
Variables	β	β	β	β	β
Operational Capabilities					
Inventory Turnover	−0.403**	−0.337**	−0.379**	−0.335**	−0.404***
Gross Margin	−0.322**	−0.352**	−0.342**	−0.394**	−0.522***
Employee Productivity	−0.317**	−0.244**	−0.303**	−0.226**	−0.571***
Controls: Industry Sector-Specific					
Environmental Munificence	−0.092**	−0.144**	−0.122**	−0.117*	−0.198**
Environmental Dynamism	0.346**	0.427**	0.284**	0.321**	0.134*
Environmental Complexity	0.129**	0.152**	0.157**	0.108**	0.056
Industry Entry Rate	0.147**	0.076*	0.219***	0.192**	0.067*
Industry Average Firm Age	0.003	0.002	0.072	0.088	0.181*
Industry Average Firm Size	0.079*	0.133*	0.137*	0.007	0.063
Industry Sales Growth	−0.084*	0.012	−0.032	−0.052	−0.144**
Controls: Firm-Specific					
Number of Employees	−0.069	0.010	−0.097	−0.054	−0.078
Percentage of Owner Equity	−0.047	−0.007	−0.062	0.000	−0.111
Controls: Time Windows					
Year 1 [*reference category*]	–	–	–	–	–
Year 2	0.132**	0.153**	0.113**	0.212**	0.089*
Year 3	0.155**	0.136**	0.257**	0.158*	0.095*
Year 4	−0.246**	−0.287**	−0.157**	−0.153*	−0.447***
Year 5	−0.244**	−0.284**	−0.322***	−0.284**	−0.362***
Year 6	−0.139*	−0.235*	−0.201**	−0.102*	−0.269*
Operational Capabilities in Time Windows					
Inventory Turnover × Year 2 [H1]	−0.207*	−0.301*	−0.283*	−0.302*	−0.369**
Inventory Turnover × Year 3 [H1]	−0.160*	−0.224**	−0.212*	−0.228*	−0.303**
Inventory Turnover × Year 4	−0.060	−0.042	0.014	0.031	−0.013
Inventory Turnover × Year 5	−0.035	−0.062	−0.003	−0.036	−0.023
Inventory Turnover × Year 6	−0.035	−0.030	0.067	−0.014	−0.061
Gross Margin × Year 2	0.053	0.096	0.025	−0.003	0.017
Gross Margin × Year 3	−0.058	−0.091	−0.133	−0.107	−0.045
Gross Margin × Year 4 [H2]	−0.191*	−0.121*	−0.207*	−0.177*	−0.359**
Gross Margin × Year 5 [H2]	−0.125*	−0.167*	−0.185*	−0.153*	−0.226**
Gross Margin × Year 6	−0.022	0.012	0.013	−0.047	−0.049
Employee Productivity × Year 2	0.016	−0.015	0.030	0.054	0.031
Employee Productivity × Year 3	−0.031	0.038	0.037	−0.049	−0.073
Employee Productivity × Year 4	−0.053	−0.096	−0.062	0.019	−0.056
Employee Productivity × Year 5 [H3]	−0.107*	−0.147*	−0.201*	−0.109*	−0.205**
Employee Productivity × Year 6 [H3]	−0.171*	−0.189*	−0.155*	−0.168*	−0.297**
Self-Selection: Mills ratios					
$\lambda_{no\ sales}$	0.153**	0.217**	0.103**	0.176**	0.351**
λ_{2006}	−0.137**	−0.152**	−0.166**	−0.178**	−0.320***
λ_{2007}	−0.142**	−0.176**	−0.161**	−0.172**	−0.313**
λ_{2008}	0.148**	0.182**	0.165**	0.151**	0.275**
λ_{2009}	0.139**	0.232**	0.097**	0.176**	0.299**
λ_{2010}	0.089**	0.087**	0.115**	0.121**	0.227**
Intercept	0.046***	0.064***	−0.024***	0.087***	0.159***
Frailty Parameter	0.706***	0.720***	0.722***	0.720***	0.873***
LR-χ^2	847.192***	872.713***	853.549***	864.989***	859.456***
Number of monthly observations	48,794	34,552	8,774	5,468	31,284

***significant at $p < 0.001$; **significant at $p < 0.01$; *significant at $p < 0.05$.
†Dependent variable is New-Venture Failure, coded as 1 = failed, and 0 = surviving for each month of 2005–2010.
††Discrete manufacturers subsample consists of all firms having two-digit SIC codes of 35 (machinery), 36 (electronics), or 38 (instruments).

unobserved heterogeneity between ventures with and without sales provides conservative estimates.

For the hypothesis tests, Year 1 (2005) is the reference year. The hypothesis tests are conducted by evaluating the statistical significance of interactions between operational capability variables and the subsequent five time windows (Years 2–6). Hypothesis 1 posited that higher *Inventory Turnover* is associated with lower likelihood of new venture failure in the *start-up* phase. Results show that higher inventory turnover is associated with lower venture failure likelihood in Year 2 ($\beta = -0.207$, $p < 0.05$) and Year 3 ($\beta = -0.160$, $p < 0.05$). Hypothesis 2 posited that greater *Gross Margin* is associated with lower venture-failure odds in the *growth* phase. Results show higher gross margin is associated with reduced likelihood of venture failure in Year 4 ($\beta = -0.191$, $p < 0.05$) and Year 5 ($\beta = -0.125$, $p < 0.05$). Hypothesis 3 posited that greater *Employee Productivity* is associated with lower venture-failure likelihood in the *stability* phase. Results show higher employee productivity is associated with lower venture-failure odds in Year 5 ($\beta = -0.107$, $p < 0.05$) and Year 6 ($\beta = -0.171$, $p < 0.05$). All three hypotheses are supported.

5.2. Robustness Tests

Four *post hoc* data analyses support the robustness of the model and hypothesis findings. First, based on the power calculation (following Heo et al. 1998) and using the PROC Power routine,[7] the model's power of 0.85 was well above statistically prescribed levels (Cohen 1988), indicating strong support. Second, as liability of smallness dynamics may differ by firm size, we split the sample into three subsamples of employee size: 1–9, 10–49, and 50–249 personnel (Table 6, column (b)). The effects of inventory turnover, gross margin, and employee productivity are consistent across firm sizes; therefore, firm size category does not change the inferences. Third, per Box-Steffensmeier and Zorn's (2001) suggestion, we assessed estimates under a piecewise constant exponential model (on-line Appendix S1) and piecewise Cox model (on-line Appendix S2). Inferences are consistent with the original specification. Fourth, given that outliers may have inordinate influence in survival analyses, we winsorized all continuous variables (the three operational capabilities, the seven industry sector-specific controls, and the two firm-specific controls) first at the 1% and 99% levels and second at the 2.5% and 97.5% levels. Winsorization results show no material changes in direction, magnitude or significance. All original inferences hold.

5.3. *Post Hoc* Analysis: Discrete Manufacturers

Given well-known differences in production systems and supply networks for discrete vs. process manufacturers (Hayes and Wheelwright 1984, Safizadeh et al. 1996), we conducted a *post hoc* analysis of a subset of firms known to be discrete manufacturers. Per Shah and Ward (2003), firms in the following two-digit SIC code industries are discrete manufacturers: 35 (machinery), 36 (electronics), and 38 (instruments). Our sample contains 544 firms in these two-digit SIC code industry sectors.[8] The shared gamma frailty Cox regression results for this subsample are shown in Table 6, column (c). As expected, the inferences for the discrete manufacturers not only hold but are stronger, both in notably larger beta values and statistical significance at $p < .01$ (rather than at $p < .05$ for the full sample).

6. Discussion

Ventures face significant environmental threats and internal resource constraints that increase the likelihood of failure. Our results indicate that inventory turnover, gross margin, and employee productivity are especially vital to venture survival, respectively, at start-up, growth, and stability phases.

This study contributes to operations management and entrepreneurship theory. Our work extends contingency notions of operational phenomena. We find that heightened effectiveness of operational capabilities is contingent at distinct new venture phases. Our findings derive from longitudinal analysis of firm-level operational factors, often called for in operations management research, but infrequently conducted. To entrepreneurship, our study identifies the operational capabilities of inventory turnover, gross margin, and employee productivity as important criteria for venture survival. This study answers calls to examine internal resource orchestration processes in new ventures (Sirmon et al. 2011).

The longitudinal methodology allowed scrutiny of the new firm's operations dynamics, and provides support for a "phased capabilities" model of operational capabilities for new ventures. This finding is consistent with the well-established "cumulative capabilities" perspective for established firms as described in manufacturing strategy literature (e.g., Ferdows and DeMeyer 1990, Noble 1995) and the "theory of competitive progression" where established manufacturing firms maximize performance by building capabilities in a defined sequence, only embarking on developing and implementing the next capability when the present capability is functioning well (Rosenzweig and Roth 2004). Similarly, we find that the new venture must emphasize particular operational capabilities in sequence. However, cumulative capabilities are considered with respect to traditional measures of *manufacturing-* and *firm-level performance*, while phased capabilities are considered with respect to *firm survival*, a notably different performance measure and one that is arguably far more relevant for new ventures. This also illustrates that operations strategy for new ventures requires focus on achievement of different fundamental firm-level performance measures than operations strategy for established firms.

The main effects of the operational capability variables are all significant, indicating that these operational capabilities are always valuable for firm survival in the 6-year time frame investigated. Importantly, the significant time-based interactions show heightened importance of operational capabilities in specific life phases of the new venture. The lack of statistically significant time-period interaction effects for the three operational capabilities, outside the specific years of the hypothesized contingent life phases, further illustrates the exceptional differential contribution to firm survival of these operational capabilities in the specific life phases. All three operational capabilities have increasing mean values over the time frame (see Table 4) as should be expected. These trends suggest the ventures are developing operations-based dynamic capabilities (Anand et al. 2009). Although operational capability values increase, the statistical tests of time-based contingencies clearly show the exceptional influence of specific operational capabilities in specific new venture life phases.

7. Conclusions

This study contributes to theory by identifying essential operational capabilities in sequence for different life phases of the new venture. This research contributes to practice by helping entrepreneurs prioritize scarce management attention and resources toward specific operational capabilities at respective new venture phases.

As in all empirical studies, this work has certain scope limitations. This study's 6-year time span is consistent with other venture survival studies. Sixty-four percent of the firms in our sample failed in this time frame. Nonetheless, the data are right censored (Helsen and Schmittlein 1993), and future research employing longer observation periods could reduce bias in estimates potentially arising from right censoring. Longer observational periods also allow more extended study of the dynamics of new ventures in the stability phase and beyond.

This study considered only new ventures engaged in manufacturing, and the findings may not generalize beyond such firms. Operations strategy and innovation for service firms differs notably from that for manufacturing firms (Ettlie and Rosenthal 2011, Menor et al. 2002, Ostrom et al. 2010). Future research should develop and test theory on operations capabilities and *new service venture* survival. In addition, future research should conduct more refined theoretical evaluation of operations strategy and capabilities for *different types of manufacturing firms*. The *post hoc* analysis showed that the hypothesized sequential, contingent operational capabilities had even stronger favorable impact on firm survival for discrete manufacturers than for the sample at large. Essential characteristics of discrete manufacturers, including the different nature of inventories, fixed assets, and labor, along with greater process-improvement opportunities and more rapid production learning help explain this. Other classifications of dominant manufacturing process type and the firm's location and role in the supply chain should be considered.

Our sample consists of Swedish firms. While Sweden is generally representative of entrepreneurial activity in developed countries (Short et al. 2009), future research should replicate this study in other developed countries to ascertain generalizability. In addition, future research should characterize operations strategy for new ventures in emerging economies (Lyles et al. 2004, Sommer et al. 2009) and assess the generalizability of our theory and findings.

This study did not consider antecedents to operational capabilities. Future research should investigate internal action programs and initiatives (Rosenzweig and Easton 2010), which may be antecedents to these operational capabilities. In addition, the development of operational capabilities suggests that operations-based learning in new ventures is a vital area for future research. The ability to turn inventories quickly, make operational process improvements leading to greater gross margins, and fostering employee productivity are all in part enabled by organizational learning and individual learning (Anand et al. 2010). Certain lean operations and process-improvement principles (including six sigma) merit adaptation to and application in the new venture context. Given the need for sequential emphasis of operational capabilities, learning in earlier phases may set an important foundation for enhanced operational capabilities and learning in later phases.

This study extends manufacturing operations strategy from the realm of *established* firms to *new* firms. Our findings open a broad, relatively untapped, but highly relevant area for inquiry on the operations function in supporting new venture formation, survival, and growth. This study considered the New Venture epoch of a firm's life (Figure 1), bounding out the prior Embryonic firm epoch and the subsequent Established firm epoch. Regarding *embryonic firms*, future research should characterize the nature of operations in firms prior to incorporation and prior to first customer shipment to help identify essential managerial decision variables for internal operations and supply chain partnerships in these very early stages. Regarding *established firms*, future research should explore how operational processes in established firms can help entrepreneurs identify potential new venture opportunities.

This study considered internal operations. The new venture's evolving supply chain (Pathak et al. 2007) and interorganizational partnerships (Terjesen et al. 2012) merit significant attention. How does a new firm initiate supply and distribution networks? How best can new ventures exploit supply chain partner resources and capabilities, and in different relationship forms, at different points in the firm's evolution? For example, the classic "make vs. buy" question (Mantel et al. 2006) may require quite different criteria and consideration in each life phase. When should new ventures opt in and out of partner and outsourcing relationships that may impact capacity availability and development of operational capabilities?

This study focused on the role of operations. Future research should examine interactions, synergies, and trade-offs between operations and other functional areas (Joglekar and Lévesque 2009, Tatikonda and Montoya-Weiss 2001), particularly marketing and finance, in supporting venture survival and growth. In addition, the individual entrepreneur's sensitivity to the role of operations in new ventures merits evaluation. What is the "operational orientation" of individual entrepreneurs and the new ventures they lead? How does operational orientation influence development of operational capabilities and the ability to shift operational foci from phase to phase with the ultimate objective of enhancing firm survival and growth?

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Notes

[1]A venture that survives the entire time frame is represented by 61–72 months of data, depending on the month in 2005 it was registered (December registration = 61 months of data, January registration = 72 months of data.)

[2]A firm is also deemed to have failed if it does not provide the required annual report information to the government for 3 years. A firm that fails to file information in a given year either ceased operations or delayed reporting due to unforeseen circumstances. To ensure that lack of availability of information was not due to reporting delays, only firms that did not report information for three consecutive years are treated as failed. Prior studies typically consider ventures as failed if financial information is not reported for 1 year (Delmar and Shane 2004, 2006). Twenty-one firms did not report for three consecutive years, but then did report information sometime after 3 years. For these cases, we coded the failure date as January of the first year it did not file income statement reports.

[3]To triangulate venture failure and date, we confirmed failure month and year with the Swedish Business Register (SBR), a government agency. SBR maintains records for all Swedish firms. In the 47 cases where there was a mismatch in month of failure, we used the average of the failure month and year reported by the two sources.

[4]A firm may fail, for all practical purposes, within Year 1; however, due to Swedish legal reporting procedures, that failure is not reported until the first month of the second year. As such, Year 2-reported failures represent practical failures in both Year 1 and Year 2.

[5]Seventy-two industry sector groups were created based on the four-digit SIC codes of the 812 new ventures. Income statement information for ventures in each four-digit SIC code group was averaged each year, forming the basis of the calculations for environmental munificence, dynamism, and complexity.

[6]These data are from the European Patent Office and were cross-referenced with the Swedish Business Register.

[7]Available in the Power and Precision software package (http://www.power-analysis.com/).

[8]The remaining 268 firms represent the other two-digit SIC code industry sectors. These firms are likely to be process manufacturers or are in sectors where the dominant production system type cannot be reliably determined.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Appendix S1: Sensitivity Test: Piecewise Constant Exponential Model for New Venture Failure

Appendix S2: Sensitivity Test: Piecewise Cox Regression Model for New Venture Failure