Inventory stickiness, environmental dynamism, financial constraints and survival of new SMEs in China

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Abstract

Purpose – Although the adoption of lean inventory management for performance improvement has been widely recognized, sticky inventory management is still a stopgap measure for new small and medium enterprises (SMEs) against survival risks. The purpose of this paper is to demonstrate the nonlinear relationship between new SMEs inventory stickiness and venture survival by focusing on the moderating effects of environmental dynamism and financial constraints.

Design/methodology/approach – Classical moderating model is employed to investigate the effects of environmental dynamism and financial constraints on the relationship between inventory stickiness and venture survival. This study uses the accelerated failure time model for survival analysis and tests the relationships based on a large set of new manufacturing SMEs in China over the period from 1999 to 2007.

Findings – The main finding is that inventory stickiness has an inverted U-shaped impact on the likelihood of survival. However, the inflection point of this inverted U-shaped relationship lies at the end of the sample. Further moderation analysis indicates that environmental dynamism positively moderates the inverted U-shaped relationship between inventory stickiness and venture survival, while financial constraints negatively moderate this relationship.

Practical implications – Most new SMEs have great potential to increase the likelihood of survival by improving inventory stickiness before achieving effective lean inventory management. Sticky inventory management can help new SMEs achieve better survival in a dynamic environment. However, new SMEs that are financially constrained should prudently implement sticky inventory management.

Originality/value – This paper contributes to the existing understanding about the likelihood of SMEs survival by addressing the role of sticky inventory management. It may be the first study to empirically demonstrate the moderating effect of environmental dynamism and financial constraints on the inverted U-shaped relationship between inventory stickiness and venture survival.

Keywords Environmental impact, Financial performance, Inventory management, Failure mode and effect analysis, Small and medium sized enterprises

Paper type Research paper

1. Introduction

For inventory to be regulated as a valuable strategic resource, inventory management is expected to be central to the survival of newly established small and medium enterprises (new SMEs). New SMEs need to be particularly mindful of their inventory management strategies because they struggle to maintain excess inventory while seeking to survive in a dynamic environment. Hence, a flexible inventory management strategy is critical to the survival of

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new SMEs. Recent developments in the field of operations management have led to an increasing interest in sticky inventory management. Unlike lean and agile manufacturing that treat inventory as a waste, sticky inventory management refers to the fact that enterprises hold excess inventory (or inventory slack) as a buffer against environmental threats during periods of decreasing revenue. That is, for new SMEs, inadequate production management experience and small scale may result in weak lean management capabilities and poor resistance to risks. Taking into account that lean inventory management requires long-term continuous implementation, competitive pressure forces new SMEs to hold excess inventory in the short term to improve survival ability. Therefore, although sticky inventory management may reduce the profitability, new SMEs prefer to increase inventory cost rather than reduce the likelihood of survival due to concerns about production interruption caused by insufficient inventory or cash flow shortage caused by high adjustment costs (Azadegan *et al.*, 2013). As argued by Delmar *et al.* (2013), the primary goal for new SMEs is to maximize survival ability rather than profitability.

For the first time, Kroes and Manikas (2018) provide empirical evidence of the existence of inventory stickiness. In addition, they empirically demonstrate the negative impact of inventory stickiness on financial performance. This intriguing result can be explained from the perspective of lean and agile manufacturing, in which inventory stickiness is a waste and should be eliminated. However, inventory stickiness may be a double-edged sword. It is believed that holding excess inventory can help enterprises raise their self-reliance and enhance their abilities to weather unexpected disturbances (Azadegan *et al.*, 2013). As a result, inventory stickiness may help enterprises mitigate potential environmental fluctuations and avoid supply chain disruptions. Especially for SMEs, the lack of organizational experience and resistance makes them more likely to adopt sticky inventory management to maintain stable production and against survival risks. Hence, it is of great significance to investigate the impact of inventory stickiness on the survival of new SMEs.

Our first contribution is the finding that the maximum point of the inverted U-shaped relationship between inventory stickiness and venture survival often lies at the extreme end of the investigated sample. Concretely, although inventory stickiness has a negative impact on financial performance that is closely related to venture survival, sticky inventory management may also help mitigate various disruptions, thus increasing the likelihood of survival. The contribution of this paper also extends to the literature on environmental dynamism and financial constraints. Prior related studies have demonstrated the moderating effects of environmental dynamism on the inventory stickiness-financial performance relationship and the inventory slack-venture survival relationship (Azadegan *et al.*, 2013; Kroes and Manikas, 2018). Thus, examining the moderating effect of environmental dynamism contributes to better understanding the role of sticky inventory management in affecting venture survival. Furthermore, although the role of financial constraints in decreasing the likelihood of survival has frequently been highlighted in the literature (Gorg and Spaliara, 2014), few researches have focused on the moderating role of financial constraints. Given that financial constraints may be closely related to inventory stickiness, it appears likely that financial constraints may moderate the impact of inventory stickiness on venture survival. In this paper, we have explicitly investigated the role of environmental dynamism and financial performance in moderating the relationship between inventory stickiness and venture survival.

The data used in this study come from a large set of new manufacturing SMEs in China over the period from 1999 to 2007. Firstly, we demonstrate the existence of the inventory stickiness of SMEs in China. Secondly, we use the survival analysis method to investigate the inverted U-shaped relationship between inventory stickiness and venture survival, suggesting that excessive inventory stickiness may lead to failure. Meanwhile, we also

find that most new SMEs still have much potential to increase the likelihood of survival by improving inventory stickiness. Finally, we demonstrate that the relationship between inventory stickiness and venture survival is positively moderated by environmental dynamism and is negatively moderated by financial constraints. That is, sticky inventory management may help new SMEs increase likelihood of survival in a dynamic environment. However, financially constrained new SMEs should prudently implement sticky inventory management.

The reminder of the paper is organized as follows. Section 2 outlines the theoretical background and hypotheses development. In Section 3, the research methodology is illustrated. Section 4 provides the empirical results. The research findings and implications are discussed in Section 5. The paper concludes in Section 6, with a discussion of limitation and future research directions.

2. Theoretical background and hypotheses development

2.1 Inventory stickiness

Inventory stickiness derives from the concept of cost stickiness and refers to the fact that the increase in inventory during periods of increasing revenue is greater than the decrease in inventory during periods of decreasing revenue. It is argued that inventory stickiness can be seen as the result of managers sluggishly reducing inventory in response to reduced demand from the perspective of operations management (Kroes and Manikas, 2018). According to the cost stickiness theory and operations management theory, there are two main reasons to explain the causes of inventory stickiness. Firstly, inventory stickiness is caused by holding costs lower than adjustment costs. Specifically, adjusting costs refer to the costs associated with disposing inventory and increasing inventory, while holding costs refer to the costs related to warehousing and so on. Hence, given the higher adjustment costs of physical assets, new SMEs are more willing to reduce expenses such as advertising costs, rather than reducing inventory that may affect production stability. The second, perhaps more important, factor is the optimistic expectations of managers. Due to the uncertainty of market demand, optimistic expectations may convince managers that future demand will increase. Although current sales are declining, managers tend to hold excess inventory to cope with future demand growth, resulting in the inventory stickiness.

For the first time, Kroes and Manikas (2018) empirically demonstrated the existence of inventory stickiness and found the negative relationship between inventory stickiness and financial performance, indicating that holding excess inventory may reflect the lack of agility. However, it is argued that new SMEs tend to hold excess inventory as a protective buffer to meet market demand and avoid supply chain disruptions (Kovach *et al.*, 2015). That is, sticky inventory management may enable SMEs to enjoy better survival ability. Related excess inventory management research provides empirical evidence for this view. Concretely, Azadegan *et al.* (2013) argued there is positive relationship between inventory slack and the likelihood of survival. Shi *et al.* (2019) also came to a similar conclusion. However, Tatikonda *et al.* (2013) showed the positive impact of inventory turnover on venture survival, suggesting that holding excess inventory may not always lead to better survival. Similarly, Wang *et al.* (2019) indicated that excess inventory is not conducive to venture survival. One reason for this contradictory conclusion may be that relative changes in revenues have not been taken into account, as it is not surprising that enterprises tend to hold excess inventory to support increasing sales when market demand increases. In this, probing into inventory stickiness contributes to a better understanding of the behavior of holding excess inventory in affecting venture survival during periods of decreasing revenue. Moreover, as Kroes and Manikas (2018) pointed out, inventory stickiness is mainly caused by operating costs and management's optimistic expectations for future growth, wherein management's optimistic expectation is affected by market instability. Then, it is well known that

environmental dynamism may play an important role in the decision-making of sticky inventory management. Meanwhile, as an important factor affecting the operating costs, financial constraints may be closely related to sticky inventory management. Therefore, considering that environmental dynamism and financial constraints are more important for inventory stickiness and venture survival, we further examine whether the effect of inventory stickiness on venture survival is further boosted by these two potential moderators. Thus, the aim of this paper is to add to our understanding of inventory management by exploring the role of sticky inventory management in affecting venture survival, with a focus on the moderating effects of environmental dynamism and financial constraints.

2.2 Inventory stickiness and venture survival

Traditionally, enterprises tend to hold excess inventory to mitigate demand fluctuations. That is, inventory stickiness may be a protective buffer against environmental uncertainty. Thus, from the perspective of inventory slack, inventory stickiness may be positively related to the likelihood of venture survival. Concretely, on the one hand, it is believed that inventory slack can raise firms' self-reliance and then increase their abilities against supply chain disruptions. On the other hand, inventory slack helps maintain a consistent and rapid pace of production, thus increasing firms' chance of survival. As inventory stickiness can better capture inventory slack during periods of decreasing revenue, inventory stickiness may contribute to increasing the likelihood of survival. Meanwhile, in this paper, our samples used in the empirical analysis are new SMEs. For new SMEs, the lack of stable supply chains and reliable operational routines make them experience a weak ability to against unexpected disturbances. That is, even simple mistakes can prove costly for new SMEs (Liao *et al.*, 2009). In this case, the ability to respond quickly and effectively to changes caused by supply chain participants is crucial to the likelihood of new SMEs' survival. As in Azadegan *et al.* (2013), inventory slack allows enterprises to act more rapidly and effectively to various supply chain disruptions. Therefore, for new SMEs, stick inventory management may be a useful risk-reduction strategy to protect themselves from failure.

Although inventory stickiness can be used to mitigate unexpected disturbances and reduce the likelihood of failure, inventory stickiness, especially for new SMEs, also means costly burdens caused by holding excess inventory, thus increasing the likelihood of failure. In this, inventory stickiness is expensive and reduces the firm's profitability. That is, a high level of inventory stickiness may drop SMEs into a vicious circle of cash strains. In addition, it is argued that excess inventory also means low efficiency in resource allocation, thus limiting the increase in competitiveness. Furthermore, it is argued that inventory stickiness will lead to suboptimal inventory decision, eventually resulting in the bullwhip effect (Kroes and Manikas, 2018). This means that excessive inventory stickiness can lead to an inefficient supply chain. In other words, if inventory stickiness is too high, it may provide a negative impact on the likelihood of survival. As a result, there may be a trading-off between inventory stickiness and the likelihood of survival. This points to a curvilinear relationship in which the positive impact of sticky inventory management on the likelihood of survival is available only up to a certain level of inventory stickiness, and becomes negative as inventory stickiness grows beyond this level, indicating an inverted U-shaped relationship between inventory stickiness and venture survival. Therefore, we propose the following hypothesis:

H1. Inventory stickiness has an inverted U-shaped relationship with the likelihood of survival.

2.3 The moderating role of environmental dynamism

Environmental dynamism, characterized by unpredictable and rapid change, refers to the degree of instability and turbulence in the environment and represents discontinuities and the unpredictability of change within an industry. It is believed that environmental

dynamism is influenced by the availability of transaction information and can capture the demand uncertainty in the market (Eroglu and Hofer, 2014).

In a dynamic environment, managers are unable to obtain the accurate information on changes in market demand in time, which makes it impossible for managers to predict and respond effectively to rapid changes in market demand. This means that increased environmental dynamism can limit and change accurate production information, making demand forecasting difficult. In other words, it will be much more difficult for enterprises to acquire and complete orders in a timely manner in a dynamic environment. If that is the case, the fleeting market demand allows enterprises to survive only if they have the ability to meet market demand quickly and effectively. That is, the key to survival in a dynamic environment is that enterprises can consistently maintain production (Bradley *et al.*, 2011). For SMEs, especially during periods of decreasing revenues, it is difficult for enterprises to maintain stable production due to the lack of adequate resources and efficient production systems. To this issue, Azadegan *et al.* (2013) argued that holding excess inventory is an effective method to maintain production in a dynamic environment. Moreover, they indicated that holding excess inventory allows enterprises to be ready to seize opportunities to take more risks and to obtain a competitive advantage, increasing their likelihood of survival. Therefore, taking into account that sticky inventory management means holding excess inventory during the period of decreasing revenues, inventory stickiness is believed to improve venture survival in a dynamic environment. Although inventory stickiness can contribute to increasing the likelihood of survival in a dynamic environment, it also means high holding costs and low resource allocation efficiency in a stable environment. Due to the small fluctuations in market demand in a stable environment, there is no need for managers to hold excess inventory to cope with sudden changes in market demand. That is, sticky inventory management may burden enterprises' cash flow and endanger the likelihood of venture survival in a stable environment. In sum, we propose that the effect of inventory stickiness on the likelihood of survival may be weaker when environmental dynamism is high rather than low. This gives us the following hypothesis:

H2. Environmental dynamism positively moderates the curvilinear relationship between inventory stickiness and the likelihood of survival.

2.4 The moderating role of financial constraints

Financial constraints refer to the fact that external financing costs are higher than internal financing costs due to asymmetric information and agency problems. Generally, the growth of enterprises mainly depends on the support of external funds, which results in the fact that financial constraints can greatly affect the likelihood of survival. However, there are significant differences in the degree of financial constraints among different enterprises. As argued by Lin *et al.* (2011), the financial constraints of state-owned enterprises and large-scale enterprises are relatively low, while SMEs usually face severe financial constraints due to the lack of sufficient guarantees and policy support. It is believed that financial constraints can impose a rather large burden on the operating costs, thereby increasing the likelihood of failure. Specifically, empirical research based on French manufacturing firms shows that financial constraints are negatively correlated with the likelihood of survival.

In addition, since sticky inventory management refers to hold excess inventory during periods of decreasing revenues, it is easy to understand that inventory stickiness leads to the drop in cash flow and exacerbates the enterprises' financial constraints. Furthermore, enterprises tend to hold physical assets to improve their mortgage capabilities, thereby leading to increased inventory stickiness. This may point to a positive interaction between financial constraints and inventory stickiness. As they both increase, the increased operating costs may expose enterprises to a high likelihood of failure compared with firms with lower

financial constraints. In short, we propose that the effect of inventory stickiness on the likelihood of survival may be stronger for financially constrained enterprises than for unconstrained enterprises. This leads to the following hypothesis:

H3. Financial constraints negatively moderate the curvilinear relationship between inventory stickiness and the likelihood of survival.

3. Research methodology

3.1 Data resource

The sample used in this study includes new manufacturing SMEs in the Chinese Annual Survey of Industrial Firms (CASIF) database (1999–2007). The CASIF database is based on secondhand data obtained from the "Industry Enterprises Statistical Reports" organized by the State Statistics Bureau of China, consisting of all state-owned firms, and some non-state-owned firms whose annual sales are more than USD700,000 in all 30 two-digit manufacturing industries. To better investigate the impact of inventory stickiness on venture survival, we only kept the non-state-owned new SMEs. Meanwhile, following the methodology in Brandt *et al.* (2012), we deleted some unsatisfactory observations as follows. First, the total assets are lower than the liquid assets, the total fixed assets and the net value of the fixed assets. Second, the firm's identification number is not unique and the registration time is not valid. Finally, there is missing value in variables. Furthermore, to avoid left-censoring problem caused by uncertain beginning time, the samples used in this analysis were registered from 1999 to 2007. In addition, to control for right-censoring problem caused by uncertain ending time, survival analysis method was employed to ensure reliability and validity, which is introduced in the following section. In the end, a total of 188,065 enterprises were considered as part of the study.

3.2 Variable measurement

The measurement of all variables is now described. Concretely, the dependent variable is venture survival (e.g. duration and failure), and the main independent variable is inventory stickiness. The moderators are environmental dynamism and financial constraints. Control variables include firm-level variables (e.g. firm size, firm productivity and capital intensity) and industry-level variables (e.g. average firm age, average firm size and industry entry rate). All relevant variables are deflated using a price index developed by Brandt *et al.* (2012). Table 1 gives the mean, standard deviations, correlations, definition and measurement description on all variables used in the analysis.

3.2.1 Venture survival. This study defines entry, exit (or failure) and duration to capture venture survival. Concretely, we define the entry as the first time the enterprise is observed and reports information, and define the exit as the enterprise fails. The duration is defined as the length of a venture from its registration to failure. In addition, we deleted the samples that enter and exit in the same year to reduce noise in the samples. Over the nine-year period from 1999 to 2007, the duration ranges from 2 to 9 years Table 2 provides the detailed venture survival information about the exit rate and survival duration for each industry.

3.2.2 Inventory stickiness. Inventory stickiness is measured by the difference between the ratio of the current inventory level divided by the previous inventory level and corresponding ratio of the current revenue over the previous revenue. Then we calculate the inventory stickiness for each firm-year as follows:

$$\mathrm{INVSTI}_{i,t} = \log\frac{\mathrm{INV}_{i,t}}{\mathrm{INV}_{i,t-1}} - \log\frac{\mathrm{SALE}_{i,t}}{\mathrm{SALE}_{i,t-1}} \quad (1)$$

Table 1. Mean standard deviation and correlations

	Variable	Mean	SD	1	2	3	4	5	6	7	8	9	10	11
1	Duration	5.68	1.97	1.00										
2	Failure	0.07	0.25	−0.19*	1.00									
3	Inventory stickiness	−0.11	1.16	0.06*	−0.01*	1.00								
4	Environmental dynamism	0.17	0.09	−0.09*	−0.03*	−0.02*	1.00							
5	Financial constraints	−3.24	0.16	−0.02*	0.03*	0.01	0.10*	1.00						
6	Average firm age	2.24	0.19	0.09*	0.04*	−0.01*	0.04*	0.02*	1.00					
7	Average firm size	11.15	0.62	−0.09*	−0.01*	−0.01*	0.21*	0.09*	−0.15*	1.00				
8	Industry entry rate	0.21	0.11	0.01*	−0.06*	0.02*	−0.25*	−0.04*	−0.06*	−0.28*	1.00			
9	Firm size	3.18	0.38	0.05*	−0.04*	0.05*	0.20*	0.47*	0.04*	0.17*	−0.05*	1.00		
10	Firm productivity	8.35	1.31	0.68*	−0.01*	0.08*	0.14*	−0.01	−0.15*	0.11*	−0.01*	0.08*	1.00	
11	Capital intensity	0.25	0.51	−0.01*	0.02*	0.02*	0.13*	0.33*	0.02*	0.11*	−0.02*	0.42*	0.02*	1.00

	Definition	Measurement description
1	The length of a venture from its registration to failure	The length of time from entry to exit
2	The venture no longer appears in the CASIF database	The value is 1 if the venture exits, and 0 otherwise
3	The indicator of sticky inventory management	The method proposed by Kroes and Mankas (2018) (Details in Section 3.2.2)
4	The degree of instability and turbulence in the environment	The antilog of the standard error of the regression slope coefficient
5	The difficulty of external financing relative to internal financing	The SA index proposed by Hadlock and Pierce (2010) (details in Section 3.2.4)
6	The average age of enterprises in an industry	The mean value of firm age at two-digit industry
7	The average size of enterprises in an industry	The mean value of firm size at two-digit industry
8	The degree of enterprises entry in an industry	The ratio of new entry ventures to the total number of plants at two-digit industry
9	The size of enterprise according to specific criteria	The logarithm of the total sales
10	The comprehensive efficiency of various production factors	The method proposed by Levinsohn and Petrin (2003)
11	The relative intensity of enterprise capital and labor	The logarithm of the ratio of capital to total employees

Note(s): *$p < 0.01$

	Industry	Firms	Obs	Duration Mean	Exit(%) Rate
13	Farm and sideline products processing	11,673	32,375	5.48	20.94
14	Food-making	3,986	11,138	5.61	19.59
15	Beverage-making	2,336	6,073	5.36	21.65
17	Textile	19,360	58,136	5.76	18.20
18	Garments, shoes and chapeau	10,947	31,356	5.78	17.67
19	Leather, fur, feather (down) and related products	4,974	14,313	5.64	18.78
20	Timber processing, bamboo, cane, palm fiber and straw products	6,077	15,575	5.17	22.29
21	Furniture manufacturing	2,759	7,545	5.61	20.33
22	Paper-making and paper products	4,878	14,801	5.88	17.59
23	Printing and record medium reproduction	2,308	6,512	6.08	16.80
24	Stationery, education and sports goods	2,480	7,202	5.92	18.81
25	Petroleum processing, coking and nuclear elding	1,438	3,792	5.04	23.80
26	Raw chemical materials and chemical products	12,975	36,245	5.63	19.05
27	Medical and pharmaceutical products	2,838	8,096	5.66	16.14
28	Chemical fiber	1,116	3,446	5.76	18.49
29	Rubber products	2017	5,629	5.82	17.12
30	Plastic products	9,676	27,423	5.87	17.49
31	Nonmetal mineral products	13,949	38,974	5.51	18.76
32	Smelting and processing of ferrous metals	5,441	15,522	5.10	22.46
33	Smelting and processing of nonferrous metals	4,251	11,434	5.36	22.31
34	Metal products	11,556	31,682	5.82	18.97
35	Universal equipment	14,799	39,418	5.78	16.33
36	Equipment for special purpose	7,771	20,512	5.74	18.24
37	Transportation equipment	7,956	21,863	5.75	18.44
39	Electric equipment and machinery	9,961	30,323	5.84	8.20
40	Telecommunications equipment, computer and others	7,512	20,285	5.90	17.11
41	Instruments, meters, cultural and office machinery	3,031	7,374	6.12	17.98
	Subtotal	188,065	527,044		

Table 2.
Descriptive statistics of venture survival by industry

The high dimensionality of the data set employed here requires some definitions. Hereafter, the index i will identify a firm, and t a year. Where INVSTI represents the inventory stickiness, INV is the inventory and SALE is the sales. Due to the availability of CASIF database, we use the sales to capture revenues. Note that inventory stickiness is only applicable during periods in which the revenue declines.

3.2.3 Environmental dynamism. In order to capture the environmental dynamism within the industry, we regressed the industry's annual sales (dependent variable) on time (independent variable) for each two-digit industry with moving five-year windows. Next, we calculated the antilog of the standard error of the regression slope coefficient, and used it to measure environmental dynamism (ED). That is, the higher the value of environmental dynamism, the greater the variability and turbulence within the industry.

3.2.4 Financial constraints. This study uses the SA index proposed by Hadlock and Pierce (2010) to capture firm-level financial constraints (FC). Unlike the traditional measures of financial constraints such as Kaplan-Zingales (KZ), paying dividends, and White-Wu indices, the SA index is based solely on firm size and age, which is more exogenous than most of the other alternatives. A firm with a high SA index is considered more financially constrained. The SA index is as follows:

$$SA_{i,t} = -0.737 \times \mathrm{ASSET}_{i,t} + 0.043 \times \mathrm{ASSET}_{i,t}^{2} - 0.04 \times \mathrm{AGE}_{i,t} \quad (2)$$

where ASSET is the natural logarithm of total assets. AGE is the number of years since the firm was set up. To reduce the effects of a few extreme values, we winsorized the components of the SA index at the 1st and 99th percentiles.

3.2.5 Control variables. In order to improve the robustness and generalizability, some firm-level and industry-level variables are controlled. To control for the effect of the firm size that might be related to the difference in allocating resources across ventures and nonlinearities in the size-survival relationship (Howell, 2015), firm size and its square term are incorporated into our model. We define firm size as the natural logarithm of the total sales. Next, firm productivity is incorporated into our model, which is calculated by using the method proposed by Levinsohn and Petrin (2003). It is argued that enterprises with high productivity may enjoy better resource-deploying ability and lower hazard rates. As further controls, capital intensity, measured by the logarithm of the ratio of capital to total employees, is used as a control variable in our model. It is believed that capital intensity could act as a proxy for scale economics, thus playing an important role in venture survival. Finally, in line with recent empirical studies (Howell, 2015), three industry-level control variables are incorporated into the model, including average firm age, average firm size and industry entry. Concretely, average firm size and average firm age are measured by the mean value of firm size and firm age at two-digit industry separately. Industry entry rate is measured by the the ratio of the number of new entry ventures to the total number of plants in each two-digit industry. Empirical evidence suggests that new ventures are more likely to fail under industries with a higher entry rate.

3.3 Model specification

Three different models are used to test our hypotheses (see flowchart in Figure 1). Concretely, Model 1 is used to identify the existence of inventory stickiness. Model 2 and Model 3 are used to explore the direct and moderating effects of inventory stickiness on venture survival separately. Therefore, Model 1 and Model 2 are used to prove hypothesis 1. Model 2 and Model 3 are used to prove hypothesis 2 and hypothesis 3, respectively. Concretely, according to the definition of inventory stickiness, Model 1 is as follows:

$$\log\frac{\mathrm{INV}_{i,t}}{\mathrm{INV}_{i,t-1}} = \alpha_0 + \alpha_1 \log\frac{\mathrm{SALE}_{i,t}}{\mathrm{SALE}_{i,t-1}} + \alpha_2 \mathrm{Decrease\_Dummy}_{i,t} \times \log\frac{\mathrm{SALE}_{i,t}}{\mathrm{SALE}_{i,t-1}} + \varepsilon_{i,t} \quad (3)$$

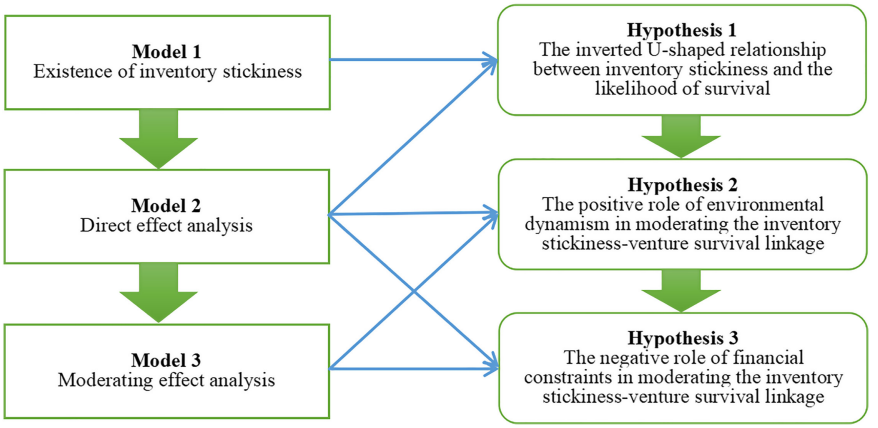

Figure 1.
The flowchart of model specification

where INV represents inventory, SALE represents sales, Decrease_Dummy is a dummy variable that takes the value of 1 when sales decreases between two periods, 0 otherwise. The coefficient α_1 captures the increase in percentage terms in inventory, with a 1% increase in sales. Similarly, the sum of α_1 and α_2 captures the decrease in percentage terms in inventory, with a 1% decrease in sales. Therefore, if inventory stickiness exists, α_1 will be positive and significant, contingent on α_2 being negative and significant.

Next, we employ accelerated failure time (AFT) model with a shared frailty log-normal regression survival analysis to test our hypothesis. Models 2 and 3 are as follows:

Model 2:

$$\ln(T_{i,t}) = \beta_0 + \beta_1 \mathrm{INVSTI}_{i,t} + \beta_2 \mathrm{INVSTI}_{i,t}^2 + \beta_3 ED_{j,t} + \beta_4 FC_{i,t} + \beta \mathrm{CONTROL} + \sum \beta_t Y_t + \sum \beta_t I_t + \mu \tag{4}$$

Model 3:

$$\ln(T_{i,t}) = \beta_0 + \beta_1 \mathrm{INVSTI}_{i,t} + \beta_2 \mathrm{INVSTI}_{i,t}^2 + \beta_3 \mathrm{ED}_{j,t} + \beta_4 FC_{i,t} + \beta_5 \mathrm{INVSTI}_{i,t}^2 \times \mathrm{ED}_{j,t} + \beta_6 \mathrm{INVSTI}_{i,t} \times \mathrm{ED}_{j,t} + \beta_7 \mathrm{INVSTI}_{i,t}^2 \times \mathrm{FC}_{i,t} + \beta_8 \mathrm{INVSTI}_{i,t} \times \mathrm{FC}_{i,t} + \beta \mathrm{CONTROL} + \sum \beta_t Y_t + \sum \beta_t I_t + \mu \tag{5}$$

where j represents the two-digit industry, INVSTI represents the inventory stickiness, ED represents the environmental dynamism, FC represents the financial constraints and CONTROL represents control variables, including firm size, firm productivity, capital intensity, average firm size, average firm age and industry entry rate. In addition, year fixed effects (Y) and industry fixed effects (I) are controlled.

4. Analysis and results

4.1 Testing for existence of inventory stickiness

Before we investigate the impact of inventory stickiness on venture survival, we need to demonstrate the existence of inventory stickiness first, based on Model 1. Corresponding results are provided in Table 3, showing that the coefficient α_1 is positive and significant ($\alpha_1 = 0.2016, p < 0.01$), and the coefficient α_2 is negative significantly ($\alpha_2 = -0.0962, p < 0.01$). These results indicate the existence of inventory stickiness.

4.2 Testing direct effects and moderating effects

Table 4 provides estimation results for the relationship between inventory stickiness and venture survival, and the moderating effects of environmental dynamism and financial

Table 3. Test for existence of inventory stickiness

Dependent variable: $\log(\mathrm{INV}_{i,t}/\mathrm{INV}_{i,t\text{-}1})$	Coefficient	Test for inventory stickiness
$\mathrm{Log}(\mathrm{SALE}_{i,t}/\mathrm{SALE}_{i,t\text{-}1})$	α_1	0.2016***(31.6786)
$\mathrm{Decrease\_Dummy}_{i,t} \times \mathrm{Log}(\mathrm{SALE}_{i,t}/\mathrm{SALE}_{i,t\text{-}1})$	α_2	−0.0962***(−5.5545)
Intercept	α_0	0.1279***(37.2919)
Observations		340,752
Adjusted R^2		0.007

Note(s): ***$p < 0.01$. t statistics in parentheses

constraints on this relationship. Column (1) reports results of the impacts of control variables on venture survival, showing that five of control variables are significantly related to the likelihood of survival. Then, we add the inventory stickiness and the quadratic term of inventory stickiness as independent variables in order to test the inverted U-shaped relationship (Hypothesis 1), as well as two moderators: environmental dynamism and financial constraints. Note that as the inventory stickiness indicator is only used for the analysis during the sales decline, the number of samples in this model is reduced. Results of the direct effect of inventory stickiness on venture survival are provided in Column (2), showing that the coefficient of the quadratic term of inventory stickiness is significant ($p < 0.01$) and negative (−0.0067), and the coefficient of inventory stickiness is significant

	(1)	(2)	(3)
Control variables			
Average firm age	−0.1016	−0.2114**	−0.2090*
	(−1.6210)	(−1.9703)	(−1.9480)
Average firm size	−0.0733***	−0.0674	−0.0652
	(−3.2142)	(−1.3733)	(−1.3290)
New industry entry	0.0287	1.1490	1.2353
	(1.0972)	(1.1553)	(1.2417)
Firm size^2	−0.0754***	−0.0240***	−0.0240***
	(−57.3969)	(−9.6130)	(−9.5831)
Firm size	1.5342***	0.5727***	0.5727***
	(60.1139)	(12.0457)	(12.0185)
Firm productivity	0.0379***	0.0600***	0.0600***
	(80.8558)	(60.1962)	(60.2031)
Capital intensity	−0.0553***	−0.0367***	−0.0362***
	(−10.7306)	(−7.2402)	(−7.1485)
Direct effect			
Environmental dynamism (ED)		0.0269	0.0235
		(0.9584)	(0.8348)
Financial constraints (FC)		−0.0052***	−0.1124**
		(−2.7455)	(−2.0541)
Inventory stickiness (IS)		0.0252***	0.0255***
		(7.4838)	(7.4067)
Inventory stickiness^2 (IS^2) H1		−0.0067***	−0.0075***
		(−6.2551)	(−6.7918)
Interactions			
$IS^2 \times ED$ H2			0.0026**
			(2.3924)
$IS^2 \times FC$ H3			−0.0361***
			(−2.6187)
IS × ED			−0.0022
			(−0.6340)
IS × FC			−0.0529
			(−1.2374)
Intercept	−0.2757	−0.2550	−0.2990
	(−0.4293)	(−0.3315)	(−0.3884)
Year fixed effects	YES	YES	YES
Industry fixed effects	YES	YES	YES
Observations	527,044	76,583	76,583
Log-likelihood	−118583.79	−21735.651	−21726.555

Note(s): ***$p < 0.01$, **$p < 0.05$,*$p < 0.1$. t statistics in parentheses

Table 4.
Test for direct and moderating effects of inventory stickiness on venture survival

($p < 0.01$) and positive (0.0252). Results suggest that an inverted U-shaped relationship exists between inventory stickiness and the likelihood of survival. That is, inventory stickiness has a positive impact on the likelihood of survival when it is low, but exhibits a negative relationship with the likelihood of survival when it is high, in support of H1.

Furthermore, Column (3) provides the results for the moderating effects of environmental dynamism and financial constraints on the relationship between inventory stickiness and the likelihood of survival. As suggested by Gligor (2016), we focus on the coefficient of the second-order interaction coefficients (i.e. quadratic term × moderator). Concretely, we find that the coefficient of the interaction term between the quadratic term of inventory stickiness and environmental dynamism is significant ($p < 0.05$) and positive (0.0026), while the coefficient of the interaction term between the quadratic term of inventory stickiness and financial constraints is significant ($p < 0.01$) and negative (−0.0361). Results suggest that environmental dynamism positively moderates the inverted U-shaped relationship between inventory stickiness and the likelihood of survival, and financial constraints negatively moderate this relationship, supporting H2 and H3.

To gain more insight into empirical results, we depict the direct and moderating effects. Concretely, we plot the curvilinear effect of inventory stickiness on survival duration in Figure 2. The figure shows the inverted U-shaped relationship between inventory stickiness and venture survival. The turning point occurs at inventory stickiness 1.8809. From the perspective of improving survival ability, the turning point reminds industrialists that this value should be used as the upper limit of inventory stickiness. Next, we plot the moderating effect of environmental dynamism on the relationship between inventory stickiness and survival duration in Figure 3. We split the environmental dynamism into two groups: low (one standard deviation below the mean) and high (one standard deviation above the mean). Then, we graph the inventory stickiness results along the survival duration at both high and low levels of environmental dynamism. As shown in Figure 3, the results support our hypothesis that environmental dynamism positively moderates the inverted U-shaped

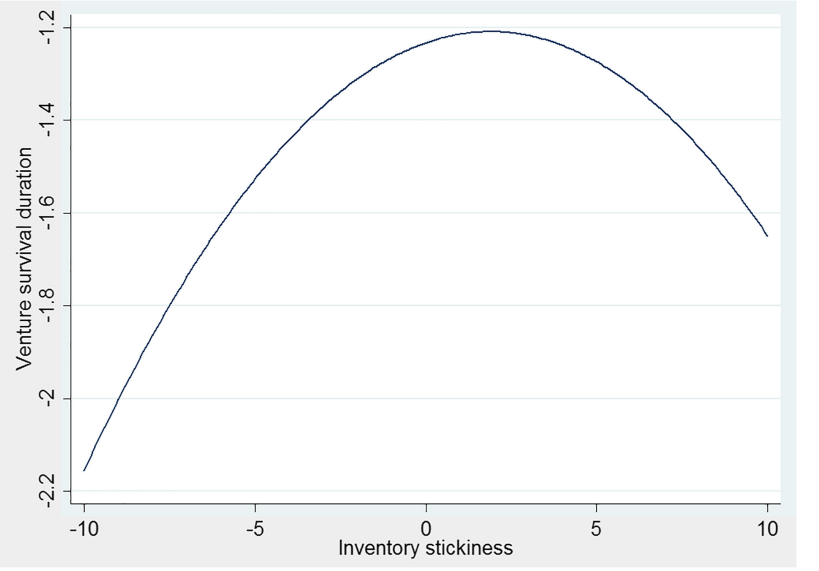

Figure 2.
The inverted U-shaped relationship between inventory stickiness and venture survival

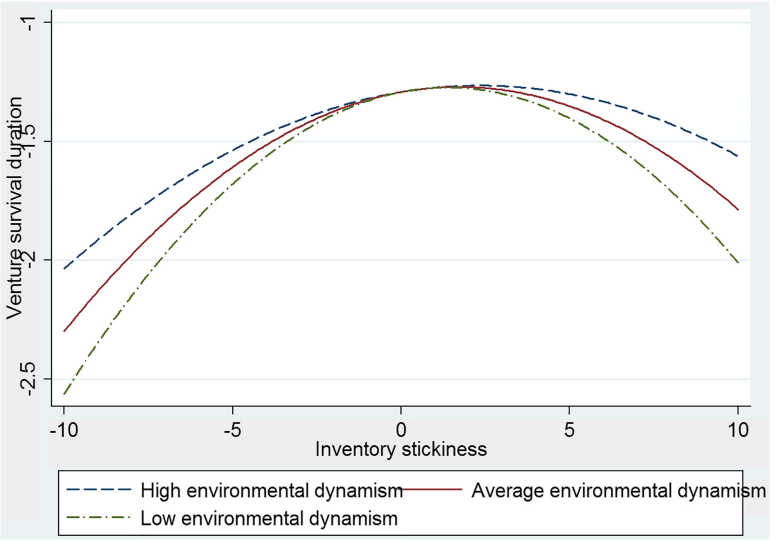

Figure 3.
The moderating effect of environmental dynamism on the relationship between inventory stickiness and venture survival

relationship between inventory stickiness and the likelihood of survival. In the same way, we graph the moderating effect of financial constraints in Figure 4. The curvilinear relationship between inventory stickiness and survival duration varies according to our predictions, suggesting that financial constraints negatively moderate the inverted U-shaped impact of inventory stickiness on the likelihood of survival.

4.3 Robustness checks

We conduct five separate robustness checks to strengthen and support our hypotheses. We mainly repeat the quadratic and interaction models of our regression analysis shown in Columns (2) and (3) in Table 4. The corresponding results support our previous findings and are presented in Tables 5 to 9.

First, we examine whether variations in survival distribution affect our results. We run log-logistic and Weibull distributions under AFT models based on the same sample. The results of log-logistic and Weibull distributions are provided in Columns (1) to (4) in Table 5 separately. We calculate the akaike information criterion (AIC) and find that the lowest value is log-normal distribution, providing evidence that log-normal is the best fit distribution. However, the results of Weibull and log-logistic distribution remain broadly the same as before.

As a second robustness check, we examine whether our results are robust to other hazard models for survival analysis. Specifically, we replicate our analysis under Cox and discrete-time hazard models in line with recent studies. Note that as the dependent variable of the Cox model is hazard rate, the positive coefficient of inventory stickiness under the Cox model indicates the reduction in the likelihood of survival. Similarly, the dependent variable of the discrete-time model is a binary variable, which equals to 1 if the venture fails, 0 otherwise. Hence, the positive coefficient of inventory stickiness under the discrete-time model means the reduction in the likelihood of survival. Therefore, the coefficients of the quadratic term of inventory stickiness in these two models are expected to be positive. Estimation results under Cox and discrete-time models are reported in Columns (1) to (4) in Table 6 separately. Concluding, the results increase our confidence in the robustness of our results.

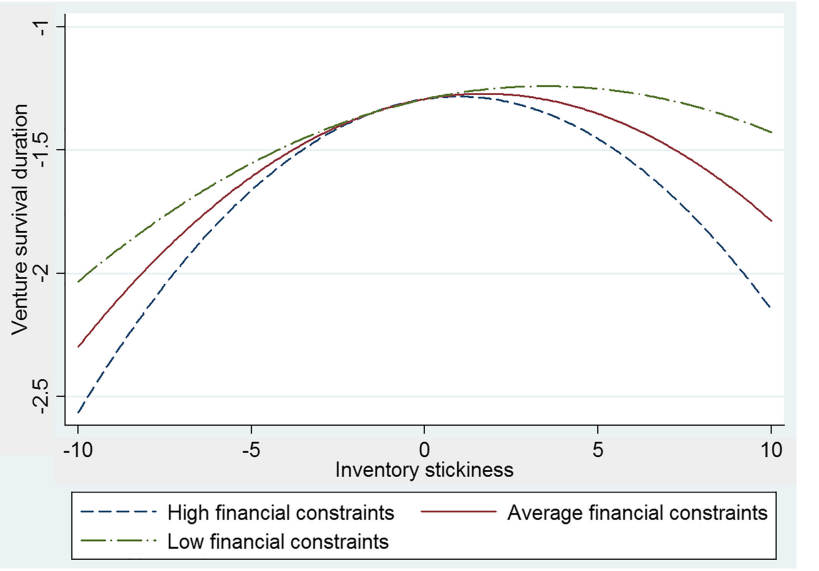

Figure 4.
The moderating effect of financial constraints on the relationship between inventory stickiness and venture survival

The purpose of the third robustness is to minimize concerns that our results are susceptible to selection bias caused by self-selection and sample selection. On the one hand, our sample only refers to ventures that reported sales in the initial year. As argued by Heckman (2013), self-selection may lead to overestimation when sampling is conducted on the outcome variables such as venture failure. To reduce this selection bias, we employ Heckman`s two-step approach to control for self-selection. We define a binary variable as the dependent variable: 1 if the firm had sales; 0, if the firm did not have sales. Then, we estimate the probit regression for each year, having these following predictor variables: firm size, industry dummies (two-digit industry), capital intensity and owner equity percentage. The obtained inverse Mills ratio is then used as a predictor in the second stage to estimate the direct and moderating effects of inventory stickiness on venture survival. Results provided in Columns (1) and (2) in Table 7 indicate that signs and statistical significance of main variables remain unchanged. On the other hand, as our sample covers non-state-owned firms with annual sales over 5 million Chinese yuan, equivalent to around USD700,000. This means that some non-state-owned firms may not actually exit or fail because their sales are just less than the lower limit. Following the methodology in Deng *et al.* (2014), we drop samples whose sales are lower than 8 million Chinese yuan. Results reported in Columns (3) and (4) in Table 7 do not suggest that sample selection affects the previous estimations as all coefficients remain unchanged.

Fourth, we also conduct an additional robustness check to rule out possible problems stemming from two debates about inventory stickiness. First, we use samples that have the same change tendency in inventory and sales. Similar results hold and are reported in Columns (1) and (2) in Table 8. Second, it is believed that the decline in sales may be temporary and that excess inventory may be used as the market condition improves. To address this problem, we examine whether our findings hold when using samples that show sales decline in some year but then increase the following year. Results are reported in Columns (3) and (4) in Table 8, and are consistent with previous findings.

	(1) Log-logistic distribution	(2) Log-logistic distribution	(3) Weibull distribution	(4) Weibull distribution
Control variables				
Average firm age	−0.2445**	−0.2410**	−0.2229**	−0.2193**
	(−2.1349)	(−2.1053)	(−2.0464)	(−2.0131)
Average firm size	−0.0861	−0.0839	−0.0862*	−0.0836*
	(−1.6174)	(−1.5750)	(−1.7126)	(−1.6613)
New industry entry	0.9850	1.0674	0.4765	0.5458
	(0.9291)	(1.0065)	(0.4656)	(0.5328)
Firm size^2	−0.0215***	−0.0217***	−0.0246***	−0.0244***
	(−8.1831)	(−8.2486)	(−10.3582)	(−10.1965)
Firm size	0.5428***	0.5459***	0.5845***	0.5804***
	(11.0121)	(11.0762)	(13.0385)	(12.8815)
Firm productivity	0.6658***	0.6657***	0.5996***	0.6004***
	(54.1211)	(54.1017)	(53.3114)	(53.3484)
Capital intensity	−0.0980***	−0.0952***	−0.0133***	−0.0135***
	(−9.5435)	(−9.1744)	(−7.8048)	(−7.8767)
Direct effect				
Environmental	0.0181	0.0151	0.0158	0.0134
dynamism (ED)	(0.5969)	(0.4962)	(0.5497)	(0.4650)
Financial constraints	−0.1461***	−0.1129**	−0.1583***	−0.1465***
(FC)	(−2.5863)	(−1.9801)	(−3.4162)	(−2.9461)
Inventory stickiness (IS)	0.0276***	0.0278***	0.0253***	0.0256***
	(8.0627)	(7.9640)	(7.5386)	(7.5051)
Inventory stickiness^2	−0.0068***	−0.0075***	−0.0066***	−0.0071***
(IS^2) H1	(−6.4536)	(−6.9378)	(−7.2533)	(−7.5975)
Interactions				
$IS^2 \times ED$ H2		0.0021**		0.0018**
		(2.0402)		(2.0988)
$IS^2 \times FC$ H3		−0.0378**		−0.0221**
		(−2.4440)		(−2.3553)
IS × ED		−0.0019		−0.0009
		(−0.5536)		(−0.2692)
IS × FC		−0.0441		−0.0323
		(−1.0361)		(−0.8110)
Intercept	0.1318	0.0698	0.4658	0.4370
	(0.1592)	(0.0844)	(0.5950)	(0.5579)
Year fixed effects	YES	YES	YES	YES
Industry fixed effects	YES	YES	YES	YES
Observations	76,583	76,583	76,583	76,583
Log-likelihood	−22357.521	−22350.033	−22711.961	−22703.999

Note(s): ***$p < 0.01$, **$p < 0.05$,*$p < 0.1$. t statistics in parentheses

Table 5. Robustness check results for alternative survival distributions

Finally, we assess whether our results are sensitive to the measurement of financial constraints. As a robustness check, we build two synthetic indices covering financial constraints as widely as possible. Concretely, we exploit information from six variables: total assets, liquidity (current asset over current liabilities), solvency (own funds over total liabilities), profitability (return on total assets), cash (cash holding over total assets) and trade credit over total assets. Then, each variable is scaled according to its corresponding two-digit industry average for each year. Next, we place for each of the six variables a number from 1 to

	(1) Cox model	(2) Cox model	(3) Discrete-time model	(4) Discrete-time model
Control variables				
Average firm age	0.5363*	0.5262*	0.6608**	0.6491**
	(1.7185)	(1.6847)	(2.2693)	(2.2257)
Average firm size	0.1963	0.1895	0.1676	0.1618
	(1.2946)	(1.2480)	(1.2564)	(1.2132)
New industry entry	−2.0553	−2.2490	−2.0549	−2.2951
	(−0.7049)	(−0.7700)	(−0.7508)	(−0.8374)
Firm size^2	0.0625***	0.0619***	0.0487***	0.0484***
	(9.3766)	(9.2513)	(7.3371)	(7.2335)
Firm size	−1.4864***	−1.4758***	−1.2506***	−1.2453***
	(−11.8913)	(−11.7723)	(−10.0418)	(−9.9337)
Firm productivity	−1.0560***	−1.0582***	−0.0254	−0.0272
	(−33.3012)	(−33.3694)	(−0.7540)	(−0.8077)
Capital intensity	0.0343***	0.0348***	0.1926***	0.1918***
	(4.4439)	(4.5070)	(14.5425)	(14.3924)
Direct effect				
Environmental dynamism	−0.0702	−0.0633	−0.1099	−0.0996
(ED)	(−0.7890)	(−0.7119)	(−1.4368)	(−1.3035)
Financial constraints (FC)	0.4214***	0.3950***	0.4028***	0.3799***
	(3.5680)	(3.2118)	(3.3652)	(2.9015)
Inventory stickiness (IS)	−0.0675***	−0.0684***	−0.0742***	−0.0759***
	(−7.5124)	(−7.4188)	(−8.2212)	(−8.2687)
Inventory stickiness^2 (IS^2) H1	0.0164***	0.0177***	0.0164***	0.0182***
	(6.6141)	(7.0948)	(6.4151)	(6.8708)
Interactions				
$IS^2 \times ED$ H2		−0.0049**		−0.0068***
		(−2.1820)		(−2.6982)
$IS^2 \times FC$ H3		0.0556*		0.0455*
		(1.7067)		(1.7109)
IS × ED		0.0028		0.0085
		(0.3125)		(0.9503)
IS × FC		0.0879		0.0796
		(0.6733)		(0.7910)
Intercept			3.2376	3.3559
			(1.5546)	(1.6090)
Year fixed effects	YES	YES	YES	YES
Industry fixed effects	YES	YES	YES	YES
Observations	76,583	76,583	51,879	51,879
Log-likelihood	−91762.441	−91755.021	−22746.431	−22737.977

Note(s): ***$p < 0.01$, **$p < 0.05$,*$p < 0.1$. t statistics in parentheses

Table 6. Robustness check results for alternative hazard models

5 according to the quintiles of its distribution. Therefore, we obtain two synthetic variables of financial constraints in different ways: a simple sum of six scores (*Score A*); the number of dimensions for which the firm/year lies in the first quintile (*Score B*). Note that both *Score A* and *Score B* are studentized and subsequently multiplied by (−1) so that higher value indicates the firm is more financial constrained. The estimation results are reported in Columns (1) to (4) in Table 9. The coefficient and significant of main variables remain broadly the same as before.

	(1) Self-selection bias	(2) Self-selection bias	(3) Sample selection bias	(4) Sample selection bias
Control variables				
Average firm age	−0.2558**	−0.2527**	−0.1415	−0.1396
	(−2.2198)	(−2.1940)	(−1.0999)	(−1.0847)
Average firm size	−0.0923*	−0.0904*	0.0024	0.0037
	(−1.7240)	(−1.6868)	(0.0408)	(0.0618)
New industry entry	0.9451	1.0261	1.7851	1.8935
	(0.8870)	(0.9626)	(1.4979)	(1.5885)
Firm size^2	−0.0224***	−0.0223***	−0.0287***	−0.0287***
	(−8.0012)	(−7.9438)	(−9.6001)	(−9.5870)
Firm size	0.5604***	0.5597***	0.6402***	0.6419***
	(10.7239)	(10.6611)	(11.1068)	(11.1051)
Firm productivity	0.6647***	0.6647***	0.7389***	0.7383***
	(53.7234)	(53.7116)	(51.3614)	(51.3040)
Capital intensity	−0.1080***	−0.1052***	−0.0292***	−0.0286***
	(−10.2492)	(−9.8660)	(−5.4090)	(−5.2987)
Direct effect				
Environmental dynamism (ED)	0.0179	0.0150	0.0858**	0.0820**
	(0.5883)	(0.4934)	(2.4880)	(2.3752)
Financial constraints (FC)	−0.2231***	−0.1829***	−0.0966	−0.0398
	(−3.3310)	(−2.6370)	(−1.5578)	(−0.6037)
Inventory stickiness (IS)	0.0275***	0.0277***	0.0327***	0.0335***
	(7.9829)	(7.9042)	(8.0766)	(8.1334)
Inventory stickiness^2 (IS^2) H1	−0.0068***	−0.0075***	−0.0079***	−0.0087***
	(−6.4489)	(−6.8887)	(−6.2810)	(−6.7247)
Interactions				
$IS^2 \times$ ED H2		0.0020**		0.0021*
		(1.9755)		(1.6689)
$IS^2 \times$ FC H3		−0.0344**		−0.0691***
		(−2.2343)		(−3.7027)
IS × ED		−0.0022		−0.0050
		(−0.6211)		(−1.2160)
IS × FC		−0.0414		−0.1191**
		(−0.9773)		(−2.4043)
Mills ratio sales	1.5842*	1.3583		
	(1.7227)	(1.4357)		
Intercept	−0.0762	−0.0851	−1.5015	−1.5471*
	(−0.0888)	(−0.0989)	(−1.6191)	(−1.6679)
Year fixed effects	YES	YES	YES	YES
Industry fixed effects	YES	YES	YES	YES
Observations	76,278	76,278	65,950	65,950
Log-likelihood	−22178.755	−22172.053	−16762.213	−16750.41

Note(s): ***$p < 0.01$, **$p < 0.05$,*$p < 0.1$. t statistics in parentheses

Table 7. Robustness check results for selection bias

5. Discussion and implications

The purpose of our study is to investigate the impact of inventory stickiness on venture survival. We firstly hypothesize the inverted U-shaped relationship between inventory stickiness and the likelihood of survival. Then, we formulate a moderation model to examine whether environmental dynamism and financial constraints would moderate this relationship. Three key findings of our study advance our understanding of the relationship between inventory stickiness and venture survival.

	(1) Same change tendency	(2) Same change tendency	(3) Next year sales increase	(4) Next year sales increase
Control variables				
Average firm age	−0.2191*	−0.2155*	−0.0955	−0.0928
	(−1.9575)	(−1.9250)	(−0.9963)	(−0.9681)
Average firm size	−0.0770	−0.0730	−0.0124	−0.0109
	(−1.5132)	(−1.4327)	(−0.2832)	(−0.2472)
New industry entry	1.4782	1.5850	1.5041*	1.5677*
	(1.4201)	(1.5221)	(1.7213)	(1.7934)
Firm size^2	−0.0226***	−0.0228***	−0.0153***	−0.0154***
	(−8.6293)	(−8.6623)	(−7.3411)	(−7.3803)
Firm size	0.5468***	0.5496***	0.3566***	0.3588***
	(10.9680)	(10.9944)	(9.0132)	(9.0569)
Firm productivity	0.7163***	0.7165***	0.7125***	0.7130***
	(56.5774)	(56.5845)	(71.7727)	(71.8128)
Capital intensity	−0.0329***	−0.0322***	−0.0240***	−0.0239***
	(−6.4725)	(−6.3162)	(−6.1358)	(−6.1070)
Direct effect				
Environmental dynamism (ED)	0.0095	0.0062	0.0642**	0.0612**
	(0.3259)	(0.2104)	(2.5572)	(2.4377)
Financial constraints (FC)	−0.1676***	−0.1243**	−0.0678	−0.0407
	(−2.8992)	(−2.0417)	(−1.4107)	(−0.8201)
Inventory stickiness (IS)	−0.0153**	−0.0147**	0.0260***	0.0267***
	(−2.4462)	(−2.3301)	(9.1563)	(9.2477)
Inventory stickiness^2 (IS^2) H1	−0.0170***	−0.0181***	−0.0039***	−0.0044***
	(−9.0431)	(−9.4288)	(−4.2973)	(−4.8154)
Interactions				
$IS^2 \times ED$ H2		0.0042**		0.0021**
		(2.3156)		(2.3301)
$IS^2 \times FC$ H3		−0.0608***		−0.0253**
		(−2.9595)		(−2.2962)
IS × ED		0.0024		−0.0028
		(0.3854)		(−0.9307)
IS × FC		−0.0690		0.0003
		(−1.2954)		(0.0098)
Intercept	−0.0341	−0.1132	−0.6514	−0.6972
	(−0.0426)	(−0.1413)	(−0.9614)	(−1.0288)
Year fixed effects	YES	YES	YES	YES
Industry fixed effects	YES	YES	YES	YES
Observations	67,068	67,068	56,847	56,847
Log-likelihood	−19231.622	−19221.56	−15612.28	−15605.131

Note(s): ***$p < 0.01$, **$p < 0.05$,*$p < 0.1$. t statistics in parentheses

Table 8. Robustness check results for inventory stickiness

5.1 Main findings

Firstly, our results show that low and moderate levels of inventory stickiness are positively related to the likelihood of survival, but higher levels of inventory stickiness produce a negative impact on the likelihood of survival (see Figure 2). Unlike previous studies on the relationship between inventory stickiness and financial performance (Kroes and Manikas, 2018), we did not find a negative linear relationship between inventory stickiness and venture survival. The argument made in support of the linear relationship is that inventory stickiness

	(1) *Score A*	(2) *Score A*	(3) *Score B*	(4) *Score B*
Control variables				
Average firm age	−0.2114**	−0.2090*	−0.2114**	−0.2088*
	(−1.9703)	(−1.9480)	(−1.9703)	(−1.9453)
Average firm size	−0.0674	−0.0653	−0.0674	−0.0659
	(−1.3734)	(−1.3290)	(−1.3734)	(−1.3430)
New industry entry	1.1490	1.2353	1.1490	1.2353
	(1.1553)	(1.2417)	(1.1553)	(1.2417)
Firm size^2	−0.0240***	−0.0240***	−0.0240***	−0.0241***
	(−9.6131)	(−9.5831)	(−9.6131)	(−9.6056)
Firm size	0.5727***	0.5728***	0.5726***	0.5734***
	(12.0459)	(12.0185)	(12.0458)	(12.0395)
Firm productivity	0.7203***	0.7205***	0.7464***	0.7494***
	(60.1973)	(60.2026)	(48.9902)	(48.9256)
Capital intensity	−0.0367***	−0.0362***	−0.0367***	−0.0363***
	(−7.2403)	(−7.1484)	(−7.2402)	(−7.1781)
Direct effect				
Environmental dynamism (ED)	0.0322	0.0276	0.0269	0.0235
	(1.1435)	(0.9791)	(0.9584)	(0.8348)
Financial constraints (FC)	−0.1066***	−0.0833**	−0.1045***	−0.0816**
	(−2.7455)	(−2.0541)	(−2.7455)	(−2.0541)
Inventory stickiness (IS)	0.0252***	0.0255***	0.0252***	0.0255***
	(7.4838)	(7.4101)	(7.4838)	(7.4068)
Inventory stickiness^2 (IS^2) H1	−0.0067***	−0.0075***	−0.0067***	−0.0075***
	(−6.2551)	(−6.7865)	(−6.2551)	(−6.7918)
Interactions				
$IS^2 \times ED$ H2		0.0038***		0.0026**
		(3.4516)		(2.3924)
$IS^2 \times FC$ H3		−0.0246***		−0.0241***
		(−2.6187)		(−2.6187)
IS × ED		−0.0004		−0.0022
		(−0.1205)		(−0.6340)
IS × FC		−0.0360		−0.0353
		(−1.2374)		(−1.2374)
Intercept	−0.2550	−0.2989	−0.2550	−0.2990
	(−0.3314)	(−0.3884)	(−0.3315)	(−0.3884)
Year fixed effects	YES	YES	YES	YES
Industry fixed effects	YES	YES	YES	YES
Observations	76,583	76,583	76,583	76,583
Log-likelihood	−21735.651	−21726.555	−21735.651	−21727.538

Note(s): ***$p < 0.01$, **$p < 0.05$,*$p < 0.1$. t statistics in parentheses

Table 9. Robustness check results for alternative financial constraints

represents the waste in firms. Although inventory stickiness may damage profitability, the added buffer protects new SMEs from failure by maintaining a medium inventory stickiness. Next, turning our attention to interpreting the inverted U-shaped curve's inflection point, we find that the inflection point is close to the right extreme range of the inventory stickiness variable. Concretely, the mean-centered inventory stickiness ranges from −10.03 to 9.33, with a mid-range equal to 0. Results in Column 2 of Table 4 indicate that the inflection point is located at a level of inventory stickiness equal to 1.88. That is, the likelihood of survival increases within the [-10.03, 1.88] range of inventory stickiness, while it decreases within the [1.88, 9.33]. Moreover, we tabulate the percentage of firms below the inflection point. In our

samples, at least 95% of the new SMEs have a lower inventory stickiness than the inflection point, indicating that inventory stickiness leads to decreasing survival likelihood only if it is extremely excessive.

Second, with the enhancement of environmental dynamism, the relationship between inventory stickiness and venture survival will become weaker such that a deviation from the optimal level of inventory stickiness will result in a smaller decrease in the likelihood of survival (see Figure 3). As far as the environmental dynamism is concerned, researches related to our study mainly focus on its moderating effect. Concretely, Azadegan *et al.* (2013) investigated the moderating effect of environmental dynamism on the relationship between operational slack and venture survival. Their results demonstrated that the likelihood of venture failure is reduced while increasing inventory slack at higher levels of environmental dynamism. That is, holding excess inventory contributes to increasing survival likelihood in dynamic environments, which is similar to results in our study. Meanwhile, another related research explored the role of environmental dynamism in moderating the impact of inventory stickiness on financial performance (Kroes and Manikas, 2018). Their results noted that environmental dynamism diminishes the negative relationship between inventory stickiness and financial performance. Therefore, in order to understand the role of environmental dynamism in moderating the impact of inventory stickiness on venture survival, the key is whether the positive effect caused by the inventory stickiness as a buffer against environment threats allows enterprises to cover up the cost effect induced by holding excess inventory. Our results suggest that this is indeed the case.

Finally, we find that a deviation from the optimal inventory stickiness results in a relatively greater decrease in the survival likelihood of the financially constrained enterprises (see Figure 4). Furthermore, overall levels of the likelihood of survival decrease as the degree of financial constraints increases, which signifies that financial constraints can increase the likelihood of failure. This may be because of the fact that sticky inventory management may place an even larger cost burden for the financially constrained new SMEs, and thus make them more vulnerable to failure. This finding is consistent with the argument that financial constraints may limit the positive effects of inventory stickiness by increasing the operating costs and risk. This finding also echoes the arguments of the negative effects of financial constraints on the likelihood of survival (Okpara, 2011).

5.2 Theoretical implications

Given the above, our theoretical implications mainly focus on the inverted U-shaped relationship between inventory stickiness and venture survival, as well as the positive moderating effect of environment dynamism and negative moderating effect of financial constraints on this relationship. Need of special note is that, for new SMEs, although moderate sticky inventory management is conducive to improving the likelihood of survival, the waste of inventory caused by excessive inventory stickiness will still damage the survival ability of new SMEs. This shows that sticky inventory management and lean inventory management are not contradictory. Both emphasize that the cost waste caused by excess inventory can damage profitability. However, new SMEs pay more attention to improve survival ability rather than increasing profits. Although lean inventory management may improve survival ability by increasing profits, considering that lean inventory management requires long-term implementation and it is difficult to achieve results in the short term, new SMEs have to hold excess inventory to ensure stable production and timely delivery. It can be seen that, for new SMEs, moderate sticky inventory management may help improve their survival ability before achieving effective lean inventory management.

5.3 Practical implications

Our study offers some important practical implications for managers of new SMEs. Our findings indicate that inventory stickiness has an inverted U-shaped relationship with the likelihood of survival. This would seem prudent for managers to recognize that sticky inventory management can help increase the likelihood of survival of new SMEs, while excessive inventory stickiness may decrease the likelihood of survival. Meanwhile, we find that the inflection point lies at the extreme end of the investigated sample. This suggests that most new SMEs still have much potential to increase the likelihood of survival by improving inventory stickiness, and they are unlikely to cross the threshold where the likelihood of survival decreases with improved inventory stickiness. However, it should be noted that the above conclusions may only apply to newly established SMEs. New SMEs limited by insufficient lean inventory management capabilities may have to sacrifice some profits to improve their survival ability. Therefore, considering that lean inventory management is a long-term and continuous implementation process, for managers of new SMEs who cannot improve inventory management in the short term, moderate sticky inventory management may be a stopgap measure to respond to the survival risks.

This research also reminds managers that they should understand the importance of environmental dynamism and financial constraints in moderating the relationship between inventory stickiness and venture survival. According to the positive moderating effect of environmental dynamism and the negative moderating effect of financial constraints, we suggest that managers should achieve a fit by improving inventory stickiness of new SMEs in a dynamic environment against supply chain disruptions. Meanwhile, although inventory stickiness is beneficial to venture survival, managers of financially constrained SMEs should prudently implement sticky inventory management. Accordingly, we trust this study will help managers to better understand how to increase the likelihood of survival.

6. Conclusion and future research

To sum up, this study takes a more sophisticated assessment of how to implement sticky inventory management in order to increase the likelihood of survival. This research adds to the theory of inventory management by exploring the role of inventory stickiness in impacting new SMEs' survival. Using a large sample of new manufacturing SMEs between 1999 and 2007 in China, we investigate the effect of inventory stickiness on venture survival, and how this effect is moderated by environmental dynamism and financial constraints. Our empirical results show that there is an inverted U-shaped relationship between inventory stickiness and the likelihood of survival. That is, lean inventory management and sticky inventory management are not contradictory but complementary. Concretely, both emphasize that the cost burden caused by excess inventory may affect the profitability and the likelihood of survival. However, considering that new SMEs pay more attention to venture survival, if effective lean inventory management cannot be achieved in the short term, sticky inventory management can be used as a stopgap measure. In addition, we find that this relationship is positively moderated by environmental dynamism and is negatively moderated by financial constraints. That is, new SMEs can improve their survival ability by increasing inventory stickiness in a dynamic environment. However, new SMEs that are financially constrained should prudently implement sticky inventory management.

However, this study also has several limitations that should be considered in the interpretation of the findings. First, the inventory stickiness indicator only applies to periods of decreasing revenues. Future studies should pay more attention to develop new indicators to capture more information on sticky inventory management. Second, the results are based entirely on Chinese new manufacturing SMEs. Although China has many of the same features as other countries in terms of operational management and market conditions, it also

has a certain degree of uniqueness. Future studies should pay more attention to other countries to extend the generalizability of our findings. Thirdly, although we have controlled the industry fixed effects as much as possible to reduce the influence of industry differences on the conclusions, industry differences still require more detailed comparative analysis. The relationship between inventory stickiness and venture survival within different industry needs to be explored. Finally, this study focuses on the moderating role of environmental dynamism and financial constraints, which are typically the main industry and firm heterogeneities. Future research should consider some other heterogeneity factors, such as firm size and environmental complexity, in order to provide a broader view of the impact of inventory stickiness on new SMEs' survival.

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