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Lean strategy in SMEs: Inventory leanness, operational leanness, and financial performance

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ABSTRACT

Lean strategy, aimed at optimizing resources, minimizing energy usage, and achieving zero waste in the production process, has been increasingly embraced to reduce systemwide costs in manufacturing. However, practitioners in small and medium-sized enterprises (SMEs) often lack the necessary expertize to implement lean strategies successfully. This study systematically examines the impact of lean strategy on the financial performance of Chinese SMEs. Specifically, we categorize lean strategy into two components: inventory leanness and operational leanness. We introduce a novel measure, the empirical production leanness indicator (EPLI), to quantify systematic production practices aimed at waste reduction. Drawing on a large sample of SMEs, our empirical findings suggest that both inventory leanness and operational leanness exhibit an inverted U-shaped relationship with an SME's financial performance. In conclusion, this study contributes to the lean literature and offers significant practical implications for SMEs seeking to benefit from adopting lean strategies.

1. Introduction

The world's manufacturing sector consumes substantial energy while producing an increased volume of waste. Moreover, this issue is even more severe in China, where the amount of energy consumption in manufacturing alone reaches up to 55.6% of the total national usage (Wen et al., 2021). Meanwhile, the rising energy cost is urging manufacturing to reconsider how to improve energy efficiency. Therefore, one significant lever to enhance the energy efficiency of manufacturing systems is to incorporate energy efficiency into daily production management (Bunse et al., 2011). Under this circumstance, lean strategy, whose primary advantage is its capability to integrate other fields, such as energy management, is one of the most effective initiatives to realize integration (Wen et al., 2021). For a clearer understanding, we categorized lean strategy into two parts: inventory leanness and operational leanness. Whereas inventory leanness means having a lower inventory level compared with similar-sized firms within the same industry and reflects the operational efficiency and flexibility of a firm (Eroglu & Hofer, 2011; Liu et al., 2023a,2023b). Operational leanness, on the other hand, refers to an effective multi-dimensional system that incorporates a series of lean practices to integrate manufacturing activities and eliminate waste that disrupts the smooth flow of production (Amin & Karim, 2013; Hofer et al., 2012; Jayaram et al., 2008; Kroes et al., 2018; Shah & Ward, 2003; Soliman et al., 2018; Tortorella et al., 2019; Womack et al., 1991). Therefore, lean strategy is a nuanced construct that reflects firms' competencies by utilizing inputs more effectively.

The implications of lean strategy on firm performance have generated a heated debate. From the perspective of lean philosophy, some researchers argue that lean practices allow various internal functions to work collaboratively and achieve operational improvements such as higher quality, lower energy consumption, higher throughput, and shorter lead times, thus increasing profitability (Kroes et al., 2018; Panwar et al., 2018; Soliman et al., 2018). In addition, Dolgui et al. (2020) also agree that lean practices offer useful techniques to reduce waste and enhance financial performance to accomplish leanness and

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agility. However, some researchers take the opposite view, contending that excessively striving for a lean strategy will adversely influence performance (Elking et al., 2017; Isaksson & Seifert, 2013; Wang et al., 2019). For example, Hosseini et al. (2019) proposed that firms implementing lean management may not assume excess inventory but will bear a higher disruption risk and related costs.

On the other hand, firms more susceptible to supply disruptions will have a higher likelihood of stockout, and this will severely damage customer loyalty and financial performance (Bendig et al., 2017a, 2017b; Bradley et al., 2011; Hendricks et al., 2009; Zhu et al., 2018). Moreover, adopting a lean strategy requires a more rapid and accurate flow of materials, which makes manufacturers more dependent on their suppliers, thus weakening firms' bargaining power (Elking et al., 2017). Notably, the outcomes of lean implementation may vary in different contexts. The prior literature also denotes that the economic ramifications of the lean strategy depend on organizational and industrial characteristics (e.g., marketplace conditions, supply chain integration extent, and the nature of the production process, etc.) (Chakrabarty & Wang, 2021; Eroglu & Hofer, 2014).

Theoretical controversy calls for more empirical investigations to explore the linkage between lean strategy and firm performance. For example, drawing on a sample of 310 manufacturing firms in the United States, Elking et al. (2017) report a linear positive relation between inventory leanness and financial performance, while other scholars suggest a non-linear association (Eroglu & Hofer, 2011, 2014; Hofer et al., 2012; Isaksson & Seifert, 2013). As for operational leanness, Hofer et al. (2012) concluded that operational leanness positively affects financial performance. In contrast, Jayaram et al. (2008) found that operational leanness exhibits a negligible relationship with financial performance. Prior survey-based studies mainly focused on large enterprises, while research on SMEs often employs the case study method to investigate how to adopt a lean strategy in SMEs (e.g., Belhadi et al., 2018a,2018b; Kumar et al., 2006) instead of evaluating lean strategies' performance implications. Given that the implementation of lean strategy can reduce waste volume, researching lean strategy in China can assist managers in finding feasible ways to reduce waste and simultaneously improve firm performance. Moreover, China, as the world's factory floor, plays an increasingly significant role globally. Therefore, it is imperative to determine the role of lean strategy in Chinese firms.

Due to the distinct organizational characteristics between SMEs and large enterprises, the findings in latter explored by previous studies may be inconsistent in former. On the one hand, compared to large enterprises, SMEs have a flatter hierarchy and more integrated functions, resulting in more effective communications between top management and employees and quicker decision-making, which may facilitate the implementation of lean strategy (Siegel et al., 2019; Yadav et al., 2019a; Yadav et al., 2019b). On the other hand, due to resources limitations, SMEs lack sufficient lean knowledge, training programs for employees, and investment required for lean initiatives, thereby severely restricting their abilities to integrate lean practices properly (Ali et al., 2020; Dora et al., 2016; Kumar et al., 2006; Siegel et al., 2019; Zhou, 2016). In addition, as SMEs increasingly play a critical role in the global supply chain, with their energy consumption accounting for over 13% of the world's total (Dey et al., 2020), it becomes necessary to empirically study the link between lean strategy and financial performance in SMEs. Motivated by this research gap, we propose the following questions:

RQ1:What is the relationship between lean strategy and SMEs' financial performance?

RQ2:To what extent should SMEs implement a lean strategy to achieve better performance?

Thus, we investigated the effect of lean strategy on firms' financial performance based on a large-scale sample of Chinese SMEs. This study contributes to the supply chain management literature by revealing two inverted U-shaped relationships (inventory leanness and operational leanness with an SME's financial performance). Firstly, it introduces a new method to measure the degree to which a firm implements operational leanness. We developed an innovative measurement, the Empirical Production Leanness Indicator (EPLI), to assess the extent of operational leanness in SMEs. Second, our novel findings deepen the understanding of the relationship between inventory leanness and firm financial performance. Third, the study explores the effect of operational leanness on financial performance. In contrast to Hofer et al. (2012), we observed a concave relationship between operational leanness and financial performance. More specifically, after a firm's operational leanness reaches a certain level, its financial performance will decline if its operational leanness continues to improve.

2. Literature review

Lean strategy is a holistic model to coordinate internal functions and supply chain partners that improves responses to customers' requirements and plays a vital role in enhancing energy and resource efficiency, effectiveness, productivity, and quality (Kroes et al., 2018; Jayaram et al., 2008; Motwani, 2003; Rahman et al., 2010; Soliman et al., 2018; Wang et al., 2019). Our lean strategy research primarily builds on two research streams. One is about how inventory and operational leanness affect financial performance generally, and the other is about the outcomes of lean strategy implementation. Table 1 summarizes the representative studies on lean strategy, according to which we can find that most existing studies focus on inventory leanness instead of operational leanness and pay particular attention to the financial and operational consequences of lean strategy.

2.1. The impact of inventory and operational leanness on firm performance

A large growing body of literature has determined the influence of inventory leanness on performance, but the results are mixed (Bendig et al., 2017a,2017b; Chakrabarty & Wang, 2021; Elking et al., 2017; Eroglu & Hofer, 2011, 2014; Hofer et al., 2012; Isaksson & Seifert, 2013; Lin et al., 2018; Wang et al., 2019; Zhu et al., 2018). Some scholars discovered that there is a positive linear relationship between inventory leanness and financial performance (Elking et al., 2017; Hofer et al., 2012), while others have argued that the relationship may be non-linear (Eroglu & Hofer, 2014; Isaksson & Seifert, 2013). More specifically, Eroglu and Hofer (2011) advanced inventory leanness, taking industry-specific contexts into account, and observed an inverted U-shaped association between inventory leanness and firm financial performance in 26 industries. Regarding operational performance, the linkage between inventory leanness and productivity is also non-linear, i.e., an inverted U-shaped (Zhu et al., 2018).

Studies also empirically examine the impacts of operational leanness on firm performance. For instance, Hofer et al. (2012) found that operational leanness has a linear positive effect on firm financial performance. However, Jayaram et al. (2008) suggested that lean manufacturing has no statistically significant impact on financial performance. Overall, there is no consensus on the influence of inventory and operational leanness on financial performance.

2.2. The outcomes of lean strategy implementation

Studies on lean strategy suggest that, in the logic of lean philosophy, implementing lean strategy could achieve a set of operational benefits, such as cost reduction, higher quality, and shorter lead times (Doolen & Hacker, 2005; Tortorella et al., 2019; Womack et al., 1991). For instance, Ivanov (2021) also assumed that lean production has many advantages, such as global sourcing, agility, and just-in-time. Thereby, lean strategy represents a great standard in operations management (Hofer et al., 2012). Moreover, the lean perspective relevant to value-creation emphasizes that lean strategy can reduce non-value-added activities by using effective lean practices (Jayaram et al., 2008; Wang et al., 2019; Yusuf & Adeleye, 2002), thus leading to a

Table 1
Representative studies on lean strategy.

Research	Year	Sample	Independent variable	Dependent variable	Shape	Methodology	Main findings
Jayaram et al. (2008)	2008	57 firms in the automotive supplier industry	Lean manufacturing, Lean design	Firm financial performance	Linear	Structural equation modeling	Lean design benefits firm financial performance; the association between lean manufacturing and firm financial performance is insignificant.
Rahman et al. (2010)	2010	187 Thai manufacturing firms	Lean practices (JIT, Waste minimization, and flow management)	Operational performance	Linear	Factor analysis, regression model	JIT, waste minimization, and flow management are associated with operational performance.
Eroglu and Hofer (2011)	2011	1600 U.S. manufacturing firms in 54 industries	Inventory leanness	Firm financial performance	Non-linear	Regression model	The relation between inventory leanness and firm financial performance is concave in numerous industries.
Hofer et al. (2012)	2012	1421 firms in 24 U.S. manufacturing industries	Operational leanness	Firm financial performance	Linear	Regression model	Operational leanness positively influences a firm's financial performance.
Eroglu and Hofer (2014)	2014	3610 firms from U.S. manufacturing industries	Inventory leanness	Firm performance	Non-linear	Regression model	Most industries have an inverted U-shaped relationship between inventory leanness and firm financial performance.
Isaksson et al. (2014)	2014	4324 publicly traded U.S. manufacturing companies across 20 sub-sectors	Inventory leanness	Firm financial performance	Non-linear	Regression model	The association between inventory leanness and firm financial performance is an inverted U-shape.
Elking et al. (2017)	2017	310 U.S. manufacturing firms	Inventory leanness	Firm financial performance	Linear	Regression model	There is a positive association between inventory leanness and firm financial performance.
Zhu et al. (2018)	2018	1709 Chinese listed manufacturing firms	Inventory leanness	Productivity	Non-linear	Regression model	An inverted U-shaped relationship exists between inventory leanness and productivity.

decrease in overhead expenses, and bolstering financial performance (Karim & Arif-Uz-Zaman, 2013; Rahman et al., 2010).

However, some researchers underline that lean strategy may not be a panacea for all firms (Eroglu & Hofer, 2011; Karim & Arif-Uz-Zaman, 2013; Shah & Ward, 2003). In other words, the financial efficacy brought by lean practices may depend on organizational and industrial characteristics (e.g., Alagaraja & Egan, 2013; Eroglu & Hofer, 2011). Meanwhile, implementing lean practices may not consistently achieve desirable objectives (Amin & Karim, 2013; Browning & Heath, 2009; Karim & Arif-Uz-Zaman, 2013). In practice, managers may not have an in-depth landscape of lean strategy's systemic and overall framework, simply engaging in lean practices based on their previous experience and personal judgment (Amin & Karim, 2013; Karim & Arif-Uz-Zaman, 2013). As a result, inappropriate lean tools may be utilized for a specific situation (Amin & Karim, 2013; Karim & Arif-Uz-Zaman, 2013; Pavnaskar et al., 2003; Tiwari et al., 2007), thus causing disruptions in manufacturing processes and locking down a firm's constrained resources such as funds and human resources, and even destroying the existing corporate structures (Amin & Karim, 2013).

Finally, we summarize several research gaps in the extant literature. First, most prior studies focused on the role of lean strategy in large enterprises, particularly in U.S. manufacturing firms. Meanwhile, case studies of procedures on applying lean strategy have dominated SMEs; however, studies on the outcomes of lean strategy using a large sample of SMEs in developing countries are relatively rare. Second, the previous research focused on the performance implications of inventory leanness instead of operational leanness (e.g., Lin et al., 2018). Thus, our study fills these gaps by simultaneously exploring the impacts of inventory and operational leanness on corporate performance for SMEs in an emerging economy context.

3. Conceptual background and hypotheses development

3.1. Inventory leanness and SMEs' financial performance

In the view of lean philosophy, inventory, regarded as waste, adversely influences a firm's operational performance and needs to be eliminated (Doolen & Hacker, 2005; Womack et al., 1991). Therefore, one benefit of inventory leanness is that SMEs can effectively control the resources occupied by inventory because bloated inventory demands large expenditures of firm resources (e.g., physical space, working capital, energy, etc.) and increases inventory management costs (Lin et al., 2018; Wang et al., 2019). In this way, SMEs can meet their current financial obligations and enhance profitability by releasing cash flows (Callen et al., 2000; Capkun et al., 2009; Elking et al., 2017; Lin et al., 2018), and exploit new opportunities and develop research and development investment to respond to the fickle customer requirements (Eroglu & Hofer, 2011; Zhu et al., 2018).

In addition, inventory leanness can help practitioners discover existent or potential problems caused by excess inventory (e.g., unreasonable scheduling, poor productivity, unsuitable plant layout, etc.) and render practitioners to focus on the resolution of the problems, thereby improving the product quality (Koumanakos, 2008; Lin et al., 2018; Mishra et al., 2013; Modi & Mishra, 2011; Ortega & Lin, 2004; Steven & Britto, 2016; Wang et al., 2019; Wild, 2017; Zhu et al., 2018). Moreover, firms with higher inventory leanness levels are better able to detect changes in the marketplace, cope with shifts in customer demands in a more timely manner (Ortega & Lin, 2004; Wang et al., 2019; Zhu et al., 2018) and flexibly adjust inventory levels based on the input information (e.g., cash holding and sales efficiency) (Chakrabarty & Wang, 2021). Thus, it is reasonable to believe a positive association exists between inventory leanness and financial performance (Elking et al., 2017; Hofer et al., 2012).

However, there are potential costs of inventory leanness, especially for SMEs. One issue is that a higher level of inventory leanness is usually associated with a higher likelihood of stock out, which may fail to meet the customer requirement expeditiously (Bendig et al., 2017a,2017b; Eroglu & Hofer, 2011; Hendricks & Singhal, 2003; Isaksson & Seifert, 2013; Zhu et al., 2018). In addition, compared with listed firms, SMEs are more vulnerable to supply chain disruptions. Thus, as the leanness of inventory goes up, the serious effects of disruptions related to equipment failure, materials shortage, etc., will be exaggerated for SMEs, consequently generating negative returns (Eroglu & Hofer, 2011; Hendricks et al., 2009; Isaksson & Seifert, 2013; Wang et al., 2019; Zhu et al., 2018). Meanwhile, frequent small replenishment batches may reduce the economies of scale in transportation (Wang et al., 2019). So, it seems that inventory leanness may also negatively affect financial performance.

SMEs usually adopt an inventory leanness strategy to improve their financial performance. However, excessive inventory leanness will

increase the risk of loss. As a result, rational quantities of inventory should be carried as a buffer to guarantee smooth material flow (Bradley et al., 2011; Hendricks et al., 2009; Wang et al., 2019). Excessive inventory occupies SMEs' restricted resources, increases operational costs, and lowers efficiency, consequently leading to a distressing financial performance. Furthermore, extreme inventory leanness may put firms in a dilemma of supply chain disruptions, backlogs, or chaos in manufacturing processes. Thus, we assume the benefits may exceed the costs at low-to-moderate inventory leanness. In contrast, the costs may exceed the benefits at moderate-to-high inventory leanness.

H1. . There is an inverted U-shaped relationship between inventory leanness and SMEs' financial performance.

3.2. Operational leanness and SMEs' financial performance

Operational leanness, which includes multiple lean practices, focuses on creating a streamlined high-quality system and is an excellent manufacturing strategy (Belekoukias et al., 2014; Garza-Reyes, 2015; Prasad et al., 2020; Siegel et al., 2019). SMEs can utilize lean practices to identify and reduce waste and non-value-added activities to increase profitability (Caldera et al., 2019; Prasad et al., 2020; Verrier et al., 2016; Womack & Jones, 1997). For example, SMEs can detect non-value-added activities and exploit opportunities by introducing value stream mapping (VSM) to boost customer value, thus satisfying markets (Jiménez et al., 2012; Kumar et al., 2006; Lian & Van Landeghem, 2007; Roth & Franchetti, 2010; Yadav et al., 2019a). Furthermore, adopting operational leanness helps SMEs optimize their resources and achieve operational efficiency, finally realizing an improvement in productivity and economic outcomes (Caldera et al., 2019; Khanchanapong et al., 2014; Piercy & Rich, 2015; Prasad et al., 2020; Resta et al., 2017; Yang et al., 2011). Specifically, with the launch of total quality management (TQM), SMEs could discover the underlying problems in the production process and take targeted measures to solve them, thus, reducing breakdowns and avoiding large quantities of unqualified products (Jain et al., 2014; Yadav et al., 2019a). In addition, operational leanness promotes environmental management practices that are positively related to environmental and financial performance (Prasad et al., 2020; Siegel et al., 2019).

Conversely, Bendig et al. (2017a,2017b) denoted that unexpected negative results, such as disruptions and chaos, may generate when SMEs seek excessive operational leanness. First, some scholars illustrate that the returns of operational leanness depend on the degree of balance between lean practices (Henao et al., 2019). However, managers in SMEs often lack sufficient expertize on lean practices, which limits their abilities to integrate and keep an appropriate balance of substantial quantities of lean practices, thereby incurring more significant administrative expenses (Ali et al., 2020; Bai et al., 2019; Panizzolo et al., 2012; Siegel et al., 2019; Yadav et al., 2019a). In addition, firms should select lean initiatives according to organizational and industrial characteristics such as market structure, production process, etc. However, the framework or methodology of implementing operational leanness is generic, and remedies and references are scarce in SME contexts, resulting in adapting lean practices erroneously (Belhadi et al., 2018a, 2018b; Siegel et al., 2019).

Second, employee commitment and involvement are essential in adopting a higher level of operational leanness (Hu et al., 2015; Yadav et al., 2019a). Nevertheless, due to the lack of essential training to comprehend the benefits of lean practices and worrying that lean practices will eliminate their jobs, employees may exhibit strong resistance to changing their behaviors to align with their organization's implementation of a lean strategy (Abu et al., 2019; Albliwi et al., 2014; Henao et al., 2019; Panizzolo et al., 2012).

Third, SMEs may revert to previous manufacturing practices when there are difficulties in implementing various lean practices, making existing investments sunk costs (Henao et al., 2019). Meanwhile, to implement holistic lean practices, considerable investments are required to develop the indispensable capabilities (e.g., infrastructure, facilities, technology, etc.), which may impair cash flows and financial performance (Achanga et al., 2006; Dora et al., 2016; Siegel et al., 2019; Yadav et al., 2019b; Zhou, 2016). So, this change becomes a big challenge for SMEs with relatively poor financial capability.

Based on these arguments, SMEs are likely to gain positive returns in financial performance as the level of operational leanness increases before reaching a certain threshold but likely to experience a negative return when operational leanness continues to rise beyond a certain point.

H2. . There is an inverted U-shaped relationship between operational leanness and an SME's financial performance.

4. Research methodology

4.1. Data source and sample

The current research focuses on SMEs in the manufacturing sector listed on the New Third Board, China's over-the-counter (OTC) market established in 2006. Unlike the Shanghai and Shenzhen Stock Exchanges, this board attracts many startups and SMEs in need of financing support. Initially, we collected accounting and financial information for the sample period 2015–2019 from the Choice database, which has been utilized in several studies (e.g., Liu & Park, 2021; Liu et al., 2023). Subsequently, after data processing, we compiled a dataset consisting of 4019 SMEs (comprising 20,090 firm–year observations) to test our hypotheses.

4.2. Variables and measurement

4.2.1. SMEs' financial performance

According to prior studies (Elking et al., 2017; Eroglu & Hofer, 2011), we used return on assets (ROA) to measure a firm's financials. ROA quantified as net income divided by total assets, can measure resource utilization efficiency and evaluate financial performance among SMEs of different sizes.

4.2.2. Inventory leanness

Based on the guideline of Eroglu and Hofer (2011) and Ballou (2000), we measured inventory leanness using the Empirical Inventory Leanness Indicator (EILI):

$$Inv = \alpha(sales)^{\beta} \tag{1}$$

where α and β depend on industry-specific characteristics representing different relationships between an SME's size (sales) and inventory among industries. Eroglu and Hofer (2011) found that the mean coefficient of the sale variable is 0.9077 and showed that it could improve the efficiency of inventory management as sales increase, resulting in economies of scale in inventory management which means that inventory levels increase at a slower speed compared to sales in most industries. EILI, in contrast to previous measures (e.g., inventory turns and its variants), considers industry differences and economies of scale in inventory management and compares inventory leanness in similar firm sizes within a specific industry. The calculation equation of EILI is as follows:

$$\ln\left(inventory_{ift}\right) = \alpha_{it} + \beta_{it}\ln\left(sales_{ift}\right) + u_{ift} \tag{2}$$

First, we regress the natural logarithm of sales on the natural logarithm of average inventory for industry i in each year t. Then, we obtain firm(f)'s EILI by standardizing u and multiplying it by -1, and thus a higher level of EILI represents a higher degree of inventory leanness.

4.2.3. Operational leanness

Inspired by Eroglu and Hofer (2011) and Saboo et al. (2017), we developed a new measure of operational leanness named the Empirical Production Leanness Indicator (EPLI). Saboo et al. (2017) utilized operational expenses as output to estimate the operational capacity and identified three factors as input: (1) current assets, (2) current property, plant, and equipment, and (3) the number of employees, which indicates that the three factors are associated with operational expenses. To evaluate operational leanness more accurately, this measure similar to EILI compares operational expenses to a benchmark level which depends on a firm's size (e.g., current assets, number of employees, etc.) and industry. The calculation equation of the degree of operational leanness is as follows:

$$\ln(operational\quad expenses_{ift}) = \gamma_{it} + \delta_{it}\ln(current\quad assets_{ift}) + \varepsilon_{it}\ln(fixed\quad assets_{ift}) + \sigma_{it}\ln(emp_{ift}) + \theta_{ift}, \tag{3}$$

where the parameters γ_{it}, δ_{it}, ε_{it} and σ_{it} are determined by industry-specific characteristics and reflect the relationship between the company's size (e.g., current assets, fixed assets, and the number of employees) and operational expenses for industry i in each year t. We regress the natural logarithm of operational expenses on the natural logarithm of current assets, fixed assets, and the number of employees to obtain them. EPLI for each firm(f)is obtained by studentizing θ_{ift} and multiplying it by -1 so that higher values correspond to higher levels of operational leanness.

4.2.4. Control variables

According to previous studies (Bendig et al., 2017a,2017b; Eroglu & Hofer, 2014; Kroes et al., 2018; Tortorella et al., 2019; Yang et al., 2011; Zhu et al., 2018), we control three variables in the regression models: (1) firm size is the natural logarithm of assets, (2) firm age is the years since the firm's founding, and (3) joint venture, a dummy variable, represents the SME which is an international joint venture. Finally, Table 2 shows our variables' correlation matrix and descriptive statistics.

4.3. Analytical approach

This paper employed the *reghdfe* Stata package to investigate the relationship among operational leanness, inventory leanness, and firm financial performance, which can alleviate the endogeneity issue by controlling multilevel fixed effects (Correia, 2017). Following this approach, we absorbed year and industry-fixed effects to obtain robust results. Our study considered endogeneity and formed a one-year gap between the dependent and independent variables. Moreover, we winsorized all raw variables at the 1% and 99% levels to avoid the effect of extreme outliers (Wilcox, 2003). Finally, our study's variance inflation factor (VIF) value ranged from 1.00 to 1.23 with a mean of 1.10 by a multicollinearity test, implying that multicollinearity is not a serious issue in our study.

5. Results

5.1. Main results

The results for ROA_{t+1} are in Table 3. In Model 1, we observed a positive and significant effect of EILI($\beta = 0.0301, p < 0.01$). As shown in Model 2, there was a statistically significant and positive relationship between EILI and ROA_{t+1} ($\beta = 0.0316, p < 0.01$), and a statistically significant, negative relationship between EILI squared and ROA_{t+1} ($\beta = -0.0077, p < 0.01$). These regression results are consistent with Hypothesis 1, indicating that inventory leanness has an inverted U-shaped association with financial performance, thus supporting Hypothesis 1. To further support H_1 (that is, an inverted U-shaped relationship exists between inventory leanness and SME financial performance), we plotted the curvilinear relationship between ELIL and ROA_{t+1} in Fig. 1. An increase in EILI leads to a rise in ROA_{t+1} ; however, beyond a certain point, firms will experience diminishing growth in ROA_{t+1}. Therefore, Fig. 1 further supports H1, which shows that the slope is positive at low and moderate levels of inventory leanness but negative at high levels.

Hypothesis 2, which predicted the non-linear association between operational leanness and financial performance, is also supported. As shown in Model 3, EPLI loaded significantly and negatively on ROA_{t+1} ($\beta = -0.0187, p < 0.01$). In Model 4, we found the coefficients of EPLI and EPLI squared were both significantly negative ($\beta = -0.0164, p < 0.01; \beta = -0.0077, p < 0.01$), which revealed an inverted U-shaped relationship between operational leanness and financial performance, thereby supporting Hypothesis 2. Then, to offer additional support for H_2, we plotted the non-linear relationship between EPLI and ROA_{t+1} in Fig. 2. We found that as EPLI increases, ROA_{t+1} increases initially, and then decreases after reaching a certain point that is below the mean, thereby supporting H_2.

5.2. Robustness tests

We performed two robustness tests concerning the choices of non-linear relationship estimations and dependent variable measures. First, we conducted the three-step procedure proposed by Lind and Mehlum (2010) to re-test the relationship between lean strategy and firm performance. According to the guideline of Haans et al. (2016), the regression model is as below:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_1^{\,2} + \varepsilon \tag{4}$$

For inventory leanness, the coefficients of EILI ($\beta_1 = -0.0078, p < 0.01$) and EILI^2 ($\beta_2 = 0.0240, p < 0.01$) are significant. Second, we determined that $\beta_1 + 2\beta_2 \mathrm{EILI}_{Left} > 0$ and $\beta_1 + 2\beta_2 \mathrm{EILI}_{Right} < 0$, where EILI is in the interval [− 2.232, 2.717], EILI_{Left} is − 2.232, and EILI_{Right} is 2.717. Third, the turning point $-\frac{\beta_1}{2\beta_2}$, equals 1.720, was found within the EILI range. When EILI is smaller than the turning point, the relationship between inventory leanness and SME financial performance is positive, however, if EILI is greater than 1.720, it is negatively related to SME financial performance.

Table 2
Descriptive statistics and correlation matrix.

Variable	1	2	3	4	5	6
1. ROA_{t+1}	1.000					
2. EILI	0.223 ***	1.000				
3. EPLI	−0.159 ***	− 0.333 ***	1.000			
4. Firm size	0.088 ***	− 0.287 ***	0.012 ***	1.000		
5. Firm age	0.042 ***	− 0.090 ***	0.049 ***	0.233 ***	1.000	
6. Joint venture	−0.006 ***	− 0.023 **	0.009	0.024 **	0.043 ***	1.000
Mean	0.034	− 0.001	− 0.010	4.651	13.117	0.028
Standard deviation	0.102	0.948	0.926	1.004	5.230	0.164

Note: * ** $p < 0.01$, * * $p < 0.05$.

Table 3
Regression results of one-year lagged ROA.

Variables	Dependent Variable: ROA_{t+1}			
	Model 1	Model 2	Mode 3	Model 4
Constant	− 0.0697 * **	− 0.0633 * **	− 0.0432 * **	− 0.0323 * **
	(0.006)	(0.006)	(0.006)	(0.006)
Firm size	0.0191 * **	0.0195 * **	0.0128 * **	0.0123 * **
	(0.001)	(0.001)	(0.001)	(0.001)
Firm age	0.0011 * **	0.0010 * **	0.0011 * **	0.0010 * **
	(0.000)	(0.000)	(0.000)	(0.000)
Joint venture	− 0.0017	− 0.0024	− 0.0030	− 0.0049
	(0.004)	(0.004)	(0.005)	(0.005)
EILI	0.0301 * **	0.0316 * **		
	(0.001)	(0.001)		
$EILI^2$		− 0.0077 * **		
		(0.001)		
EPLI			− 0.0187 * **	− 0.0164 * **
			(0.001)	(0.001)
$EPLI^2$				− 0.0077 * **
				(0.001)
Year dummy	Fixed	Fixed	Fixed	Fixed
Industry dummy	Fixed	Fixed	Fixed	Fixed
Observations	14,163	14,163	12,470	12,470
R^2	0.100	0.109	0.058	0.067
F-statistics	242.6 ***	225.1 * **	96.81 * **	85.63 * **

Note: Huber-White robust standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

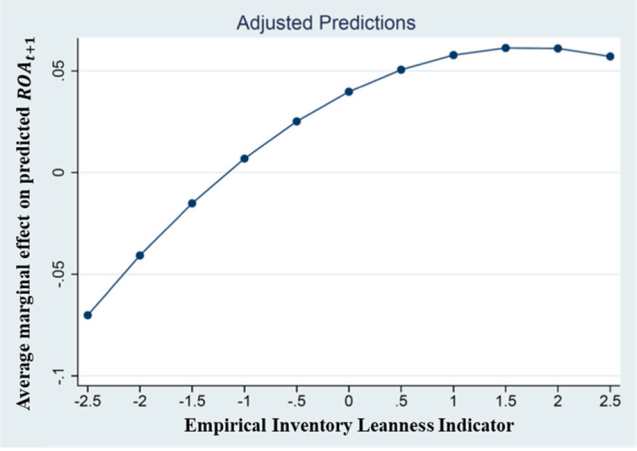

Fig. 1. The inverted U-shaped relationship between inventory leanness and financial performance.

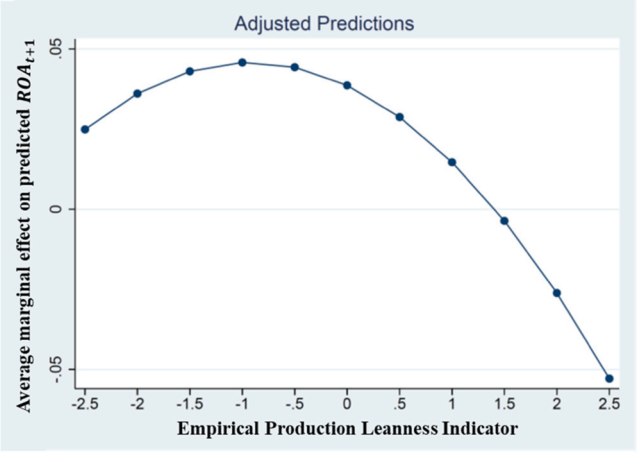

Fig. 2. The inverted U-shaped relationship between operational leanness and financial performance.

Regarding operational leanness, the coefficients of EPLI ($\beta_1 = -0.0155, p < 0.01$) and $EPLI^2$ ($\beta_2 = -0.0084, p < 0.01$) are negative and significant. Second, the interval is [− 2.2344, 2.8593]. Thus, we found $\beta_1 + 2\beta_2 EPLI_{Left} > 0$ and $\beta_1 + 2\beta_2 EPLI_{Right} < 0$. Third, the turning point $-\frac{\beta_1}{2\beta_2}$ is − 0.9238, which is in the EPLI range. In other words, as operational leanness increases, SME financial performance increases if EPLI is less than the turning point, and then beyond − 0.9238, the relationship between operational leanness and SME financial performance is negative. Overall, the three-step procedure generated consistent results consistent with the main results.

In addition, we employed return on sales (ROS) as the alternative dependent variable to ensure the robustness of our main results (shown in Table 4). We found EILI had a significant and positive impact on ROS_{t+1} in Model 5 ($\beta = 0.080, p < 0.01$) and Model 6 ($\beta = 0.087, p < 0.01$). Also,

Table 4
Regression results of one-year lagged ROS.

Independent Variables	Dependent Variable: ROS_{t+1}			
	Model 5	Model 6	Mode 7	Model 8
Constant	− 0.310 * **	− 0.281 * **	− 0.2708 * **	− 0.1963 * **
	(0.020)	(0.019)	(0.021)	(0.020)
Firm size	0.051 * **	0.053 * **	0.039 * **	0.036 * **
	(0.004)	(0.004)	(0.004)	(0.004)
Firm age	0.005 * **	0.005 * **	0.005 * **	0.004 * **
	(0.001)	(0.001)	(0.001)	(0.001)
Joint venture	0.023 *	0.020	0.017	0.004
	(0.012)	(0.013)	(0.016)	(0.016)
EILI	0.080 * **	0.087 * **		
	(0.004)	(0.004)		
$EILI^2$		− 0.035 * **		
		(0.003)		
EPLI			− 0.078 * **	− 0.063 * **
			(0.006)	(0.005)
$EPLI^2$				− 0.054 * **
				(0.005)
Year dummy	Fixed	Fixed	Fixed	Fixed
Industry dummy	Fixed	Fixed	Fixed	Fixed
Observations	14,342	14,342	12,497	12,497
R^2	0.072	0.090	0.068	0.107
F-statistics	111.90 * **	95.26 * **	74.96 * **	68.29 * **

Note: Huber-White robust standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

we observed a significant and negative association between EPLI and ROS_{t+1} in Model 7 ($\beta = -0.078, p < 0.01$) and Model 8 ($\beta = -0.063, p < 0.01$). Model 6 and Model 8 further confirmed the inverted U-shaped relationships between financial performance and lean strategies regarding inventory leanness ($\beta = -0.035, p < 0.01$) and operational leanness($\beta = -0.054, p < 0.01$). These results are consistent with our main findings.

6. Discussion and implications

Although a few studies focused on implementing lean such as frameworks and remedies for adopting a lean strategy, studies that scrutinize the relationship between lean strategy and the financial performance of SMEs in emerging markets are still very rare. However, SMEs are pressured to implement cost-effective energy efficiency measures (Dey et al., 2020). Given this, understanding how lean strategy may affect financial performance is important. Therefore, this study investigated the impacts of lean strategy by examining the influences of inventory leanness and operational leanness on the SME's financial performance.

6.1. Theoretical contributions

This study makes several theoretical contributions. First, the research enhances our knowledge of the impact of inventory leanness in the SME context. Consistent with Eroglu and Hofer (2011), the study showed that inventory leanness has an inverted U-shaped association with SMEs' financial performance. Fig. 1 shows a positive performance impact of inventory leanness when shifting from low-to-moderate levels of inventory leanness. The financial ramifications related to inventory leanness begin to decrease at a higher level of inventory leanness. Moreover, the adverse influences of inventory leanness will likely grow at higher levels. The results indicate that costs associated with inventory leanness may outweigh its benefits beyond a certain threshold. Hopp and Spearman (2021) proposed the process lens of lean strategy, which suggests that waste elimination is one of the core goals of a lean strategy. Inventory leanness directly reduces obvious forms of waste and facilitates firms to leverage fewer resources (e.g., physical space, working capital, etc.) to achieve customer satisfaction and cost efficiency. Therefore, SME performance will improve as the level of inventory leanness increases. Notably, Zipkin (2000) argued that inventory and time buffers are solutions to address variability. As inventory levels decline, the time buffers increase, resulting in supply disruptions and stockouts, thus impeding economic outcomes of inventory leanness. Overall, the impact of inventory leanness on financial performance is an inverted U-shaped.

Second, this study contributes to operational leanness literature by investigating the relationship between operational leanness and financial performance in SMEs. This research indicates that an inverted U-shaped relationship exists between operational leanness and financial performance, which differs from the view of Hofer et al. (2012), who reported a positive impact of operational leanness on financial performance. Specifically, our empirical findings indicate that low levels of operational leanness are positively associated with performance, whereas moderate and high levels result in negative performance returns. This inconsistency may stem from our focus on SMEs in China, while Hofer et al. (2012) focused on domestic manufacturing firms in the US. The specific institutional contexts of different countries may yield inconsistent findings, compounded by variations in the measurement of operational leanness. Furthermore, SMEs can enhance their performance by employing simple lean practices such as visual and 5 S management to identify and address obvious waste, thereby improving productivity. However, Hopp and Spearman (2021) argue that, from a network perspective of lean strategy, it is crucial to systematically apply various lean practices. Yet, SMEs often lack the expertize to integrate different lean practices, particularly when striving for higher levels of operational leanness. The absence of remedies and references for utilizing specific lean practices to visualize waste makes it challenging for SMEs to identify underlying causes and effectively eliminate significant waste, diverting limited resources to lean practices that may have minimal positive impacts on performance.

6.2. Practical implications

Our study raises awareness of the significance of inventory and operational leanness on SMEs' financial performance and suggests that both inventory leanness and operational leanness have non-linear impacts on SMEs' financial performance. Concerning inventory levels, practitioners in SMEs should strengthen inventory management and determine an appropriate inventory level based on the characteristics of their firms and industries, instead of solely pursuing excessive inventory reduction. Expanding inventory levels reduces the risk of stockouts and disruptions and diminishes time buffers that shorten delivery times. However, this may raise inventory maintenance costs and consume limited resources. In contrast, increasing time buffers can lower inventory management costs, but it might compromise customer satisfaction. Therefore, SMEs should make trade-offs between inventory and time buffers to address supply and demand variability. Second, it is sensible for managers to implement reasonable lean practices and arrange the sequence of lean adoption systematically to achieve desirable economic outcomes due to a non-linear relationship between operational leanness and performance. For example, SMEs could first apply VSM to detect significant waste and then utilize lean practices corresponding to specific waste. Finally, our findings offer a novel approach for SMEs to enhance their financial performance by reducing waste. From a lean strategy perspective, determining the appropriate level of lean implementation based on the firm's unique characteristics is crucial.

6.3. Limitations and future research

There are several limitations to this study. First, we did not examine the effect of the interactions between inventory leanness and operational leanness on financial performance. Hopp and Spearman (2004) argued that a combination of inventory, time, and capacity could buffer waste caused by variability. Firms may simultaneously implement operational leanness and inventory leanness to adopt a comprehensive lean strategy to find solutions to variability. So, it is necessary to determine the most efficient collection of inventory leanness and operational leanness levels. Second, we need to investigate the effect of sequences of lean practices adoption on the relationship between lean strategy and financial performance. Researchers have pointed out that the sequences of lean practices are critical influencing factors for successful lean strategy implementation (Hopp & Spearman, 2021; Yadav et al., 2019a).

7. Conclusion

This study employed the fixed effect regression method to examine the relationship between SME lean strategy and financial performance. More specifically, we first evaluated the influence of inventory leanness on an SME's financial performance and found that inventory leanness has an inverted U-shaped relationship with financial performance. Moreover, we further examined the effect of operational leanness on an SME' financial performance. We also found an inverted U-shaped relationship between operational leanness and financial performance. The lean strategies bridge the energy efficiency gap and help excavate the underutilized energy related to production by incorporating energy efficiency into production (Wen et al., 2021). However, only the correct lean level can improve energy usage, reduce the emission of waste and thus bring positive effects (Ali et al., 2020). Therefore, the prerequisite for obtaining the expected outcomes of lean management is to find the

lean threshold that matches organizational features. In summary, the study sheds novel light on lean strategy literature and provides significant implications for SMEs that aim to reduce waste and achieve efficiency by introducing a lean strategy.

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The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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