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Slacking for Success

Navigating Unfavourable Environments in the Swedish Manufacturing Industry

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ABSTRACT

This thesis examines the impact of lean and slack resource management strategies on the performance of Swedish manufacturing firms. Drawing on lean manufacturing theory, it investigates a negative linear relationship between operational slack and firm performance, explores the potential for a non-linear relationship and analyzes whether slack mitigates the adverse effects of industry-specific environmental dimensions on firm performance. The study provides empirical support for resource leanness, and finds a non-linear relationship between operational slack and firm performance. The study not only contributes with empirical evidence from a Swedish context but also discusses a departure from traditional lean approaches towards a more balanced perspective that integrates considerations of both efficiency and resilience.

Keywords: Operational Slack, Lean Resource Management, Slack Resource Management, Swedish Manufacturing, Firm Performance, Environmental Dimensions

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TABLE OF CONTENTS

1 INTRODUCTION

In this thesis, our aim is to contribute with evidence from a Swedish context, to a longstanding debate within the operations management literature: whether it is more beneficial for manufacturing firms to minimise excess resources or to retain a surplus (Modi & Mishra, 2011). The Japanese car manufacturer Toyota pioneered the concept of reducing resources by implementing the Toyota Production System (TPS), later renamed the lean production system approach. The success of Toyota, marked by significant gains in market share within the car industry, prompted a widespread adoption of lean production principles across various manufacturing industries (Gerhard Plenert, 2007; Womack et al., 1990).Chen et al.'s (2005) study from 1981 to 2000 underscores the transformative impact of the TPS, revealing a consistent decline in inventory levels among US manufacturing firms after its widespread adoption. Throughout the years, this development has incited a vast amount of research into the efficiency of waste reduction, particularly in inventory management. Lean management theory, which emphasises efficiency by minimising waste (Womack et al., 1990), is supported by a wealth of research, arguing a positive relationship between resource leanness and firm performance. (e.g. Capkun et al., 2009; Chen et al., 2005; Eroglu & Hofer, 2011; Koumanakos, 2008; Kovach et al., 2015; Modi & Mishra, 2011). However, an alternative perspective presents the advantages of maintaining excess resources, referred to as *slack* (Modi & Mishra, 2011), especially in volatile markets and unfavourable environments. (Hendricks et al., 2009; Kovach et al., 2015)

Recently, attitudes toward resource management have shifted as a response to disruptive events such as the COVID-19 pandemic and geopolitical tensions, including the Russo-Ukranian conflict. One author describes it as a revision of supply chain management from the "Just-In- Time" (JIT) lean management approach to a more cautious "just-in-case" strategy (Allenbach-Ammann, 2022). This shift highlights a growing recognition of the need to balance resource efficiency with resilience. Furthermore, a report published by EY in January 2022 revealed that 79% of chief executives have either already adjusted or plan to adjust their global supply chains in response to evolving market dynamics (Guerzoni et al., 2022). As of January 2024, the discourse surrounding resource optimisation has continued to evolve. (Guerzoni et al., 2024) note that "re-configuring supply chains, including near-shoring," and "adjusting our presence in certain markets in response to geopolitical instability" were cited as top priorities in the subsequent twelve months. We believe examining the relationship between resource management and firm performance is significant and timely, given the recent doubts about lean practices and the growing inclination towards operational slack for increased resilience.

1.1 BACKGROUND

1.1.1 Lean Management Theory

Krafcik (1988) introduced the term "lean" to describe the TPS. He defines lean, as opposed to buffered production systems, as characterised by minimum inventory levels, cost savings, and flow assembly lines designed to identify and address quality issues efficiently. The idea of JIT is to remove all forms of buffers, such as inventories and intermediate storage, within and outside of the organisation. Consequently, every minor disturbance in production is noticed. When defects in the assembly line are discovered, so are opportunities to improve the production system. Efficiency is obtained by precisely timing the manufacturing of each component, ensuring the correct quantity and quality to integrate into the production flow seamlessly (“Perspectives on the Productivity Dilemma,” 2009). Theoretically, the potential gains of a lean production system are significant (Krafcik, 1988). In the renowned book "The Machine That Changed the World" by Womack et al. (1990), the authors depict lean production as utilising “less of everything”, including labour, manufacturing capacity, investments, and production time. They highlight that a lean production system strives towards declining costs, zero defects and zero inventories. Holding fewer inventories enables a fast identification and a better understanding of defects in the assembly line, making it easier to pinpoint and resolve issues effectively ("Perspectives on the Productivity Dilemma," 2009).

However, a lean system may also increase the risk of stock depletion, which may halt production (Krafcik, 1988). From a lean perspective, this risk encourages companies to learn more about their production processes to prevent interruptions. It is argued that the need for such knowledge is less pressing when the firm has excess resources to provide a buffer against production delays. In this way, lean inventory generates valuable insights that, over time, make an organisation more flexible and efficient (Alles et al., 1995; "Perspectives on the Productivity Dilemma," 2009). Proper implementation should, hence, result in fewer defects and a higher level of efficiency, ultimately improving firm performance. While promising in theory, the practical effectiveness of lean manufacturing remains a widely debated topic (Modi & Mishra, 2011; "Perspectives on the Productivity Dilemma," 2009). In our study, we concentrate on the operational elements of lean management theory, particularly in inventory, supply chain and capacity leanness. We define a lean firm as characterised by minimal inventory, reduced capacity and short cash conversion cycles (CCC).

1.1.2 Slack Resource Theory

From a lean management perspective, slack and buffer resources of any form is considered an inefficiency, the ultimate objective being to eliminate waste ("Perspectives on the Productivity Dilemma," 2009). However, many studies argue for the usefulness and even necessity of slack. According to Nohria and Gulati's (1996) definition, a firm possesses slack when it maintains resources beyond the minimum required for its designated output level. They point to unused capacity, unexploited opportunities and an excess of employees as examples of slack resources. Bourgeois1981OnSlack asserts that firms strategically retain slack as a reserve of current or potential resources, allowing the organization to adapt to intense internal and external pressures. The advantages of slack have been the subject of extensive research. It has, for instance, been shown to foster innovation (Geiger & Cashen, 2002; Nohria & Gulati, 1996), increase risk taking (Moses, 1992), and, more crucially for our purposes, to act as a buffer against unfavourable industry environments (e.g. Hendricks et al., 2009; Kovach et al., 2015). In this thesis, we view slack as the antithesis of leanness. In line with the principles of lean production systems, which advocate for zero waste, a highly lean firm with minimal resources lies at one end of the spectrum, while a firm with a considerable amount of slack lies at the opposite end. We focus on operational resource components of slack and leanness, namely inventory, capacity and the supply chain.

1.1.3 The Swedish Context

Previous research related to lean production systems in the Swedish context, mostly consists of interview or survey-based studies. For example, case studies have been conducted on Scania (Oudhuis & Tengblad, 2022) and Volvo Group (Netland & Ferdows, 2016), two Swedish firms that have famously adapted their production systems according to lean principles. Furthermore, Cagliano et al. (2006) included 19 Swedish firms in a survey-based study investigating the influence of lean production on supply chain integration for European firms. Winroth (2012) conducted a follow-up case study on eight Swedish manufacturing firms, many of which indicated significant effort in implementing lean production methods and reported substantial impact on their operations. In essence, while lean production systems are prominent in Sweden, there is limited documentation regarding the effects of lean and slack resource strategies on firm performance, especially using large datasets.

Indeed, our search for empirical investigations concerning resource management and its impact on manufacturing firm performance within the Swedish context, revealed a significant scarcity of relevant literature. We found only a handful of studies, such as one conducted by Azadegan et al. (2013a) in which the authors investigate the effect of slack resources on new business survival in Sweden. Furthermore, with a focus on financial slack, Bradley et al. (2011a) similarly examined the role of slack resources in generating value for new firms. Another study by Bradley et al. (2011b) investigated the relationship between financial slack and growth using a sample of Swedish firms. Nevertheless, we did not find any previous studies using a large dataset of Swedish manufacturing firms to explore the relationship between resource levels and financial performance.

1.2 PURPOSE & CONTRIBUTION

In this thesis, we aim to extend the understanding of the relationship between resource management strategies, (lean and slack) and firm performance within the context of Swedish manufacturing firms. Our study addresses three core considerations. Firstly, we investigate the possibility of a negative linear relationship between operational slack and Swedish manufacturing firm performance. Subsequently, we explore whether the relationship exhibits a quadratic functional form, thereby discerning whether an optimal level of resource holding exists (Eroglu & Hofer, 2011; Isaksson & Seifert, 2014; Modi & Mishra, 2011; Tang, 2006). Finally, inspired by the recent attention towards the benefits of slack, we investigate whether slack mitigates the effects of two industry-specific environmental dimensions on firm performance in the Swedish context (Hendricks et al., 2009; Kovach et al., 2015).

The main contribution of this thesis to the existing body of research lies in the contextual setting and scope of our sample. As discussed in Section 1.1.3, the impact of resource management on Swedish manufacturing firm performance is a largely unexplored area. Many existing studies conducted in Sweden tend to be focused on new, small or medium-sized firms (e.g. Azadegan et al., 2013a; Bradley et al., 2011a, 2011b). Furthermore, apart from a few (e.g. Modi & Mishra, 2011), research in the resource management field overall, uncommonly include both slack and lean perspectives. Typically researchers take the view of either one or the other. Secondly, our investigation includes the utilisation of the "Empirical Leanness Indicator" (ELI) variable proposed by Eroglu and Hofer (2011). While this variable has previously been employed to define inventory and capacity leanness (Bendig et al., 2017; Eroglu & Hofer, 2011; Hofer et al., 2012; Isaksson & Seifert, 2014), we extend its application to also define supply chain (cash conversion cycle) slack. These three forms of slack have previously been used in studies with similar investigations (Hendricks et al., 2009; Kovach et al., 2015), albeit not using Eroglu and Hofer's (2011) ELI measure. We will, hence, in an unprecedented manner, include the cash conversion cycle as an ELI variable, as a proxy for a firm's supply chain efficiency. Moreover, while (Eroglu & Hofer, 2011) used it as a metric of leanness, in our study, we intend to use it as a measure of operational slack. We adjusted the metric to signify having more resources than the industry average, unlike ELI, which indicates having fewer resources.

2 LITERATURE REVIEW & HYPOTHESES

2.1 THE DIRECT EFFECTS OF SLACK ON FIRM PERFORMANCE

2.1.1 Inventory

Lean production systems strive for minimal inventory levels — an essential strategy for reducing waste within the production process (Womack et al., 1990). A survey by Fullerton and Mcwatters (2001) revealed that more than two-thirds out of 91 formal adopters of JIT reported declines in total inventory, underscoring the importance of inventory management for lean practices. Following lean production principles, organisations eliminate various forms of waste with the intent of improving efficiency and performance. In this view, lower inventory levels are expected to translate into higher firm performance (Eroglu & Hofer, 2011).

Research in the lean inventory management field have both corroborated and disputed the association between lean inventory and improved performance. Early research predominantly relied on survey data and yielded mixed findings on the impact of adopting lean practices on firm performance (e.g. Balakrishnan et al., 1996; Fullerton & Mcwatters, 2001; Shah & Ward, 2003). The subjectivity and biases inherent in such methodologies incentivised subsequent studies to confirm the leanness-performance link more rigorously, using large data sets and continuous measures of inventory leanness (Hofer et al., 2012). One such study by Capkun et al. (2009) found a significant positive relationship between the inventory-to-sales ratio and financial performance when studying US manufacturing firms from 1980 to 2005. Additionally, Chen et al. (2005) analysed whether financial markets assign higher values to firms with leaner inventory. While their research found no evidence of a direct, short-term relationship, they discovered significant valuation differences over time, indicating that firms with slightly below average inventory levels performed the best. Although this stream of research yielded more robust findings, the results remained mixed. Cannon (2008), for instance, criticised extant studies for their lack of comprehensive performance measures. In contrast with lean management theory, he found that inventory performance was not associated with overall performance improvement. Evidence suggests that not all firms benefit from reduced inventories; for some, it might even impair performance. Nevertheless, later studies corroborate a positive relationship between lean inventory and improved firm performance. (e.g. Eroglu & Hofer, 2011; Isaksson & Seifert, 2014; Modi & Mishra, 2011)

In conclusion, the findings of prior studies have, over time, been inconsistent. Yet, a majority of previous research support a positive and significant link between keeping low inventory levels and improved firm performance. Consequently, we find it reasonable to assume that an increase in inventory slack, which effectively corresponds to a decrease in inventory leanness, will likely have a negative relationship with financial performance.

2.1.2 Capacity

Lean production involves a combination of various lean practices that operate synergistically (e.g. Eroglu & Hofer, 2011; Shah & Ward, 2003). For a more comprehensive investigation, we include another resource management practice, namely capacity slack, also referred to as property, plant and equipment (PPE) slack, following the precedence of several earlier studies (e.g. Azadegan et al., 2013a; Bendig et al., 2017; Hendricks et al., 2009; Kovach et al., 2015; Kroes et al., 2018; Modi & Mishra, 2011). In line with lean manufacturing principles, waste elimination also entails strategic allocation of capital by addressing inefficiencies in warehouse space and machinery utilization (Holweg, 2007). A company adopting a lean manufacturing approach will aim to use as little capacity as possible to generate its output since leanness, by definition, implies the reduction of waste in all forms (Womack et al., 1990). Accordingly, by our definition, a firm with more PPE than similar peer firms, holds operational slack. Kovach et al. (2015) find that absent of industry condition variables, both PPE slack and inventory slack have a negative relationship with firm performance. Modi and Mishra (2011), likewise, find PPE efficiency, that is, the opposite of PPE slack, to exhibit a positive effect on both accounting and market performance. Therefore, similar to how we expect inventory slack to reduce firm performance, we anticipate capacity slack to yield a negative relationship.

2.1.3 Supply Chain

A third component of operational slack that we have decided to include is supply chain slack, in line with the research by Hendricks et al. (2009) and Kovach et al. (2015). The cash conversion cycle indicates the overall efficiency of supply chains. It is calculated as the time inventory is stored plus the time until customers provide payment, minus the credit time received from suppliers. In theory, a firm that has adopted lean manufacturing principles and JIT will have a shorter CCC and therefore a lean supply chain (Hendricks et al., 2009). Yet, Kovach et al. (2015) finds supply chain slack to have a significantly positive relationship with ROA, but a negative and significant with ROS. Nevertheless, we base our expectations on that a longer CCC indicates a higher degree of waste in the supply chain, which as discussed in Section 1.1.1, according to lean management theory should result in lower performance.

Hypothesis 1 – Based on the reviewed literature, it is apparent that lean production principles, including efficient inventory management, optimal capacity utilization, and streamlined supply chains, are important factors for firm performance in manufacturing contexts. Despite some inconsistencies in previous research findings, there is a prevailing consensus on the positive association between lean practices and firm performance. Therefore, we posit that increased operational slack, including inventory slack, capacity slack, and supply chain slack, will likely have a negative impact on the performance of Swedish manufacturing firms:

H1: Increased operational slack reduces the firm performance of Swedish manufacturing firms.

Underlying this hypothesis is the assumption that prior findings from international research hold in the Swedish Manufacturing setting. To test our hypotheses, we employ a slightly altered version of Eroglu and Hofer's (2011) ELI measure which compares a firm's inventory levels with those of similar-sized firms in the same industry. Research previous to theirs often relied on variations of turnover rates, such as inventory days (e.g. Chen et al., 2005; Koumanakos, 2008) and inventory scaled by sales (e.g. Cannon, 2008; Capkun et al., 2009; Swamidass, 2007). Eroglu and Hofer (2011) argue that contrary to these measures, ELI accounts for economies of scale and provides a more precise consideration of industry-specific characteristics. Comparing ELI and inventory turnover as metrics of leanness, they found evidence that ELI yields more robust and statistically significant results. While in Eroglu and Hofer's (2011) paper, ELI is employed as a inventory leanness measure, we adopt it as a measure for operational slack, for inventory slack like the original paper, and capacity slack, as suggested by (Bendig et al., 2017). Furthermore, we extend its usage to define supply chain slack, which to our knowledge is a a novel application of the metric.

2.2 A NON-LINEAR RELATIONSHIP

Several studies have proposed a non-linear relationship between inventory leanness and performance. These studies suggest a threshold for the positive relationship, beyond which incremental improvements in leanness result in detrimental effects on performance. Eroglu and Hofer (2011) find that the functional form of the inventory leanness-performance relationship varies across industries. For some industries, a linear form suffices to explain the variation, but for most, they found an inverted U-shaped relationship, suggesting an optimal inventory level. A substantial part of this paper is devoted to arguing for a better leanness (ELI) measure, as discussed in the section above. Consequently, there is a reduced depth of exploration into non-linearity, a gap which is addressed and elaborated upon in a subsequent research paper by Isaksson and Seifert (2014). Notably, they test the non-linearity of ELI against more robust econometric analyses, focusing primarily on endogeneity, industry heterogeneity and time concerns. While in some cases, an inverted U-shaped relationship is found, in many, they observe solely diminishing effects, suggesting that the curve's apex occurs at the outer boundaries of their sample. Hence, it is unreasonable to assume the existence of a definitive optimal point.

Similarly, Modi and Mishra (2011) investigate whether the leanness-performance relationship is more nuanced than extant research had previously claimed. The results indicate that while leanness is generally beneficial, an excessive focus on reducing resources yields diminishing returns and, in some cases, even detrimental effects on firm performance. Their investigation included both inventory and PPE leanness. Both measures of leanness revealed similar results — evidence for an inverted U-shaped relationship. In their interpretation of these findings they imply there exists benefits of holding some slack. Gains in performance from leanness exhibit diminishing returns for inventory and PPE resources up until an inflexion point, at which further leanness harms ROA. However, their study also incorporates stock returns and Tobin's Q as measures of firm performance, for which the optimal level of resource efficiency is identified at very high levels, aligning with the findings of Isaksson and Seifert (2014). Nonetheless, the relationship still demonstrates diminishing returns. Another argument favouring slack is discussed by Hendricks and Singhal (2003). They argue that while a lean inventory strategy is heavily assumed to be advantageous, many fail to consider the significant risks associated, particularly the potential for stock depletion. Shortages may disrupt the supply chain, leading to unfavourable stock-market reactions, as evidenced by their findings. This illustrates that there may be benefits to holding some buffer resources. It may be easy for firms to disregard this risk since the upside of lean resources is more tangible than the potential downsides, such as lost sales (Isaksson & Seifert, 2014).

Research adopting a slack-oriented perspective have also investigated a non-linear relation to measures of profitability. For example, Tan and Peng (2003) found a curvilinear relationship between various forms slack held by Chinese manufacturing firms and performance. Similarly George (2005) found significant, negative coefficients for squared slack variables, using a sample of privately held firms, such that performance initially decreases and then increases with rising levels of slack. Additionally, Bradley et al. (2011a) include quadratic forms of slack and generally find significant coefficients for their slack variables.

Hypothesis 2 – Based on the literature review above, we investigate whether operational slack has a curvilinear relationship with firm performance. Similar to Modi and Mishra (2011), we explore the potential for non-linearity on both inventory and capacity, however, diverging from their paper, we also investigate non-linearity in supply chain slack. Consequently we propose the following hypothesis:

H2: The relationship between operational slack and Swedish manufacturing firm performance is concave.

2.3 SLACK RESOURCES AND ENVIRONMENTAL CONDITIONS

A prominent subject within slack research is the argument that lean resource management practices are not suitable for all contexts. Wefald et al. (2010) found that the relationship between slack and performance is influenced by the industry within which the firm operates. For some industries, inherent factors such as product characteristics, manufacturing methods, demand fluctuations, or supply conditions deem lean manufacturing strategies impractical (Eroglu & Hofer, 2011). Many argue that in certain cases, slack resources can mitigate adverse effects. For instance, in complex industries (e.g. George, 2005), during supply chain disruptions (Hendricks et al., 2009; Kleindorfer & Saad, 2005), in unpredictable or unstable environments (Azadegan et al., 2013b; Kovach et al., 2015) and when the firm is in a venture stage (Azadegan et al., 2013a). In a survey based study,Azadegan et al. (2013b) propose that the benefits of lean operations depend on the environmental context. Their regression analysis finds evidence that in more dynamic industries, as opposed to stable ones, the effect of lean operations on performance is negative. Conversely, in industries classified as complex, the opposite is found. Kovach et al. (2015) test whether slack positively moderates the relationship between industry instability and firm performance. Based on Hendricks et al.' 2009 method, they use three forms of operational slack: capacity slack, inventory slack, and supply chain (CCC) slack. The results partially confirm their prediction. While they find capacity slack to buffer the effects of environmental instability on performance, the same is not found for inventory slack nor CCC slack. Interestingly, for CCC slack they find the opposite to be true – as instability increases, the accounting performance of firms with a high CCC decreases — a finding that supports lean management theory.Hendricks et al.' 2009 study pertains to the role of slack in mitigating the stock market's reaction to supply chain announcements, finding that capacity slack and CCC slack to decrease the severity. They argue that slack makes it easier for firms to recover from disruptions. Neither Kovach et al. (2015) nor Hendricks et al. (2009) have found support for inventory slack mitigating adverse effects on firm performance. We address this by using Eroglu and Hofer's (2011) more robust measure for slack to see if the result changes.

An extensively employed taxonomy (e.g. Azadegan et al., 2013b; Boyd, 1990; Bradley et al., 2011b; Keats & Hitt, 1988; Kovach et al., 2015) of determining the environmental condition of an industry was developed by Dess and Beard (1984). They define three primary environmental dimensions: Munificence, Dynamism, and Complexity. Like many previous to us (e.g. Azadegan et al., 2013a; Bradley et al., 2011a) we employ only two of these dimensions, albeit with slight alterations: Munificence, which we label Hostility, by taking its opposite and Dynamism, which we refer to as Instability, similar to Azadegan et al.; Keats and Hitt's (2013a, 1988) studies. As outlined in Dess and Beard's (1984) original paper, Munificence relates to an environment's ability to sustain continuous growth, determined by the sales growth rate. When utilized within an industry context, a high degree of Munificence suggests that the industry is well-endowed in resources to support growth, while a low degree implies a hostile market wherein firms engage in intense competition for resources (Boyd, 1990; Pagell & Krause, 2004). Dynamism, on the other hand, refers to volatility and difficulty of predicting patterns and mirrors risk within an industry. (Keats & Hitt, 1988; Pagell & Krause, 2004)

***Hypothesis 3* –** Drawing from the methodologies and rationale of the aforementioned studies, we lastly explore how operational slack defined by inventory, capacity and supply chain slack interacts with Hostility and Instability in an industry and the consequent impact on firm performance:

H3a: *(Hostility)* The relationship between Swedish manufacturing firm performance and hostility is moderated by operational slack.

H3b: *(Instability)* The relationship between Swedish manufacturing firm performance and instability is moderated by operational slack.

3 SAMPLE & METHODOLOGY

3.1 SAMPLE

Table 3.1: **Sample Selection**

	Excluded	Firm-year Observations
Total manufacturing firm-year observations		816,244
Excluding observations with reporting periods outside of 360 to 370 days	-230,316	585,928
Excluding subsidiaries and firms with frequent restructuring	-221,921	364,007
Excluding micro-firms as defined by EU standards	-214,042	149,965
Excluding for Missing or Insignificant Financial Data	-19,156	130,809
Excluding per Data Truncation (1^{st} and 99^{th} Percentiles)	-20,185	110,624
Excluded for Insufficient Industry Firm-year Observations	-1,397	109,227
Final Sample		**109,227**
	Total Firms	**11,348**

The data utilized in this study is sourced from the Serrano dataset (Weidenman, 2024), covering the period from 2000 to 2022. Our sample focuses exclusively on manufacturing firms classified under SNI 2007 codes 10 to 33. To ensure consistency and to minimise potential biases arising from varying financial reporting durations, we include only firms whose reporting periods ranged between 360 and 370 days. Furthermore, we exclude micro-firms from our analysis, which is defined by the European Commission (2003), as having either a turnover or a balance sheet total not exceeding €2 million[1], and no more than ten employees. The rationale for this exclusion is that micro-firms generally lack the structural and process efficiencies necessary to apply lean strategies, primarily due to their restricted size and limited resources. Further exclusions are made for subsidiaries and firms experiencing frequent restructurings. This strategy aligns with the reasoning behind excluding micro firms — aiming to mitigate effects induced by external governance and

1 This amount is approximately equivalent to 23.3 million SEK at the time of writing.

restructuring rather than operations. A significant factor in this decision is the lack of data on the decision-making autonomy of subsidiaries, which is crucial given that such autonomy can vary widely and influences performance, as emphasized by Galli Geleilate et al. (2020). Additionally, we exclude observations lacking essential financial data or containing economically irrational figures, such as negative values for sales or inventory. We identify a considerable number of outliers which could potentially bias the analysis. Therefore, we truncate at the 1^{st} and 99^{th} percentiles, effectively removing only the outlying 1% on each side of the distribution. Additionally, we eliminate observations in industries represented by fewer than 44 firm-years, as defined by the complete 5-digit SNI07 code. Lastly, all monetary values are adjusted for inflation to reflect year 2000 values.

The final sample consists of 11,348 manufacturing firms, active between 2000 and 2022, with standardized reporting periods and significant economic presence. These firms also exhibit stability, and are presumably autonomous – conditions that are essential for a clear evaluation of how operational slack influences firm performance.

3.2 VARIABLES

DEPENDENT VARIABLES

3.2.1 Return on Assets (ROA)

Return on Assets (ROA) is extensively used to evaluate firm performance in the operational efficiency context (e.g. Capkun et al., 2009; Eroglu & Hofer, 2011; Isaksson & Seifert, 2014; Kovach et al., 2015). We apply Johansson and Runsten's (2014) definition for calculating ROA:

$$\text{ROA}_{k,t} = \frac{\text{Adj. Operating Profit}_{k,t}}{\text{Total Assets}_{k,t-1}} \tag{3.1}$$

where,

- Adj. Operating Profit$_{k,t}$ includes operating profit after adjustments for depreciation and amortization, inclusive of financial income, and adjusted for items affecting comparability for firm k at time t.
- Total Assets$_{k,t-1}$ represents the opening book value of assets for the current year for firm k, reflecting the closing balance of the previous year, hence $t-1$.

3.2.2 Return on Sales (ROS)

Similarly to ROA, Return on Sales (ROS) is also a widely used metric for measuring operational efficiency. Again, followingJohansson and Runsten's (2014) defintion of profit margin, we define ROS as:

$$\text{ROS}_{k,t} = \frac{\text{Adj. Operating Profit}_{k,t}}{\text{S}_{k,t}} \tag{3.2}$$

where,

- Adj. Operating Profit$_k$, t is defined same as in ROA (3.1)
- $\text{S}_{k,t}$ is the Net Sales for firm k at time t.

The Dupont Analysis framework (Johansson & Runsten, 2014) clarifies the relationship between Return on Assets (ROA) and Return on Sales (ROS) by dividing ROA into profit margin (ROS) and asset turnover. This analysis provides insights into how profitability and asset efficiency impact ROA, considering factors like inventory levels and PPE. Understanding both ROA and ROS enhances strategic decision-making and operational assessment which offers a clearer view of a company's operational effectiveness.

INDEPENDENT VARIABLES

3.2.3 Empirical Slack Indicators (ESI)

As discussed in the literature review, the Empirical Leanness Indicator (ELI) was developed by Eroglu and Hofer (2011) to measure inventory leanness and was subsequently adopted by Bendig et al. (2017) to measure PPE (capacity) leanness. The method involves regressing the natural logarithm of sales on the natural logarithm of total inventory for each firm and year to obtain the residuals:

$$\ln(\mathrm{INV}_{k,t}) = a_{i,0} + b_{i,1}\ln(\mathrm{S}_{k,t}) + \zeta_i + \tau_t + \epsilon_{k,t} \tag{3.3}$$

where,

- $\ln(\mathrm{INV}_{k,t})$ represents the natural logarithm of firm k's inventory at time t,
- $\ln(\mathrm{S}_{k,t})$ denotes the natural logarithm of firm k's sales in the same time period,
- $a_{i,0}$ is the intercept for industry i,
- $b_{i,1}$ is the coefficient of the natural logarithm of sales,
- ζ_i represents the firm fixed effects,
- τ_t denotes the year fixed effects, and
- $\epsilon_{k,t}$ represents the residuals.

[noitemsep] The residuals $\epsilon_{k,t}$ are studentized to compute the ELI. Traditionally, the ELI is derived by inverting the sign of these studentized residuals, with positive values indicating greater inventory leanness. However, to simplify our analysis and interpretation, we retain the residuals in their original form. Aligning more closely to assess slack. Consequently, we term this measure the Empirical Slack Indicator (ESI).

$$\ln(\mathrm{ASSET}_{k,t}) = \alpha_{k,t} + \beta_1\ln(\mathrm{SALES}_{k,t}) + \zeta_i + \tau_t + \varepsilon_{k,t} \tag{3.4}$$

In this model:

- $\ln(\mathrm{ASSET}_{k,t})$ represents the natural logarithm of a specific asset for firm k in year t, which can be either $\ln(\mathrm{INVENTORY}_{k,t})$ for the Inventory ESI (ESI^{INV}) or $\ln(\mathrm{PPE}_{k,t})$ for the Capacity ESI (ESI^{PPE}),
- $\alpha_{k,t}$ is the intercept of the regression model,
- β_1 is the coefficient of the natural logarithm of sales,
- ζ_k represents the firm fixed effects,

- τ_t denotes the year fixed effects, accounting for common external influences affecting all firms during year t, and
- $\varepsilon_{k,t}$ represents the residuals of the regression, which after being studentized, are referred to as ESI^{INV} or ESI^{PPE}. Positive values of these residuals indicate higher levels of slack (less leanness), whereas negative values suggest greater leanness relative to industry and size peers.

Supply Chain Slack

Building upon the work of Kovach et al. (2015), our analysis extends through the lens of the Cash Conversion Cycle (CCC). As discussed in Section 2.1.3, we employ the CCC as a proxy for assessing the operational efficiency of a firm's supply chain.

$$\text{CCC}_{k,t} = \frac{\text{INV}_{k,t}}{\text{COGS}_{k,t}} + \frac{\text{Accounts Receivable}_{k,t}}{S_{k,t}} - \frac{\text{Accounts Payable}_{k,t}}{\text{Purchases}_{k,t}} \tag{3.5}$$

wherein $\text{Purchases}_{k,t}$ are defined as:

$$\text{Purchases}_{k,t} = \text{COGS}_{k,t} + \text{Closing Inventory}_{k,t} - \text{Opening Inventory}_{k,t} \tag{3.6}$$

Following the ESI methodology described earlier, we derive the CCC ESI by applying the regression model specified in Equation 3.4 to the natural logarithm of CCC and studentizing the residuals.

ENVIRONMENTAL CONDITIONS

3.2.4 Hostility

Adopting the methodology described by Dess and Beard (1984), we operationalise Hostility using the slope coefficient β_1, derived from a rolling regression model of industry sales or operating income. We utilize a 5-year window for our analysis, in line with the typical planning horizon and current market dynamics suggested by Keats and Hitt (1988), deviating from the 10-year window used in the original study by Dess and

Beard (1984). The Hostility, say for a focal year of 2008, is then calculated using data from the years 2004 to 2008 per this methodology.

$$Y_{i,j,t} = \alpha_{i,j,t} + \beta_{1,i,j,t} \cdot t + \epsilon_{i,j,t}, \tag{3.7}$$

where,

- $Y_{i,j,t}$ denotes industry sales ($j = s$) or operating income ($j = o$) for industry i at time t,
- $\beta_{1,i,j,t}$ is the slope coefficient, indicating the rate of change in Y over a 5-year rolling window, and
- $\epsilon_{i,j,t}$ is the residual component of the regression.

To account for industry size differences in our analysis, we normalize the slope coefficient $\beta_{1,i,j,t}$ by dividing it by the 5-year rolling mean value $\bar{Y}_{i,j,t}$ for each industry at time t. The Hostility of industry i at time t is then quantified as the average of these normalized growth rates for both industry sales and operating income:

$$\text{Hostility}_{i,t} = \sum^{J} \frac{\beta_{1,i,j,t}}{\bar{Y}_i, j, t} \bigg/ 2 \tag{3.8}$$

where,

- $\bar{Y}_{i,j,t}$ denotes the mean of $Y_{i,j,t}$ across the same 5-year window, used for normalizing the slope coefficient.

Despite the complex notation, the Hostility metric fundamentally captures a simple concept: the size-adjusted 5-year growth rate of an industry at time t.

3.2.5 Instability

Consistent with previous research, we quantify Instability by the variability within an industry. We measure this through the standard error of the regression slope coefficient

$\beta_{1,i,j,t}$ from the same equations as used to assess Hostility, again dividing by $\bar{Y}_{i,j,t}$ to account for industry size.

$$\text{Instability}_{i,t} = \sum^{J} \frac{SE(\beta_{1,i,j,t})}{\bar{Y}_{i,j,t}} \Big/ 2 \tag{3.9}$$

where,

- j represents either sales, operating income, and
- $SE(\beta_{1,i,j,t})$ signifies the standard error of the regression slope coefficient for industry i, j at time t.

3.2.6 Control Variables

Based on prior research we introduce several control variables in our model. Mainly drawing from Isaksson and Seifert (2014), we detail the specific variables below:

Firm Size ($Size_{k,t}$)

As evidenced in previous studies (e.g., Chen et al., 2005; Eroglu & Hofer, 2011; Isaksson & Seifert, 2014), controlling for firm size is crucial. Net sales serve as a proxy for size and are logarithmically transformed to stabilize variance and reduce skewness (Adding 1 ensures no loss of values in the log transformation when sales are zero).

$$\text{Size}_{k,t} = \ln(1 + \text{S}_{k,t})$$

where,

- $\text{S}_{k,t}$ represents the net sales for firm k at time t.

Sales Growth (g_s)

The same studies (e.g., Chen et al., 2005; Eroglu & Hofer, 2011; Isaksson & Seifert, 2014) underscore the importance of controlling for sales growth. Simply defined as:

$$g_s = \frac{\text{S}_{k,t} - \text{S}_{k,t-1}}{\text{S}_{k,t-1}}$$

Debt-to-Assets Ratio (D/A)

The Debt-to-Assets Ratio (D/A) quantifies a firm's financial leverage by relating total liabilities to total assets. This metric is used to assess financial stability and operational flexibility, as discussed by Isaksson and Seifert (2014) and Bendig et al. (2017). Following the definition provided by Weidenman (2024) from the Serrano Database, we define the D/A as:

$$\text{D/A} = \frac{\text{Adj. Total Liabilities}}{\text{Total Assets}}$$

where, Adjusted Total Liabilities consists of non-current liabilities, current liabilities, provisions, and deferred tax liabilities. Deferred tax liabilities are computed by applying the current tax rate (28%)[2] to the untaxed reserves.

Labor and Capital Expenditure Intensity Metrics

Lastly, as outlined by Isaksson and Seifert (2014), we also employ Labor Intensity ($\text{EMP/A}_{k,t}$) and Capital Expenditure Intensity ($\text{CAPX/A}_{k,t}$) as control variables for firm k at time t. Labor Intensity is the number of employees divided by total assets, reflecting the human capital intensity of the firm:

$$\text{EMP/A}_{k,t} = \frac{\text{Number of Employees}_{k,t}}{\text{Total Assets}_{k,t}}$$

Conversely, Capital Expenditure Intensity assesses the firm's investment scale relative to its size, calculated as the ratio of capital expenditures to average assets:

$$\text{CAPX/A}_{k,t} = \frac{\text{Capital Expenditures}_{k,t}}{\text{Average Assets}_{k,t}}$$

where Capital Expenditures include changes in fixed assets plus depreciation and amortization, as indicated by Johansson and Runsten (2014).

2 As given by Weidenman, 2024

3.3 REGRESSION MODEL

$$
\begin{aligned}
Y_{k,t} = \alpha + \sum_k \delta_k \chi_{k,i,t} + \beta_1 \text{Hostility}_{i,t} + \beta_2 \text{Instability}_{i,t} \\
+ \beta_3 \text{INV}_{k,t} + \beta_4 (\text{INV}_{k,t})^2 + \beta_5 \text{PPE}_{k,t} + \beta_6 (\text{PPE}_{k,t})^2 \\
+ \beta_7 \text{CCC}_{k,t} + \beta_8 (\text{CCC}_{k,t})^2 + \sum_k \gamma_k \Gamma_{k,i,t} + \mu_i + \tau_t,
\end{aligned}
\tag{3.10}
$$

where,

- $\chi_{k,i,t}$, control variables for firm k in industry i at time t;
- $\text{Hostility}_{i,t}$ and $\text{Instability}_{i,t}$, environmental variables;
- $\text{INV}_{k,t-1}$, $\text{PPE}_{k,t-1}$, and $\text{CCC}_{k,t-1}$, lagged ESI for INV, PPE, and CCC, respectively, to avoid issues of reverse causality;
- $\Gamma_{k,i,t}$, interaction terms of environmental variables with each slack indicator;
- μ_i and τ_t, fixed effects for industry and year, respectively.

Following recommendations of Abadie et al. (2022), we cluster standard errors at the firm level to control for heterogeneity, also controlling for correlation of errors across firms due to common economic, regulatory, and operational influences.

3.3.1 Robustness Testing

Resource Efficiency Ratios (RERs)

In order to substantiate the findings from the primary analysis using the Empirical Slack Indicators (ESIs), we employ Resource Efficiency Ratios (RERs) as an alternative operational efficiency measure to ELI/ESI. This methodology is based on the work of Hendricks et al. (2009) and Modi and Mishra (2011), providing a more robust framework for assessing efficiency across different resources. The RER for a specific resource j

(either total property, plant, and equipment (PPE) or total assets) for firm k in year t is defined as follows:

$$RER_{k,t}^{j} = \frac{S_{k,t}/R_{k,t}^{j} - \mu_{RER}^{j}}{\sigma_{RER}^{j}} \tag{3.11}$$

where:

- $S_{k,t}$ represents the sales of firm k in year t,
- $R_{k,t}^{j}$ denotes the average value of resource j for firm k in year t, either total PPE or total assets,
- μ_{RER}^{j} is the industry mean efficiency of resource j, calculated excluding the focal firm to prevent bias in the analysis,
- σ_{RER}^{j} is the standard deviation of efficiency for resource j within the industry, also calculated excluding the focal firm's data.

The RERs are integrated into the robustness analysis to ensure that the observed effects are consistent across different operational efficiency metrics and are not merely artifacts of the measurement technique.

Adjusted CCC (Adj. CCC)

Another alternative measure is the adjusted CCC(Adj. CCC), which follows the normalization used in our Resource Efficiency Ratios (RERs). The adjusted CCC for a firm k in year t is calculated as follows:

$$\text{Adjusted CCC}_{k,t} = \frac{\text{CCC}_{k,t} - \mu_{\text{CCC}}}{\sigma_{\text{CCC}}} \tag{3.12}$$

where,

- $\text{CCC}_{k,t}$ is the Cash Conversion Cycle for firm k in year t,
- μ_{CCC} is the mean CCC of the industry, calculated by excluding the focal firm from the dataset to avoid bias,
- σ_{CCC} is the standard deviation of the CCC within the industry, also calculated by excluding the focal firm to ensure an unbiased measure of variability.

4 EMPIRICAL RESULTS

4.1 DESCRIPTIVE STATISTICS

Table 4.1 provides summary statistics for our key measures as used in the final regression. It should be noted that there is a discrepancy in the number of observations, 53,537, compared to the initial sample shown in Table A.1 of 109,227. This reduction is principally due to the lagged ESIs, which invariably results in the omission of the first year's data for each firm. Additionally, our approach to calculate measures of Hostility and Instability necessitates a complete five-year data span. Consequently, no values can be assigned to any year preceding 2005 (in some cases even later).

Table 4.1: **Descriptive Statistics**

	Obs.	Mean	SD	Min	Median	Max
Total Inventories	53,537	1,679	2,545	0.0000	777	32,817
Total PP&E	53,537	2,474	3,731	1.0902	1,083	40,083
Net Sales	53,537	13,618	12,983	267.1035	9,231	86,512
Size	53,537	9.1512	0.8722	5.5914	9.1305	11.3681
Debt-to-Assets Ratio	53,537	0.5498	0.2330	0.0646	0.5487	1.2830
CAPX/A	53,537	-0.0427	0.0871	-0.3770	-0.0377	0.4569
EMP/A	53,537	0.0012	0.0009	0.0000	0.0010	0.0062
Sales Growth	53,537	0.0706	0.2441	-0.6598	0.0480	2.0391
Return on Sales	53,537	0.0661	0.0941	-0.5515	0.0543	0.6546
Return on Assets	53,537	0.1142	0.1401	-0.3135	0.0924	0.7682
ESI INV	53,044	0.0238	2.2537	-8.2620	0.3418	5.2918
ESI PPE	53,339	0.0046	2.0054	-5.8750	0.2110	4.8837
ESI CCC	53,353	0.2074	1.4810	-5.4762	0.2246	4.5823
Hostility	53,537	-0.0006	0.0937	-0.2402	-0.0181	0.4256
Instability	53,537	0.0051	0.0054	0.0002	0.0034	0.0396

All values are in thousands of year 2000 Swedish Krona (SEK), except for ratios.

The data reveals substantial heterogeneity within the sample. For instance, while the average inventory level is 1,679 thousand SEK, the standard deviation is considerably larger at 2,545 thousand SEK, indicating significant variation among firms. Similarly, the mean value for PPE is 2,474 thousand SEK, with a standard deviation of 3,731 thousand SEK. The average net sales stand at 13,618 thousand SEK. Firm size, centers around a mean of 9.1512 with a notable standard deviation of 0.8722. The debt-to-assets ratio averages 0.5498, highlighting a tendency towards high leverage among firms. Capital expenditures to assets (CAPX/A) and employee expenses to assets (EMP/A), are modest on average. However, sales growth and profitability metrics such as return on sales (ROS) and return on assets (ROA) exhibit both moderate means (0.0661 and 0.1142, respectively) and wide dispersions, suggesting variability in financial performance. In the analysis of empirical slack indicators (ESI), several key findings emerge. First, the mean for ESI INV stands at 0.0238, with a standard deviation of 0.2537. This indicator exhibits a substantial range, evidenced by a minimum value of -8.2620 and a maximum of 5.2918, highlighting significant variability among observations. The median value of 0.3418 suggests a positive central tendency, albeit skewed by several extreme outliers as indicated by studentized residuals exceeding 3, which is considerably high. Similarly, ESI PPE shows an average value of 0.0046, but with a higher standard deviation of 2.0054, signaling considerable dispersion in the data. The values range from -5.8750 to 4.8837. The median of 0.2110, while positive, also indicates potential skewness in the distribution, again corroborated by notable extreme outliers. For ESI CCC, the mean is observed at 0.20704 with an even wider standard deviation of 1.4810. This indicator presents the most significant spread among the three, ranging from -5.4762 to 4.5823. The median value here is 0.2246, which underscores the potential influence of outliers on the distribution. Turning to the indicators of Hostility and Instability, which are similarly critical in this context, we find that Hostility has a mean of -0.0006 and a standard deviation of 0.0937. The range here is quite wide, from -0.0181 to 0.4256, suggesting varied degrees of hostility environments across the sample. Instability shows a mean of 0.0051 and a standard deviation of 0.0054, with its values spanning from 0.0002 to 0.0396. These measurements indicate a relatively stable environment, albeit with some instances showing higher variability. The observed extreme values in ESI INV, ESI PPE, and ESI CCC indicate the presence of significant outliers, which are considerably distant from the majority of data points. The presence of such outliers is critical, as they suggest extreme cases that could potentially influence the overall analysis. These extremes, particularly those with studentized residuals above 3, denote very large deviations from predicted values based on the model, necessitating further investigation into their causes and implications. This highlights the importance of robust outlier management techniques to ensure a reliable analysis and interpretation of the empirical slack indicators within the sample.

4.2 RESULTS

We estimate three models (Quadratic, Simple, Complex) to examine the relationship between firm slack, environmental dimensions, and performance (ROA, ROS). Detailed results are presented in Table 4.2 and Table 4.4. The Quadratic model includes lagged slack measures and controls. The Simple model adds interactions between linear slack and environmental variables. The Complex model adds interactions with squared slack terms.

Model Selection

The regression analysis yielded noteworthy findings. For the ROA regressions, the Complex model exhibited the lowest corrected Akaike Information Criterion (AICc) value (-77821.648), suggesting a superior fit compared to the Quadratic and Simple models. However, the Bayesian Information Criterion (BIC) favored the Quadratic model (-77665.225), indicating a more parsimonious fit. In the ROS regression, the Simple model outperformed the others based on AICc (-116675.906). Conversely, the BIC favored the Quadratic model again (-116547.408). This pattern suggests that while simpler models

Table 4.2: **Regression Table: Return on Assets**

	Quadratic Model		Simple Model		Complex Model	
	Estimate	SE	Estimate	SE	Estimate	SE
Intercept	-0.0320***	(0.0106)	-0.0329***	(0.0106)	-0.0307***	(0.0106)
Controls						
Size	0.0263***	(0.0011)	0.0265***	(0.0011)	0.0265***	(0.0011)
Debt-to-Assets	-0.1448***	(0.0040)	-0.1445***	(0.0040)	-0.1442***	(0.0040)
CapEx / Total Assets	0.1044***	(0.0076)	0.1037***	(0.0076)	0.1038***	(0.0076)
Emp / Total Assets	-7.8291***	(1.2708)	-8.0526***	(1.2759)	-8.1789***	(1.2762)
Sales Growth	0.1993***	(0.0039)	0.1990***	(0.0039)	0.1990***	(0.0039)
Slack Measures[a]						
PPE	-0.0098***	(0.0005)	-0.0110***	(0.0006)	-0.0113***	(0.0006)
$(PPE)^2$	-0.0011***	(0.0002)	-0.0011***	(0.0002)	-0.0016***	(0.0002)
INV	-0.0084***	(0.0007)	-0.0088***	(0.0008)	-0.0093***	(0.0009)
$(INV)^2$	-0.0011***	(0.0001)	-0.0011***	(0.0001)	-0.0012***	(0.0002)
CCC	-0.0070***	(0.0009)	-0.0068***	(0.0012)	-0.0063***	(0.0012)
$(CCC)^2$	0.0010***	(0.0003)	0.0010***	(0.0003)	0.0010***	(0.0004)
Environmental Factors						
Hostility	-0.0276***	(0.0082)	-0.0309***	(0.0084)	-0.0243**	(0.0110)
Instability	-1.2877***	(0.1848)	-1.2657***	(0.1861)	-1.7211***	(0.2342)
Interactions - Environmental Hostility						
PPE x Hostility			0.0017	(0.0034)	0.0010	(0.0034)

$(PPE)^2$ x Hostility					-0.0013	(0.0014)
INV x Hostility			-0.0118**	(0.0047)	-0.0145***	(0.0055)
$(INV)^2$ x Hostility					-0.0010	(0.0010)
CCC x Hostility			0.0169**	(0.0075)	0.0191**	(0.0079)
$(CCC)^2$ x Hostility					0.0015	(0.0025)
Interactions - Environmental Instability						
PPE x Instability			0.2097***	(0.0717)	0.2509***	(0.0698)
$(PPE)^2$ x Instability					0.0762***	(0.0279)
INV x Instability			0.0478	(0.0872)	0.1348	(0.1004)
$(INV)^2$ x Instability					0.0283	(0.0190)
CCC x Instability			-0.0211	(0.1319)	-0.1040	(0.1410)
$(CCC)^2$ x Instability					-0.0030	(0.0435)
Observations	53,537		53,537		53,537	
Adjusted R^2	0.303		0.303		0.304	
AICc	-77789.651		-77812.909		-77821.648	
BIC	-77665.225		-77635.162		-77590.583	
Fixed Effects[b]	Yes		Yes		Yes	
Clustered Standard Errors[c]	Yes		Yes		Yes	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[a] All slack measures are lagged by 1 year,

[b] Includes both Industry and Year fixed-effects,

[c] Clustered at the firm-level

offer adequate explanatory power, the Quadratic model consistently provides a marginally superior fit without introducing excessive complexity.

RESULTS AND INTERPRETATION

Looking at Table 4.2, the slack indicators consistently show significant negative coefficients across all models, both for the linear and squared terms, suggesting evidence in support of *H1* and *H2*. However Table 4.4 presents the opposite effect. ESI PPE exhibits have a significant positive relationship with ROS across all models, both linearly and in its quadratic form. ESI CCC follows this same relationship with ROS, with a positive coefficient both on the linear and square term. ESI INV on the other hand still shows a negative effect on ROS and its quadratic term is also negative.

Hostility and Instability are found to have a consistently negative relationship with both ROA and ROS, highlighting the challenges firms face in adverse conditions and supporting *H3a* and *H3b*. The presence of these factors tends to decrease firm performance, indicating that external environmental pressures and uncertainties can significantly affect operational effectiveness. Moreover, the interaction terms, particularly between slack measures and environmental variables, reveal some interesting insights. For instance, the interaction between PPE and environmental instability has a positive effect on ROA in the Quadratic and Complex models, implying that substantial physical assets may buffer the adverse effects of environmental instability on asset returns. However, the interaction between PPE and Hostility negatively impacts ROS across models, implying that in hostile environments, heavy investments in physical assets might not translate into increased sales efficiency. Lastly, the control variables are deemed to be relevant in our models showing significant relationships across all models and financial performance metrics.

Table 4.4: **Regression Table: Return on Sales**

	Quadratic Model		Simple Model		Complex Model	
	Estimate	SE	Estimate	SE	Estimate	SE
Intercept	0.1277***	(0.0106)	0.1273***	(0.0107)	0.1275***	(0.0106)
Controls						
Size	0.0037***	(0.0011)	0.0038***	(0.0011)	0.0038***	(0.0011)
Debt-to-Assets	-0.1199***	(0.0034)	-0.1200***	(0.0034)	-0.1200***	(0.0034)
CapEx / Total Assets	0.0986***	(0.0059)	0.0985***	(0.0059)	0.0986***	(0.0059)
Emp / Total Assets	-22.3997***	(0.8652)	-22.3671***	(0.8685)	-22.3581***	(0.8687)
Sales Growth	0.0834***	(0.0024)	0.0833***	(0.0024)	0.0833***	(0.0024)
Slack Measures[a]						
PPE	0.0013***	(0.0005)	0.0014**	(0.0006)	0.0014**	(0.0006)
$(PPE)^2$	0.0003*	(0.0001)	0.0003**	(0.0001)	0.0003*	(0.0002)
INV	-0.0087***	(0.0005)	-0.0090***	(0.0007)	-0.0090***	(0.0008)
$(INV)^2$	-0.0008***	(0.0001)	-0.0008***	(0.0001)	-0.0008***	(0.0001)
CCC	0.0031***	(0.0007)	0.0036***	(0.0010)	0.0036***	(0.0010)
$(CCC)^2$	0.0008***	(0.0002)	0.0008***	(0.0002)	0.0006**	(0.0003)
Environmental Factors						
Hostility	-0.0232***	(0.0058)	-0.0243***	(0.0058)	-0.0158**	(0.0075)
Instability	-0.7508***	(0.1367)	-0.7365***	(0.1360)	-0.7587***	(0.1702)
Interactions - Environmental Hostility						
PPE x Hostility			-0.0062**	(0.0026)	-0.0068**	(0.0029)

$(PPE)^2$ x Hostility					-0.0008	(0.0011)
INV x Hostility			-0.0047	(0.0035)	-0.0074*	(0.0043)
$(INV)^2$ x Hostility					-0.0009	(0.0008)
CCC x Hostility			0.0055	(0.0055)	0.0079	(0.0059)
$(CCC)^2$ x Hostility					-0.0004	(0.0018)
Interactions - Environmental Instability						
PPE x Instability			-0.0210	(0.0569)	-0.0246	(0.0621)
$(PPE)^2$ x Instability					-0.0092	(0.0220)
INV x Instability			0.0496	(0.0725)	0.0577	(0.0919)
$(INV)^2$ x Instability					0.0030	(0.0158)
CCC x Instability			-0.0823	(0.1125)	-0.0891	(0.1215)
$(CCC)^2$ x Instability					0.0198	(0.0333)
Observations	53,537		53,537		53,537	
Adjusted R^2	0.252		0.253		0.253	
AICc	-116671.834		-116675.906		-116670.437	
BIC	-116547.408		-116498.159		-116439.371	
Fixed Effects[b]	Yes		Yes		Yes	
Clustered Standard Errors[c]	Yes		Yes		Yes	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[a] All slack measures are lagged by 1 year,

[b] Includes both Industry and Year fixed-effects,

[c] Clustered at the firm-level

5 DISCUSSION & ANALYSIS

Our results provide strong evidence that slack variables, by our specification of the term, operational slack has a negative impact on ROA. This negative relationship implies that excess resources are detrimental to asset returns, and thereby endorses lean management theory. This finding aligns with the expectations outlined in *Hypothesis 1* and is consistent with of previous research findings as discussed in the literature review Capkun et al., 2009; Eroglu and Hofer, 2011; Modi and Mishra, 2011, e.g. etc. The outcome aligns logically with a lean perspective since an excess of resources implies their underutilization, resulting in reduced operational efficiency and consequently performance.

Hypothesis 2 concerns the quadratic form of the slack-performance relationship and more specifically predicts the relationship to be concave. This partially is supported by our results. In the ROA regression model, all three components of operational slack show significant, negative quadratic terms. Thus, the relationship exhibits an inverted U-shaped form. However, the results from the ROS regression model shows a different result. While the quadratic terms for PPE and Inventory slack are negative, CCC is positive. Our results show the opposite from that of (Kovach et al., 2015), in which they found the quadratic term for CCC to be negative in the ROA model but positive in the ROS regression. Additionally, it appears that the turning point for most of our slack terms lies close to the boundary or beyond the maximum value of ESIs. Consequently, generally our results align with that of Isaksson and Seifert, 2014, that is, the existence of an optimal point unsupported.

Both Hostility and Instability show a significant and negative relationship with ROA. This highlights the challenging nature of operating under adverse conditions. The negative coefficients indicate that increased environmental uncertainty or industry hostility directly decreases the effectiveness with which firms deploy their assets to generate earnings. This supports Dess and Beard's (1984) taxonomy stating that that external pressures strain firm operations and limit their ability to execute strategies effectively. This finding is consistent with our expectations underlying hypothesis *H3*. Nevertheless, *Hypothesis 3* itself is only partially supported by our findings, capacity slack being the only measure of operational slack aligning with our expectations. In the Complex and Quadratic models, the interaction between capacity slack and environmental instability shows a positive effect on ROA, This suggests that in unstable environments, having an excess of PPE assets serves as a protective buffer, enabling firms to maintain or even enhance asset returns despite external pressures.

5.0.1 The Paradox of Slack and Return on Sales

In this section of our analysis, we delve deeper into the seemingly paradoxical relationship identified between operational slack and Return on Sales (ROS), as revealed by our data. From a lean perspective, we should find that slack decreases performance, as we did for the relationship with ROA. Intriguingly, our findings suggest that increased operational slack corresponds to enhanced ROS, a relationship that contradicts the expectations derived from our literature review and furthermore opposes lean management theory. This raises the question of whether it is appropriate to reexamine the theoretical role of slack in determining firm performance. According to the Dupont analysis, which we highlighted in the methodology section, an increased level of assets, ceteris paribus, leads to a decreased operational efficiency. This illustrates that Return on Assets (ROA) is a product of the profit margin and the asset turnover ratio. From this angle, it may be the case that firms experiencing a low asset turnover prioritize enhancing their profit margins over asset turnover improvements. This prioritisation strategy might stem from a pragmatic recognition of limited managerial focus; optimally, a firm might not be able to improve both dimensions simultaneously. This presents a possible explanation for our results which reveal a nuanced dynamic: firms with poorer asset turnover unexpectedly demonstrate improved profitability metrics. It may suggest a strategic disposition, caused by prioritisation of ROS above asset turnover efficiencies. It might be the case that such firms intentionally maintain higher slack not merely as a buffer against environmental uncertainties but also as a strategic lever to penetrate market segments or develop product offerings that command higher profit margins, rather than focusing on volume turnover. This strategy emphasizes profit maximization even at the potential expense of asset turnover.

This interpretation of the data implies that firms with significant slack strategically prioritize enhancing ROS over improving asset turnover. This focus on ROS, rather than asset efficiency, which might indicate a strategic alignment where organizations intentionally seek to boost profitability metrics that directly affect their bottom line.

Moreover, this perspective not only corroborates our findings but also underscores the need for a deeper understanding of how firms navigate the intricate balance between slack, asset turnover, and profitability. It highlights the strategic importance of context-aware resource management, where decisions about slack are shaped not just by the need for operational efficiency but also by broader strategic objectives aimed at maximizing customer satisfaction and profit margins. These insights are essential for dissecting the complex and sometimes contradictory relationships observed in our dataset, emphasizing the need for a multidimensional approach to assess the impact of slack on financial outcomes.

5.1 ROBUSTNESS ANALYSIS

To substantiate our findings, we explore alternative indicators of slack and operational efficiency. Tables referenced as Table 4.2 and Table 4.4 extend the analysis of our primary regression models, incorporating measures of resource efficiency in lieu of conventional slack variables. Notably, a significant proportion of our variables display non-significant coefficients. This phenomenon could indicate potential limitations in the validity of our measures or suggest that our findings might not be as robust as initially assumed. A deeper investigation into standard regression diagnostics provides insights into these nuances.

5.1.1 Efficiency Analysis

In assessing model efficiency, our approach entailed adjusting for varied operational efficiency metrics and juxtaposing these outcomes against our primary analysis. This examination helps ascertain the sensitivity of our findings to the operational definitions employed, reinforcing the validity of our conclusions or highlighting potential fragilities.

The application of the Variance Inflation Factor (VIF) test underscored severe multicollinearity in our robustness checks, with the most extreme case presenting a VIF exceeding 394,000. Such extreme multicollinearity undermines the reliability of hypothesis testing due to inflated standard errors, even though it might not bias the coefficient estimates. By contrast, the original models yielded far lower VIF values, peaking at 6.84 — a figure that, while elevated, does not pose any concern regarding the precision of the coefficient estimates. Multicollinearity primarily affects the confidence intervals and p-values, potentially obscuring significant relationships due to overinflated error terms. Our findings here necessitate a cautious interpretation of the robustness models, perhaps prompting a reconsideration of model specification or the adoption of dimensionality reduction techniques such as principal component analysis.

5.1.2 Normality of Errors

The assumption of normally distributed residuals, which is crucial for valid inference in many regression analyses, faces scrutiny based on our diagnostic checks (Figures A.5 to A.8). These quantile-quantile plots show marked departures from normality, particularly in the tails, indicating possible outliers or heavy-tailed distributions. Such anomalies can severely undermine the validity of our hypothesis tests.

In response to these findings, we implemented the Shapiro-Wilk test, which confirmed the non-normality of the residuals. Intriguingly, this issue has not been addressed in prior literature, leading us to question whether earlier scholars overlooked this analysis or simply did not encounter this anomaly in their datasets. If the latter is the case, it prompts further investigation into what variables might be absent from our model that were present in prior studies, potentially explaining the discrepancy in our findings.

6 CONCLUSION

Many a years have passed since Toyota first implemented their famous production system and many scholars have, since, studied the effect of lean management and slack resource theory. Yet evidence linking these strategies to firm performance has remained elusive. In this thesis we have tried to add a piece to this puzzle, examining the relationship between operational strategies—specifically operational slack—and firm performance under conditions of environmental instability and hostility within the context Swedish manufacturing firms.

Our study distinguishes itself by employing a dual-analytic approach that encompasses both lean and slack perspectives. This integrative approach facilitates a comprehensive examination of how these management strategies influence firm performance. Our results reveal a negative linear relationship between operational slack and Return on Assets (ROA), supporting lean management theories by suggesting that excess resources may impede asset efficiency. Underscoring the detrimental effects of underutilized resources on operational efficiency.

However, the relationship between operational slack and firm performance is not straightforward. Our analysis also uncovers a quadratic, inverted U-shaped relationship in the ROA model, suggesting a decreasing marginal effect of leanness on firm performance. The discussion extends into the realm of environmental challenges where both Hostility and Instability exert a significant negative influence on ROA, confirming the detrimental impact of adverse conditions on firm performance. However, the interaction effects suggest that in certain contexts, such as unstable environments, excess capacity can serve as a protective buffer, enhancing asset returns. This highlights the contextual sensitivity of operational strategies and the potential benefits of tailored resource management.

In the Return on Sales (ROS) model, we encounter a paradoxical relationship where increased slack appears to enhance ROS, challenging the conventional notion of lean management theory. We speculate that this might stem from the fact that firms with lower asset turnover may strategically opt to boost their profit margins rather than improving asset turnover.

This strategic choice might arise from a recognition of the limitations in managerial capacity, where optimizing both asset turnover and profit margins simultaneously may not be feasible. As a result, firms may prioritize profit margins, particularly in scenarios where asset turnover improvements are challenging. This decision may not be just a buffer against environmental uncertainties but could also serve as a strategic lever to penetrate higher-margin market segments or develop premium product offerings. It is evident that in the Swedish manufacturing industry, what might initially be perceived as ’slacking’ might, in reality, be a sophisticated strategy for navigating the rough waters of unfavorable environments. This approach challenges the traditional view of lean management theory by demonstrating that, sometimes, more is indeed more.

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APPENDIX

Table A.1: **Correlation Matrix**

	ROS	ROA	INV	PPE	CCC	L.INV	L.PPE	L.CCC	HOST.	INST.	Size	D/A	CAPX/A	EMP/A
Return on Sales	1.000													
Return on Assets	0.732	1.000												
ESI INV	-0.168	-0.183	1.000											
ESI PPE	0.028	-0.148	0.060	1.000										
ESI CCC	-0.112	-0.209	0.741	0.092	1.000									
L.ESI INV	-0.147	-0.160	0.957	0.056	0.709	1.000								
L.ESI PPE	0.027	-0.152	0.064	0.963	0.089	0.067	1.000							
Hostility	-0.076	-0.106	-0.003	0.003	-0.010	0.001	0.005	1.000						
Instability	-0.047	-0.056	0.010	-0.005	-0.018	0.007	-0.008	0.305	1.000					
Size	0.010	0.147	0.223	0.112	0.078	0.220	0.109	-0.054	0.002	1.000				
Debt-to-Assets Ratio	-0.354	-0.258	0.150	0.095	0.169	0.136	0.088	-0.001	-0.011	0.088	1.000			
CAPX/A	0.136	0.155	0.028	-0.099	0.033	0.028	-0.220	-0.054	0.014	0.079	-0.041	1.000		
EMP/A	-0.244	-0.013	-0.108	-0.285	-0.140	-0.109	-0.276	-0.030	-0.075	-0.031	0.273	-0.086	1.000	
Sales Growth	0.212	0.367	-0.063	-0.045	-0.143	-0.003	-0.012	-0.095	-0.044	0.168	0.078	0.116	0.040	1.000

Table A.2: **Regression Table: Return on Assets**

	Quadratic Model		Simple Model		Complex Model	
	Estimate	SE	Estimate	SE	Estimate	SE
Intercept	0.0947***	(0.0148)	0.1012***	(0.0156)	0.0916***	(0.0179)
Controls						
Log Size	0.0165***	(0.0011)	0.0164***	(0.0011)	0.0160***	(0.0011)
Debt-to-Assets	-0.1713***	(0.0050)	-0.1696***	(0.0043)	-0.1666***	(0.0040)
CapEx / Total Assets	0.1501***	(0.0076)	0.1501***	(0.0076)	0.1500***	(0.0076)
Emp / Total Assets	5.5272***	(1.4479)	5.0512***	(1.2246)	4.1834***	(1.1431)
Sales Growth	0.2051***	(0.0040)	0.2053***	(0.0040)	0.2057***	(0.0039)
Resource Efficiency Measures[a]						
RER PPE	0.0948***	(0.0261)	0.0974***	(0.0263)	0.0625*	(0.0375)
$(\text{RER PPE})^2$	0.0451***	(0.0167)	0.0417**	(0.0168)	0.0164	(0.0249)
RER INV	0.0040	(0.0059)	0.0081	(0.0078)	0.0064	(0.0086)
$(\text{RER INV})^2$	0.0001	(0.0008)	0.0000	(0.0007)	0.0009	(0.0028)
ADJ CCC	-0.0071***	(0.0027)	-0.0111***	(0.0010)	-0.0123***	(0.0010)
$(\text{ADJ CCC})^2$	0.0000***	(0.0000)	0.0000***	(0.0000)	0.0002	(0.0001)
Environmental Factors						
Hostility	-0.0235***	(0.0085)	0.0602	(0.0379)	0.0721	(0.0694)
Instability	-1.4090***	(0.1905)	-2.5776***	(0.6910)	-1.4057	(1.2554)
Interactions - Environmental Hostility						
RER PPE x Hostility			0.0713	(0.0448)	0.1088	(0.1682)

$(\text{RER PPE})^2$ x Hostility					0.0205	(0.1050)
RER INV x Hostility			0.0539	(0.0396)	0.0530	(0.0422)
$(\text{RER INV})^2$ x Hostility					0.0007	(0.0121)
ADJ CCC x Hostility			-0.0263*	(0.0138)	-0.0048	(0.0067)
$(\text{ADJ CCC})^2$ x Hostility					0.0008***	(0.0002)
Interactions - Environmental Instability						
RER PPE x Instability			-0.8567	(0.7452)	2.8147	(2.7557)
$(\text{RER PPE})^2$ x Instability					2.5138	(1.7179)
RER INV x Instability			-0.8631	(0.6723)	-1.1418	(1.6984)
$(\text{INV})^2$ x Instability					-0.2229	(0.8789)
ADJ CCC x Instability			0.5638**	(0.2457)	0.2123	(0.1371)
$(\text{ADJ CCC})^2$ x Instability					-0.0214	(0.0135)
Observations	53,535		53,535		53,535	
Adjusted R^2	0.270		0.272		0.275	
AICc	-75322.486		-75425.997		-75672.275	
BIC	-75198.061		-75248.251		-75452.099	
Fixed Effects[b]	Yes		Yes		Yes	
Clustered Standard Errors[c]	Yes		Yes		Yes	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[a] All resource efficiency measures are lagged by 1 year,

[b] Includes both Industry and Year fixed-effects,

[c] Clustered at the firm-level

Table A.3: **Regression Table: Return on Sales**

	Quadratic Model		Simple Model		Complex Model	
	Estimate	SE	Estimate	SE	Estimate	SE
Intercept	0.1768***	(0.0115)	0.1770***	(0.0119)	0.1744***	(0.0125)
Controls						
Log Size	-0.0011	(0.0010)	-0.0012	(0.0010)	-0.0013	(0.0010)
Debt-to-Assets	-0.1235***	(0.0035)	-0.1229***	(0.0034)	-0.1219***	(0.0034)
CapEx / Total Assets	0.0910***	(0.0055)	0.0911***	(0.0055)	0.0911***	(0.0055)
Emp / Total Assets	-21.6901***	(0.8582)	-21.8407***	(0.8156)	-22.1491***	(0.8072)
Sales Growth	0.0879***	(0.0025)	0.0880***	(0.0025)	0.0881***	(0.0025)
Resource Efficiency Measures[a]						
RER PPE	-0.0024	(0.0137)	-0.0051	(0.0145)	-0.0177	(0.0191)
$(\text{RER PPE})^2$	-0.0032	(0.0091)	-0.0020	(0.0091)	-0.0113	(0.0130)
RER INV	0.0066*	(0.0036)	0.0103**	(0.0051)	0.0125**	(0.0055)
$(\text{RER INV})^2$	-0.0003	(0.0005)	-0.0004	(0.0005)	0.0016	(0.0018)
ADJ CCC	-0.0026**	(0.0010)	-0.0038***	(0.0006)	-0.0044***	(0.0006)
$(\text{ADJ CCC})^2$	0.0000**	(0.0000)	0.0000***	(0.0000)	0.0001	(0.0001)
Environmental Factors						
Hostility	-0.0237***	(0.0058)	0.0074	(0.0252)	0.0027	(0.0449)
Instability	-0.7690***	(0.1385)	-0.8545*	(0.4905)	-0.7459	(0.8306)
Interactions - Environmental Hostility						
RER PPE x Hostility			0.0130	(0.0314)	0.0044	(0.1096)

$(\text{RER PPE})^2$ x Hostility					-0.0077	(0.0686)
RER INV x Hostility			0.0339	(0.0249)	0.0304	(0.0257)
$(\text{RER INV})^2$ x Hostility					-0.0015	(0.0081)
ADJ CCC x Hostility			-0.0095	(0.0064)	-0.0022	(0.0048)
$(\text{ADJ CCC})^2$ x Hostility					0.0004***	(0.0001)
Interactions - Environmental Instability						
RER PPE x Instability			0.4745	(0.5827)	1.8085	(1.8644)
$(\text{RER PPE})^2$ x Instability					0.9183	(1.2325)
RER INV x Instability			-0.5895	(0.4745)	-1.5577	(1.0957)
$(\text{INV})^2$ x Instability					-0.5909	(0.5883)
ADJ CCC x Instability			0.1770	(0.1154)	0.0600	(0.0901)
$(\text{ADJ CCC})^2$ x Instability					-0.0123*	(0.0073)
Observations	53,535		53,535		53,535	
Adjusted R^2	0.234		0.235		0.236	
AICc	-115382.542		-115400.180		-115467.018	
BIC	-115269.005		-115233.322		-115246.842	
Fixed Effects[b]	Yes		Yes		Yes	
Clustered Standard Errors[c]	Yes		Yes		Yes	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[a] All resource efficiency measures are lagged by 1 year,

[b] Includes both Industry and Year fixed-effects,

[c] Clustered at the firm-level

Figure A.4: **Quantiles of Residuals against Quantiles of Normal Distribution**

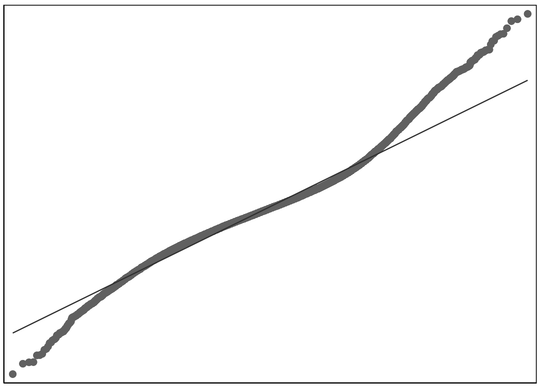

Figure A.5: **Simple Model: ROA**

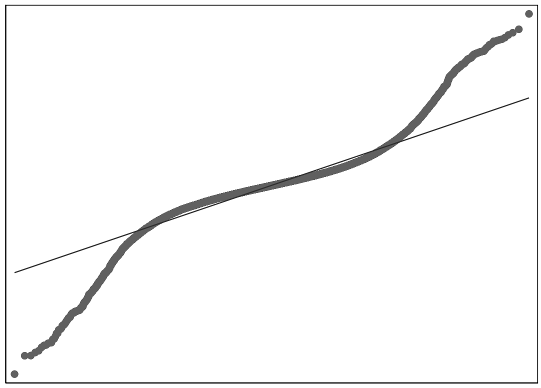

Figure A.6: **Simple Model: ROS**

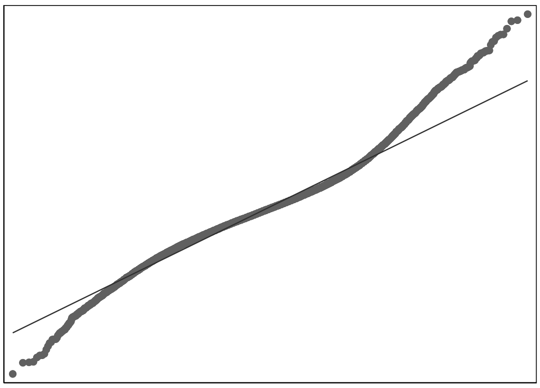

Figure A.7: **Complex Model: ROA**

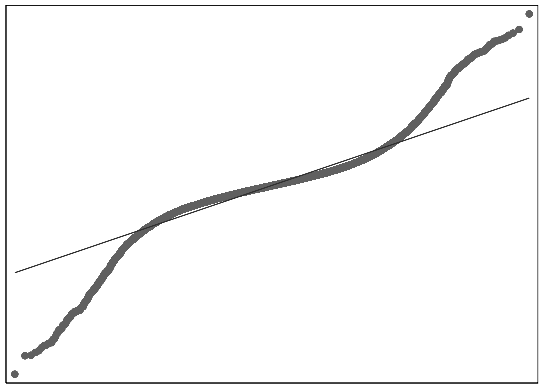

Figure A.8: **Complex Model: ROS**