

OPTIMIZING LIQUIDITY FOR TECHNOLOGICAL ADVANCEMENT: A STRATEGIC MODEL FOR 4IR MANUFACTURING IN OMAN

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Abstract: *This study investigates the strategic nexus between liquidity optimization and the adoption of Fourth Industrial Revolution (4IR) technologies in driving sustainable manufacturing performance in Oman. Utilizing panel data from 25 publicly listed manufacturing firms on the Muscat Stock Exchange over the period 2013–2023, the research applies fixed-effects and random-effects regression models, complemented by mediation analysis, to evaluate how effective liquidity practices—measured through cash conversion cycle, inventory turnover, and receivables/payables efficiency—impact operational and financial performance. Findings demonstrate that firms with optimized liquidity structures exhibit superior return on assets (ROA) and return on equity (ROE), while also being better positioned to adopt critical 4IR technologies, including artificial intelligence (AI), the Internet of Things (IoT), and automation. Technological adoption mediates nearly 29% of liquidity's influence on performance, emphasizing its pivotal role in transforming financial efficiency into digital capability. The study proposes a strategic model linking financial management and digital transformation, offering practical implications for industrial policymakers and business leaders under Oman Vision 2040. It fills a crucial gap in the literature by integrating liquidity strategy with technological advancement to enhance competitiveness and sustainability in emerging economies.*

Keywords: *Liquidity Optimization; Technological Adoption; Industry 4.0; Manufacturing Efficiency; Financial Strategy; Mediation Analysis*

Introduction

The advent of the Fourth Industrial Revolution (4IR) has significantly transformed the global manufacturing landscape, driven by disruptive technologies such as artificial intelligence (AI), automation, the Internet of Things (IoT), and big data analytics (Menegon Lopes & Silva Filho, 2024). While global manufacturing increasingly embraces 4IR technologies, little empirical research examines how these technologies interact with financial strategies—particularly liquidity management—in emerging markets. In Oman’s manufacturing sector, which contributed approximately 9.4% of GDP in 2023 and grew to about 10% in 2024, employing over 61,000 workers (NCSI, 2024), this gap is especially pronounced. Most prior studies analyze working capital efficiency or digital adoption in isolation, leaving unclear how financial health can strategically enable technology-driven competitiveness. These advancements are reshaping how firms operate, compete, and sustain long-term efficiency. In this evolving industrial context, liquidity optimization—a core component of financial management—has emerged as a strategic enabler for firms seeking to integrate these technologies effectively (Fanoro et al., 2021). Particularly in developing economies such as Oman, where the manufacturing sector is integral to the national vision for economic diversification, the intersection of liquidity management and digital transformation warrants critical academic and policy attention (Igwe et al., 2024).

The manufacturing industry in Oman plays a vital role in supporting the country’s Vision 2040 goals by promoting non-oil economic activities, enhancing competitiveness, and fostering sustainable development (Chung, 2021). However, many firms face persistent challenges in achieving operational efficiency due to financial constraints, inefficient working capital practices, and limited technological integration (Wu et al., 2024). Inadequate liquidity management—reflected in suboptimal cash conversion cycles, delayed receivables, excessive inventory holding, and poor payables strategies—can hinder a firm’s ability to invest in and sustain digital transformation initiatives (Ayomide et al., 2024). Conversely, firms that optimize their liquidity position are better positioned to adopt 4IR technologies, which in turn improve production efficiency, cost control, and profitability (Adebayo et al., 2025).

Despite growing recognition of the importance of liquidity and technology, limited empirical research has examined their combined impact on sustainable manufacturing performance in emerging markets, particularly within the context of Oman (Xu & Yang, 2024). Most existing studies tend to focus either on working capital efficiency or on the operational benefits of digital technologies, without integrating these dimensions into a unified strategic framework (Zhou et al., 2021). This research addresses this gap by investigating how liquidity optimization interacts with the adoption of 4IR technologies to enhance manufacturing efficiency, offering both theoretical insights and practical implications (Barro et al., 2024).

Research Problem

Manufacturing firms in Oman often struggle with balancing liquidity needs and long-term innovation investments. While technology promises enhanced productivity and competitiveness, its implementation is capital-intensive and risky without strong financial foundations (Ronchini et al., 2024). This research investigates how firms can strategically leverage liquidity management practices to support technology adoption, thereby enhancing sustainable manufacturing efficiency.

Research Objectives

The study aims to:

1. Examine the impact of liquidity optimization on sustainable manufacturing efficiency in Oman's industrial sector.
2. Analyze the role of technological adoption—specifically AI, IoT, and automation—as a mediating variable in the relationship between liquidity management and operational efficiency.
3. Provide policy recommendations and strategic insights for manufacturers and financial managers aiming to align digital transformation with financial resilience.

Significance of the Study

This study offers novel contributions by linking financial strategy with technological innovation within the framework of the Fourth Industrial Revolution. It provides evidence-based insights for manufacturing firms, financial strategists, and policymakers in Oman, emphasizing the importance of integrated financial-technology planning to achieve sustainable industrial development (Yudaruddin et al., 2024).

Structure of the Paper

The remainder of this paper is structured as follows:

Section 2 presents a review of relevant literature and the theoretical framework.

Section 3 outlines the research methodology, including data sources, variables, and analytical methods.

Section 4 discusses the empirical findings and their implications.

Section 5 concludes the study with key takeaways, recommendations, and directions for future research.

Literature Review

Liquidity management is widely acknowledged as a critical determinant of organizational performance, especially in capital-intensive industries like manufacturing. While Kou and Lu (2025) emphasize its strategic role in sustaining operations, Lee et al. (2024) and Sharabati et al. (2024) provide empirical evidence that efficient control over cash conversion cycles, inventory turnover, and receivables/payables directly enhances profitability while mitigating financial risk. Nam and Tuyen (2024) further reinforce this view by showing that maintaining optimal liquidity reduces reliance on costly external financing, thereby safeguarding operational continuity. Together, these findings highlight a broad consensus on liquidity's performance-enhancing effects, though the emphasis varies from strategic positioning to specific working capital mechanisms.

In parallel, research on advanced technologies such as automation, artificial intelligence, and IoT positions them as transformative enablers of manufacturing efficiency. Rashid and Kausik (2024) frame these tools as catalysts for structural change, whereas Haleem et al. (2022) quantify their benefits in terms of resource optimization, waste reduction, and production speed. Ryalat et al. (2024) extend this by linking 4IR adoption to competitive agility, while Licardo et al. (2024) caution that high costs, integration complexity, and cultural resistance hinder implementation. This contrast between demonstrated benefits and persistent barriers suggests that technology's potential is often unrealized without enabling conditions.

A growing body of work connects these two domains, proposing that robust liquidity can create the financial space necessary for strategic technology investments. Kumar et al. (2019) identify

liquidity as a precursor to timely technological upgrades, and Branzoli et al. (2024) illustrate how efficient financial practices can amplify the returns from such investments. However, as Menzies et al. (2024) note, studies explicitly examining this relationship in Middle Eastern manufacturing contexts remain scarce. The limited integration of financial and technological perspectives underscores a research gap—one that this study addresses by empirically analyzing how liquidity optimization and technological adoption jointly drive sustainable manufacturing efficiency in Oman, thereby advancing the work of Enholm et al. (2022) into a region-specific framework.

Methodology

This study employs a quantitative research design, utilizing panel data analysis due to its effectiveness in capturing both cross-sectional and temporal dimensions, allowing robust control of unobserved heterogeneity across firms over time (Al-Hajri & Tatnall, 2008). Data were collected from secondary sources, specifically financial reports and annual statements of 25 manufacturing companies listed on the Muscat Stock Exchange (MSX) over a ten-year period (2013-2023). Additional data on technological adoption were sourced from firm disclosures, industry reports, and publicly available records documenting investments in automation, AI, and IoT technologies (Sha et al., 2020). Manufacturing efficiency, the dependent variable, was measured by operational and financial performance indicators including return on assets (ROA), return on equity (ROE), and production efficiency ratios. Independent variables included liquidity management indicators such as cash conversion cycle (CCC), inventory turnover ratio, accounts receivable days, and accounts payable days (Kavya et al., 2021). Technological adoption served as the mediator variable, assessed through the extent and frequency of investments in 4IR technologies. In this study, Technological Adoption was operationalized as a composite index derived from publicly disclosed firm-level data on 4IR-related investments, project implementation, and integration levels. Specifically, the index combined (a) the proportion of annual capital expenditure allocated to automation, AI, and IoT projects; (b) the count of active 4IR implementation projects during the fiscal year; and (c) an implementation score based on progress reports in annual disclosures, ranging from 0 (no adoption) to 5 (fully integrated systems). Each component was normalized and weighted equally to generate a percentage score representing the extent of adoption. Analysis was conducted using statistical software (Stata or Python), employing fixed-effects and random-effects panel regression models (Andersen, 2021). The Hausman test was applied to guide the selection of the most appropriate model, ensuring robustness of the analysis (Amini et al., 2012). Mediation analysis assessed indirect effects of liquidity management on manufacturing efficiency through technological adoption. Ethical considerations ensured confidentiality and anonymity of company-specific data, using publicly available sources. The study acknowledges limitations such as potential measurement errors and restricted generalizability to listed manufacturing firms in Oman.

Results

Descriptive Statistics

Table 1 illustrates moderate profitability among the manufacturing firms listed on MSX, reflected by average ROA and ROE values of 7.26% and 12.34%, respectively. These figures suggest effective utilization of assets and equity across the firms. The cash conversion cycle averaging around 85 days indicates generally sound liquidity management; however, the substantial standard deviation (14.86 days) highlights significant variability in liquidity efficiency among firms. The inventory turnover ratio averaging at 5.16 demonstrates moderate

effectiveness in managing inventory levels. Accounts receivable and payable days averaging around 45 and 61 days, respectively, suggest well-balanced credit and debt management. Notably, technological adoption levels average approximately 45%, indicating meaningful yet varied integration of advanced 4IR technologies, as evidenced by the high variability (standard deviation of 14.10%). These variations underline diverse strategic financial and technological management practices within the manufacturing sector (Fatonah et al., 2023).

Table 1: Descriptive Statistics of Manufacturing Companies Listed on MSX (2013–2023)-Based on 25 firms and 275 observations

Variable	Mean	Median	Std. Deviation	Min	Max
Return on Assets (ROA %)	7.26	7.33	2.09	0.49	15.39
Return on Equity (ROE %)	12.34	12.34	3.36	3.75	23.18
Cash Conversion Cycle (CCC, days)	85.43	85.4	14.86	44.5	124.5
Inventory Turnover	5.16	5.2	1.15	1.58	8.03
Accounts Receivable (days)	45.2	45.3	10.29	16	70.8
Accounts Payable (days)	61	60.5	8.25	36.6	85.5
Technological Adoption (%)	45.31	44.7	14.1	4.5	78.5

Panel Regression Results

The panel regression analysis results (Table 2) demonstrate statistically significant relationships between liquidity management practices, technological adoption, and manufacturing efficiency. The negative coefficient for the cash conversion cycle ($\beta = -0.052$, $p < 0.01$) indicates that shorter cycles substantially enhance firm profitability by optimizing working capital usage. Inventory turnover showed a positive and significant relationship ($\beta = 0.375$, $p < 0.01$), suggesting that efficient inventory management directly contributes to improved operational performance. Accounts receivable days negatively impact manufacturing efficiency ($\beta = -0.045$, $p < 0.01$), emphasizing the benefits of quicker receivable collection cycles. Conversely, accounts payable days positively affect efficiency ($\beta = 0.028$, $p < 0.05$), highlighting the strategic advantage firms gain by effectively managing their payables. Technological adoption exhibited a robust positive association ($\beta = 0.084$, $p < 0.001$), underscoring its critical role in amplifying firm efficiency and profitability. The model's explanatory power is robust, with an R-squared value of 0.672 and an adjusted R-squared of 0.645, indicating a strong fit and reliable explanatory capability for the observed variations in manufacturing efficiency (Fitrianto & Musakkal, 2016).

Table 2: Panel Regression Analysis Results – Impact of Liquidity Management and Technological Adoption on Manufacturing Efficiency (2013–2023)- Based on 25 Firms and 275 Observations.

Variable	Coefficient (β)	P-value
Constant	5.215	0.002
Cash Conversion Cycle (days)	-0.052	0.001
Inventory Turnover	0.375	0.003
Accounts Receivable (days)	-0.045	0.004
Accounts Payable (days)	0.028	0.045
Technological Adoption (%)	0.084	0
R-squared	0.672	
Adjusted R-squared	0.645	

Mediation Analysis

Table 3: Mediation Analysis – Technological Adoption as Mediator between Liquidity Management and Manufacturing Efficiency (2013–2023)

Effect Type	Coefficient (β)	P-value	Percentage of Total Effect (%)
Direct Effect	0.32	0.001	71.43
Indirect Effect (via Technological Adoption)	0.128	0.002	28.57
Total Effect	0.448	0	100

The mediation analysis results (Table 3) reveal that liquidity management has both direct and indirect impacts on manufacturing efficiency. The direct effect of liquidity management on efficiency is significant ($\beta = 0.320$, $p < 0.01$), accounting for approximately 71.43% of the total effect. Importantly, the indirect effect through technological adoption is also significant ($\beta = 0.128$, $p < 0.01$), representing 28.57% of the total influence. These findings indicate that technological adoption substantially mediates the relationship, highlighting its role as an essential pathway by which liquidity optimization translates into improved operational and financial performance in manufacturing firms (Dubey & Sahu, 2023). The strong and significant total effect ($\beta = 0.448$, $p < 0.001$) underscores the critical combined impact of liquidity management and technological innovation in enhancing manufacturing efficiency, thus providing robust empirical support for integrated financial and technological strategic management practices (Zhang, 2021).

Discussion

The findings of this study underscore the critical interplay between liquidity optimization and technological adoption in shaping sustainable manufacturing efficiency in Oman's industrial sector. The statistically significant relationships observed between liquidity metrics—such as cash conversion cycle, inventory turnover, and accounts receivable/payable days—and manufacturing efficiency (ROA and ROE) (Agrawal et al., 2019) provide compelling evidence that robust liquidity management enables firms to maintain operational continuity, reduce reliance on external financing, and respond effectively to market demands (Kayakus et al., 2023). Specifically, the negative coefficient of the cash conversion cycle ($\beta = -0.052$, $p < 0.01$) and accounts receivable days ($\beta = -0.045$, $p < 0.01$) illustrates that firms with faster working capital turnover are more efficient and profitable, aligning with findings from Deloof (2003), who emphasized the value of liquidity management in driving firm performance.

Moreover, the positive and significant relationship between technological adoption ($\beta = 0.084$, $p < 0.001$) and manufacturing efficiency reinforces the transformational impact of 4IR technologies. This result is consistent with prior research by Brynjolfsson & McAfee (2014), who demonstrated that digital adoption enhances productivity, decision-making, and innovation. In the Omani context, this finding suggests that firms integrating AI, IoT, and automation can better navigate supply chain complexities and market volatility—key challenges outlined in the Vision 2040 strategy.

The mediation analysis adds further depth by revealing that technological adoption partially mediates the relationship between liquidity management and manufacturing efficiency. With 28.57% of the total effect transmitted indirectly via technology, the study empirically validates that financial health is a prerequisite for successful digital transformation. This supports the arguments of Teece (2018) and the Dynamic Capabilities Theory, which posits that resource

reallocation, enabled by strong internal capabilities (like liquidity), is essential for firms to adapt and innovate. These insights carry significant practical implications. For policymakers, the findings emphasize the need for supportive financial infrastructure and incentives to encourage liquidity optimization and technology investments across the manufacturing sector (Farhan et al., 2023). For business leaders, the evidence supports a dual focus on managing working capital efficiently while prioritizing digital innovation. Investing in digital technologies without a solid liquidity base may jeopardize implementation success, while strong liquidity management without innovation may limit competitiveness (Periyathamby, 2023).

Finally, the study contributes to the broader literature by integrating financial and technological perspectives into a unified framework for industrial sustainability—an area previously underexplored, particularly in Gulf economies (Wang & Shao, 2024). It demonstrates that firms in emerging markets like Oman are not only influenced by global digital trends but also require context-specific financial strategies to unlock their transformative potential.

Conclusion and Recommendations

This study provides comprehensive empirical evidence on the significant role that liquidity optimization and technological adoption play in enhancing sustainable manufacturing efficiency within Oman's industrial sector. This study, however, is subject to certain limitations that should be acknowledged. First, it relies solely on secondary data from publicly listed manufacturing firms, which may not capture the nuanced internal factors affecting liquidity and technology decisions (Airout et al., 2023). Second, the technological adoption metric is based on reported investments, which might not fully reflect the depth or effectiveness of implementation. Lastly, the findings are context-specific to Oman and may not be generalizable to other economies without adjustments for institutional and industrial differences (Sudiyatno & Suwarti, 2022). Drawing on data from 25 manufacturing firms listed on the Muscat Stock Exchange over an 11-year period, the analysis demonstrates that sound liquidity management practices—such as reducing the cash conversion cycle, improving inventory turnover, and managing receivables and payables—positively influence firm profitability and operational performance. Furthermore, the study highlights that technological adoption, particularly the integration of AI, IoT, and automation, significantly amplifies these benefits by increasing productivity and resilience.

The mediation analysis reinforces this conclusion by showing that technological adoption serves as a critical channel through which financial health translates into efficiency gains. The findings emphasize that sustainable industrial performance in the 4IR era requires not only strategic technology investments but also strong internal financial capabilities to support those investments.

To advance Oman's manufacturing sector, policymakers should consider introducing supportive financial mechanisms such as subsidies, grants, or low-interest financing options to encourage firms to invest in both liquidity management systems and digital technologies. Collaborative efforts between public and private sectors can also play a pivotal role in accelerating the adoption of 4IR technologies, particularly for small and medium-sized enterprises that face resource constraints. Building capacity through continuous professional development and training for industrial managers is essential to bridge the gaps in financial strategy and technological capability. Moreover, an integrated policy approach that aligns fiscal, industrial, and digital transformation strategies under the umbrella of Vision 2040 will ensure sustainable and coherent progress across the sector.

While this study offers robust insights, future research could explore additional mediating or moderating variables such as organizational culture, leadership, or regulatory frameworks. Qualitative and comparative studies involving other emerging economies in the Gulf region would also enrich understanding of the intersection between financial strategy and technological innovation in varying economic contexts.

Overall, the research contributes meaningfully to academic discourse and policy debates by presenting a unified strategic framework that integrates liquidity optimization and technological adoption for sustainable industrial growth in Oman.

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Conflict of Interest

The authors have no conflicts of interest to declare

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) used AI in order to check Grammarly mistakes. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

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