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Lean Manufacturing Implementation in Developing Countries: Evidence from Jordanian Industrial Companies

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ABSTRACT

In today's fiercely competitive landscape, industries are increasingly embracing lean manufacturing strategies for survival. However, the adoption of lean principles in Jordanian manufacturing sectors remains relatively new. This study aims to evaluate the current state of lean adoption in Jordanian industries, focusing on its techniques, motivations, and challenges. Employing a quantitative methodology, surveys targeted Production, Operation, and Quality Managers in Jordanian organizations. Out of 300 distributed questionnaires, 176 valid responses were received, representing a response rate of 58.7%. The findings indicate a relatively low adoption of lean practices in Jordanian industries, though firms that have implemented lean report significant benefits, particularly in quality enhancement and cost reduction. Key challenges include inadequate training, a scarcity of experts, and complexities in small batch production. While the study's sample size is limited, caution is warranted in interpreting the results. Further empirical research is needed to quantify the performance benefits of lean adoption. This study sheds light on lean adoption in Jordanian manufacturing, informing knowledge development and guiding future efforts to promote lean practices in the industrial landscape.

Keywords: Lean Implementation, Developing Countries, Industrial Companies, Jordan.

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INTRODUCTION

The industrial sector in Jordan serves as a crucial economic driver, significantly impacting both local and international growth trajectories (Matar & Unaizat, 2018). Manufacturing enterprises, as noted by Golroudbary and Zahraee (2015), grapple with myriad challenges including global environmental degradation, resource scarcity, and unchecked exploitation of natural resources, all of which inflate production costs.

Efficiency and productivity are paramount concerns, prompting industries to devise innovative management practices (Holweg, 2007; Zahraee et al., 2014; Asad et al., 2023). In today's fiercely competitive landscape, manufacturing companies strive for enhanced performance to ensure their survival (Abdullah Hokoma et al., 2008). The pursuit of efficiency and competitiveness has led to the adoption of unique management practices (Holweg, 2007; Zahraee et al., 2014a). A primary challenge facing producers today is the timely, cost-effective, and quality delivery of products or materials (Holweg, 2007; Majali et al., 2022). The lean production approach, as exemplified in Japan and the United States of America, plays a pivotal role in enhancing outcomes for large industrial enterprises (Nawanir, Teong, & Othman, 2013).

Lean manufacturing (LM) methodology, utilized under various names and forms, has proven to be a successful management strategy, focusing on waste reduction and revenue generation (Almasarweh, 2020). However, transitioning to LM poses significant hurdles, particularly in grasping its core concept and philosophy (Balle, 2005; Suleman, 2016). Implementing LM requires systematic thinking and methodical approaches, necessitating changes in measurement, control, and accounting systems (Alves et al., 2022). The piecemeal deployment of LM systems may hinder its full potential and organizational performance (Mumani et al., 2022).

Holistic application of LM can lead to widespread adoption as a best manufacturing practice across industries and countries (Holweg, 2007). Its core motivation lies in rationalizing systems to produce high-quality finished products at the speed of customer demand with minimal waste (Shah & Ward, 2003; Sahoo, 2019). Jordanian manufacturing enterprises face numerous challenges, including outdated systems, market limitations, technological obsolescence, and resource shortages (Wangwe et al., 2014). Addressing these issues requires strategic shifts towards lean thinking and lean accounting, facilitating data-driven decision-making (Uday et al., 2023).

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Implementing LM promises enhanced competitiveness, job creation, technological advancement, and efficient resource utilization. However, research on lean manufacturing adoption in Jordan remains scant (Ayoogh, 2006). This study aims to bridge this gap by investigating the application of lean manufacturing in Jordanian organizations and addressing the challenges of its adoption.

LITERATURE REVIEW

Lean Manufacturing

LM, initially proposed by Toyota in the 1950s as the Toyota Production System (TPS), aimed to enhance production efficiency and reduce costs by minimizing waste and non-value-added operations (Womack et al., 2007; Buer et al., 2018). The surge in Japanese imports during the 1980s sparked Western firms' interest in LM adoption (Holweg, 2007), which further intensified after the early 1990s oil crisis (Womack et al., 2007). Renowned for its global excellence in cost, quality, flexibility, and responsiveness, the concept of LM has proliferated across industries and nations (Schonberger, 2007; Suleman et al., 2024; Demirkesen, 2021). LM's objective within an organization is to streamline production flow by eliminating waste and non-value-added tasks, enabling firms to compete globally by offering lower costs, faster delivery, and higher-quality products (Srinivasaraghavan & Allada, 2006).

Lean manufacturing perceives any operation consuming resources but failing to deliver value to the end consumer as wasteful and in need of elimination (Womack et al., 2007; Shah & Ward, 2007; Antony, 2011; Buer et al., 2018; Sahoo, 2019). Pettersen (2009) suggested that LM tools and concepts significantly impact high-performing businesses. Based on their literature citation frequency, Shah and Ward (2003) classified 22 LM tools into four categories: human resources, total quality management, just-in-time management, and total preventative management. Lean tools can be further categorized into externally directed tools and internally directed tools. Internal methods pertain to aspects such as supplier and customer relationships, while external methods comprise processes, equipment, product design, human resources, and production planning. Nevertheless, many organizations that implement externally focused lean methodologies face difficulties when attempting to incorporate external interactions with suppliers and consumers to attain optimal performance. Furthermore, although lean methodologies are increasingly embraced in internal domains such as operations and management, the process of shifting from conventional production systems to lean

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manufacturing is intricate (James, 2006; Wyrwicka & Mrugalska, 2017; Bashar et al., 2024). An effective transition to lean manufacturing (LM) can be facilitated through the gradual incorporation of lean concepts and practices (James, 2006). In this change process, organizational culture, finances, leadership, management, skills, and expertise have been identified as critical variables (Bashar et al., 2024).

Despite its potential benefits, many businesses struggle to adopt lean techniques (Balle, 2005; Papadopoulou & Ozbayrak, 2005), with scholars attributing implementation failures to misunderstandings of primary system goals and ideas (Schonberger, 2007; Demirkesen, 2021), cultural variations, lack of knowledge leading to tool misuse (James, 2006; Pavnaskar et al., 2003; Asif et al., 2021), and inadequate development of a lean culture supporting LM (Liker & Hoseus, 2008; Jorgensen et al., 2007; Asad et al., 2021). Effective communication is deemed critical in supporting lean manufacturing techniques, particularly in organizations newly implementing lean (Tanudiharjo et al., 2021). Implementing LM holistically throughout an enterprise's lifespan aids in the development of lean thinking and practices, enhancing essential business processes to address challenges such as market volatility and increasing client demand (Demirkesen, 2021).

Lean Practices and Tools in Different Manufacturing Industries

In order to improve efficiency in various industries such as manufacturing systems, port container terminals, supply chain management, construction management, banking systems, and building systems, various methodologies and approaches are utilized. These include computer simulation, statistical analysis, and lean manufacturing techniques (Zahraee, 2016; Shahpanah et al., 2014; Sadeghifam et al., 2015). Among these tactics, lean manufacturing and thinking are widely used across different industries and are considered valuable. Below is a concise summary of various lean methods:

- Just in Time (JIT): Handling a client's request by drawing all necessary resources precisely when needed, starting from the latest assembly of unfinished content.
- Kanban: Utilizing visual signals to facilitate flow, pulling items through the process as required by the customer.
- Cellular Manufacturing: Organizing the entire process into cells containing all necessary equipment and personnel for specific products or related groups of items.

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- 5S: Implementing predefined work activities to efficiently organize the workplace, emphasizing housekeeping and shop floor management.
- Total Preventive Maintenance (TPM): Involving employees in organized equipment maintenance to detect irregularities and prevent breakdowns.
- Poka-Yoke: Employing techniques to "error-proof" the manufacturing system.
- Visual Control: Utilizing visual performance measurements on the shop floor overseen by a team of employees.
- Single-Minute Exchange of Dies (SMED): A continuous improvement technique focusing on reducing setup time.

Utilizing lean principles and practices as inspiration, scholars have implemented timesaving and productivity-enhancing methodologies including Value Stream Mapping (VSM) and Method Time Measurement (MTM). Marksberry et al. (2011), for instance, investigated the function of lean tools and principles in business processes. To decrease preparation time, Deros et al. (2013) implemented SMED lean methodologies in assembly lines. To optimize manufacturing processes, VSM application on assembly lines was evaluated by Alvarez et al. (2009). Farris et al. (2009) examined the effects of lean production on staff attitudes and problem-solving abilities in six manufacturing organizations. Habib et al. (2023) presented a systematic methodology for the integration of lean techniques and VSM.

A fuzzy membership function was suggested by Amin et al. (2021) as a means of evaluating the efficacy of lean principles within manufacturing systems. Rubio and Corominas (2008) implemented a reverse logistics system within the context of lean manufacturing. An electronic manufacturing company was the subject of the implementation of diverse lean tools by Doolen and Hacker (2005), who emphasized the impact of economic, organizational, and operational factors on lean implementation. To optimize production line design, Subramani and Narayanasamy (2009) implemented simulation software and lean principles in the pump manufacturing industry. The study conducted by Jayaram et al. (2010) investigated the effects of decentralized decision-making and preventative maintenance on performance parameters of production systems. The adoption of lean manufacturing in the electrical sector of Malaysia was evaluated by Wong et al. (2009), who found that Malaysian manufacturing enterprises have, to some degree, implemented the methodology.

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RESEARCH METHODOLOGY

Development of Survey Instrument

Data for this study was collected using a questionnaire that was adapted from the one used by Panwar et al. (2015). It was divided into three sections. The preliminary section comprised five inquiries pertaining to the general information of the organization. The subsequent section comprised three inquiries centered on awareness of lean manufacturing. Finally, the challenges of agile manufacturing were discussed. In this particular section, four inquiries were presented in the following order: "justifications for not adopting lean," "justifications for adopting lean," "lean practices," and "obstacles encountered during lean implementation." The challenges identified in the implementation of lean methodology are detailed in Table 3, accompanied by pertinent items and literature references. "Lean practices" were evaluated using a five-point Likert scale: 1 (insist on never using) to 5 (constantly using). An identical scale was applied to all items, with 5 representing "most important" and 1 representing "not important."

Survey Administration

To meet the study's objectives, 300 Jordanian industrial manufacturing enterprises were selected as the study's population. The sample was drawn from Jordan's directory of ISO 9001 accredited industries with a minimum operational tenure of ten years. Participation in the study was sought from Production and/or Operation Managers, as well as Quality Managers. The questionnaire was distributed online, initially yielding a low response rate despite multiple reminders. Consequently, additional measures were employed to enhance response rates. Face-to-face interviews were conducted to elicit a few responses, while in other instances, responses were obtained through third-party sources, resulting in a successful improvement in response rates. Further efforts to boost responses included sending follow-up messages followed by phone calls. Ultimately, 169 responses were received.

Observations of Survey

The response rate amounted to 30%, yielding 169 responses. Of these, 16 were incomplete and thus excluded from further analysis. It is noteworthy that the response rate in this study is comparable to similar research conducted in the Indian context. For instance, Upasani (2012) and Pandey et al. (2010) achieved response rates of 17.5% and 18.02%, respectively. However,

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as indicated by Malhotra and Grover (1998) and Sahay et al. (2006), this response rate is deemed appropriate for this type of study.

Upon introducing the concept of lean manufacturing, respondents were queried about their awareness of it. Surprisingly, 115 respondents (76.7%) affirmed their familiarity with lean manufacturing. Moreover, when asked about its perceived advantages for manufacturing industries, 105 respondents (70.0%) acknowledged its benefits. Consequently, the study suggests that the majority of firms in the Jordanian manufacturing sector are acquainted with lean manufacturing and recognize its value to operational efficiency. However, only 33 respondents (22.0%) reported implementing lean manufacturing, a statistic in line with expectations (refer to Table 1). Further analysis reveals that out of 101 respondents from major manufacturing industries, 31 (30.6%) have adopted lean manufacturing, while 70 (69.3%) have not. Surprisingly, a mere 4.1% of respondents from minor process businesses have embraced lean manufacturing.

Table 1: *Awareness about lean implementation in Jordanian manufacturing industries*

Industry size	**# of respondents**	**Familiar with lean manufacturing**		**Think lean is useful for process industries**		**Implemented lean Industry manufacturing.**	
	n (%)	Yes	No	Yes	No	Yes	No
Large	101 (67.0%)	95 (94.1%)	6 (5.90%)	89 (88.1%)	12 (11.9%)	31 (30.6%)	70 (69.3%)
Small	49 (33.0%)	20 (40.8%	29 (59.2%)	16 (32.6%)	33 (67.4%)	2 (4.1%)	47 (95.9%)
Total	150 (100%)	115 (76.7%)	35 (23.3%)	105 (70.0%)	45 (30.0%)	33 (22.0%)	117 (78.0%)

Test of Reliability for Internal Consistency

All the factors of the various variables as posed in the questionnaire were tested for reliability. Tables 2, 3, 4, and 5 below show the results. The high values of Cronbach's Alpha coefficient show that all the variables relevant to the issues are internally consistent.

Reasons for Not Adopting Lean into Practice

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117 out of the 150 Jordanian manufacturing industries surveyed had yet to apply lean practices. A single-sample t-test (with a test value of 3) was employed to ascertain the significant reasons for not implementing lean. Table 2 illustrates the mean values of reasons for not implementing lean in Jordanian production industries, along with their ranking (based on mean scores).

Table 2 also presents one-sample t-statistics. Surprisingly, “Lack of education and expertise on lean” (2.769, p = 0.007) and “Large batch production is necessary for capacity utilization” (2.274, p = 0.025) emerged as key reasons for not implementing lean. Additionally, the notion that manufacturing industries already face a lack of senior management interest and support is another significant reason for the absence of lean implementation. Conversely, Jordanian production businesses do not perceive the typical process attribute of process industries, "process dependence on time and temperature," as a key impediment to lean implementation. Remarkably, cultural barriers and lack of time are not identified as major obstacles to adopting lean practices.

Table 2: *One sample t-test not adopting lean.*

Cronbach's Alpha	**N of Items**
.720	9

Reasons of not implementing lean	**Mean**	**Rank**	**t**	**Sig. (two-tailed)**	**Mean difference**
Large batch production is necessary for capacity utilization	3.28	2	2.274	0.025	0.284
Process industries already have continuous production	3.04	4	0.226	0.821	0.037
Lack of education and expertise on lean	3.31	1	2.769	0.007	0.312
Lack of financial resources	2.76	5	-1.515	0.133	-0.239
Lack of time	1.66	9	-18.693	0.000	-1.339
Cultural barriers (resistance to change)	2.43	7	-5.278	0.000	-0.569
Specific characteristics of process industries (time, temperature, and process dependence)	2.21	8	-7.562	0.000	-0.789
Lack of senior management’s interest and support	3.06	3	0.438	0.662	0.064

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Lean is complex to implement	2.62	6	-2.583	0.011	-0.376

Reasons of Implementing Lean

To determine the key reasons for implementing lean in Jordanian industrial processes, a one-sample t-test (with a test value of 3) was used. Table 3, based on the mean and t-statistics, ranks the reason for undertaking lean in Jordanian manufacturing industry.

Table 3: *One sample t-test lean adoption.*

Cronbach's Alpha	**N of Items**
.750	8

Reasons of implementing lean	**Mean**	**Rank**	**t**	**Sig. (two-tailed)**	**Mean difference**
Elimination of wastes	3.20	1	1.071	0.291	0.195
To decrease production costs	2.71	3	-1.668	0.103	-0.293
To improve quality	2.98	2	-0.108	0.914	-0.024
To facilitate JIT production	2.65	4	-1.920	0.062	-0.472
To increase demand management efficiency	2.56	6	-1.962	0.057	-0.439
To increase customer satisfaction	2.61	5	-2.011	0.051	-0.390
To increase supply chain efficiency	1.68	8	-12.28	0.000	-1.317
To increase utilization of space	2.49	7	-6.481	0.000	-0.512

The primary motivation for adopting lean in Jordanian Manufacturing industries is to "Elimination of wastes" (1.071, 0.291). Other important motivations for implementing lean include “improve quality” (-0.108, 0.914), “cost reduction” (-1.668, 0.103), “facilitate JIT production” (-1.920, 0.062), and “improved demand management efficiency” (0.964, 0.034). However, the current study found that “To increase supply chain efficiency” and “increase utilization of space” are not key motivations for implementing lean in Jordanian process industries.

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Lean Tools Implemented in Jordanian Manufacturing Industries

According to Table 4, significantly higher used lean tools are 5S (2.873, 0.006), Quality management program (1.894, 0.065), TPM (-1.140, 0.261), "Continuous improvement programs" (-0.766, .448), Work standardization (-1.673, 0.102), SPC (-1.402, 0.168), Visual control (-4.309, 0.00) and "Setup reduction" (-3.584, 0.001).

Table 4: *One-sample t-test (test value 3) lean tools widely employed in Jordanian industrial firms.*

Cronbach's Alpha	**N of Items**
.810	20

Lean tools/ practices	**Mean**	**Rank**	**t**	**Sig. (two-tailed)**	**Mean difference**
Value stream mapping (VSM)	2.17	16	-4.201	0.000	-0.506
5S	3.78	1	2.873	0.006	0.780
Quick changeover techniques (SMED)	2.24	12	-3.235	0.002	-0.756
Setup reduction	2.41	8	-3.584	0.001	-0.829
Lot-size reduction	2.37	9	-3.173	0.003	-0.634
Total Productive Maintenance (TPM)	2.89	3	-1.140	0.261	-0.317
Visual control	2.49	7	-4.309	0.000	-0.634
Work standardization	2.68	5	-1.673	0.102	-0.317
Statistical process control (SPC)	2.66	6	-1.402	0.168	-0.341
Quality management program	3.46	2	1.894	0.065	0.463
Takt time	1.71	19	-8.583	0.000	-1.102

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Pull production	1.73	18	-11.47	.000	-1.268
Production levelling	1.80	17	-6.815	.000	-1.195
Mistake proofing	2.27	11	-3.271	.002	-0.732
Kanban	2.22	13	-3.114	.003	-0.780
Cellular manufacturing	1.56	20	-18.34	.000	-10.44
Flexible and cross functional teams	2.31	10	-4.140	.000	-0.829
Continuous improvement programs	2.80	4	-0.766	.448	-0.195
Supplier integration and partnership	2.21	14	-2.877	.006	-0.732
Long-term relationship with suppliers	2.19	15	-3.056	.004	-0.729

Cellular manufacturing, takt time, "pull production," Production levelling, VSM, and Long-term relationship with suppliers are all lean manufacturing concepts that are not utilized or are only utilized infrequently in Jordanian manufacturing industry.

Challenges While Implementing Lean in Process Industries

Table 5 presents the data of a one-sample t-test (test value 3) used to identify the most critical hurdles in implementing lean in the Jordanian manufacturing industry. The greatest hurdle in implementing lean in Jordanian manufacturing industries, according to our research, is “lack of training” (0.606, 0.548); "to ease small batch production" (0.194, 0.847); “to arrange lean implementation experts” (-1.355, 0.183); and “to support JIT purchasing” (-2.197, 0.034). These are all primary challenges. Surprisingly, Jordanian manufacturing companies do not see "cultural barriers" or "identifying techniques for setup time reduction" as major obstacles to lean implementation. While implementing lean in the Jordanian manufacturing industry, the “perishable nature of products” and “short lead times” are not key difficulties.

Table 5: *One sample t-test challenges while implementing lean.*

Cronbach's Alpha	N of Items

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.777		11			
Challenges while implementing lean	**Mean**	**Rank**	**t**	**Sig. (two-tailed)**	**Mean difference**
To facilitate small batch production	3.05	2	0.194	0.847	0.049
To identify techniques for setup time reduction	2.49	7	-2.114	0.041	-0.512
To deal with typical process characteristics (time and temperature, etc.)	2.39	8	-2.837	0.007	-0.610
To arrange lean implementation experts	2.63	3	-1.355	0.183	-0.366
Skepticism/ cultural barriers	2.54	6	-1.998	0.053	-0.463
Lack of training	3.12	1	0.606	0.548	0.122
Short lead times	2.20	10	-4.193	0.000	-0.805
Perishable nature of products	1.83	11	-10.65	0.000	-1.171
Improper information exchange across supply chain	2.24	9	-5.135	0.000	-0.756
To facilitate JIT production	2.56	5	-1.547	0.130	-0.439
To facilitate JIT purchasing	2.61	4	-2.197	0.034	-0.390

DISCUSSION

We conducted this research specifically on the Jordanian manufacturing industry. According to our findings, 22.0 percent of the manufacturing companies examined have implemented lean manufacturing. In a survey of 79 Indian manufacturing firms, Ghosh (2013) discovered that 80 percent had applied lean to a significant degree. Jordan's industrial sector is observed to be lagging behind other developing countries' manufacturing sectors in terms of lean adoption. Although the rate of lean adoption in Jordan's manufacturing industry is relatively lower compared to China and European countries (Chen & Shang, 2008; Gebauer et al., 2009), it is encouraging that it exceeds that of other developing countries (Abdullah Hokoma et al., 2008; Abdullah Hokoma et al., 2010; Gyampah & Gargeya, 2001; Sebtaoui et al., 2020).

According to survey responses, the second reason for not applying lean principles in the Jordanian manufacturing industry is the "need for big batch production for capacity utilization." Industrial firms typically consist of large, high-capacity machines (Gurumurthy & Kodali,

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2011). Running these machines near full capacity is often preferable for economies of scale. Moreover, competitive pressures necessitate manufacturing companies to operate at high capacity (Lehtonen & Holmstrom, 1998). Reducing batch sizes under maximum capacity can decrease efficiency and increase resource costs (Ahmad et al., 2005). Therefore, finding solutions to produce in smaller quantities with large, dedicated equipment remains a significant challenge.

The primary barriers to implementing lean are identified as lack of education and expertise. According to Chahal & Narwal (2017), lack of understanding of lean principles is a major hurdle in implementing lean in industries of developing countries (Ta'Amnha et al., 2023). Ghosh (2013) noted that "lean" is still a relatively new concept, requiring significant time for manufacturing industry personnel to grasp and develop the necessary skills for lean manufacturing adoption. Panwar et al. (2015) also emphasized the importance of learning the implementation of lean manufacturing.

Jordanian manufacturing industries that have adopted lean perceive "elimination of waste" as the most significant motivation. However, according to Garza-Reyes et al. (2012), the primary motivation for manufacturing sectors to adopt lean is "customer satisfaction." It is logical for Jordanian manufacturing companies to adopt lean manufacturing practices to reduce waste. Our findings are consistent with Jain and Lyons (2009) and Lyons et al. (2013), who found that waste reduction was the primary reason for implementing lean in UK industries.

Other significant reasons for implementing lean in Jordanian manufacturing systems include "reducing manufacturing costs" and "improving quality," according to our findings. The quality of raw materials used in industrial processes varies, affecting yield variability. Additionally, exceptional quality is crucial due to heightened competition being a critical business criterion. These factors underscore why lean is being utilized to enhance quality.

Our findings align with Chahal & Narwal (2017), indicating that "cost reduction" and "waste elimination" are primary drivers of lean implementation in industries of developing countries. Furthermore, our findings support Singh et al. (2010a), Singh et al. (2010b), and Ghosh (2013), indicating that developing countries' manufacturing sectors view lean implementation as beneficial for reducing lead times, lowering costs, expanding product ranges, and surviving in competitive environments.

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5S, TPM, “visual control,” “standardized work,” SPC, “continuous improvement program,” and “quality management program” are the most utilized lean tools in Jordanian industrial sectors where lean principles have been applied. According to Jain and Lyons (2009), 5S is widely adopted in industrial processes as a lean practice. Billesbach (1994), Jeanes (1995), and Mukhopadhyay and Shanker (1995) obtained similar results, suggesting that 5S is crucial for establishing a work environment conducive to lean production (Melton, 2005). We believe that 5S can help eliminate non-value-added activities in the early stages of lean adoption.

TPM can also be more effectively implemented with the support of 5S. TPM is a critical lean tool utilized in Jordanian industrial processes. Shah and Ward (2003) and Palacios Gazules et al. (2023) also found TPM practices to be crucial for manufacturing systems.

According to our study, “visual control” is widely employed as a lean tool in Jordanian manufacturing systems. “Visual control” aids in effectively communicating information to the shop floor. Most Jordanian manufacturing businesses that have adopted lean utilize visual control for this purpose. Panwar et al. (2015) found that “standardized work” significantly contributed to cost reduction in the UK food industry. Similarly, our findings indicate that "standardized work" is widely adopted as a lean tool in Jordanian manufacturing sectors. This investigation only considered ISO 9001-certified companies. Therefore, manufacturing firms that have adopted lean use "standardized work" as a key strategy. Interestingly, we found that SPC is considered a significant lean technique in the Jordanian manufacturing sector.

The extensive use of "standardized work" and SPC in Jordanian manufacturing industries supports the argument that quality improvement remains a top priority for businesses in the era of globalization (Dangayach & Deshmukh, 2003). The application of these lean methodologies provides key insights into lean implementation in Jordanian manufacturing:

Lean tools such as 5S, TPM, “visual control,” “standardized work,” “quality management,” and “continuous improvement” are not exclusive to lean; they are widely adopted management practices for production line management, quality control, and fostering a global manufacturing environment. Therefore, it is not surprising that they are frequently employed in Jordanian industries. Some of these practices may have been in use by Jordanian industries prior to formally adopting lean. In contrast, traditional lean techniques such as cellular manufacturing, Takt time, Kanban, and “pull production” remain less common in Jordanian manufacturing systems.

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- Jordanian industrial firms predominantly utilize lean techniques such as 5S, TPM, and “continuous improvement” because they can be implemented without significant changes in production methods or setups. Implementing these techniques does not require substantial resource commitments such as financial investment or time.
- These tools and techniques are not industry-specific, making it relatively straightforward to find professionals capable of implementing them.
- Since these tools and techniques do not necessitate small batch production, they are more prevalent in Jordanian industrial systems.
- These tools not only aid in quality control but also contribute to waste reduction.
- Given the early stage of lean manufacturing adoption in Jordanian manufacturing systems, lean tools that do not heavily rely on process characteristics, such as 5S, TPM, and visual control, are prioritized.

Interestingly, previous research highlights Value Stream Mapping (VSM) as a primary activity in lean manufacturing implementation in Jordanian manufacturing systems (Seth et al., 2008; Aadithya et al., 2023). However, our research found that VSM implementation is uncommon in Jordanian industrial processes. Additionally, the current analysis identified "reducing production costs," "waste elimination," and "quality improvement" as the primary objectives of lean implementation in Jordanian industries. According to our findings, a significant challenge in lean implementation is "producing in small batches." Oduoza (2009) found that batch sizes in industrial processes are dictated by machine tool capacity constraints.

Implementing "production leveling" and "pull systems" in such an environment is challenging. This may explain why Jordanian manufacturing companies have not widely adopted lean techniques such as "pull production," "Kanban," and "production leveling." Powell et al. (2010) noted that producing in small batches is a major challenge in industrial processes due to machine tool capacity limitations. Moreover, extensive setup and changeover times necessitate large batch runs in industrial processes to maximize resource utilization (Houghton & Portougal, 1995). Another significant challenge in lean implementation is securing lean experts and providing training and education. Panwar, Nepal, et al. (2015) found that one of the most challenging aspects of implementing lean in manufacturing systems is finding capable leadership to drive the change.

It is evident that lean manufacturing is still in its early stages in Jordan. Furthermore, the discrete nature of lean tools and practices makes it challenging to find professionals capable of

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adapting these approaches to suit the needs of process industry setups. In a recent study of UK enterprises, Bhasin (2012) identified "lack of managerial skills to execute lean" as a significant barrier to lean implementation. Interestingly, Jordanian industrial companies do not view skepticism and cultural barriers as major obstacles to lean implementation. These findings contrast with previous studies (Melton, 2005; Sewig, 2008; Garza-Reyes et al., 2012; Bhasin, 2012).

The key findings of this study can be utilized to formulate a lean implementation strategy in the Jordanian industrial sector:

- Lean manufacturing is a relatively new concept in Jordan. However, Jordanian industrial firms are aware of it and believe it can enhance their performance.
- The primary motivations for implementing lean are nearly identical across Jordanian manufacturing industries; however, Jordanian industries significantly lag behind global manufacturing industries in lean adoption. Therefore, there is ample opportunity for lean principles to be applied in Jordanian manufacturing sectors.
- Jordanian industrial companies that have adopted lean find it highly effective in reducing waste and improving quality.
- The major lean techniques implemented by Jordanian manufacturing firms generally focus on waste reduction or quality enhancement. Lean techniques associated with Just-In-Time (JIT) manufacturing are relatively less common in Jordanian industrial sectors.
- The primary challenge for Jordanian manufacturing companies in adopting lean is producing in small batches. Organizing lean specialists and providing staff training are also significant challenges when adopting lean.
- Management of Jordanian manufacturing firms feel that “Lack of education and expertise on lean” is a primary reason for not using lean manufacturing to boost performance.
- The “cultural barrier” is no longer an essential cause for the failure to implement lean in manufacturing systems. This finding is critical in the Jordanian setting. This result indicates that acceptance of any change has steadily improved, making it much simpler to apply new techniques, such as lean principle.

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CONCLUSION

This research aims to assess the state of lean implementation in Jordan's manufacturing industry. Based on the literature reviewed, topics related to lean implementation in Jordanian manufacturing systems were categorized into four areas: "reasons for not adopting lean," "reasons for implementing lean," "lean tools," and "challenges to adopting lean." According to the survey, adoption of lean manufacturing in Jordanian manufacturing sectors remains limited. The primary reasons for not implementing lean include "lack of knowledge," "lack of education," "inadequate training," and the necessity for "large batch production for capacity utilization."

It has also been found that lean approaches such as 5S, TPM, "work standardization," "quality management," and "visual control" are widely utilized in the Jordanian manufacturing industry. The most significant motivations for implementing lean are "enhancing quality" and "waste elimination." However, the study's findings indicate that the major hurdles to lean implementation are "adapting to small batch manufacturing" and "lack of training."

Given the small sample size in this study, caution should be exercised when generalizing the findings. While our analysis suggests that lean could be highly effective if adopted in the Jordanian manufacturing sector, we advocate for further empirical research to quantify the benefits of lean implementation. This would encourage Jordanian industrial companies to adopt lean practices. Moreover, since the concept of lean is still new to Jordanian manufacturing firms, additional research is needed to identify areas where lean could be more effectively applied. Chowdary and George (2012) noted the challenges practitioners face in identifying functional areas for waste reduction. There is also a need for studies aimed at developing strategies to implement lean techniques associated with "Just-In-Time (JIT) production," such as "pull production" and Kanban, in manufacturing companies.

There is limited evidence of lean adoption among small industrial firms based on our findings. Therefore, further research is warranted to examine the feasibility of implementing lean in small manufacturing businesses by addressing their unique challenges individually. Lastly, additional empirical studies focusing on methodologies and benefits of lean manufacturing across other industry sectors such as metals and textiles are needed. This will not only encourage industries to adopt lean practices but also provide actionable recommendations for

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implementation. The dissemination of such research will enhance understanding of lean principles and help dispel misconceptions surrounding lean adoption in industrial sectors.

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