Implementation of World Class Manufacturing in Egyptian Industry
A Case Study of Critical Analysis of Drivers, Barriers, And Success Factors

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Abstract :

This paper study examines the implementation of World Class Manufacturing (WCM) techniques within Egyptian manufacturing firms, with a focus on identifying the critical drivers and barriers influencing their adoption. The research aims to bridge the gap in empirical evidence regarding WCM practices in developing economies, particularly Egypt, by providing a nuanced understanding of the factors that shape successful implementation.

Key Words: World class manufacturing, Egypt, Developing countries, AHP analysis, organizational change.

تطبيق التصنيع من الطراز العالمي في الصناعة المصرية
دراسة حالة للتحليل النقدي للدوافع والمعوقات وعوامل النجاح

الملخص:

تتناول هذه الدراسة تطبيق تقنيات التصنيع من الطراز العالمي في إحدى الشركات الصناعية المصرية، مركّزة على تحديد الدوافع الأساسية والعوائق المؤثرة في نجاح التبني.

تهدف الدراسة إلى سد الفجوة البحثية في الأدبيات المتعلقة بـ التصنيع من الطراز العالمي في الاقتصادات النامية، ولا سيما في مصر، عبر تقديم تحليل تجريبي قائم على دراسة حالة.

تشير النتائج إلى أن نجاح التصنيع من الطراز العالمي يرتبط بوضوح بالمواءمة الإستراتيجية، التزام القيادة، وإدارة التغيير المنهجية، في حين أن مقاومة العاملين تمثل عائقًا رئيسيًا أمام الاستدامة التنافسية. كما تكشف الدراسة عن فجوات بين الإطار النظري والواقع التطبيقي تعود لعوامل تنظيمية وثقافية خاصة بالسياق المصري، مما يستدعي صياغة إرشادات عملية تتلاءم مع هذه البيئة .

اعتمدت الشركة محل الدراسة على خطة متعددة المراحل شملت ادوات التحسين مثل (التاءات الخمس ، كايزن، السلامة، إدارة الجودة، الصيانة الذاتية، والصيانة المهنية)، وحققت نتائج ملموسة مثل: تحسين الكفاءة التشغيلية، خفض زمن الإعداد، تحقيق وفورات مالية (٥٣٦ ألف يورو من مشروعات كايزن)، وتقليل التوقفات بنسبة ٣٠%.

تؤكد الدراسة أن التصنيع من الطراز العالمي ليس مجرد أدوات تشغيلية بل يمثل تحولًا ثقافيًا واستراتيجيًا نحو التميز التشغيلي المستدام. كما توفر هذه التجربة نموذجًا قابلاً للتكرار للمصنعين المصريين والإقليميين الساعين للتنافسية في الأسواق العالمية.

الكلمات المفتاحية :التصنيع من الطراز العالمي ، مصر، الدول النامية، تحليل عملية التسلسل الهرمي التحليلي ، التغيير التنظيمي.

1.INTRODUCTION

Nowadays, each market requires fierce competition between firms, clients are more and more demanding. High customization and frequent innovations are necessary to sustain profits over the years. An accurate plan is fundamental, so companies invest a lot on defining strategic targets that could lead to potential advantages against competitors. In addition, globalization and digital age have increase the importance of rapid evolutions of products, and consequently on working environments. This continuous evolution is accompanied by a reduction of volumes, if once a model was manufactured identical for many years, today even ancient products require continuous improvement to compete with equivalent products available in the market. High customization has increased manufacturing costs, changing completely the industry from past times. If once the target was to fill the market with the more products possible, today companies perform marketing analysis to forecast sales volumes and consequently produce the strict necessary to avoid costly unnecessary stocks. In addition to avoiding unnecessary production, modern companies cover required high investments with intense cost reduction. Each aspect of a plant is analysed in order to find and erase all sources of waste, to save money and at the same time improve product, process and working environment. This continuous improvement must involve the entire organization, and to be performed correctly, it needs an easy and effective methodology. It is for this reason that around the 2000s Japanese professor h. Yamashina theorized world class

manufacturing (WCM) model, which became the standard approach in many successful companies, manufacturing companies worldwide have been implementing world class Manufacturing (WCM) to increase their global competitiveness and improve their productivity and has assisted organizations to regain their competitive edge.

The biggest weakness and danger of the WCM program is the necessity to engage the whole organization (from top management to operators) in its implementation and it is hard work to change the mentality of the workers, and especially to change their attitude towards their work. Until now, workers did what they were told to do, according to the procedures. In the new system they are required to take all the responsibility for their job, according to the rule: "Do the same thing, but start thinking, what can be done in order to make your job easier, lighter, more effective and better quality. In other words, try to show people possible effects, give them tools, teach them how to use them and encourage them to use them. In the author's opinion it is the most important and the most difficult element of the implementation of WCM Program.

The second weakness of the initial implementation period is the long wait for the first effects, and it is also very important for there to be visible and active involvement of top management and careful choice of the initiatives and implementation area.

The Government of Egypt has always strived to improve its industrial sector. Over the years, ministries and government

entities have used different approaches and implemented different projects that have improved certain industries substantially, However, as it is the case in most less developed countries, Egypt aims to diagnose and find solutions for the severe problems that hinder the growth and development of its manufacturing sector.

1.1 Literature review insights

However, a review of the literature reveals that production managers in manufacturing companies have seen the implementation of world class manufacturing (WCM) as a panacea, which will cure the previously mentioned illnesses. Hence, the Government of Egypt understands the importance of WCM in the development of the national economy and has been investing heavily for the fast growth and development of WCM in the country. Undoubtedly, WCN offers increased opportunities for economic development and plays a crucial role in rapid economic change, productive capacity improvements and international competitiveness enhancement for developing countries in general and Egypt in particular.

Literature suggests that the WCM is the best alternative for implementation and to achieve or maintain competitive advantages (Okhovot et al. 2012; Fullerton et al., 2003). He further stated that the term WCM is applied for organizations that achieved a competitive global advantage through the use of their manufacturing capabilities. Firm should continue to demonstrate

their excellence in manufacturing through dominance of the world markets, to be called a world class manufacturer.

Although many writers have focused on the area of WCM since Schonberger's work in 1986, very few of the studies have collected empirical evidence which would outline and highlight the important factors included within WCM. Only a few studies on WCM implementation in developing countries have appeared recently (Salaheddin, 2005; Saxena and Sahay, 2000).

Undoubtedly, a combination of external and internal factors including population growth, weak infrastructure, and foreign debt, increasing inequalities between individuals, groups and regions has prevented many developing countries from achieving significant socio-economic improvements. Some developing countries such as Egypt have, therefore, made manufacturing management their prime agenda. They are going through a process of restructuring their manufacturing systems to emphasize competition, integration with global markets and increasing level of privatization. Global competitors operating in global markets almost always tend to have world-class performance Thus, to compete in global markets; Egyptian manufacturing necessarily needs to acquire world-class performance.

With this perspective, this paper presents basic principles and characteristic features of the World Class Manufacturing model and implementation requirements of such a model. This program is a compilation of a modern approach to production systems development as it is based on the concept of Toyota Production

System, Lean Manufacturing elements and Total Quality Management. The case study, based on the examples from one of Egyptian manufacturing industry, shows some of the problems of this concept. Together with other problematic issues, successful implementation of WCM philosophy on the road to achieving its potential benefits.

1.2 Barriers to and drivers of world class manufacturing overview

Table 1 summarizes the barriers to adopting WCM from selected studies [5-14] that were chosen for their diversity and comprehensive contribution to understanding the barriers to and drivers of adopting WCM in various settings.

Table -1: Barriers to Adopting WCM from Selected Studies

Reference	Study focus and setting	Key contributions
Terra *et al.* [5]	Challenges and barriers to WCM and I4.0 paradigms using case studies from five countries.	Pointed out barriers such as lack of knowledge of the applied methods and tools, lack of competent human resources, and employee resistance [5].
Eid [6]	Factors affecting the success of WCM implementation in less developed countries, using Egypt as a case study.	Categorized WCM critical success factors as strategic factors (e.g., management commitment, continuous improvement) and tactical factors (e.g., technical capability and production facility) [6].
Haleem *et al.* [7]	Key factors that drive the successful implementation of WCM, using critical success factors and interpretive structural modelling.	WCM successful implementation drivers' hierarchical model with excellent top management as the most important critical success factor to WCM [7].
Dev and Attri [8]	Using graph theory to analyze barriers to the WCM.	I identified twenty-nine barriers to WCM from the literature and classified them as behavioral (e.g., employee resistance), non- behavioral (e.g., inadequate tools and equipment), human and cultural barriers (e.g., lack of knowledge), and tactical barriers (e.g., lack of planning
Hicks and Matthews [9]	Elicit the root causes of failed WCM implementation.	Pointed out barriers to WCM from literature, e.g., lack of commitment from the organization, incomplete implementation.

Nordin *et al.* [10]	Barriers to and drivers of sustainable manufacturing in Malaysia, using a self- administered questionnaire.	The top barriers include overall incremental cost, lack of specific ideas on what to do and when, and lack of awareness.
Salaheldin and Eid [14]	Using mail questionnaires to illustrate how WCM techniques have been implemented in Egyptian manufacturing firms.	Drivers of WCM include global issues and the need to reduce operating costs. Significant barriers to WCM include poor planning and lack of knowledge.
Murugesan *et al.* [11]	Overview of WCM implementation in the South Indian manufacturing companies.	The study highlighted significant barriers to WCM as "investment costs, difficulty in understanding WCM principles, and workforce resistance".
Ng *et al.* [13]	A case study of a Malaysian semiconductor manufacturing firm, using semi-structured interviews.	Barriers included a lack of long-term commitment from top management, lack of competent human resources, lack of buy-in from shop floor staff.

The literature consistently identifies management commitment gaps, workforce resistance, knowledge deficiencies, and cost barriers as universal challenges to WCM implementation across diverse contexts (Terra et al., 2015; Eid, 2016; Murugesan et al., 2011), while highlighting the critical importance of strategic leadership, continuous improvement culture, and technical capabilities as key success factors (Haleem et al., 2017; Eid, 2016), with developing economies facing additional constraints from resource limitations and implementation knowledge gaps (Nordin et al., 2010; Salaheldin & Eid, 2014), ultimately revealing an implementation paradox where organizations often address technical WCM elements while neglecting the necessary socio-cultural transformations (Dev & Attri, 2018; Ng et al., 2013).

1.3 Research gap

The research gap identified in this study pertains to the limited availability of documented research on the

implementation of World Class Manufacturing (WCM) techniques within Egyptian manufacturing firms. This study seeks to address this gap by offering A case study evidence on the application of WCM techniques in the context of one of Egyptian manufacturing Firm, However, as with any research endeavour, certain limitations must be acknowledged.

First, the study is constrained by its reliance on a sample drawn exclusively from one of Egyptian manufacturers, which limits the generalizability of the findings to other contexts or regions. Second, the cross-sectional nature of the data collection restricts the ability to establish causal relationships between variables. Given that this study represents one of the initial efforts to explore the state of WCM implementation in Egypt, it also highlights the need for further research. Recommendations for future studies are provided to build upon these preliminary findings and deepen the understanding of WCM practices in similar contexts.

1.4 Research aim

The primary aim of this research is to examine the implementation of World Class Manufacturing (WCM) techniques within one of Egyptian manufacturing firms, with a focus on understanding the current state of WCM adoption in Egypt. The study seeks to provide a comprehensive framework and practical guidelines to facilitate the successful implementation of WCM practices among Egyptian manufacturers. In addition to its practical contributions, this

research aims to enrich the operations management literature, particularly in the domain of WCM implementation.

1.5 Research objectives

To analyse the practical implementation of WCM methodologies within Egyptian manufacturing enterprises, emphasizing the identification of processes, strategies, and frameworks utilized to integrate these techniques into their operational systems.

To establish a set of comprehensive guidelines and best practices tailored to the unique industrial, economic, and cultural dynamics of Egypt, facilitating the successful adoption and execution of WCM principles by Egyptian manufacturers.

To investigate the potential benefits and outcomes associated with the implementation of WCM practices by Egyptian manufacturing firms, including improvements in operational efficiency, product quality, and overall organizational performance.

By addressing these objectives, the research provides a holistic understanding of WCM implementation in Egypt, offering practical guidance for industry practitioners and theoretical contributions to the academic community.

1.6 Research questions

The following research questions have been formulated to explore how the implementation of World-Class Management (WCM) can be successfully initiated, with a specific reference to the case company:

- **What are the critical factors that both drive and inhibit the implementation of WCM techniques in the case of the company?**

This question explores the interplay of enabling and constraining variables that influence the adoption and execution of WCM practices.

- **How can actionable guidelines be developed to facilitate the successful implementation of WCM principles by the case company?**

This question focuses on creating a practical framework tailored to the unique industrial, economic, and cultural context of Egypt

- **How can WCM be implemented effectively and efficiently in the initial stage to ensure future success?**

This question focuses on developing actionable recommendations and best practices for initiating WCM implementation in a manner that maximizes efficiency and effectiveness, while laying a strong foundation for sustained success.

1.7 Research hypotheses

This research seeks to empirically test the hypothesis that the proposed case study explains a significant portion of the variance in the successful implementation of World-Class Manufacturing (WCM) within Egyptian manufacturing case company. The following hypotheses are formulated to guide the investigation:

Null Hypothesis (H0): There is no significant variance in the implementation of WCM practices among Egyptian manufacturing case company.

This hypothesis posits that the adoption and success of WCM practices do not vary significantly across case company, suggesting uniformity in implementation outcomes.

Alternative Hypothesis (H1): There is a significant variance in the implementation of WCM practices among Egyptian manufacturing case company.

This hypothesis challenges the null by proposing that differences in organizational, cultural, or operational factors lead to varying levels of success in WCM implementation.

1.8 Scope

Since most of the literature on World Class Management is limited, some information exists on the concept behind it. Also, a lot of information is available for the implementation of other concepts. Therefore, this research thesis is to provide an overview of world class management but also investigate and describe it within the case company.

The researcher focuses on the initial stage of WCM, this is done as the case company is currently in the process of implementing WCM. The research scope includes and excludes:

1.8.1 Included in scope

Framework of World-Class Management (WCM):

The study will explore the theoretical foundations and frameworks of WCM, providing a comprehensive understanding of its principles and methodologies.

Critical Factors for WCM Implementation in the Initial Stage:

The research will identify and analyse the key factors that influence the initiation of WCM practices, focusing on the case company's current implementation efforts.

Empirical Study with the Case Company:

The study will conduct an in-depth empirical investigation of the case company's WCM implementation process.

Recommendations for Future WCM Implementation:

Based on the findings, the research will provide actionable suggestions to guide the case company and other organizations in effectively implementing WCM in the future.

1.8.2 Excluded from scope

Entire Implementation Phase:

The research will not cover the full lifecycle of WCM implementation, as it is limited to the initial stage of adoption.

Comparative Analysis with Other Companies:

The study will not include comparisons of WCM implementation across different organizations, as its focus on the case company.

2. METHODOLOGY

2.1 Case study

A case study is an in-depth research approach that seeks to describe, understand, and examine phenomena within their real-world context, particularly in organizational settings. As Yin (1994) asserts, a case study is an empirical inquiry that investigates contemporary phenomena within their natural

environment, especially when the boundaries between the phenomenon and its context are not clearly defined. Consequently, the case study method is deemed highly appropriate for this research, as it facilitates a profound interpretation and exploration of the case company's experiences and practices.

Case study research is a widely utilized methodological approach among students and scholars. It can be structured as either a single-case study or a multiple-case study, depending on the research objectives and scope (Yin, 2008). This master's thesis adopts a single-case study design, enabling the researcher to focus intensively on a singular target and examine it in depth. By concentrating on a single case, the study allows for a detailed and comprehensive exploration of the phenomenon under investigation. Furthermore, compared to a multiple-case study approach, a single-case study is more time-efficient and requires less extensive data collection, making it a pragmatic choice for this research context.

In this empirical study, a leading global company player in sustainable packaging solutions manufacture industry located in Egypt was selected as the focal case for several compelling reasons. First, the company initiated its WCM (World Class Management) project three years ago, during which it encountered numerous and complex challenges. To this day, the

company continues to face various obstacles in the implementation of WCM.

The researcher's experience as a WCM Engineer at the company from 2022 to 2024 provided unique insights into the implementation process. The WCM program was initiated in 2022 following a meeting with stakeholders responsible for similar programs in other companies. This led to a visit to a sister company (under the same holding company but located in a different country), where the WCM program was already well-established. This experience, marked by initial setbacks and eventual successes, proved invaluable.

While the case study method offers significant value, it is not without limitations, which must be carefully addressed to ensure the rigor and validity of the research. One key limitation is the potential risk of failing to obtain the necessary information required to develop a comprehensive understanding of the case.

2.2 Data collection

A method of collecting the research data is needed. In this research thesis, qualitative and quantitative information related to the research objectives is used.

2.3 Analytic Hierarchy Process (AHP) questionnaire

The research was conducted using a survey design, as this approach involves administering the questionnaire once to a sample of the target population (Babbie, 1999). Kerlinger (2007) elaborates

that surveys are employed to study both small and large populations by examining a representative sample. This method enables the identification of variable incidence, relative distribution, and interrelationships among variables, providing a systematic framework for analysing patterns and trends within the data.

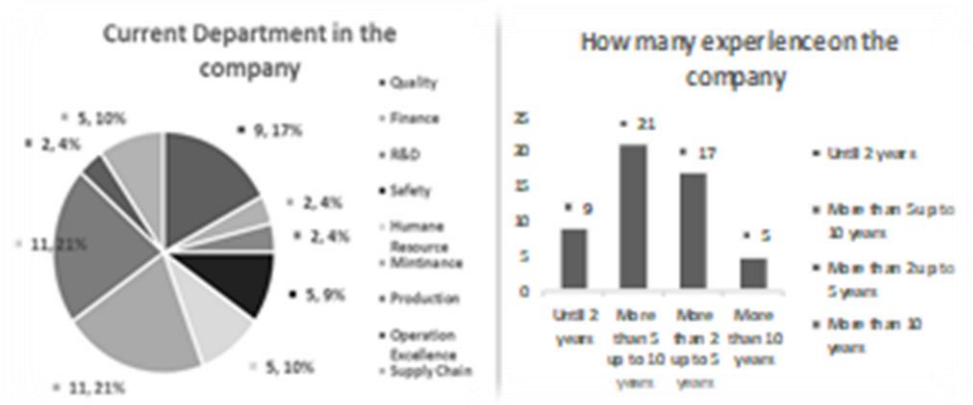
One viable approach for conducting survey research is the utilization of the Analytic Hierarchy Process (AHP). Initially proposed by T. Saaty (1977, 1980), AHP has emerged as one of the most widely adopted methods for decision-making. Its popularity stems from its user-friendly framework, which facilitates multi-criteria decision-making across diverse fields (Vargas, 1990). The AHP process involves aggregating decision-makers' judgments through pairwise comparisons, quantifying the relative importance of each alternative for individual decision-makers. This methodology not only identifies the most preferred alternative but also ranks all alternatives based on their perceived significance. Consequently, integrating AHP into survey research questionnaires enables a more precise and nuanced understanding of respondents' perceptions compared to traditional methods (Sato, 2003, 2004).

2.4 The sample

The composition of the sample can be characterized as follows: In terms of years of experience, a small proportion of participants (10%) reported having more than 10 years of experience, while the largest segment (approximately 40%) had

between 5 and 10 years of experience. The sample represented a diverse range of departments within the organizations. Specifically, 21% of respondents were affiliated with the Engineering Department, an equal proportion (21.1%) represented the Production Department, 17% were associated with the Quality Department, and 10% each were from the Supply Chain Department and Human Resources Department, Regarding the positions held by respondents, the majority were Operators, Foremen, or Technicians within their respective organizations. Additionally, 21% held roles as Team Leaders or Section Heads, 17% served as Senior Engineers or Engineers, and 14% occupied positions as Heads or Managers. see Figure 1.

Fig -1: Composition of the Sample



The data were analysed using the Analytical Hierarchy Process (AHP), a robust and effective tool for analysing multi-

criteria decision-making problems. AHP provides a structured decision-making procedure that represent the problem through a hierarchical framework. By leveraging qualitative judgments from experts and users, AHP employs a nine-point scale to prioritize criteria through pairwise comparison matrices. When multiple decision-making criteria are involved, AHP serves as a valuable method for ranking decision alternatives based on input judgments, facilitating a systematic and transparent decision-making process (Saaty). In this study, AHP was employed to elucidate the factors underlying the World Class Manufacturing (WCM) methodology and to provides a structured and evidence-based approach to understanding the critical factors influencing WCM implementation, offering valuable insights for both theoretical advancement and practical application in industrial settings.

The data were analysed using factor analysis, as the primary objective was to identify the constructs emerging from the collected data. The results of this analysis serve to either validate or refute the conceptual model, thereby determining whether the model should be retained or modified, the constructs were evaluated to ensure their reliability and validity. Specifically, Cronbach's alpha (α) reliability coefficients and item-to-total correlations were calculated for each construct, following established guidelines (Nunnally & Bernstein, 1994). The results of these analyses are presented in Table 2. All constructs

demonstrated strong internal consistency, with Cronbach's alpha values ranging from 0.846 to 0.879 These values exceed the widely accepted threshold of 0.60 for basic research, as recommended by Nunnally (1978).

Table -2: Reliability statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.867	.829	28

3. ANALYSIS AND RESULTS

3.1 Method of evaluation using AHP

The analytical hierarchy process (AHP) is an effective tool in analyzing multi-criteria to support the decision-making process it provides a decision-making procedure that presents the problem through a hierarchical structure. Based on the qualitative judgement of experts and users, developed a nine-point scale to promote the priorities of criteria through the pairwise comparison matrix.

3.2 Steps of AHP

1. Define the decision elements or subject areas that constitute the decision hierarchy.
2. Using pair-wise comparisons to judge the relative importance of decision elements.
3. Calculating the relative weights of decision elements using eigenvalue method.

4. Ranking the relative weights of decision elements to be able to rate the decision alternatives

3.2.1 Identify a Pool of Decision or Subject Elements

Selecting major subjects was based on the expertise and knowledge of factors that facilitate or hinder the implementation of WCM Identified in Literature.

The major subjects were divided into eight areas as follows:

- Top management support and leadership
- Change management and resistance to culture change
- Employee training and development
- Employee communication and information flow across department
- Employee teamwork collaboration and implementation of challenges
- Strategic planning and organizational objective
- Performance measurement and implementation of challenges
- External support and consultancy

3.2.2 Getting the Employer's Input Through Pair-wise Comparisons

To accomplish this task a questionnaire was designed and distributed to eight professionals covering different WCM factors, Figure 2. The questionnaire was designed to evaluate the relative importance of the different factors. The professional was asked to give a score on the left or right scale from 1, 3, 5, 7 or 9

in a pair wise comparison relating the relative importance of the factors together. In comparing the importance of one factor relative to the other factor, the factor under comparison was listed on the left column of the comparison table, while the other factors were listed on the right column.

For example, if the professional would see that, the factors under comparison is more important than the other factors; he would give it a score on the left scale and if the other subject is more important he would give it a score on the right scale, see Figure 2.

Fig -2: Comparison of the Importance of Top Management Support and Leadership to Other Factors

Factor I	Evaluation									Factor II
	9	7	5	3	1	3	5	7	9	
Top Management Support and Leadership										Change Management and Resistance to culture change
										Employee Training and Development
										Employee Communication and Information Flow across department
										Employee Teamwork Collaboration and Implementation of Challenges
										strategic planning and organizational objective
										performance measurement and Implementation of Challenges
										External Support and Consultancy

3.2.3 Rank the Pairwise Comparisons

A matrix was constructed by listing the subjects in both the left column and the top row. The relative rankings were then recorded in the body of the table (see Table 3). For example, when comparing the "Top management support and leadership "

(listed in the left column) with itself (listed in the first row), the ranking is assigned a value of 1. When comparing the " Top management support and leadership " (left column) with the " Change management and resistance to culture change " (first row), if the professional assigned a score of 5, the reciprocal value of 1/5 is recorded when comparing the " Change management and resistance to culture change " (left column) with the " Top management support and leadership " (first row). This reciprocal relationship ensures that all diagonal entries in the matrix are 1, while the entries below the diagonal are the reciprocals of those above it, once all pairwise comparisons were ranked, the sum of the rankings in each column was calculated. This step facilitates the aggregation of individual judgments and provides a basis for further analysis, such as determining the relative weights of each factor.

Table -3: Pair-wise comparison reciprocal matrix

Ranking the Factor Criteria	Top Management Support and Leadership	Change Management and Resistance to culture change	Employee Training and Development	Employee Communication and Information Flow across department	Employee Teamwork Collaboration and Implementation of Challenges	strategic planning and organizational objective	performance measurement and Implementation of Challenges	External Support and Consultancy
Top Management Support and Leadership	1	3	3	3	5	3	3	3
Change Management and Resistance to culture change	1/3	1	3	3	3	3	3	3
Employee Training and Development	1/3	1/3	1	1	3	3	1	1
Employee Communication and Information Flow across department	1/5	1/3	1	1	1	1	1	5
Employee Teamwork Collaboration and Implementation of Challenges	1/5	1/3	1/3	1	1	3	3	1
strategic planning and organizational objective	1/3	1/3	1/3	1	1/3	1	1	5
performance measurement and Implementation of Challenges	1/3	1/3	1	1	1/3	1	1	3
External Support and Consultancy	1/3	1/3	1	1/5	1	1/5	1/3	1
SUM	3.07	6.00	10.67	11.20	14.67	15.20	13.33	22.00

3.2.4 Normalize Pairwise Comparisons

To simplify the comparison between the numerical values, the pairwise comparisons were normalized relative to the sum of each column, as illustrated in Table 4. Normalization was achieved by dividing each value in a column by the sum of that column. This normalization process ensures that the sum of each column equals 1, thereby facilitating a clearer and more standardized comparison of the relative weights of each factor.

Table -4: Normalized pair-wise comparisons

NORMALIZE	Top Management Support and Leadership	Change Management and Resistance to culture change	Employee Training and Development	Employee Communication and Information Flow across department	Employee Teamwork Collaboration and Implementation of Challenges	strategic planning and organizational objective	performance measurement and Implementation of Challenges	External Support and Consultancy
Top Management Support and Leadership	0.3261	0.5000	0.2813	0.2679	0.3409	0.1974	0.2250	0.1364
Change Management and Resistance to culture change	0.1087	0.1667	0.2813	0.2679	0.2045	0.1974	0.2250	0.1364
Employee Training and Development	0.1087	0.0556	0.0938	0.0893	0.2045	0.1974	0.0750	0.0455
Employee Communication and Information Flow across department	0.0652	0.0556	0.0938	0.0893	0.0682	0.0658	0.0750	0.2273
Employee Teamwork Collaboration and Implementation of Challenges	0.0652	0.0556	0.0313	0.0893	0.0682	0.1974	0.2250	0.0455
strategic planning and organizational objective	0.1087	0.0556	0.0313	0.0893	0.0227	0.0658	0.0750	0.2273
performance measurement and Implementation of Challenges	0.1087	0.0556	0.0938	0.0893	0.0227	0.0658	0.0750	0.1364
External Support and Consultancy	0.1087	0.0556	0.0938	0.0179	0.0682	0.0132	0.0250	0.0455
SUM	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

3.2.5 Calculate Inconsistency Factor and Eigenvalue

Data collected through methods that rely on individual opinions, such as pairwise comparisons, often exhibit inconsistencies due to subjective judgments. To address this, the inconsistency factor must be calculated for each questionnaire to identify and exclude inconsistent responses. The first step in this process involves calculating the average weight of importance, as

demonstrated in Table 5. This is achieved by summing the weights of the pairwise comparisons for each row and then dividing the total by the number of factors to obtain the average. Note: The sum of all average weights of importance should equal 1, ensuring consistency in the weighting process.

Next, the Eigenvalue is computed through matrix multiplication of the average weights of importance and the normalized pairwise comparisons. This is represented as follows:

- Matrix (a): The normalized rankings matrix
- Matrix (b): The average normalized factors matrix
- Matrix (c): The inconsistency factor matrix

The Eigenvalue calculation provides a quantitative measure of consistency, allowing researchers to identify and address any discrepancies in the data. This step is critical for ensuring the reliability and validity of the results derived from the pairwise comparison process.

Table -5: Calculating the eigenvalue

NORMALIZE	Top Management Support and Leadership	Change Management and Resistance to culture change	Employee Training and Development	Employee Communication and Information Flow across department	Employee Teamwork Collaboration and Implementation of Challenges	strategic planning and organizational objective	performance measurement and Implementation of Challenges	External Support and Consultancy
Top Management Support and Leadership	0.3261	0.5000	0.2813	0.2679	0.3409	0.1974	0.2250	0.1364
Change Management and Resistance to culture change	0.1087	0.1667	0.2813	0.2679	0.2045	0.1974	0.2250	0.1364
Employee Training and Development	0.1087	0.0556	0.0938	0.0893	0.2045	0.1974	0.0750	0.0455
Employee Communication and Information Flow across department	0.0652	0.0556	0.0938	0.0893	0.0682	0.0658	0.0750	0.2273
Employee Teamwork Collaboration and Implementation of Challenges	0.0652	0.0556	0.0313	0.0893	0.0682	0.1974	0.2250	0.0455
strategic planning and organizational objective	0.1087	0.0556	0.0313	0.0893	0.0227	0.0658	0.0750	0.2273
performance measurement and Implementation of Challenges	0.1087	0.0556	0.0938	0.0893	0.0227	0.0658	0.0750	0.1364
External Support and Consultancy	0.1087	0.0556	0.0938	0.0179	0.0682	0.0132	0.0250	0.0455
SUM	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Average of Normalized Factors (ANF)	Inconsistency Factor (IF)	IF/ANF
0.2844	2.6256	9.2336
0.1985	1.8448	9.2951
0.1087	1.0413	9.5793
0.0925	0.8540	9.2321
0.0972	0.8984	9.2464
0.0844	0.7547	8.9369
0.0809	0.7203	8.9035
0.0535	0.4826	9.0283
1.0000	The eigenvalue:	
	λ_{max} =	9.1819

Eigenvalues, referred to as (λ) are a special set of scalars associated with a linear system of equations (i.e., a matrix equation) that are sometimes also known as characteristic roots, characteristic values (Hoffman and Kunze 1971), proper values, or latent roots (Marcus and Minc 1988). The determination of the eigenvalues and eigenvectors of a system is extremely important in physics and engineering, where it is equivalent to matrix diagonalization and arises in such common applications as stability / consistency analysis, the physics of rotating bodies, and small oscillations of vibrating systems, to name only a few.

Table -6: Relation between matrix size and random index (RI)

Matrix size (nxn)	1	2	3	4	5	6	7	8	9	10
Random Index (RI)	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

The inconsistency index (ICI) of a matrix of comparisons is given by:

$$ICI = \frac{\lambda_{max} - n}{n - 1}$$

Where, ‘n’ is the matrix size and in our case the matrix is 8x8, so ‘n’ equal 8.

Applying the above equation, the ICI for the first questionnaire as an example can be calculated as follows:

Inconsistency Index:

$$ICI = \frac{\lambda_{max} - n}{n-1} = \frac{1.18}{8-1} = \frac{1.18}{7.00} = 0.17$$

The inconsistency ratio (I.C.R.) is obtained by comparing the I.C.I. with the appropriate one of the following set of numbers, each of which is an average random consistency index (R.I.), Table 6. The RI is derived from a sample of size 500 of randomly generated reciprocal matrix using the scale 1/9, 1/8, …., 1, …., 8, 9 to see if it is about 0.10 or less (Saaty tolerated 0.20 but not more). If it is not less than 0.10, you may study the problem and revise the judgments, Saaty (1980). However, some fields and industries have different minimum values. Be sure to check for your study area.

The inconsistency ratio (ICR) for the first questionnaire as an example can be calculated as follows:

Inconsistency Ratio:

$$ICR = \frac{ICI}{RI} = \frac{0.17}{1.41} = 0.1197$$

3.2.6 Final AHP Results Summary

Table 7 lists the average of normalized factors, their geometric mean, their normalized geometric mean w.r.t. the sum of the geometric mean, ICI and ICR for each questionnaire.

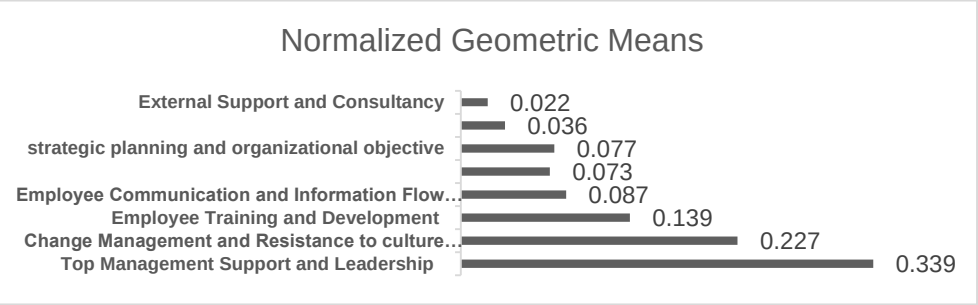
Table -7: Geometric Mean and Normalized Geometric Means of WCM Factors, and Inconsistency Indices

calculating the geometric and normalized geometric means	*Geometric Mean*	*Normalized Geometric Means*
Top Management Support and Leadership	0.336	0.339
Change Management and Resistance to culture change	0.226	0.227
Employee Training and Development	0.138	0.139
Employee Communication and Information Flow across department	0.086	0.087
Employee Teamwork Collaboration and Implementation of Challenges	0.073	0.073
strategic planning and organizational objective	0.076	0.077
performance measurement and Implementation of Challenges	0.036	0.036
External Support and Consultancy	0.022	0.022
	1.0	***1.00***
The inconsistency index (ICI)	***0.318***	
The inconsistency ratio (ICR)	***0.225***	

The target sample size of 73 achieved a 100% response rate, with all 73 questionnaires completed and returned. Of these, 52 responses were identified as valid based on the inconsistency ratio (ICR). The average inconsistency ratio for the valid responses was 0.225%, which falls within the acceptable threshold for consistency. Responses with an inconsistency ratio exceeding 0.25% were excluded from the analysis to maintain the reliability and validity of the findings.

The factors and their corresponding normalized geometric means were plotted in ascending order, as illustrated in Figure 3. This figure visually represents the priority of each WCM Factor, ranging from the most significant to the least significant. In this analysis, "Top Management Support and Leadership" emerged as the most critical factor, while "External Support and Consultancy" was identified as the least significant. This prioritization provides valuable insights into the relative importance of each factor, guiding strategic decision-making and resource allocation.

Fig -3: Prioritization of WCM Factors Using Normalized Geometric Means



3.3 Key Findings from AHP Analysis

The findings of the study revealed that four key factors significantly influence the successful implementation of World Class Manufacturing (WCM):

1. Top Management Commitment: The necessity of unwavering support and engagement from senior leadership.
2. Strong Leadership: The importance of effective leadership to drive and sustain WCM initiatives.
3. Overcoming Resistance to Change: Strategies to address cultural resistance and foster organizational buy-in.
4. Effective Training: The need for comprehensive training programs to equip employees with the skills and knowledge required for WCM.

These factors were identified as critical drivers, underscoring the importance of strong leadership and effective management of organizational change in achieving WCM objectives.

The results highlight the need for proactive engagement from top management and strategic approaches to address cultural resistance, ensuring a smoother and more effective implementation process.

By identifying these critical factors, the study provides a deeper understanding of the elements that either facilitate or hinder the successful implementation of World Class Manufacturing (WCM).

3.4 Comparison of Empirical Data with Literature Review

Based on the ideas from various various Literature sources, the researcher developed a comparative framework to examine the success factors for WCOM (World Class Operational Management) implementation during the initial stages, as outlined in Table 8. These success factors each play a distinct and critical role in the implementation process. The analysis reveals that no single factor can be omitted, as all are integral to the successful deployment of WCM. This comparative approach highlights the alignment between empirical findings and theoretical perspectives, providing a comprehensive understanding of the factors driving WCM implementation.

Table -8: Comparison of success factors: literature vs. case study for initial WCM implementation

Successful factors	*Literature mentioned*	*Case study mentioned*	Main obstacles on the initial stage of WCM
Top management commitment	✔	✔	*
Clear strategy, short-term target	✔	✔	
Prepared plan Big pictures of WCO implementation	✔		
Leadership	✔	✔	*
Team working	✔	✔	
employee education and training	✔	✔	*
External support WCOM coordinator	✔	✔	
Communication/ information	✔	✔	
Employee resistance	✔	✔	*
Change management	✔	✔	*
Appropriate monitoring and measures	✔	✔	
Motivation / awareness	✔	✔	
Financial constraints	✔		
Inadequate tools and equipment	✔		

From Table 8, it is evident that change management factors were not explicitly addressed in the existing literature. However, the findings of this study reveal a significant relationship between change management and WCM (World Class Management), a connection that has been overlooked by previous researchers. This suggests that WCOM is not solely designed to enhance operational performance but is intrinsically linked to organizational change.

WCM transforms the company's working environment by integrating individual tasks into more complex, team-based activities. This shift from individual work to teamwork reflects WCM's broader objective of fostering a more structured, systematic, and collaborative working culture. Such a

transformation inherently requires a strategic focus on continuous development and cultural change.

3.5 Further Suggestions for the Case Company in the Next WCM Implementation at the Initial Stage

To promote effective adoption of World-Class Manufacturing (WCM) principles, the case company must tackle key challenges using a structured, multi-faceted approach:

- Top Management Commitment & Leadership:

Challenge: Limited awareness and commitment from leadership hindered early implementation.

Solution: Create a shared vision through executive workshops, aligning WCM goals with corporate strategy. Secure ongoing support from senior leadership to encourage organizational buy-in.

- Leadership Development:

Challenge: Lack of capable team leaders to guide WCM initiatives.

Solution: Introduce a structured leadership program focused on change management, problem-solving, and team dynamics to empower leaders at all levels.

- Employee Engagement & Resistance Management:

Challenge: Resistance to change, especially among middle management and those attached to traditional methods. Solution: Use two-way communication strategies, such as town halls and

feedback loops, to explain WCM benefits. Involve employees in pilot projects to showcase quick wins and encourage ownership.

- Teamwork & Cross-Functional Collaboration:

Challenge: Isolated operations hinder overall improvement. Solution: Create cross-functional Kaizen teams to address prioritized losses, along with collaborative tools like digital dashboards to track progress and share insights.

- Training & Competency Building:

Challenge: Theoretical training lacks practical application. Solution: Use a "learn-by-doing" approach, integrating WCM tools (5S, TPM, SMED) into daily tasks. Add change management training to help with cultural transitions.

By identifying these factors, the company can better understand what helps or hinders WCM implementation. This understanding will boost the chances of successful WCM implementation in the future. By systematically addressing these areas, the company can overcome initial obstacles and build a strong foundation for WCM excellence.

4. CONCLUSIONS

The primary objective of this master's thesis is to explore strategies for enhancing WCM implementation during its initial stages by identifying the critical success factors associated with its execution with a comprehensive literature review to delineate the key factors influencing WCM implementation. Subsequently, an

analysis of the implementation process at the company revealed that a significant proportion of employees, team leaders, and top management experienced confusion during the initial phase.

To address this issue, the author identified key success factors by comparing empirical findings with academic literature, thereby proposing a more effective and efficient approach to WCM implementation.

Furthermore, the case study highlighted several obstacles encountered by the company during the initial stages, including a lack of top management commitment, insufficient leadership, inadequate communication, and limited motivation or awareness among stakeholders to drive WCOM implementation.

In response to these challenges, the author provides actionable recommendations to mitigate these barriers and facilitate a smoother implementation process.

Additionally, it is crucial to identify potential threats and opportunities associated with WCM (referred in the case company context) and communicate these clearly to employees. This approach will help build a shared understanding of the initiative's value and encourage active participation at all organizational levels.

Regarding the discrepancies observed between the success factors identified in the empirical case study and those highlighted in the academic literature, several explanations can be posited:

- A more extensive and systematic review of literature pertaining to success factors in WCOM implementation during initial stages may be required.
- The empirical findings may be influenced by the specific business environment and current organizational state of the case company.
- The temporal dimension of implementation is challenging to assess due to the ambiguous definition of the term "initial stage ".
- There is a lack of comprehensive analytical tools to investigate success factors specifically related to WCM implementation in its early phases.

4.1 Contribution of Research

As highlighted in the introduction, company studies in this field have primarily focused on related concepts, such as "world-class" practices, with limited attention given to World-Class Management (WCM). This master's thesis makes several contributions to the existing body of knowledge.

- Firstly, it provides a comprehensive and logically structured overview of the WCM framework, offering clarity and depth to the understanding of its principles and implementation processes.
- Secondly, it identifies critical success factors that enhance the effectiveness of WCM implementation during its initial

stages, thereby offering practical insights for future applications.

- Additionally, this research enriches the academic and practical understanding of WCM implementation by examining its application within the context of a manufacturing company; By doing so, it not only bridges a gap in the literature but also provides a case-specific perspective that can serve as a valuable reference for other organizations seeking to implement WCM.

4.2 Limitations of the Research

This thesis is subject to several limitations that should be acknowledged:

- Focus on the Initial Stage: The research emphasizes the initial stage of WCOM implementation rather than the entire implementation process. This narrow focus may limit the generalizability of the findings to later stages of WCOM adoption.
- Single-Case Design: The study employs a single-case design, which, while providing in-depth insights, may lack the robustness and reliability that could be achieved through a multiple-case study approach. Comparative analysis across multiple cases could yield more comprehensive and generalizable conclusions.

- Time Constraints: The scope of the research was constrained by time limitations, which restricted the ability to conduct a more in-depth investigation into certain aspects of WCOM implementation.
- Limited Access to Information: The study faced challenges in accessing comprehensive information related to "world-class operational management," which may have impacted the breadth and depth of the analysis.
- Multi-Case Studies: Employing a multiple-case research strategy would enable comparative analysis across different industries or organizational contexts. This approach could identify common and unique success factors, enhancing the generalizability of the findings.

REFERENCES

[1] Chaison, G. (2012). The new collective bargaining. Springer.

[2] Darnall, R. W. (2002). The world's greatest project. Difin.

[3] de Felice, F., & Petrillo, A. (2015). Optimization of manufacturing system through world class manufacturing. IFAC-PapersOnLine, 48(3), 741-746.

[4] de Felice, F., Petrillo, A., & Monfreda, S. (2013). Improving operations performance with world class manufacturing technique: A case in automotive industry. In M. Schiraldi (Ed.), Operations management. IntechOpen.

[5] Dev, N., & Attri, R. (2015). Analysis of barriers to world class manufacturing using graph theory. In Proceedings of the Twelfth AIMS International Conference on Management (pp. 1319-1327).

[6] Ebrahimi, M., Baboli, A., & Rother, E. (2019). The evolution of world class manufacturing toward Industry 4.0: A case study in the automotive industry. IFAC-PapersOnLine, 52(10), 188-194.

[7] Eid, R. (2009). Factors affecting the success of world class manufacturing implementation in less developed countries: The case of Egypt. Journal of Manufacturing Technology Management, 20(7), 989-1008.

[8] Enke, J., Glass, R., Kreß, A., Hambach, J., Tisch, M., & Metternich, J. (2018). Industrie 4.0 - Competencies for a modern production system: A curriculum for Learning Factories. Procedia Manufacturing, 23, 267-272.

[9] Flynn, B. B., Schroeder, R. G., & Flynn, E. J. (1999). World class manufacturing: An investigation of Hayes and Wheelwright's foundation. Journal of Operations Management, 17(3), 249-269.

[10] Garetti, M., Rosa, P., & Terzi, S. (2012). Life Cycle Simulation for the design of Product-Service Systems. Computers in Industry, 63(4), 361-369.

[11] Gilchrist, A. (2016). Industry 4.0: The industrial internet of things. Apress.

[12] Hicks, J., & Matthews, J. (2010). The barriers to realising sustainable process improvement: A root cause analysis of paradigms for manufacturing systems improvement. International Journal of Computer Integrated Manufacturing, 23(7), 585-602.

[13] Hobbs, D. P. (2003). Lean manufacturing implementation. APICS.

[14] Kenett, R. (2015). Total Quality Management: Introduction. Wiley StatsRef: Statistics Reference Online.