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Supply Chain Challenges in Ceramic Sanitary Ware: A Case Study and Solutions

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Abstract
In the fiercely competitive ceramic sanitary ware market, companies employ a range of strategies to meet consumer demands and expand their market presence. This study delves into a detailed analysis of the supply chain within a Thai-based ceramic sanitary ware company, employing the IDEF0 and SCOR models. The primary challenge revolves around the quality of raw materials, which can be traced back to weaknesses in the quality assurance and supplier selection systems. To effectively address this issue, the manufacturer can implement appropriate sourcing strategies, enhance supplier selection and evaluation processes, and institute a vendor development program. This comprehensive approach plays a pivotal role in mitigating the procurement, production, delivery, and return issues that have subsequently arisen. Ultimately, this research significantly contributes to ceramic sanitary ware supply chain management. It underscores the critical importance of resilient strategies and methodologies in tackling the complex challenges inherent in this industry.

Keywords: Sanitary Ware Factory, Supply Chain Analysis, Integration Definition for Function Modeling, The Supply Chain Operations Reference Model.

1. Introduction

The global ceramic sanitary ware market is poised for substantial growth, with projections indicating a rise from 32.11 USD billion in 2022 to 34.41 USD billion in 2023, reflecting a compound annual growth rate (CAGR) of 7.2%. Looking further ahead, the ceramic sanitary ware market is anticipated to reach 44.55 USD billion by 2027, sustaining a CAGR of 6.7% [1]. Major players in the ceramic sanitary ware market in Thailand include industry leaders such as LIXIL Corporation, Kohler Co., Roca Sanitario SA, American Standard Brands, Grohe AG, TOTO Ltd., and Siam Sanitary Ware Industry Co., Ltd. Other key players are Hansgrohe SE, Duravit AG, Jaquar & Company Pvt Ltd, Hansgrohe Group [2]. The present situation within the ceramic sanitary ware industry in Thailand reveals a landscape teeming with dynamism, underscored by a compelling narrative of steady growth and the perpetual evolution of market trends. In recent years, there has been resilient demand for ceramic sanitary ware products such as toilets, sinks, and bathroom fixtures, driven by factors such as urbanization, increasing disposable incomes, and a heightened emphasis on hygiene and aesthetics [3]. This heightened demand has led to a proliferation of both local and international factories entering the Thailand market, intensifying competition, and driving innovations in product design and technology. Furthermore, sustainability has emerged as a significant concern, prompting companies to adopt eco-friendly production methods and materials. However, the industry also faces challenges, including rising raw material costs, labour shortages, and economic uncertainties, which may impact its path to long-term sustainability. These factors underscore the need for entrepreneurs to diligently maintain and adapt their management strategies to achieve an appropriate balance between maintaining product quality and containing production costs. Proficient analysis and monitoring of the complete supply chain assume a pivotal role, enabling entrepreneurs to identify areas of inefficiency and optimize production processes. Through these measures, entrepreneurs can discover opportunities to reduce costs without compromising product quality, thus ensuring their competitive edge in a market where both price sensitivity and quality standards are essential.

This research focuses on a case study within the ceramic sanitary ware industry in Thailand, covering aspects ranging from production and sales to export. Nevertheless, supply chain management within the company case study has been underemphasized, leading to an inefficient approach in terms of the analysis and oversight of the entire supply chain. Such oversights have a direct impact on the industry's competitiveness, affecting its ability to reduce costs, streamline operational timelines, and maintain the desired service standards, all of which are critical to maintaining sales and market share within the ceramic sanitary ware industry. To address these challenges, this article proposes the utilization of the Supply Chain Operations Reference Model (SCOR model) and Integration Definition for Function Model (IDEF0) to enhance the analysis and monitoring of the complete supply chain. The IDEF0 model can help identify the shortcomings of existing supply chain processes by mapping variables such as input, output, control, constraints, and mechanisms.

The structure of this research is organized into three primary sections. The introductory section provides a comprehensive overview of the ceramic sanitary ware industry in Thailand, supported by relevant statistical insights. The subsequent section, which forms the core of the research, focuses on the analytical tools deployed for dissecting the supply chain within the ceramic sanitary ware industry of a case study, offering critical insights derived from our analysis. Finally, the paper culminates by offering a set of recommendations tailored to process improvement, based on the findings from the in-depth case study analysis.

2. Methodology

In this research, the author conducted a comprehensive study of the supply chain within a prominent ceramic sanitary ware business in Thailand. To facilitate this examination, the Integration Definition for Function Model (IDEF0) was employed as a powerful tool for creating detailed business process models, offering an intricate illustration of the organization's activities. Within the IDEF0 framework, these activities are depicted as boxes, with leftward-pointing arrows denoting the necessary inputs for each activity and rightward-pointing arrows symbolizing the outputs derived from their successful execution.

Furthermore, the controls governing these activities, encompassing aspects such as delivery schedules, standards, company policies, and regulatory constraints, are represented through arrows positioned at the top of the respective activity boxes. Concurrently, the mechanisms supporting these activities, including human resources, machinery, and computer systems, are indicated by arrows located beneath the activity boxes. Each activity field within the IDEF0 model is associated with a code situated in the right corner, defining the sequential order of activities (e.g., A1, A2, ..., and A5). Notably, the model employs a solid arrow line to signify the current state of activities, while a dotted arrow line serves as a conduit for indicating proposed enhancements aimed at augmenting the efficiency of the ceramic sanitary ware supply chain and refining overall business processes. The primary objective underlying the utilization of IDEF0 is to furnish a comprehensive representation of overall supply chain stakeholders and business process analysis of a case study. This encompasses a thorough examination of the requirements and functions associated with each activity, all while progressing in a coherent and goal-oriented manner. this approach empowers business process analysts with the tools needed to grasp the broader organizational landscape while retaining the capacity for detailed scrutiny and analysis.

The IDEF0 model has been used to analyze various business processes, such as a small-sized Thai chili paste supply chain [4], chilled beef in Thailand [5], cordyceps beverage in Thailand [6], Fresh Vegetables in Thailand [7], Logistics provider in Indonesian [8], a mass rapid transit (MRT) [9], a 3D Studio [10], a mine reclamation project [11].

The Supply Chain Operations Reference (SCOR) Model was meticulously devised with the overarching aim of elucidating the multifaceted supply chain business operations that place customer satisfaction at the forefront of their endeavors. The supply chain activities comprise five pivotal components. These components encompass planning (Plan), procurement (Source),

production (Make), distribution (Deliver), and return (Return).

SCOR model serves as an indispensable framework that not only delineates but also visualizes the entirety of business activities intrinsic to the attainment of customer satisfaction. It achieves this by establishing standardized processes and illuminating the intricate interconnections between them. In practical terms, this multifaceted model equips organizations with a holistic perspective of their existing practices within the supply chain domain. This comprehensive understanding, in turn, empowers organizations to identify and address any prevailing supply chain challenges or inefficiencies, ultimately culminating in the enhancement of their overall supply chain processes.

SCOR model can be implemented to improve supply chain management and enhance performance and value in various industries. It has been applied in the chicken-egg distributor industry to address supply chain problems and improve organizational performance, particularly in aspects of consumer satisfaction and financial flow congestion [12], The SCOR model has also been used in the textile industry to obtain customer satisfaction and improve the supply chain process for other products [13], Overall, the SCOR model offers a framework for designing and customizing supply chains to meet specific organizational needs.

3. Result And Discussion

3.1 The Overview of a Case Study

This case study delves into a prominent factory located in the Saraburi Province, Thailand, which specializes in the production and distribution of ceramic sanitary ware. This factory has strategically positioned itself within the Industrial Zone to serve as a central hub for its cutting-edge bathroom products. Their operations encompass the entire spectrum, from manufacturing to distribution and even exportation of large-scale premium ceramic sanitary ware products. It's noteworthy that this establishment functions both as a factory and a distributor of sanitary ware. The factory primarily exports its products, with around 98% of its total production destined for markets in the United States, China, Japan, and various Asian countries. The remaining 2% of its output is reserved for domestic sales within Thailand. Impressively, this factory has successfully expanded its market presence not only in countries like Japan, China, and the United States but also in numerous nations throughout Asia and Europe.

3.2 Business Process Analysis of the Ceramic Sanitary Ware Supply Chain

Within the supply chain examined in this case study, there are five key stakeholders. The first group comprises suppliers, which encompass both overseas and local suppliers responsible for furnishing the ceramic sanitary ware factory with the necessary raw materials, adhering to specified material requirements and delivery schedules. The central and most critical stakeholder in this supply chain is the ceramic sanitary ware factory itself. This facility primarily operates on a make-to-order basis, serving its overseas clientele. Upon receipt, the raw materials are dispatched to the factory, where they undergo rigorous management through a well-structured production control system. This system ensures the quality and compliance of incoming raw materials. The production process within the ceramic sanitary ware factory is a meticulously orchestrated series of crucial steps. It begins with a thorough examination of sales forecasts, followed by the formulation of production plans tailored to specific SKU (Stock Keeping Unit) requirements. The factory also exercises precise control over the quantities of raw materials procured and maintains strict oversight of the production process itself, including work instructions and machinery utilization. Furthermore, the factory places a strong emphasis on upholding product quality standards throughout both the in-process and out-process stages of production. Following the production of premium products, the completed ceramic sanitary ware products are distributed through affiliated traders, which function as integral components for sales, marketing, and warehousing on behalf of the factory. In the case of export sales, these finished products are transported from the warehouse to affiliated traders within the same corporate group. For domestic distribution, the finished products are shipped from the warehouse to the distribution centers operated by retailers. These affiliated traders and distribution centers are entrusted with the critical tasks of upholding warehouse standards and maintaining precise inventory control. To

accomplish this, they engage in a meticulous analysis of demand data, ensuring that all pertinent information is effectively relayed back to the manufacturing plant. This collaborative effort serves the overarching goal of optimizing production control.

Subsequently, the products are transported to retailers, including modern trade outlets, by the orders placed by these establishments. Throughout this stage, meticulous attention is directed toward various facets, encompassing product pricing within stores, the array of available product types, and stock levels in both showrooms and warehouses. In the event of encountering any defective products or raw materials, the organization conducts comprehensive investigations. These investigations are thoughtfully designed to pinpoint the root causes of issues and implement enhancements within the production process, as illustrated in Figure 1. This unwavering commitment to continuous improvement underscores the company's dedication to delivering high-quality sanitary ware products to its valued customers. Our target consumers primarily belong to the high-end or premium segment, with international customers being a significant clientele. Therefore, our primary objective revolves around ensuring customer satisfaction through the delivery of premium service and top-notch quality.

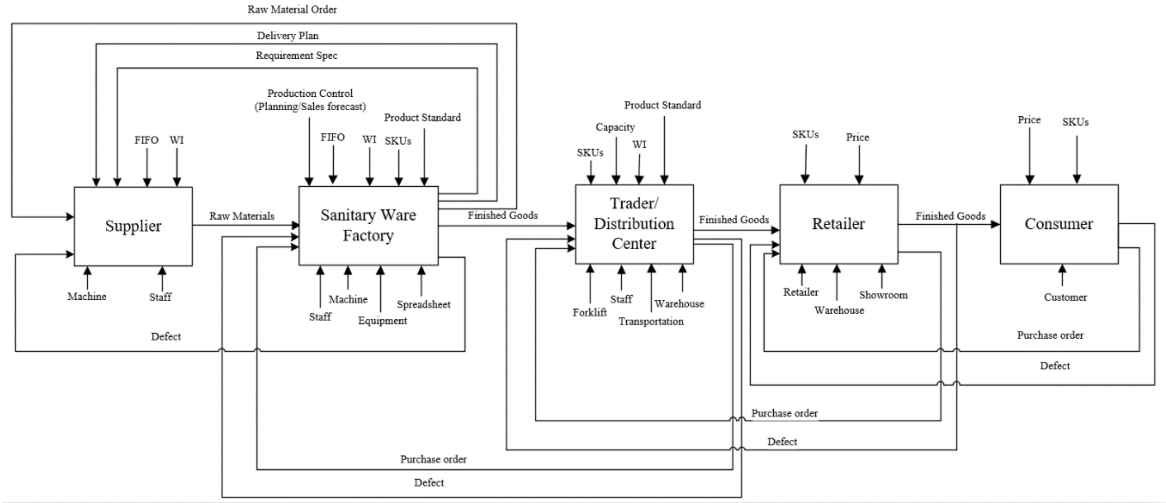

Figure 1. The business process of the ceramic sanitary ware supply chain (IDEF0 Level 0)

3.3 Business Process Analysis of the Ceramic Sanitary Ware Factory

Figure 2 provides a visual representation of the operational workflow of the ceramic sanitary ware manufacturer. The primary objective of this study is to undertake a comprehensive analysis of the business processes within the ceramic sanitary ware factory, with a specific emphasis on elucidating five pivotal activities. The initial activity denoted as A1, involves the planning phase. During this stage, a comprehensive examination of sales demand data is undertaken to formulate a production plan. This plan encompasses the acquisition of raw materials and outlines delivery schedules as its resultant outputs.

Currently, the planning process takes into consideration various factors, including sales forecasts, production capacity, process capabilities, product specifications, and the inventory levels in the warehouse. However, the factory often experiences delays in responding to unforeseen events, and it grapples with a high rate of defective raw materials due to its reliance on single-sourcing strategies. To address these issues, improvements can be made by incorporating scenario planning into the sourcing strategy. This approach enhances the factory's preparedness for potential disruptions in the production line, allowing for quicker responses when unexpected events occur. Additionally, exploring alternative sourcing options and adopting multiple sourcing strategies can contribute to a more robust and resilient supply chain.

The second activity within the ceramic sanitary ware factory's business process is sourcing (A2). During this stage, meticulous attention is given to raw material specifications, raw material costs, and the evaluation of key performance indicators (KPIs) for suppliers. Currently, a pressing issue faced by the factory is the high incidence of defective raw

materials. This challenge predominantly stems from an emphasis on quantity control at the expense of quality assurance and a supplier evaluation process that places a heavy focus on pricing considerations. However, a fundamental hurdle within this sourcing process is the inconsistency in the quality of the raw materials supplied. To tackle this challenge effectively, it is recommended to introduce an additional task focused on cooperative identification of the underlying causes of defects and the incorporation of Failure Mode and Effects Analysis (FMEA) within the production processes of suppliers. Moreover, the initiation of vendor development programs can play a pivotal role in guaranteeing that suppliers consistently uphold the requisite quality standards. These collective endeavors are poised to culminate in the establishment of a resilient and relevant supplier evaluation framework.

The third activity within the ceramic sanitary ware factory's business process is manufacturing or production (A3). During this stage, raw materials and packaging transform into finished products through the use of machinery and equipment. The production process hinges on the pre-planned production schedules generated during the planning phase and the raw materials obtained during the sourcing stage. At present, the factory is grappling with operational hurdles, notably production stoppages caused by insufficient raw material supplies and discrepancies in the quantity of incoming raw materials for the production line. To address these issues effectively, it is advisable to institute a vendor development program with the primary objective of ensuring that suppliers consistently provide raw materials that meet quality standards. This program falls under the purview of quality assurance responsibilities. Additionally, we should implement a verification process for raw material quantity checks upon arrival to prevent discrepancies in the quantity of incoming raw materials for our production lines. These proactive measures aim to eliminate the underlying quality issues originating from the suppliers.

The fourth activity in the ceramic sanitary ware factory's business process is delivery (A4), which includes the distribution of finished products from the warehouse to customer distribution centers. This involves the utilization of forklifts and trucks, efficient route management, and delivery capacity calculations based on inputs from the delivery planning activity. The current delivery process faces some challenges. First, there exists a considerable distance between the stock location and the laboratory, which is responsible for conducting quality checks before outbound shipments. This spatial separation has resulted in delays in the process. Second, the absence of well-defined routing plans and schedules for material handling results in operational inefficiencies. Lastly, arises with incorrect picking of raw materials or products has been observed. To tackle these challenges, several solutions are proposed. First, the layout will be adjusted to relocate stock closer to the laboratory, mitigating the issue of excessive distance and streamlining the confirmation process before outgoing shipments. Second, clear routing paths for forklifts will be established, and their routes and schedules will be optimized to address the lack of material handling and delivery plans, thereby enhancing overall efficiency. Finally, the implementation of clear product labeling in the warehouse and the introduction of visual controls will be undertaken to significantly reduce human errors during the picking process, ultimately resulting in improved accuracy and operational efficiency in the delivery process.

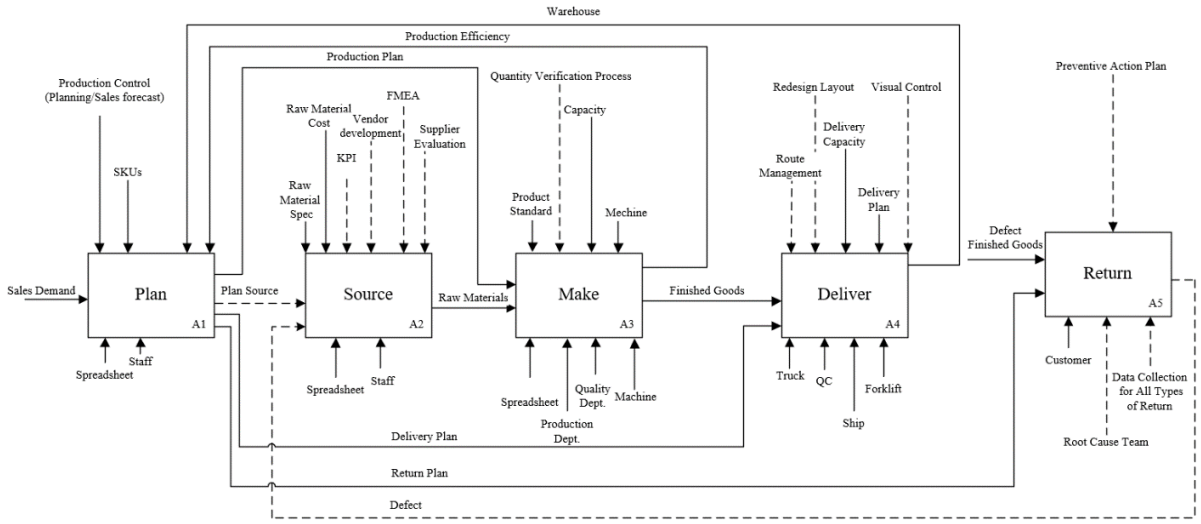

Figure 2. The business process of the ceramic sanitary ware supply chain manufacturer (IDEF0 Level 1)

The fifth activity in the ceramic sanitary ware factory's business process is Return (A5). It entails the management of the return process for defective raw materials or products within the production cycle. Its central objective revolves around the analysis of issues and the formulation of prevention and corrective plans to ensure the prevention of such defects from reaching customers or recurring within the factory. However, the current process faces notable challenges. First, there is a deficiency in the existence of a systematic data recording system that comprehensively documents the historical records of defects associated with returned parts. Second, there is an absence of structured analysis concerning the root causes underlying these return issues. To address these encounters effectively, two critical actions are recommended. First, establish a comprehensive data collection system that encompasses all varieties of returned components. It would facilitate the meticulous preservation of a detailed defect history, thereby aiding in future analysis and prevention endeavors. Second, establish a dedicated Quality Control (QC) team, equipped with QC tools tailored for in-depth analysis of the root causes behind returned components. This team would enable proactive measures in prevention and corrective actions, ultimately resulting in marked improvements in product quality and, consequently, higher levels of customer satisfaction. A synopsis of the issues and recommendations is presented in Table 1.

A notable concern has come to the forefront, primarily revolving around the quality of raw materials. This issue can be traced back to deficiencies in quality assurance procedures and the criteria used for selecting suppliers. To tackle this challenge head-on, we propose a multifaceted solution that involves the implementation of targeted sourcing strategies, enhancements to supplier selection and evaluation processes, and the introduction of a vendor development program. By adopting this comprehensive approach, the goal is to effectively mitigate the quality-related problems that have been causing difficulties throughout the procurement, production, delivery, and return processes. This proactive approach is crucial in not only addressing the existing issues but also preventing their recurrence in the future.

Table 1. Outline of Current Problems and Improvement

Activity	Problem	Improvement Guidelines
Plan	Single sourcing for most suppliers	Find alternative sourcing and use multiple sourcing strategies
Source	High return on defective raw materials	A collaborative finding of root causes of the defect and implementation FMEA of supplier production processes

	Mainly focus on quantity control rather than quality assurance	Vendor development to assure that suppliers produce conformance raw materials
	Supplier evaluation is focused on the price	Establish a suitable supplier evaluation
Make	Production shift due to not sufficient raw materials	Vendor development to assure that suppliers produce conformance raw materials
	Mismatch number of incoming raw materials fed into the production line	Implement a pre-relocation raw material quantity verification process
Deliver	Long distance from stock to the lab	Adjust the layout and find a nearby place to put the stock for quality-checking
	No routing plan and scheduling for material handling	Establish the routing path for the forklift optimize the route and schedule
	Wrong picking	Attach the label of products in the warehouse and use visual control to prevent human error
Return	No data record about defect detail	Establish the data collection for all types of return
	No systematic analysis of the root cause of return	Establish the QC team to implement the QC tools for root causes. Develop a preventive action plan to monitor and assess its efficiency and effectiveness.

4. Conclusion

Our research employs Integration Definition for Function Modeling (IDEF0) and The Supply Chain Operations Reference model (SCOR), to conduct a comprehensive analysis of the ceramic sanitary ware supply chain in Thailand. This study introduces root cause solutions aimed at optimizing operational efficiency and reducing costs, with a primary focus on improving the quality of raw materials. These solutions encompass the implementation of a vendor development program with suppliers, the adoption of multiple sourcing strategies, and the establishment of a more robust preventive quality assurance system. By addressing these issues, we aim to resolve subsequent challenges in production, distribution, and returns. In essence, this study makes a significant contribution to the current body of knowledge related to ceramic sanitary ware supply chain management. It underscores the paramount importance of research methods in effectively addressing multifaceted operational challenges. The data and solutions derived from this research provide valuable case studies that can assist ceramic sanitary ware manufacturers in enhancing their business operational efficiency.

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