



The present state of the cosmetics supply chain in Thailand and the prospective role of Independent Quality Assurance Verifiers (IQAVs) within the supply chain

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ABSTRACT

Within the well-established European cosmetic supply chain, Independent Quality Assurance Verifiers (IQAVs) such as NATRUE and COSMOS have been nurtured, facilitating the growth of robust markets and industries. In contrast, the cosmetics supply chain in Thailand remains enigmatic and insufficiently delineated. This opacity constrains the potential for quality assurance entities to establish and perform their functions. Therefore, the disorganized supply chain and the lack of IQAVs have given rise to unethical practices, truncated product life cycles, and diminished quality within the cosmetics supply chain. To address these concerns, the current study employs a bifurcated approach: 1) examining the extant state of Thailand's cosmetics supply chain, and 2) suggesting strategic positioning for IQAVs to enhance the Thai supply chain. A series of comprehensive interviews were conducted with numerous eminent experts representing various supply chain roles. By scrutinizing stakeholders in the Thai cosmetics supply chain, the research probes the reasoning behind the shortened product life cycles and identifies essential success factors for the improvement and expansion of the industry. The study utilized the IDEFO framework to assess the supply chain's present condition and then adopted the PESTEL analysis to discern potential strategic roles for IQAVs. In conclusion, the study suggested that Thai authorities either establish their certification standards and processes or cooperate with extant foreign IQAVs to adapt their standards to the local environment. This research contributes to an understanding of the prevailing circumstances and introduces a strategic function for IQAVs in supporting Thailand's aspiration to become ASEAN's beauty hub.

1. Introduction

The global cosmetics market held a valuation of USD 307.69 billion in 2020 [1]. Owing to its strategic location and prominence in the Asia Pacific region, Thailand emerges as an ideal candidate for growth and expansion within the cosmetics market. With an anticipated market valuation exceeding USD 7.3 billion in 2022, Thailand is poised to become the beauty epicenter of ASEAN. To capitalize on this potential, businesses may partake in a multitude of activities across the supply chain, encompassing cosmetic

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manufacturing, collaborative product development with local enterprises, utilizing Thailand as an Original Equipment Manufacturer (OEM) nexus, and procuring raw materials locally. Furthermore, the alignment of regulations with ASEAN through the implementation of the AHCRS (ASEAN Harmonized Cosmetic Regulatory Scheme) is predicted to enhance business opportunities throughout the entire supply chain [2].

Despite the profusion of opportunities within the cosmetics industry, numerous obstacles have hindered its growth. A primary challenge lies in the Thai cosmetics sector's excessive reliance on imported ingredients. Recent data reveals that approximately 90 % of the ingredients employed in cosmetics manufacturing in Thailand are imported from countries such as the US, Europe, Japan, and South Korea. This is unexpected considering the nation's abundance of local herbs, which could potentially yield up to 200,000 cosmetic ingredients, as reported in a 2017 industry analysis by Kasikorn Bank. The dependence on foreign sourcing has curtailed the industry's capacity for growth and development [3].

The intricacy of this issue originates from the insufficient commercialization of ingredient research, culminating in a scarcity of natural active ingredients within the market. Despite the presence of thousands of technologies for natural ingredients, universities, and research institutes have encountered difficulties in commercializing them. As a result, the majority of cosmetics products exhibit limited differentiation, contributing to a brief product life cycle since they are derived from identical ingredients procured from traders.

Uncommercialized research or intellectual properties (IPs) have not been exploited within the industry due to various factors, such as the absence of a platform for commercialization or the exorbitant costs associated with verifying IP properties. Consequently, invested research remains unutilized. The lack of swift and affordable independent quality assurance verifiers (IQAVs) for the examination and analysis of cosmetics products and ingredients within the industry constitutes a critical concern. This verification deficit gives rise to another problem in the Thai cosmetics supply chain: the dissemination of deceptive and counterfeit product and ingredient innovations.

The significance of IQAVs in guaranteeing the safety and quality of cosmetics ingredients is paramount. These impartial entities deliver essential verification of supplier assertions pertaining to ingredient safety, sustainability, and ethical sourcing, thereby cultivating trust among consumers and stakeholders across the supply chain. In Europe, NATRUE and COSMOS stand as two eminent IQAVs. Both organizations have instituted rigorous standards and certification procedures that ensure cosmetics ingredients adhere to elevated benchmarks for safety, environmental sustainability, and ethical sourcing.

The standards formulated by these IQAVs encourage fair competition among suppliers and instill confidence in consumers that the products they utilize are responsibly sourced and safe. The certification process employed by IQAVs typically encompasses an audit of the supplier's operations and supply chain, in addition to ingredient testing. Although this process may prove costly and lengthy for suppliers, it ultimately bolsters trust and augments the overall quality of the supply chain.

The accelerated expansion of the beauty industry in Thailand has resulted in numerous cosmetic companies accentuating their products' effectiveness by referencing laboratory-scale efficacy. Nonetheless, during production, cosmetics manufacturers frequently modify the formulation, and there is an absence of unambiguous regulations to guarantee that the claimed efficacy and outcomes are verified and scrutinized. This practice directly influences the quality of the Thai cosmetics industry, as most products exhibit shorter lifespans. Vague regulations and the lack of efficacy evaluations lead to cosmetics products failing to fulfill their advertised claims, engendering a loss of consumer trust and a less competitive industry. This occurs despite the presence of Section 6, Article 41, clauses 1 and 2 of the Cosmetics Act B.E. 2558 (2015) in Thailand, which stipulates that cosmetics advertising must not contain statements intended to deceive consumers or exert detrimental effects on society. Such statements may encompass claims regarding a product's origin, condition, quality, quantity, or properties. Assertions considered false or exaggerating the truth, or those causing grave misunderstandings of the product, such as through the mention of spurious scientific data, statistics, or other untruthful statements, are also prohibited under this clause [4].

These provisions exist to ensure that consumers are not misled by false or overstated claims made by cosmetic manufacturers, which could jeopardize their health or precipitate societal issues. Although the current regulation furnishes a lucid definition of deception, its implementation has devolved into a complex maze that numerous cosmetics manufacturers have already navigated. They have devised methods to circumvent the legal definition as delineated by the regulation.

While IQAVs hold an indispensable function in safeguarding the safety and quality of cosmetics ingredients, Thailand lacks a comparable organization. Nevertheless, a considerable demand persists for third-party verification to ascertain the safety and quality of cosmetics ingredients. One potential solution for Thailand involves devising its certification standards and processes or collaborating with existing IQAVs to adapt their standards to the local milieu. However, the implementation of IQAVs standards in Thailand may encounter challenges stemming from a deficiency of awareness or comprehension among suppliers and consumers regarding the significance of third-party verification.

The primary objectives of this study revolve around investigating the existing structure of the cosmetics supply chain in Thailand and strategically enhancing and reconfiguring this supply chain through the establishment of IQAVs. The integration of IQAVs is anticipated to substantially enhance both operational efficiency and overall effectiveness of the cosmetics supply chain, with the insights gained from this research having the potential to stimulate a diverse range of emerging research initiatives, thereby enriching the cosmetics industry. Furthermore, the study's findings offer invaluable guidance to numerous cosmetics brand owners, especially those grappling with complexities related to ingredient formulation transparency. This affects cosmetics manufacturers and ingredient suppliers alike, and the resultant consequences of these challenges are evident in the shortened product lifespan observed within the Thai cosmetics sphere. This study is set against the backdrop of an exhaustive examination of the cosmetics supply chain in Thailand, encompassing a comprehensive analysis of various industry components. These aspects include a detailed scrutiny of both internal and external regulatory frameworks influencing the supply chain, along with a meticulous examination of the various stakeholders

involved. Additionally, the study delves into the intricacies faced by cosmetics manufacturers and ingredient suppliers, presenting potential strategies that hold the potential to optimize not only the supply chain's operational efficiency but also its efficacy.

The research framework commences with an extensive global and Thai cosmetics industry overview, incorporating significant statistics to establish the study's significance. The literature review comprises three core segments: (1) an investigation of Thai cosmetics regulations, (2) an in-depth analysis of the Thai Cosmetics Supply Chain, and (3) a survey of pertinent cosmetics supply chain studies. The methodology expounds the research approach, emphasizing in-depth interviews for data collection and analysis. IDEFO and PESTEL analyses systematically evaluate internal and external supply chain factors, structuring the scrutiny of cosmetics supply chain intricacies. The results and discussion section includes four subdivisions: (1) internal supply chain critical factors, (2) stakeholder depiction, (3) supply chain analysis of Thai cosmetics manufacturers, and (4) external supply chain critical factors. The conclusion underscores pivotal findings, highlighting the study's role in enhancing understanding and refinement of Thailand's cosmetics supply chain, its implications for the Thai cosmetics industry's future trajectory, and potential avenues for further research.

2. Literature review

2.1. The Thai cosmetics regulation

According to the Thai FDA's official website, cosmetics regulation in Thailand encompasses both pre-marketing and post-marketing activities. However, products possessing pharmaceutical properties or presented as pharmaceutical items fall outside the scope of cosmetic regulation. The Cosmetic Act of B.E. 2558 (2015) has shifted regulatory emphasis from pre-marketing to post-marketing activities [5]. The rationale behind this transition was to ensure cosmetic product quality through technical requirements compliance and adherence to good manufacturing practices. Although the Thai FDA maintains authority over the cosmetics industry, complexities arising from factors such as industry development and policy considerations have extended beyond the Thai FDA's purview. Consequently, the Thai FDA relies on self-regulation by the cosmetics industry to guarantee consumer safety. However, recent challenges indicate that this self-regulation system may be ineffective, inefficient, or inappropriate.

A recent Thai Food and Drug Administration publication discussed cosmetic notification via e-Submission and Monitoring [6]. While 99 % of cosmetics misrepresentation is restricted to inaccurate packaging information, there is limited scrutiny regarding the actual ingredient percentages declared on the product compared to the formulation. Few verification systems exist to confirm actual ingredient percentages, often imposing high costs on brand owners. The Thai FDA prioritizes ingredient control for cosmetic safety, meticulously reviewing and approving ingredients before adding them to the Cosmetic Committee's approved list. Nonetheless, a personnel shortage in the Department of Medical Science, responsible for investigating reported cosmetics product and ingredient violations, has resulted in considerable delays in ingredient inspection and analysis.

The cosmetics industry presents a complex situation despite explicit legal provisions against illicit activities. The Thai FDA's scope does not encompass products with pharmaceutical properties that modify the human body's functions or structure. This raises questions about the entity or agency responsible for validating claims or ingredient formulations beyond the Thai FDA's jurisdiction. Some critiques of the cosmetics industry focus less on consumer safety concerns and more on the ethical implications of selling illusions. One such critique examines the relationship between ethics and consumerism in the cosmetics sector, highlighting the negative perception of a highly profitable industry that exploits consumer vulnerability through deceptive marketing claims. Additionally, a study evaluating three categories of claims, including scientific, performance, and subjective claims, found that a higher number of claims were misleading rather than accurate [7].

2.2. The Thai cosmetics supply chain

The Thai cosmetics industry exerts a noteworthy environmental influence, predominantly attributed to the intricate and heterogeneous nature of its supply chain. This intricate network involves multiple stakeholders characterized by divergent environmental, social, economic, and ethical attributes. The interwoven nature of these relationships and interactions renders the supply chain susceptible to an array of risks, with the potential to engender detrimental ramifications for sustainability. These risks encompass circumstances or occurrences linked to sustainability that carry the capacity to evoke adverse responses from stakeholders spanning the entire expanse of the supply chain [8].

One of the most pressing sustainability concerns in cosmetics supply chains is the preservation of socio-biodiversity. This term encompasses the diversity of life and culture, including the diversity of plant and animal species, ecosystems, and human communities. Preserving socio-biodiversity is critical for the long-term sustainability of cosmetics supply chains, as many cosmetic products rely on ingredients that are sourced from fragile ecosystems, such as rainforests and coral reefs. Overexploitation of these resources can lead to environmental degradation, loss of biodiversity, and social conflicts, which ultimately threaten the sustainability of the entire supply chain [9]. Despite the importance of socio-biodiversity preservation, there are concerns that other sustainability issues, such as fairness concerns, may negatively impact wholesale prices, carbon emission reduction levels, and green marketing efforts. This is because fairness concerns may not always be beneficial for maximizing utility for manufacturers [10].

In Thailand, despite having abundant natural resources, the Thai cosmetics industry heavily relies on imported ingredients due to the lack of available local options. While there has been research on local ingredients, many of these studies have not been commercialized or developed into viable options for cosmetics production. The lack of investment in local ingredients has led to missed opportunities for the industry to promote sustainability through the use of local, environmentally friendly ingredients, and instead perpetuates the unsustainable and environmentally damaging practice of importing ingredients from other countries. A study showed

that using herbal ingredients and being natural could create high-end cosmetic products that serve a niche market and add significant value to the industry [11]. By investing in the development and commercialization of local ingredients, the Thai cosmetics industry could not only promote sustainability but also capitalize on unique characteristics that set its products apart from those of other countries.

2.3. The related study of cosmetics supply chain

The global cosmetic industry has been studied across diverse nations, including Indonesia, China, Brazil, Malaysia, Iran, and Finland. In Indonesia, the augmentation of efficacy in beauty industry enterprises situated in Jakarta is achieved through the strategic integration of Total Quality Management (TQM) principles and Supply Chain Integration. TQM operates as a systematic framework for quality management, permeating organizational structures and emphasizing the integration of quality principles across all operational dimensions. Correspondingly, Supply Chain Integration facilitates harmonized interactions among companies, suppliers, and customers within a unified system [12]. Furthermore, an analysis of the supply chain dynamics of international companies venturing into the competitive Chinese market revealed the prevailing and forthcoming challenges and opportunities for foreign cosmetics firms [13]. In the context of the Brazilian cosmetic supply chain, a study strived to identify potential sustainability risks inherent to supply networks. Utilizing Interpretive Structural Modeling (ISM) and matrix cross-impact multiplication (MICMAC), the study revealed the pivotal significance of “technology and innovation risks” and “legal and responsibility risks” as influential variables. Notably, enterprises emphasizing “legal and responsibility risks” exhibit reduced vulnerability to “security risks” relative to “boycott risks,” culminating in “financial risks.” The study also observed the comparatively lesser influence of “financial risks,” “boycott risks,” and “ecological damage risks” on sustainability risks [8]. Shifting the focus to the Malaysian cosmetics sector, the investigation unveiled a notable awareness among manufacturers regarding Halal cosmetics, highlighting their comprehensive understanding of requisites, stakeholders, and essential protocols for obtaining Halal certification [14]. Similarly, in Iran, the production of Halal cosmetic products mandated collaborative supply chain efforts and accountability. The implementation of a Halal policy traceability system was deemed integral in ensuring the production of premium-quality Halal cosmetics, governing aspects ranging from raw material selection to distribution. Within Islamic markets, the success of Halal cosmetics hinged on establishing consumer confidence through effective communication of product benefits and alignment with evolving consumer preferences [15]. Expanding its purview, the study assessed supply chain performance through cost and financial metrics, specifically examining supply chain cost optimization within the framework of a case study involving a Finnish SME cosmetics distributor [16]. The effectiveness of cost optimization strategies was contingent upon a comprehensive understanding of the company’s operational dynamics. The feasibility of such optimization necessitated the utilization of key financial indicators such as ROI, Operating Profit Margin, and Inventory Turnover Ratios, collectively shedding light on the supply chain’s impact on the company’s financial resilience.

3. Methodology

3.1. Data collection

The study encompassed an extensive array of 36 interviews, engaging key stakeholders embedded within the cosmetics industry supply chain. This heterogeneous cohort consisted of three farmers, two ingredient manufacturers, two ingredient suppliers, two packaging manufacturers, two ingredient traders, two packaging traders, five cosmetics manufacturers, two cosmetics traders, five brand proprietors, two regulatory officers from the Thai FDA, two distributors, two retailers (including supermarkets and department stores), in addition to three consumers and two researchers affiliated with research institutions. In tandem, the study conducted 15

Table 1
Profile of the cosmetics manufacturers.

#	Position of respondents	Size (S, M, L)	Type	Product	Number of Employees	Domestic/Export (D/E)
1	Research and Development Manager	S	OEM, OBM	SC	10	D
2	Business Development Manager	M	OEM, OBM, ODM	SC, PC	100	D/E
3	Managing Director	S	OEM, OBM, ODM	SC, PC	10	D
4	Sales Manager	M	OEM, OBM	SC, PC, M	80	D/E
5	Business Development Section Manager	L	OEM, ODM	SC, PC, M	2800	D/E
6	Product Development Supervisor	M	OBM	SC	250	D/E
7	Sales Manager	M	OEM, ODM	SC	200	D
8	Sales Manager	M	OEM, OBM, ODM	SC, PC, M	70	D/E
9	Managing Director	M	OEM	SC	100	D
10	Assistant to Business Development Manager	L	OEM, ODM	SC, PC, M	3000	D/E
11	Project Management	M	OEM, OBM, ODM	SC, PC, M	70	D/E
12	Senior Sales Officer	M	OEM, ODM	SC, PC, M	100	D/E
13	Brand Manager	M	OEM, OBM, ODM	SC, PC	90	D/E
14	Purchasing Manager	M	OEM, OBM, ODM	SC, PC	70	D/E
15	Marketing Manager	M	OEM, OBM, ODM	SC, PC	90	D/E

Note: OEM = Original Equipment Manufacturer, OBM = Original Brand Manufacturer, ODM = Original Design Manufacturer, SC = Skincare Care, PC = Personal Care, M = Makeup.

supplementary interviews with cosmetics manufacturers, whose extensive industry acumen contributed invaluable insights and expertise. The comprehensive profiles of these interviewees are meticulously cataloged in [Table 1](#). The principal objective of these interviews was to procure an enhanced understanding of the cosmetics supply chain within Thailand, thereby facilitating the amplification of value chains for cosmetics manufacturers. The formulated interview questions were strategically designed to solicit information spanning various dimensions, encompassing participants' roles within the supply chain, identification of suppliers and clients, explanation of operational responsibilities within their respective enterprises, exploration of existing challenges, and an examination of external factors that exert influence on the supply chain environment. The inclusivity of the interviewee spectrum, encompassing actors from farmers and manufacturers to regulatory officers and end consumers, engendered a comprehensive and multi-dimensional vantage point on the cosmetics supply chain. Through this comprehensive approach, the study endeavored to construct a cohesive tableau delineating the interplay among disparate entities, processes, challenges, and influences intrinsic to the cosmetics supply chain in Thailand. Such a holistic comprehension assumes paramount significance in cultivating synergistic collaboration, innovation, and streamlined coordination among the manifold stakeholders, thereby propelling the progression and sustainability of the cosmetics industry within the region.

3.2. Data analysis

An exhaustive exploration of the cosmetics value chain was conducted using qualitative data derived from in-depth interviews, followed by the identification of critical success factors through the application of the PESTEL Analysis framework. Six industry experts, including three from the manufacturing sector, assisted in the analysis process. The activities of cosmetics manufacturers within the supply chain were assessed by employing the Integration Definition for Function Modeling (IDEF0) methodology, a prevalent approach for representing the decisions, actions, and operations of organizations, processes, or systems [17]. The IDEF0 approach has been applied to numerous supply chains, such as the Thai chili paste supply chain [18], hotel, restaurant, and catering businesses in Thailand [19], a raw milk collection center [20], cordyceps beverage [21], chilled beef in Indonesia [22], organic rice [23], temperature-controlled third-party logistics provider in Indonesia [24], the effect of Covid-19 on small-sized blue crab manufacturers [25], pineapple leaf fiber supply chain [26], frozen shrimp manufacturers [27], chicken-based pet food supply chain [28], alcohol sanitizer supply chain [29], canned pet food supply chain [30], and operational challenges in the cold chain farm-to-consumer delivery during the Covid-19 pandemic [31]. The IDEF0 model consists of two primary components: function boxes and arrows. Function boxes signify activities, processes, and transformations, while arrows represent data and objects associated with those functions. Within the cosmetics value chain, the functions are depicted as square boxes with a code indicating their rank. Inputs, controls, and resources required for the functions are represented by arrows originating from various directions. Outputs are illustrated by arrows pointing to the right. Solid lines denote current functions, while dashed lines signify suggested enhancements to improve the agility of the cosmetics manufacturers' value chain. The IDEF0 analysis was performed at two levels: Level 0 offered an overview of cosmetics supply chain stakeholders, and Level 1 concentrated on analyzing cosmetics manufacturers' proposed activities, in conjunction with the independent quality assurance verifier's activities.

4. Findings and discussion

4.1. Internal supply chain critical factors in the cosmetics supply chain

Based on current literature reviews, it is apparent that several important factors impact the internal supply chain of cosmetics. From a supplier's perspective, independent quality assurance verification is essential to ensure the quality of ingredients and minimize delivery problems. Collaboration between stakeholders is also necessary to optimize the supply chain and ensure the timely delivery of high-quality products. Maintaining quality standards throughout the supply chain is also a critical factor for cosmetics manufacturers. On the other hand, customers also play a vital role in the internal supply chain of cosmetics. Legal and responsibility risks can arise when suppliers fail to meet sustainability standards, underscoring the importance of careful supplier selection and monitoring. Changes in consumer behavior, particularly in Thailand, also impact the internal supply chain as consumers become more concerned with sustainability and ethical practices. With these factors in mind, a multifaceted approach is necessary to optimize the internal supply chain of cosmetics. By prioritizing these critical factors, cosmetics manufacturers can produce high-quality, sustainable products that meet consumer expectations while minimizing legal and responsibility risks. These factors have been identified and emphasized in the current literature, highlighting their significance in the cosmetics industry as shown in [Table 2](#).

Table 2
Critical success factors within the cosmetic supply chain.

Stakeholders	Factors	Description
Suppliers	Delivery Problem	Lack of independent quality checker for ingredient formulation
	Collaborative Relationship	It occurs when two or more people work together to accomplish common goals.
Customers	Quality	Quality of the ingredients as well as the final product that delivers safe and efficient results.
	Legal and Responsibility Risk	A customer may bear responsibility for the shortcomings of its suppliers if they fail to meet the expected sustainability standards.
	Thai consumer buying behavior	Changes in the way consumers make decisions in purchasing products

4.2. Stakeholders description of the cosmetics supply chain and Their Functions

Within the framework of the supply chain stakeholder theory, the process of discerning stakeholders embedded within the supply chain emerges as of paramount importance. In contrast, attributing stakeholder status to specific entities in the absence of substantiating their indispensable roles in furnishing essential support or their potential to withdraw such support can lead to resource allocation deviations from an optimal organizational standpoint [32,33]. Consequently, this section undertakes the task of delineating the primary stakeholders inherent to the Thai cosmetics supply chain and subsequently engaging in interviews to elucidate their perspectives on sundry facets and intricacies within the chain. These stakeholders encompass cosmetics manufacturers, research institutions representing ingredient suppliers, brand proprietors, clients, and regulatory officers affiliated with the Thai FDA. The present Thai cosmetics supply chain discloses the identification of thirteen stakeholders, explicated in Table 3, alongside the presentation of the supply chain schematic depicted in Fig. 1. The interviews conducted inferred that particular processes embedded within the value supply exert an impact on the product life cycle of Thai cosmetics under manufacture, a phenomenon attributed to the industry's responsiveness to consumer demand.

Fig. 1 illustrates the interconnected entities participating in upstream and downstream product, service, financial, and information flows [34]. These intricate processes extend from the ultimate supplier to the ultimate customer. The supply chain for cosmetics products in Thailand starts with farmers who produce the raw materials needed for ingredient makers to create cosmetics ingredients. The ingredients can be purchased by cosmetics manufacturers from the ingredient maker, ingredient supplier, or through ingredient traders. Ingredient suppliers can include university and government research institutes that conduct further research on cosmetics

Table 3
The stakeholders in the cosmetics supply chain and their functions.

Stakeholders	Activity	Roles
1. Farmers	At the first level of ingredients supply, farmers are the ones who plant and grow living organisms such as crops, plants, and fruits for raw materials. As of 2021, there were approximately 7.4 million agricultural households in Thailand.	Source of raw material
2. Ingredient Maker	After obtaining or purchasing raw materials from farmers, ingredient makers are responsible for the creation of ingredients developed through various technologies. They include government institutes researchers as well as university researchers or independent companies specializing in cosmetics ingredients formulation and production.	Research and development
3. Ingredient Supplier	Raw material suppliers provide bulk ingredients to cosmetics manufacturers through ingredient traders. These include both local and overseas ingredient suppliers.	Source of other raw materials
4. Packaging Manufacturer	A packaging supplier provides packaging for products. The supplier may also provide services such as designing the packaging, printing the labels and logos, and assembling the products.	Source of packaging
5. Ingredient Traders	Ingredient traders buy ingredients from the source to resell them to cosmetics manufacturers.	Resells ingredients
6. Packaging Trader	Packaging traders buy cosmetics packaging from the manufacturer and resell it to the cosmetics manufacturer.	Resells packaging
7. Cosmetics Manufacturer	A cosmetic manufacturer is a company that produces cosmetic products for consumers' consumption. Cosmetics Manufacturers can be brand owners themselves or they can be in the form of Original Equipment Manufacturer (OEM) which designs and manufactures cosmetics based on specifications by brand owners. In Thailand, cosmetics manufacturers are classified into three types: a. Global Manufacturers such as Beiersdorf (Nivea and Eucerin), Kao (Biore); b. Local Brand Manufacturers such as Mistine and Giffarine; and c. Local OEM Manufacturers: As of 2021, Thailand has 2000 cosmetic OEM manufacturers.	Process cosmetics ingredients into finished cosmetics products.
8. Cosmetics Traders	Cosmetics traders can act as intermediaries between cosmetics manufacturers and brand owners in certain cases. Typically, they possess trading expertise, maintain extensive connections to key industry players, and have well-established distribution channels to facilitate the efficient delivery of products to customers.	Resells cosmetics
9. Brand Owners	Brand Owners are people, a category of persons, or companies who manufacture or sell cosmetics under their brand label.	Seller
10. Thai FDA	The Cosmetic Act B.E. 2558 (2015) [4] stipulates that the role of the Thai FDA on cosmetics is to promote and enhance cosmetic production, importation, and sales according to the standards. To inspect, monitor, and do surveillance on cosmetic enterprises; monitor cosmetic advertisements in compliance with the standards and regulations. With these, Cosmetics Manufacturers and Brand Owners are obligated to follow the standards provided by the Thai FDA.	Controls and implements regulations on cosmetics
11. Distributors	A cosmetics distributor is responsible for the transport, storage, and selling of finished cosmetics goods from the manufacturer and/or brand owners to the final consumers. In Thailand, there are three types of importers and distributors: a. Import Subsidiaries of International Brands; b. Authorized Distributors which are Thai companies handling various brand products; and c. SME's Importers and Distributors.	Distribute
12. Retailer	In Thailand, cosmetics retailers play a crucial role in enabling consumers to browse and purchase cosmetic products. The retailing channels available to consumers in Thailand include department stores, specialty stores, convenience stores, supermarkets or hypermarkets, and e-commerce platforms.	Retail
13. Consumer	An individual who buys cosmetic products for personal use. The value of the Thai cosmetics consumer market reached \$6.8 billion in 2020, which accounts for nearly 25 % of the total sales of \$27.7 billion across all ASEAN countries.	Consume

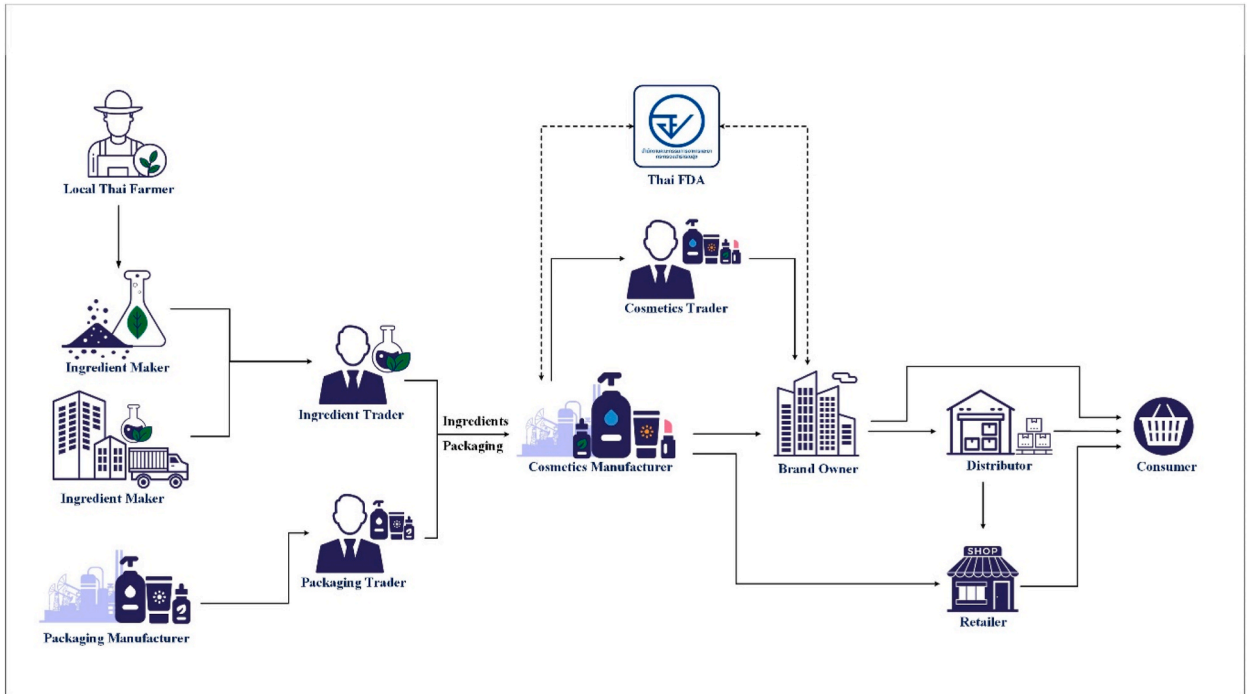


Fig. 1. The cosmetics supply chain in Thailand.

ingredients to add more value to their products. OEM companies, which fall under the category of cosmetics manufacturers, then create cosmetics products using standard formulations that specify the base, active, color, and fragrance as required by brand owners. The Thai FDA oversees the regulations for cosmetics and checks for any prohibited ingredients in the products submitted by the cosmetics manufacturer to ensure the quality, safety, and efficacy of the products. However, the Thai FDA relies heavily on the cosmetic industry to practice self-regulation to ensure consumer safety, as the scope of regulations for cosmetics is limited. After obtaining the necessary documentation from the Thai FDA, cosmetics manufacturers can proceed with mass production of the products, which can then be delivered directly to brand owners or through cosmetics traders who serve as middlemen. Cosmetics products can be distributed and sold through various channels, including distributors and retailers. In Thailand, retailers have a variety of channels, such as department stores, convenience stores, specialty stores, supermarkets, and hypermarkets. Consumers have the option to purchase products from distributors or retailers, or directly through online channels.

4.3. Supply chain analysis of the Thai cosmetics manufacturer

To identify the key success factors in reshaping and improving the Thai cosmetics supply chain, the first stage involves identifying the constraints and pain points of the stakeholders through interviews. Following this, an in-depth analysis of the main concerns of

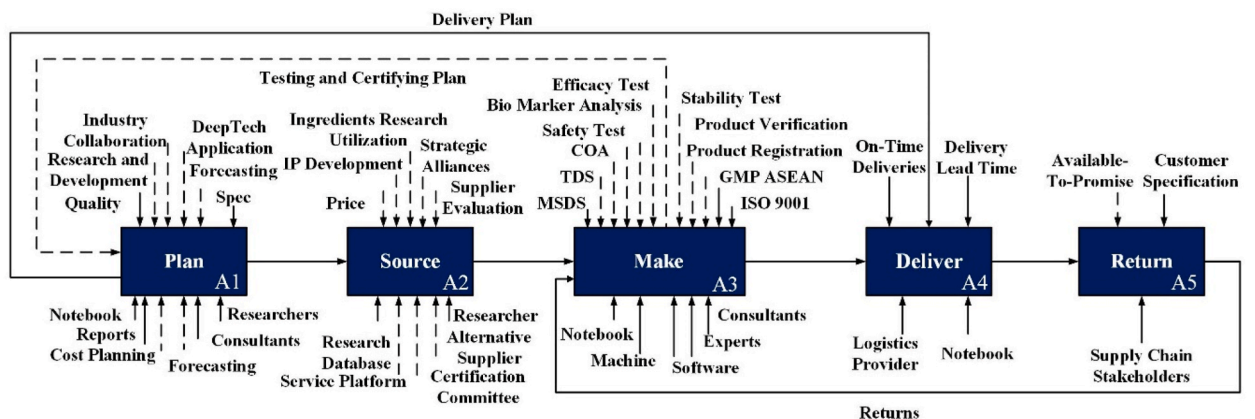


Fig. 2. The business process of Thai cosmetics manufacturers (IDEFO Level 1).

cosmetics manufacturers was conducted through another interview. The opinions of the respondents were aggregated, and it was found that the main reasons behind the short product life cycle of Thai cosmetics and beauty products are the lack of cosmetics ingredient differentiation, as well as fake or misleading innovations. The interview results also emphasized the need for an independent quality assurance verifier that understands consumer demand and provides exceptional service beyond the standards to offer solutions to industry barriers.

4.3.1. Business process proposal for a cosmetics manufacturer

This study proposes a business process to address the research questions raised in the paper's introduction by analyzing and studying the opinions of respondents. The proposed process for a cosmetics manufacturer was analyzed using the IDEF0 level 1, which is composed of five major activities: plan, source, make, deliver, and return (illustrated in Fig. 2). The plan phase involves strategic forecasting to secure cosmetics ingredients and invest in additional production lines, which is crucial due to the pandemic's uncertainty making it difficult to obtain supplies. Cosmetics manufacturers closely monitor their ingredient sources, resources, and suppliers to acquire necessary materials. During the make phase, raw materials and packaging are converted into the final product with the help of machinery, equipment, and resources. The IQAV ensures quality control by offering testing, certifications, and other services. The delivery phase focuses on preparing for timely distribution to brand owners, customers, and distributors, with delivery date and time being critical. Finally, the return process involves customers returning any non-compliant products to the factory, where the cosmetics manufacturer takes the necessary steps to fix any issues and meet brand owners' requirements before redelivering the product.

4.3.2. Problem analysis and proposed strategies for cosmetics manufacturers

After conducting interviews and analyzing the results, this paper aims to discuss the key pain points of stakeholders in the Thai cosmetics supply chain and provide strategies to improve it as shown in Table 4.

(i) Plan

As Thailand relies heavily on imported cosmetic ingredients, brand owners struggle to compete if they lack technology or innovation in their products, resulting in a high failure rate among SMEs. For cosmetics manufacturers, depending solely on suppliers limits their ability to diversify their product lines. To address this, the paper suggests investing in research and development to develop their intellectual properties, including high-value active ingredients, which can give them a competitive edge. Respondents have indicated that fake or misleading innovations, such as overclaims or ineffective doses of active ingredients, are another major reason for the short product life cycle of Thai cosmetics. This results in no repeat customers and is consistent with other issues raised by the respondents, including manipulated information from salespeople. This paper highly suggests that cosmetics manufacturers should provide quality control test services such as safety tests, efficacy tests, and product stability testing to be performed and conducted by IQAVs as depicted in Fig. 3. Moreover, biomarker analysis will also be crucial as it examines the level of substances (active ingredients) in products. This will determine the impact and competitive advantage of a company's product compared to others. The respondents strongly stated that to guarantee the effectiveness and safety of products and their raw materials, quality control in the cosmetics industry is crucial. Efficiency, affordability, and timeliness are important factors for respondents if they want to use the service of an IQAV. With this, this paper also suggests that innovation and technology are other success factors for reshaping the Thai cosmetics manufacturers' supply chain. With state-of-the-art technologies and continuous innovations and advancements, the dissemination of factual data and results is guaranteed, and fake innovations will be greatly lessened if not fully eliminated.

The ethics problem arising from the self-declaration system through E-submission to the FDA is the final concern. Manufacturers

Table 4
The improvement guideline for the cosmetics supply chain.

Activities	Problems (As is)	Improvement Guidelines (To be)
Plan	<ul style="list-style-type: none"> • Fake or misleading innovations • Hidden costs from some suppliers and manufacturers 	<ul style="list-style-type: none"> • Identify biomarkers and provide high-value active ingredients by IQAV • Provide a transparent cost planning program
	<ul style="list-style-type: none"> • Low forecast accuracy • Too many similar products on the market • Ethics problem due to self-declaration system through E-submission to FDA 	<ul style="list-style-type: none"> • Provide industry forecasting, using aggregation • Invest in research and development • IQAV collaborates with FDA, universities, and research institutes
Source	<ul style="list-style-type: none"> • Undifferentiated ingredients • Undefined organizational assets 	<ul style="list-style-type: none"> • Utilize ingredient research from universities and research institutes • IP development through creating a long-term strategy in utilizing assets
Make	<ul style="list-style-type: none"> • Supplier inflexibility resulting in added costs • Difficulty in finding alternative suppliers 	<ul style="list-style-type: none"> • Collaborate with strategic alliances and alternative suppliers • Utilize ingredient sourcing platforms
	<ul style="list-style-type: none"> • Manipulated information from salespeople • Short shelf life of products 	<ul style="list-style-type: none"> • Providing safety and efficacy testing by IQAV • Providing product stability test
Deliver	<ul style="list-style-type: none"> • Long lead time for delivery of laboratory results • Late on deliveries 	<ul style="list-style-type: none"> • Include on-time deliveries as a metric for KPI • Invest in machines that improve production and efficiency
Return	<ul style="list-style-type: none"> • Communication problems post-sales stage 	<ul style="list-style-type: none"> • Implement ATP (Available-To-Promise) as KPI
	<ul style="list-style-type: none"> • Delivered outputs (production scale) differ from the agreed sample (lab scale) 	<ul style="list-style-type: none"> • Verify and test through an IQAV to determine the cause of the problem

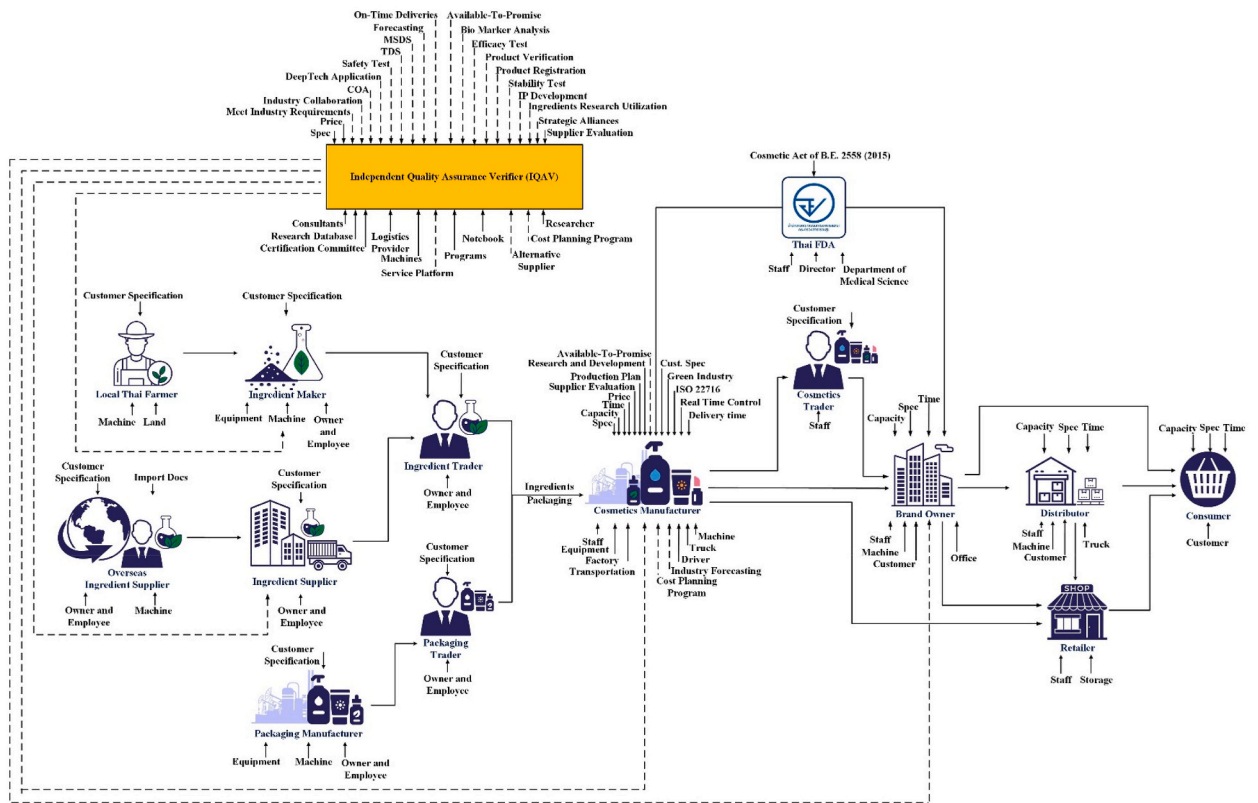


Fig. 3. The proposed business process of the Thai cosmetics supply chain (IDEFO Level 0).

failed to provide manufacturing formulations that aligned with their declaration, and they made claims about active ingredients that were supported by research but did not manufacture them with those ingredients or used ineffective doses. To mitigate this issue, a collaboration between the IQAVs, FDA, universities, and research institutes could be beneficial. Additionally, the paper proposes that IQAVs, as a facilitator in the supply chain, offers business consulting services with deep technology for cosmetics ingredients, utilizing research from universities and institutes to address the issue of undifferentiated ingredients in the market. This will contribute to the growth of local farmers and ingredient makers at the start of the supply chain while increasing the competitive advantage of the Thai cosmetics industry. Finally, the paper highlights Research and Innovation and Collaborative Relationships as key success factors for reshaping the cosmetics supply chain in Thailand. Several strategies were addressed to lessen the pain points of stakeholders in the cosmetics supply chain. One of the recommendations is to offer Industry Forecasting Reports and Presentations to cosmetics manufacturers, as many stakeholders have low forecast accuracy. The paper also suggests implementing a transparent cost-planning program that integrates with the services offered by cosmetics manufacturers, as hidden costs from some suppliers and manufacturers are a common issue among respondents.

(ii) Source

To address the issues of undifferentiated ingredients, undefined organizational assets, supplier inflexibility resulting in added costs, and difficulty in finding alternative suppliers, a match-making service platform for stakeholders is proposed. This platform can eliminate supplier inflexibility and promote more collaborative strategic alliances within the network. It can also enhance digital competitiveness and leverage platform technology, which are identified in the literature review as key success factors for reshaping the cosmetics supply chain. The platform can optimize resource usage by providing an easy way to find ingredients and better match the demand and supply gap between stakeholders. Respondents were inclined to embrace this proposed ingredient platform, as they anticipated that all information and services would be readily accessible and available at the tap of a button in today’s fast-paced world. Additionally, long-term strategy development for IP utilization of assets and utilizing ingredient research from universities and research institutes can be incorporated.

(iii) Make

As reported by the respondents, several prominent factors that contribute to the abbreviated product life cycle of Thai cosmetics encompass the presence of spurious or deceptive innovations, manipulation of information by sales personnel, and the prevalence of

products with limited shelf life. To address these challenges, this study strongly advocates for cosmetics manufacturers to avail themselves of quality control testing services offered by IQAVs, specifically encompassing (1) Safety Tests [35–37], (2) Efficacy Tests [38–40], and (3) Product Stability Testing [41].

First, in ensuring pragmatic safety assurance, an approach akin to the European SCCS (Scientific Committee on Consumer Safety) model could be adopted. The SCCS formulates its opinions by amalgamating presented evidence with provided guidance, thereby transcending rigid adherence to regulatory guidelines tests [35–37]. This stands in contrast to the prevailing practice in Thailand, which predominantly centers on compliance solely with regulatory mandates. Nonetheless, it is imperative to recognize that surpassing these regulations often proves pivotal for the creation of high-caliber cosmetics. The European model underscores the value of a balanced approach, harmonizing regulations with adaptable guidance, and fostering the development of cosmetic products that prioritize safety, efficacy, and innovation. This underscores the significance of not merely conforming to regulations but also embracing proactive measures that elevate product standards and bolster consumer trust.

Second, the IQAVs might consider adapting the NATRUE and COSMOS approach for pragmatic efficacy testing, a certification renowned for its alignment with industry-standard certifications. This accreditation resonates with the essence of nurturing consumer trust and product integrity [42]. Its significance lies not only in guiding consumer choices but also in propelling the industry toward enhanced transparency and accountability—vital elements within an evolving cosmetic landscape. This integrated approach harmonizes with the European emphasis on amalgamating regulations with adaptable guidance, advocating a holistic perspective on cosmetics production that encompasses safety, innovation, and consumer contentment.

Additionally, biomarker analysis should be conducted to evaluate not solely the concentration of active ingredients in products, but also their effectiveness. Respondents stressed that quality control is pivotal to ensure the safety and efficacy of products and their constituent raw materials. Efficiency, affordability, and timeliness were deemed paramount factors in relation to IQAV services, according to respondents. Thus, this study posits that innovation and technology emerge as critical success factors in reshaping the Thai cosmetics supply chain. By integrating cutting-edge technologies and sustained advancements, factual data and outcomes can be disseminated, while the prevalence of spurious innovations can be curtailed, if not eliminated.

Third, this study revealed that product stability pivots on the assessment of packaging materials in direct contact with the product, as they wield the potential to substantially impact the product's overall safety. Integral to the stability testing process is gauging the compatibility between the product and its container. This appraisal serves a dual purpose: not only does it provide insights into the likelihood of substance migration, but it also unveils potential interactions between the product and its packaging. Moreover, this evaluation identifies any conceivable degradation of the product upon exposure to the packaging, a phenomenon influenced by external environmental factors Tests [36]. In light of this, the present study asserts that conducting a comprehensive assessment of packaging and safety for cosmetic products is imperative to ensure stability, quality, and safety over their intended shelf life. Through rigorous evaluation of packaging material compatibility, potential migration risks, and product-container interactions, manufacturers can make informed decisions about appropriate packaging choices and optimal storage conditions. This methodical approach not only safeguards the product's integrity but also augments consumer trust by consistently delivering cosmetics that meet safety and quality benchmarks.

(iv) Deliver

The respondents articulated concerns regarding protracted lead times for receiving laboratory results and encountered communication challenges with service providers within the cosmetics industry. In response to these concerns, this study proposes the implementation of On-Time Deliveries as a pivotal performance indicator for both cosmetics manufacturers and IQAVs [43–45]. Furthermore, the respondents identified financial backing from either the government or the private sector as a seminal driver for propelling the Thai cosmetics industry forward. Subsidies or funding mechanisms are anticipated to invigorate the cosmetics value chain and ameliorate the overall industry, a perspective underscored by the respondents.

The intricacies inherent in operating within a make-to-order production framework are underscored by the phenomenon of delayed deliveries [46]. In endeavors to allure and retain clientele, production enterprises frequently commit to short lead times, coupled with customizable order quantities and delivery schedules. Accentuating the pertinence of timely result delivery, the expeditious receipt of outcomes from IQAVs assumes a heightened significance. This expeditious delivery facilitates expeditious access to crucial findings for cosmetics manufacturers, facilitating agile and well-informed decisions across the gamut of product development and release phases. Such a streamlined process, facilitated through the deployment of On-Time Deliveries, not only expedites time-to-market but also augments cost-effectiveness, as manufacturers circumvent unwarranted delays and their associated expenditures.

(v) Return

A study on product returns management underscored the significance of effectively addressing the complexities inherent in handling returned goods. The realm of product returns presented a pivotal challenge due to the inherent uncertainties surrounding pricing, demand fluctuations, and product quality. In light of these challenges, businesses must prioritize enhancing their information transparency to adeptly navigate the intricacies of end-user product return behavior [47].

According to respondents, cosmetics manufacturers faced communication issues after sales, which could negatively impact customer satisfaction and retention. To address this concern, this paper recommends implementing ATP (Available to Promise) as a key performance indicator. ATP measures a manufacturer's capacity to fulfill orders based on inventory availability and production capabilities. Various studies have collaboratively advanced the development of solutions targeting the effective management of the

multifaceted domain of product returns. This collective body of research endeavored to navigate the complexities inherent in handling returned goods with strategic efficacy [47–51]. While the focus on product returns remains paramount, it's imperative to underscore that ATP extends its significance beyond this specific area. ATP, as a key performance indicator, holds intrinsic value in multiple operational aspects, including inventory management, order fulfillment, and proactive customer communication. By embracing ATP as a holistic tool, businesses stand to enhance their operational agility, optimize resource allocation, and elevate customer satisfaction across a spectrum of endeavors, extending far beyond the confines of product returns. Moreover, using ATP as a KPI can improve transparency and enable cosmetics manufacturers to communicate proactively with their customers, potentially leading to better customer satisfaction and loyalty.

Also, some respondents noted a key issue with received cosmetic products: discrepancies between the delivered items and the agreed-upon product sample in terms of quality and specifications. This situation leads to delivery delays and compromises the overall product quality and consistency. To tackle this concern, this paper proposes that companies engage in IQAV services. These verifiers would investigate the root causes of the issues, confirming any deviations made from the original product sample.

4.4. External supply chain critical factors in the cosmetics supply chain

In the preceding section, an in-depth exposition was provided on internal supply chain factors, encompassing activities and their associated challenges. These findings lend themselves to mitigation through the application of pertinent strategies. However, it is imperative to acknowledge the presence of external supply chain critical factors, which reside beyond the purview of direct stakeholder control. In this context, the optimal approach lies in cultivating awareness and devising comprehensive plans within the ambit of risk management strategies to effectively address these external factors. In this section, the critical factors for the cosmetics supply chain are summarized based on existing research and publications as shown in Table 5. These factors include both opportunities and risks that can have a direct or indirect impact on the chain. Stakeholders can leverage these opportunities and also take measures to manage and mitigate the risks. These factors are identified using Francis Aguilar's PESTEL Analysis, a widely used tool in strategic decision-making by professionals and companies.

Moreover, the pervasive impact of institutional theory on organizational strategies is fundamentally rooted in the exertion of "external pressures." This phenomenon culminates in a gradual convergence of organizational practices over temporal horizons, yielding a harmonized operational milieu that inherently fosters the vigilant observation of the surrounding environment for potential collaborative avenues. This paradigmatic stance seamlessly aligns with the espousal and integration of preminent practices within the organizational framework.

4.4.1. Political

The Thai government has been actively providing support to the cosmetics industry in alignment with its overarching national economic strategy known as "Thailand 4.0." This strategy is centered around the transformation of the Thai economy, placing a

Table 5
Critical success factors using PESTEL analysis.

Factors	Sub-factors	Description
Political	National Economic Strategy	Thailand 4.0 Policy
	Political Instability	Street protests due to politics and social issues
	Self-serving interests in related industry associations	Cosmetics Associations with different interests
Economics	The industry leader in ASEAN	Thailand as a manufacturing hub in ASEAN
	Major Cosmetic Market in ASEAN	Biggest cosmetic market in Southeast Asia
	Upper-Middle-Income Classification	Those with a GNI per capita between \$4046 and \$12,535 (2021)
	Inflation Rate	Rate of increase in prices over a given period
Society	Free Market Economy	The economy is free and driven by the price mechanism.
	Demographics Challenges	Thai aging society
	Wellness Awareness	Growing acceptance of wellness and prevention care
	A Rise in Disposable Income	income remaining after the deduction of taxes and other mandatory charges
Technology	Pandemic Effects	An epidemic over a wide area, crossing borders
	Research and Innovation	Cosmetics ingredients being advanced by further research interest
	Digital Competitiveness	Fast-developing Thai Digital Infrastructure
	Technology and Innovation Risk	Inaccuracies in incapacity definition.
	Information and communication technology (ICT)	The use of systems, such as computers and telecommunications, to store, retrieve, and transmit information.
Environment	Platform Technology	An affiliate system can serve as a digital platform for buying and selling cosmetics ingredients.
	Bountiful Resources	Thailand's abundance in the supply of natural resources suitable for cosmetics ingredients
	Droughts Impacting the Supply of Ingredients	Increase in temperature due to climate change
Legal	Ecological Threats	Processes and events that may cause harmful ecological or physiological impacts on an ecosystem
	Specific Industry Regulations	The Cosmetic Product Act, B.E. 2558 (2015)
	Human Resource Issues	Lack of manpower in government agencies with jurisdiction responding to reported cosmetics violations
	Government Support	Government income tax reduction incentives for R&D

significant emphasis on value-driven industries that are bolstered by innovation, technology, and creativity. This strategic approach has illuminated substantial growth potential for the cosmetics sector in Thailand [52]. Despite the government's robust backing, the cosmetics industry in the country has encountered formidable challenges stemming from political instability and economic turbulence. The disruptions caused by the Thai protests of 2020–2021 had adverse effects on business operations, while the COVID-19 pandemic further exacerbated the nation's economic downturn and elevated unemployment rates. Additionally, the sector has been exposed to risks arising from political unrest and the self-serving motives of cosmetic associations.

Within the framework of Thailand's cosmetics landscape, two prominent entities are intricately linked with the cosmetics sector: the Thailand Cosmetic Cluster and the Thailand Cosmetic Manufacturer Association. These entities have emerged in parallel with the expansion of the cosmetics market in Thailand, underscoring the increasing significance of the industry. However, given their relatively recent establishment, it is plausible that they might not yet have achieved widespread recognition and influence. This dynamic implies substantial potential for enhancement and growth within these associations, as they strive to fortify the sector's coherence, standards, and impact. Nonetheless, positive indications of progress are discernible. The fervor of major street protests has waned in 2022, suggesting the possibility of a more stable political climate. Moreover, the government's ambitious aspiration to position Thailand as the preeminent beauty hub within the ASEAN region holds promise for the burgeoning growth of the cosmetics industry. It is noteworthy, however, that while these opportunities beckon, certain cosmetics manufacturers could still grapple with the challenge of striking a harmonious equilibrium between pursuing profitability and adhering to the comprehensive product life cycle, particularly in response to the evolving demands of consumers.

4.4.2. Economics

During the 1980s, Thailand was one of the "Tiger Cub Economies" together with Indonesia, Malaysia, the Philippines, and Vietnam, and its economy experienced rapid growth. Currently, the country is in a steady growth phase of economic development, according to the World Bank. In less than a generation, Thailand has transformed from a low-income to an upper-middle-income country, with a GDP per capita of 6379 USD and high purchasing power, creating potential market opportunities for the cosmetics industry. Thailand has a free-market economy with a strong domestic market and a growing middle class, and the private sector is the main driver of growth. However, the recent inflation rise of 7.66 % as of June 2022, a 14-year high, posed a significant threat to the cosmetics supply chain by triggering rising costs that made it difficult for stakeholders in the supply chain to maintain their profit margins over time [53].

4.4.3. Social

Thailand is one of the countries in the world that is aging rapidly. Projections indicated that the proportion of people aged 60 and above would increase from 13 % in 2010 to 33 % in 2040 [54]. The Thai government has developed the 2nd National Plan for the Elderly (2002–2021) to tackle the challenges posed by population aging. The plan's key strategies included addressing demographic changes, providing social support and protection for older adults, and promoting their financial independence. Additionally, wellness awareness is increasing in Thailand, and the country is becoming a prominent player in health and medical tourism worldwide. With the projected 25 % annual growth in global medical tourism, patients who are willing to travel have access to a wide range of hospitals and healthcare facilities located in various regions [55]. Thailand is experiencing an increase in disposable income among its population, which is a positive social factor. McKinsey Global Institute (MGI) research showed that the country's consumption could increase substantially over the next decade, from US\$120 billion annually to US\$410 billion [56]. By 2030, up to 90 % of the population in Thailand could be classified as members of the "consumption class." This group is defined as those who earn more than \$11 per day in purchasing power parity and can afford not only necessities like food and shelter but also discretionary spending. This represented a significant increase from the 35 % recorded in 2000 and the current 70 %. The proportion of the population in the two highest consumption tiers, those who spend more than \$30 per day, is expected to quadruple from 20 % today to 40 % in 2030.

4.4.4. Technology

Thailand has made significant progress in transitioning to a digital economy and developing its digital infrastructure in the past decade. This has resulted in improvements in various measures of digital infrastructure and accessibility for a significant portion of the population. The country's e-commerce market is one of Southeast Asia's fastest-growing, with the gross value of online goods increasing by 68 % in 2021 and projected to grow by 14 % from 2021 to 2025. Moreover, biotechnology companies are leveraging Thailand's resources to advance cosmetic ingredients through further research interests. The rise of technology-based startups, or tech startups, is also rapidly changing Thailand's business landscape, as these innovative businesses develop and offer new products and services using cutting-edge technology. Similar to the findings in Brazil, a discernible risk landscape emerged on technology and innovation, encompassing challenges characterized by the potential for inaccuracies in defining incapacitation, the specter of technological obsolescence, and the susceptibility to damages and failures arising from design deficiencies or project scaling inadequacies [8].

4.4.5. Environment

Thailand's strategic location at the crossroads of Southeast Asia's continental region positions it to potentially become a regional powerhouse. Its heartland, which consists of vast lowlands in the Chao Phraya River Basin, has enabled Thai rulers to establish a cohesive ethnic and economic foundation. The country's geography is diverse, with the Chao Phraya and Mekong rivers being the most important waterways in rural areas. These rivers and their tributaries are used for large-scale crop production. Additionally, Thailand has abundant local herbs that can be used to create over 200,000 cosmetics ingredients [3]. As found in the previous study in Brazil, a

nexus of environmental perils came to the fore, encompassing concerns aligned with ecological degradation and pollution, the proliferation of prodigious product waste and packaging, the vulnerability to natural cataclysms, the incidence of heatwaves and droughts, and the pressing specter of water scarcity [8].

4.4.6. Legal

The Cosmetic Act B.E. 2535 (1992) served as Thailand's primary cosmetic regulation for more than two decades until it was revised to align with the ASEAN Cosmetic Directive (ACD) in 2008. However, the Cosmetic Act B.E. 2535 (1992) was not fully compliant with the ACD. As a result, the Thai government implemented an amended act called the Cosmetic Act B.E. 2558 (2015) on 9 September 2015 to ensure full compliance with the ACD. To encourage and support private sector research and development, the Thai government allows companies to reduce their taxes based on three times the cost of their R&D expenditures. The amount of tax reduction permitted for each company depends on its income [57]. Additionally, Thailand is emerging as a prominent player in the cosmetics industry within the region, leading to a growing demand for its products as a viable alternative to those produced in other Asian countries.

5. Conclusions

The present study has achieved two principal objectives. Initially, it provided a pioneering examination of the cosmetic supply chain in Thailand, employing the IDEFO framework and comprehensive interviews with 36 respondents. While the extant supply chains encompass fundamental components and basic operational capacities, the cosmetic supply chains still grapple with issues of efficiency and effectiveness, akin to cosmetic supply chains documented in other developing nations like Indonesia [12], China [13], Brazil [8], Malaysia [14], Iran [15], and Finland [16]. Predominantly problematic aspects, as discerned through the IDEFO analysis, reside in the sourcing and production phases, consistent with analogous research in developing countries such as Indonesia, China, and Brazil. It is noteworthy, however, that the delivery facet in Thailand exhibits relatively fewer challenges due to robust infrastructure and competitive shipping services.

Secondarily, employing the lens of stakeholder theory, a gap analysis has recommended the incorporation of the IQAV's role to bolster the efficiency and efficacy of Thailand's extant supply chain. By addressing concerns tied to misleading innovations in cosmetics manufacturing and bolstering ingredient reliability, the IQAVs present considerable potential for reshaping the industry landscape (SCCS, NATRUE & COSMOS) [35–37,42].

The study's findings hold implications for managerial benefits. Insights derived from the IDEFO analysis not only illuminate the present state of the supply chain but also unveil latent prospects for improvement, geared towards fostering collaborative synergies among supply chain stakeholders and curtailing the product life cycle of domestically produced cosmetics. Furthermore, a more comprehensive comprehension, encompassing the identification of latent IQAV functions within the existing context, uncovers a multitude of untapped potentials poised to propel industry advancement. For instance, micro-level managerial implications stem from visualizing "critical weaknesses" within the disclosed supply chain flow, particularly concerning sourcing and production. Thailand could adopt pertinent managerial techniques to mitigate these vulnerabilities as utilized in other countries [8,12–16]. On a macro level, the proposed role of IQAVs, endorsed by Thai policymakers, aligns with the Thailand 4.0 economic enhancement plan. Legislators could adopt European models (such as SCCS, NATRUE & COSMOS [35–37,42]) to facilitate the integration of customized IQAVs into Thailand's economic milieu.

The findings also furnish a robust qualitative foundation for future research within the same domain and related realms. In the same domain, the qualitative insights will aid in the formulation of pragmatic research inquiries, ripe for further exploration using quantitative approaches such as designing questions for longitudinal industry surveys. These annual surveys can serve as a guiding compass to ensure the industry's growth occurs at an appropriate pace. In terms of related areas, the cosmetic industry can be further subdivided into discrete segments such as natural ingredients and food supplements, among others. The proposed methodology holds promise for adaptation to each segment, enabling insights to be gleaned through multifaceted segment analyses.

Data availability statement

The article incorporates synthesized data, which is both included and referenced within the article. However, the remaining data remains unavailable due to confidentiality constraints.

CRediT authorship contribution statement

Wuttipong Panitsettakorn: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft. **Pornthipa Ongkunaruk:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Supervision, Writing – review & editing. **Thaweephan Leingpibul:** Conceptualization, Investigation, Methodology, Supervision, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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