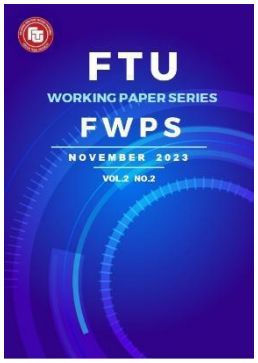

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LÃNG PHÍ THỰC PHẨM Ở CÁC DOANH NGHIỆP CHUỖI CUNG ỨNG VIỆT NAM: ĐÁNH GIÁ HIỆU QUẢ MÔ HÌNH QUẢN TRỊ TINH GỌN

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Tóm tắt

Lãng phí thực phẩm (FLW) đã trở thành một vấn đề ngày càng được quan tâm do những hậu quả xã hội, kinh tế và môi trường của nó. Tại Việt Nam, có vẻ như hầu hết các nhà cung cấp dịch vụ chuỗi cung ứng (SCaaS) không biết đến vấn đề này. Chính điều này thúc đẩy nhóm tiến hành nghiên cứu về chủ đề này. Với dữ liệu sơ cấp được thu thập từ 102 công ty SCaaS tại Việt Nam thông qua bảng câu hỏi, nhóm đã sử dụng phương pháp nghiên cứu định lượng để đánh giá hiệu quả của việc áp dụng mô hình quản lý chuỗi cung ứng tinh gọn (LSCM) đến hiệu quả giảm lãng phí thực phẩm. Kết quả cho thấy mối tương quan tích cực đáng kể giữa các thành phần khác nhau của mô hình và hiệu suất giảm lãng phí. Từ đó, các tác giả nhấn mạnh việc ứng dụng rộng rãi các mô hình tinh gọn trong chuỗi cung ứng thực phẩm, đặc biệt là trong khâu phân phối và đề xuất sự cần thiết của hệ thống chia sẻ thông tin giữa các tác nhân trong chuỗi cung ứng thực phẩm. Bài nghiên cứu này có ba mục tiêu chính. Đầu tiên, đề xuất áp dụng các biện pháp quản lý chuỗi cung ứng tinh gọn trên toàn quốc thông

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qua đo lường mức độ giảm lãng phí dựa trên việc triển khai các biện pháp đó tại các doanh nghiệp dịch vụ chuỗi cung ứng của Việt Nam. Thứ hai, thúc đẩy nghiên cứu chuyên sâu về tác động của việc áp dụng chiến lược chuỗi cung ứng tinh gọn đến hiệu quả giảm lãng phí thực phẩm. Thứ ba, kêu gọi hành động từ nhiều tổ chức khác nhau, bao gồm cả các cơ quan chức năng nhằm giảm bớt tình trạng lãng phí nghiêm trọng ở Việt Nam.

Từ khóa: lãng phí thực phẩm, chuỗi cung ứng thực phẩm, nhà cung cấp dịch vụ chuỗi cung ứng, quản lý chuỗi cung ứng tinh gọn.

FOOD LOSS AND WASTE AMONG VIETNAM FOOD SUPPLY CHAIN SERVICE PROVIDERS: AN APPROACH FROM LEAN MANAGEMENT MODEL

Abstract

Food loss and waste (FLW) has become an increasingly-concerning issue owing to its social, economic and environmental consequences. In Vietnam, it is likely that most Supply Chain as a Service (SCaaS) providers are unaware of this problem, which motivates the team to conduct research on this FLW topic. With the primary data collected from 102 Vietnam SCaaS companies through questionnaires, the team has used quantitative research methods to assess the efficiency of applying Lean Supply Chain Management (LSCM) on Food Loss and Waste Reduction Performance. The result showed a significantly positive correlation between different components of LSCM and the performance of FLW reduction. From that, the authors highlighted a widespread application of lean models in the food supply chain, especially in the phase of distribution and suggested a need for an information sharing system among food supply chain actors. The contribution of this paper is twofold. First, it proposes adopting LSCM practices nationwide by measuring FLW reduction based on the implementation of such practices in Vietnamese SCaaS enterprises. Second, it motivates in-depth research into the impact of applying lean supply chain strategies on FLW management performance. Third, it calls for actions from various organizations including the authorities to alleviate the serious FLW in Vietnam.

Keywords: food loss and waste, food supply chain, Supply Chain as a Service providers, lean supply chain management

I. Introduction:

Food loss and waste (FLW) topic has become a high-profile issue, which has attracted many governments, non-governmental organizations (NGOs) and other actors that are included in the FSC regarding environmental impacts associated with the inefficient use of natural resources (water, land), social impacts and economic impacts (Luo et al., 2021). The Food and Agriculture Organization of the United Nations - FAO (2019) estimates that approximately 14 percent of the world's food, valued at $400 billion, is lost every year between harvest and the retail market. Similarly, an estimated 17 percent of food is wasted at the retail and consumer levels (UNEP, 2021). Meanwhile, 690 million people in the world are still suffering from starvation, about 2 billion facing food shortage and malnutrition, and 144 million children under 5 years old are malnourished (FAO, 2020). Half of them live in Asia and more than one-third in Africa (FAO, 2022).

Vietnam is listed as one of the countries having the most serious food waste problem. It is estimated that roughly 8 million tonnes of edible food is lost or wasted every year, which amounts to

3.9 billion dollars in economic loss (CEL Consulting, 2018). As far as the FSC is concerned, food waste occurs at all stages of Vietnam's FSC, from the pre-harvest to human consumption stage (Hoài, 2022). As for the outbreak of the Covid-19 pandemic, FLW has become worse since disruption in traffic and commuting leads to congestion in the labor workforce at the site of raw materials supplies, transportation services and logistics. Consequently, Covid-19 pandemic has obviously exacerbated food insecurity and inequality in Vietnam (Hoài, 2022).

According to Hoài (2022), the loss and waste in the perishables group accounted for a relatively high proportion. In addition, currently, few studies on the impact of supply chain management on alleviating loss and waste of spoiled food are implemented in Vietnam. Considering the significance of perishables supply chain management not only for national food security, but also assists in controlling passivity to confront with force majeure situations such as Covid-19 pandemic, the team chose the topic "Food Loss and Waste among Vietnam Supply Chain Service Providers: An Efficiency Assessment of Lean Management Model".

II. Literature review:

1. Lean Supply Chain Management:

Lean is described as a management philosophy that strives to find and remove waste from an organization's value chain (Shah and Ward, 2007). LSCM can be characterized as a collection of businesses connected by upstream and downstream flows of goods, services, information, and money that cooperate to cut down on costs and waste by effectively sourcing what is required to satisfy specific client needs (Vitasek et al., 2005).

Agus and Hajinoor (2012) have identified costs, flexibility, quality and delivery as the most popular problems in the supply chain, which could result in a huge loss of resources and revenues. In terms of FSC, it is understandable that non-manufacturing actors including food procurement, warehousing and distribution are closely interlinked. Applying the lean models in such stages can boost the overall FLW reduction performance, which highlights improved delivery performance to either retailers or customers (Abushaikha et al., 2018) and an exchange of high-quality information (Nimeh at al., 2018).

2. Food Loss and Waste Reduction:

Food loss and waste reduction (FLWR) is the term for preventing or reducing food loss and waste at all stages of the food supply chain, from production to consumption. The measurement of FLW reduction associated with supply chain practices is clearly illustrated in previous studies. By implementing material flow analysis, Chroneer and Wallström (2016) estimated the total rate of avoidable food losses, and recommended an appropriate model that can be used to reduce FLW in Japan. The incorporation of technology and storage structures has enhanced FLW reduction by estimating storage losses, quality after storage, and maintained seed viability (Kumar and Kalita, 2017).

According to Wesana et al. (2019), a nutrient-rich food supply chain in Uganda has facilitated the application of VMS approach to identify food and nutrient losses caused by overproduction,

inappropriate processing and defects in the milk group. Moreover, FLW mitigation after incorporating information systems, supply chain strategy, and network design is evaluated based on four criteria: minimum loss, high quality of food, damage-free guarantee, and the role of food preserving system in eliminating FLW (Tan et al., 2022).

3. Lean Supply Chain Management and FLW Reduction:

Since LSCM and FLW reduction are positively correlated, many companies are strategizing with an aim to gain a competitive edge, making them stand out with corporate social responsibility in the increasingly unpredictable global market. Obviously, most existing literature suggests a positive association between LSCM and FLW reduction. Galanakis (2019) suggested several lean manufacturing practices for minimizing FLW, which implicitly imply an invisible link between such two elements. Moreover, Rossini et al. (2023) used Toyota as an example for using lean production for achieving sustainability and reducing waste. However, there is very little empirical evidence to prove this theory, especially in the case of Vietnam. For example, Vy (2017) used 5S and Kaizen tools to build a lean management model for trees-manufacturing enterprises in Kon Tum but failed to show the correlation between the model and its effect on FLW level statistically. Such lack of knowledge foundations has called for an empirical investigation into the aforementioned relationship.

4. Components of Lean Supply Chain Management:

1) Lean Procurement:

Lean procurement principles can be referred to as small lots that are often bought regularly from a limited number of suppliers who deliver the goods in precise amounts at a predetermined time and location and who also push their own suppliers to do the same (Wilson et al., 2009). The connection between the buyer and the supplier is built on a long-term perspective that includes trust and commitment (Wilson et al., 2009). If necessary, the buyer will provide financial and technological support to help the supplier handle some of its operational issues (Wilson et al., 2009). This demonstrates why lean procurement emphasizes the importance of smooth flow of high-quality information among customers, suppliers and other actors thanks to modern technology (Greg et al., 2006).

Three key principles are also included to ensure the effectiveness of the cycle (Despres et al., 2006). Firstly, transformation from “push” to “pull” supply chain mentions some kinds of alerts to foster better coordination and communication among buyers, providers and partners. Secondly, developing a flexible and quickly responsive supply chain can boost the adaptability level of a SCaaS business when there are substantial fluctuations in the global demand, hence shorter lead-times and more proactive solutions. Thirdly, waste elimination can enhance the workflow as not only are “no touch” processes implemented but separate orders for goods are also completely eliminated. Adopting such tactics, procurement professionals can save up their time for other strategic management tasks.

H_1*: The application of lean procurement practices has a positive impact on FLW reduction.*

2) Lean Warehousing:

Lean warehousing is defined as the collection of factors to enhance warehouse aspects with a total participation of employees (Anđelković et al., 2016). By practicing lean warehousing, supply chain providers are responsible for the delivery of products from farm to fork and assurance of quality during the transportation process (Dharmapriya et al., 2011). Besides, lean warehousing is responsible for assembling the orders efficiently and reducing inventories (Tziatzios, 2021). Lean warehousing includes eliminating non-value adding activities at all operation functions: receiving, put-away, picking, and despatch/shipping (Myerson, 2012).

Lean warehousing has been effectively used by many supply chain service companies. One-piece flow, pull systems, standardized work, and other appropriate lean warehousing techniques were implemented by Toyota, which contributed to the mitigation of waste (Rossini et al., 2023). Hence, it is extremely suitable to set WHS as an independent variable to consider the relationship with FLW reduction.

H_2*: The application level of lean warehousing measures has a positive effect on FLW reduction.*

3) Lean Production:

There has been difficulties to formulate a clear definition of the term that integrates all its elements. One of the most used definitions is that lean production includes just-in-time practices, defects control, improvement strategies, resource reduction, standardization and scientific management techniques (Pettersen et al., 2009). The purpose of implementation of lean management models in the production stage is for minimizing wastes originating from unnecessary processing steps, waiting time, excess inventory and overproduction (Mrugalska and Wyrwicka, 2017).

Lean production implementation is advantageous for businesses regarding the quality of employees' work and systems inside the organizations (Pettersen et al., 2009). FLW status has been improved through innovations applied in various stages of the FSC (Aramyan et al., 2021). Considering the correlation between lean production is applied in SCaaS providers, it is advisable to choose PDT as one of the independent variables for the study.

H_3*: There has been a positive correlation between the implementation of lean production strategies and FLW reduction.*

4) Lean Distribution:

Rather than concentrate on the systems-driven approach to interpret lean in the distribution stage, Reinchhart and Holweg (2007) defined the term as eliminating waste in the downstream supply chain, while making the right product at the right time and location to final consumption. This definition can apply to all types of supply chain (Reinchhart and Holweg, 2007), especially in the food supply chain, although the diversity of products and market factors facilitated different implementation patterns of lean distribution.

One of lean distribution practices, the "pull" method, decreases lead times and the lot size multiplier, does away with "hedging", and simplifies the replenishment process, it is worth

implementing to make a difference (Zylstra, 2005). Lean approaches are likely to change distribution in terms of lead times, decreased overall inventory and logistics costs, and reevaluation of direct shipping from plant when looking at the distribution process as a whole (Zylstra, 2005). So the team decides to choose DTB as an independent variable of the model.

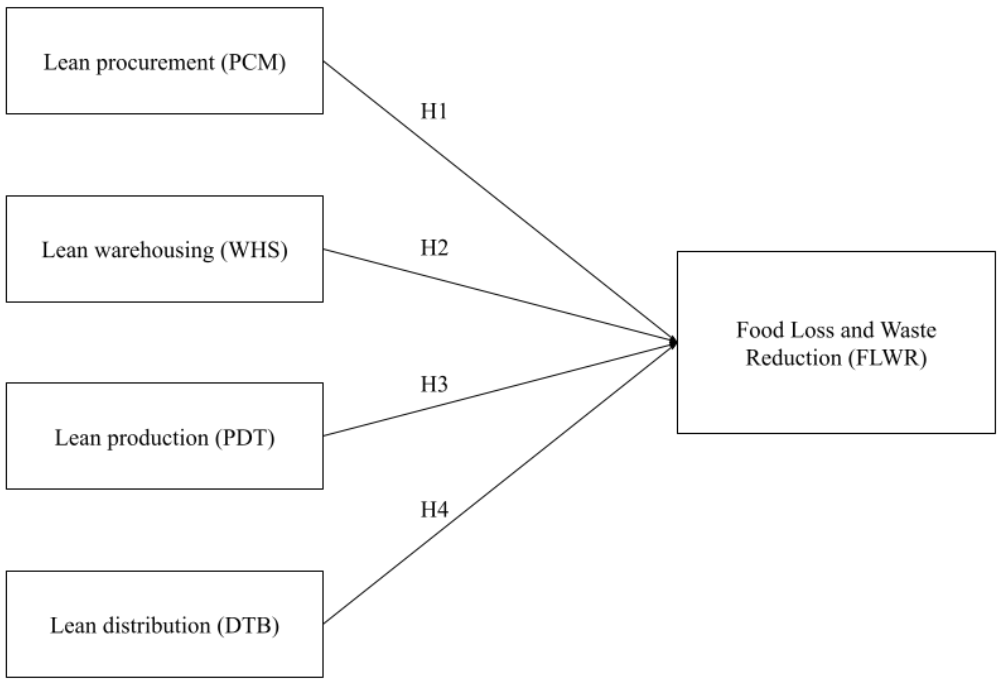
H_4*: The level of applying lean practices in distribution improved FLW reduction.*

III. Research Methodology:

1. Research Modeling:

Based on the literature of independent variables, the authors propose the following research model:

Figure 1: Research Model



Source: *Synthesized by the authors*

Lean Procurement Scale: The authors decide to retain or eliminate any observed variables in order for the suitability of the scale applied to Vietnamese SCaaS providers. For example, "real-time visibility" for materials storage has already caught Vietnamese FSC companies' attention that assists enterprises in controlling the right amount of inventory, automatically updates inventory data and ensures accurate inventory information (Smartlog, 2020 and VILAS, 2021). A typical observed variable supporting the tendency of adopting real-time visibility below is "The company has created real time visibility into inventory in motion". In addition, in lean procurement, mechanisms and

innovations to facilitate free flow of information are in the growth stage and have the potential to flourish and evolutionize the LSC process (VILAS, 2021).

Lean Warehousing Scale: This scale includes 5 observed variables, coded from WHS1 to WHS5, showing the relationship between the application of lean warehousing strategies and FLW status. Compared to the conventional process, adopting innovations in operating the storage process, especially smart warehouses proves to be more productive by providing enough resources with reduced time (CNC-VINA, 2019). By applying lean management strategies in warehousing operation, the FLW problem will be substantially improved. That is why the authors develop and suitably the scale for lean warehousing to the situation of Vietnam.

Lean Production Scale: The authors use two scales comprising 4 observed variables encoded from PDT1 to PDT4 to show the correlation between lean production models are implemented in production and its effects on FLW reduction. Innovations assist humans in managing and controlling the production stage to ensure the quality requirements of products, ensure the information flow to consumers and reduce FLW (TCI, 2022). A typical observed variable supporting this development is "The process of production is always closely monitored online and updated with customers to ensure flow of goods".

Lean Distribution Scale: The scale includes: 6 observed variables coded from DTB1 to DTB6 representing how FLW status is influenced after applying lean practices. A typical observed variable of the challenging stress scale is "Customers are always notified and updated with the distribution process of their goods". Nowadays, the advance of applications assists managers, operators and customers in managing and processing orders, making the distribution process more convenient, and helping manufacturers deliver goods at the right time and location to the right customers (Sthink, 2021). In particular, Just-in-time technology reduces time for distribution and ensures products meeting quality standards (VILAS, 2022.. The decision to choose 6 observed variables in the lean distribution scale is relevant to the operation of LSC in Vietnam.

FLW Reduction Scale: The scale from Tan et al. (2022) that includes 4 observed variables, coded from FLWR1 to FLWR4, showing how FLW reduction is achieved after the implementation of lean management models. Firstly, we look at the amount of FLW and determine how much it is costing the business through the variable "Our firm experiences minimum food loss and waste in the food supply chain". As some of the main components of lean management model, lean distribution and production should ensure the quality of food that meet the safety requirements in order to lessen FLW status in both companies and consumers. Secondly, the two observed variables "The quality of food remains at the highest level in our food supply chain" and "Our food supply chain system ensures damage-free food from food acquisition to deliver" clearly express the significance of applying lean management in maintaining quality and reducing waste. Besides, the effectiveness of such innovations is also evaluated based on their protections from FLW in the FSC.

Table 1: Scale description

Stage	Encoding	Observable variables	Reference
Lean Procurement	PCM1	The company has created real time visibility into inventory in motion	Thuranira, M. (2016)

	PCM2	The company has eliminated lead times for critical materials	Abushaikha et al. (2018) Smartlog (2021)
	PCM3	The company has integrated suppliers in the entire supply chain to improve customer service	V. (2021) T. & T. (2022) Payoneer (2020)
	PCM4	The company has mechanisms in place to ensure free flow of information to a supply chain	Tai (2022) V. (2021)
Lean Warehousing	WHS1	The management of the company supports lean warehousing by providing enough resources	Thuranira, M. (2016) Abushaikha et al. (2018) CNC-VINA (2019) Onnet (2022) TopERP (2022)
	WHS2	The process of storage is always monitored and controlled online	
	WHS3	Any errors during the warehousing storage are spotted and handled immediately with regular maintenance	
	WHS4	The process of storage is always adjusted and updated with suppliers and customers to ensure the flow of information	
	WHS5	The mechanisms in place have reduced waste and operational cost	
Lean Production	PDT1	There is an increase in product flow through elimination of all non-value added activities in the company	Thuranira, M. (2016) Abushaikha et al. (2018) CRIF D&B A. (2022) V. (2022)
	PDT2	The company has flexible production techniques using minimal inventories of raw materials	
	PDT3	The process of production is always closely monitored online and updated with customers to ensure flow of goods	

	PDT4	There is an integration of vision, culture and strategy to serve the customers with high-quality, low-cost and short-delivery times in the company	
Lean Distribution	DTB1	The company has a sound distribution system to ensure smooth flow of goods and services to the customers	Thuranira, M. (2016) Abushaikha (2018) Sthink (2021) V. (2022)
	DTB2	Chances of delivering to the wrong customers are extremely low	
	DTB3	Chances of spoiling goods while transportation are extremely low	
	DTB4	Chances of delivering goods late are extremely low	
	DTB5	There is a relation between transportation and JIT system in the company	
	DTB6	Customers are always notified and updated with the distribution process of their goods	
FLW Reduction	FLWR1	Our company experiences minimum food loss in the food supply chain	Tan et al. (2022)
	FLWR2	The quality of food remains at the highest level in our food supply chain	
	FLWR3	Our food supply chain system ensures damage-free food from food acquisition to deliver	
	FLWR4	Our lean management model helps us in protecting the food loss in the supply chain	

Source: *Synthesized by authors*

2. Data Collection:

The experimental research is conducted on the basis of survey inquiries with Vietnamese SCaaS providers to provide a primary database for evaluating FLW reduction associated with lean practices

are implemented in Vietnam SCaaS companies. Questions are designed in the form of closed, open or multiple choices with selected answers or Likert scale assessments. The contents of the questions are aimed at: (1) determining the impact of application of lean management practices associated with different stages of the FSC; (2) assessing the efficiency of applying LSCM into FLW reduction strategies. The team adapted questionnaire items from previous studies, mainly from two research: Thuranira (2016) and Tan et al. (2022) and tailored them to align with the context of Vietnamese SCaaS providers.

The survey was conducted over a three-week period from 13th February to 6th March 2023. The team expected to collect more than 150 responses and used non-probability sampling to investigate the importance of lean model in FLW reduction in the FSC. The delivery of surveys to Vietnamese LSPs is conducted either by sending an email with an online survey made with Google Forms directly to the enterprises or contacting employers of LSPs through LinkedIn. The target audience was not concentrated in urban areas but in all provinces that have food SCaaS providers implementing lean management models. These enterprises mainly provide services: food procurement, food warehousing, food production, and food distribution. A wide range of companies provide other logistics services including international express delivery, commerce, medical law consulting, etc.

3. Data Analysis:

The raw data was gathered and structured systematically to allow for empirical analysis. To describe the responses, descriptive statistics, namely frequencies, percentages, and means, were employed. After using Cronbach's Alpha and EFA to To model the link between the dependent variable and the independent factors, linear regression was also used.

The following regression equation evaluates the influence of the application level of lean practices associated with different stages on FLW reduction (Thuranira, 2016):

$$\mathbf{FLWR} = \beta_0 + \beta_1 \mathbf{PCM} + \beta_2 \mathbf{WHS} + \beta_3 \mathbf{PDT} + \beta_4 \mathbf{DTB} + \varepsilon$$

Where:

PCM = Lean Procurement

WHS = Lean Warehousing

PDT = Lean Production

DTB = Lean Distribution

FLWR = Food Loss and Waste Reduction

β_0 = Constant factor

β_1 = Coefficient of Lean Procurement

β_2 = Coefficient of Lean Warehousing

β_3 = Coefficient of Lean Production

β_4 = Coefficient of Lean Distribution

ε = Error term

III. Results and Discussion:

1. Sample description:

After the data collection process, 116 respondents successfully filled in the survey form although we targeted 150 participants. This represents a response rate of 77.3%, which was good because a response of 70% or more is ideal for analysis (Mugenda, 2003).

To ensure data quality, the authors decided to eliminate some responses that were considered improper because they did not meet our requirements, some have either identical answers or perfunctory acts. The authors also eliminated responses that contained too many neutral choices, which means a lack of clearness in the respondents' viewpoint. After the elimination process, we finally collected a total of 102 valid responses.

2. Cronbach's Alpha testing:

Based on previous studies, each observable variable in the same scale, which indicated different practices in the same stage, tends not to have much correlation, which acts a constraint for measuring reliability level within such variables with Cronbach's Alpha. Since there is consistency in the observable variables of FLW reduction, the reliability test will be conducted on the variable representing FLW reduction through Cronbach's Alpha value. Variables having item-rest correlation lower than 0.3 will be eliminated and the scale will be accepted to be used in the next analyzing steps when Cronbach's Alpha value is 0.6 or higher.

Table 12: Cronbach's Alpha Results

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
FLWR1	10.5196	4.569	0.472	0.804
FLWR2	10.1471	4.483	0.503	0.797
FLWR3	10.4314	4.565	0.424	0.820
FLWR4	10.6373	4.194	0.529	0.791
PCM1	10.80	6.812	0.548	0.647
PCM2	10.70	6.861	0.510	0.669
PCM3	10.73	6.914	0.498	0.677
PCM4	10.63	6.805	0.509	0.670
WHS1	13.61	12.227	0.619	0.753

WHS2	13.66	11.922	0.503	0.790
WHS3	13.66	12.054	0.609	0.755
WHS4	13.64	11.491	0.629	0.747
WHS5	13.41	11.781	0.570	0.766
PDT1	10.77	7.490	0.641	0.696
PDT2	10.64	7.160	0.580	0.723
PDT3	10.76	7.166	0.571	0.728
PDT4	10.86	7.550	0.537	0.745
DTB1	17.30	19.230	0.645	0.774
DTB2	17.25	18.573	0.620	0.778
DTB3	17.30	19.683	0.507	0.802
DTB4	17.31	19.473	0.512	0.801
DTB5	17.28	18.906	0.580	0.787
DTB6	17.11	18.325	0.618	0.778

Source: *Authors calculated in SPSS20*

Cronbach's Alpha of the dependent variable's scale is good (higher than 0.8), which indicates a strong internal correlation among observable variables. Thus, 4 observable variables of FLW Reduction are reliable enough to be used for the next analyzing stages. Meanwhile, 4 independent variables got the values of Cronbach's Alpha greater than 0.6, proving the reliability of each scale.

3. Relationship between FLW Reduction and LSCM Components:

A multiple regression model was applied to determine the correlation between the adoption of lean management practices in different types of the FSC: procurement, warehousing, production, distribution and FLW management performance after the adoption.

Table 2: Regression Function Results

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig
	Beta	Std.Error	Beta		
Constant	-0.576	0.371		-1.552	0.124
PCM	0.235	0.117	0.120	2.013	0.047
WHS	0.240	0.102	0.181	2.362	0.020

PDT	0.255	0.081	0.223	3.141	0.002
DTB	0.474	0.073	0.504	6.456	0.000

Source: Authors calculated in SPSS20

FLWR = - 0.576 + 0.235PCM + 0.240WHS + 0.255PDT + 0.474DTB

The economic significance of the regression function is as follows:

β_1 = 0.235, meaning that when SCaaS providers adopt lean practices in the procurement process, FLW status is positively affected by 0.235. Then we fail to reject H_1 at the 5% significance level. It was confirmed that there was a positive relationship between lean procurement was implemented in Vietnam SCaaS providers and the estimated amount of FLW. The results suggest that FSC companies should incorporate lean practices to efficiently monitor ingredients and inventory treatment process, as well as ensure a smooth information and procurement flow from the beginning of the FSC.

β_2 = 0.240, indicating that for lean warehousing adopted, there is a positive impact result with 0.240. Then we fail to reject H_2 at the 5% significance level. Lean management model applied in the warehousing stage has contributed to the minimization of loss and waste. It is likely that the status of FLW in companies will improve once they are adhere to detailed regulations and handle unexpected situations related to FLW well.

β_3 = 0.255, which means as for the implementation of lean management strategies in the production stage, FLW status is improved by 0.255. Then we fail to reject H_3 at the 5% significance level. The implementation of lean management model in production may have a positive correlation with FLW elimination. In addition to ensuring the flow of goods in the production process, the combination of lean practices in serving high-quality, low-cost and fast-delivery products has an impact on FLW reduction.

β_4 = 0.474, showing that if the application of lean distribution increases by 1, FLW reduction is achieved by 0.474. Then we fail to reject H_4 at the 5% significance level. Lean management model also profoundly affects the amount of FLW in the distribution stage. Indeed, the incorporation of lean practices such as JIT, sound distribution system, etc. is of great importance for companies aiming to reduce FLW in the FSC. Delivery efficiency is also believed to substantially improve FLW scenario in some companies.

4. Model Defect Detection:

1) Multicollinearity Testing:

The authors set the significance level at 5% and the hypothesis as follows:

H_0: VIF $\geq\geq$ 2 (the regression model has multicollinearity).

H_1: VIF < 2 (the regression model has no multicollinearity).

Table 3: Multicollinearity Results

Model	Unstandardized Coefficients		Standardized Coefficients	Collinearity Statistics	
	Beta	Std.Error	Beta	Tolerance	VIF
Constant	-0.576	0.371			
PCM	0.235	0.117	0.120	0.882	1.133
WHS	0.240	0.102	0.181	0.531	1.884
PDT	0.255	0.081	0.223	0.623	1.605
DTB	0.474	0.073	0.504	0.514	1.944

Source: *Authors calculated in SPSS20*

The mean VIF for the overall regression model can be easily computed at 1.6415, which is less than 2 in order to identify multicollinearity.

We can reject H_0. The regression model has no multicollinearity at the 5% significance level. Since different stages include different practices in lean management model, it tends to not have much correlation between the dependent variable and independent variables, as well as among the independent variables. This acts as an important conclusion for the reliability of variables and the scale.

2) Heteroscedasticity Testing:

Using Prob - Chi^2 to test heteroscedasticity, the authors set the significance level at 5% and the hypothesis as follows:

H_0: Prob - Chi^2 < 0.05 (the regression model has heteroscedasticity in the residuals).

H_1: Prob - $Chi^2 \geq$ 0.05 (the regression model has homoscedasticity in the residuals).

Table 4: Heteroscedasticity Results

Nonparametric Correlations

		ABSZRE	PCMm	WHSm	PDTm	DTBm
ABSZRE	Correlation Coefficient	1.000	0.061	0.117	0.032	0.072
	Sig. (2-tailed)		0.541	0.243	0.753	0.473
	N	102	102	102	102	102

PCMm	Correlation Coefficient	0.061	1.000	0.387	0.265	0.337
	Sig. (2-tailed)	0.541		0.000	0.007	0.001
	N	102	102	102	102	102
WHSm	Correlation Coefficient	0.117	0.387	1.000	0.440	0.607
	Sig. (2-tailed)	0.243	0.000		0.000	0.000
	N	102	102	102	102	102
PDTm	Correlation Coefficient	0.032	0.265	0.440	1.000	0.494
	Sig. (2-tailed)	0.753	0.007	0.000		0.000
	N	102	102	102	102	102
DTBm	Correlation Coefficient	0.072	0.337	0.607	0.494	1.000
	Sig. (2-tailed)	0.473	0.001	0.000	0.000	
	N	102	102	102	102	102

Source: *Authors calculated in SPSS20*

Prob - Chi^2 = 0.0968 that is greater than 0.05. This indicates that there are almost constant variances in the residuals and the model exhibits insignificant heteroscedasticity. Then we can reject H_0H_0 at the 5% significance level.

3) Autocorrelation Testing:

To evaluate the Durbin-Watson value, the authors use D_L and D_U in the Durbin-Watson Table.

Table 5: Durbin-Watson Test Evaluation

0	D_L	D_U	4 - D_U	4 - D_L	4
Positive correlation	Cannot conclude	No autocorrelation	Cannot conclude	Negative correlation	

Source: *https://www.youtube.com/watch?v=J9GJzJbmskY*

The authors set the significance level at 5% and the hypothesis as follows:

H_0: cov (u_i, u_j) = 0 (There is no autocorrelation between the disturbances).

H_1: cov (u_i, u_j) $\neq$ 0 (The regression model has autocorrelation between the disturbances).

Table 6: Autocorrelation Testing

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin - Watson
1	0.834	0.696	0.684	0.38569	1.826

Source: *Authors calculated in SPSS20*

The Durbin-Watson value is 1.826. With 102 observations and k = 4, we have D_L = 1.592 and D_U = 1.758. From that, we can conclude that there is no autocorrelation between each value of errors. Then, we fail to reject H_0 at the 5% significance level. The results confirm the aforementioned conclusion again that few signals of correlation among independent variables prove vital to the efficiency of variable choices and testing.

4) Normality distribution:

Prior to testing whether there is normality distribution in the model, the authors first calculate the normality distribution by using the histogram results:

Table 7: Histogram results

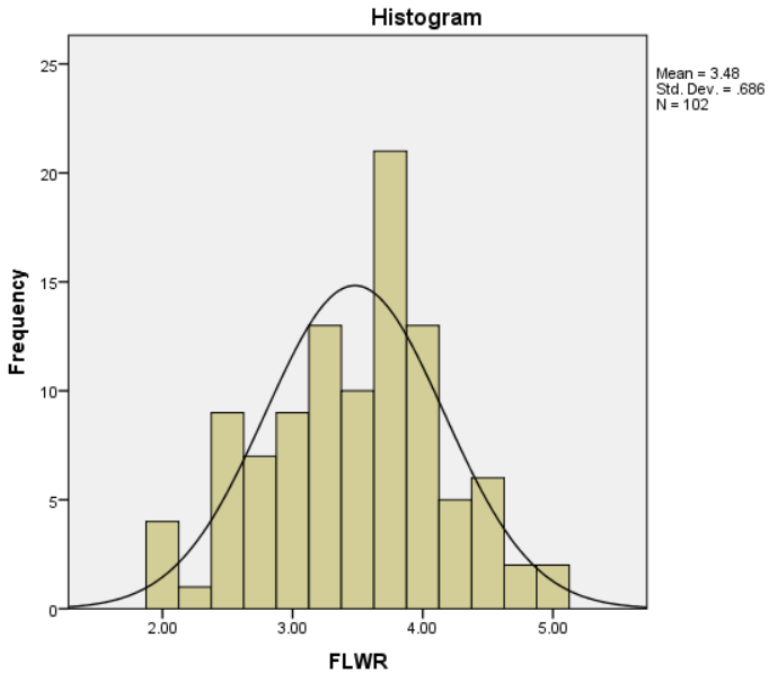
Descriptive Statistics

	Skewness		Kurtosis	
	Statistic	Std. Error	Statistic	Std. Error
FLWR	-0.152	0.239	-0.364	0.474

Source: *Authors calculated in SPSS20*

The results of these important indicators are shown in the histogram results and table above. As can be seen, the skewness and kurtosis have the values of -0.152 and -0.364, respectively. Indeed, when observing the standard curve, we see that the data is distributed quite evenly with the curve shaped like a bell.

Figure 2: Histogram



Source: *Authors calculated in SPSS20*

The Kolmogorow-Smirnov and Shapiro-Wilk tests:

Besides using the histogram to identify whether the model has normality distribution, we use the Kolmogorov-Smirnov and Shapiro-Wilk methods. With 102 observations, these methods are appropriate for normality distribution testing.

Table 8: Tests of normality

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
FLWR	0.135	102	0.000	0.975	102	0.046

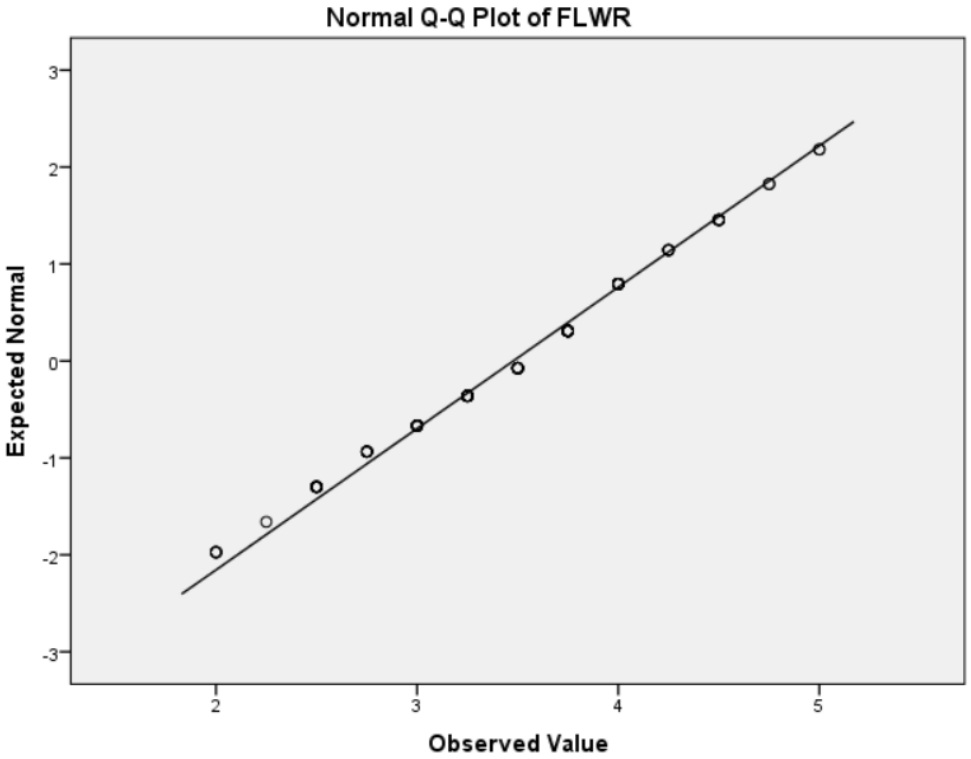
Souce: *Authors calculated in SPSS20*

It is obvious that the Shapiro-Wilk test has Sig. = 0.046. This value is less than the alpha value 0.05, but it is closer to 0.05. So it can be concluded that this test is almost normally distributed, which means that the number of observations is nearly large enough to form a bell-shaped curve

The Q-Q Plot:

To consolidate the normality distribution of the model, the team uses the Q-Q plot, which shows a visualization of the distribution of data, often used for studies with large sample sizes (more than 100).

Figure 3: The Q-Q Plot



Source: *Authors calculated in SPSS20*

The dots are all above the trendline. This provides further evidence that the above distribution is mostly a normal distribution.

5) Model Fit Testing:

The authors use analysis of variance (ANOVA) to test the model fit. If the significance level of at least 95% (Sig. < 0.05), the model is fitted.

We set the significance level at 5% and the hypothesis as follows:

H_0: Sig. F test $\geq\geq$ 0.05 (the regression model is unfitted).

H_1: Sig. F test < 0.05 (the regression model is fitted).

Table 9: Model Fit Results

ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	33.083	4	8.271	55.599	0.000
Residual	14.429	97	0.149		
Total	47.513	101			

Source: *Authors calculated in SPSS20*

The value F = 55.599 and Sig. F test is equal to 0.000 < 0.05, which means the combination of independent variables in the model can be explained by the change of the dependent variable. In other words, there is at least one independent variable affecting the dependent variable FLWR. The R squared is different from 0, which indicates that the linear regression model can be generalized and applied to the population.

We can reject H_0. The model is fitted at the 5% significance level.

6) Independent Variables Fit Testing:

Using SPSS, the fit of the regression model between lean management practices and FLW reduction is evaluated.

Table 10: Independent Variables Fit Results

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin - Watson
1	0.834	0.696	0.684	0.38569	1.826

Source: *Authors calculated in SPSS20*

There is no standard at how much R^2 is adjusted for the model to meet the requirements. However, some professionals recommend that the value of the adjusted R^2 should range from 0.4 to 0.7.

From Table 4.7, the adjusted R^2 is 0.684. This means that the independent variables explain 68.4% of the variation of the dependent variable. Therefore, the model is fitted at the 5% significance level by using the adjusted R^2.

5. Discussion:

This study was conducted with the analysis of 102 valid respondents, who were employees and managers from different SCaaS companies. The authors highlight the importance of lean management practices in procurement, warehousing, production, and distribution in alleviating the FLW in Vietnam. The result of the study has revealed that FLW reduction is positively correlated with the elements of a LSCM system. Moreover, most enterprises have been in business for over 4 years and they have incorporated lean procurement, lean warehousing, lean production, lean distribution, and other LSCM components to alleviate FLW status.

The FLW reduction associated with lean management practices at all stages from procurement, warehousing, production, to distribution is affected by the business's adoption. It is clearly illustrated that lean management strategies implemented in the distribution process plays a crucial role in minimizing FLW in the FSC, followed by lean in production, warehousing, and procurement. The result of this study is consistent with the theory of lean thinking application in warehousing and other stages by Abushaika et al. (2018) and Tan et al. (2022).

In order to confront the FLW issue, individuals who have authority like senior management, decision-makers should take these concepts and practices into consideration in operating a more sustainable FSC. Especially, the management needs to ensure that their suppliers are well-informed to take advantage of the full benefits of LSCM models. They should also adhere to strict standards and requirements for food manufacturing and its quality, which in turn eliminate loss and waste as little as possible.

IV. Conclusions:

FLW has become an ubiquitous issue in the early 21th century, but its significance has just been brought into attention by recent events like the Covid-19 pandemic. Considering the need to create a more sustainable and eco-friendly food supply chain to mitigate FLW, suppliers, manufacturers, retailers, and consumers are increasingly becoming conscious of the urgency to stop wasteful activities since the Covid-19 pandemic. There has been controversy about the definition of FLW and its association with different stages of the FSC. In the context of Vietnam, we take a waste-focused approach in which FLW occurs at the final consumption stage. Hence, based on previous reliable research, the authors choose the definition of FLW as the combination of the "loss" aspect and the "waste" aspect that occur at all stages of the FSC.

The authors emphasize the importance of lean management practices in procurement, warehousing, production, and distribution in alleviating the FLW. In detail, FLW management performance is positively correlated with the elements of a LSCM system. The FLW reduction associated with lean management practices at all stages from procurement, warehousing, production, to distribution is affected by the business's adoption. It is clearly illustrated that lean management strategies implemented in the distribution process plays a crucial role in minimizing FLW in the FSC, followed by lean in production, warehousing, and procurement. Most of the enterprises have been in business for over 4 years and they have incorporated lean management models to alleviate FLW status.

To confront the FLW issue, individuals who have authority like senior management, decision-makers should take these concepts and practices into consideration in operating a more sustainable FSC. Especially, the management needs to ensure that their suppliers are well-informed to take advantage of the full benefits of LSCM models. They should also adhere to strict standards and requirements for food manufacturing and its quality, which in turn eliminate loss and waste as little as possible. The study recommends a need for information sharing on the lean supply chain management components and their importance to the improvement of waste treatment systems. Therefore, all actors in the FSC including producers, distributors, processors and consumers should collaborate to foster a better communication process. This way, they can together build up a quickly responsive supply chain regardless of fluctuations in the global market. Additionally, the government plays an important role in introducing more "lean" policies to encourage widespread application of this model. The implementation of these recommendations will give value to this study.

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