

## INNOVATIVE WINE SUPPLY CHAIN VISIBILITY FRAMEWORK

Pappim Puangseereekul<sup>1</sup> and Theeraya Mayakul<sup>1\*</sup>

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### Abstract

Thailand has one of the highest wine import rates in Asia. The import taxes are expensive, especially luxury and premium wines and thus causing to the smuggling of wine or illegal import of wine by forgery import documents often happens. Moreover, Thailand does not have an effective supervision that enable able to verify the verification of imported wines against the documents submitted by the importer, limiting to only random inspection. As a result, the researcher has studied and designed the conceptual framework for wine supply chain visibility which focuses on the wine import and export process to ensure transparency and governance of the wine supply chain. It also aims to bring maximum benefits to institution in Thailand including other stakeholders. By institution in Thailand is able to increase the accuracy and reduce the time to verify the imported wine against the importer's documents in the system, while other stakeholders can verify the authenticity and current status of the wine at any time.

The conceptual framework of wine supply chain visibility is assessed by ten experts in the relevant fields such as wine, logistic and supply chain, technology, food and beverage, agricultural and Thai Customs answering the eleven questionnaires, and approach evaluated by Content validity index (CVI) statistical. The result and feedback from experts are positive, where all experts support the idea of the conceptual framework although there are some suggestions that can be applied and developed in the future conceptual framework.

**Keywords:** TRANSPARENCY ; GOVERNANCE ; WINE INDUSTRY ; COLD CHAIN ; LOGISTICS AND SUPPLY CHAIN

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<sup>1</sup> Division of Information Technology Management, Faculty of Engineering, Mahidol University, Nakorn Pathom, 73170, Thailand

\* Corresponding author E-mail address: Theeraya.may@mahidol.edu

## Introduction

In the past, wine was not as popular in Thailand compared to other types of alcoholic beverages, especially imported wines from abroad. As of today, imported wine has recently grown its popularity. In Thailand, wine is seen as a healthy drink and usually gifted to people as it can represent richness and quality in society. It is not only the elderly or middle-aged people who enjoy having wine, but teenagers and working age people also became interested in having wine. This has made the wine industry an important part in the global and national economical level.

Wine is both an art and science, as wine production is a combination of creativity and innovative technology. There are countless details for wine lovers to explore. Wine is differentiated from other beverages, where each bottle of wine is unique in its own way. This is the charm of wine where both the taste and aroma of the wine indicates where the wine is originated. Each country produces wine in different tastes and aromas, where even in the same country, the wine produced has different taste and aroma depending on each topography. The value and price of wine is high due to multiple factors such as given grape varieties, production process and vineyard's dedication. There are other challenges that are uncontrollable factors like the climate changes, planting area, and manufacturing process error (spoilage yeasts, elimination of microorganisms, etc.). The hard-working of vineyards dedicated to one wine bottle provides high-quality, value and enhances the experiences in the wine industry.

However, the import process is the most important obstacle contributing to the growth of the wine market in Thailand. Import regulations and laws including import documents are constantly changing by government. The import taxes are extremely expensive as there is no effective system to verify the accuracy of the import process. Especially, critical processes like import wine list and wine inspections cannot be done in a short time and fail to verify the accuracy of import documents and actual quantity of wine, limiting to only inspecting the products randomly. Hence, leading to smuggling of wine to evade taxes and wine with the

illegal label in the market. This way, the consumers will miss the information and impact on the wine's quality. Therefore, the government tends to lose the revenue from this cause. Additionally, other stakeholders such as retailers and customers cannot trust that if the product is legal and authentic.

In order to overcome this problem is a way and opportunity to propose the digital transformation. This will permit to build a stronger process by applying the relevant technologies such as internet of thing (IoT), cloud computing, Electronic Data Interchange (EDI), identifier technology, and blockchain in order to prevent the modification, and thereby increasing the accuracy along with the reliability of data. Based on cold chain logistics, it can control and maintain the temperature.

Therefore, the purpose of this study is to build the conceptual framework which is based on the import and customs regulations accompanied by food safety and quality regulations to balance the transparency, traceability, as well as reliability in wine import and export process and ultimately increasing the tax governance and customers' trust.

## Related Works

### 1. Wine Industry

The wine industry reflects ideologies of relaxing lifestyle and scenic countryside. Wine is a high-value industry, and it is competed to others with high risk, therefore it is not surprising that large and small winemaker are seeking ways to produce better quality and larger quantities. However, wine production is also a significant business sector with economic factors that drive the manufacturing processes, and to succeed in today's market, the winemaker needs to genuinely understand the internal and external factors that inspire the purchase power (Bisson et al., 2002).

#### 1.1 Wine Supply Chain

A wine supply chain consists of grape grower, wine producer, bulk distributor, transit cellar, filler and packer, distributor, retailer, and customer. Each stakeholder is responsible for specific and different activities that must be tracked and traced in order to make sup-

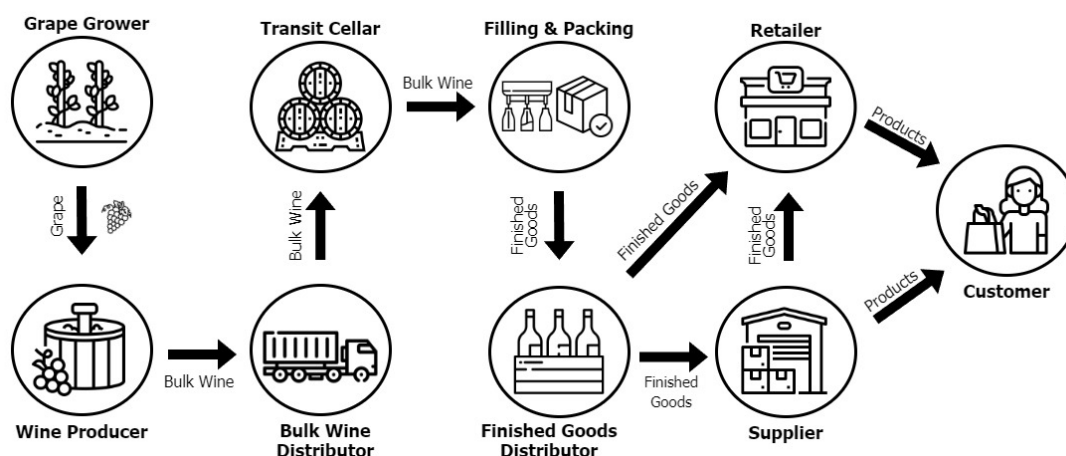


Figure 1. A representative scenario of wine supply chain (Cimino & Marcelloni, 2012)

ply chain traceability possible (Tao et al., 2014) (Mattsson & Sonesson, 2003) as shown in Figure 1.

### 1.2 Brand Protection and Anti-Counterfeiting

Counterfeit wines may occur in many ways, as it does with other customer goods and services, however wine supply chain has opportunities for counterfeit in wine, tax evasion and other duty evasion via falsification of documents, smuggling (Lars Holmberg, 2010). Wine is also one of the most alcoholic beverages that is subject to fraud and mislabeling (Villano et al., 2017). Moreover, Bull (2016) has mentioned that counterfeiters in the wine industry have certainly improved their efforts when attempting to imitate and fake vintage wines.

To overcome the problems for brand protection and anti-counterfeiting in wine industry and wine supply chain, Popović et al. (2021) and Šandi et al. (2018) have applied cloud technologies and Internet of Things like mobile technology, smart tags such as QR-code, RFID, NFC, etc.

## 2. Traceability

Traceability is known as the principle of “one step back one step forward” (Demestichas et al., 2020), is the ability to track a product’s history or information, and to locate a life cycle of product by using the recorded identifications (Armstrong et al., 2008). It can be the entire supply chain from the origin of the product to the end of the process like harvest through allocation, storage, processing, distribution and sales. Otherwise, it could track only a part of a production chain, such as internally in one of the steps in the chain, for example

the production process (Moe, 1998).

Traceability is one of the best management tools as it enhances production efficiency and the generation of reliable risk assessment models, which can be used to identify various elements that create quality and safety issues (Cimino & Marcelloni, 2012).

## 3. Transparency

Traceability and transparency are two terms that interconnect with each other, but have completely different meanings. Transparency refers to the entire supply chain's visibility and it is the extent of all stakeholders in a supply chain that share the understanding and access to the product’s information that each stakeholder require, without loss, noise, delay, or distortion of the information, and where traceability refers to access the specific sub-level information and recorded in each process of supply chain such as manufacturing, transportation, retailer, wholesaler, etc. It can be tracked and traced with each process that has been made from what, how, where, why and when from upstream to downstream. For instance, in agri-food sector, it mainly focuses on preventing food safety hazards, in case of any hazardous incident happen, its source can be identified and immediately suppressed the spreading (Sunny et al., 2020).

According to Hofstede (2003), transparency might be made to enhance the value of product, and customers are willing to pay more if they are aware of the product's quality and provenance.

4. Cold Chain

Cold chain is one of the best processes in the supply chain for goods and products in many industries such as pharmaceutical industry, food and beverage industry that require temperature-controlled storage, and transportation to preserve product quality and lifetime, reduce product wastage and leverage the satisfaction for consumers in terms of quality. Hence, cold chain has been accepted as the best practice for medicine, vaccine, food, and beverage including the premium product. Wine also needed to be controlled with the right temperature throughout the transportation in or-

der to ensure the quality of products. In addition, the end-to end visibility is operated and measured through a cold chain. (Srinivasan et al., 2015) (Parvis et al., 2009) (Bamakan et al., 2021) (Bogataj, 2005) (Lakshmi & Vijayakumar, 2012) (Zhang et al., 2017)

5. Technologies use in Wine Supply Chain

At present, advancements in technologies have played a significant role in the wine industry. There are several attractive areas in wine chains where the product's quality, transparency and traceability are becoming a major concern for both winemakers and consumers by employing technologies as shown in Table 1.

Table 1. Technologies for Wine Supply Chain

Technology	Description	References
RFID Barcode QR-code	Record product's information such as origin of the product, information and date of manufacture, components, and location.	Sun (2009) Sun (2012) Urbano et al. (2020)
Sensor Data logger	Measure and record the temperature of the product in real-time.	Lang et al. (2011) Papert et al. (2016)
Internet of Things (IOT)	Connected multiple devices like sensors, actuators, and other devices and all the information together to monitor and interact as well as collect and transmit real-time data within a firm and supply chain	Masetti et al. (2018) Abdel-Basset et al. (2018) Verdouw et al. (2018) Wei et al., (2020) Rejeb et al. (2020) Humayun et al. (2020)
Electronic Data Interchange (EDI)	Exchange the documents within and without organization	Kuan and Chau (2001) Jackson and Sloane (2003) Pawar and Driva (2000) Kreuwels (1992)
Geographic Information System (GIS)	Capturing, collecting, storing, retrieving, analyzing, and displaying geospatial data by showing the location and the attributes of geographical	Chang (2004)
Cloud Computing	Storage of documents over the network and allows users to access information through any device with internet access.	Paul and Ghose (2012) Islam et al. (2012) Irion (2012) Hashemi et al. (2013) Srinivasan et al. (2015)
Blockchain	Enables the transparent real-time data sharing across a network, and network consensus can delete or update the transaction.	Lai and Chuen (2018) Zhao et al. (2019) Tijan et al. (2019) Helliari et al. (2020) Adamashvili et al. (2021)

## 6. Problems and limitations in Import

Transport, storage, and retail operations contribute to the deterioration or damage of packaging. Transport-related causes include shipment vibrations, overhang on pallets, wrong size of pallet, humidity, and temperature (Haussinger et al., 1993). During the transportation, the quality of food can be monitored by intelligent packages. In order to observe the kinetics of changes which might be influenced from environment conditions like time and temperature, it can be monitored by a time and temperature indicator or trimethylamine (TMA) which indicates fish spoilage (Heising et al., 2017).

## 7. Standards and Regulations

In many countries, governments have implemented traceability systems as a tool for quality and safety. International trade should have standardized standards and regulations to ensure traceability between government and other stakeholders in the supply chain. Therefore, the government should drive organizations to develop and implement traceability systems by complying standards and regulations as followings:

1) Import and Customs Regulations: Import License, Label License, Warning Label, Liquor Sell License, and Type of Excise Stamps and Tax Registration

2) Food Safety and Quality Regulations: Hazard Analysis Critical Control Point (HACCP), Good Agricultural Practices (GAP), and Good Manufacturing Practice (GMP)

## 8. Customer Awareness

Customers have become more aware of the safety of food and products they consume due to the safety concerns of raw materials and how the products have been made, which can lead to diseases. More-

over, some customers are willing to purchase reliable products, and traceability creates customer's reliability and confidence by allowing them to verify information about a product from the beginning until the end of processes (Romero-Torres, 2020)

## Research Methodology

After related works have been reviewed, the researcher designed the conceptual framework for the wine supply chain. The contribution of this paper is to develop the framework to provide accuracy, transparency, and good governance. Therefore, to achieve the objective, the framework was based on the previous study as following five-procedure: 1) Analysis of goals, stakeholders, and requirements 2) Data and work process analysis 3) Technologies analysis 4) Conceptual framework, and 5) Evaluation and discussion, as shown in Figure 2.

1) Analyzing the current situation in the wine industry and supply chain, researcher adopt the cold chain as the standard and best practice in logistics and supply chain. The cold chain is remarkably well known for improving product quality. The pharmaceutical industry's cold chain can be used to deliver premium wines at constant temperatures to maintain taste and quality. One main advantage of cold chain in the pharmaceutical industry is controlling vaccine temperatures during transportation from manufacturing to the patient. If there is a change in temperature or other factors during transportation, the manufacturer and driver will be notified to prepare for any issues.

Implication of cold chain for wine products as applications, features and requirements of vaccine

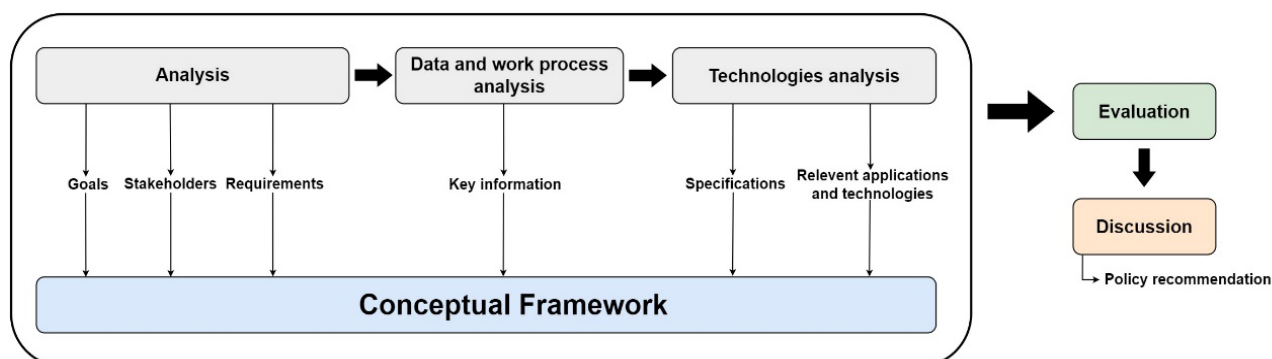


Figure 2. Research Methodology Process

and wine are similar. For example, temperature control, data interchange, tracking, alert notification, data visibility, protect package break, and related technologies like IoT, sensor, RFID, cloud and blockchain, which benefit all stakeholders of wine supply chain to track wine status, monitor temperature especially at the point of declaration import wine to verify import documents with speed, accuracy, and transparency.

2) Defining roles and responsibilities of key stakeholders as shown in Figure 3., providers consist of vineyard, winemaker and supplier where all provide the necessary documents for export, ensure that the wine has been controlled with temperature maintained and enabling to prevent counterfeit wine. Customers consist of forwarder, importer, government, retailer and customer where all will be able to access the necessary documents for import's process as well as be able to authenticate the wine.

3) Designing the work process for transmitting data for exporting wine to Thailand as shown in Figure 4. involves vineyards, winemakers, and suppliers uploading relevant information and documents to a cloud. The documents are accessed by forwarders and importers, and inventory and temperature data are verified during transport using identification technology and sensor monitors. The government verifies import documents against actual wine lists and quantities, and retailers and customers can verify wine authenticity using a QR-code linked to the cloud, while administrators control and maintain access to the databases and cloud for all stakeholders.

4) After defining the data and work processes, the conceptual framework can be designed as shown in Figure 5. There are two key stakeholders, provider (vineyard, winemaker, supplier, and administrator) and customers (forwarder, importer, government, retailer,

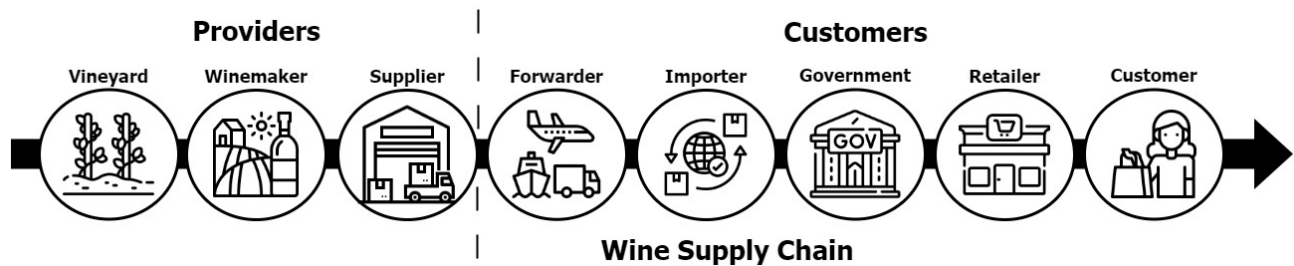


Figure 3. Mapping the wine supply chain (Cimino & Marcelloni, 2012)

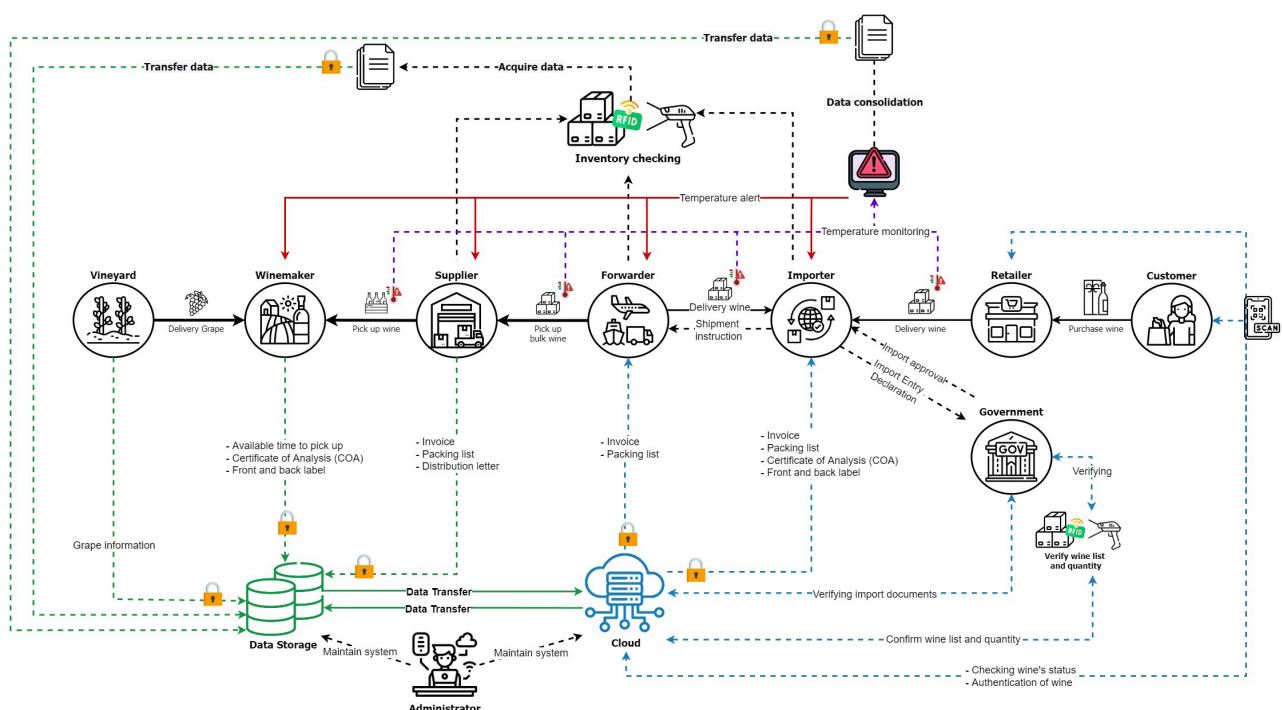


Figure 4. Data and work processes

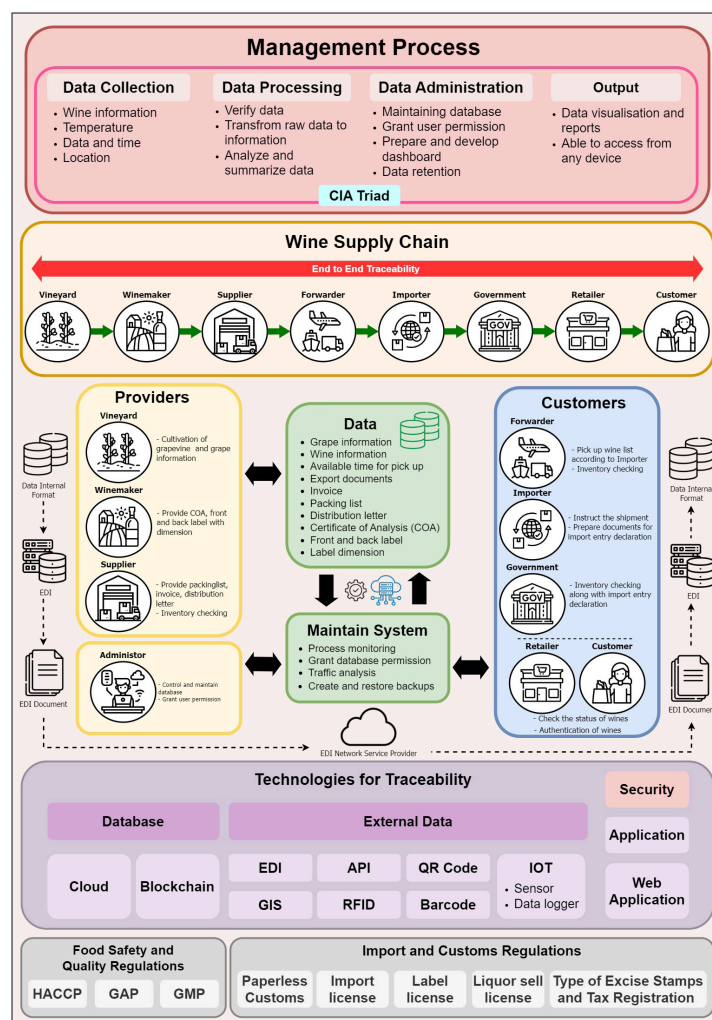


Figure 5. Conceptual Framework

and customer). In the framework, there are three categories of technology for traceability and visibility; Database (Cloud and Blockchain); External Data (EDI, GIS, API, RFID, QR-code, Barcode and IOT); Security where data collection, data processing, data administration, and output of management process is in accordance with CIA Triad (Confidentiality, Integrity, and Availability), and this framework complies with Food Safety and Quality Regulations (HACCP, GAP, GMP), and Import and Customs Regulations (Paperless customs, Import license, Label license, Liquid sell license, and Type of Excise Stamps and Tax Registration).

## Evaluation

After the conceptual framework is designed and the work process is presented, the questionnaire is evaluated using the Content Validity Index (CVI) based on a four-point Likert scale to focus on acceptability, efficacy, satisfaction, and applicability. Furthermore, it

is important to emphasize the acceptability of the conceptual framework that can be utilized.

Content Validity Index (CVI) is the most generally used index in order to determine the context validity of words. Thus, experts access each item based on their personal experience and opinion, giving a rating using a four-point Likert scale consisting of 4 = Highly Relevant, 3 = Quite Relevant, 2 = Somewhat Relevant, and 1 = Not Relevant, to find the relationship and agreement of CVI for item-level content validity index (I-CVI). The acceptable I-CVI value should not be less than 0.78 for 6 to 10 experts, whereas the acceptable I-CVI should be 1.00 when there are 5 or less than 5 experts.

The equation for computing CVI as follows:

$$I - CVI = \frac{A}{N}$$

where A is the number of experts in agreement, and N is the total number of experts.

Previous study has proposed a modified kappa  $k^*$  approach for assessing content validity, the criterion of Kappa is as follows; multi-rater Kappa data support the value of Kappa ( $k^*$ ) where experts are more likely to accept that validity factor. The accepted kappa value is more than 0.60, or it can be defined as excellent ( $k^* > 0.74$ ), good ( $k^* = 0.60-0.74$ ), or fair ( $k^* = 0.40-0.59$ ) respectively.

The equation for computing Kappa ( $k^*$ ) value as follows:

$$k^* = \frac{(I - CVI - P_c)}{(1 - P_c)},$$

and,

$$P_c = \left[ \frac{N!}{A!(N-A)!} \right] 0.5^N,$$

where  $P_c$  is probability of chance agreement, and  $N$  is the number of experts.

## Results

The evaluation of eleven questions are based on Organization for Economic Co-operation and Development (OECD) evaluation criteria which include rele-

vance, coherence, effectiveness, efficiency, impact, and sustainability, where all criteria might not be suitable for this research. According to the purpose of this study, the preferred and suitable criteria are coherence, efficiency, and impact.

The result is shown in Table 2. demonstrated CVI value is 0.97 and Kappa Value of 11 items were excellent, all value is acceptable by ten experts.

## Discussion

The responses from ten experts were positive and they all agreed with the concept of traceability and technologies could be the right kind of tool to support accuracy, transparency, visibility, and governance for importing premium wine in future by following Standard Operating Procedures (SOP) to avoid communication errors and increase work efficiency. Some experts were concerned about Food Safety and Quality Regulations as the regulations of food and beverage might not be cleared in medication, vaccine, wine, and luxury product due to it is different category of products, as well as the ambience of wine storage might be different from other product categories.

**Table 2.** Agreement index calculation of CVI and Kappa ( $k^*$ )

Items	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	Agreement Number	I-CVI	$k^*$	Evaluation
I-1	3	4	4	3	3	3	4	4	4	4	10	1.00	1.00	Excellent
I-2	3	3	4	3	4	4	4	4	4	4	10	1.00	1.00	Excellent
I-3	3	3	4	3	3	4	4	4	4	3	10	1.00	1.00	Excellent
I-4	3	3	4	2	3	4	4	4	4	4	9	0.90	0.90	Excellent
I-5	3	4	4	2	4	4	4	4	4	4	9	0.90	0.90	Excellent
I-6	3	4	4	3	4	4	4	4	4	4	10	1.00	1.00	Excellent
I-7	3	3	4	3	4	4	4	4	4	4	10	1.00	1.00	Excellent
I-8	3	3	4	3	4	4	4	4	4	4	10	1.00	1.00	Excellent
I-9	3	4	4	3	3	4	4	4	4	4	10	1.00	1.00	Excellent
I-10	3	3	4	2	3	3	4	4	4	4	9	0.90	0.90	Excellent
I-11	3	3	4	3	3	3	4	4	4	4	10	1.00	1.00	Excellent
Average proportion of agreement across ten experts											0.9727			

Note: I is Item and E is Expert

All experts thought that this conceptual framework would be useful and helpful in terms of policy and as the strategic plan in the future to prevent the counterfeit and reduce the illegal import by encouraging and gathering all technologies based on food safety and quality regulations, and import regulations also need to be a critical factor in wine supply chain, and all stakeholders would be promptly known regarding the change in any regulations.

Although the technology in the conceptual framework is suitable to point out the traceability and visibility in the wine supply chain, all must be supported by the government including various importing laws and regulation in order to be effective and efficient in practice. Moreover, technology like blockchain is expensive and the system is also complicated. It may probably not be worth for low-priced products, but premium wine is a high-priced product. In order to achieve the most cost-effective and economical use, application of the proposed concept framework may be considered by the government for the import of other high-price products.

## Conclusion

The fraud and counterfeit in the wine industry whether label counterfeiting, forgery of import documents, and illegal import cause the government to lose

a huge amount of revenue in respect of customs and import taxes. According to research objectives, this work identified traceability of data transmission between wine supply chains in consideration of transparency, visibility, and governance to increase the accuracy and reduce time consumption in the import process with the help of relevant technology and cold chains' concept.

The conceptual framework was designed and developed through qualitative methods and the result is accepted based on the calculation of content validity and multi-rater kappa statistics. The experts covering the perspectives of government regulators, business operators in the wine industry, logistic and supply chain, technology, and customers.

## Acknowledgement

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