Blockchain-based traceability system adoption in the wine global value chain (GVC): A unified theory of acceptance and use of technology (UTAUT) framework of analysis, the example of the Chinese market for Bordeaux wine

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Abstract

Food security and authenticity as a field of business practice and research has been gaining interest in the past decades as economies move towards greater use of digital solutions and services. The advantages of blockchain applications are well known, from enabling a distributed database for transactions so that every user can verify the transactions directly to irreversibility of records, and to integration with other core technologies that enable persistency, anonymity and auditability through cryptographic hash, digital signature, and a distributed consensus mechanism. But blockchain technology for full deployment in future internet systems remains in its emerging phases and faces challenges such as scalability and transactional privacy cannot be guaranteed. Using the unified theory of acceptance and use of technology (UTAUT) framework of analysis, this study brings insights from empirical data collected from respondent interviews with producers and traders in the wine industry between Europe and China on their perspective of the effectiveness of anti-counterfeit instruments and traceability systems, focusing on blockchain traceability systems. The purpose of the investigation is to identify the barriers to technology acceptance and use, and to gauge the extent consumer trust can be restored with blockchain traceability systems. The findings indicate that enthusiasm towards the adoption and use of a blockchain traceability system differs in perspective between Europe and China. The difference in technology uptake and use seems dependent upon both international and local business environments that support and facilitate conditions of use for emerging technologies. The findings also indicate that traceability systems should in essence be used together with other more socially tactile, services oriented strategies such as customer relationship building, product branding and customer education.

Keywords
Digital services, blockchain, traceability, technology adoption, wine, global value chain

Introduction

Chinese consumer demand is increasing in parallel to the country's increasing globalization and economic transaction power, placing the consumer goods consumption at 38 trillion RMB in 2018 (MOFCOM, 2019). Stronger income, better education and greater mobility have contributed to the emergence of a newly educated and wealthy class with evolving consumer tastes and preferences (Masset *et al.*, 2016). According to a survey done by Chinese Consumer Confidence, Chinese consumers are willing to invest and pay more for food and drinks, personal electronics, home appliances and cosmetics

(Heiskanen, 2019). The Chinese market for product and services consumption are influenced by a history, culture and values that are different from that of a Western consumer (Huang and Lu, 2017; Pierre, 2014). Due to its rapid socio-economic developments in the past four decades, the contemporary Chinese wine market makes for an interesting case example of the study of several emerging dimensions of global and local market trends (García-Cortijo *et al*., 2019).

China imported 3.9 billion USD worth of wine in 2018, where it is estimated to be the world's second-largest wine consumer by 2023 with a market value of approximately 23 billion USD (Kaizen Crypto, 2019). The growing wine market in China has attracted a likewise growing industry of counterfeiters (Jones, 2013; Mustacich, 2015). The popularity of Bordeaux wines, for example, has led to a proliferation of counterfeit wines (Mora, 2014; Shaw, 2013) where it is estimated that for every authentic bottle of French wine produced, there exists at least one counterfeit bottle of French wine on the Chinese market (Wang, 2020a).

The Chinese authorities have made progress in curbing counterfeit wines in reaching the consumer market (Wang, 2018). In 2020, the CIVB (Conseil Interprofessionnel du Vin de Bordeaux) won a landmark victory in its decade-long fight against fakes in China after a counterfeiter was handed an 18-month suspended prison sentence (Shaw, 2020). But even as active measures to counterfeiting get increasingly intense, the general consumer trust in the food and drinks industry has continued to decline in the past decade due to a series of incidents of food fraud/adulteration and contamination, both accidental and deliberate in nature (Jourdan, 2014; Zhou, 2006). As such, food traceability has come to be of increasing importance, applied as a tool in supply chain management in order to restore consumer confidence (Ringsberg, 2014; Kher *et al*., 2010).

There are several food fraud incident types that can be directed at consumers in the China wine market. These include (i) adulteration, where a component of the finished product is fraudulent; (ii) tampering, where a legitimate product and packaging are used in a fraudulent manner; (iii) simulation, where an illicit product is designed to look like but not exactly copy the authentic product and (iv) counterfeiting, which refers to an Intellectual Property Rights infringement, that includes all aspects of the adulterated product and packaging being fully replicated.

In terms of properties of the product itself, instruments and techniques used to detect wine adulteration can be divided into two main types. The first are bio-chemical tests to identify for physical product characteristics such as using inductively coupled plasma mass spectrometry (ICP-MS) that separate elements based on their physical properties and measure their presence and quantity in a given sample (Pepi and Vaccaro, 2018); using isotope ratios in combined methods to identify the origin of wine in geographical correlation (Perini *et al*., 2015); high-performance liquid chromatography (HPLC) to analyse wine phenolics to determine type of grape and/or extent of dilution (Castellari *et al.*, 2002) and high resolution melting (HRM), a powerful molecular technique to detect genetic variation in and profile product (Pereira *et al.*, 2018). Collectively these methods are referred to as "analytical methods". Analytical methods, while important, contribute to only part of the food traceability system.

The second type of anti-counterfeit instruments are technology oriented such as radio frequency identification (RFID) and near-field communication (NFC) technology for short ranged sure exchange of information (Coskun *et al.*, 2013; Pigini et al., 2017). QR (quick response) codes are connate to NFC and RFID, in being able to reveal various product characteristics including genetic information. However, these technologies can often be counterfeited themselves (Przyswa, 2014; Tkachenko *et al.*, 2016), even when they are in phases of early development and application (Tallapragada, 2018; Sanz-Valero *et al*., 2016).

A traceability system, defined as a system that, by means of recorded identifications, seems to hold potential as a technology service with the ability and capacity to access any or all information relating to the entity of interest throughout its life cycle (Olsen and Borit, 2013). Blockchain in traceability systems applied to the management of supply chains for example, could potentially help provide greater integrity and transparency of the product throughout the supply chain (Tapscott and Euchner, 2019). In its most fundamental form, blockchain is defined as a distributed database of records or a public ledger of all digital transactions/events executed and shared among the participants (Angelis and Ribeiro da Silva, 2019). There is little need for a central authority in blockchain because digital transactions in the public ledger are validated by an accord of the participants in the system, which allows for traceability and, in turn, security. In addition, because every block is connected to the previous one, as the number of participants and blocks grow, it becomes increasingly difficult to modify logged information without having a network consensus (Angelis and Ribeiro da Silva, 2019; IBM, 2019; Olsen and Borit, 2013; Song *et al.*, 2019; Tapscott and Euchner, 2019). Yet blockchain technology and digital service solutions for full deployment in future Internet systems remains in its emerging phases and faces challenges such as scalability and transactional privacy cannot be guaranteed *(Bhardwaj and Kaushik, 2018; Biryukov et al.*, 2014; Henry *et al.*, 2018; Jawaheri *et al.*, 2017; Zheng *et al.*, 2018).

The main research interest in this empirical qualitative, corpus driven study focuses on the challenges and barriers to implementation and use of digital services and solutions in the supply chain. Taking the example of European wines imported into China intended for market end-consumers, this study focuses on emerging forms of technology services such as blockchain in traceability systems.

Technology adoption research is perhaps one of the most mature streams of information science and services research (Venkatesh *et al*., 2016). Yet, research pertaining to an overview of technology services and adoption of new traceability systems for wine supply chains remain under studied from the perspective of a unified theoretical framework because most adoption on blockchain for example, have been studied from developer perspectives and to what extent the technology can be useful (Mieras *et al.*, 2019; Shermin, 2017; Song *et al*., 2019). As such, interacting with different stakeholders along the wine supply chain in Europe and in China, a unified theory of technology acceptance and use (UTAUT) is applied as framework of analysis to the data collected. The tripartite purpose of the analysis is (i) to uncover the contextual barriers to the uptake of new/emerging technologies in the wine industry, (ii) to review the potentials of blockchain technology as a wine traceability system and (iii) to contribute to academic theory building in applications of the UTAUT framework to the acceptance and use of digital services *i.e*. blockchain in food traceability. In working towards the tripartite purpose of this study, two research questions (RQs) have been formulated:

> RQ1. Applying the UTAUT framework, what barriers and challenges can be identified in studying the acceptance and use of blockchain-based traceability systems for the global wine value chain?
>
> RQ2. To what extent can emerging blockchain-based digital services and solution restore trust in the wine global value chain (GVC) stakeholders (including market end-consumers)?

This paper is structured as follows. Due to that this study contains multiple stakeholder perspectives and includes a cross-section of scholastic disciplines, literature review in section 1 contains three segments, giving a current state-of-the-art overview of (i) the wine market in China, including its marked developmental phases from between

2005 to 2017 where distinct development phases of wine product and services consumption have been identified by scholars and practitioners, (ii) the role of blockchain technology in GVCs and (iii) UTAUT applications and studies. Section 2 outlines the research methodology applied in this study, followed by the findings and discussion in section 3. Section 3 also contains some qualitative insights from interview data collected for this study. Study limitations and conclusions are written in section 4.

1. Literature review

1.1 The wine market, China

China's approximately 7000-years long history in producing and consuming alcohol in the form of baijiu based on rice (Shen and Antonopoulos, 2017), and its current emerging taste and preference for imported grape wines has catalysed global interests in the Chinese wine market. Being the globe's most populous country, with an expected 1.4 billion in population by 2020, China is the fifth largest wine market in the world as measured by total annual consumption (Blazyte, 2020; Statista, 2019) and has recently surpassed France to become the largest red wine market in the world (China Wine Competition, 2018; Wang, 2020a).

China's current development in its wine market both in its domestic production of red wines, as well as general consumption pattern, is most likely influenced by China's opening up in the 1980s, in the period of reformation and embracing of a new Chinese perspective market economy. With a loosening of agricultural controls and enterprise, China made foreign investments attractive by various policy measures. From 1980 onwards, landmark joint ventures in the wine industry were forged with foreign know-how and expertise in winemaking in collaboration with local network connections, labour and market access (Wang and Clarke, 2019). In terms of production in the grape-wine category, 5 countries represent 50% of the world vines cultivation (Figure 1) of which China has 12% global land area for vine production. In 2015, a total of 341 000 ha of land or 4% of the world's vineyards were dedicated to the cultivation of Cabernet Sauvignon, a black wine grape variety originating from Bordeaux, derived from a crossing of Cabernet Franc and Sauvignon Blanc. The largest producing countries of this grape variety today are China, France, Chile, the United States and Australia (OIV, 2017).

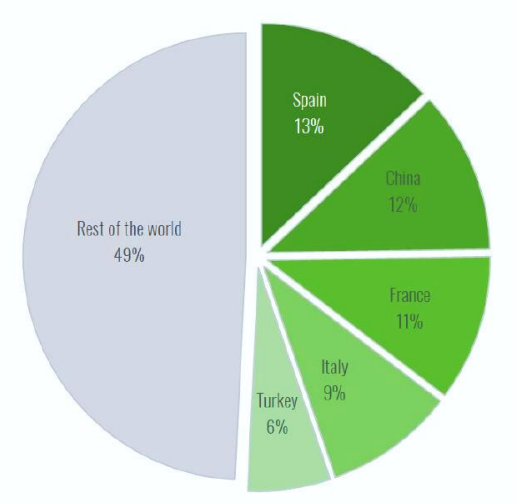

Figure 1. Area under vines. 7.4 mha is the global area under vines production in 2018 for wine grapes, table grapes or dried grapes in production or awaiting production (OIV, 2019, p. 3)

The consumption patterns of wine in China is bolstered by a young, increasingly affluent and mobile population. China's annual consumption of alcohol has steadily increased in the past five years (Yu *et al*., 2009). In 2019, the annual consumption of alcohol was approximately 64 billion litres, with an expected consumption of 65 billion litres of alcohol by 2020 (Statista, 2019).

Imported wines hold the highest volume share in the combined 1st-tier[1] cities of Beijing, Guangzhou, Shanghai and Shenzhen. These cities account for approximately 53% volume of imported wine sales with on-trade channels representing 80% of total sales (Government of Canada, 2019). The strong presence of expatriates and internationally educated young professionals and consumers are part of the contributing reasons to the high interest in imported wines. Consumer knowledge in China about wine is increasing in part because of Chinese tourism to wine drinking countries, and the number of foreign trips is expected to reach 200 million by 2020 (Government of Canada, 2019). Wine imports are both from old and new world wine producing regions. The top old-world countries of wine import for China are France, Spain and Italy, and the top new world regions include Australia, Chile, South Africa and New Zealand (Blazyte, 2020; Karlsson, 2019).

The Chinese wine market can be further segmented into bulk and bottled wines, the former being more competitive on the market with a CIF (cost, insurance and freight) price of around 0.6 EUR per litre. Bulk wine imports are mainly from Chile, Spain and Australia. The Chinese wineries most interested in bulk wines are located in the Yantai area, Shangdong province and near Shacheng in Hebei province. Bottled wines have a higher average CIF price of 2.6 EUR per litre in the first half of 2017. This higher price might prove a challenge for the average Chinese consumer household (particularly in 3rd and 4th tier cities) due to what disposable income allows. 3rd and 4th tier cities are however home to more than one million residents each, and are seen as opportunities for the wine market growth in China (EUSME Centre, 2017; Masset *et al.*, 2016).

In the span of less than 2 decades, three distinct phases of growth can be identified for the Chinese import wine market (Countryman and Muhammad, 2018). The first phase from 2005 to 2009 marks the emergence of the China imported wine market, with France as main supplier to the Chinese market. Wines from the Bordeaux region were first movers into the Chinese wine market, and as such, enjoyed a competitive market position for some years. The access and sourcing of fine wines into mainland China is also due to structural changes such as opening of the market in Hong Kong, and the reduction in excise duties in 2008 (Masset *et al.*, 2016).

The second phase from 2009-2014 has some nuance to its development due to various influencing factors, not the least, the changing political environment of the country. There was considerable hype surrounding high-end Bordeaux wines, *e.g.* Château Lafite or Château Mouton, which were being purchased as gifts due to their perceived status (Masset *et al.*, 2016). This contributed to increased prices, with the price of some vintages increasing six-fold in a few years. However, in 2012, with China's new anti-corruption policies, the sales of high-ends wines went down considerably, and the

[1] China's cities are ranked in a 4-tier system based on Gross Domestic Product (GDP), ranging from USD 350 trillion to USD 20 billion. All 1st-tier have a GDP over USD 300 billion. Most 4th-tier cities have a GDP below USD 17 billion (SCMP, 2016).

imports dropped dramatically from 2012 to 2013, and remained stable through 2014, returning to a "real market" (Zhou, 2015).

This 'real market' described by Zhou has since then matured, giving rise to the third phase of development beginning in 2015. In 2015, only about 65% of wine consumers in China were aware of Australia as a wine-producing country, compared to 90% for France, 81% for China and 69% for Italy (Corsi *et al.*, 2016). Studies on consumer preferences for wines in China indicate that the Chinese market has its own distinct curve of sensory evolution (Williamson *et al.*, 2018). Chinese wine consumers differ from their western counterparts in the way that they respond to wine attributes. Apart from wanting to enjoy the sophistication and relaxation that the experience of wine consumption brings, Chinese wine consumption behaviour is deeply rooted in the knowledge and use of traditional Chinese medicine (TCM) and the use of traditional medical systems in Asia (Jiang and Quave, 2013).

The grape wine, from being something only wealthy businessmen would purchase as a gift or for extravagant banquets without sensory or taste consideration (Lockshin *et al.*, 2017), is increasingly being consumed by the Chinese middle-class as a way of living healthy. Consumers also focus more on the flavours of the wine consumed in order to make informed decisions on their purchases (Williamson *et al.*, 2018).

1.2 Blockchain as digital service solution in traceability

The era of new globalization, Globalization 4.0 are activities and transactions of the cyber world, involving digital services, e-commerce and 3D printing (Vanham, 2019). The digitalization of services and transactions were borne of the convergence of physical infrastructure and information technology that in turn, give rise to socio-economic challenges (Pezzuto, 2019; Vanham, 2019). A lack of transparency in services transactions occur due to the manner and speed of developing technologies where accurate and reliable data are difficult to acquire (Pezzuto, 2019).

In address to the increasing challenge of transparency of data acquisition, a promising emerging technology released in a white paper in 2008 is blockchain, a digital service solution that can record transactions between parties in an efficient, verifiable, and permanent manner (Gupta, 2017; Iansiti and Lakhani, 2017). Commonly discussed as being the technology behind Bitcoin, blockchain (or distributed ledger technology) today has applications beyond financial services and markets to include social businesses (Mukkamala, 2018), the fashion industry (Choi, 2019), healthcare (Engelhardt, 2017), smart cities (Bhushan, 2020; Sun *et al.*, 2016), smart contracts (Danzi, 2017; Goldenfein and Leiter, 2018; Nugent, 2016), the energy industry (Hinterstocker *et al.*, 2018; Oh *et al.*, 2017) and government and e-government sectors (Geneiatakis, 2020; Jun, 2018; Tshering and Gao, 2020). As such, blockchain is not so much considered a disruptive technology but rather, a foundational technology with the potential to create new foundations for our economic and social systems (Gupta, 2017; Iansiti and Lakhani, 2017). The impact of this technology adoption and use will be long term and observed in the following decades depending upon its acceptance and use. An industry example in which blockchain can make foundational changes is its potential applications and use in the management of supply chains and traceability in the food and drinks industry (Gopi *et al.*, 2019; Kamilaris *et al.*, 2019; Kuhn, 2019; Mieras *et al.*, 2019; Qian *et al.*, 2020).

1.2.1 Blockchain in food and drinks supply chain

In 2014 the dynamics of the global wine supply chain from Europe to China is characterised by diverse sales and distribution structures that result in highly uncertain business environments (Manuj and Mentzer, 2008). The Chinese are relatively quick to

adopt new technologies and are avid users of the Internet (Juanwen, 2011; Qiu, 2012; Salazar, 2011). The Chinese internet population was around 883 million in 2019 and is expected to be 1.14 billion by 2025. In comparison, the United States Internet user-base was 281 million in 2019 (Thomala, 2020). The majority of the population access the Internet through their smartphones, via Chinese developed social media sites and microblogging sites such as WeChat, Weibo, Youku and Douban (Pradier, 2020; Tong, 2010).

Chinese developed social media sites have attracted considerable interest from the French wine industry, where they have set up their own Weibo pages including Brane-Cantenac from Bordeaux, CIVB, Les Huit de Loire, JX Bordeaux, Moët and Chandon, Wines of Provence, Rhone Valley Wines and the Bergerac Group. Yet, in terms of GVC mapping, non-standard platforms of trade, differing regional laws of trade and the need for continued relationship building between the stakeholders create a need for reliable traceability tools and traceability systems (Bouzdine-Chameeva and Ninomiya, 2011; Gereffi *et al.*, 2005; Gereffi and Lee, 2016; Patchell, 2008; Pradier, 2020) .

An example of a European founded multinational enterprise (MNE) who offers food and drinks blockchain-based traceability as a services solution is German founded Siemens AG. Figure 2 (Siemens, 2019, p.2) illustrates how their blockchain-based traceability system operates, and how it connects with the Internet-of-Things (IoT) that much characterises current workings of the manufacturing industry.

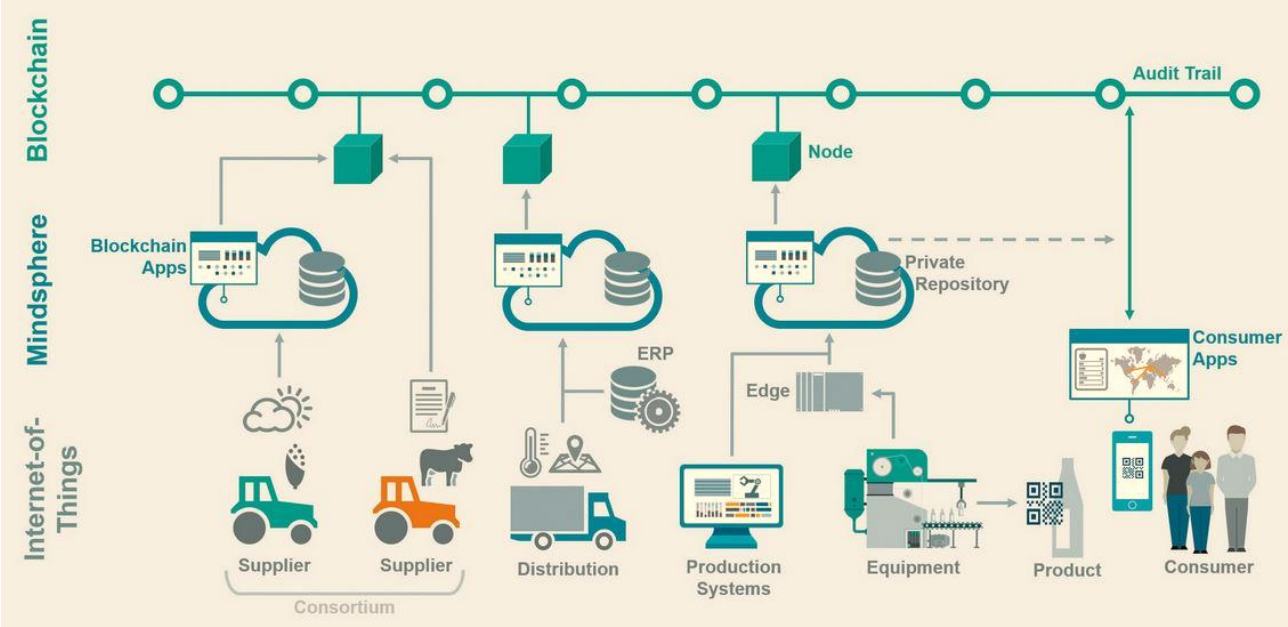

Figure 2. Conceptualisation of a blockchain-based traceability system by Siemens AG (Siemens, 2019, p. 2)

In the business context of MNEs, earlier phases of blockchain-based technologies saw challenges with collecting and transferring data to the blockchain in industrial environments which threatened its feasibility, however, with increasing access to the Internet, provision of digital solutions and services, cloud computer and the decreasing cost of IoT, MNEs have found it relatively relevant to adopt blockchain-based services and solutions for their clients (PwC, 2018; Siemens, 2019; Zhang *et al.*, 2019).

The business context and GVC of wine between Bordeaux, France and China however differs from that of the MNE due to that most wine producers in Bordeaux are family owned, labour-intensive small medium enterprises (SMEs). As such, the wine

supply chain faces a different set of challenges, which is the general subject of investigation of this study, using a UTAT perspective.

1.2.2 Studies on blockchain adoption and use

Even if MNEs seem to find it relatively relevant to adopt and provide blockchain-based digital services and solutions, the technology for full deployment in IoT remains in its emerging phases, with differential rates of technology adoption for different industry sectors (Galvez *et al.*, 2018; Iansiti and Lakhani, 2017). Most blockchain-based adoption studies have focused on the application possibilities and scalability of blockchain as a main barrier to acceptance and use of the technology (Biryukov *et al.*, 2014; Henry *et al.*, 2018; Jawaheri *et al.*, 2017; Pedrini *et al.*, 2018; Zheng *et al.*, 2018). Other studies conducted on the challenges to blockchain adoption come from the perspective of technological maturity (Wang *et al.*, 2016), from a value driver perspective (Angelis and Ribeiro da Silva, 2019), innovation theory perspective (Clohessy and Acton, 2019; Reddick *et al.*, 2019). Table 1 (Olsen *et al.*, 2019, p. 31) is an example of barriers to blockchain adoption as given by respondents who worked in the agriculture food product supply chain, specifically in the red meat supply chain and the herb and spices supply chain. This study also distinguishes between a traditional electronic traceability system and a blockchain-based traceability system. Table 1 has 3 colours. The light green shading indicates potential benefit and the dark green shading indicates strong favourability of using a blockchain-based system. The faint red shade indicates potential challenges to the adoption of blockchain-based traceability system for the supply chains studied. This study showed that when deciding between a traditional implementation of an electronic traceability system and a blockchain-based one, system priorities needed to be identified. If transparency, integrity and robustness is important, then a blockchain-based solution is relevant. If however, speed and data confidentiality are important, then a traditional electronic traceability system is preferred (Olsen *et al.*, 2019).

Table 1. A generic cost and benefits overview of a blockchain traceability system for the food product supply chain (Olsen *et al.*, 2019, p. 31)

Comparison criteria	**Traditional electronic traceability system**	**Electronic traceability system based on blockchain technology**
Suitability of database	Records (claimed) variable states, versatile	Records transactions, well suited for recording transformations
Data quality and veracity	Data provider must check and vouch for data quality and veracity	Data provider must check and vouch for data quality and veracity, but fraud frequency may be lower, as risk of getting caught is higher
Immutability, integrity and transparency	Data elements can be overwritten; needs additional recording (transaction log or similar) to document this	Only the transactions are recorded, which means a higher level of integrity and transparency of the claimed values
Confidentiality	Easy to integrate tiered levels of access	Can be done, but to some degree it goes against the philosophy of what a blockchain implementation is meant to support
Trust	Based on trust in the food business and the brand	Still based on trust in the food business and the brand, but trust may be higher because of higher degree of data integrity and transparency

Robustness	Duplication, back-up, and other means of providing robustness must be provided by external processes	Robustness and duplication of data is built into the system
Speed and efficiency	As good as you can get	Significant overhead related to duplication, error checking, consensus mechanisms, and calculating the state of variables based on transactions
Interoperability	There is a plethora of systems, implementations, and database structures, there are a number of standards for TRU (traceable resource unit) identification and Electronic Data Interchange, and there are very few standards defining how the recorded data elements should be named and measured. This means that system interoperability (exchange of data) is a big problem.	Blockchain-based systems are less diverse; they all record transactions (transformations) rather than state values, and they are all immutable. Interoperability and data interchange between blockchain-based food traceability systems is easier than between existing systems, any many of the success stories reported is because a higher degree of interoperability has been achieved.

Current literature indicates that studying blockchain in traceability systems adoption for the food and drinks industry from a unified theoretical framework of analysis remains understudied (Schuetz and Venkatesh, 2020; Wong *et al.*, 2020). In that sense, the methods and findings of this study aim to complement other UTAUT (unified theory of acceptance and use of technology) studies that have investigated for blockchain adoption in the financial sector (Schuetz and Venkatesh, 2020), in supply chain management in the building and construction industry (Wong *et al.*, 2020) and supply chain management in manufacturing industries using surveys and structural equation modelling (Fosso Wamba *et al*., 2020).

1.3 Technology use and acceptance studies

The past forty years have seen scholars design theories/models in understanding of the influencing elements of acceptance and use of technologies. In the 1970s, Theory of Reasoned Action (TRA) was put forth by Fishbein and Ajzen *(Ajzen, 2012; Vallerand et al.*, 1992), which explained a person's behavioural tendencies with the aim of predicting changes and interpreting particular personal behaviour. TRA was formulated based on the assumption that behaviour is shaped by intentions that in turn depend on personal attitudes and subjective norms. A decade later, Theory of Planned Behaviour (TPB), was proposed an extension of TRA working on the assumption that behaviours could be controlled by certain parameters in context (Ajzen, 2011). A Technology Acceptance Model (TAM) was proposed to explain the causal relationships between internal psychological variables such as beliefs, attitudes and behavioural intention and actual information technology (IT) system (Davis *et al.*, 1989). The widely studied and considered valid TAM model was based on the two constructs of the User that were Perceived Usefulness (U) and Perceived Ease of Use (E). These constructs were considered more effectively applicable in predicting individual acceptance behaviour across various information technologies and their users. Subsequent models developed include the combined TAM and TPB, resulting in TAM versions 2 and 3 (TAM2/TAM3)

that focused on the impact of experience of use of technology (Taylor and Todd, 1995). TAM2/TAM 3 models were a theoretical extension of the TAM that included the perspectives of subjective norms and job relevance when accepting the use of new technologies (Venkatesh and Bala, 2008; Venkatesh and Davis, 2000) and Unified Theory of Acceptance and Use of Technology, UTAUT (Venkatesh *et al.*, 2003). The 6 broad constructs of UTAUT include:

(i) performance expectancy (PE) – the degree to which an individual believes that using the system will help them improve on job performance
(ii) effort expectancy (EE) – the degree of ease of use by the individual of the system
(iii) social influence (SI) – the degree to which the individual perceives it important that others perceive them to use the new system
(iv) behavioural intention (BI) – the degree to which the individual intends to use the system
(v) use behaviour (UB) – degree of affect on the part of the individual when using the system
(vi) facilitating conditions (FC) – the degree to which the individual feels they have the resources and support (technical / organizational) to use the system

An additional four constructs that moderate technology acceptance and use are gender, age, experience and voluntariness of use (Figure 3).

UTAUT continues to be widely used across various technology management studies even if other models of technology acceptance such as Model of Acceptance with peer support (Venkatesh, Sykes, Venkatraman, Sykes, and Venkatraman, 2014) and Content Acceptance model (Barelka *et al.*, 2013) have been proposed.

The UTAUT model generally focuses on the causal (cause and effect) relationship between individual attitudes towards using a technology, personal tendencies towards using a technology, actual use of a technology and identifying performance expectancy of a technology. In this model, FCs are taken as the main determinant factor in the use of a technology or system (Venkatesh *et al.*, 2003).

This study applies the 6 broad constructs of UTAUT in investigating the acceptance and use of anti-counterfeit technologies in the wine supply chain.

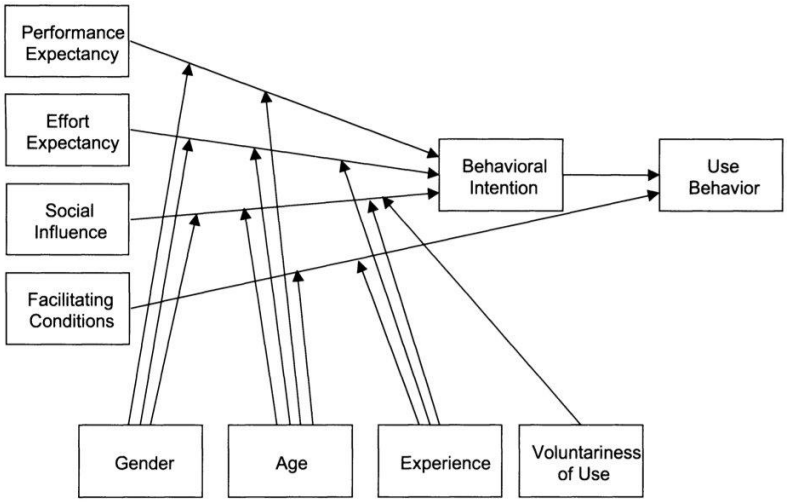

Figure 3. Model of Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh *et al.*, 2003, p. 447).

2. Research method

Taking a qualitative approach, this study applies UTAUT as a framework of analysis in order to understand user intention and behaviour in adoption and use of blockchain-based traceability supply chain solutions in the food and drinks supply chain, specifically the global wine value chain. 3 field studies were conducted between 2018 and 2019 to Bordeaux, France, to Shanghai, China and to Chengdu, China. A total of 16 respondents from Europe (5 respondents) and China (11 respondents) were interviewed. The interviews were transcribed in accordance to the Gothenburg Transcription Standard version 6.4 (Nivre *et al.*, 2004) in order to make the collective interview texts machine readable for a word concordance analysis (i.e., finding of words, phrases and corpus structures for how the respondents speak about a topic in detailed context).

The respondents are stakeholders in the global wine value chain. The UTAUT framework of analysis is relevant for this qualitative analysis because it has a strong academic-practitioner user and application base (Javidnia *et al.*, 2012; Lee and Song, 2013; Venkatesh and Bala, 2008; Venkatesh *et al.*, 2014; Viswanath *et al*., 2002) and it offers a comprehensive overview of various dimensions to technology adoption and use. However, there are limitations to the UTAUT framework of analysis, where it is individual user-based focused, and time-instantaneous, which is capturing technology use and acceptance at one specific point of technological maturity (Cordeiro, 2018; Mckeown and Anderson, 2016; Williams, 2015). For the purposes of this study, the individuals interviewed represent ideas and workings behind their organizations, where it is assumed that the implementation of a blockchain-based traceability system will need to be an organization decision. In the case of the global wine supply chain between Bordeaux, France and China, international trade agreements might need to be discussed between multiple organizations along the wine supply chain. As such, the factors of "gender", "age" and "voluntariness" of use in the UTAUT framework might not be as relevant for the purposes of this study, and the respondents are broadly classified as "Producers" (2 respondents who were in the business of grapevine growing, and wine production in France), "Traders" (11 respondents who were in the business of importing, exporting and distributing wine between France and China) and "Governance" (3 respondents who were in government and/or government related institutions that support the global wine value chain and who have the goal of supporting trade between Europe and China). In general, the respondents ranged in age between late 20s and late 50s. They were mostly male (13 males, 3 females) and could in general be described as knowledgeable of European and Chinese cultures. 2 respondents were fluent in speaking both French and Mandarin, switching between the languages as the interview progressed. Some French respondents have lived in China for more than a decade, and some Chinese respondents have had extensive network contacts with French wine producers even if they had not themselves lived in France.

Each interview followed a semi-structured interview guideline created for the purposes of this study to illicit open-ended and closed-ended answers. This is in order to tailor for the perspectives of the respondents based on their main role played along the wine supply chain. The semi-structured interview gave a flexible framework to which the main purpose was to encourage the respondents to share their insights on the wine trade between Bordeaux and China, highlighting the challenges they faced, and if there were any means used by their own organizations to address those challenges. The interviews were transcribed in accordance to the Göteborg Transcription Standard version 6.4 (Nivre *et al.*, 2004), which provides a means for standard orthography to be used in a manner targeted at recording pauses, interruptions and para-linguistic activities during the communication.

The transcribed interviews formed a small data corpus of about 55 371 words. A small corpus is defined as a data corpus of less than 80 000 words (Aston, 1997) with specific advantages such as focused subject to be studied, and more efficient access to words in context for deeper qualitative analysis. In this study, the corpus has the advantage that its contents are highly focused on the topic of wine supply chain management between Bordeaux, France and China, and that information was quick to access/find in the corpus data. The concordance software AntConc (Anthony, 2019) was used to facilitate co-occuring words (phrases, sentence structures) and keyword in context (kwic) analysis, where keywords such as "blockchain", "technology", "fake wine" or "counterfeit" can be searched efficiently in the compiled interview transcripts.

3. Findings and discussion

The UTAUT framework is designed to effectively investigate user perspectives on technology acceptance and use. In this study, the respondents and the organizations in which they belong were broadly grouped into functions located along the wine GVC which are Producers, Traders and Governance. The respondents were viewed as actors within enterprises and institutions in the network of the wine GVC. The 6 dimensions used when discussing with the respondents include their PE (performance expectancy), EE (effort expectancy), SI (social influence), BI (behavioural intention), BU (behaviour use) and FC (facilitating conditions).

In address to RQ1, what barriers to blockchain-based traceability systems can be identified in current methods and tools of wine traceability found in the wine GVC, Table 2 shows the subjective modal or attitudinal expectations of the respondents with regards to blockchain traceability systems and its expected future impact on their organization or enterprise. It can be seen that the 6 broad categories of UTAUT in relation to acceptance and use of anti-counterfeit instruments and traceability systems had varying importance for the respondents, depending on their business priorities, the size of their enterprises and their perspectives adopted.

With some reservations from a few respondents, most respondents in both regions (Europe, EU; China, CN) had high expectations (of *performance expectancy, PE*), that a blockchain based traceability system will be quite effective. What remains uncertain would be the cost of and extent of efficiency (*effort expectancy, EE*) once implemented. For some respondents, mostly in Europe, who are producers and in governance institutions, a blockchain-based traceability system has potential to be implemented with varying degrees of relevance. For larger operations, it can help towards greater accounting of product life cycle assessment and the wine growing impact of production on the environment. Concern for the environment is high as the respondents, particularly the Producers and wine growers acknowledge that the warming climate might in the near future, impact the type of grapes that are grown in the region. In that sense, broader policies and infrastructural support from the government for example, would certainly be socially influential (*social influence, SI*), and behaviour changing, in the manner of intention to use the system (*behavioural intention, BI*) as well as how using the system will affect their daily work routines (*behaviour use, BU*). Regional agreements and policies, even though not at the top of the minds of most producers and traders of wine, are believed to either incentivise or de-incentivise the acceptance and use of blockchain traceability systems (*facilitating conditions, FC*).

Table 2. Ranked subjective modal expectations of respondents on (L = Low, M = Moderate, H = high or "-" for no response) for blockchain traceability system in terms of future impact on their wine supply chain management using the dimensions of PE

(performance expectancy), EE (effort expectancy), SI (social influence), BI (behavioural intention), BU (behaviour use) and FC (facilitating conditions)

Resp.#, Region	PE	EE	SI	BI	BU	FC
1. Governance, EU	H	H	H	M	-	L
2. Trader, EU	H	H	L	L	L	M
3. Trader, EU	H	H	H	H	M	M
4. Producer, EU	H	H	M	L	L	M
5. Producer, EU	H	H	M	L	L	L
6. Governance, CN	H	M	L	L	M	H
7. Governance, CN	H	L	-	-	-	H
8. Trader, CN	H	M	L	M	-	M
9. Trader, CN	H	L	H	M	M	H
10. Trader, CN	M	M	H	-	-	H
11. Trader, CN	H	L	M	M	-	M
12. Trader, CN	H	L	M	M	L	M
13. Trader, CN	H	H	M	M	-	M
14. Trader, CN	H	L	M	M	-	H
15. Trader, CN	M	M	M	H	-	M
16. Trader, CN	H	L	H	M	M	H

The following sections discuss the findings in greater detail for Producers, Traders and those in Governance of the wine GVC and network.

3.1 Producers

Two respondents were French producers of Bordeaux wine in France. There are over 14 000 wine growers in the Bordeaux region producing 600 mL of wine annually (Hall *et al.*, 2018). The respondents worked collaboratively in a French collective for the region and were small family businesses that in high season, would engage help for the labour intensive harvest from extended family members and neighbours, after which they would throw a harvest party. They described their businesses as fairly low technology oriented (compared to larger Château operations), and still rooted in wine growing tradition of using the family recipe to produce wine. Due to the size of their operations, they saw little need for adopting advanced digital service solutions in logistics for their wine making

process. As such, their expectations and perceptions of a blockchain-based traceability system are High on the PE and EE, where they expected a blockchain-based traceability system to be a highly efficient digital solution for its purposes, but it would also mean that they would expend energy and time to learn how to implement and integrate that system with their current processes. They ranked Moderate on the SI or social influences, saying that if the collective in general moved towards increased digitalization, then they too might be incentivised to adopt digital solutions. Their expectations were Low on the BI, BU and FC. They did not know of any current facilitating conditions in either government infrastructure or policy for small enterprises that would encourage them to use a blockchain-based traceability system. One respondent voiced that even if there were facilitating conditions, they would not adopt the technology due to privacy reasons. Some stages in wine processing were highly held family recipes, and if adopting a digital services solution would mean that they needed to log their processes for greater transparency, it would discourage them from a full adoption of that technology. In terms of BU or behaviour use, one respondent acknowledged that the wine growers collected was "…very compartmented, with many small groups of people working different. I think many of us would also like to keep it this way because it is our tradition. If there is fraud then it is outside, and not for us to handle. The French government will take care of that. We have nothing and we can do nothing." What French wine producers can guarantee for a geographically indicated product is product and process authenticity, but once bottled or delivered to an intermediary, they seem to currently have little control of what might happen in the process of the supply chain management.

3.2 Traders

For the Traders, the most salient UTAUT category with high positive modality is that of PE. Respondents in Europe and China cite high performance expectancies based on different enterprise priorities, even if they broadly held the position of "Traders" in the wine GVC and network. Nuances of perspectives come through between European and Chinese traders. In China for example, Traders were concerned about the point of view of their end-consumers, where prestige and politeness of face is of high concern. Bordeaux wine is highly prestigious compared to other new world wines, even if trends might change in the near future. A blockchain-based traceability system may be helpful to the extent that it can verify for their customers, that the bottle has origins and is authentically Bordeaux. Chinese traders were highly concerned about counterfeiters who sell fake Bordeaux wines, that leads to a scandal in the distribution and continued loss of trust from consumers. Facilitating conditions (FC) are improving for the Chinese market, as many have acknowledged that the authorities on both sides have stepped up efforts to improve the integrity of the wine GVC between Europe and China.

The respondents who had High expectations for facilitating conditions cited a vast improvement in the curb of the counterfeit wine market in China since about a decade ago when the market was described as "the Wild West". But even if counterfeit measures have been adopted by many Chinese trading companies, such as the use of holographic stickers or Quick Response (QR) codes that when scanned can verify country of origin, there remains worry about the reputation of wine sellers. As one Chinese trader ($TCN3) relates:

> $TCN3: we have been working with our china customs service for a common solution / right now there is one nfc [near field communication] code per bottle / but they can still copy it / so it creates a lot of work for us to check and verify / we have many labels and quantities / sometimes we also get the news that our wines

> are copied / everything is original except the wine inside / this will affect our reputation badly

For European traders, the question of product sustainability, geographically indicated products, and farming impact on the environment are combined issues with food traceability, safety and authenticity. These contextual elements are highly encouraging and relevant for the adoption of a blockchain-based traceability system. But due to French wine producers being mostly small family-based enterprises, with their intention (BI) to use blockchain-based traceability systems ranging from moderate to low due to scalability and cost, Traders thus need to follow suit and a traceability system cannot be implemented without cross-platform interoperability, the reason for the Moderate social influence (SI), behavioural intention (BI) and a general lack of comment in behavioural use (BU). Traders could not see that there would be any intention to adopt a blockchain-based traceability system between France and China, much due to that governance policies need to be agreed upon between the countries, not in the least a shared digital platform of services solutions for logistics that currently does not exist.

There is also worry from European traders of trust erosion from consumers. As respondent $TCN1 relates:

> $TCN1: the problem is that it is not only me it is the customer / the customer is misled / they go into a shop and it is wine bordeaux they look at / the wine is not famous / it is from chateau moussard / as a trader you know there is no chateaux moussard / but then the sellers say chateaux moussard is bordeaux but less famous / so you see the customer is lost by the offer because 30 to 40% is lafey / which is fake

However, even if $TCN1 feels worried for the customer, the respondent is neither too enthusiastic about blockchain traceability systems nor other technological anti-counterfeit instruments:

> $TCN1: you mean technology to help with new bottle labels / or other systems // no it's too long process / all this fake wine is happening now / you need controls / you can read now on wine boxes / wrong translations from french to chinese / wrong prints / these are not technologically advanced ways of anti-counterfeit / they are normal ways to see counterfeit products / you need just more strict controls

Even if the Chinese business environment provides high FCs for acceptance and use of emerging technologies, some current misgivings remain about the implementation of a blockchain traceability system in relation to enterprise privacy. $TCN6 relates:

> $TCN6: yes if more people imitate you / it means you are still very famous in china / and sometimes we do not disclose our figures / because we do not want our competitors to know our progress / because there are many counterfeiters / as what you see in china / there are many wine producers / they want to make the luxurious fake wine

3.3 Governance

There were 3 individuals who worked in government institutions with the aim of bolstering EU-China trade where one could see that together with wine traders, individuals in governance consistently work towards improving of market and consumer

trust. In address to RQ2, to what extent can emerging blockchain-based traceability systems can restore trust in the wine GVC stakeholders, including market end-consumers? Responses were both optimistic and cautious at the same time with regards to a complete blockchain-based traceability system adoption across regions. While there were high performance expectations (PE) with adopting a blockchain-based traceability system, it was acknowledged that there would be considerable amount of effort (EE) that needs to be dedicated towards a behaviour change (Moderate and Low BI as well as BU). The facilitating conditions (FC) were viewed differently, depending upon regional business contexts and technology developments. Respondents from China for example were more optimistic, having seen new technologies for counterfeit measures being adopted. The past decade has also seen increased efforts in China to hold fake wine producers responsible by law (Shaw, 2020). The European side were more cautious, acknowledging that it will take time and effort to create operation standards between the regions as facilitating conditions for full adoption of a blockchain-based traceability system.

3.3.1 Complex accounting systems

Quick technology adoption and use in China was expected in the Chinese business environment, where activities seem to move faster. The Chinese business context is generally characterized as fast evolving with relatively high uncertainties due to the market's vulnerability to the forces of globalization. Due to the long wine GVC and the number of interconnected networks and stakeholders involved, a full adoption of a blockchain-based traceability system that functions smoothly between the EU and China will take time to develop. At the moment, with most wine imports arriving in from Hong Kong[2] and then brought to mainland China, there exists a complex recording of goods that are incoming and outgoing, where import numbers and names can be changed (*i.e.* from French to Mandarin). In such a context, records can likely be lost. As one respondent ($TCN11) relates:

> $TCN11: we know that one of the ways that the counterfeiters operate is that they get in touch with a wine merchant and they make a purchase / they purchase a small quantity / and then they have all the documents to make this batch of genuine wine / but then they are producing the wines locally / and then the batch was exported to china / with all the original documents and everything / but the contents are fake / for the average consumer / they look at the market / and some of them only want the best wine for the cheapest price / that's it / so that's the way it works / and there are no controls at all / because the system runs both ways // and the numbers are changing / different regions in china / different numbers of counterfeiters and sometimes different system of accounting / in some regions there is no system where you check what is coming in and getting out / there's no record keeping / there are no labels / nobody seems to care

3.3.2 Relationship and network knowledge intensive

Rebuilding consumer trust takes time and leadership by example. This means maintaining a wide network of knowledge workers, bridging both the French producers and traders with the Chinese traders and consumers. It requires timely information sharing

[2] Hong Kong leads Bordeaux wine exports with 16% market share, ahead of China (15%) and the US (13%) with 10 million bottles of exported Bordeaux wines worth 327 million EUR in 2018 (Wang, 2019).

and customer education about origin of product and how to identify counterfeit products which are activities outside the reach of blockchain-based digital services and solutions. To that extent, individuals in the CIVB for example have conducted wine tasting sessions as a means to socialize and educate their customer base on the wines of Bordeaux. As one respondent ($TCN2) relates:

> $TCN2: we have to work very hard to get those top customers to come to a tasting / you have to plan the event / you can't also just go to where they are and do a dinner and expect them to be there / it doesn't work that way // with importers / we give our importers tools and information to sell the tasting sessions and events / to create such events / you have to create a bond between you and the importer // and if you decide to make a market visit / probably the most important is to do the events and create this bond between your importer where they also can share the information // this way / you get to know the business / where you get to know the problems they're facing and what you can do to resolve that set of problems // also provide examples / if you're going to the market to a visit / you've got to take some wine / you've got to take the samples and give the samples / I mean there's no reason you would turn up and expecting they're providing all your bottles / you've got to give them the allowance to do so / so we provide examples

3.3.3 Language translation challenges

The issue of language, intellectual property rights (IPR) and trademarking can prove to be a challenge when products cross between Europe and China. One respondent cited lengthy trademark application times as well as language translation challenges due to the different writing systems. In such instances, a trademark of a company can be filed and approved, only to find that a similar trademark had been registered by a different company and a trademark infringement case ensues. In such instances, it could potentially take years in court to untangle the situation with a resulting loss of branding, product sales and consumer trust.

In some instances, a general lack of knowledge about Europe and France leads to mislabeling when the wines are imported and recorded. As respondent $TCN7 relates:

> $TCN7: what I assume in some cases is / and I'm not 100% extremely sure / but some of the bottles they arrive like this / they arrive from france / from italy / and then they put a label which is different / so they will purchase in regions where it is cheap / let's say languedoc / and then you put medoc or put whatever you want / a region that you know will sell at a higher price / and they could do it because they are thinking they are actually helping this trade / because the fact that the bottles come with these mini labels / the misunderstanding is that the bottle is free to put any new label on it / and then when you translate it into chinese / it can also be a different thing / a more expensive product

Language translations can hinder anti-counterfeiting efforts when trying to make regional systems compatible. Currently there exists numerous digital traceability system platforms that are currently non-compatible and thus non-interoperable. Standards between regions also differ for authentic product identification between the European Union (EU) and China and product labels / names get recoded upon entry into China.

While blockchain-based systems are more homogenous and therefore more interoperable, this feature is an emerging application. Most successful applications are

based on the existence of parallel standards in electronic data exchange and data content.

Conclusion

The subject of food security, traceability and authenticity is one of developing interest for both academia and practitioners. This study takes a qualitative approach in applying UTAUT as a means to understand general attitudes and behaviour intention in stakeholders along the global wine GVC in adopting a blockchain-based traceability system. Taking the wine GVC and the example of the Chinese market for French Bordeaux wine, stakeholders whose organizations and institutions represented different functions along the wine GVC were interviewed. In applying the 6 broad UTAUT categories, the findings showed that a blockchain-based traceability systems is promising in its delivery of authentic wines tracing and logistics tracking. However, facilitating conditions (FC) needed to be coordinated between EU and China and the multiple stakeholders in the wine GVC network will need to be committed in effort (EE) to make a change in their operational processes in this digital service solution transformation.

A guiding purpose for this study is to contribute to the growing literature on technology adoption studies, particularly applying a unified theoretical perspective such as UTAUT. The novelty of contribution and findings is the subject of UTAUT application to study the behavioural intention to adopt a blockchain-based traceability system for multiple stakeholders situated along the wine GVC network between the EU and China, in particular, France and China.

This study is limited to the context of stakeholders (Producers, Traders and respondents in Governance positions) in the wine GVC, specifically that of Bordeaux wines. Whilst carrying out interviews for this study, it was noted that other French produced wines such as those from Languedoc and Burgundy might become increasingly popular. Wines produced in Australia such as Penfolds and new world produced wines are also being increasingly explored by Chinese wine consumers. The label "Made in China" is also getting a luxurious branding with the French luxury multinational LVMH Moët Hennessy investigating (since 2011) possibilities to cultivate Bordeaux-variety grapevines in the mountainous corridors of Ao Yun in the Yunnan province which borders Tibet (Schneider, 2019). These industry and market developments indicate that the Chinese wine market will continue to be an interesting subject of study in terms of counterfeiting technology adoption by wine merchants and importers as well as the rapidly evolving taste preferences of the Chinese consumers for wine.

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