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Co-creating interactive dining experiences via interconnected and interoperable smart technology

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ABSTRACT

Dining is an essential part of daily life, and the business of any restaurant is to satisfy its customers by co-creating positive dining experiences on every occasion and at every stage in the process. This paper proposed an interconnected and interoperable smart service network to co-create interactive post-pandemic dining experiences that are beneficial to both the customers and restaurant operators by broadcasting personalised location-based promotional messages aggregated from external contextual information collected via sensors attuned to customer dining habits; shape expectations via ambient, sensory information, and images; interact with customers and assist their dining choices by artificial intelligence recommendation systems; and can cook and deliver meals by automated robotic technologies. The theoretical contribution of this paper focuses on developing a smart dining experience framework which optimises the interaction among smart technology, service staff, restaurant managers, customers, and their collective experience. Restaurant managers' awareness and integration of smart technologies and smart services can enhance the overall customer dining experiences and post-dining feedback for continuous real-time improvement.

KEYWORDS

Smart technology; value co-creation; dining experience; restaurant service; smart network

1. Introduction

Eating-out is an immensely popular and growing trend, and diners are increasingly more global in their tastes and lifestyle choices. Furthermore, people tend to spend more time at work nowadays, leaving less time for cooking and eating. Bernard et al. (2012) have identifiedsome of the many reasons people choose to eatoutside their homes, such as for social occasions (e.g. birthdays, anniversaries, Valentine's Day, Christmas and the New Year), business meetings, convenience,as well as time savings related to purchasing ingredients, cooking meals, and washing up afterwards. Other reasons include the pleasantness of a restaurant atmosphere and being able to enjoy thecooking and serving skills of the kitchen and wait-staff. Regardless of the reasons for eating-out, once the customer makes a decision, the dining experience then becomes a primary reason that affects their subsequent decision to re-patronize the restaurant or go elsewhere.

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Previous studies conducted on restaurant technology mainly focused on operations management and yield-management (Leung & Law, 2013). For decades, information technology has been recognised for its contributions in offering more convenient access and potentialities for existing customers, better cost-effectiveness, and more efficient delivery of products and services (Bethapudi, 2013; Huo, 1998; Kimes, 2008). With the more recent popularity of smartphones and mobile applications, an increasing number of self-service technology and autonomous devices have become available for restaurant service providers and patrons. The advancements in self-service technology have become increasingly more significant, influential, and are being incorporated not only directly into the dining experience (Beldona et al., 2014),but also the customers' overall experiences including changes upon their attitudes and behaviours (Dabholkar & Spaid, 2012). In short, smart technology has been and continues to be adopted across the restaurant industry at different levels and with different impacts upon customers and restaurant operators. However, there have been limited studies about smart technology service and the restaurant dining experience (Ivanov et al., 2017).

The evolution and emergence of smart technology service in the dining experience parallels the increasing number of customers and their varied dining preferences. Strategic use of smart technology can enhance efficient service and help provide an exciting and hopefully memorable dining experience. Many restaurant companies are utilising smart technologies to provide sophisticated dining experiences. With unique value co-creation with customers via smart technologies, restaurateurs can gain a competitive advantage in the midst of a highly dynamic and changing industry. However, the knowledge and emerging ideas about how to comprehensively incorporate smart services into the restaurant dining experience is in its infancy.

Restaurant service is a significant part of touristic activities. With the increasing role of technology in restaurant service, the development of smart cities has direct implications upon the implementation of smart restaurant services. For instance, sensors and beacons enable organisations to identify the customer's location and send out push-promotion messages. Robots and self-service devices encourage customers to take control and personalise their own desired services, while AI and machine learning ability provides indicators of customer behaviours and revenue forecasting. However, smart city cannot be implemented without local government support. For example, Taiwan began providing free Wi-Fi access points to all residents and tourists in 2011. This measure satisfied the public need for internet access during outdoor leisure or business activities. Thereafter, the National Development Council initiated the smart city project with open government databasesfor public access(TECO, 2019). The most recent project, 'Smart Taipei', solicitated industry practitioners to submit proposals on seven steeringareas, including smart traffic, smart buildings and data security (SmartCity.Taipei, 2019). This measure created the smart city infrastructure, and all industries are allowed to access this government-owned smart network. Here, they can implement smart technology and enhance their smart services.

This paper aims to shed more light on the restaurant manager's awareness and use of smart services that can enhance the overall customer dining experience and elicit post-dining feedback that is valuable for future operational improvements. This conceptual study draws upon an extensive body of research on restaurant technology development and adaptations. These sources were assessed and analysed to yield a preliminary smart

service foundation model/framework. This smart service foundationmodel/framework, in turn, was used to further explore the developments of information technology in the restaurant industry. Finally, the authors examined the implementation of technology in restaurant management, operations, and customer service.

2. Literature review

2.1. Dining experience

An array of diverse studies (Dixon et al., 2009; Namkung et al., 2007; and, Wijaya et al., 2013) have categorised the dining experience into different approaches and/or stages. For instance, Dixon et al. (2009) investigated customer preferences for restaurant technology innovations, and proposed five distinct dining stages: pre-arrival, post-arrival, pre-process, in-process, and post-process. Later, Kimes and Collier (2014) proposed a similar series/sequence of six dining experience stages: pre-arrival, post-arrival, pre-process, in-process, post-process and turnover. In Namkung and Jang (2010), the author-s'inquiry about service failures in restaurants, introduced the dining stages of reception, ordering, meal-consumption and checkout. Within the meal-consumption stage, they proposed several sequential service stages which are post-arrival, pre-process, in-process, and post-process. The findings and insights of these studies have greatly fine-tuned the considerations of researchers and practitioners alike.

A more recent study conducted by Wijaya et al. (2013)focused upon international visitors' dining experiences and categorised the dining experience into three main stages: pre-dining stage, during-dining stage and post-dining stage. According to Wijaya et al. (2013), the pre-dining stage is defined as the process of forming and creating expectations of customers toward the restaurant via different marketing channels, marketing materials and activities. Customer expectations are the beliefs held by customers about service delivery which are used as the standards and reference points against which the overall quality and performance will be evaluated by customers (Zeithaml et al., 2012). This information will inform future customersabout a restaurant's products and service standards before the customer makes their dining decision.

Wijaya's second during-dining stage relates to the actual encounters of customers from the moment they enter the restaurant until just before making payment. This is the stage when restaurant operators deliver the expected standards of products and provide services to the customer/diner. Encounters between customers and wait-staff during dining can be divided into three sequential steps, which include pre-meal, in-meal, and post-meal. The pre-meal process occurs upon entering the restaurant until the order taking process is complete. The in-meal process occurs when the waitstaff serves the diner(s) and consumption of the meal is completed. The last step is the post-meal process which refers to the bill payment.

In the during-dining stage, the overall restaurant environment is critical because it affects the customer's dining experience. The restaurant environment includes the restaurant ambience (such as lighting, music and temperature) and other physical attributes such as interior decorations and the cleanliness of the observable dining area and surroundings. The third stage of dining is the post-dining stage which happens after the customers leave the restaurant and their memories of their dining experience are still fresh in their minds.

Customer perceptions of quality throughout all the dining stages are relative to the fulfilment of customer expectations and customer satisfaction (Zeithaml et al., 2012). Therefore, the post-dining stage offers a prime time for restaurant companies to collect feedback via evaluation tools such as questionnaires. Customers can share and/or rate their dining experience which will help the management to better understand the quality of their products and services offered as well as customers'behavioural intentions (Ryu & Han, 2011). Posting recent feedback and reviews of customers comments on websites, enables prospective and repeat customers to reflect upon and realistically imagine the quality of service they are likely to receive. From this feedback, the restaurant owners or management can identify any gaps that exist between their promised standards and the actual service delivered; afterwards, steps can be taken to enhance the customer dining experience. Moreover, restaurant managers should generate and update different marketing information accordingly in order to increase customer revisit intention (Barber et al., 2011).

The dining experience processes, evaluation, and action planning can benefit from the incorporation of smart technology facilities and functions. It has been demonstrated that doing so actually increases the customer's overall dining satisfaction as well as a restaurant's operations efficiency and effectiveness (Cheong et al., 2010; Neuhofer et al., 2014; Oronsky & Chathoth, 2007). Indeed, a recent study on customer dining experience reported findings on emotional values that impact customer loyalty intentions (Yrjölä et al., 2019) and another study highlighted service staff (e.g. appearance and quantity) and found that aesthetics (e.g. interior design and decorations) have influenced customer satisfaction and loyalty (İşçi et al., 2018). Therefore, capturing the insights of numerous customers also plays an important role in creating value for dining customers (Erkmen & Hancer, 2018). Allthese elements – emotional values, service staff, aesthetics and roles of other customers- should be considered and incorporated into the design and adaptation of smart technology for enhancing customer dining experiences. These elements are further discussed and explained in the next section concerning the value co-creation process and technology.

2.2. Value co-creation process and technology

Huo (1998) highlighted that a technology based restaurant along with capital availability are the two essential prerequisites for increasing market share and profits. Additional studies on restaurant technology have focused on the meal ordering process (Kim et al., 2009; Tan & Chang, 2010) and making payments (Kimes & Collier, 2014). One particular study aboutcustomer preferences for specific features of restaurant technology innovations identified five different categories: the digital menu, self-service kiosk, online operations, payment-based service innovations, and queuing (Dixon et al., 2009). Dixon et al. (2009) found that frequent technology users tend to visit a restaurant more often than infrequent users. The same study also found that different customer demographic segments have different acceptance levels of usage as well as hold different perceptions of the added value by using technology.

Robotic technologies, for instance, focus upon prediction and automated production management. Robotic systems help reduce waiting time by tracking customer arrivals, initiating cooking processes upon the customer's arrival and providing kitchen and

waitstaff with instructions that will expedite the cooking and serving processes (Noone & Coulter, 2012). Technologies provide restaurant companies a better means for cost control and consistent product quality. Routine service delivery processes are streamlined, efficiencies increased, and value co-created elements based upon customers' interests can be incorporated in a timely and meaningful manner.

Service Dominant Logic, for instance, is a relatively new marketing concept where products, either goods or services, are viewed in terms of the service offered by them to fulfil customers' needs. 'Service' is defined as the application of competencies through deeds, processes, and performances for the benefit of another entity or the entity itself (Vargo & Lusch, 2006). Value co-creation can be described as a form of collaborative creativity of customers with service providers. In the value co-creation process, the customer and service providers interact and together co-create valued outcomes for one another. Typically, a service provider initiates the process and involves customers in the creation of meaning and value in order to improve the organisation's knowledge-acquisition processes as well as service satisfaction for the customer (Kijima & Arai, 2016).

Kijima and Arai (2016) proposed a process model of value co-creation comprised of four distinct phases: (a) co-experience of service, (b) co-definition, (c) co-elevation and (d) co-development. Co-experience of service is the process in which neither the customers nor the service providers know much about the capabilities and expectations of each other but share the mutual internal model to co-define and achieve a mutual understanding of the best possible service. Co-definition occurs when customer and provider interact and co-define a common internal model that provides a clearer understanding and predetermines the preferences, capabilities, and expectations such that both parties will be happy and satisfied. Co-elevation describes the zigzag shaped spiral process of customer expectations and service provider abilities in performing key services. In this process, both parties are influencing and adjusting to each other with the express intent to elevate the service standard. Co-development of value is the collaboration that transpires when customers evaluate the values and then service providers learn from the customers' responses. These four phases succinctly illustrate the value-added interactions of smart services technology and their incorporation in another wise ordinary restaurant dining experience. The first two phases help both provider and customer to share their internal model through a mutual understanding between them; and the other two phases help providers to develop service innovations (Spohrer et al., 2007).

2.3. Smart network with the Internet of Things (IoT) and Artificial Intelligence

'Smart' has become a popular term when referring to the automation of business operations via interconnecting and interoperable applications, the Internet of Things (IoT), and social media developments (Gretzel et al., 2015). The integration of smart features has increased automation and simplified daily business activities (Buhalis & Amaranggana, 2015; Buhalis & Leung, 2018). Smart technologies enable users to almost instantaneously obtain valuable information and receive precise services from information that has been accumulated from various technical devices (Li et al., 2017). The main attraction and benefit to a smart network is its interoperability with public and private organisations' free exchange of valuable data, the ubiquitous network of IoT connected devices, smart sensors, and the capability of big data transfer from IoT to real-time

control of devices (Sun et al., 2016). The strategic integration of smartness means the restaurant can interconnect multiple stakeholders (business partners and customers) through a detailed and dynamic environment to support automated and customised service and business information interchange (Buhalis & Leung, 2018).

Components of smart cities (Boes et al., 2016; Harmon et al., 2015; Jin et al., 2014; Nuaimi et al., 2015) and the interconnectedness with smart tourism (Boes et al., 2016; Gretzel et al., 2015; Wayne, 2016) have been explored in prior research studies. Some studies have examined the electronic data interchange among internal hotel application systems (Leung & Law, 2013) and smart hospitality networks (Buhalis & Leung, 2018). The majority of these studies, however, focused on the hotel guest's experiences with in-room technology (Leonidis et al., 2013; Neuhofer et al., 2015), organisational performance (Bin Ayob & Ibrahim, 2016; Melián-González & Bulchand-Gidumal, 2016), and revenue management activities (El Haddad, 2015; Ng, 2010). However, how smart technologies affect the dining experience has been largely overlooked.

Contemporary restaurant management requires a tremendous amount of data. Internal big data (such as reservation history and marketing statistics) and external data (information collected from the external macro-environment such as nearby events, weather and surrounding environment) are required in order to provide customised restaurant services to customers as well as support management's strategic planning (Ramos et al., 2015). To provide effective and efficient restaurant service, restaurant managers should adopt technologies that can be interconnected and interoperable within the smart network at-large.

Smart networks cannot be successful without sensors and beacons. Sensors assist applications with monitoring the ongoing activities both inside and outside the business entity. With the help of sensors, information can flow seamlessly within applications (Yick et al., 2008). The IoT and the Internet of everything have revolutionised and reengineered business processes (Porter & Heppelmann, 2014); IoT provides conventional physical objects with machine-to-machine interconnections via the internet or remote control by users (Hersent et al., 2011; Holler et al., 2014). As each physical object communicates with one another, human intervention decreases and human errors are minimised (Alsaadi & Tubaishat, 2015). A decade earlier, Buhalis and O'Connor (2005) suggested that technologies designed for ambience and intelligence should be the focal point of developments in hospitality and tourism. These include sensor technology, embedded systems, ubiquitous communications, media management, natural interaction, contextual awareness, and emotional computing.

A restaurant's servicescape is arguably the most crucial component in the big-picture of any dining experience since it creates an immediate perceptual image in a customer's-minds (Kotler, 1973). Modifying a restaurant servicescape can alter a customer's sensory cues (Lin, 2004). With the combination of dynamic data collected via IoT network plus technologies such as 3D image projection with augmented reality and ambient intelligence, restaurant servicescapes can easily be modified and co-created to enhance a customer's dining experience. For example, beacons identify a guest's location and send out personalised messages according to the customers' profile preferences (Toedt, 2016). With the implementation and development of smart city networks, sensors installed around the city collect massive external data such as weather, road conditions and traffic situations that assist restaurant managers in providing customised

information and personalised services to their guests. These contextual data are sent to customers via a mobile app to heighten their pre- and post-dining experience.

Artificial Intelligence (AI) aggregates sizeable internal data sets from multiple sources by using mathematical models to compute and maximise the accuracy of management decision making (Poole et al., 1998). AI applications are emerging to add value to all processes including customer services, strategic planning, and forecasting. AI not only facilitates human-to-machine interaction but accelerates machine-to-machine interoperation. IoT handles enormous amounts of data capture, computation, and processing. Data collected from both internal and external environments via IoT objects are analysed by the central smart system. By incorporating IoT, big data and AI, the automation of restaurant service can be enriched. According to Buhalis and Leung (2018), applications within the smart network must be interconnected and interoperable in order to maximise service and minimise human error.

3. Method

This conceptual study drew upon an extensive body of research materials and case studies on F&B technology development and implementation. User acceptance and perceptions, managerial implications and expectations were assessed and analysed to help shape the preliminary smart service network proposed in this paper. Upon this foundation, future researchers can continue exploring the developments of ICT in the F&B industry and the ongoing re-engineering of restaurant management, operations, and customer service.

Desk research was the primary method of data collection for this study. The main research lenses were the hospitality context and its emerging smart technologies. Due to the rapid evolution of technology in the F&B industry, academic journal articles and Internet reports were readily accessible and consulted. From these sources, information about smart restaurant service network developments, future trends predictions, and challenges to smart service were closely examined.

Resources included journal articles, conference papers, statistics, and industrial reports. Keyword searches were used with combinations of tourism, restaurant, service, and ICT terms. Major search keywords were used in combinations such as: 'ICT in food and beverage', 'ICT adoption', 'innovation', 'F&B operation with ICT', 'impact of ICT' 'technology-assist service', 'interconnect and interoperate', 'Internet of things', 'smart service' 'service automation', 'decision making' 'strategic planning', 'customer operate device', and 'data exchange'. Only materials published after 2010 were included for content analysis to ensure the most recent technologies and methodologies were referenced. Additionally, cases and technologies related to F&B service were classified according to Kijima and Arai (2016) to address the present and then forecast the next generation of smart restaurant service. The smart network model presented in this study was adopted from the smart hospitality model proposed by Buhalis and Leung (2018).

3.1. Interconnected and interoperable smart technologies in restaurant

A smart restaurant service network architecture (Figure 1) includes four distinct levels with everything ultimately grounded within the'restaurant servicescape' in a unique co-creation of a customers' dining experience. At the 'network layer', the environment and

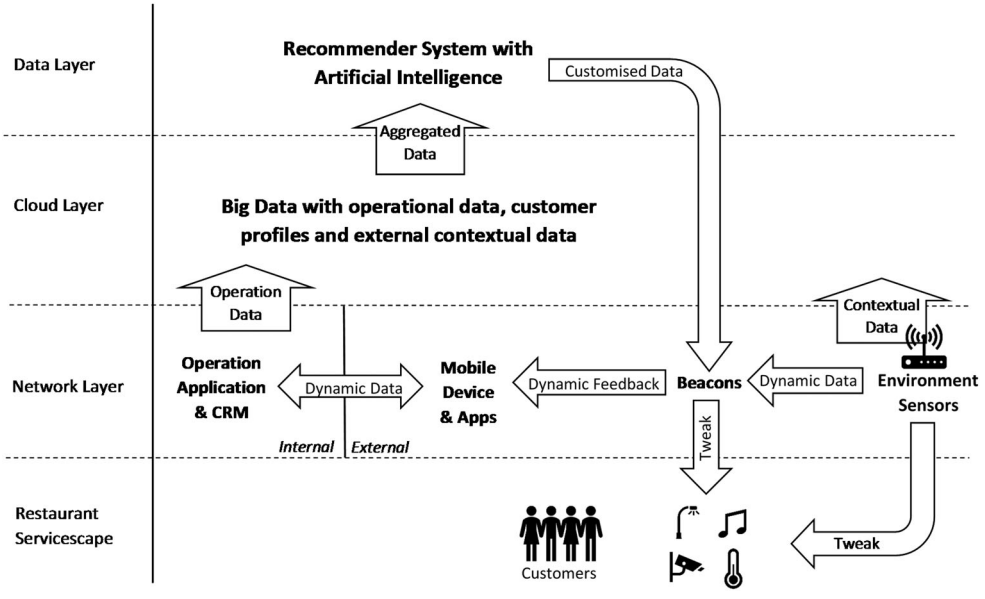

Figure 1. Proposed smart network in restaurant servicescape.

ambience of the restaurant can be modified via sensors and beacons to alter customers' sensory cues. Sensors can detect external brightness intensity and temperature level and send signals to individual systems to tweak the settings to maximise the customer's comfort (for example, energy management and ambient intelligence). At the 'cloud layer', individual customer profiles are aggregated; subsequently, recommendations are formulated at the 'data layer'. Eventually, feedback provides even more customised data for alterations such as changing the restaurant atmosphere with different colour lighting and/or images projected on the nearby walls and tables. In such a manner, every dining experience can be uniquely co-created.

Smart technologies and the three-layer smart IoT network infrastructure support creative servicescape changes like those mentioned above (Jin et al., 2014). The key activities at these three layers extract, store, aggregate, process, customise, exchange data/information, disseminateand then made accessible via mobile apps, social media, application software, IoTs, sensors and beacons. Since all application systems are interconnected and data are interchangeable, minimal human interaction is required and errors lessened.

Interconnected staff and guest operation applications, such as restaurant and table management systems, are routinised within an interactive customer ordering system. IoT, beacon and sensors, mobile apps and various kinds of sensors extract and collect contextual data from the external environment and social media platforms. With the wide range of web-enabled restaurant management applications, the communication among systems is moved from propriety customised interface programmes to a standard web communication protocol (e.g. XML) which spurs the movement toward ever more smart networks. Mobile devices and apps act as a communication hub with customers at the centre. Customised dynamic promotional push messages are sent to customers' mobile devices according to their location, dietary preferences, and visit history; this and more has been extracted from operation application and sensors. Activities conducted

on mobile apps are transferred to the software applications and CRM and thus regenerate the network with up-to-date customer information.

Data generated from operation applications and the external contextual data are stored on the Cloud and are available for sharing. Various types of sensors installed all around the city collect external contextual data such as weather forecasts, traffic conditions, parking space locations, and web crawlers extract any nearby event details and social media reviews from various websites. All data is then aggregated into various data cubes by date, time, geographical location, market segments, event types, weather conditions, and so forth for big data analysis. AI incorporated recommender systems then extract the required data from these data cubes for further analysis. By combining the customer's profile and historical dining preferences, the AI recommender system provides meal recommendations via the interactive ordering system and tweaks the servicescape ambience to match diners' desires.

3.2. Proposed smart dining experience cycle

The five elements of the dining experience cycle proposed by Dubberly and Evenson (2008) include: connection, expectation, interaction, value co-creation, and sharing.

Every dining experience begins with connection when service providers try to make an effective and affective first impression with customers. First impressions are critical. This connection can be initiated via technology channels such as websites and telephone calls as customers make enquiries and reservations. If customers can make their reservation smoothly and successfully and service employees are able to provide satisfactory answers to their questions, then a positive first impression is achieved even before the customers arrive at the restaurant.

The second element is customer expectations which include the ideas and feelings of a customer towards the products or services that he/she anticipates. These expectations could be influenced by advertising, word-of-mouth, and past experiences (Hamza & Zakkariya, 2013). Before dining, customers may search and obtain information about a restaurant's menu, locationand other relevant information via online websites such as the company's webpage, Facebook page or blogs. Also, expectations could be influenced by friends and family who have previously dined at the restaurant and have shared their dining experiences. Advertising also influences expectations; promotion and advertising via social media such as Instagram and Facebook could affect customer expectations.

The third element is the interaction with service employees which occurs by walking into the restaurant and engaging service employees face-to-face. Interactions include communication between customers and service employees on customers' needs and wants throughout their entire dining experience. These interactions give rise to the fourth element, a naturally emerging value co-creative exchange. Finally, customers share their dining experience on social networks and then the dining experience cycle starts a new.

4. Technology and the co-creation of smart restaurant dining experiences

The purposed smart network shown in Figure 1 should be embedded within a larger smart city network so that sensors within an entire city can capture external environmental data for big data analysis by AI-enabled applications. Customers canusesmart applications that

are interconnected and interoperable to contact restaurants, form their dining expectations before arrival, interact with restaurant staff and/or automated systems, and afterwards, share their dining experience on the social network. Technologies play a crucial role at all stages in the dining experience and are greatly enabled via the smart network levels both macro and micro. The following sections analyse existing smart technologies and suggest future directions for additionaldevelopment.

4.1. Technology connects customers with restaurants

The customer dining experience starts with expectation formation (Wijaya et al., 2013). When customers start to plan their dining event, marketing information and other sources such as blogs, Facebook pages, and company websites influence the customer's expectations of the restaurants' likely product and service quality. A restaurant'spublic image and/or reputation traditionally originated primarily by word-of-mouth (WoM) amongst friends, but nowadays, WoM is mostly spread via social media. Restauranteurs need to be savvy to this new normal reality.

Social media provides a real-time interactive platform for diners to share after-visit experiences/reviews with potential future customers. Modern-day customers are greatly influenced by social media and online review websites whenever making their restaurant choices (Hwang & Park, 2015). Plainly stated, good word-of-mouth is critical; commercial advertising alone is not sufficient to attract and influence customers' decisions of where to dine. The existence of social media enables people to spread word-of-mouth easily and rapidly. A customer can research adining venue via social media with smart digital devices and technologies, consider user reviews and ratings, and then maketheir dining decision. Specific review comments with detailed insights from previous customers' dining experiences directly or indirectly influence their visit intention (Han et al., 2009; Loo et al., 2013). Any negative comments posted on these platforms directly impactsthe company/restaurant image and decreases customer visit and re-patronage intentions.

Waiting for customers to make their choice of where to dine is being overly passive for any aspiring restaurant owner/manager. To capture customers' attention, especially highly valued repeat customers, mobile apps can be pro-active by sending customised push promotion messages. Mobile apps assist a restaurant manager to communicate effectively and maintain good relationships especially with repeat customers. Furthermore, the mobile app provides additional pre-dining services that can increase customer loyalty.

For instance, restaurant managers can send out customised promotional messages according to each customer's dining preference or current location (via GPS). Restaurant mobile apps are also interconnected with restaurant customer relationship management (CRM) and loyalty programmes so that members' profiles and their preferences can be transferred between customer mobile phones and restaurant applications. Message content can also be customised according to a customer's dietary needs, dining habits in CRM, and seasonal activities to increase the attractiveness of marketing campaigns and brand loyalty. Reservations can be made online via mobile apps withbooking details automatically transferred to the restaurant management system (RMS) and table management system (TMS). Waitstaff can prepare ahead of time forthe customer's arrival. The customer can even pre-order popular seasonal dishes and avoid any disappointment caused by missing a special offering.

4.2. Technology interacts with customersand forms expectations

Expectations are formed at various stages in the overall dining cycle. Before the customer arrives, GPS in smartphones allow mobile applications to identify the customer's location and provide location-based push messages that enhance the pre-dining experience. For example, location-based information such as road conditions or traffic updates are provided while customers are on the way to the restaurant. For some popular restaurants, the mobile app can also handle wait-list customers. AI can predict thefinishing time of diners and then notify the wait-list customer via mobile app by analysing the historical data from RMS and TMS system. In this manner, customers can arrive at the restaurant at the most opportune time. Also, parking space availability can be shown on asmartphone map when geofencing is installed around a city; this can significantly reduce the search time for a parking space when a customer arrives near the restaurant.

Customers often interact with their companion guests before arriving at the restaurant; at these times, they can access the interactive ordering system. Smart service technologies enable customers to place and even customise their food orders via touch devices. Pizza Hut in 2014, for example, allowed customers to personalise their pizza orders via an interactive touch table. Moreover, Domino's Pizza makes use of AI systems to examine the quality of each pizza before delivery.

A touch table screen size is large enough for a customer to place an order and incorporate interactive entertainments. Many restaurants prefer using tablets rather than a touch tablet because a tablet does not require complicated maintenance, is relatively economical, and easy to replace. Therefore, a touch tabletis quite affordable and manageable for small to medium size restaurants. Repeat customers can log in to their membership via tablets and retrieve their transaction history and profile data. The AI-supported recommender system provides suggestions that are based on customers' dietary preferences and even display warning messages whenever the customer has ordered dishes that contain allergic ingredients. Voice recognition systems allow customers to use voice commands to place orders; this is especially beneficial for customers with motion difficulties.

For customers who speak different languages, an application *Google Translate* provides two features that improve the pre-meal experience. First, *Google Translate* recognises printed words via its optical character recognition (OCR) capabilities, and then instantly translates words into the desired language. Second, the speech recognition system records and pronounces the translated text. International customers will no longer be worried about language barriers with the wait staff, and thus more inclined to visit local restaurants for domestic cuisines.

Image projection can be also used for modifying the ambience of the restaurant and enriching the dining experience. *Le Petit Chef* is a 3D imaging and mapping technology introduced in 2015 that tells the story about the making of the specific cuisine or dish that the customer has ordered. The video is projected directly in front of each customer on the table and shows the preparation process of the meal and how the dish is presented – sometimes done in a humorous way which livens the moment. The projection can also alter the dining ambience as the system can utilise different colours and patterns that match different customers' dining purposes. Other than 3D projection images, three-dimensional real images supported by holography can heighten a visual stimulation response from a customer. With the support of AI, customers can communicate and

interact with the holographic image to obtain any essential dietary information. Dubai Airport, for example, launched the first hologram 3D virtual assistants to provide inquiry service using the customers' primary language. Restaurants can make use of this technology to allow diners to obtain additional menu item information via the virtual assistant.

The best way to 'wow' a customers is to deliver unexpected incidents (Cohen, 1997). Smart technologies can provide extra delight for customers during their dining experience. Food serving is no longer simply the delivery of dishes by the wait staff to the customer's table; food delivery can be done by using smart technologies.

In 2016, a restaurant in the United Kingdom was the first to use roller coaster-like tracks to deliver food to customer's tables. Robot servershave revolutionised the restaurant service delivery process. China's first robotic restaurant was launched in 2016 with 30 robots thatserved food to about 200 diners. However, due to the safety of restaurant guests, the travelling speed of the robot is necessarily slow. Also, the travel route is inflexible as robots must follow a fixed magnetic track to deliver meals. Drones were first introduced for military use but are now widely commercialised. The size of commercial drones is getting smaller and smaller. Drones can be auto-piloted via an internal GPS so that arestaurant can adopt it for food delivery (Bamburry, 2015). Other than door-to-door delivery service, TGI Friday introduced drones for photo-capturing the special moments of the customers in 2014. The Singapore chain restaurant *Timbre* employed flying drones in 2015 as robotic waitstaff to deliver food to customer tables. Understandably, many users have questioned the safety of in-door flying drones. For example, a high-speed spinning drone blade might cut someone, or a drone might fall when it has depleted its battery and any spillage of hot food on a customer could have serious consequences.

The importance of internal sensors is also increasing. Restaurant managers can utilise sensors to monitor the internal and external environment and adjust the lighting and room temperature automatically. Providing a 'green' environment is obligatory for any eco-friendly restaurant brand image, while monitoring temperature and electrical output can also reduce energy costs (Jackson, 2013).

4.3. Technology co-created values

A restaurant's ambience is usually static and comprised mostly of decorations and lighting. Prior studies have found that a restaurant's physical environment can affect a customer's food choice (Biswas et al., 2017) and dining experience (Ryu & Han, 2011). Whena customer steps into a restaurant, the restaurant's servicescape immediately influences the customer's first impressions, and at this point smart technologies can initiate value co-creations. Restaurants with ambient intelligence can interact with diners in order tococreate a new dining experience, a new sense of the servicescape.

The five senses (sight, sound, smell, taste, and touch) are considered crucial to experience-centric services. Customers' feelings about the physical environment through their senses can elicit customers' emotional responses(Zomerdijk & Voss, 2010). As an illustration, research has demonstrated the effect of music, colours, and lighting in retail environments (Turley & Milliman, 2000). Games could increase customers' expectations before they enjoy their cuisine and also increase the retention rate (Harakal & Berger, 2017). Therefore, restaurants could prepare mini games related to their cuisine or

backgrounds for diners to interact with while they are waiting for their meals.3D image or video projections with the combination of background music and colour technologies could easily change the ambience and atmosphere of arestaurant in a very short time and without large-scale renovation. In addition, holographic images of stereoscopic 3D food could significantly facilitate customers' perceptions of the restaurant experience (Lai & Chen, 2018). Restaurant managers can change a restaurant theme according to the customers' requirements or festive seasons. The overall restaurant decorations can also be modified via 3D image mapping so an entire restaurant theme can be changed whenever a special event is held. For example, if the customer is celebrating abusiness event with Chinese customers, the projection system can project images related to Chinese culture to make the event more special and memorable (Haeckel et al., 2003).

Restaurants have started to test 3D printingto create delicious and visually impressive dishes. Chefs can design culinary masterpieces and use Food Ink for printing. Recently, 3D food printers have built food by ink and layer-by-layer to form a 3D object; however, only limited types of raw materials can be used. These food printers cannot print fibres from Food Ink, so the texture of the end-product is still quite different from real food. Also, aesthetic food plating can increase readers' intention to taste a dish and/or visit a restaurant (Wang, 2011). For special festivals or events, for instance, the 3D food printer can be used to print characters or a company's logo to impress the guests.

Technology can also help co-develop and strengthen security regardingdiningpayments. Prevention of credit card information theft cases has been discussed for decades but there are still some difficulties that have proven hard to eliminate altogether, especially when the leakage of information originates from an employee (Murphy, 1993). An employee can capture credit card details by swiping the card on a specific card reader. However, recent technology allows diners to pay-at-the-table which reduces theft. Technology, in this manner, ushers in a new kind of restaurant security service process. By incorporating the pay-at-table system with the interactive ordering system customers can settle their bills by using acredit card or digital entry. This self-service system allows the customer to interact with the system directly, so the employee does not have an opportunity to access a diner's credit card details. In addition, customers can easily split checks and settle their individual bills without informing, requesting, and then waiting for the waitstaff to handle multiple bills. Moreover, this high-tech payment system prompts customers to double-check their itemised bill before making payment. Customers can spend their time to carefully check the itemised bill without rushing to ensure they only pay for what they have consumed. If there are any errors or questions about the bill, customers can click the 'Help Calling' icon in the system for waitstaff to then attend to their inquiries and help solve any billing issues. Therefore, the overall dining experience can be enhanced by higher payment security, accurate payment, and shorter payment processing time.

Finally, contemporary restaurant management must accommodate the disabled diners' needs. Current advances in technology have been a catalyst forthe development of useful tools. Those diners with physical disabilities encounter challenges in feeding themselves; these diners may have poor fine motor skills, grasping difficulties and symptoms related to Parkinson's disease. Several companies have developed smart assistive eating devices that stabilise vibrations and enable diners to have a pleasant dining experience in the restaurant without embarrassment. Thesesmart devices can be part of the IoT network in the

future. Smart devices allow a customer's medical history to be downloaded to one's personaldevice to fine-tune the motion stabiliser and thereby achieve maximum steadiness.

4.4. Technology encourages sharing

The visual presentation of food plays a crucial role in restaurant marketing nowadays. An increasing number of customers are posting high quality Instagram photos with reviews of their restaurant experiences (Salleh et al., 2016). Diners have become de-facto marketers by posting photos of visually aesthetic and appealing food often times with special attention to attractive plating. Also, 3D food printers allow chefs to design their own masterpieces and use food ink to print the item. Therefore, the post-dining experience can influence many customers' decision to return or discontinue patronage of a particular restaurant (Barber et al., 2011).

Negative comments from customers must be handled properly and promptly by restaurant managers. A prior study has shown that an unhappy customer could be transformed into a loyal customer if their complaint is handled properly (Ateke et al., 2015). Multiple feedback channels should be conveniently offered to diners for submitting their comments, suggestions, and/or ratings to better understand the diners' satisfaction level. In relation to this, a mobile app is the most recommended platform for diners for capturing their feedback; many mobile apps are bundled with diner membership and loyalty programmes and thus can incentivize diners to share. Any messages which the customer leaves on the app will be brought to the attention of the manager immediately via push messaging and will also be recorded onto the CRM. Managers can always access the CRM system to review customers' needs and concerns and then take appropriate action-steps to address those concerns with specific services and interventions. However, not all diners have smartphones or are willing to download an appropriate app. Restaurant manager might consider offering an attractive promotional campaign to encourage their customers to install and use appropriate apps – a 'win-win' proposition.

In addition to ubiquitous mobile apps, an interactive ordering system is another channel that allows diners to provide feedback. At the moment dinersare settling their bill, the system can pop up a simple satisfaction survey inviting diners to submit their responses and comments. Similar to the interactive ordering system, which is also interconnected with the RMS and CRM, the diners' feedback is then immediately linked to the customer's profile viathe mobile app. The feedback form must be simple and straightforward without open-ended questions since customers might not want to spend too much time answering survey questions while at the same time settling their bill. Restaurant managers are able to obtain a detailed picture and deeper understanding of actual customer satisfaction through the integration of basic/timely app-based surveys.

Finally, social media has emerged asthe most common platform by whichcustomers can registertheir comments, suggestions, and feedback. Customers' comments on social media can be closely monitored with web sensors. Sensors can prompt the restaurant manager to follow up and reply immediately or as soon as possible whenever negative comments are posted online. Social media is an open and generally anonymous platform, so restaurant managers might encounter difficulties when attempting to follow up with specific customer's feedback. Figure 2 illustrates the various smart technologies that contribute to each stage of the dining experience cycle.

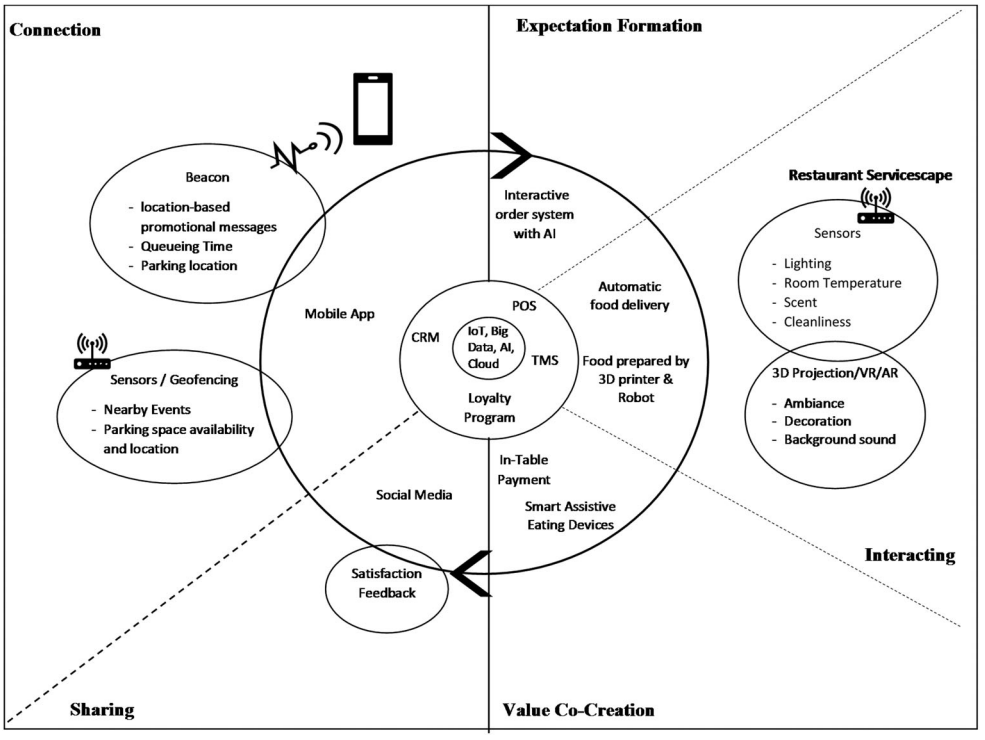

Figure 2. Technologies in dining experience cycle.

5. Discussion and conclusions

This study proposed a smart restaurant infrastructure that enhances customers' dining experiencesat three stages, including the pre-dining, during-dining and post-dining stage. Technologies play a crucial role in a smart network by connecting customers, interacting with them to form expectations, co-creating values, and encouraging customers to share their experience with others. Such networks require a large amount of data interchange among different technology platforms and applications. Moreover, to ensure data accuracy and reduce human intervention, all software platforms must be interoperable (Buhalis & Leung, 2018; Leung & Law, 2013). To serve this purpose, a standardised technology platform and communication protocol must be in place (Leung & Law, 2013).

Connecting customers starts with beacons and sensors. By using sensors installed around the city to detect the mobile phone owner's location, beacons could send out location-based marketing messages via mobile apps or push messages (Neuhofer et al., 2015). Customers can also retrieve traffic data from those sensors to plan their routes, avoid traffic, and identify the closest parking lot. To maintain the best customer's pre-dining experience, the more sensors and beacons installed around the city, the more accurate and precise location information could be obtained.

Based on a customer's historical consumption details, an AI-enabled interactive order recommender system could provide suitable dish recommendations and details regarding the source of ingredients. This would assist with forming expectations during the ordering process. Furthermore, smart building and intelligent ambient could extract weather data

via big data or sensors to adjust the ambience of the restaurant(Leung, 2020). While customers wait for their meals, the restaurant servicescape could be altered based on the type of cuisine, themes, seasons, and weather to create different dining ambiences.

Smart technology reduces human contact, especially during a pandemic when customers are aware of infection and hygiene standards. For instance, a contactless payment system could allow customers to settle payments directly at their table. This would eliminate direct interaction with the waitstaff. However, if data security of the data network is not well-established, customers will not feel comfortable using a self-settle payment system. Therefore, the data network in a smart city will be responsible for handling secure payments.

6. Implications, limitations and future research

A majority of existing studies on technology implemented in restaurants have been limited in their scope (Ahn & Seo, 2018; Kincaid & Baloglu, 2006; Oronsky & Chathoth, 2007). These studies are partially related to how technology influences dining experiences. In addition, thus far, studies about smart technology and co-creation in dining experiences are scant. However, they are currently in demand due to a lack of manpower and the advancement of technology. Therefore, the theoretical contribution of this study is to offer a comprehensive picture about how smart technology and value co-creation are incorporated in the entire dining experience. This study is therefore based on a variety technology knowledge and co-creation of dining experiences. As a result, these findings will enhance existing literature on smart technology and dining experiences. This study also provides future directions for empirical investigations on this topic.

Seeking a smart dining experience is a trend that seems likely to continue into the foreseeable future. The critical purposes of smart dining are to assist restaurant operators and diners alike in developing a personalised and interactive relationship with the expressed goal to create memorable dining experiences. Ultimately, customers will be highly satisfied and will not only choose to return to the restaurant but will spread positive word-of-mouth reviews and feedback. In other words, smart technologies can provide restaurant operators and service providers the ability to achieve high level efficiency and effectiveness in the delivery of quality products and services as well as intimacy with their customer base. In doing so, restaurant companies can more aptly compete, sustain, and even grow their business in a highly competitive environment. Table 1 summarises the technologies discussed in this study in different dining stages and throughout the experience cycle.

Several managerial implications are identified in this study. First, with the aid of smart technologies, customers can stave off boredom or impatience with self-entertainment apps during long waiting periods. This might reduce customer complaints during long downtimes that occasionally occur such as waiting for seats, waiting for meal ordering, and/orwaiting for mealsto be served. A long wait period at any point in the dining experience is considered a service failure (Dan & Howard, 1998). Research has indicated that a long wait has undesirable impact on customer future behaviour such as a longer duration until a customer decides to return to the restaurant and shorter dining duration when actually there(De Vries et al., 2018). On the other hand, by eliminating or minimising wait times, a restaurant's total revenue could increase by up to 15% (De Vries et al., 2018). For example,

Table 1. Smart applications for dining experience in each dining stage.

	Pre-Dining	During-Dining	Post-Dining
Connect and Expectation Formation	- Social Media - Mobile App - Location Based Push Message Geofencing - AI Quality Control		- CRM - Tracking App
Interaction and Value Co-creation	- Queue Managment - Translation - Voice ordering - AI Recommender System - Holographic/Gamification - Ambient and Sensory control	- Automatic food delivery - Drone photo capture - Robot Service - 3D printer - Eating Assistance - Ambient Control - Video projection	- Online Payment at table - Food wastagemonitoring
Sharing	- Social Media	- Social Media	- Review Sites - CRM - Tracking App

3D imaging/mapping with specially designed apps and devices about a restaurant's cuisine can shorten the ordering time. Meanwhile, intelligent building with an ambience control system will alter the dining atmosphere and offer an eco-friendly option. Here, it will save energy by changing the internal environment according to current weather conditions.

In is interesting to note that the emotional responses and behaviour of customers and employees tend to affect each other (McColl-Kennedy & Smith, 2006). When customers are happy, employees will be happy to serve them. Happy customers and employees would also generate a higher employee retention rate, which may ultimately increase organisational profits. Moreover, positive emotional values have been found to be highly important in shaping dining customers subsequent behavioural intentions (Yrjölä et al., 2019). Therefore, adaptation of smart technologies could trigger more positive emotions during the entire customer dining experience.

Second, with the implementation of smart technologies, the restaurant's overall operations and productivity are leveraged and should lessen the frequency of mistakes starting from the moment of booking a reservation until the final bill payment. Smart technology systems and devices enable arestaurant to attain higher accuracy and reliability of service delivery which, in turn, has direct impact on customer and employee satisfaction. By reducing the frequency of wrong-orders or wrong-billing there will likely be a corresponding reduction of customer complaints and loss-of-revenue. In order to ensure the continuous implementation of smart service dining experiences, smart technology knowledge, skills and ability are indispensable. Restaurant leadership is essential in supporting the entire investment, integration, training, and operations of smart service technologies.

Third, this study provides restaurant owners and practitioners with comprehensive ideas on how to incorporate smart technology throughout the dining process. Currently, a small but growing number of restaurants find smart technologies affordable and are willing to invest in them. However, larger chain restaurants are in an even stronger position to adopt some of the aforementioned ideas in their new outlets or restaurants. The restaurant owners and particularly prospective investors can conductfeasibilitystudies to assess the viability and practicality of certain targeted markets' acceptance/usage of

smart technologies. Vendor representatives and consultants from smart technology software companies can select the most appropriate technologies and customisations for any restaurant dining theme and concept. However, as mentioned in the discussion section, a successful smart restaurant network must be incorporated with the government smart city network to obtain adequate big data for business analysis and external environment forecasting. As a result, to encourage a tourism organisation to adopt smart technology and provide a smart service, the national government must play a leading role. In this respect, the government must design the smart network infrastructure, standardised the communication platform and protocol, and invite technology practitioners to form a steering team to initiate ideas to optimise the outcome.

Perhaps the main limitation of this study is its singular focus only on restaurant dining experience processes. Business ecosystems are far more complex; a comprehensive restaurant system includes a vast array of stakeholders that form an interconnected network with smart technologies that enhance effectiveness and efficiency of the operations among various systems at various levels. The F&B ecosystem should include not only the customers but also employees and the entire supply chain. The smart network can interconnect all sorts of applications so that all systems are interoperable. Future research should be expanded to include all stakeholders' applications and more closely examine their automatic data interchange.

The smart service framework proposed in this study addresses the most inner part of the restaurant business as shown in Figure 3. The proposed smart F&B network includes

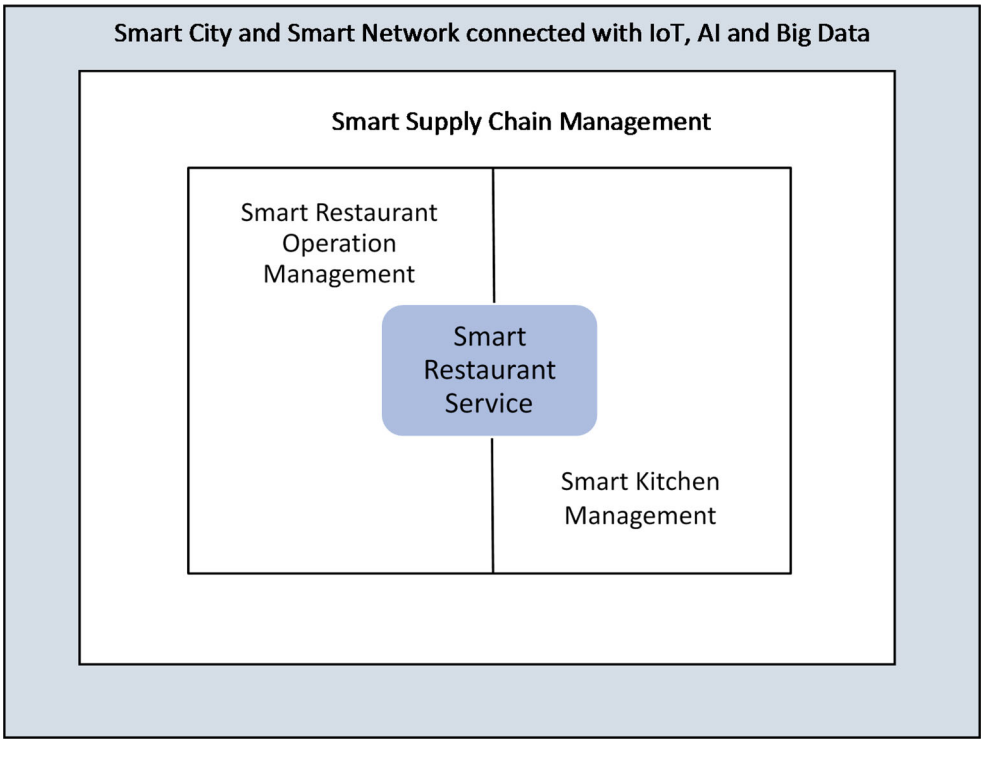

Figure 3. Future smart F&B management network.

service (dining experience), operation management (revenue management, marketing, and human resources), kitchen management (inventory and cost control, procurement), and supply chain management (quotation and ordering system). Within this proposed smart F&B network, all application systems among stakeholders are interconnected and interoperable which imply data within the network should be and can be free flowing throughout the entire ecosystem. Recently, many F&B internal applications are interface-ready,that is, data is ready for exchange; however, external applications are rarely interconnected and interoperable.

Future systems require supply chain applications such as price comparisons, procurement, inventory control and logistics that are interconnected and interoperable with restaurant applications to enable a human-free platform. Moreover, the whole network must work within a smart city network; the external environment context can be included in Big Data and then examined and analysed by an AI system to provide accurate forecasts of restaurant businesses and consumer behaviour. Future research studies should also include Delphi interviews with restaurant managers and restaurant investors as well as experimental studies with customers. Findings and insights derived from the rich viewpoints of customers and users will increase the understanding about smart technologies and their integration and implementation in restaurants. In short, smart technologies help craft a unique dining experience for customers that bring economic and social benefits to customers, employees, and companies; a happy customer is indeed a repeat customer.

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