Application Of Delivery Drone Technology as A Delivery Solution in the Urban Areas

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Abstract

The potential of drone delivery to become a delivery solution in the big city is currently among the most intensely discussed emerging technologies, likely to expand mobility into the third dimension of low-level airspace. Depending on how quickly the regulatory body allows the technology to advance, hurdles like safety risks, the suitability of the drone technology, related technical factors associate with the failure of the drone delivery operation, and the consumer acceptance towards the technology are currently preventing this futuristic supply chain management solution from becoming a widespread commercial reality. A quantitative approach through a mass survey at Cyberjaya, Malaysia, manage to collect 150 complete questionnaires that were analyzed using the Structural Equation Modelling (SEM). The results show that all the constructed assumptions are statistically significant in influencing the consumer's acceptance of the introduction of the drone delivery service. The findings implicate the consumer concern towards the capability of the drone delivery operator to ensure the safety of the operation that includes the issue of the drone technology, safety features, and the drone technical factor that is currently associated with the drone delivery failure.

Keywords: Supply Chain Management, Delivery solution, Drone Technology, Safety acceptance, urban area.

1 Introduction

As urbanization continues, many cities have to adjust to population growth and chronic congestion that has always been a challenge for delivery service providers. Thus, a deeper understanding of metropolitan rhythms and flows for solving delivery problems in large cities demands solutions outside the conventional box. As such, drones are seen to have great potential to emerge as a solution to the delivery problem in big cities. However, user acceptance of drone applications needs to be investigated, which is the main interest of this study.

While drones promise to make delivery costs cheaper, use less labour, and be more environmentally friendly than ground-based vehicles, the drone operation itself also faces limitations such as distance travel and low carrying capacity. In addition, unexpected events, such as rain and goods accidents, are more likely to occur with adverse effects in drones than in ground-based vehicles.

Delivery of goods is a complicated task, especially when it comes to food, electronic gadgets, and others, which are prone to damage. Keeping the goods in excellent condition and handling the goods properly when they arrive at the customer's table is not an easy task which requires a complex quality system and coordination among the network throughout the entire logistic process.

2 Framework background and hypothesis development

2.1 Consumer acceptance of using drone services.

Creating a superior customer experience can differentiate between companies (Grewal, Levy, and Kumar 2009; Verhoef et al. 2009). It involves the aspect of cognitive, emotional, social, and physical responses of the customer to the quality service of the delivery drone. The experience is not limited to those elements that the drone operator can control (e.g. service interface, retail atmosphere, assortment, price), but also elements that are outside the control of the drone operator (e.g. influence of others, the purpose of using drone delivery, etc) (Verhoef et al. 2009). In developing innovation in the delivery service, it is essential to understand the factors influencing customer acceptance in shipping goods using drones and the value of the service.

2.2 Technology of drone

The delivery drone is one type of Unmanned Aerial Vehicle (UAV) that can be operated by humans remotely or can fly independently through a flight plans that are controlled by software (M. A. Khan et al., 2018; Dukkanci et al., 2019). It can carry a bundle of up to 5kg and covering an area of 50 km square with the most extreme speed of up to 65km/hour. Besides, it only requires a landing zone of around 2m2 for delivery and collection. Drones have the capacity to productively provide the allocation to the precise address with a time outline of one hour (Ba & Management, 2019).

Drone technology has been using for a long time by defence organizations and tech-savvy users. However, the advantages of this technology far exceed the needs of these sectors. With drone accessibility increasing, many dangerous and high-paying jobs in the commercial sector have been replacing with drone technology. The ability of drones to perform increasingly complex tasks most cost-effectively makes this technology start to attract the attention of the logistics provider.

Drones come in different sizes, with the largest drone is used for military purposes. The next size is unmanned aircraft, which have fixed wings and require short runways. This type of drone is used for surveillance to cover a large piece of land, work in areas such as geographical surveys, or combat poaching. The latest drones have twin Global Satellite Navigation Systems (GNSS), such as GPS and GLONASS. Drones can fly in GNSS mode and not satellites. DJI drones, for example, can fly in P-Mode (GPS & GLONASS) or ATTI modes that do not use GPS. Precise drone navigation is critical while flying, especially for mapping, landscape surveys, and SAR (Search & Rescue) missions.

The new high-tech drones also have a collision-avoidance system. The technology uses resistance detection sensors to scan the environment, while software algorithms and SLAM technology create images in 3D maps that allow the drone to sense and avoid.

This factor has a direct influence on the outcomes of decisions. Past study has proved that the new high-tech drones now feature collision avoidance systems (Lin Shan, 2019). They use obstacle detection sensors to scan the environment, while software algorithms and SLAM technology create the images in 3D maps that allow the drone to feel and avoid. This study proposes the following hypothesis to investigate the effectiveness of the technology of drones in providing a safe drone operation.

H1: There is a relationship between the technology of drone and the consumers' perception of the effectiveness of safe drone operation.

2.3 Safety measure and standards

In the study of delivery drone applications, it is essential to ensure the safety of other flying vehicles when drones are operating and performing their tasks (Lin Shan et al, 2019). If there is a dramatic increase of drones deployed in the area, information on drones is becoming essential to avoid collisions and interference. In addition, if there is an aircraft flying nearby, such as a helicopter, it could risk the pilot that might miss seeing the drones. Hence, drone communication between flying vehicles is, therefore, are critical to ensure the safety of the carrying goods and the public in the area where the drone is operating.

A delivery drone is capable of flying a few miles, would have a sufficient mass and power that could seriously harm someone with their propeller blades or by impact should there any technical failure during the operation. Moreover, the delivery of drones is something new to the public, of which any mishap or erratic behaviour during the flying can only further confirm the public suspicions towards the safety design of drone operation.

Unfortunately, the cost of designing and operating a safe drone may add complexity, weight, and cost to the device. According to (Li et al.,2019), safety is vital because it can identify the potential risks in complex systems and reliable operation at an acceptable cost. Hence, the design of the delivery drones should always consider the context of safety.

Indeed, the industry and customers will gain benefit from the introduction of the delivery drone, but safety issues regarding the operation of the drone are also a concern to be discussed (Ba & Management, 2019). There could be a risk to human safety if the drone is suddenly malfunctioning in the middle of operations and crash to the ground (Vergouw et al., 2016, Lin Shan et al (2019). As such, the following hypothesis was developed to investigate the safety measure and its impact on consumer perception.

H2: There is a relationship between the safety measure of delivery drone with the consumers' perception towards the effectiveness of safety drone operation.

2.4 Technical factor

There may be thousands of components and millions of lines of software within a commercial drone. Almost any element that fails for any reason may cause the entire system to fail, resulting in the discontinuity of the controlled flight or the complete loss of the delivery vehicle and the resulting liability from the crash. In addition, the sources of failure are not new or unknown. One major source of failure is the component, assembly, or delivery that induced latent defects that fail in use. Another source is the interaction of the system with the environment. Effects of salt fog, wind, radiation, and many weathers stresses, along with dust, debris, insects, animals, etc., all impact and eventually degrade the performance of the system. The next source of technology-based failures is the lack of sufficient understanding by the design team of the operating stresses placed on the system. The team may have some information on the temperature and humidity ranges to be expected, and possibly information on a range of other environmental stresses. The team may also have information on the number and distances of the daily delivery schedule. However, these are often estimating and often lack details to allow for full characterization and assessment of the performance of the reliability. Moreover, design teams usually consider the challenges of technology.

Risk assessment tools help to identify and prioritize which risks to be addressing and addressing. The technological risk with this approach is the level of uncertainty and lack of knowledge about what was thought through and resolved during the development process. This is a particular challenge facing a new system for which we may expect very high-performance reliability: it is impossible to detect any failure mechanism that might prevent a product from realizing its expectations of reliability.

The following are hypotheses to answer the influence of technical factor with the consumer perception.

H3: There is relationship between the technical factors with the consumers' perception towards the effectiveness of safety drone operation

2.5 Demographic

Although the legislative environments across the world vary concerning drones and their use, it is likely safe to assume that the demographics around the board are relatively similar. The study by Yu-Che Chen and Chenyu Huang (2020) on demographics of drone users suggested that the younger age and higher educational attainment groups are more likely to accept the delivery using the drone in the city as compared to the general adult population. Interestingly, demographic factors such as age, education, and income do not appear as statistically significant factors, implies that, for the matter of regulatory compliance, other factors are more salient than demographics. However, in this study, the factor of demographics was tested on their influence to the consumer towards the acceptance of the technology of drone, safety measure and technical factor for the safe drone operation.

Hence, the following hypotheses were developed to answer the various relationship.

H4: There is a relationship between the demographic and the perception of consumer towards the effectiveness of safety drone operation.

H5: There is relationship between the demographic and the technology of drone towards the consumer acceptance of the delivery drone operation.

H6: There is relationship between the demographic with the safety measure towards the consumer acceptance of the delivery drone operation.

H7: There is relationship between the demographic with the technical factor towards the consumer acceptance of the delivery drone operation.

3 Methodology

3.1 Survey instrument

A total of 14 observed variables was developed to constitute the measurement of the exogenous and endogenous variables. The exogenous variable of technology of drone consists of 2 items, safety measure and standard consist of 4 items, technical factor consists of 4 items and driver demographics consists of 4 items. Meanwhile, the endogenous of customer perception consists of 3 items. This study also adopted a measuring scale of 5-point Likert scale measuring the respondent perception towards the developed variables. The demographics variables questioned the demographics factor such as age, gender, and level of education, and income. While the consumer perception questioned the acceptance of the consumers for the delivery drone operation as a delivery solution in the big city.

3.2 Sample

A total of 382 respondent were approached randomly to complete a questionnaire within Johor Bahru, Malaysia through a blasting email and face to face approach using a simple random sampling technique. From the 382 distributed questionnaires, only 185 questionnaires (48%) were answered and returned, which was deemed sufficient to proceed with the SEM analysis. The collected data were then checked using the Mahalanobis distance to identify the multivariate outliers, which were deleted permanently, leaving only 150 datasets to be used for further analysis.

3.3 Data analysis

This study adopted Structural Equation Modelling (SEM) In the application method of the (SEM), a few steps must and suitable to be included in ensuring all the data gathered are strong enough to support the theory given. Therefore, the researcher is using all the steps written below to acquire the results.

Step 1 – Assumption Check
i) Multivariate Normality
ii) Multicollinearity Test
iii) Sampling Size in SEM

Step 2 – Model Specification
i) Exploratory Factor Analysis (EFA).
ii) Reliability Analysis (Pilot Test)

Step 3 – Model Identification Confirmatory Factor Analysis
i) Convergent Validity
ii) Model Fitting

Step 4 – Model Evaluation

Step 5 – Model Modification

4 Results and Findings

4.1 Demographic profiles of respondents

The respondent involved in this study mostly are female (60.7%) and female (39.3%) with majority of them are between 21-29 years old (37.3%), followed by the age range between 30-39 years old (26%), and above 40 years old (27.3%). Approximately 9.3% of the respondent are less than 20 years. In this study, most respondents are the resident at Cyberjaya city, Selangor. Most of the respondent have a good tertiary education background which consists of diploma (24%), bachelor degree (56%), master or doctoral degree (8%), left only 12% with high school or less.

4.2 Construct validity, dimensionality, and reliability

All constructs from the AMOS output were analyzed to calculate the average variance extracted (AVE), composite reliability (CR), and Cronbach's Alpha, as shown in Table 1. All constructs achieved a higher Cronbach's Alpha of more than 0.7 which was recommended by Hair et al (2006). AVE and composite reliability (CR) result also shows all the constructs have achieved the minimum requirement for each parameter (Byrne, 2001, 2006; Hair et al., 2010).

Table 1: Construct validity, dimensionality, reliability, and item Loadings

Construct	Item	Standaradised loading	CR	AVE	Alpha Cronbach
Technology of drone	TD1	0.984			
	TD2	0.681	0.83	0.72	0.821
Safety measures and standarad	SMS1	0.984			
	SMS2	0.356			
	SMS3	0.905	0.82	0.63	0.801
Technical Factor	TF1	0.942			
	TF2	0.252			
	TF3	0.805	0.74	0.53	0.706
Demographic	D1	0.962			
	D2	0.881			
	D3	0.239	0.77	0.59	0.839
Consumer perception	CP1	0.980			
	CP2	0.991			
	CP3	0.154	0.81	0.6	0.852

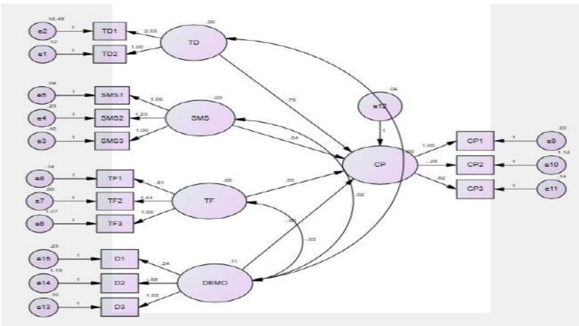
4.3 Model analysis

The test of the structural model was performed using SEM in order to examine the hypothesized conceptual framework by performing a simultaneous test. Table 2 depicts that the goodness-of-fit for the model was met: Chi-square/df = 2.121, CFI = 0.945, GFI = 0.868, AGFI = 0.807, NFI = 0.902, and RMSEA = 0.075. The overall values provided evidence of a good model fit. All of the model-fit indices exceed the respective common acceptance levels suggested by previous research, following the suggested cut-off value, demonstrating that the model exhibited a good fit with the data collected. Thus it was possible to proceed to examine the path coefficients. Properties of the causal paths for the structural model (standardized path coefficients (β), standard error, and hypotheses result) are signified in Table 5. The number of distinct sample moments for the model is 253. The number of distinct parameters to be estimated is 80 and degrees of freedom is 173. The level of significance (α) was set at 0.05. The square multiple correlation for the structural equations index connotes that the predictors interactivity, customisation, usefulness, ease of use, responsiveness, and brand image have together explained 79.9% of the variance in satisfaction. In other words, there are other additional variables that are important in explaining satisfaction and trust that have not been considered in this study

Table 2: Fit indices for two different models

Fit Index	Cut-off value	Model value
CMIN/DF (Chi-Square/Degrees of Freedom)	≤ 4	3.67
CFI (Comparative Fit Index)	> 0.9	0.993
TLI (Tucker-Lewis Index)	> 0.9	0.946
RMSEA (Root Mean Square of Error Approximation)	<0.9	0.649

Figure 2. The Result of Proposed Research Model (Standardized Path Coefficients)



4.4 Hypotheses Verification

The positive and strong standardized value between demographic and readiness, demographic and knowledge, knowledge, and readiness, and demographic and readiness via knowledge (0.740, 0.840, 0.530, 0.370 respectively) indicate that the H1, H2, H3, H4, stated in the proposed model are verified.

Table 3: Summary of Hypotheses Testing Results

Hypothesizes relationship		Path Coefficient	S.E	CR	p-value	Conclussion
H1	There is relationship between the technology of drone and the consumers' perception towards the effectiveness of safety drone operation	0.880	0.036	2.439	0.040	Supported
H2	There is relationship between the safety measure and standard with the consumers' perception towards the effectiveness of safety drone operation	0.911	0.060	15.135	0.000	Supported
H3	There is relationship between the technical factors with the consumers' perception towards the effectiveness of safety drone operation	0.154	0.052	2.975	0.035	Supported
H4	There is a relationship between the demographic with the consumers' perception towards the effectiveness of safety drone operation	0.312	0.025	12.514	0.000	Supported
H5	There is relationship between the demographic with the technology of drone	0.681	0.081	8.453	0.000	Supported
H6	There is relationship between the demographic with the safety measure and standard	0.356	0.680	5.229	0.000	Supported
H7	There is relationship between the demographic with the technical factor	0.050	0.034	1.464	0.010	Supported

Note: β = standardised beta coefficients; S.E. = standard error; C.R. = critical ratio; *p< 0.05

5 Conclusion

This study was conducted to analyse and assess the viewpoint of the consumer on the application of drone technology as a delivery solution in the city area. Drone technologies are known as one of delivery of goods by air that can carry the goods from one point to another point at certain distances. It uses not only can maximize the costs of the consumers but can also save time and conform for consumers (Daniele Giordan et al, 2020). This study validated the technology of drone, safety measure and standard, and technical factor of the drone technology as essential determinants of consumer perception towards the capability of drone to deliver parcel or goods in the city area.

The finding also recognizes the influence of demographic factor to influence the acceptance of drone operation by the consumer (Ben Rossi, 2017; Li et al,2019). Apart from that the demographic factor such as age, gender and education play a positively role in accepting the technology of drone This supported Riley Panko (2020) that suggested consumer is sceptical on the drone capability to deliver the goods to the house but they are excited to see the drone itself with their eyes. This is because of the exposure of current development in technology among the young generation which is easier to accept a new process for improvement based on technology based.

In order to gain more consumer confident towards drone application in the city area, the drone operator should focus in increasing the existing technology, addressing all the technical factor that commonly associated with the failure of drone operation and establish a standard safety procedure to operate in all type of weather and condition.

Apart from the approval by the local and aviation regulation, drone operator also needs to build positive customer experience with the technology, which not only offer a source of cost savings, but it can also distinguish them from the competitor crate satisfaction and loyalty. As such, the introduction of the drone as a new solution for delivery at the city area should be supported by the positive image of the benefit of the technology that consumer can experience in improving the lead time of the delivery. Fail to impress the capability of the drone will increase the challenges of drone introduction to the delivery market.

This study mange to explore the initial framework for the acceptance of the drone operation. However, further study is require to establish a standard safety procedure for drone operation as a benchmark before it being materialise.

Acknowledgment:
We would like to extend our sincerest gratitude to all the respondents who took part in this research.

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