A Qualitative Case Study on the Use of Drone Technology for Stock Take Activity in a Third-Party Logistics Firm in Malaysia

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Abstract. The activity of stock taking in any business is important and must be done on a regular basis because as it ensures the company is on the right track to reach its business target. This case study is concerning the use of drones for stock taking. The main focus for this case study is the use of drones for stock taking in a Malaysian third party logistics company (company XYZ). This work will look to address on how effective or beneficial is the use of drone technology for stock take method in company XYZ and adoptability level of company XYZ to adopt drone technology. This study is in the form of an exploratory research which uses qualitative means to gather data in regards to the adoption of drone method for stock take in the company. Purposive sampling method is employed in this study. Data were collected based on interview and questionnaire done on the warehouse manager & assistant manager, stock control manager, and head of operations department. The outcome of this work showed that drone method of stock take is in fact very beneficial as there was significant reduction of duration for the stock take activity.

1. INTRODUCTION

Stock take is a physical verification of the quantities and condition of all goods kept in the warehouse. It is usually done to show evidence of existing stock in an audit or to find out stock discrepancies in the business [1]. Instead of conducting one massive stock take event once a year, it would be more efficient if stock take events were conducted more frequent throughout the year, and on a regular basis [2]. By maintaining accurate stock records between each stock take event, it is easier to provide an accurate account of stock levels when it is needed. Consequently, this also allows the firm to concentrate on pin-pointing and eliminating causes of errors easier and single out items that have the highest risk. This method of spreading the inventory count is the basis of cycle counting (also known as perpetual inventory checking) [3].

The global trend of businesses to run lean (in order to achieve greater efficiency) means that inventories are kept lower, with a greater need for more timely and accurate data updates of inventory levels. This is because one major disadvantage of having high inventories is the fact that it hides product defects and stock inaccuracies [4]. Other than that, record accuracy is a crucial aspect of the company as a whole because many departments within the company make decisions assuming and trusting that the records of inventory levels are accurate.

Another reason for having better record accuracy is as systems become more integrated, information (including stock levels) get shared from one end of a supply chain to the other end,
making it very important that the correct levels of inventory to be shared across all parties in the supply chain [5]. Unmanned Aerial Vehicles or ethereal vehicle that does not convey a human administrator, utilizes streamlined powers to give vehicle lift, can fly self-governingly or be guided remotely [6]. These drones can be applied to both in military applications (gathering intelligence, used for armed attacks, for test targets, or as electronic countermeasures) and also in civilian applications (law enforcement, environmental monitoring, or agriculture) [7].

However, the current trend shows that these drones are expected to be rapidly adopted into diverse industries, and also in various aspects of our daily life, performing a wide range of activities from delivering a package, to diving into the water for a specific underwater operation [8]. Other uses of drones in logistics industry are the automation of stock take in warehouses [9]. Olivares [10] presented a work on analysing the usage of drone in the internal logistics to monitor the assembly line. Carlsson [11] analyzed the proficiency of a conveyance framework in which an unmanned automated vehicle (UAV) gives administration to clients while making return excursions to a truck that is itself moving. Murray [12] presented a work on ideal steering and delivery of unmanned airplane, and conveyance trucks, in this new worldview of package conveyance for logistics. Olivares [13] performed assessment by PC recreation of the task of a drone for transporting materials in an assembling plant of plastic items. Liu et al. [14] tested the automated drone’s efficiency in package conveyance in endeavor to illuminate conveyance issues in remote towns. Cordova [15] proposed an armada overseeing model for drones that play out the conveyance or pickup of provisions and materials in a generation plant. Ulmer [16] investigated how drones can be joined with normal conveyance vehicles to enhance same-day conveyance execution for logistic and parcel delivery application.

Graham [17] stated in his study in 2016 that there are 4 factors which influence ease of adoption of drone technology in a company, and these 4 factors are technology factor, human/organization factor, economic and political environment factor, and legislation hurdles. Relative advantage also encompasses the extent of the new technology bringing strategic benefits in terms of greater efficiency and ease of management, such as in improved reliability in operations and simplifying processes [18]. In addition, Perceived benefits are one of the most important drivers of technology adoption in all industries [19]. Also, there has been reports that the main reasoning of drone failure is from the failure or inadequate functioning of individual components that might result in accidents [20] This concerns the device reliability of the drone technology, or how reliable can a drone operate without breaking down. Also, investing in a new technology is also a form of business risk. In fact, a study indicates a correlation between organization size and intent to adopt a new technology [21]. Furthermore, top management support is also essential for supplier selection and supplier evaluation processes.

This case study is concerning the use of drones for stock taking. The activity of stock taking in any business is important and must be done on a regular basis. The main focus for this case study is the use of drones for stock taking in a Malaysian third party logistics company (company XYZ).

The purpose of this case study is to firstly explore the effectiveness of using drone method for stock take activities in warehouses. Since drone use for stock take activities or even for use in the logistics industry is a very new concept in Malaysia, this study aims to provide an indicator for the benefits of drone use and to ease the adoption of drone technology in this industry here. Secondly, the purpose of this case study is by determining the ease of adoption within company XYZ, the company can leverage this information and take into consideration of this outcome to consider implementing drone stock take method for all its products. Company XYZ being an industry leader in the logistics of cold chain in Malaysia, such decision to adopt this technology will set an example and pave the way for more drone technology involvement in supply chain operations in Malaysia.

This study has chosen to adopt the Technological, Organization and Environment (TOE) framework as it best represents the adoption of a new technology in a logistics firm. Therefore, this case study focuses on the 3 factors for adoption which are technological factor, organizational readiness, and external environment.
2. METHODOLOGY

2.1. Research Design
This study is in the form of an exploratory research which uses qualitative means to gather data in regards to the adoption of drone method for stock take in the company. Qualitative research is chosen as the means for this case study. By grouping these factors and adopting the well-established TOE (Technological, Organizational & Environment) framework, the framework of this study is shown in Figure 1. The factors of adoption are grouped into 3 independent variables which are the technological factor, organizational readiness, and external environment and the ease of adoption as the dependent variable. The validation or acceptance process of content covers from gathers the data until analyzing the data to evaluate the reliability of the research [22-25]. Therefore, this study will employ face validity in its data collection or interview process.

![Figure 1. Framework of this study](image)

2.2. Sampling Design
In this study, non-probability sampling design approach is used where the data collected will be analysed to understand TOE (Technology, Organizational and Environmental) factors for the adoption of drone stock take method. Purposive sampling method is employed in this study where data is collected within the identified specific target groups. In further detailing, this is reflected in the judgment sampling method, where first-hand information is obtained from the selected few persons who are the experts in the topic. The scope and nature of this case study is specific and clear, where it involves the use of drone technology for stock take in the warehouse of third party logistics company XYZ. Therefore, the chosen candidates for the interview are the warehouse manager & assistant manager, stock control manager, and head of operations department who have both direct and indirect experience and involvement in the company’s drone stock take activity.

2.3. Conducting the Research
As this case study focuses on the use and adoption of drone technology for stock take in company XYZ, the respondents for this interview are professionals who have direct involvement with stock take activities with managerial views. Such selected respondents are head of operations department, stock control manager, warehouse manager and assistant manager. The first contact was made with the head of operations department, Mr.V for which a formal interview was successfully arranged. In this hour long interview, Mr.V was very helpful in providing much information, and later also helped by approaching other managers in the company as suitable respondents to this study.

However, due to the time constraints and seeing as the company was in its busy period, Mr.V agreed that the following interviews with respondents will be done through paper questionnaires with open-ended questions. Follow up calls to the respondents were done if necessary, to obtain further
clarification for their answers. Also, at the mid-point of this case study, a second questionnaire was sent to respondents to gather new information to support the framework of this study.

Initially there were a total of 5 respondents, with the first respondent via face to face interview, and the remaining 4 respondents via paper questionnaires. However, seeing as the last respondent was only an executive level (warehouse executive), it is not the most suitable candidate to obtain managerial views regarding adoption. Furthermore, after the fourth respondent, it is found that the data has already reached saturation point where more of the same information and feedback from the respondents was being repeated. Therefore, this study takes into account of the feedbacks of the 4 respondents, which are the head of operations department, stock control manager, warehouse manager and assistant manager.

2.4. Data collection and analysis
The method of data collection used in this case study is face to face interview. In concluding the research method, non-probability sampling face to face interview was used. In addition, the collection of data through interviewing was done and coding these data, where there is constant comparison involved was done.

3. RESULT AND DISCUSSION
The interview questions in both the semi-formal interview and questionnaire. The respondent’s opinion in regards to the performance and the adoption factors (cost and human management factor) of drone technology in the company was analyzed and it is presented according to the questions. Table 1 shows the respondents view on the benefits of using drone for inventory checking in your company. Thus based on Table 1, the conclusion of the drone technology efficiency mainly lies in the response found in the first question, which were the benefits brought to the company through this new technology. Firstly and mainly, all respondents agree that drone method is far faster in completing the stock take as compared to the manual method. As a whole, they responded that the drone method would take about one day to complete this activity, whereas the manual method would take up a few days. This time saving outcome thus also brings in other benefits, which are reduced cost (monetary and human resource) in the stock take operation and also reduced down time. The cost saving benefit mentioned here refers to a cost efficiency offered by the drone method, where all respondents agree for a reduced need for manpower and MHE to conduct the stock take. This is because manual method incurs higher costs associated with higher manpower requirement and all other costs associated with operating MHE’s

| Respondent | Answer |
|------------|--------|
| Respondent 1 | In respondent 1 view, the benefits are that it faster and that it requires less manpower than human method of stock take |
| Respondent 2 | According to respondent 2, the first clear advantage is that stock check with drone is faster than manual method, because it has less down time on stock take. |
| Respondent 3 | The advantages brought by drone technology is firstly a reduction of required manpower for the stock take |
| Respondent 4 | According to respondent 4, the first benefit of drone technology is that it is faster than manual stock take method |

Table 2 shows the respondents view on how reliable is the drone technology as compared to manual checking method for stock take. Based on Table 2, there is a resounding agreement by all respondents that drones significantly minimizes mistakes in its data by eliminating human error found in the manual method. This is supported with the photo capture function of the drones, where each item count is supported by photo evidence. This then further increases the count confidence in the stock take. Additionally to this photo capture function, 2 out of the 4 respondents also mentioned that drones are able to quickly provide a bird’s eye view of the stock at the warehouse floor. This is reliable in a sense that stock levels can always be quickly captured visually to see if it actually matches
the stock level recorded in the system, and thus any abnormally high or low inventory can be quickly captured. 2 out of 4 respondents also noted that the drones can be more effective and reliable if it is linked to the WMS system of the company warehouse.

Table 2. Respondents view on how reliable is the drone technology as compared to manual checking method for stock take

| Respondent | Answer |
|------------|--------|
| Respondent 1 | Respondent 1 noted that drones are more reliable than human (manual) method of checking because in manual method there is human error. |
| Respondent 2 | According to respondent 2, his view is that mistakes (due to human error) can be reduced thanks to the functions of drone which can take pictures which serves as photo evidences. |
| Respondent 3 | Respondent 3 reiterated that the reliability of drones are better than manual method because drone method eliminates human error and that drones can take pictures during the count process. |
| Respondent 4 | Respondent 4 states that drone method is more reliable than manual method as the drones can take picture as an evidence of the scan, and thus provides greater count evidence. |

Table 3 shows the respondents view on the limitations of this drone technology for use of inventory checking. Thus based on Table 3, 3 out of 4 of the respondents mentioned that the main limitation of drone is that it is inoperable in cold temperatures. To be specific, the drones cannot operate in the cold chambers which can reach to as low as -25°C because this will cause misting in the drone camera lens, making it impossible for the drone to make proper scans through its camera, and also such low temperatures can even cause the drone to breakdown because the its batteries are inoperable at such low temperature. This is a real limitation for drone use in this company as there are a significant amount of goods stored in cold chambers in this company.

The second limitation is regarding to it not being able to integrate with WMS system, as previously discussed. This is mentioned by 2 of the 4 respondents, by which this is both a limitation and one aspect which could also increase the reliability of the drone results. The next limitation is that drones cannot be used for stock take of items of mixed/varying packaging size in a single run, as pointed out by respondent 1 and 2.

Table 3. Respondents view on the limitations of drone technology for use of inventory checking.

| Respondent | Answer |
|------------|--------|
| Respondent 1 | According to respondent 1, the limitation of the current drone technology used in this company is that it is not integrated with the existing Warehouse Management System currently used. |
| Respondent 2 | The limitations as described by respondent 2 is that drones are not suitable for storage chambers with temperatures reaching -25°C because at such cold temperatures, there are misting of the drone lens and drones are unable to effectively scan the IDs and take photo. |
| Respondent 3 | According to respondent 3, drones are limited to cold and icy environments, where cold chambers reaching to very low temperatures (as low as -25°C) would make the drone inoperable. Also drones cannot perform the physical confirmation of “touch and count” which can only be done in manual method. |
| Respondent 4 | Respondent 4 states that the drone is temperature sensitive according to respondent 4, and should not be left to operate in cold chambers to ensure it does not break down. The drone’s limitation is also that it is not linked to the WMS. |

Table 4 shows the respondents view on the other potential of drone use at the warehouse. Thus based on Table 4, In regards to the potential use of drones in the warehouse, all four of them observe that drones can be used for greater roles and involvements in warehouse security. Respondent 2 and 3 accredit such potential to the drone’s great mobility and speed, offering a quick way to provide surveillance at anywhere or any height within the warehouse. Respondent 1 added that with the extra level of security that drones offers, it is well suited for surveillance of high value items.
Table 4. Respondents view on the potential use of drones at the warehouse.

| Respondent  | Answer |
|-------------|--------|
| Respondent 1| Other potential uses that respondent 1 foresee in drone technology is in the use of security of high value items. High value items are usually kept in a highly guarded and limited access area in a warehouse. By having a drone to operate this area, it can perform quick rounds for security check in that area. |
| Respondent 2| Since drones are very mobile, respondent 2’s opinion is that drones can provide added warehouse security since they can act as mobile surveillance. He also added that drone can be employed to any other warehouse tasks involving reaching to tight spaces, high or dangerous places since drones are very flexible. |
| Respondent 3| According to respondent 3, because of the flexibility and speed of drones, drones can be used to conduct immediate spot checks, which will help increase security of items in warehouse. |
| Respondent 4| Respondent 4 views further potential of drones in the area of security surveillance in the warehouse and also in monitoring movement of trucks. This is because of the flexibility and capability of drones in offering quick surveillance from any high or hard to reach areas. |

Table 5 shows the respondents view on what are the main hindrances/difficulties/challenges for the company to expand drone use to conduct stock check. Thus based on Table 5, interestingly, it is found that all 4 respondents gave different views regarding this. Respondent 1 mentioned that as a 3PL company, it must comply to the requirement of its customers, and it is the customers who has the biggest say in whether their products are to use drone method or manual method for the stock take activity. Respondent 2 on the other hand views that drone method cannot apply for all items simply because drones are just not capable of handling effectively all items which are variously sized. Respondent 3 however noted that the main difficulty lies within the limitation of the drone technology, where the drone is inoperable at cold chambers. Respondent 4 views that the proper training within the company that the drone technology is the biggest challenge to ensure a proper adoption of this technology.

Table 5. Respondents view on what are the main hindrances/difficulties/challenges for the company to expand drone use to conduct stock check.

| Respondent  | Answer |
|-------------|--------|
| Respondent 1| Respondent 1 concluded that such drone use for the customer’s product will depend on the customer’s agreement. |
| Respondent 2| According to respondent 2, the main difficulty if drones were to be used for stock take for all products in the company is that drones are difficult to use for cartons with varying size. |
| Respondent 3| According to respondent 3, the largest hindrance would be that the drone cannot be operated at very low temperatures such as cold chambers, in which a significant number of items held in inventory in this company are kept in cold chambers. |
| Respondent 4| According to respondent 4, the main challenge as mentioned is that the drone technology does not integrate with the WMS system, because it will be far more beneficial if it did integrate. Other challenges are related to the reliability of the data from the drones and whether if drone is properly trained and everyone is well educated regarding its operation. |

Table 6 shows the respondents view regarding the investment cost for this drone. Thus based on Table 6, 3 out of 4 of the respondents have the opinion that drone technology is not a high investment and that the costs are easily justifiable in the long run.

Table 6. Respondents view on the investment cost for this drone.

| Respondent  | Answer |
|-------------|--------|
| Respondent 1| According to respondent 1, the investment for drone technology is considered to be small, and it would definitely bring in the returns of investment in a long run. |
| Respondent 2| Respondent 2 views drone technology as a small investment where there is a small cost trade off, and it is justifiable in the long run. |
Respondent 3 views that drone technology is a large investment when considering the cost of purchasing and installing the equipment and also the cost incurred to train workers.

Respondent 4's opinion is that the investment cost for drones is small, however it is a sensitive equipment which requires that the person in charge to be well trained to operate it.

Table 7 shows the respondents view regarding the human management required to handle this drone operation. Thus based on Table 7, In terms of the management factor, 3 out of the 4 respondents agree that such adoption of drone technology is possible only if proper training is provided as it is a very important aspect. Respondent 1 added that proper training must be provided to the person in charge, and even supervisory roles to ensure there is no manipulation of the data collected by drones which can lead to inaccurate inventory levels.

| Respondent | Answer |
|------------|--------|
| Respondent 1 | Respondent 1 views that proper training is very important and crucial to ensure no manipulation of the drone technology occurs in its use. Even with the promise of “elimination of human errors” that the drone offers, drones are also susceptible to human manipulation. |
| Respondent 2 | As mentioned by respondent 2, drones are a new technology, and thus it is difficult to find the right person as there are not many experts around currently. |
| Respondent 3 | Respondent 3 mentions that proper training is very important to ensure the success of implementing this new drone technology |
| Respondent 4 | Respondent 4 views that the training aspect is very important, and that the person in charge operating the drone should be well trained to prevent drone breakdowns and achieve accurate results in its operation. |

Table 8 shows the respondents view on comparing drone technology to other technology (such as robots) for inventory stock take. Thus based on Table 8, both respondents 1 and 4 agree that drones are superior than AGV solutions, in which drones are easier to handle and less cumbersome than AGV, and that it is also less expensive than AGV. Respondent 2 and 3 however did not have any views regarding this comparison.

| Respondent | Answer |
|------------|--------|
| Respondent 1 | Respondent 1 opinion is that drone technology is simpler, better and a cheaper solution to robots or AGV alternatives for inventory stock takes. |
| Respondent 2 | Respondent 2 views that drones are more efficient and quicker than manual check by human. However, in terms of comparison against AGV, respondent 2 could not comment regarding this comparison. |
| Respondent 3 | Respondent 3 views that drone technology for stock take is a new thing and it needs more time to evaluate its true effectiveness. |
| Respondent 4 | According to respondent 4, drone technology is an easier and more convenient approach than robots in performing the stock take activity. |

Table 9 shows the respondents view on contingency plan in case of drone downtime/breakdown. Based on Table 9, there were split opinions where both respondent 1 and 4 mentioned that a backup drone should be kept on standby in such an event, whereas both respondent 2 and 3 viewed that human workforce should take over (reverting to manual method) when such event occurs.

| Respondent | Answer |
|------------|--------|
| Respondent 1 | Respondent 1 views that the contingency plan should be a one-to-one concept. Meaning that a separate backup drone is to be kept for standby at the event where the drone in use malfunctions. |
Respondent 2 replied that the contingency plan in case the drone malfunctions during operation is to have standby workers to continue with manual method of stock take.

Respondent 3 The contingency plan as mentioned by respondent 3 is to have standby staff to continue the stock check by manual method in case of drone breakdown.

Respondent 4 Respondent 4 noted that in case of a drone breakdown in operation, a spare drone should be kept on standby to take over and continue the operation.

Table 10 shows the respondents view on drone capturing the product identification help in the inventory count accuracy process. Based on Table 10, Respondent 1 explains that drones offer a quick method to do stock take and thus it is the method used for the first round of stock take. Respondent 3 and 4 explains the process of how the drone works, which is that the drone flies over to the individual pallets, and then scans the pallet ID and capturing a photo of the pallet ID as photo evidence. Respondent 2 however concludes that there is close to zero mistakes of stock take through the drone method, and even highlight the speed of this drone method by mentioning that stock take via drones would only take about a day where manual method would take a week to complete.

Table 10. Respondents view on drone capturing the product identification help in the inventory count accuracy process.

| Respondent | Answer |
|------------|--------|
| Respondent 1 | Respondent 1 views that As the drone is capturing the pallet ID and it is transferred to the WMS, and WMS to match with the stock take activity, it will be good that it can match with what we have in the system with a list of what have been captured and thus, identifying which pallet has not been captured. |
| Respondent 2 | Respondent 2 states that since drones are already very quick and increases the count accuracy of the overall stock take process, the whole process can be completed by drones within about a day whereas it would take a team of workers about a week by manual method. |
| Respondent 3 | Respondent 3 views that drone technology is very useful and helps to the inventory count process by having photo evidence for later reference. |
| Respondent 4 | According to respondent 4, the drone captures the product ID through container ID for pallets. Then, the information on container ID will be captured through the drone scanning process. This is how the drone uses product identification to increase accuracy for the count process. |

Table 11 shows the respondents view on other competitor companies using a special drone technology which is able to perform stock take for frozen and chilled chambers, will they adopt it? Based on Table 11, all respondents said that they will adopt the technology.

Table 11. Respondents view on other competitor companies using a special drone technology, will they adopt it?

| Respondent | Answer |
|------------|--------|
| Respondent 1 | It will significantly influence adoption. Because of such a drone technology can be used for stock take for both chambers of different temperature, they are more reliable and last longer, and they will also speed up the inventory count process. |
| Respondent 2 | Respondent 2 states that it will significantly influence adoption. This is because such drones are hardy and can be used in bigger temperature ranges, drones are robust and can operate for longer hours, and that drones do not breakdown easily and are quite reliable. |
| Respondent 3 | Respondent 3 replied that this would significantly influence adoption. This is because such drones can be used in different temperature chambers, drones are generally robust and will last longer, and that process of inventory count will be done more efficiently. |
| Respondent 4 | Respondent 4 replied that this would significantly influence adoption. This is because drones are more reliable and can last longer, and that they can be operated in a bigger range of temperature. |
Table 12 shows the respondents view on company’s image to become “high-tech and a technology leader in the industry can be a reason to adopt the latest drone technology for stock take?. Based on Table 12, all of them responded yes, they will adopt for company image.

Table 12. Respondents the respondents view on company’s image to become “high-tech and a technology leader in the industry

| Respondent  | Answer                                                                 |
|-------------|------------------------------------------------------------------------|
| Respondent 1 | Respondent 1 views that company image is very likely the reason to adopt such technology |
| Respondent 2 | Respondent 2 views that company image is very likely the reason to adopt such technology |
| Respondent 3 | Respondent 3 views that company image is very likely the reason to adopt such technology |
| Respondent 4 | Respondent 4 views that company image is very likely the reason to adopt such technology |

Figure 2 shows the overall response on drone technology usage. Based on Figure 2, all of the respondents agree (100%), that the usage of drone technology is reliable, improves work operation and it reduces man power needed for checking the stocks of the logistic company. On the other hand, 75 % of the respondents have agreed that the usage of drone technology enables fast stock checking and it minimizes mistakes. Furthermore, 75 % of the respondents have agreed that the investment for drone technology is small and the company can adapted to the technology. In addition, 50 % of the respondents agree that the usage of drone technology reduces safety risk, provides a bird eye view of the overall logistic stock checking process and it is a better solution for logistic stock checking. Thus, in general, all respondents believe that adapting to the drone technology is beneficial for the logistic company.

![Figure 2. Overall response on drone usage](image)

4. CONCLUSION
In conclusion, it is found that drone method of stock take is in fact very beneficial, as all 4 respondents agree on its many benefits. The benefits are a significant reduction of duration for the stock take activity (it can be completed in hours instead of days or weeks), significant reduction of required resources for the stock take activity (requiring one or two people as compared to a few persons and various MHEs in the manual method), increased reliability of the operation due to photo evidence and the elimination of human related errors. This satisfies the first research question of this case study. Hence, it follows that drone method of stock take should be adopted to replace traditional method of stock taking (by manual means) whenever possible as it brings far more benefits to the company. However, company XYZ cannot at the moment adopt drone technology for other chilled and frozen products in its warehouse due to temperature limitations. These drones are inoperable at such low
temperatures (from 0°C to -25°C), and thus stock take for these products must be operated using manual method (using manpower).

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