Use of IoT in the Design of an Inventory Management System for Omni-Channel Retailing

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Abstract

This research studies the use of Internet of Things (IoT) in the design of an Inventory Management System for Omni-Channel Retailing by learning the factors in the use and its benefits or outcomes taken from one of the Technology Adoption Model which is Technology-Organization-Environment. With the continued growth of retail in our region, the popularity of e-commerce affects the future of the retail industry in the Philippines, which means that businesses must adopt a digital strategy. To identify factors that predict the use of IoT in the design of an Inventory Management system for an Omni-channel retailing in a sample of individuals in management position, a binary logistic regression analysis was conducted, simultaneously including Organizational, Technological and Environmental context into the model. Retail companies who are gearing towards an omni-channel retailing should review the Organizational context as it greatly affects the decision to use IoT based on the result of the test. Also, Customer preference is the top to be associated by the management to influence their reason to use IoT. Most customers nowadays expect stores to provide an ease in shopping experience. Working both offline and online strategy should be considered to have a unique customer-centric service delivery.

Keywords
Internet of Things, Retail, Omni-channel, Inventory Management

1. Introduction

The IoT has been predominantly being used by different industry to automate processes and improve bottom line result. In order to have outstanding omni-channel shopping experiences, big retailers and a lot of brand owners are gradually moving to IoT technology. It is still possible to completely use the introduction of this IoT growth in the retail sector to enable businesses to take full advantage of this evolving trend.

The retail market size of the global IoT is projected to rise from USD 14.5 billion in 2020 to USD 35.5 billion by 2025, at a Compound Annual Growth Rate (CAGR) of 19.6% over the forecast period (MarketsandMarkets, 2020). Among region it is Asia Pacific that is expected to witness the fastest growth rate in retail IoT Industry where one of the core operations which is Supply Chain is projected to lead operations management segment for IoT Retail market share. The rapidly decreasing cost of IoT sensors and hardware, customer desire for a smooth shopping experience, and growing acceptance of smart payment solutions are key factors driving market growth. According to the 2015 Global Shopper Survey, 96 percent of shops are gearing towards bringing IoT devices into their operations with the hope that it'll strengthen relationships with consumers (see Figure 1).

IoT is recognized and accepted in the SCM literature for the fact that knowledge has tremendous importance in Supply Chain Management (SCM). The importance lies in two facets of the information available in the supply chain: the consistency and quantity of the information that facilitates decision making in the supply chain (Shteren & Avrahami, 2017). Needless to say, that accurate and real time inventory update is crucial especially in making economic decisions. The basic supply chain is increasingly transforming into what is known as a Supply Chain Network due to the exponential developments in technologies such as ubiquitous wireless and internet networks (Awad & Nassar, 2010). Companies have started to understand the potential of information technologies, especially the "Internet of

Things," to radically change their industry in order to increase productivity. As an alternative to automating inefficient systems, enterprises now want to re-engineer their business processes with technology as an enabler.

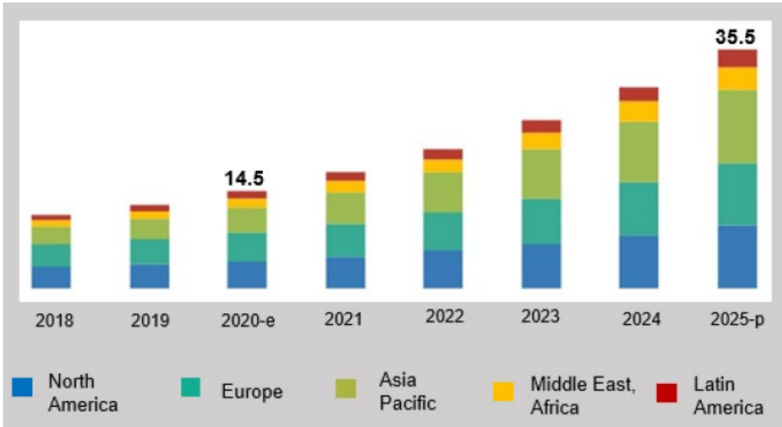

Figure 1. IoT Regional Retail Market (in USD Billion)

In this review, the author will study the usage of the IoT in the design of an Omni-Channel Retailing Inventory Management System by learning the variables in the use and its benefits or effects from one of the Technology Adoption Model, Technology-Organization-Environment (TOE).

The purpose of this thesis was to answer the following research questions that would help fulfill the goal. Such research questions include a description of the structure of the research study discussed in the thesis. RQ1: What are the significant factors that influence the use of IoT in the design of an Inventory Management System for Omni-Channel Retailing? RQ2: In what way does the use of IoT in the design of an Inventory Management System for Omni-Channel Retailing driven by; a) Organizational context b) Technological context c) Environmental context.

1.1 Objectives

The aim of this analysis is to study the variables affecting an organization's decision to use IoT in the design of an Omni-Channel Retailing Inventory Management System, including organizational, technological and environmental drivers and constraints. The researchers are thus trying to achieve the following:

- To identify the significant factors that influence the use of IoT in the design of an Inventory Management System for Omni-Channel Retailing.
- To verify the extent to which Organizational context, Technological context and Environmental context can influence the choice to use IoT in the design of an Inventory Management System for Omni-Channel.

The project offered an important opportunity to gain an understanding of the application of the IoT in the implementation of an Omni-Channel Retailing Inventory Management System. On an item-by-item basis, retailers that have introduced IoT solutions have gained unparalleled clarification about their stock condition.

- Retail Managers or Supervisors will be able to recognize how the use of IoT in the design of an Inventory Management System for Omni-Channel Retailing can improve his/her decision making in terms of managing the inventory.
- Customers will be able to understand the key drivers related to the use of IoT in the design of an Inventory Management System for Omni-Channel Retailing and its advantages in terms of on time stock availability.
- Through the use of this study, the owners or future retail company owners will learn the impact of IoT in the design of an Inventory Management System for Omni-Channel Retailing and the significant drivers for its implementation.
- The study contains information and other ideas from the past researchers which will serve as basis for further studies. The Future Researchers may use this study for it contains results, procedures and other data that may contribute to their study.

2. Literature Review

This chapter shows different literature relevant to the thesis that offers perspectives. Researchers used multiple references and used other knowledge important to the analysis.

2.1 Internet of Things

Back in 1912, the first telemetry machine was carried out in Chicago. It is said to have used telephone lines to monitor power plant data. In the 1930s, when a system known as a radio probe was commonly used to map weather conditions from balloons, telemetry extended to weather tracking. In 1957, Sputnik and the Space Race were launched by the Soviet Union (Elbounani, El Kiram, & Achbarou, 2015). This was the introduction of aerospace telemetry that provided the basis for today's global satellite communications.

The Internet of Things' strengths include the creation of new technologies, utilities and electrical devices that support the needs of consumers and businesses through the use of networks that enable the two parties to generate or use more detailed knowledge in the form of autonomous sensing, machine learning and adaptation to the user's circumstances or desires. If it does not encompass at least all agencies, the Internet of Things definition may be interpreted as ambiguous or frail. The existence of the Internet of Things allows boundaries to be removed between agencies and collaborators. The concept of IoT should not be restricted to one business unit or one function either, since the Internet of Things network is not limited to one or a few business units or industries, but can instead demonstrate the cross-functional capacity of IoT. The future growth of one department could also rely on other divisions, such as Marketing, R&D, IT and Supply Chain Management, as well as other departments (Celik, 2016).

As technical, social, and competitive forces drive businesses to develop and reinvent enterprises, IoT adoption is quickly gaining traction. As IoT technology advances and the numbers of organizations embrace the technology, IoT cost-benefit analysis will become a matter of great interest. Because of the potential and uncertain benefits and high investment costs of the IoT, organizations need to closely evaluate any benefits and threats caused by the IoT and ensure that their capital are judiciously spent.

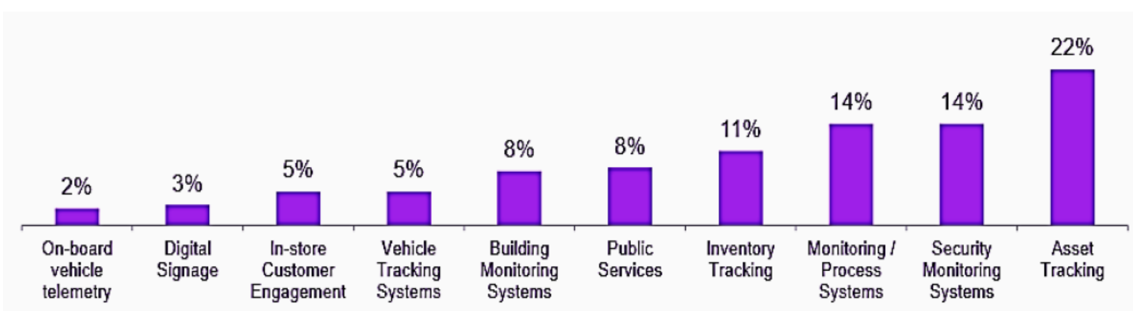

Figure 2. Types of IoT solutions being adopted (Source: IDS/TELUS)

Figure 2 shows that companies choose to implement IoT for monitoring or tracking. An organization’s inventory contributes majority of its asset, thus the 11% share in the contribution on the type of IoT solution reasons for adoption is part on the top list. Based on recent reports, within the next 24 months, 30 percent expect to implement an IoT solution, 7 percent of companies are actively implementing IoT solutions and 6 percent of organizations are currently adopting IoT solutions (Mahajan, 2015).

2.2 Omni-Channel Retailing

Omni-channel retail may be delineated as a consumer-focused approach for the promoting of multi-channel merchandising. It's a robust strategy adopted by retailers for up client expertise, business performance, sales and loyalty. Through the use of an Omni-channel retail strategy, retailers are able to supply consistent expertise to their customers across all platforms. Retail companies become equipped to provide to the customers’ wants with a common, central information of product, prices and promotions. Through different retail channels, customers can consistently get the product and promotions.

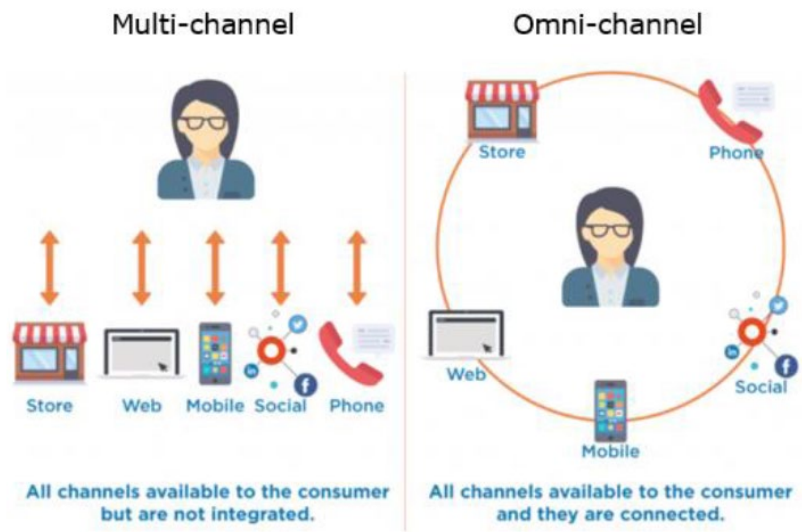

Figure 3. Omni-channel vs Multi-Channel Retailing (Source: fitsmallbusiness.com)

Figure 3 shows the difference between omni-channel and multi-channel retailing. Omni-channel approach allows for the integration of everything your business needs. With the multi-channel experience, customers can choose from a few channels that aren't directly aligned with one another. The corporate is the one that decides for the customer which channel most accurately fits the customer experience. Omni-channel, on the opposite hand, allows the customer to use many various channels that are well coordinated. Here, the customer decides what channel to use. They revolve round the customer and that they can, therefore, choose their preference.

The deep omni-channel retailing presence of the company – and therefore the way digital technology has been associated with the experience of in-store – also provides a transparent competitive advantage (Zentes et al., 2011). Needless to mention, because it requires complete channel convergence, the highest degree of channel integration is omni-channel retailing. Customers can buy in tandem across all retail outlets, since the omni-channel structure is intended as a comprehensive organization, preferably at every touchpoint of any available retail platform. Therefore, consumers should merge networks as they see fit, counting on their personal needs. For example, when shopping at the retailer's brick and mortar store, they can use the retailer's shopping software on their smartphones to check product barcodes to gather more details over the mobile Internet.

2.3 Omni-Channel Inventory Management

Omni-channel inventory management is the process of controlling all the inventory of your business, through all the retail networks on which you sell it. Channels such as brick and mortar stores, e-commerce stores, smartphone pop-ups, and even social media sites such as Facebook enable retailers to market their goods and services to the customer base as broadly as possible.

There are a number of business procedures, with the use of a spreadsheet, often small-scale companies often begin to manage inventory. While some company is at this stage, the management team should be prepared to see the stock, handle distribution with a small team and have a rule of thumb about when reordering is the right time and how much to buy. A potential situation in which a business sells through a single channel, maybe a supermarket, an online platform, or a mobile site, but if you start selling through several channels, you can begin to face a few problems.

Inventory management becomes a whole new challenge as company expands in distribution networks. It may also be appropriate to assign a certain quantity of stock to each outlet, but consider the manual shuffling and continuous checking that is needed just to ensure that your prospective buyers are typically shown some level of stock. There's likely hated showing out of stock, interestingly, you actually have plenty available, but not on the right platform.

There are inventory issues that may influence the company's growth and profitability as retailers want to increase business by engaging in multi-channel networks.

- Lack of Visibility – Without IoT, tracking sales and orders coming from different channel and warehouses will not be easy.
- Manual Management – Tools such as IoT or RFID must be in place for multi-channel retailing to succeed and manage the scale.
- Overstocking and Overselling – Difficulty to manage the supply and demand can lead to keeping too much inventory which is expensive. Same also if you overselling will lead to inventory inaccuracy and customer complain.
- Lack of Business Insights – Knowing how the sales and inventory is changing overtime is necessary to be able to predict the future and make timely decisions. Understanding the data relating to your inventory and customers will leverage position in the market.

2.4 Philippines Retail Channel Trend

We have observed the Philippines retail industry's steady growth despite the slowdown of retail industry all over the world. Despite the sustained growth of retail in our country, e-commerce popularity is influencing the future of the Philippines retail market, means to say that companies must put digital strategy into place (Juego, 2020).

With 9,231 establishments or 8% of the total for the industry, retail sales of wearing/clothing had the largest number of establishments, followed by establishments engaged in retail sales of drugs and pharmacy products with 7,6599 establishments (6.6 percent) (see Figure 4). The overall revenue of PHP4.1 trillion was generated by the entire sales and retail industry and suffered a total cost of PHP3.9 trillion in 2016, where retail sales in supermarkets generated the maximum revenue of PHP332.1 billion (8.2 percent) (see Figure 5). With the high number of retail establishments in the Philippines adopting a new retail strategy is a must for retailers to remain competitive in the marketplace (Omnirio, 2019).

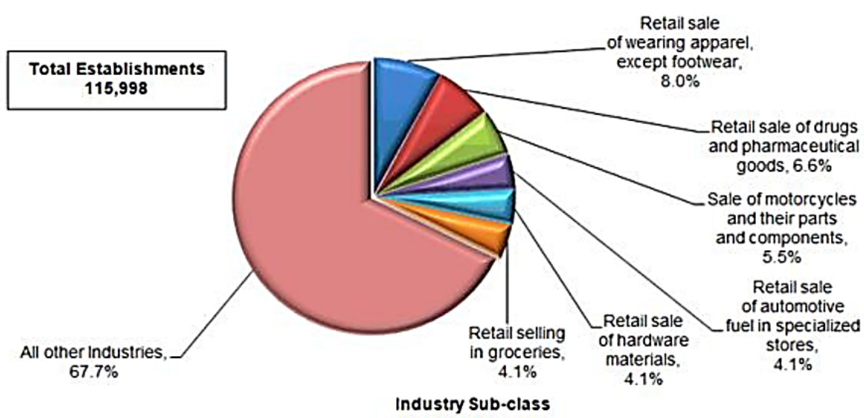

Figure 4. Percentage Distribution of All Establishments for Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles by Industry Sub-class; Philippines, 2016 (Source: Philippines Statistics Authority, 2019)

The top three domestic players in the country are SM Retail, Puregold and Robinsons Retail (Food Industry Asia, 2016). With massive store network growth and multi-channel approach, these three big retailers are building up their footprints.

Philippines retail industry will remain with physical and digital presence to sustain consumer interest. Retailers has to ensure that they are available for their customers both online and offline. However, the effort of being in a multi-channel still leave the company with certain challenges.

- Customers would right away want to know the stocks availability in a particular store since Multi-channel retailers have a separate Inventory system across all their channel.
- Store Managers wants to compare the sales among all the sales channel since there is no direct correlation on the different channels where they sell (physical store, social media, web store).

Omni-channel retailing advances from Multi-channel because of the limitations in the latter. Customers like fast and seamless transaction and as a company who wants to grow, Omni-channel should be considered.

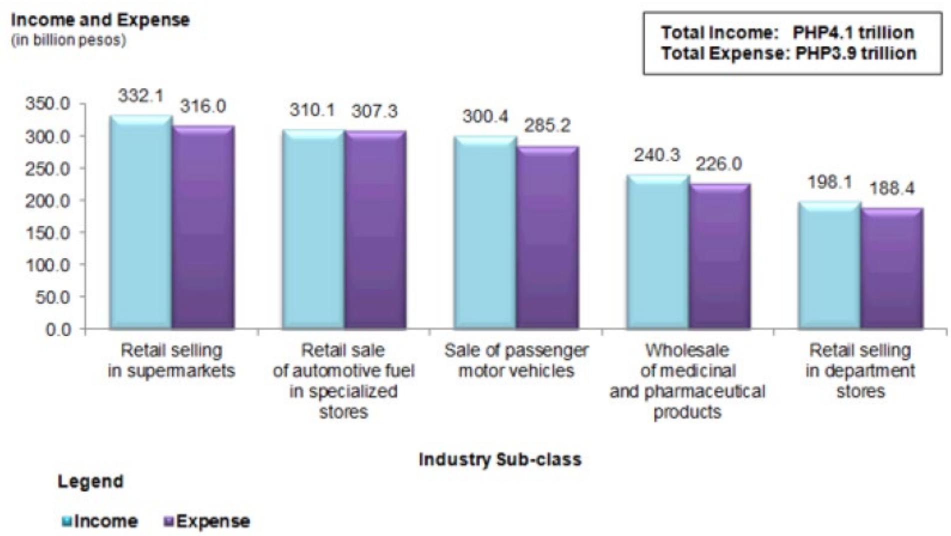

Figure 5. Income and Expense of Five Leading Industries for All Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycle Establishments by Industry Sub-class; Philippines, 2016 (Source: Philippines Statistics Authority, 2019)

2.5 Technology-Organization-Environment (TOE) Framework

In 1990, Tornatzky and Fleisher developed the technology-organization-environment (TOE) system. It identifies factors affecting the implementation of technology and its likelihood. TOE defines the mechanism by which technical developments are introduced and applied by an organization and is affected by the technological nature, the context of the structure, and also the environmental context seen in Figure 6.

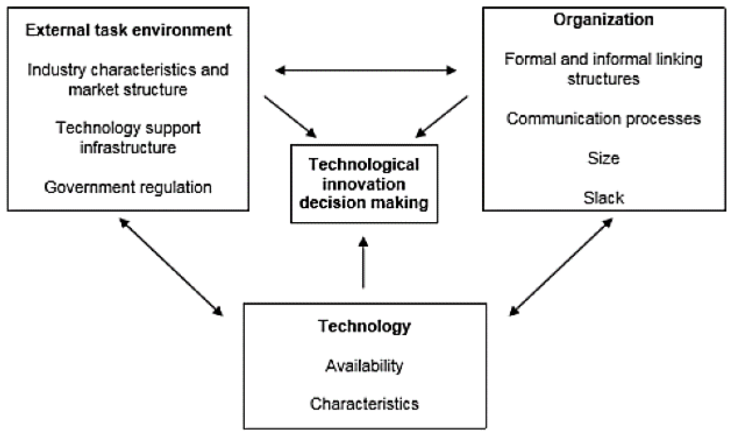

Figure 6. Technology, Organization, and Environment Framework (Tornatzky & Fleischer, 1990)

The technical background in Figure 6 involves the internal and external developments which are important to the organization. Equipment and processes are part of infrastructure. The organizational background applies to the company's features and resources, as well as the scale of the company, degree of centralization, degree of rationalization, hierarchy of management, human resources, sum of slack services, and staff linkages. The environmental context encompasses the industry's scale and composition, the rivals of the business, the context of macroeconomics, and even the regulatory climate (Tornatzky & Fleischer, 1990).

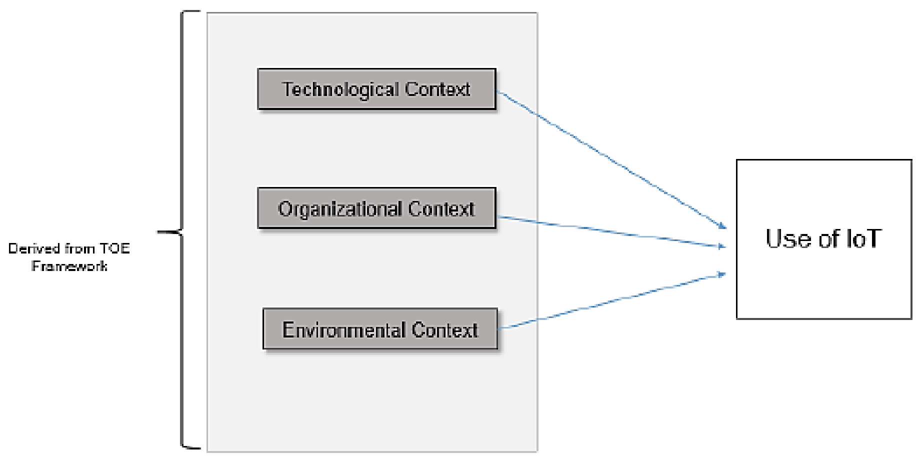

Figure 7. Technology, Organization, and Environment Framework (Tornatzky & Fleischer, 1990)

TOE Model (Tornatzky & Fleischer, 1990) will be the basis of this study, drivers and constraints will be identified within the three contexts (technology, organization and environment) to determine if each context influences existing multi-channel retail organization to adopt RFID in becoming an omni-channel level. Based on previous literature review analysis with respect to IT acceptance models at the business level, the TOE Paradigm stands out because it contains the meaning of the environment (not found in other theories such as DOI), may well explain the adoption of intra-company innovation and hence finds this model to be more accurate (Oliveira & Martins, 2010). For example, some of the environmental variables such as stakeholder pressure and knowledge strength could be more important relative to other types of technology in the RFID implementation analysis in the hospital sector, so the TOE system was seen as a model (Ozturk, 2012).

In Figure 7 shows the research model use for this study. TOE framework is chosen to best suit the objective of this research in reviewing the factors that influences the use of IoT.

2.6 Research Hypothesis

Working theories are taken into account to provide clarification, precision and emphasis on our study issue. Its capacity to add direction, detail and emphasis to a research analysis is the significance of hypotheses. They direct a researcher to gather precise data and thereby have a greater emphasis (Mühl, 2014). Four (4) theories were formulated from the two research questions addressed in Chapter 1 to study the relationships enumerated in the research context.

For Research Question 1: "RQ1: What are the significant factors that influence the use of IoT in the design of an Inventory Management System for Omni-Channel Retailing?

- Hypothesis 1: There significant factors that influences the use of IoT in the design of Inventory Management system for an Omni-Channel Retailing.

For Research Question 2: "In what way does the use of IoT in the design of an Inventory Management System for Omni-Channel Retailing driven by; a) Organizational context b) Technological context c) Environmental context?

- Hypothesis 2: Organizational Context, significantly influences the use of IoT in the design of an Inventory Management System for Omni-Channel Retailing.
- Hypothesis 3: Technological Context, significantly influences the use of IoT in the design of an Inventory Management System for Omni-Channel Retailing.
- Hypothesis 4: Environment Context, significantly influences the use of IoT in the design of an Inventory Management System for Omni-Channel Retailing.

3. Methods

The proposed design to be used for this study is the explanatory sequential mixed methods technique. It requires a two-step project in which, in the first phase, the researcher gathers quantitative data, analyzes the findings, and then uses the results to prepare the second qualitative phase (or expand on it). Usually, the quantitative findings tell the categories of participants to be purposefully chosen for the qualitative stage and the types of questions that the participants will be asked. The overarching aim of this design is to better clarify the original quantitative findings in greater depth with the qualitative details. In the first step, a standard approach could include gathering survey data, reviewing the data, and then following up with qualitative interviews to better understand the answers to the survey.

Choosing mixed methods approach is also for "triangulation" so that the data collected and analyzed from the different methods will both enrich and confirm the research hypotheses. Triangulation provides checking and comparison on findings from a particular method (Greener, 2008).

3.1 Quantitative and Qualitative Design

The key research tool to be used in data collection is the questionnaire. The questionnaire consists of close-ended questions where, from a certain number of choices, respondents can select their responses. The bulk of the questions will be based on "None" and range from "Low" to "High" based on Likert-like options. The questionnaire would also call for factual facts.

The proposed sample size for Logistic regression (Hsieh, Bloch, & Larsen, 1998):

$$n = \frac{(Z_{1-\alpha/2} + Z_{1-\beta})^2}{P_1(1-P_1)\beta^{*2}}$$

where n is the required total sample size, β^* is the effect size to be tested the null hypothesis H0 : $\beta 1=0$ against the alternative H1 : $\beta 1=\beta^*$, where $\beta^* \neq 0$, P1 is the overall event rate at the mean of X, and Zu is the upper uth percentiles of the standard normal distribution.

Methods of data collection in case study studies involve organized, semi-structured or unstructured interviews in detail. The chosen case studies will be carried out by a more thorough qualitative analysis of selected organisations in order to verify the findings of an exploratory survey by means of a questionnaire performed during the first step. Via a case study interview, respondents from the previously carried out survey were asked to show their concern. Retail workers in management and executive roles will be interviewed in this case study to verify the results of the survey.

The target respondents for the survey are employees who's working in the retail sector and the company is in a multi-channel retailing.

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4. Data Collection

In the first phase, the data collection will take place in two different steps, with thorough quantitative sampling and in the second, qualitative phase, another purposeful sampling. The key concept is to draw explicitly on the quantitative effects of the qualitative data gathered. Extreme or outlier examples, important predictors from the attempt to implement IoT for an omni-channel retailing, significant findings relating to variables of causes, negligible outcomes, or even demographics can be the predictive outcomes that are then focused on.

The quantitative and the qualitative datasets in this method would be evaluated independently. To prepare the qualitative follow-up, the quantitative findings can then be used. Not only can the sampling process indicate the quantitative data, but it will also lead to the kinds of qualitative questions to be posed to participants in the second step. There will be general and open-ended qualitative analysis issues.

Both descriptive and inferential statistical tools or methods will be applied for analyzing the collected data. SPSS and Microsoft excel will be the primary data analysis software to be used. Major statistical tool which will provide data to answer the research questions is Binary Logistics Regression – A statistical model that predicts the probability of an outcome of two values (Park, 2013). For our research question we have two possible outcomes or dependent variable (categorized whether “Use IoT” or “Not use IoT”) and a set of independent variables which are the predictors from TOE Framework.

5. Results and Discussion

The study and evaluation of data obtained from surveys has been addressed in this chapter. The following are included in this chapter: Descriptive Statistics, Test of Value using Pairwise, Association, Goodness of Fit, and Binary Regression.

5.1 Descriptive Analysis

Figures 8 to 11 demonstrate the demographic profiles of survey respondents employed in a multi-channel retail sector. There are four characteristics that was analyzed in the research; (a) the size of the organization where the respondent is working, (b) the nature of the retail organization, (c) the length of stay in the company and their (d) job designation. By learning more about the characteristics of the respondents, retail businesses will be better equipped to make informed management decisions.

Data from the 67 respondents who replied using the Google form was retrieved. Usage of SPSS (Social Sciences Statistical Package) for the study and application of both descriptive and statistical analysis.

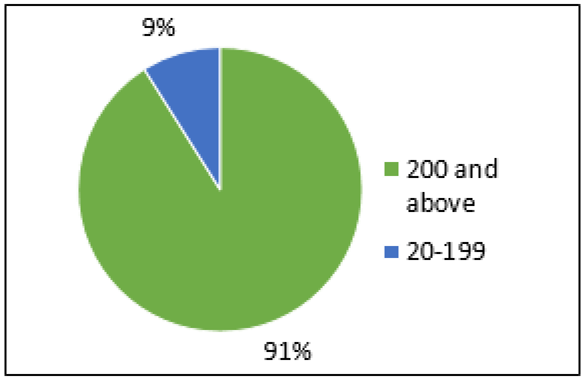

Figure 8. Number of Employees

In Figure 8 - Survey Respondent's Organization's Number of Employees, show that 91% of the survey respondents belongs to a company who has 200 and above number of employees.

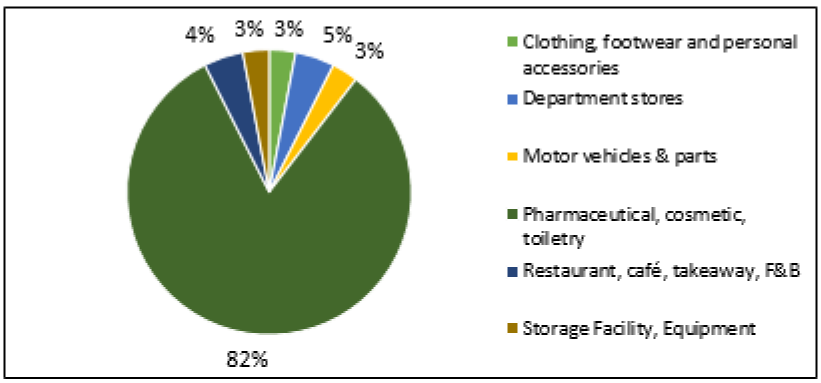

Figure 9. Nature of Retail Organization

In Figure 9 - Survey Respondent Organization's Retail Nature, shows that 82% of the survey respondents are from pharmaceutical, cosmetic, toiletry industry.

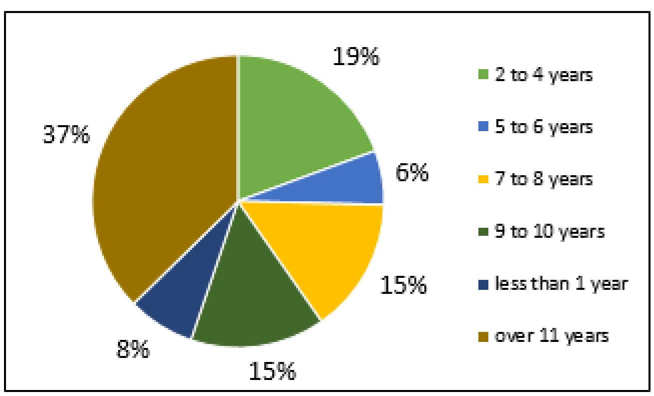

Figure 10. Length of Service

In Figure 10 - Survey Respondents Length of Service, shows that 73% of the survey respondents stayed with their company for more than 5 years. 52% more than 9 years.

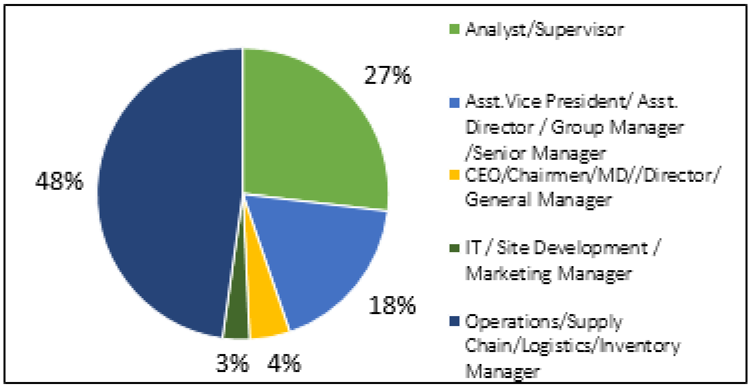

Figure 11. Job Designation

In Figure 11 - Survey Respondent's Job designation, shows that 48% are in the middle management role, 15% in the top management role.

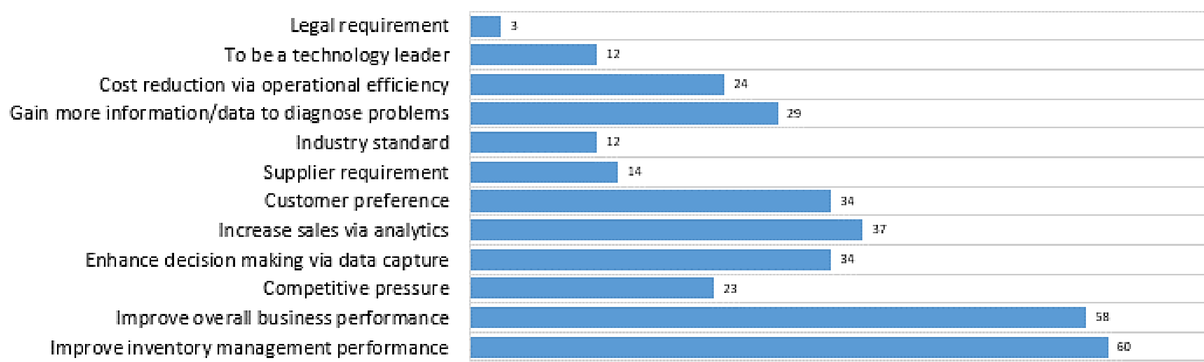

Figure 12. Reason for the Use of Internet of Things

In Figure 12 - Clustered chart shows Improve Inventory Management Performance and Improve overall business performance are the top reason for the use of IoT in their company.

The output provides three relevant pieces of information in the SPSS Pairwise Correlation: (1) the Pearson correlation coefficient; (2) the degree of statistical significance; and (3) the sample size. Table 1 provides the detailed details, i.e. the Pearson correlation coefficient results, to explain the relationship between the two variables in our study.

Coefficient Value Strength of Association
$0.1 < | r | < .3$ small correlation
$0.3 < | r | < .5$ medium/moderate correlation
$| r | > .5$ large/strong correlation

Table 1. Pairwise Correlations, Correlation Value, r

No.	Types of IoT	Improve inventory management performance	Improve overall business performance	Competitive pressure	Enhance decision making via data capture	Increase sales via analytics	Customer preference	Supplier requirement	Industry standard	Gain more information/data to diagnose problems	Cost reduction via operational efficiency	To be a technology leader	Legal requirement
1	Improve inventory management performance	1	-.135	.247*	.249*	.281*	.347**	.176	.032	0.2	.255*	.16	.074
2	Improve overall business performance	-.135	1	.193	.312*	.085	.400**	.202	.184	.079	.203	.184	.085
3	Competitive pressure	.247*	.193	1	.209	.209	.398**	.402**	.482**	.193	.312*	.400**	.299*
4	Enhance decision making via data capture	.249*	.312*	.209	1	.314**	.224	.213	-.007	.439**	.176	.382**	.213
5	Increase sales via analytics	.281*	.085	.209	.314**	1	.374**	.315**	.186	.241*	.047	.029	.195
6	Customer preference	.347**	.400**	.398**	.224	.374**	1	.433**	.304*	.379**	.238	.382**	.213
7	Supplier requirement	.176	.202	.402**	.213	.315**	.433**	1	.430**	.292*	.229	.334**	.421**
8	Industry standard	.032	.184	.482**	-.007	.186	.304*	.430**	1	.063	.138	.188	.275*
9	Gain more information/data to diagnose problems	.2	.079	.193	.439**	.241*	.379**	.292*	.063	1	.415**	.299*	.248*
10	Cost reduction via operational efficiency	.255*	.203	.312*	.176	.047	.238	.229	.138	.415**	1	.300*	.290*
11	To be a technology leader	.16	.184	.400**	.382**	.029	.382**	.334**	.188	.299*	.300*	1	.464**
12	Legal requirement	.074	.085	.299*	.213	.195	.213	.421**	.275*	.248*	.290*	.464**	1

Table 2 shows the level of statistical significance (p-value) of the correlation coefficient used in this study of .005. The test explains if there is a statistically significant relationship between the variables.

Table 2. Pairwise Correlations, Test of Significance, *P*

No.	Types of IoT	Improve inventory management performance	Improve overall business performance	Competitive pressure	Enhance decision making via data capture	Increase sales via analytics	Customer preference	Supplier requirement	Industry standard	Gain more information/data to diagnose problems	Cost reduction via operational efficiency	To be a technology leader	Legal requirement
1	Improve inventory management performance		.278	.044	.042	.021	.004	.155	.795	.105	.037	.197	.552
2	Improve overall business performance	.278		.118	.01	.492	.001	.1	.136	.525	.099	.136	.493
3	Competitive pressure	.044	.118		.089	.09	.001	.001	0	.117	.01	.001	.014
4	Enhance decision making via data capture	.042	.01	.089		.01	.069	.084	.955	0	.155	.001	.083
5	Increase sales via analytics	.021	.492	.09	.01		.002	.009	.132	.049	.707	.814	.114
6	Customer preference	.004	.001	.001	.069	.002		0	.012	.002	.053	.001	.083
7	Supplier requirement	.155	0.1	.001	.084	.009	0		0	.017	.063	.006	0
8	Industry standard	.795	.136	0	.955	.132	.012	0		.611	.265	.128	.024
9	Gain more information/data to diagnose problems	.105	.525	.117	0	.049	.002	.017	.611		0	.014	.043
10	Cost reduction via operational efficiency	.037	.099	.01	.155	.707	.053	.063	.265	0		.013	.017
11	To be a technology leader	.197	.136	.001	.001	.814	.001	.006	.128	.014	.013		0
12	Legal requirement	.552	.493	.014	.083	.114	.083	0	.024	.043	.017	0	

A Pearson's pairwise correlation was run to assess the relationship between variables on the reason to use IoT.

There was a moderate positive correlation between Customer preference and Improve inventory management performance, r = .347, $P < .05$, with Customer preference explaining 5.4% of the variation in Improve inventory management performance.

There was a moderate positive correlation between Customer preference and Improve overall business performance, r = .400, $p < .05$, with Customer preference explaining 6.9% of the variation in Improve overall business performance.

There was a moderate positive correlation between Customer preference and Competitive pressure, r = .398, $P < .05$, with Customer preference explaining 9.6% of the variation in Competitive pressure.

There was a moderate positive correlation between Customer preference and Increase sales via analytics, r = .374, *P* < .05, with Customer preference explaining 9.4% of the variation in Increase sales via analytics.

There was a moderate positive correlation between Customer preference and Supplier requirement, r = .433, *P* < .05, with Customer preference explaining 8.9% of the variation in Supplier requirement.

There was a moderate positive correlation between Customer preference and Industry standard, r = .304, *P* < .05, with Customer preference explaining 5.9% of the variation in Industry standard.

There was a moderate positive correlation between Customer preference and Gain more information/data to diagnose problems, r = .379, *P* < .05, with Customer preference explaining 9.5% of the variation in Gain more information/data to diagnose problems.

There was a moderate positive correlation between Customer preference and To be a technology leader, r = .382, p < .05, with Customer preference explaining 7.4% of the variation in To be a technology leader.

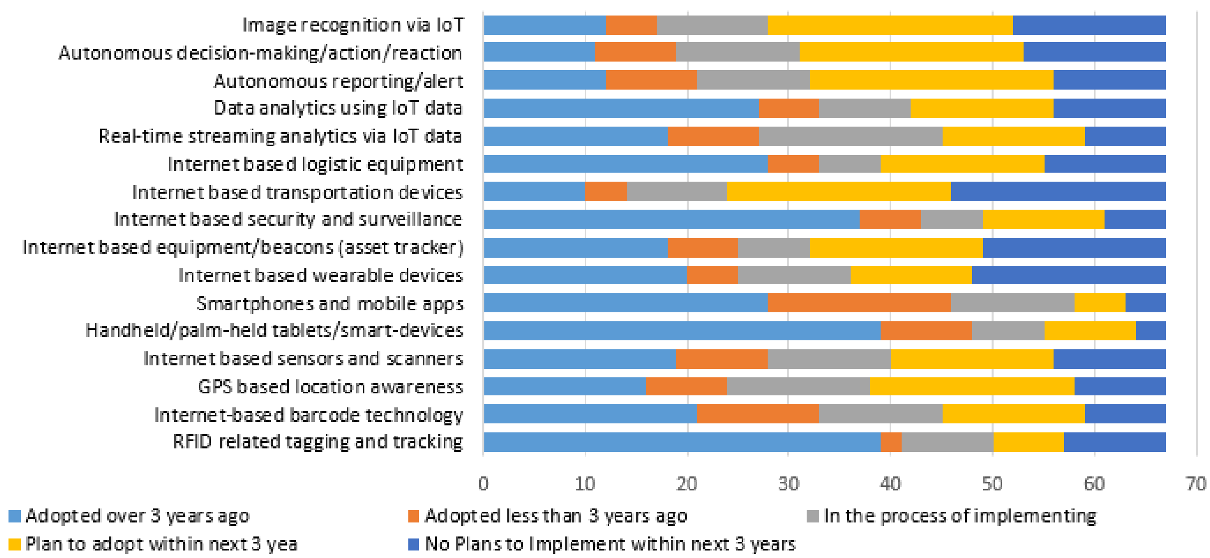

Figure 13. Clustered Chart of Survey Response on the Type of IoT used in their Organization

In Figure 13 Clustered Chart of Survey Response on the Type of IoT used in their Organization. Most of the respondents had answered "RFID related tagging and tracking" and "Handheld/palm-held tablets/smart-devices" had been adopted over 3 years ago. "Smart phone and mobile apps" is the IoT which had been currently adopted by most of the respondents. "Real-time streaming analytics via IoT Date" is in the process of implementing in their organization. "Image recognition", "Autonomous decision-making/action/reaction" and "Autonomous reporting/alert" are the type of IoT which they plan to adopt within the next three years. "Internet based transportation devices", "Internet based equipment/beacons (asset tracker)" and "Internet based wearable devices" are the types IoT which they have no plans to implement within the next three years.

5.2 Test of Goodness of Fit

A. Chi-Square and Sig. is the chi-square statistic and its significance level. The value given in the Sig. column is the probability of obtaining the chi-square statistic given that the null hypothesis is true (Bruin, 2011). This test if predictors accounted for a significant amount of variance in success.

Based on Table 3, "RFID related tagging and tracking" probability of obtaining chi-square statistic (8.467) if there is in fact no effect of the independent variables, taken together, on the dependent variable. This is, of course, the p-value, which is compared to a critical value .05 to determine if the overall model is statistically significant. In this case, the model is statistically significant because the p-value is less than .05.

Below IoT types are with $P < .05$

- RFID related tagging and tracking
- GPS based location awareness
- Handheld/palm-held tablets/smart-devices
- Internet based wearable devices
- Internet based transportation devices
- Internet based logistic equipment
- Real-time streaming analytics via IoT data
- Data analytics using IoT data
- Autonomous reporting/alert

B. Hosmer-Lemeshow statistic indicates a poor fit if the significance value is less than .05. Hosmer and Lemeshow Test for goodness of fit. This is a complicated statistical measure that tells you how good your model is (Analyzing your data with logistic regression in SPSS, n.d.). What you need to look at is the significance measure. If this measure is less than .05, your model does NOT fit your data very well. You want this to be larger than .05.

Result: All IoT types are with $P > .05$

C. Nagelkerke R Square is a method that explains the variation (Laerd, 2018). The values are sometimes referred to as Pseudo R^2 values. It measures how well the model fits the data. The higher the R^2, the better the model fits your data. R^2 is always between 0% and 100%.

Result: Same result of Chi-square, above mentioned IoT types listed have more than 15% of the variance.

Table 3. Binary Logistics Regression: Test of Model Coefficients and Goodness of Fit

No.	Types of IoT	Chi square (Tests of Model Coefficients)		Hosmer and Lemeshow Test (Goodness of Fit)	Nagelkerke R Square
		χ2	*P* value	*P* value	R^2
1	RFID related tagging and tracking	8.467	.037	.320	17.5%
2	Internet-based barcode technology	4.558	.207	.112	9.2%
3	GPS based location awareness	10.718	.013	.520	19.8%
4	Internet based sensors and scanners	6.726	.081	.767	12.9%
5	Handheld/palm-held tablets/smart-devices	7.856	.049	.887	18.2%
6	Smartphones and mobile apps	4.354	.226	.814	11.5%
7	Internet based wearable devices	18.662	.000	.171	32.5%
8	Internet based equipment/beacons (asset tracker)	6.714	.082	.703	12.7%
9	Internet based security and surveillance	2.206	.531	.773	4.7%
10	Internet based transportation devices	13.289	.004	.247	24.7%
11	Internet based logistic equipment	16.46	.001	.365	29.3%
12	Real-time streaming analytics via IoT data	13.107	.004	.183	24.7%
13	Data analytics using IoT data	11.032	.012	.822	20.7%
14	Autonomous reporting/alert	9.308	.025	.827	17.3%
15	Autonomous decision-making/action/reaction	5.261	.154	.746	10.1%
16	Image recognition via IoT	3.913	.271	.706	7.6%

5.3 Test of Significance

The "Variables in the Equation" in SPSS shows the contribution of each independent variable to the model and its statistical significance. Table 4 summarizes the statistics significance of the test.

Table 4. Binary Logistics Regression: Test of Significance of Independent Variables/Predictors

No.	Types of IoT	*Predictors / Variables in the Model*		
		Organizational *P* value	Technological *P* value	Environmental *P* value
1	RFID related tagging and tracking	.017	.508	.115
2	Internet-based barcode technology	.145	.159	.789
3	GPS based location awareness	.576	.013	.216
4	Internet based sensors and scanners	.488	.045	.704
5	Handheld/palm-held tablets/smart-devices	.021	.259	.432
6	Smartphones and mobile apps	.42	.104	.103
7	Internet based wearable devices	.034	.006	.533
8	Internet based equipment/beacons (asset tracker)	.136	.071	.702
9	Internet based security and surveillance	.855	.165	.469
10	Internet based transportation devices	.179	.024	.868
11	Internet based logistic equipment	.004	.18	.041
12	Real-time streaming analytics via IoT data	.007	.117	.317
13	Data analytics using IoT data	.018	.079	.68
14	Autonomous reporting/alert	.029	.409	.083
15	Autonomous decision-making/action/reaction	.12	.194	.65
16	Image recognition via IoT	.157	.292	.635

Significance test of Independent Variables measures if a variable is a significant predictor in the use of IoT.

A. Organization context with $P < 0.05$

- RFID related tagging and tracking
- Handheld/palm-held tablets/smart-devices
- Internet based wearable devices
- Internet based logistic equipment
- Real-time streaming analytics via IoT data
- Data analytics using IoT data
- Autonomous reporting/alert
-

B. Technological context with $P < 0.05$

- GPS based location awareness
- Internet based wearable devices
- Internet based sensors and scanners
- Internet based transportation devices
-

C. Technological context with $P < 0.05$

- Internet based logistic equipment

Upon running Correlation Data analysis in Excel, there was a moderate positive correlation between "Organizational Context" with technological context, r = .530. A strong correlation between "Organization Context" with Environmental Context", r = .708 and between "Technological Context" with "Environmental Context", r = .755.

6. Conclusion

For Research Question 1: "RQ1: What are the significant factors that influence the use of IoT in the design of an Inventory Management System for Omni-Channel Retailing?

- Null Hypothesis 1: There are no significant factors that influences the use of IoT in the design of Inventory Management system for an Omni-Channel Retailing.
- Alternative Hypothesis 1: There are significant factors that influences the use of IoT in the design of Inventory Management system for an Omni-Channel Retailing.

For RQ1, we accept the alternative hypothesis that there are significant factors that influence the use of IoT in the design of Inventory Management system for an Omni-Channel Retailing. Improve Inventory Management Performance and Improve overall business performance are the top reason for the use of IoT in their company. In terms of the relationship between the reasons for the use IoT, “Customer preference” was frequently associated with the other reasons they chose, followed by “To be a technology leader”, “Supplier Requirement” and “Competitive pressure”.

For Research Question 2: “In what way does the use of IoT in the design of an Inventory Management System for Omni-Channel Retailing driven by; a) Organizational context b) Technological context c) Environmental context?

- Null Hypothesis 2: Organizational Context, does not significantly influences the use of IoT in the design of an Inventory Management System for Omni-Channel Retailing.
- Alternative Hypothesis 2: Organizational Context, significantly influences the use of IoT in the design of an Inventory Management System for Omni-Channel Retailing
- Null Hypothesis 3: Technological Context, does not significantly influences the use of IoT in the design of an Inventory Management System for Omni-Channel Retailing.
- Alternative Hypothesis 3: Technological Context, significantly influences the use of IoT in the design of an Inventory Management System for Omni-Channel Retailing.
- Null Hypothesis 4: Environment Context, does not significantly influences the use of IoT in the design of an Inventory Management System for Omni-Channel Retailing.
- Alternative Hypothesis 4: Environment Context, significantly influences the use of IoT in the design of an Inventory Management System for Omni-Channel Retailing.

To identify factors that predict the use of IoT in the design of an Inventory Management system for an Omni-channel retailing in a sample of individuals in management position, a binary logistic regression analysis was conducted, simultaneously including Organizational, Technological and Environmental context into the model. The results indicated that, together, the predictors accounted for a significant amount of variance in success, for the 9 out of the 16 IoT types. The Nagelkerke pseudo-R2 indicated approximately an average of 17% of the variance in the Use of IoT was accounted for by the predictors overall. Out of all of the predictors in the model, Organizational context was a significant independent predictor on the use of IoT.

Thus, for RQ2.a we accept the alternative hypothesis that Organizational Context significantly influences the use of IoT in the design of an Inventory Management System for Omni-Channel Retailing in the 7 Types of IoT “RFID related tagging and tracking”, “Handheld/palm-held tablets/smart-devices”, “Internet based wearable devices”, “Internet based logistic equipment”, “Real-time streaming analytics via IoT data”, “Data analytics using IoT data” and “Autonomous reporting/alert”.

In addition, for RQ2.b we accept the alternative hypothesis that Technological Context significantly influences the use of IoT in the design of an Inventory Management System for Omni-Channel Retailing in the 3 Types of IoT i.e. “GPS based location awareness”, “Internet based wearable devices”, and “Internet based transportation devices”.

Lastly, for RQ2.c we accept the alternative hypothesis that Environmental Context significantly influences the use of IoT in the design of an Inventory Management System for Omni-Channel Retailing in 1 Types of IoT i.e. “Internet based logistic equipment”.

Retail companies who are gearing towards an omni-channel retailing should review the Organizational context as it greatly affects the decision to use IoT. Organizational context is the characteristics and resources of the firm, as well as the firm’s size, degree of centralization, degree of rationalization, managerial structure, human resources, quantity of slack resources, and linkages among workers. Since only 12% of retailers globally offer mature Omni-channel experiences, there is a need for the rest of the retailers to leverage and identify how they can enter into this world of Omni-channel (Ramadan, 2017). Omni-channel retailing will only be successful if key players across all department can come together and follow this new trend. Before taking this road, planning to execution and actual adaption strategy is needed.

There are wide varieties of IoT that can be used in order to fulfill the requirement of the company amongst which are to improve inventory management performance and improve overall business performance. Customer preference is the top to be associated by the management to influence their reason to use IoT. Most customers nowadays expect stores to provide an ease in shopping experience. We have seen customers who have changed their shopping behavior from the traditional brick and mortar but also in digital. Working both offline and online strategy should be considered to have a unique customer-centric service delivery.

RFID related tagging/tracking equipment and Handheld/smart-devices are early adopted IoT types and had been successfully used and gained benefits by retail companies. Though it is not a very sophisticated machine, unlike the launching of AI, it had proven that it can improve inventory management or item monitoring. The capabilities that omni-channel can bring are undeniably an absolute must for retail sustainability, and RFID technology helps provide retailers with the versatility and resilience they need (Nagpal, 2017).

References

Awad, H. A. H., & Nassar, M. O., Supply chain integration: Definition and challenges. Proceedings of the International MultiConference of Engineers and Computer Scientists 2010, IMECS 2010, I, 405–409, 2010.

Celik, F., Internet of Things as a source of future marketing tools. Retrieved from https://essay.utwente.nl/70097/1/Celik Ferhat %282016%29 Internet of Things as a source of future marketing tools.pdf, 2016.

Elbounani, S., El Kiram, M. A., & Achbarou, O., Introduction to the Internet of Things Security. 11th International Conference on Information Assurance and Security (IAS), (March), 1–29. Retrieved from http://community.thingspeak.com/tutorials/introduction-to-the-?internet-of-things?-and-thingspeak, 2015.

Food Industry Asia, The Philippines: A Rising Star in Asian Retailing, 2016.

Greener, S., Business Research Methods.[e-book] Dr. In Sue Greener and Ventus Publishing ApS. Available through: http://www.bookbon.com., Retrieved from http://gent.uab.cat/diego_prior/sites/gent.uab.cat.diego_prior/files/02_e_01_introduction-to-research-methods.pdf, 2008.

Hsieh, F. Y., Bloch, D. A., & Larsen, M. D., A simple method of sample size calculation for linear and logistic regression. Statistics in Medicine, 17(14), 1623–1634. https://doi.org/10.1002/(SICI)1097-0258(19980730)17:14<1623::AID-SIM871>3.0.CO;2-S, 1998.

Juego, A., PH retail scene alive and kicking, January 2020.

Laerd. Laerd Statistics, Retrieved November 1, 2021, from Lund Research Ltd website: https://statistics.laerd.com/spss-tutorials/binomial-logistic-regression-using-spss-statistics.php, 2018.

Mahajan, S., Internet of Things , Big Data , Business Intelligence & Mobility What is the Internet of Things ?, 2015.

MarketsandMarkets, Internet of Things (IoT) in Retail Market, Retrieved from https://www.marketsandmarkets.com/Market-Reports/retail-iot-market-43188550.html, March 6, 2020.

Mühl, J. K., Research methodology. Contributions to Management Science, 75–100. https://doi.org/10.1007/978-3-319-04069-1_4, 2014.

Nagpal, A., Using RFID for Omnichannel Fulfillment Success. Retrieved from https://multichannelmerchant.com/operations/using-rfid-omnichannel-fulfillment-success/, 2017.

Omnirio. Which is a better retail strategy?, 2019.

Ozturk, A., Organizational-Level RFID Technology Adoption in the Hospitality Industry. 17, 629–642, 2012.

Park, H. A., An introduction to logistic regression: From basic concepts to interpretation with particular attention to nursing domain. Journal of Korean Academy of Nursing, 43(2), 154–164. https://doi.org/10.4040/jkan.2013.43.2.154, 2013.

Philippine Statistics Authority, 2016 Annual Survey of Philippine Business and Industry (ASPBI), 2019.

Ramadan, S., OmniChannel Marketing:The Roadmap to Create and Implement Omnichannel Strategy For Your Business. Retrieved November 1, 2021, from https://www.amazon.com/OmniChannel-Marketing-Implement-Omnichannel-Strategy/dp/1520268149, 2017.

Shteren, H., & Avrahami, A., The value of inventory accuracy in supply Chain management-case study of the yedioth communication press, Journal of Theoretical and Applied Electronic Commerce Research, 12(2), 71–86. https://doi.org/10.4067/S0718-18762017000200006, 2017.

Tornatzky, L. G., & Fleischer, M., Processes of technological innovation, In Lexington books, 1990.

Zentes, J., Morschett, D., Schramm-Klein, H., Zentes, J., Morschett, D., & Schramm-Klein, H., Store Location – Trading Area Analysis and Site Selection. In Strategic Retail Management, https://doi.org/10.1007/978-3-8349-6740-4_11, 2011.

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