On Evaluation of NFC Technology in Hypermarkets Using the DEMATEL-based Analytic Network Process

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Abstract. Hypermarkets, a combination supermarket/department store, offer consumers convenient access to a wide range of goods, often at considerable discounts. Operating on a high-volume, low sales margin model, hypermarkets offer discounts to draw additional consumer traffic. Over the past 20 years, hypermarkets have become quite popular in Taiwan, and have forced many less-competitive local retailers out of business. Today, however, new technologies and consumer expectations present hypermarkets with a threat from online shopping. This research seeks to develop improved strategies to help hypermarkets stabilize and win back market share by enhancing the customer's shopping experience through implementing NFC mobile shopping methods. This study proposes an evaluation framework that involves interdependence and feedback among dimensions and criteria, and uses the DEMATEL-based Analytic Network Process (DANP) to obtain the influential criteria weighs, and eventually obtain the weight of the super matrix of the important factors to identify key factors for introducing NFC shopping in hypermarkets.

Keywords: NFC, Mobile Shopping, Hypermarket, DEMATEL, Analytic Network Process

1. INTRODUCTION

The global retail industry is adopting an "Omni-Channel" approach, combining multiple online and offline channels to provide consumer different shopping experience, while expanding sales opportunities and enhancing market competitiveness. In September 2012, Wal-Mart, for example, launched a new payment system called "Scan & Go" to save the company labor costs and obtain critical real-time consumer shopping behavior and reactions to special offers. While in-store and post-purchase consumer behavior are all important business information, such information mentioned earlier can be very difficult to grasp. Not only that, they can be difficult to clearly convey actual internal consumer demand to product manufacturers (Pantano, 2016).

In a May 2012 survey of online shopping behavior, MasterCard International found that over 40% of people in Taiwan with access to internet-enabled mobile devices either have previously or have considered using mobile shopping applications. Surprisingly, only 15.4% of consumers report being highly satisfied with their mobile shopping experience. This leaves considerable room for elevating the consumer's experience of mobile shopping. In fact, Pantano (2016) pointed out that retailers need to develop new mobile service competences, and integrate and synthetize physical retail settings with mobile opportunities and functionalities. Wiechert *et al*. (2009) found while NFC based services were on average conceded to be able to accelerate the checkout process at the point-of-sale, it could also provide shoppers with more benefits beyond faster payments.

As many companies are actively seeking to develop operation modalities that integrate multiple sales channels, including communications platforms, online stores, physical stores and catalogs. Those that are unable to leverage information technology to improve customer service and satisfaction will face severe challenges and missed opportunities. Morosan (2016) explored intentions to use NFC-MP in hotels, and found that performance expectancy was the highest predictor of intentions, while hedonic motivations, habit, and social influences have relatively lower effects. Apanasevic (2016) found that depending on the ability of mobile payment providers to build networks of both retailers and consumers simultaneously, such services would be attractive to them. The present study seeks to propose ways of optimizing hypermarket revenues, develop mobile shopping, and enhance shopping security", and explores the feasibility of outfitting hypermarkets with NFC-based mobile shopping systems.

This study considers both Decisions Making Trial and Evaluation Laboratory (DEMATEL) with Analytic Network Process (ANP). DEMATEL was proposed by Fontela & Gabus (1976) as an approach to hierarchical recognition to clarify the causality between variables. Its main purpose is to identify the interdependence between multiple criteria and their degree of influence (Tamura & Akazawa, 2005). DEMATEL not only creates a structural model of the causal relationship between elements, but also shows the dependencies between elements in the handling criteria (Hori & Shimizu, 1999). Analytic Network Process (ANP) was proposed by Saaty in 1996 as an extension of the decision analysis method. It is similar to AHP in that pairwise comparisons are used to judge the importance of the element, but it contains a graphical structure which reflects the mutual influence between the cluster and node to form a web-like structure.

Both methods have been widely applied in academic research. DEMATEL applications include Ranjan (2016) in railway, Shao (2016) in automobile, Efe (2016) in healthcare, Nawaz (2013) in education. Meanwhile ANP applications are Rezaei (2014) in airline Pourmohammad (2016) in banking service. Lombardi (2014) investigated a framework for the design of retail policies, strategies, and action. Hybrid methods are Govindan (2016) in logistic, Jyh-Fu (2012) in mobile communication, Wang (2012) and Liu (2014) in brand. These studies show that DEMATEL and ANP are mostly in complex critical assessments across many areas. However, it has not been used to assess the development of mobile commerce, a gap which the present study seeks to fill.

2. METHODOLOGY

This study focuses on how hypermarkets evaluate NFC shopping processes in an effort to identify key factors with high weight values to provide a suitable final plan for the implementation of NFC shopping for hypermarkets. We first review the relevant literature and confirm analysis methods. A hybrid MCDM model is proposed with DEMATEL and ANP to evaluate each perspective and criterion, and to measure the importance of each factor.

The DEMATEL questionnaire was constructed and analyzed for the selection of key dimensions/criteria in an ANP framework. The collection of a large number of survey items may negatively impact analysis consistency, thus this section applies DEMATEL to filter out highly related factors and those with causal relatedness. The relative importance criteria were found by asking 15 experts in the hypermarket domain, including 12 individual with rich experience in hypermarket operations and three experts in the field of NFC system planning.

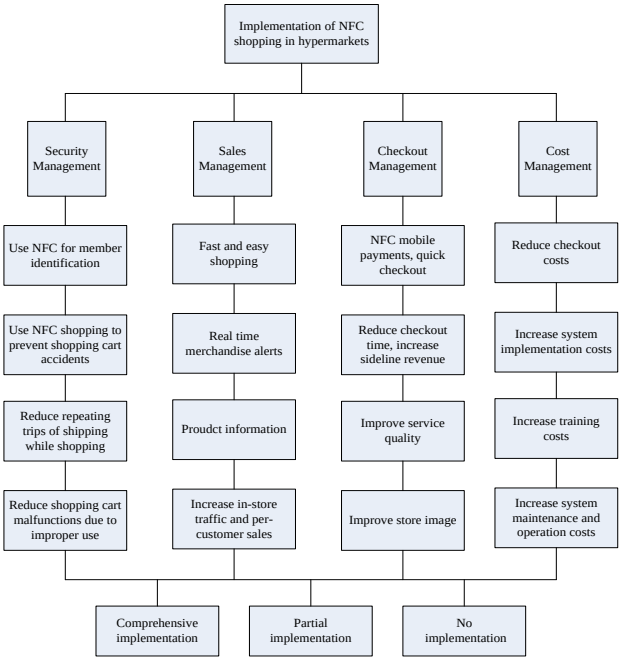

Figure 1: Hierarchical framework for the introduction of NFC shopping analysis in hypermarkets

The survey was administered in two sections. In the first section, the dimensional analysis is done to select four dimensions of five. Question responses ranged from 0 to 3 with a high score meaning high importance and the calculation was done ref. to Jharkharia & Shankar's paper (2004). In the second section, the component structure of each criterion is analyzed to understand the direction and intensity of the factors and sub-factors.

A visual structural matrix and causal diagram is shown in Fig. 1; the preliminary hierarchical framework is divided into four levels: objectives, dimensions, factors, and solutions for subsequent ANP analysis of key analysis items. The completed questionnaires were subjected to ANP to determine interrelations among constructs and then to calculate the weighting of the various constructs, with higher weight correlating with increased impact. Compared with the study's objectives and background, key factors with higher weightings are discussed and summarized as a reference for the hypermarket operators and related academic researchers.

For the objectives of the framework, this study seeks to help hypermarkets respond to declines in annual revenue, and to evaluate key factors and feasible solutions for the introduction of NFC shopping in hypermarkets. Following with all the criteria related to the introduction of NFC shopping in hypermarkets, the content of this level includes a total of four categories: "A-Security Management, B-Sales Management, C-Checkout Management, and D-Cost Management. Then, within each criteria, dimensions are further constructed for evaluation.

For Security Management, four dimensions include "A1 Use NFC for member identification", "A2 Use NFC shopping to prevent shopping cart accidents", "A3 Reduce in-store cart loads", and "A4 Reduce shopping cart malfunctions due to improper use". For Sales Management, four dimension include "B1 Fast and easy shopping", "B2 Real time merchandise alerts", "B3 Product information", and "B6 Increase in-store traffic and per-customer sales". For Checkout Management, there are "C1 NFC mobile payments", "C3 Quick checkout, reduce checkout time, "C6 Increase sideline revenue, Improve service quality", and "C8 Improve store image". For Cost Management, four dimensions are "D2 Reduce checkout costs", "D5 Increase system implementation costs", "D7 Increase training costs", and "D8 Increase system maintenance and operation costs".

Interviews with industry experts reveal that NFC system implementations can be categorized as comprehensive, partial and none. The comprehensive implementation takes place at one time across all departments, with simultaneous across-the-board implementation of NFC mobile shopping systems. The objective is to quickly achieve complete system implementation and good process convergence across all departments, thus maximizing overall efficiency. Then, partial implementation means that hypermarkets prioritize NFC mobile shopping system implementation in specific departments. Finally, following an assessment of the organization's needs and potential implementation benefits, the organization elects not to implement NFC mobile shopping systems.

3. RESULTS AND DISCUSSION

This section focuses on using the research architecture for data analysis. First, respondents indicate the degree of direct influence on a scale o 0,1, 2, and 3, "No influence", "Low influence", "Medium influence", and High influence", respectively. These averages were then used to create an initialized relational matrix, a normalized relational matrix and a total impact relational matrix. Column D presents the sum total of the total impact relational matrix, and column R is the sum total of each row. The resulting data were analyzed using Excel to calculate the average values for each factor. The dispatcher criteria have positive values of *D-R* and thus greatly influence the other criteria. The receivers have negative values of *D-R* and are influenced by the other criteria. The resulting table is used to construct an operational table for the total impact relational matrix (see Table 1).

Table 1 shows the extent of the impact of each criterion and dimension. Checkout Management has the greatest direct impact on others (D_C-R_C=0.493) in total difference whereas Security Management (D_A-R_A=-0.650)is the most easily influenced by others. For the security management dimension, "A1 Use NFC for member identification" is influenced by the rest of criteria. For the sales management dimension, "B1 Fast and easy shopping" has the greatest direct impact whereas " B2 Real time merchandise alerts" is the most easily influenced. For the checkout management dimension, "C6 Improve service quality" is easily influenced; however, both "C1 NFC mobile payments" and "C3 Quick checkout, Reduce checkout time" have the greatest direct impact. For the cost management dimension, "D2 Increase training costs" is the most easily influenced while "D5 Increase system implementation costs" has the most direct impact.

The value of *D+R* indicates the degree of relationship of each criterion with the other criteria. The relationship is stronger with higher values of *D+R*, whereas the relationship is weaker with lower values. Factors in the total impact relational matrix, with the degree of correlation for the security management dimension from greatest to smallest are as follows: A2 > A3 > A4 > A1. The order of correlation for sales management dimension factors is as follows: B1 > B6 > B2 > B3. The order of correlation for checkout management dimension factors is as follows: D5 > D2 > D7 > D8. Because the degree of relatedness for D+R are clearly smaller than the others, these factors have a lower impact and thus can be excluded. Therefore, the DEMATEL analysis results confirm the four dimensions and 16 factors used in this study.

Table 1: Total influence matrix for dimensions/criteria

criteria	D	R	D+R degree of correlation	D-R causal relationship
A	3.031	3.681	6.712	-0.650
A1	2.823	2.935	5.758	-0.111
A2	3.719	3.426	7.146	0.293
A3	3.444	3.153	6.598	0.291
A4	3.270	3.027	6.297	0.243
B	4.332	4.211	8.543	0.120
B1	3.034	2.208	5.242	0.826
B2	2.265	2.772	5.037	-0.506
B3	2.227	2.277	4.504	-0.050
B6	2.388	2.001	4.388	0.387
C	4.011	3.518	7.528	0.493
C1	3.387	3.220	6.607	0.167
C3	3.300	3.129	6.430	0.171
C6	2.695	2.822	5.517	-0.128
C8	2.512	2.575	5.087	-0.063
D	3.119	3.194	6.313	-0.075
D2	1.515	1.524	3.039	-0.008
D5	2.165	1.647	3.812	0.517
D7	1.483	1.697	3.180	-0.213
D8	1.380	1.184	2.564	0.196

Sorted from greatest to smallest, the *D+R* degree of correlation is B > C > A > D, indicating that experts expect that NFC shopping implementation in hypermarkets will improve sales, checkout, security and cost management. Combined with the *D-R* causal relationship, we see that B and C are the key factors. These two items are not only highly correlated, but can impact other factors, thus during implementation, progress evaluation of B and C can not only improve management practices, but can also continuously improve other dimensions. The *D+R* degree of correlation for E is considerably lower than the other items, indicating that the dimension has a relatively low impact. It was thus excluded from subsequent analysis, and was not included in the Stage 2 questionnaire.

In addition to the existing hierarchy of the top-down relationship, ANP analysis also focuses on the element interdependence, which sets ANP apart from AHP. Therefore, the key objective of this stage is to identify external dependencies between elements. Through the collected assessments, we use the relationship between the design matrixes to process the factor dependencies of the questionnaire and the domain expert responses. Once the completed questionnaires are recovered, the threshold for determining dependency between two variables is each factor having four or more votes. Using "A1 Use NFC for member identification" as an example, the score results show that "B1 Fast and easy shopping", "B6 Increase customer traffic and per-customer sales", "C8 Improve store image" and "D5 Increase system implementation costs" are all mutually dependent. Figure 2 maps out the factor dependency network, showing external dependencies among the elements. Thus we can next use the factor dependency network relationship to design the ANP questionnaire for distribution to domain experts and subsequent analysis.

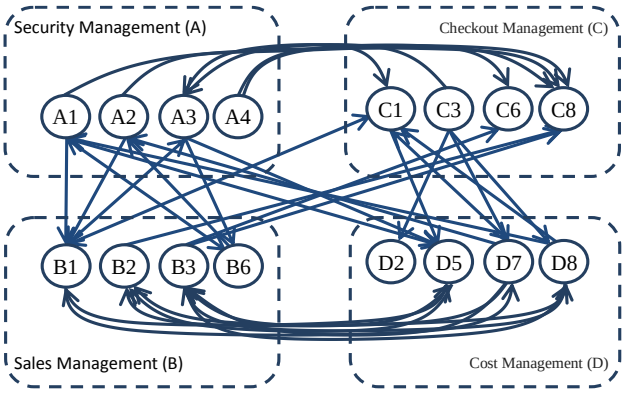

Figure 2: Factor dependency network

This study uses the Super Decisions software package developed by Saaty et al. (1996) to conduct ANP computational analysis. The ANP expert questionnaire was divided into four sections. The first section focuses on comparing the four dimensions for implementing NFC shopping in hypermarkets to determine their relative importance. Then, within each dimension, pairwise comparisons of its elements were performed to determine their relative importance. Finally, from this element comparison we determine the importance of each solution. Because the ANP questionnaire content is based on pairwise comparisons of its importance, when completing the questionnaire, the domain experts select the more important of a pair of elements, and a higher weighting indicates greater importance.

Table 2: Random Index

N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
R.I.	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.48	1.48	1.56	1.57	1.59

Following Satty's recommendation, when the consistency indicator (*C.I.*) value and the consistency comparison ratio (*C.R.*) $\leqq 0.1$, the error of the best analysis result is acceptable. *C.I.* and *C.R.* values > 0.1 indicate a conflict in the questionnaire results (Saaty, 1980). R.I. stands for random index and represents an average *C.I.* for a huge number of randomly generated matrices of the same order. In this study, each of the four dimensions includes four factors to create a 4x4 matrix. Therefore N=4 and R.I. is 0.90. The consistency ratio formula and the R.I. index table (Table 2) are used to produce the results in Table 3, where the *C.I.* and *C.R.* values for each factor are $\leqq 0.1$, indicating that the 15 domain experts were highly consistent in their weightings for the various factors and dimensions, suggesting that the questionnaire results are credible.

Table 3: Consistency Ratio results

Item	C.I.	C.R.
A1 Use NFC for member identification	0.03100	0.03444
A2 Use NFC shopping to prevent shopping cart accidents	0.00000	0.00000
A3 Reduce transport redundancies while shopping	0.00393	0.00437
A4 Reduce shopping cart malfunctions due to improper use	0.00000	0.00000
B1 Fast and easy shopping	0.00898	0.00998
B2 Real time merchandise alerts	0.00000	0.00000
B3 Product information	0.00604	0.00671
B6 Increase in-store traffic and per-customer sales	0.00585	0.00650
C1 NFC mobile payments, quick checkout	0.02763	0.03070
C3 Reduce checkout time, increase sideline revenue	0.00105	0.00117
C6 Improve service quality	0.00000	0.00000
C8 Improve store image	0.00000	0.00000
D2 Reduce checkout costs	0.00000	0.00000
D5 Increase system implementation costs	0.00278	0.00309
D7 Increase training costs	0.04165	0.04628
D8 Increase system maintenance and operation costs	0.01790	0.01989
A Security Management	0.04735	0.05261
B Sales Management	0.04550	0.05056
C Checkout Management	0.03769	0.04188
D Cost Management	0.01112	0.01236
G- Implementation of NFC shopping in hypermarkets	0.06831	0.07590

The matrix values are produced by factor dependency. Therefore, because the total factor weighting values for each dimensional module in the original super matrix equals 1, we are unable to compare the overall factor importance, and the original super matrix is normalized. Following normalization, the total values for each row in the super matrix equals 1, and is thus called a weighted super matrix. Finally, the weighted super matrix is continuously self-multiplied so that each element in the matrix converges to a fixed limit, referred to as an extreme super matrix. At this point, we can compare the overall weighting of each factor to obtain the key factors for this study.

Table 4: Ranked Criteria weightings for NFC shopping implementation in hypermarkets

Name	Group wt.	Extreme wt.	Rank
B1 Fast and easy shopping	0.169	0.073	**1**
C1 NFC mobile payments, quick checkout	0.127	0.055	**2**
D5 Increase system implementation costs	0.113	0.049	**3**
C8 Improve store image	0.101	0.044	**4**
A3 Reduce transport redundancies while shopping	0.087	0.038	**5**
D7 Increase training costs	0.080	0.035	**6**
B2 Real time merchandise alerts	0.076	0.033	**7**
B3 Product information	0.060	0.026	**8**
D8 Increase system maintenance and operation costs	0.054	0.024	**9**
A2 Use NFC shopping to prevent shopping cart accidents	0.040	0.017	**10**
B6 Increase customer traffic and per-customer sales	0.034	0.015	11
A1 Use NFC for member identification	0.030	0.013	12
C6 Improve service quality	0.028	0.012	13
A4 Reduce shopping cart malfunctions due to improper use	0.000	0.000	14
C3 Reduce checkout time, increase sideline revenue	0.000	0.000	14
D2 Reduce checkout costs	0.000	0.000	14

Table 5: Ranked alternatives weightings for NFC shopping implementation in hypermarkets

Name	Group wt.	Extreme wt.	Rank
F1 Comprehensive implementation	0.508	0.287	**1**
F2 Partial implementation	0.353	0.199	**2**
F3 No implementation	0.139	0.079	**3**

Table 4 uses the weighting values of the extreme super matrix to rank the factor and alternatives weightings for the analysis of the key factors and alternatives of the present study. In order, the top ten ranked factors are "B1 Fast and easy shopping" (0.073), "C1 NFC mobile payments, quick checkout" (0.055), "D5 Increase system implementation costs" (0.049), "C8 Improve store image" (0.044), "A3 Reduce transport redundancies while shopping" (0.038), "D7 Increase training costs" (0.035), "B2 Real time merchandise alerts" (0.033), "B3 Product information (0.026)", "D8 Increase system maintenance and operation costs" (0.024), and "A2 Use NFC shopping to prevent shopping cart accidents" (0.017). In terms of evaluating NFC shopping in hypermarkets, the dimensions are ranked as follows: D Cost Management, A Security Management, C Checkout Management, and B Sales Management. Finally, the alternatives are ranked as follows (see Table 5): F1 Comprehensive implementation (0.287), F2 Partial implementation (0.199) and F3 No implementation (0.079). This indicates that the domain experts' evaluation of NFC mobile shopping recommended comprehensive implementation.

Table 6: Weights of top ten factors with respect to implementation alternatives

Criteria	Implementation Alternatives		
	Comprehensive	Partial	No
B1 Fast and easy shopping	0.533	0.349	0.118
C1 NFC mobile payments, quick checkout	0.492	0.370	0.138
D5 Increase system implementation costs	0.547	0.328	0.125
C8 Improve store image	**0.572**	0.309	0.119
A3 Reduce transport redundancies while shopping	0.514	0.352	0.134
D7 Increase training costs	0.464	**0.405**	0.131
B2 Real time merchandise alerts	0.534	0.344	0.122
B3 Product information	0.476	0.363	0.161
D8 Increase system maintenance and operation costs	0.507	0.344	0.149
A2 Use NFC shopping to prevent shopping cart accidents	0.366	0.382	0.251

With respect to each alternative, Table 6 shows results with respect to each implementation alternatives, ranked factors play domain roles differently in the implementation of NFC shopping systems. For example, when considering comprehensive implementation of NFC mobile shopping systems, managers focus most on whether such implementation can effectively improve store image; however, when considering partial implementation, managers would focus most on whether it increases training costs.

4. CONCLUSIONS

The growth of mobile shopping has been driven by the increasing popularity of wireless smart phones and tablet computers, allowing consumers to shop anywhere at any time. Consequently it has contributed to significant changes in consumer behavior, and has emerged as a new avenue for stimulating buying incentives and decision-making processes. This study can help hypermarket managers to identify key factors on the implementation of NFC shopping thereby to provide a suitable final plan for such implementation.

A hybrid MCDM model is proposed with DEMATEL and ANP to evaluate each perspective and criterion, and to measure the importance of each factor. Data collection included input from 15 experts in the hypermarket domain, including 12 individual with rich experience in hypermarket operations and three experts in the field of NFC system planning. Compared with the study's objectives and background, key factors with higher weightings are discussed and summarized as a reference for the hypermarket practitioners and related academic researchers. In the study, several factors for the implementation of NFC shopping synchronizes with new technologies and consumer expectations present hypermarkets, i.e. "Fast and easy shopping (B1)", "NFC mobile payments, quick checkout (C1)", and "Real time merchandise alerts (B2)", and "Product information (B3)".

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