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Developing a causal relationship among factors of e-commerce: A decision making approach

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ABSTRACT

This study introduces the decision-making trial and evaluation laboratory (DEMATEL) method to develop a causal relationship between factors of e-commerce. Differently from the typical correlation analysis which directly used two groups of variables to measure strength of correlation, this decision making approach develops two groups of factors which are known as cause and effect groups to enhance the significance of e-commerce. A survey approach was used to collect data from a purposeful sampling of undergraduate students at a public university in Malaysia. Empirical data were computed using the seven-step of DEMATEL method where the initial decision matrix was transformed to total relation matrix prior to developing cause and effect diagram. Not only did the DEMATEL unravel the relationship between factors, the DEMATEL method also provides degrees of importance of all factors. The main finding of this study is the visualization of the causal relationship among factors of e-commerce through a digraph, where the factor 'information about products or services' is mutually influenced by the factors 'convenience', 'ease of use system' and 'web reputation'. E-commerce companies should, however, carefully evaluate the cause and effect factors, and the degree of importance of factors when offering services or products via online.

1. Introduction

One of the many growing businesses in today's internet of things era is e-commerce. It is one of the possible ways in running business transactions empowered by the internet. In layman's terms, e-commerce stands for electronic commerce and it is also known as e-business. E-commerce is popularly defined as the process of trade and exchange goods, services, or information through an electronic medium, primarily the internet (Turban et al., 1999). According to Ngai and Wat (2005), e-commerce also can be defined as a modern business methodology that addresses the needs of organizations, merchants, and consumers to cut costs while improving the quality of goods and services and increasing the speed of service delivery. Tsai and Cheng (2012) reported that marketing via online has benefits of accessibility in terms of time and distance, convenient way of searching product, lower price and without the limitation of location. This is among the major reasons why e-commerce has been accepted as a convenient way in business transactions and at the same time may threaten many traditional ways of doing business. In the midst of rapid growth in global internet usage, e-commerce is expected to continue to grow rapidly. There are almost twenty million internet users in Malaysia, and approximately fifty percent of it has online shopping experience or transacting online. According to Nadaraj (2015), Malaysia's total e-commerce transactions in 2011 may be worth as much as RM900 million and increase to RM5 billion in 2015. The Statistics Portal (2016), highlights that revenue in the e-commerce market amounted to US$894 million in 2017, and expected to grow 23.2% annually in which resulting in a market volume of US $2585 million in 2021. User penetration is about at 65.7% in 2017 and is expected to hit 76.8% in 2021. The significance of e-commerce in today's business climate has attracted substantial research in e-commerce not only in technical supports of the inter-

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net and e-commerce systems, but also has been extended to search for success factors of e-commerce.

There are multiple factors and issues that can be associated with the success of e-commerce as a medium of business transactions (Losethakul and Boulton, 2007; Viehland, 2000). Table 1 summarises the research focus and multiple factors that determining the success of e-commerce.

Most of the literature acknowledged the contribution of multiple factors to the success of e-commerce. Correlation analysis is one of the most commonly used statistical evidences to support the association among the multiple contributing factors. For example, Senarathna et al. (2014) indicated that a positive correlation between culture and e-commerce adoption. They also concluded that hierarchy cultural characteristics have a negative correlation with e-commerce adoption. Lin et al. (2016) explored a correlational study using structural equation modelling to link between e-service quality and logistics service quality to customer satisfaction. Bao et al. (2016) made a confirmation on the positive correlation between customer satisfaction and trust using partial least square approach. Very recently, a study was conducted by Lin et al. (2018) to examine the association between service justice and negative emotion, and also service dissatisfaction. Data from users were analysed using partial least square method of structure equation modelling where the correlation between multiple factors was obtained. The correlational results indicate that service justice has a negative significant correlation with negative emotion, and negative emotion significantly induces service dissatisfaction. Also, negative emotion and service dissatisfaction were positively correlated with service justice. In another correlational study, multiple factors behind the development of e-commerce services such as frequency of internet shopping, logistic aspects of e-commerce services, and the criteria for the evaluation of quality of e-commerce services based on customer satisfaction were found correlated with five aspects of logistics in e-commerce (Gajewska and Zimon, 2018). Aspects of logistics that included in this study were reliability of the supply, completeness of the supply, shipping price, delivery time, and the choice of a courier company. The Pearson correlation analysis was chosen to determine the impact between the surveyed factors. However, these statistical approaches require a number of assumptions to be fulfilled. For example, the assumptions of the random sample and homogeneity of data are required to be tested prior to analysing with correlation analysis (Triola, 2008). Perhaps these are some of the disadvantages and limitations of the statistical approaches. In contrast to these approaches, this paper intends to propose a cause-effect relationship between factors of e-commerce using a multi-factor decision making approach where no assumptions are made against data or experiment. Furthermore, despite a long list of possible factors and issues contributes toward the success of e-commerce, little information is available on which factors are more important than the other. It is hypothesized that there is some extent of causal relationship among these factors, and more importantly these factors are not equally important. Moreover, the relative importance of the factors compared to other factors is difficult to measure due to its subjectivity and intangibility. In particular, this study will examine two main research questions. The first question asks about the most important factor contributing toward the success of e-commerce and the second question of this study is whether there exist a causal relationship among factors. In response to these problems and research questions, this study aims to carry out a better solution in visualizing the cause-effect relationship among factors as well as to measure the importance of factors that contribute to the success of e-commerce. The method used must be capable to provide all these answers and be able to capture the causal relationship among multiple factors of e-commerce. One of the appropriate methods that purposely used to capture causal relationship among multiple factors of decision problems is the decision-making trial and evaluation laboratory (DEMATEL).

The DEMATEL method was widely used for researching and solving complicated and intertwined problems group in many issues (Fontela and Gabus, 1976). Primarily, the DEMATEL method is used in analysing the causal relationships in many cases including lean management where factors in a machine tool manufacturing firm located in the national capital region of India were investigated (Sharma et al., 2016). In addition, the method was able to project and to solve problems visually with digraphs and able to convert the interrelations among the cause group and effect group of factors into an intelligible structural model of a system (Jeng, 2015). The beauty of DEMATEL was described by Tzeng and Huang (2011), where the related factors of a decision problem can be divided into the cause group and effect group. Moreover, the DEMATEL method was particularly pragmatic way to visualize the structure of complex causal influences with digraphs. Based on these advantages, it is believed that the DEMATEL method can provide an efficient tool in solving multiple factors problems specifically in unravelling the interactions among factors in e-commerce. The words criteria and factors are used interchangeably in this paper as to apt with the DEMATEL method.

Table 1
Reviews of research focus and factors determining the success of e-commerce.

Sources/ Authors	Research Focus	Factors determining success of e-commerce
Paynter and Lim (2001)	Issues that may dampen the success of e-commerce.	1. Lack of privacy declaration 2. Poor product statements 3. Slow delivery of products 4. Limited discount 5. Doubt about security
Shah Alam et al. (2011)	Factors affecting adoption of e-commerce among small and medium-sized enterprises.	1. Relative advantage 2. Compatibility 3. Organizational readiness 4. Manager's characteristics 5. Security
Almousa (2013)	Factors that encourage more users to purchase products or services via online.	1. High international shipping cost 2. Weak or unavailability of aftersales support 3. Unavailability of international shipping on sellers' site 4. Unavailability of residential postal address 5. Website language 6. Fear of product unarrival
Martínez-López et al. (2015)	Psychological factors that determining the use of e-commerce in developing countries.	1. Trust and perceived usefulness 2. Consumer's attitude 3. Third parties opinions
Kabango and Asa (2015)	Determining the most essential factors for development and effectiveness of e-commerce.	1. Trust and loyalty 2. Accessibility and awareness 3. Quality and benefits 4. Security and privacy
Ziemba et al., (2016, 2017)	Factors of website usability becomes one of the most critical factors affecting online businesses' success.	1. Website quality 2. Users experience 3. Information quality 4. Service Interaction

2. Related literature review

This section is divided into two sub-sections. The first subsection reviews the computational methods used in e-commerce research. It is presented to provide a gap between the computational method uses in this study and the other computational methods used in the past research.

2.1. Literature review of computational methods used

A considerable amount of literature has been published on the methods used for evaluating the success of e-commerce. Therefore, this section provides a short literature review on the methods used in e-commerce research. It is summarised in Table 2.

These reviews show the importance of e-commerce in today's business transactions. It can be seen that there are various approaches of computational methods used, ranging from typical statistical analysis to integrating models. This review indicates that no study so far has specifically applied the DEMATEL method in factors related to e-commerce research. To bridge the literature gap between the DEMATEL and other computational methods, this paper proposes an application of DEMATEL to the case of e-commerce'.

2.2. Literature review of evaluation factors

The goal of this sub-section is to review evaluation factors of e-commerce and to determine the most appropriate factors in e-commerce. This section extends a description about the factors influencing the success of e-commerce that used in this study. The factors of website usability (Ziemba et al., 2016, 2017) and security (Kabango and Asa, 2015), are already mentioned in Table 1 where these two factors are crucial for development and effectiveness of e-commerce. These two factors are also shared by other researchers, for examples, Gregg and Walczak (2010), Makki and Chang (2015) and Valmohammadi and Dashti (2015). Some authors have suggested the factors of information about products or services (Salehi et al., 2012), incentive offer (Jairak et al.,

Table 2
Review of computational methods used in e-commerce research.

Research articles	Types of Computational Method/Analysis	Computational Methods Used	Contributions
Lee et al. (2012)	Statistical analysis	Structural Equation Modelling (SEM)	The SEM was used as a computational tool in positioning the customization programs of e-commerce companies that lead to better relationships with consumers. The SEM model illustrates the influence of customizations' perception program on the opinion toward the program and consumer future commitment to relationship with the e-commerce environment.
Jusoh and Goh (2012)	Statistical analysis	Inferential statistics of one-way ANOVA and Pearson's correlation	The statistics method was implemented to find factors influencing consumers' attitude towards e-commerce purchases. This study also looks into how socio-demographic, pattern of online buying and purchase perception affect consumers' attitudes towards online shopping.
Li et al. (2013)	Integrating decision making model	Preference similarity analysis, recommendation trust analysis, social relation analysis and the Analytic Hierarchy Process	The combined method was used to investigate a social recommender mechanism for e-commerce in Taiwan. In the study, a social recommender system that can produce personalized output recommendations by referring the preference similarity, recommendation trust, and social relations was proposed.
Jairak et al. (2014)	Statistical analysis	Survey method, prediction analysis and a fuzzy linguistic	The method was used to introduce a road map for establishing trust management strategy in e-commerce services. Purchaser opinions using a quality based assessment were employed to identify factors affecting trusts and satisfaction in e-commerce services.
Valmohammadi and Dashti (2015).	Statistical analysis	Interpretive Structural Modelling (ISM) and Fuzzy Analytical Network Process (FANP)	The method was used to identify and prioritize the interactive barriers of e-commerce implementation. The combination of ISM-FANP has illustrated the influenced relationship and calculates the ranking of the obstacles of e-commerce.
Chen et al. (2015)	Statistical analysis	Partial least squares (PLS)	The PLS was used to propose conceptual model of online purchase perceived risk factors in China.
Zhu and Chen (2016)	Statistical analysis	Descriptive statistics and Multinomial logistic regressions	A survey based on Theory of Planned Behaviour was used to investigate the various effects of normative social influence on online shopping application and intention among urban residents in China.
Yang et al. (2016)	Decision making model	Data Envelopment Analysis (DEA)	A two-stage analytic framework with DEA was used to examine a set of efficiency evaluation criteria in e-commerce firms.
Guzzo et al. (2016)	Statistical analysis	Correlation and Regression analysis	A survey approach was used to identify factors that usually influence the adoption of online commerce, focusing in particular on how social influence acts in this process. Data were collected from an Italian sample and analysed using correlation and regression analysis.
Haleema and Iyengar (2016)	A mathematical model	Negotiation model	A mathematical model was developed in e-commerce environment to determine the concession speed of negotiation issue handles the dynamicity of the negotiation environment and reflects the importance of each negotiation issue
Vojir and Smutny (2017)	Intelligent model	Mining association rules using the GUHA	The rules introduced in the form of a method for creating personalized offers in e-commerce. This method was based on method that creating personalized marketing strategies in e-commerce.
Alhijawi and Douglass (2017)	Statistical analysis	Multiple linear regressions	A survey approach was employed to investigate the factors that affect the customer satisfaction and e-loyalty in this type of e-commerce.
Malhotra and Rishi (2018)	Intelligent model	HDFS- Map Reduce Relevancy Vector algorithm	An algorithm was developed to assist customers in making an online purchase decision by providing personalized page ranking order of E-Commerce web links in response to E-Commerce query.

2014), ease of use system and convenience (Alhijawi and Douglass, 2017). Table 3 summarises the description for each evaluation factor used in this study and also its respective sources.

It seems that most of these factors are almost similar to what have been suggested by other researchers. Evaluation factors used in this research have been compiled from the literature. This study summarizes it into six factors that directly determine the success of e-commerce. The chosen factors are based on two facets of e-commerce framework. One facet considers the products or services while the second facet taken into account from the perspective of supporting technologies or websites for e-commerce. The six factors are considered concurrently in searching their causal relationships by using the DEMATEL method. To the best of authors' knowledge, this is the first study dealing with e-commerce in the context of unravelling the relationship between factors that specifically using the DEMATEL.

3. Methodology

In this section, data collection, descriptions about the participants and the evaluation model DEMATEL are presented. Data was collected based on a survey method. Questionnaires were prepared to tap information about the degree of influence of factors influencing e-commerce from a group of targeted participants. A total of one hundred and twenty five questionnaires were distributed to participating undergraduate students at a public university in Malaysia. All of these young participants were chosen based on purposeful sampling, where their ages were between nineteen and twenty three years old and selected on the basis of experiences in online purchasing wide ranges of products from cosmetics, clothing, and electronics to stationaries. They were asked to rate the degree of influence between two factors in the scales of 0 and 4. It was done in pairwise comparison manner where one factor was compared to another factor. For example, the question is 'What is the degree of influence between Factor A compared to Factor B, and the response may 'High Influence' which is correspond to scale 3. They were given approximately one week to complete the survey. A response rate of seventy percent was received. In other words, eighty seven students completed and returned the questionnaire. The DEMATEL method was used as an evaluation model. The averaged responses received in the form of scales were then transformed into the first step of decision matrix of the DEMATEL.

Table 3
Evaluation factors and their brief descriptions.

Reseachers/Sources	Evaluation Factor	Description
Gregg and Walczak (2010).	Website Reputation	Consumers concern about reliability of business on the web and they prefer to make a purchase or business transaction with the well-known reputation online shop.
Salehi et al., (2012)	Information about Products or Services	Information about products or services on the website should be accurate, up-to-date and easy to understand format to help customers make decisions when they shop online.
Jairak et al. (2014)	Incentive Offers	Incentive offers affect trusts and satisfaction of experienced buyers when online shopping. Incentive offers like special discounts for products or services and special discount can persuade customers to purchase online.
Makki and Chang (2015), Valmohammadi and Dashti (2015)	Security and Privacy	Buyers feel more comfortable while shopping as website will protects their information. Security and privacy is a major concern of consumers while making payments through online.
Alhijawi and Douglass (2017)	Ease of Use System	Good navigation and easy-to-use system that making websites more user-friendly for online consumers. Website should be simple and clear that make online customers easy to access information, to find the item that want and order products.
Alhijawi and Douglass (2017)	Convenience	Convenience of website information can attract attention of customers and to make a connection between customers and the goods or service. Customers may take shorter times for searching products or services and have wider payment choices.

3.1. Evaluation model

One of the goals of the DEMATEL method was finding all the direct and indirect of causal relationships and strength of influence between all variables of a complicated system by using matrix calculation (Lee et al., 2010). The DEMATEL method could turn a complex system into an interrelation and simplified the relationships between influencing factors of e-commerce into justified cause and effective relationship to hunt out the important problem in the multiple factors of e-commerce. In this paper, we propose the seven-step of computational procedures of DEMATEL method. The proposed procedures are retrieved from Tzeng and Huang (2011), Amiri et al. (2011) and Falatoonitoosi et al. (2013).

The computational procedures are presented as follows.

Step 1: Develop the initial direct-relation matrix.

The initial direct-relation matrix, $[a_{ij}]_{n\times n}$ is a $n \times n$ matrix A where each part of a_{ij} is denoted as the degree of the factor i affects the factor j. There are five levels ranging between 0, 1, 2, 3, and 4 to describe the causal relationship between n different factors based on H respondents' opinion. The degrees of influence are given in the following scales. 0 = no influence, 1 = low influence, 2 = medium influence, 3 = high influence, and 4 = very high influence.

The matrices obtained from the $n \times n$ non-negative matrix is constructed as $X^k = \left[x_{ij}^k\right]_{n\times n}$, with $1 < k < H$ where H is the number of respondents. The $n \times n$ matrix A that represents all respondents' opinions is calculated by averaging each respondent's score using the following equation.

$$[a_{ij}]_{n\times n} = \frac{1}{H}\sum_{k=1}^{H}\left[x_{ij}^k\right]_{n\times n} \quad (1)$$

Step 2: Normalize the initial direct-relation matrix.

By normalizing the average matrix A, the normalized initial direct-relation matrix D can be obtained in which the value of each element in matrix D is between 0 and 1. Thus, the normalization can be done using Eq. (2).

$$D = s \times A \quad (2)$$

Where $s = \min\left(\frac{1}{\max_{1\le i\le n}\sum_{j=1}^{n} a_{ij}}, \frac{1}{\max_{1\le j\le n}\sum_{i=1}^{n} a_{ij}}\right)$

Step 3: Calculate the total-relation matrix.

The total-relation matrix T is a $n \times n$ matrix and is defined as

$$T = [t_{ij}]_{n\times n},\ i,j = 1,2,\ldots,n$$

The total-relation matrix $T_{n\times n}$ is derived as follows:

$$\begin{aligned} T &= \sum_{m=1}^{\infty} D_i = D + D^2 + \cdots + D^m = D\left(I + D + D^2 + \cdots + D^{m-1}\right) \\ &= D\left[\left(I + D + D^2 + \cdots + D^{m-1}\right)(I - D)\right](I - D)^{-1} \\ &= D(I - D)^{-1}(I - D)(I + D + D^2 + \cdots + D^{m-1}) \\ &= D(I - D)^{-1}(I - D^m) \end{aligned}$$

Therefore, the total-relation matrix $T_{n\times n}$

$$= D(I - D)^{-1},\ \text{as } m \to \infty \tag{3}$$

Step 4: Calculate sum of row (r) and sum of column (c)

In the total-relation matrix T, the sum of rows and the sum of columns are expressed by vector r and c, respectively.

$$T = [t_{ij}]_{n\times n'},\ i,j = 1,2,\ldots,n$$

$$r = \left[\left(\sum_{j=1}^{n} t_{ij}\right)\right]_{n\times 1} = [t_{i.}]_{n\times 1} \tag{4}$$

$$c = \left[\sum_{i=1}^{n} t_{ij}\right]_{1\times n} = [t_{.j}]_{1\times n} \tag{5}$$

where vector r and vector c separately expressed as the sum of rows and the sum of columns from total-relation matrix $T = [t_{ij}]_{n\times n}$.

Step 5: Calculate the prominence and relation of total-relation matrix T.

The vector $(r + c)$ is called prominence which indicates the degree of importance role of each criterion. On the other hand, the vector $(r - c)$ is called relation which may divide factors into a cause and effects groups. Basically, if the relation is positive, the criterion tends to fall under the cause group. On the contrary, if the relation is negative, then the criterion tends to fall under the effect group.

Step 6: Select a threshold value (p) to obtain the digraph.

The threshold value is aimed to eliminate some insignificant effects that reduce the complexity of system by showing the effects greater than the threshold value in the digraph. Compute the threshold value by calculating the average of the criterion in matrix T using Eq. (6).

$$p = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}[t_{ij}]}{N} \tag{6}$$

Step 7: Construct a cause and effect relationship diagram.

The causal diagram can be obtained by mapping all coordinates $(r + c,\ r - c)$onto two-plane which may provide some insight when making decisions. The causal diagram visualizes the importance and classification of all criteria (Suo et al., 2012).

4. Implementation

Data collected from the case was computed using the proposed computation steps. The linguistic terms used for pairwise comparisons are transformed into real numbers. A simplified computation according to the seven-step procedure is presented as follows.

Step 1: Calculate the initial direct-relation matrix A.

The matrix element a_{ij} which was assigned an integer score ranging from 0, 1, 2, 3 to 4, denotes the pairwise comparisons between any two factors. The higher score shows that the greater improvement in i is required to improve j. The average scores of six factors are arranged in the matrix A using Eq. (1).

$$A = \begin{bmatrix} 0 & 2.70 & 2.26 & 2.27 & 2.52 & 2.61 \\ 2.54 & 0 & 2.07 & 2.04 & 2.50 & 2.25 \\ 2.34 & 2.29 & 0 & 2.01 & 2.22 & 2.40 \\ 2.34 & 2.32 & 2.18 & 0 & 2.37 & 2.38 \\ 2.56 & 2.60 & 2.25 & 2.35 & 0 & 2.47 \\ 2.60 & 2.46 & 2.36 & 2.52 & 2.56 & 0 \end{bmatrix}$$

Row 1 to row 6 of the matrix A represent the average evaluation scores (pairwise comparisons) of the six factors: Information of Products or Services (A), Conveniences (B), Incentive Offers (C), Security and Privacy (D), Ease of Use System (E) and Website Reputation (F) respectively.

Step 2: Normalize the initial direct-relation matrix A.

The normalized initial direct-relation matrix D is constructed using Eq. (2).

$$\mathrm{D} = \begin{bmatrix} 0 & 0.22 & 0.18 & 0.18 & 0.20 & 0.21 \\ 0.20 & 0 & 0.17 & 0.16 & 0.20 & 0.18 \\ 0.19 & 0.18 & 0 & 0.16 & 0.18 & 0.19 \\ 0.19 & 0.19 & 0.17 & 0 & 0.19 & 0.19 \\ 0.20 & 0.21 & 0.18 & 0.19 & 0 & 0.20 \\ 0.21 & 0.20 & 0.19 & 0.20 & 0.20 & 0 \end{bmatrix}$$

Step 3: Calculate the total-relation matrix T.

The total-relation matrix T is calculated using Eq. (3).

Matlab computational software is used to calculate the multiplication of D with the inverse of $(I - D)$.

Therefore,

$$\mathrm{T} = \begin{bmatrix} 3.42 & 3.64 & 3.28 & 3.28 & 3.53 & 3.54 \\ 3.36 & 3.22 & 3.06 & 3.06 & 3.31 & 3.29 \\ 3.32 & 3.34 & 2.89 & 3.03 & 3.26 & 3.27 \\ 3.41 & 3.44 & 3.11 & 2.97 & 3.35 & 3.35 \\ 3.56 & 3.60 & 3.25 & 3.26 & 3.34 & 3.50 \\ 3.63 & 3.65 & 3.31 & 3.32 & 3.56 & 3.39 \end{bmatrix}$$

Step 4: Calculate the row summation (r) and column summation (c).

We can obtain the sum of rows and the sum of columns from a total-relation matrix using Eqs. (4) and (5). Table 4 presents the sums of rows and columns of matrix T.

Step 5: Calculate the prominence and relation of total-relation matrix T.

The vector $(r + c)$ is called a prominence whereas the vector $(r - c)$ is called a relation. If the relation is positive, the criterion is a net causer which belongs to the cause group. However, if the relation is negative, the criterion is a net receiver which belongs to the effect group. Table 5 shows the prominence and relation among factors.

Step 6: Compute the threshold value in order to draw a digraph.

Table 4
Row summation (r) and column summation (c) among factors.

r	c
20.69	20.70
19.30	20.89
19.11	18.90
19.63	18.92
20.51	20.35
20.86	20.34

Table 5
Prominence and relation among factors.

Factors	r	c	Prominence $(r+c)$	Relation $(r-c)$
Information of Products or Services (A)	20.69	20.70	41.39	−0.01
Conveniences (B)	19.30	20.89	40.19	−1.59
Incentive Offers (C)	19.11	18.90	38.01	0.21
Security and Privacy (D)	19.63	18.92	38.55	0.71
Ease of Use System (E)	20.51	20.35	40.86	0.16
Website Reputation (F)	20.86	20.34	41.20	0.52

The threshold value (p) is calculated prior to constructing the cause and effect diagram. The threshold value is calculated using Eq. (6).

Threshold value, $\mathrm{p} = \frac{3.42+3.64+3.28+\ldots+39}{36} = 3.34$

Elements that higher than the threshold element are identified. The indicated elements are shown in Table 6.

Value of t_{ij}^{*} indicates the interrelationship between two factors. For example, t_{AB} indicates the interrelationship between Factor A (Information of Products or Services) and Factor B (Conveniences) in total-relation matrix T.

The threshold value guides authors to draw a digraph. For example, the t_{AB} $(3.64) > p$ (3.34) can be represented by arrow in which Factor B (Conveniences) is affected by Factor A (Information of Products or Services). The whole relationship among factors can be drawn in a digraph where the direction of influence can be visualised. Digraph is a good way to visualize about the causal relationship among these factors. The DEMATEL digraph of the evaluation factors are demonstrated in Fig. 1.

In Fig. 1, the arrows show the direction of the influence. It is shown that factor A is influenced by factor D. It shows that the factor A has mutual influence with factor B, factor E, factor F and itself. Next, the factor B is influenced by the factor D, factor E, factor F and is mutually influenced by the factor A.

In addition, factor C does not influence to the others and also does not receive effect from the others. In other words, factor C is independent where no other factor can be related to factor C. The factor D influences on the factor A, factor B, factor E and factor F. Besides, the factor E influences on factor B and factor E is influenced by factor D. The factor E is also mutually influenced by the factor A and factor F. Based on the figure above, the factor F is influenced by the factor D, whereas the factor F influences on the factor B. At the same time, the factor F has mutual influence with the factor A, factor E and itself.

Step 7: Construct a cause and effect relationship diagram.

The cause and effect diagram is drawn using the coordinates $(r+c)$ and $(r-c)$. The values of $(r+c)$ stands for the degree of importance among factors. The values of $(r-c)$ indicates the relation among factors where negative values are grouped as effect factor and positive values are grouped as cause factors. Table 7 shows the cause and effect groups as a result of the prominence and relation values.

Apart from prominence and relation values, Table 7 also displays the rank of each factor and also the rank of factor in respective group. It can be seen that Factor A (Information of Products or Services) is ranked as the most important factor in the prominence whereas Factor C (Incentive Offers) is the least important factor. The cause and effect diagram is built by mapping the data set into horizontal axis and vertical axis. Fig. 2 shows the position of factors in the cause and effect diagram.

It is shown that Factor C (Incentive Offers), Factor D (Security and Privacy), Factor E (Ease of Use System) and Factor F (Website Reputation) are grouped into the cause group. On the other hand, Factor A (Information of Products or Services) and Factor B (Conveniences) are fallen under the effect group. The value of (r+c) indicates the degree of importance of factors in determining the success of e-commerce. It can be seen that Factor A (Information of Products or Services) is the most important factor because it has the greatest (r+c) value with 41.4.On the other hand, Factor C (Incentive Offers) with (r+c) value of 38 is identified as the least important factor due to it its lowest value of (r+c). However, Factor A (Information of Products or Services) is affected by other factors owing to its position in effect group. The preference of importance of six factors, causal factors, and effect factors are summarized in Table 8.

All in all, the results conclude that the Factor A (Information about products or services) is the most important factor in sustaining the success of e-commerce.

For the purpose of comparative analysis, the data of e-commerce was also applied to the fuzzy DEMATEL to observe the consistency of the results. The fuzzy DEMATEL uses triangular fuzzy numbers while the DEMATEL used real numbers in defining as linguistic scales. Interestingly, the results of the preferred factors and the causal relationship using the DEMATEL are consistent with the result of the fuzzy DEMATEL. The full results using the fuzzy DEMATEL can be retrieved from Abdullah and Lim (2018). The results support the notion that the DEMATEL is not sensitive to the type of numbers used in defining scales of degree of influence.

5. Conclusions

E-commerce is continuously moving towards uptrend direction and can be considered about reaching its maturity stage. There are

Table 6
Indicated elements in total-relation matrix T.

	Information of Products or Services (A)	Conveniences (B)	Incentive Offers (C)	Security and Privacy (D)	Ease of Use System (E)	Reputation (F)
Information of Products or Services (A)	3.42*	3.64*	3.28	3.28	3.53*	3.54*
Conveniences (B)	3.36*	3.22	3.06	3.06	3.31	3.29
Incentive Offers (C)	3.32	3.34	2.89	3.03	3.26	3.27
Security and Privacy (D)	3.41*	3.44*	3.11	2.97	3.35*	3.35*
Ease of Use System (E)	3.56*	3.60*	3.25	3.26	3.34	3.50*
Website Reputation (F)	3.63*	3.65*	3.31	3.32	3.56*	3.39*

* Indicates higher than the threshold value.

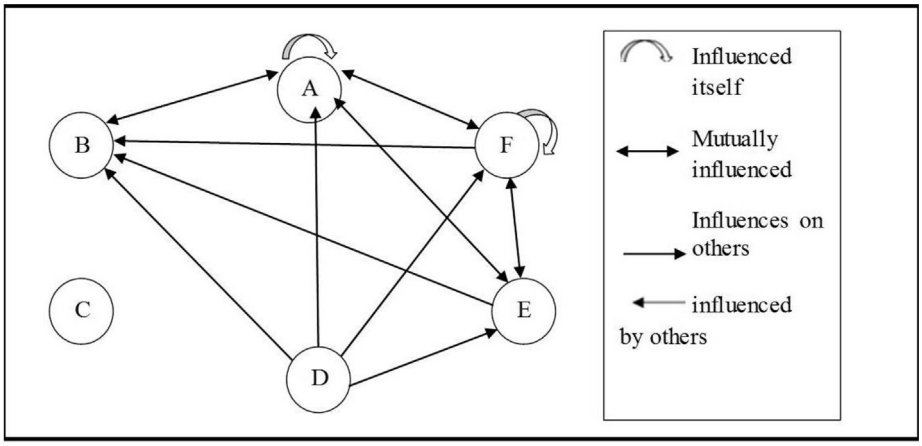

Fig. 1. Digraph of factors. *Note:* Factor A (Information of Products or Services), Factor B (Conveniences), Factor C (Incentive Offers), Factor D (Security and Privacy), Factor E (Ease of Use System), and Factor F (Website Reputation).

Table 7
Prominence and Relation values.

Factors	Prominence $(r+c)$	Rank of factors	Relation $(r-c)$	Cause/Effect Group	Rank of factors, according to groups
Information of Products or Services (A)	41.39	1	−0.01	Effect	(1)
Conveniences (B)	40.19	4	−1.59	Effect	(2)
Incentive Offers (C)	38.01	6	0.21	Cause	3
Security and Privacy (D)	38.55	5	0.71	Cause	1
Ease of Use System (E)	40.86	3	0.16	Cause	4
Website Reputation (F)	41.20	2	0.52	Cause	2

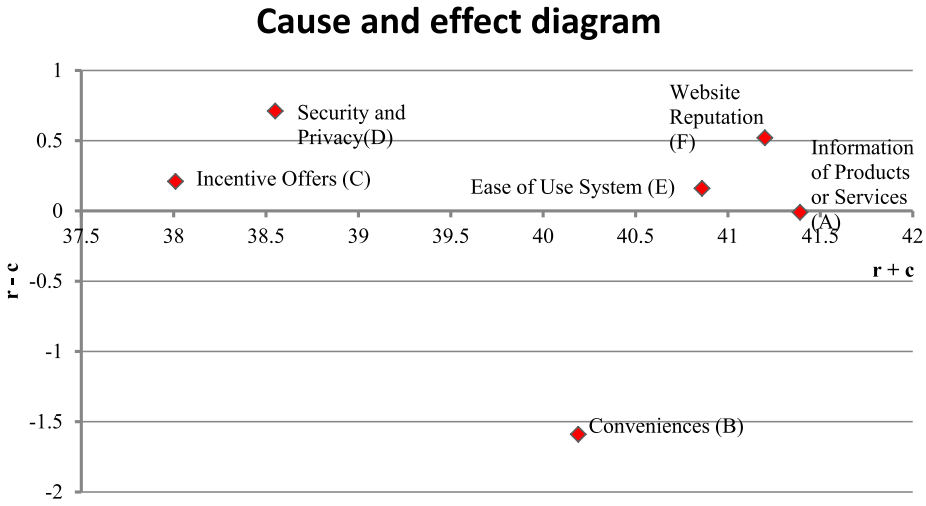

Fig. 2. Cause and effect diagram of factors.

Table 8
Preference of importance for factors.

Net Group	Causal factors: C, D, E, F Effect factors: A, B
Preference of importance	A ≻ F ≻ E ≻ B ≻ D ≻ C.

Note: The symbol ' ≻' indicates 'more important than'. Factor A (Information of Products or Services), Factor B (Conveniences), Factor C (Incentive Offers), Factor D (Security and Privacy), Factor E (Ease of Use System), and Factor F (Website Reputation).

many intangible factors that can be associated with the successful adoption of e-commerce. However, there are some challenges in unravelling the relationships between causal factors and effect factors of e-commerce. The present study was designed to unravel the causal relationships among factors of e-commerce using a multi-factor decision making approach. The DEMATEL method has been chosen to determine the causal relationship and the degree of importance of the factors. Sums of rows and columns of the total relation matrix have divided factors into a cause and effects groups. In general, this study has demonstrated the causal relationship among the factors. The result of DEMATEL revealed that Factor B (Conveniences) is the most easily be influenced by other factors such as Factor A (Information of Products or Services), Factor D (Security and Privacy), Factor E (Ease of Use System), and Factor F (Website Reputation). The most important factor in the success of e-commerce is Factor A (Information of Products or Services) fol-

lowed by Factor F (Website reputation). The results are slightly inconsistent with the study conducted by Yoon and Occeña (2015), where perception of website quality influenced trust in e-commerce. In this study, the DEMATEL method proposed two main innovations in the context of unravelling the key success factors of e-commerce. The first innovation is the construction of digraph where the direction of influence among factors was presented. This innovation is one of the theoretical contribution of the DEMATEL. The second innovation is the development of cause and effect diagram where the evaluation factors were divided into two groups. This research has potential applications particularly in providing a new understanding of the key success factors of e-commerce. However, this research could be improved in several ways. It is recommended that further research could be undertaken in the following areas. First of all, the evaluation factors should be added more in the future studies as it will provide a better outlook for e-commerce research. Factors such as logistics and services could be included in the future investigation. The resources of products, storage and shipping are among the crucial processes that need to be accounted in managing logistics thereby would create a successful e-commerce business. The factors could also be evaluated by fewer numbers of experts with multi-person decision analysis as a new analytical approach instead of multi-factor decision making.

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