A HYBRID FUZZY APPROACH TO SUCCESS IN E-COMMERCE ADOPTION IN IRANIAN MANUFACTURING SMEs

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ABSTRACT

E-commerce adoption is one of the most controversial subjects among small and medium enterprises (SME)s in Iran. The present study is conducted with the aim of identifying the most important factors in e-commerce adoption – reviewing the causal relationships and clustering them. To identify the most important factors, the data is collected by questionnaires filled by 95 experts who were chosen as researchers' judgment. Examining the causal relationships among the studied factors and clustering is done by fuzzy decision making trial and evaluation laboratory (DEMATEL) and interpretive structural modelling (ISM) techniques respectively. Data is collected from 12 experts and analysed by MATLAB and EXCEL software. According to the results, government support as one of the causal factors among critical factors effecting on e-commerce adoption is the highest influential factor, along with cost of public's training. Both factors are put into the first cluster. Moreover, organisational flexibility plays an intermediate role between the first and the third cluster.

Keywords: e-commerce, small and medium enterprises, causal relationships, fuzzy DEMATEL, interpretive structural modelling

INTRODUCTION

Over the last two decades the Internet and World Wide Web have improved people's lifestyle in all over the world (Anic et al., 2019; Afshin et al., 2016). As the time passes, the traditional commerce will no longer be able to respond to the modern requirements, so new commerce methods will be required (Fabisiak, 2018; Cegarra-Navarro et al., 2007). The Internet provides a new approach in the markets to connect sellers with potential customers who are searching online for information related to a product or service (Khatwani & Srivastava, 2018). Early study on e-commerce by Kalakota and Whinston in 1998, proposed a parochial definition of e-commerce – buying and selling of information, products, and services through computer networks such as Internet (Awa et al., 2015). E-commerce allows customers to benefit from a quicker and cheaper shopping. In fact, e-commerce not only has changed the way of selling or purchasing, but it has also changed the business perspective from production focus to customer intimacy (MacGregor & Vrazalic, 2005).

Studying about information, communication, and technology (ICT) related to small and medium enterprises (SMEs) is critical, because the large number of employees works in SMEs. SMEs consist between 40% and 50% of the country's GDP (Nasehi Far et al., 2009) and drive the informal sector of countries' economy particularly in developing countries (Upadhyaya et al., 2017). Governments in many countries give considerable attention to the adoption of e-commerce by SMEs (Rahayu & Day, 2015), because they can access to larger markets without expanding physical presence (Quaddus & Hofmeyer, 2007). Despite this great attention of governments, the adoption of e-commerce by SMEs is still far behind in comparison with the adoption of it by large companies (Walker et al., 2016; Shemshad et al., 2015), because they do not have proper training and sufficient resources for investment in this area (Monavarian et al., 2014).

In Iran, there are several barriers in expanding e-commerce including basic resources, environmental factors, lack of infrastructure, cultural and education problems (Nakhai Kamalabadi et al., 2008). However, nearly 30% of the economic value added are made by SMEs. They play an important role on economic growth (Ueasangkomsate, 2015). A number of different e-commerce adoption barriers is documented in research studies. Some of these include the high costs associated with e-commerce, the lack of technical resources, difficulty of e-commerce technology (MacGregor & Vrazalic, 2005). Since 1995, Iran has enjoyed a dramatic increase in IT adoption. This growth developed an excellent environment for expansion of IT in the country. Although Iran invests heavily

on spread of Internet among governmental institutions and private sectors compared with other Middle East countries (Nakhai Kamalabadi et al., 2008), e-commerce expansion rate is still moderate or low.

Studies about implementing e-commerce in SMEs indicate that factors like knowledge management, human resource management (HRM), organisational development, production scheduling, foreign relations management, communications systems, and financial management are among critical failure factors. Besides, to determine the situation of e-commerce in a country, some factors need to be examined such as government support, consumers, business, and technical infrastructure as well as social and cultural background. Also, managerial factors, technical infrastructures, and social background may play different role in each country (Amiri & Salarzehi, 2010). As a result, it is necessary to re-examine these important factors in Iran as well. The contribution of the paper is to create an understanding framework related to the factors affecting on the SMEs' success in e-commerce adoption in Iran as a developing country. It could help SMEs to have a clear road map and give them some guidelines to plan implementing e-commerce successfully. This research composed of three stages based on final goal:

- Stage One: Identifying the most important key success factors in e-commerce in SMEs

- Stage Two: Investigating causal relations among studied factors using fuzzy decision making trial and evaluation laboratory (DEMATEL)

- Stage Three: Prioritising clusters of identified factors using interpretive structural modelling (ISM)

LITERATURE REVIEW

It is about a decade that the concept of ICT has emerged as a new and robust phenomenon in the world (Choshin & Ghaffari, 2017). IT applications related to commercial and economical processes have led to the creation of a new field called e-commerce (Feizollahi et al., 2014). Many economists believe that there has been a revolution similar to the industrial revolution in recent years (Ismail Pour & Javidi, 2015; Sajjadi Amiri et al., 2010). Fathian et al. (2008) conducted a study to e-readiness assessment of non-profit ICT SMEs in Iran. They found that organisational features such as ICT infrastructures, ICT availability, security and legal environment are the most effective factors on e-commerce adoption.

Not only is e-commerce cheaper, faster, and easier compared with traditional commerce (Salehi et al., 2012), but also it has a lot of merits such as improving productivity, cost saving, changing in the markets' size and structure, and eliminate intermediaries (Sajjadi Amiri et al., 2010). In addition, it enables SMEs to increase their customers, develop new markets, and improve communication with customers; besides, it increases revenue growth and reduces cost (Johnston et al., 2007). However, the vast majority of SMEs have the same challenges in utilising e-commerce such as direct communication with customers, security, technical support, employees training, high cost of information integration, and changes in organisation (Beck et al., 2005).

A systematic literature review on e-commerce success factors done by Fouskas et al. (2020) examined 24 articles from 2013 to 2017. They categorised success factors in four groups including factors related to site design, factors related to marketing technique, factors related to safety and reputation, and factors related to customers' support. Zumstein and Kotowski (2020) with the aim of studying success factors of e-commerce among 300 online shops found that more than the half of the e-shops offer free shipping and already one third provides personalised content or product offers. The vast majority of companies provide discount codes for shopping online. Analysing different success factors, this contribution shows that customer, service, and data-driven online shops generate higher conversions rates and revenues. Finally, successful omnichannel vendors are using a variety of digital marketing channels.

In a study, to identify inhibiting factors of e-commerce adoption in Nigeria, Awa et al. (2015) found that SMEs have not fully exploited e-commerce yet, because of non-transparency in government support programs, financial problems, firm's size, confidentiality of information, infrastructural inadequacy, and lack of openness and business integration. Moreover, Sorayaei and Mehdizadeh (2006) in identifying barriers and restrictions of electronic exchanges recognised that technological and environmental factors are the most important barriers compared with variables such as financial, individual, and organisational barriers.

Research conducted by Migiro (2006) to map ICT diffusion and e-commerce adoption among 380 manufacturing SMEs in Kenya indicated that high cost of IT software, limited budget, and lack of technical knowledge are the most important barriers. Choshin and Ghaffari (2017) with the aim of investigating effective factors on e-commerce success in SMEs using structural equations modelling found that customer satisfaction, costs, organisational

and technological infrastructures, Internet speed, network traffic, customers' awareness, employees' skills, and managers' knowledge have a significant impact on e-commerce success. Besides, Radfar and Ghozati (2014) to study solutions for improving e-commerce in the field of industrial machinery production divided effective factors on successful e-commerce implementation to four dimensions including supportive institutions, legal issues, technological, social, and cultural infrastructures.

Using a systematic literature review with the aim of identifying factors affected on e-commerce implementing, Ismail Pour and Javidi (2015) indicated that technological infrastructure, organisational infrastructure, information infrastructure, operating infrastructure, policies, and strategies have the most effect on the success of e-commerce implementation. Jennex et al. (2004) investigated key infrastructures affecting the success of SMEs in developing economies. They found that workers' skills, client interface, and technical infrastructure are the most important factors to the success of business-to-business (B2B) e-commerce. In addition, Bamdad Soofi et al. (2012) determined that the effective factors on e-commerce adoption are managers' support, organisational culture, financial resources, technological infrastructures, market conditions, staff, and government support.

In terms of web pages, Ramadhanti and Slamet (2020) aimed to investigate the effect of website quality on the e-commerce success of SMEs in Indonesia based on the managers' perspective using partial least square-structural equation modelling (PLS-SEM). Results show that website quality have the most significant influence on e-commerce success. Meanwhile, service quality has no effect.

In spite of the many potential advantages of e-commerce, its adoption by SMEs remains limited because SMEs are different in comparison with large companies in e-commerce implementation (Monavarian et al., 2014). However, it cannot be denied that there have been studies conducted regarding e-commerce adoption by businesses. To identify effective factors on e-commerce in SMEs, Salarzehi et al. (2013) indicated that among variables including organisational factors, environmental factors, and specific features of e-commerce, the most effect is related to specific features of e-commerce and the least impact is related to organisational factors. Moreover, Sajjadi Amiri et al. (2010) found that government support, managers' support, efficient and qualified employees with adequate information about e-commerce are the most important factors in e-commerce adoption.

Therefore, current research to study the most important factors in successful e-commerce adoption in SMEs identified five dimensions based on the literature review. Table 1 presents initial effective factors on e-commerce adoption in SMEs in five dimensions. As can be seen in Table 1, each factor has a code.

Table 1

Initial effective factors on e-commerce adoption

Indices		Code	Researchers, year
Technological Infrastructure	Hardware facilities	T_1	Choshin & Ghaffari (2017)
	Software facilities	T_2	Rahayu & Day (2015)
	Internet speed and broadband	T_3	Awa et al. (2015)
	ISP's penetration rate	T_4	Ismail Pour & Javidi (2015)
	Information security	T_5	Radfar & Ghozati (2014)
			Bamdad Soofi et al. (2012)
			Sajjadi Amiri et al. (2010)
			Fathian et al. (2008)
			Sorayaei & Mehdizadeh (2006)
			Beck et al. (2005)
Organisational Infrastructure	Organisational structure	O_1	Zumstein & Kotowski (2020)
	Firms' strategy	O_2	Choshin & Ghaffari (2017)
	Planning	O_3	Rahayu & Day (2015)
	Business process re-engineering	O_4	Ismail Pour & Javidi (2015)
	Organisational flexibility	O_5	Bamdad Soofi et al. (2012)
	Organisational inclination	O_6	Salarzehi et al. (2013)
	Rate of changes	O_7	Sajjadi Amiri et al. (2010)
	Managerial support	O_8	Fathian et al. (2008)
	Employees' skill	O_9	Sorayaei & Mehdizadeh (2006)
			Beck et al. (2005)
			Jennex et al. (2004)
Supportive Institutions	Banking networks	S_1	Fouskas et al. (2020)
	Stock exchange	S_2	Ramadhanti and Slamet (2020)
	Customs	S_3	Ismail Pour & Javidi (2015)
	Goods and services supplier	S_4	Radfar & Ghozati (2014)
	Hard/Software manufacturers and web developers	S_5	Sajjadi Amiri et al. (2010)

Table 1: (*continued*)

Indices		Code	Researchers, year
Environmental Infrastructure	Legal issues	E_1	Fouskas et al. (2020)
	Government support	E_2	Zumstein & Kotowski (2020)
	Customers' awareness about e-commerce	E_3	Choshin & Ghaffari (2017)
			Rahayu & Day (2015)
	People's trust to e-commerce	E_4	Awa et al. (2015)
	Market issues	E_5	Ismail Pour & Javidi (2015)
	Cultural issues	E_6	Radfar & Ghozati (2014)
			Salehi et al. (2012)
			Bamdad Soofi et al. (2012)
			Salarzehi et al. (2013)
			Sajjadi Amiri et al. (2010)
			Sorayaei & Mehdizadeh (2006)
Costs	Cost of hardware	C_1	Choshin & Ghaffari (2017)
	Cost of IT software	C_2	Awa et al. (2015)
	Cost of preparing networks and database	C_3	Bamdad Soofi et al. (2012)
	Cost of installing and maintaining	C_4	Sajjadi Amiri et al. (2010)
	Cost of accessing to the Internet	C_5	Sorayaei & Mehdizadeh (2006)
	Employees' training	C_6	Migiro (2006)
	Cost of public's training	C_7	Beck et al. (2005)

Note: ISP = Internet Service Providers

RESEARCH QUESTIONS

According to the literature review and research aims, the research questions can be stated as follows:

Stage 1:

- Q1: What are the most important effective factors on e-commerce adoption?

Stage 2:

- Q2.1: Which factors have the most and the least impact on the others?
- Q2.2: Which factors have been the most and the least affected by the others?
- Q2.3: Which factors have the most and the least interaction with the others?
- Q2.4: Which factors are causal and which ones are affected factors?

Stage 3:

- Q3: How is clustering of effective factors on e-commerce adoption?

METHODOLOGY

In terms of purpose, the present study is practical and placed in the category of descriptive research which is done in three stages as shown in Figure 1.
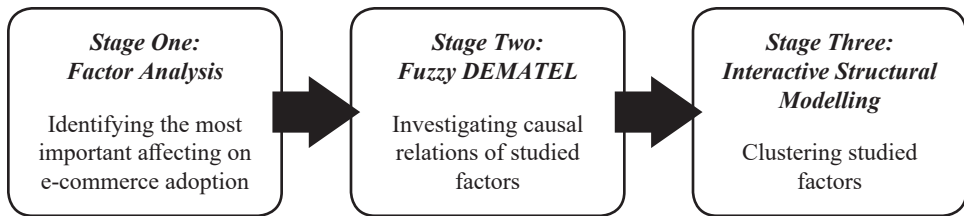

Figure 1. Research stages

Stage 1: Factor Analysis

To identify the most important factors affecting on e-commerce adoption (Q_1), the reliability of the questionnaire is examined by using Cronbach's alpha and composite reliability (CR). Reliability coefficient is expected to be greater than 0.7. Before the factor analysis, sampling adequacy test (KMO $\geq$ 0.6), and Bartlett test (sig $\leq$ 0.05) were examined. To identify the most effective factors on e-commerce adoption, the fit of the research model was examined by test of significance (*t*-value $\geq$ 1.96), load factor $\geq$ 0.7, AVE $\geq$ 0.05, $R^2 \geq$ 0.03, $Q^2 \geq$ 0.1, and goodness of fit (*GOF)* $\geq$ 0.15, respectively (Shafiei Nikabadi & Hakaki, 2018).

In terms of statistical sample, the data is collected among 95 experts including people who have at least three years of work experience in the field of e-commerce and having a relevant college degree to the fields of computer, business management, and e-commerce. The research used judgmental sampling, which is a technique used to access those who enjoys special features.

Stage 2: Fuzzy DEMATEL Technique

To investigate causal relations of studied factors, fuzzy DEMATEL has been used (answering the second question of the research). Fuzzy sets establish inherent uncertainty available in preferences, goals, and limitations available in

deciding issues (Habibi et al., 2014). The pairwise comparison matrix is formed based on the parameters extracted in the previous stage and data collected by 12 experts' opinions. According to Table 2, the expert opinions converted to triangular fuzzy numbers including lower bond, middle bond, and upper bond: $\tilde{x}_{ij} = (l_{ij} \cdot m_{ij} \cdot u_{ij})$.

Table 2
Fuzzy range of the phased DEMATEL technique

Linguistic variable	Integer scale	Fuzzy equivalent
No influence	0	(0.0, 0.1, 0.3)
Low influence	1	(0.1, 0.3, 0.5)
Medium influence	2	(0.3, 0.5, 0.7)
High influence	3	(0.5, 0.7, 0.9)
Very high influence	4	(0.7, 0.9, 1.0)

To plot causal model of the research, four phases must be done respectively (Sheng-Li et al., 2018; Habibi et al., 2014):

Phase one: Aggregating experts' opinions to create fuzzy direct influence matrix (DIM) by:

$$\tilde{z} = \frac{\tilde{x}^1 \oplus \tilde{x}^2 \oplus \tilde{x}^3 \oplus \ldots \oplus \tilde{x}^p}{p} \tag{1}$$

p is the number of experts, and $\tilde{x}^1, \ldots, \tilde{x}^p$ is pairwise comparison matrix of each expert.

Phase two: Normalising fuzzy *DIM* by dividing each element of *DIM* to parameter (K):

$$\tilde{N} = \frac{DIM}{K} \tag{2}$$

$$K = \max_{1 \leq i \leq n} \left(\sum_{j=1}^{n} u_{ij} \right) \tag{3}$$

$\sum_{j=1}^{n} u_{ij}$ calculated by aggregating upper bond of fuzzy numbers for each row of *DIM*.

Phase three: To construct fuzzy TIM, normalised fuzzy *DIM* have to be divided in three sub-definite matrices:

$$
N_l = \begin{bmatrix} 0 & l_{12} & \cdots & l_{1n} \\ l_{21} & 0 & \cdots & l_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ l_{n1} & l_{n2} & \cdots & 0 \end{bmatrix} \quad
N_u = \begin{bmatrix} 0 & u_{12} & \cdots & u_{1n} \\ u_{21} & 0 & \cdots & u_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ u_{n1} & u_{n2} & \cdots & 0 \end{bmatrix} \quad
N_m = \begin{bmatrix} 0 & m_{12} & \cdots & m_{1n} \\ m_{21} & 0 & \cdots & m_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ m_{n1} & m_{n2} & \cdots & 0 \end{bmatrix} \tag{4}
$$

Then, the fuzzy TIM is computed by summing the direct and indirect influences by:

$$
T_l = N_l \times (I - N_l)^{-1}
$$
$$
T_m = N_m \times (I - N_m)^{-1} \tag{5}
$$
$$
T_u = N_u \times (I - N_u)^{-1}
$$

I is identity matrix, and each element of TIM is calculated according to $\tilde{t}_{ij} = (t_{ij}^l \cdot t_{ij}^m \cdot t_{ij}^u)$.

Phase four: Definite TIM (crisp number) completed by the mean method $\left(\dfrac{L + M + U}{3}\right)$ for each element of fuzzy TIM. After obtaining definite TIM, sum of rows (R), sum of columns (C) should be calculated respectively.

$$
R = [r_i] = \left[\sum_{j=1}^{i} TIM_{ij} \right]_{n \times 1} \qquad C = [c_j] = \left[\sum_{j=1}^{i} TIM_{ij} \right]_{1 \times n} \tag{6}
$$

(R) indicates direct and indirect effect of each factor to the others and (C) reflects direct and indirect effects which each factor receives from the others. The horizontal axis vector ($R + C$) shows the interaction of each factor with other factors, and the vertical axis vector ($R - C$) shows the pure effect that each factor contributes to the system. If ($R - C$) is positive, the factor is causal. Else, the factor is influenced.

Stage 3: Interpretive Structural Modelling

ISM has been used for clustering studied factors (answering the third question of the research). It is a powerful qualitative tool and helps in presenting a complicated system in a simplified way and facilitates the identification of the structure within a system. The procedure of the ISM contains four phases, respectively (Shakerian et al., 2020, Raut et al., 2017):

Phase one: Making structural self-interaction matrix (SSIM) for studied factors based on collected data from experts in previous stage, before converting to fuzzy number. First, all expert's matrices have to aggregate by the mean method:

$$X = \frac{\sum_{i=1}^{p} x^i}{p} \tag{7}$$

p is the number of experts, and is pairwise comparison matrix of each expert. Then, to obtain SSIM, each element of X matrix that are equal or greater than 3 is shown by 1 and the rest will be 0. In addition, the elements on the main diagonal of the matrix are shown by 1 as well.

Phase two: Building reachability matrix using the SSIM by the following assumption: If a factor such as A is associated to B and also B is associated to C, then A is inevitability relevant to C and must be put 1 for that element which shows association of A and C.

Phase three: From the final reachability matrix, for each factor, reachability set, antecedent set, and intersection set are derived. Each set is defined as follow:

- Reachability Set: Consists of the factor itself and the other factor that it may impact.

- Antecedent Set: Consists of the factor itself and the other factor that may impact it.

- Intersection Set: Consists of factors which are in common between reachability set and antecedent set.

Phase four: Clustering using iteration method has three steps:

1. Factors having equal reachability and intersection set are in the same cluster.

2. After determining each cluster, identified factors should be deleted from all sets.

3. Back to the first step to investigate next cluster.

RESULTS

Stage 1: Factor Analysis

Ninety-five questionnaires out of 110 distributed questionnaires were suitable for statistical analysis. Prerequisites for entry into the set of structural equation tests studied in accordance with Table 3.

Table 3
Prerequisites for entry into the structural equation tests

Questionnaire	Cronbach's alpha	Composite reliability	KMO	Bartlett's test
Technological infrastructure	0.703	0.786	0.728	Sig = 0.000
Supportive institutions	0.722	0.809	0.763	Sig = 0.000
Environmental infrastructure	0.871	0.904	0.818	Sig = 0.000
Organisational infrastructure	0.829	0.867	0.700	Sig = 0.000
Costs	0.715	0.801	0.613	Sig = 0.000

The results of Cronbach's alpha coefficients, the composite reliability, sampling adequacy (KMO) and Bartlett's test were confirmed according to Table 3. Subsequently, all factors passed test of significance (t-value $\geq$ 1.96). Next, factors with load factor higher than 0.7 are selected. As a result, indices C_2, C_3, C_4, C_5, and C_6 from costs structure, T_1, T_2, and T_3 from technological infrastructure structure, O_1, O_3, O_6, O_8, and C_9 from organisational infrastructure structure, and S_1, S_2, and S_3 from supportive institutions are removed from the research model (see Table 1 to find indices name). Next, studying AVE, R^2, Q^2 and *GOF* show the fit of the research model was confirmed according to Table 4.

Table 4
Model validity test results

Questionnaire	AVE	R^2	Q^2	GOF
Technological infrastructure	0.72	0.55	0.37	
Supportive institutions	0.66	0.56	0.34	
Environmental infrastructure	0.62	0.75	0.45	0.611
Organisational infrastructure	0.60	0.65	0.39	
Costs	0.68	0.34	0.71	

The *GOF* acquired 0.611 suggests a good fit for model. Finally, ISP's penetration rate, information security, goods, and services supplier, hard/software manufacturers and web developers, legal issues, government support, customers' awareness, people's trust to e-commerce, market issues, cultural issues, firms' strategy, business process re-engineering, organisational flexibility, rate of changes, cost of hardware, cost of public's training are identified as the most important effective factors on e-commerce adoption in Iranian SMEs.

Stage 2: Fuzzy DEMATEL

After identifying the most important effective factors on e-commerce adoption, influential relation map is studied using fuzzy DEMATEL. First, fuzzy DIM obtained by fuzzy mean according to research methodology. To normalise fuzzy DIM, K is calculated 11.82. Then, R, C, $R + C$, $R - C$ are investigated for each factor and arranged from the highest to the lowest (H to L), after calculating definite TIM (see Table 5).

According to Table 5, based on (R), government support has the highest influence and rate of changes has the least influence on the others. According to (C), firms' strategy takes the highest and cost of hardware takes the least impact from other factors. According to ($R + C$), people's trust to e-commerce has the highest and cost of hardware has the least interaction with the others. Moreover ($R - C$) column shows that ISP's penetration rate, hard/software manufacturers and web developers, legal issues, government support, customers' awareness, people's trust to e-commerce, cost of hardware, and cost of public's training, are considered as causal factors whereas information security, goods and services supplier, market issues, cultural issues, firm's strategy, business process re-engineering, organisational flexibility, and rate of changes are considered as effected factors.

Table 5
Fuzzy DEMATEL result

Based on (R)	H to L	Based on (C)	H to L	Based on (R + C)	H to L	Based on (R − C)	H to L
E_2	3.743	O_2	3.470	E_4	6.901	E_2	0.815
T_4	3.499	E_5	3.463	S_5	6.865	E_1	0.382
S_5	3.484	E_4	3.448	O_2	6.818	T_4	0.210
E_1	3.463	O_7	3.424	T_4	6.788	S_5	0.103
E_4	3.453	S_5	3.381	E_5	6.784	C_7	0.096
E_3	3.403	T_5	3.377	T_5	6.748	E_3	0.058
T_5	3.371	E_3	3.345	E_3	6.748	C_1	0.044
O_2	3.348	O_4	3.301	E_2	6.671	E_4	0.005
E_5	3.321	T_4	3.289	E_1	6.544	T_5	−0.006
E_6	3.114	S_4	3.196	O_7	6.280	E_6	−0.024
C_7	2.995	O_5	3.143	E_6	6.252	O_2	−0.122
S_4	2.962	E_6	3.138	O_4	6.222	E_5	−0.142
C_1	2.936	E_1	3.081	S_4	6.158	S_4	−0.234
O_4	2.921	E_2	2.928	O_5	6.049	O_5	−0.237
O_5	2.906	C_7	2.899	C_7	5.894	O_4	−0.380
O_7	2.856	C_1	2.892	C_1	5.828	O_7	−0.568

Stage 3: Interpretive Structural Modelling

After building SSIM, final reachability matrix is obtained by checking relevancy of the studied factors one by one for clustering in next phase (see Table 6).

Table 6
Final reachability matrix

	T_4	T_5	S_4	S_5	E_1	E_2	E_3	E_4	E_5	E_6	O_2	O_4	O_5	O_7	C_1	C_7
T_4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
T_5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
S_4	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0
S_5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
E_1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
E_2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
E_3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
E_4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 6: (*continued*)

	T_4	T_5	S_4	S_5	E_1	E_2	E_3	E_4	E_5	E_6	O_2	O_4	O_5	O_7	C_1	C_7
E_5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
E_6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
O_2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
O_4	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0
O_5	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0
O_7	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0
C_1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
C_7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Next, for the clustering studied factors, reachability set, antecedent set, and intersection set are extracted from final reachability matrix (Table 6) for each factor. Table 7 indicates clustering progress based on iteration method.

Table 7
Clustering progress using iteration method

Code	Reachability Set	Antecedent Set	Intersection Set	Level
T_4	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	1
T_5	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	1
S_4	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	T_4, T_5, S_4, S_5, E_1, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1	T_4, T_5, S_4, S_5, E_1, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1	1
S_5	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	1
E_1	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	1
E_2	T_4, T_5, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, C_1, C_7	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	T_4, T_5, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, C_1, C_7	
E_3	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	1
E_4	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	1

Table 7: (*continued*)

Code	Reachability Set	Antecedent Set	Intersection Set	Level
E_5	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	1
E_6	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	1
O_2	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	1
O_4	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	T_4, T_5, S_4, S_5, E_1, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1	T_4, T_5, S_4, S_5, E_1, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1	1
O_5	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, O_2, O_4, O_5, O_7, C_1, C_7	T_4, T_5, S_4, S_5, E_1, E_3, E_4, E_5, E_6, F_{11}, O_4, O_5, O_7, C_1	T_4, T_5, S_4, S_5, E_1, E_3, E_4, E_5, O_2, O_4, O_5, O_7, C_1	
O_7	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	T_4, T_5, S_4, S_5, E_1, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1	T_4, T_5, S_4, S_5, E_1, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1	1
C_1	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	1
C_7	T_4, T_5, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, C_1, C_7	T_4, T_5, S_4, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, O_4, O_5, O_7, C_1, C_7	T_4, T_5, S_5, E_1, E_2, E_3, E_4, E_5, E_6, O_2, C_1, C_7	

Code	Input Set	Output Set	Common Set	Level
E_2	E_2, C_7	E_2, O_5, C_7	E_2, C_7	
O_5	E_2, O_5, C_7	O_5	O_5	2
C_7	E_2, F_{16}	E_2, F_{16}	E_2, C_7	

Code	Input Set	Output Set	Common Set	Level
E_2	E_2, C_7	E_2, C_7	E_2, C_7	3
C_7	E_2, C_7	E_2, C_7	E_2, C_7	3

To prioritise the clusters, we should take into account the fact that the first cluster/level has the lowest and the last cluster has the highest significance. The graph of the clusters is drawn in Figure 2 shows prioritising of clusters.
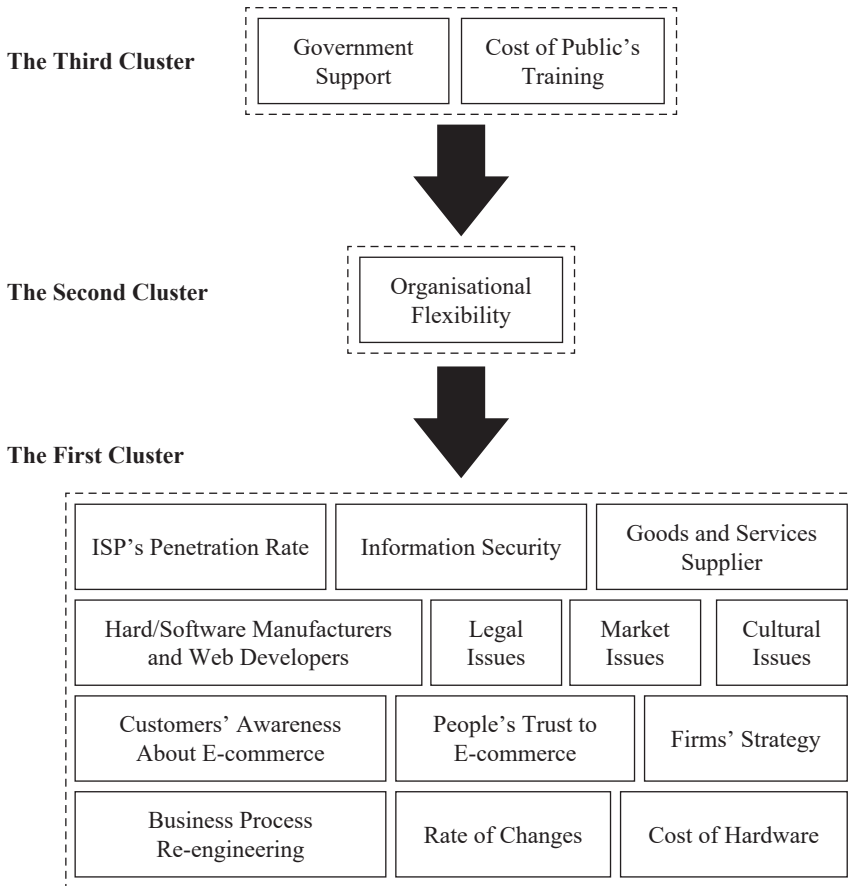
Figure 2. Prioritising of clusters

CONCLUSIONS

The study is conducted with the aim of investigating the factors affecting on e-commerce adoption among Iranian SMEs. Then, it presented a causal model of identified factors. Unlike Fouskas et al. (2020), Zumstein and Kotowski (2020), Choshin and Ghaffari (2017), Rahayu and Day (2015), Awa et al. (2015), Radfar and Ghozati (2014), and Sajjadi Amiri et al. (2010) that only examined the important factors in e-commerce adoption, this study enumerated the most important factors affecting e-commerce adoption using SEM at the first stage. Moreover, the causal relations among studied factors are examined at the second stage using fuzzy DEMATEL. Finally, investigated factors are categorised and levelised by ISM technique.

At the first step, factor analysis, the presented conceptual framework showed a good validity in terms of structure. After examining the criteria such as test of significance (*t*-value ≥ 1.96), load factor (≥ 0.7), R^2 (≥ 0.3), Q^2 (≥ 0.1), AVE (≥ 0.5) and *GOF* (≥ 0.3), the most important effective factors on e-commerce adoption identified in five dimensions (technological infrastructure, organisational infrastructure, supportive institutions, environmental infrastructure, and cots). Therefore, the most important effective factors on e-commerce adoption in Iranian SMEs are ISP's penetration rate, information security, goods, and services supplier, hard/software manufacturers and web developers, legal issues, government support, customers' awareness, people's trust to e-commerce, market issues, cultural issues, firms' strategy, business process re-engineering, organisational flexibility, rate of changes, cost of hardware, and cost of public's training.

Next, the causal relations of the investigated factors are studied by fuzzy DEMATEL. Influential relations map is drawn as can be seen in Figure 2. Besides, there are four other results in the second stage (see Table 5):

1. Government support has the highest influence on the other factors; ISP's penetration rate and hard/software manufacturers and web developers are taking next ranks. Also, the lowest effect on the others related to rate of the changes. Organisational flexibility and business process re-engineering are taking next ranks.

2. The highest effected factor from the others is firms' strategy. Market issues and people's trust to e-commerce are taking next ranks. Although a false strategy gets organisation to decadent period, a convenient strategy promotes the organisational growth which could be shown in various forms such as market development. Moreover, when organisation experiences new situations, strategies should be changed again and decision makers should be aware of all factors affecting firms' strategy. The lowest effected from the others is related to cost of hardware, cost of public's training, and government support respectively.

3. The most interaction with other factors (*R* + *C*) is related to people's trust to e-commerce, hard/software manufacturers and web developers, and firms' strategy respectively. However, the least interaction is related to cost of hardware, cost of public's training, and organisational flexibility respectively. Based on experts' opinions, people's trust to e-commerce has the highest interaction with other factors because people should buy things not in person. Hence, companies should pay close attention to each action due to the fact that it could be influenced on public's trust.

4.   According to $(R - C)$, results indicated that government support, legal issues, ISP's penetration rate, hard/software manufacturers and web developers, cost of public's training, customers' awareness about e-commerce, cost of hardware, people's trust to e-commerce are considered as causal factors. whereas, information security, cultural issues, firms' strategy, market issues, goods and services supplier, organisational flexibility, business process re-engineering identified as factors affected from the others.

At the third stage, investigated factors are categorised by ISM. The first cluster with the most priority includes government support and cost of public's training. The second cluster consists of only organisational flexibility. Remaining factors including ISP's penetration rate, information security, goods and services supplier, hard/software manufacturers and web developers, legal issues, customers' awareness about e-commerce, people's trust to e-commerce, market issues, cultural issues, firms' strategy, business process re-engineering, rate of the changes, and cost of hardware are in the third cluster with the lowest priority.

As a result, government support and cost of public's training are categorised in the first cluster which has the highest priority. As mention before, government support has the highest effect on the other e-commerce success factors in Iranian SMEs. According to experts' opinions, the orientation and policy of e-commerce in Iran are one-sided road. In fact, government is seen as an independent factor in e-commerce. It is recommended that government tries to establish flexible relationships with the private sector. Moreover, based on experts' viewpoints, especially in developing countries where e-commerce infrastructure is at the disposal of the state, government support is crucial to absorb the investment of private sector on e-commerce. Therefore, governments must put supportive packages for investors in order to boost e-commerce improvement. In other word, if businesses have not enough support from State, they attempt for establishing e-commerce will fail. Moreover, Iran has too much ambiguity in legal issues related to companies which are tried to adopt e-commerce. Therefore, government support as a law enforcement has a significant role to keep enterprises rights safe.

Experts normally believe e-commerce is a new concept in developing countries such as Iran. Thus, one of the requirements of successful e-commerce adoption is public's training and promoting people's awareness about e-commerce by long- and short-term training plans. In fact, educating people about e-commerce and using internet are very important topics in the prosperity of e-commerce. Therefore, the government must invest in training plans or cover cost of people's

training. Financially, cost of public's training can control all e-commerce achievement and it is really important to have operational plans. Besides, it is advised to the SMEs trying to implement e-commerce to have a comprehensive information related to people's awareness about applying e-commerce. Statistics indicates that people's lack of knowledge about e-commerce is one of the failure reasons of e-commerce exploitation by companies.

Organisational flexibility in the second cluster has an intermediate role for connecting the first cluster to the factors in the third cluster. Experts do believe that being alone in the second cluster indicates the high importance of organisational flexibility. Flexibility enables organisations to have the best reactions in the face of changing circumstances. For instance, employees normally show resistance to changes in organisations especially when the changes are about ICT; since staffs do not have enough information about using computers and e-commerce. As mentioned before, people or employees have less awareness about e-commerce; hence, improving training system can be helpful to make organisations much more flexible. Based on experts' opinions, because employees have not been trained and supported enough, they oppose to new technologies. As a result, organisations should be more flexible and encourage staffs by providing training courses about using new technologies, as well as giving them assurance that their job will not be eliminated by entrance new methods or technologies into the organisation.

Finally, the following recommendations for future studies are proposed:

1. Examination of e-commerce adoption indices in different enterprises can play a complementary role to the study.

2. Designing a fuzzy expert system in order to determine company's readiness in terms of e-commerce adoption.

3. Examination the role of organisational learning and knowledge management on e-commerce adoption.

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