Key Dimensions of Effective Factors in RFID Technology Development in the Supply Chain of Iran`s Auto-Industry

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ABSTRACT

RFID technology has great potential to improve the benefits of supply chain management. Auto- manufacturing is a competitive industry that every player of it needs great operation efficiency to gain competitive advantage to survive. RFID systems are good enhancements to supply chain processes, Therefore it's obvious that every industry has to pay great attention to this IT solution, and in this case the auto industry which is the industry of industries is not an exemption. Auto industry is one of the areas which need the help of information technology and its solution - RFID- to track each auto part from the beginning to the end of its supply chain. In this research we study the key dimensions of factors influencing on RFID technology development in the supply chain of Iran's auto industry by using the structural equation modeling (SEM) method. The results indicate that security and technology dimensions have greater influence on RFID development in the nation`s auto industry than other dimensions.

Keywords

Radio Frequency Identification (RFID) – Supply Chain Management – Structural Equation Modeling – Auto-Industry

1. INTRODUCTION

RFID technology shows great potential for process improvement and cost reduction related to supply chain management. The supply chain has become the central organizing unit in today's global industries [1]. Furthermore, in today's environments in which competition is among supply chain networks rather than individual firms, firms are confronted with the need to effectively manage increasingly extending supply chain activities beyond the boundary of the firms [2]. As firms extend supply chain activities beyond the boundary of the firms, the need for new inter-firm information technologies has increased significantly. RFID technology is the most advanced technology for supply chain integrity and traceability [3]. As evidenced by Wal-Mart's RFID mandate to its suppliers, RFID has received significant attention as a viable supply chain management technology. RFID invested in supply chain is expected to enhance information sharing and collaboration between supply chain partners due to its automated data collection and transmission capabilities. A case study on a system of integrating mobile commerce and RFID applications illustrates that the RFID provides greater visibility of the operations data and improves the control processes [4]. According to Lin, there exist several barriers for a corporation to adopt RFID technology effectively and efficiently. For example there are financial requirements to prepare the facilities for RFID. There is the readability problem since RFID does not guarantee a 100% success rate in the item level. There is the coordination problem because the synergies would be sacrificed if some members in the supply chain do not adopt RFID technology [5].

Auto industry is one of the competitive industries that need RFID to improve the visibility of supply chain management and gain competitive advantage. The automotive industry already uses RFID, e.g. in vehicle immobilizers since the 1990s. But the adoption in supply chain processes, however, is just at the beginning. This encompasses all those processes that are associated with the movement and shipping of goods from raw-materials stage up to the final products which are delivered to customers as well as backwards at the end of the product`s life for recycling purposes, i.e. procurement, inventory management, assembly control, order processing, distribution, transportation, quality control, theft control, anti-counterfeiting, and warehousing [6, 7]. There are lots of factors influencing on the development of RFID in the supply chain of auto-industry. According to Sanayei these factors can be grouped in 6 dimensions which include cost, technology, infrastructure, international standards, security and other factors. [8].

The objective of this research is to study and prioritize the dimensions of effective factors in the development of RFID in the supply chain management of Iran's automotive industry. We hope the results of this study help the management in the research and development units of the nation`s auto manufacturers.

2. LITRATURE REVIEW

Supply chain RFID is an emerging application that has attracted a lot of attention from researchers and practitioners in the US, Europe, and Asia [9]. RFID allows automatic identification and data capture using radio waves, a tag, and a reader. The tag can store more product data than traditional barcodes [10]. The tag contains product data in the form of Electronic Product Code (EPC), a global RFID- based item identification system developed by the Auto-ID Center. Product data the RFID tag stores include product ID, production location, production date, and shipping container ID. A number of studies view information sharing as one of the major supply chain management activities [11, 12, 13]. RFID technology enables supply chains to easily and inexpensively collect and share information, thus enhancing supply chain visibility. The enhanced supply chain visibility leads to reduced stock-out, lower labor costs, reduced transaction costs, and improved inventory management in their supply chains [14]. In addition to the above-mentioned data storage and information sharing capability, RFID improves information quality significantly. Managers may not use information provided from supply chain partners if they do not have confidence in information quality, and further more will not share their own information with their partners. While RFID technology is known to provide more accurate, current, and reliable information to supply chain partners than the traditional barcode technology, which leads to a better collaboration among supply chain partners, challenges such as false read, data over load, real-time acquisition of data, data security, and privacy must be dealt with [15]. RFID has several important advantages over traditional bar coding: items can be read from a distance without optical line of sight, multiple tags can be read simultaneously, and item specific data can be written on a tag [16]. The RFID technology yields several important benefits within supply chains. Among others, automated data tracking without human intervention offers faster processing, more accurate inventory records, and advanced shipping notices. Thus, product shrinkage, transaction errors, charge backs, misplaced products, and incorrect product identification can all be reduced [17, 18].

There are many methods to study RFID system. It`s possible to use analytical models, simulation models, and also case studies. Analytical models use mathematical approaches and simplify the real-world systems. Simulation studies yield in a better understanding of systems by system dynamics and simplifying the real world by simulation softwares. Case studies are the real experiments of RFID in small and simple environments.

Silver and et al. mentioned the importance of real-world models as a vital mean for decision-making [19]

Lin presented an integrated framework for the development of radio frequency identification technology in the logistics and supply chain management, and identified the key factors of RFID technology in the logistics and supply chain management. A complete set of five dimensions and 24 factors with a hierarchy structure was presented, using the fuzzy Delphi and fuzzy AHP for analysis. A structural procedure of RFID system establishment was also constructed based on the key dimensions and factors, with the expectation of establishing the RFID system in an effective and efficient manner. Then, based on the experience of Taiwanese government and industry, the sequence of companies for adopting the RFID technology was discussed. Thus, an integrated framework for the development of RFID technology, which includes the hierarchy of factors, structural procedure, and sequence of adoption, was presented by the researcher [5]. Sanayei et al. studied the factors influencing the development of radio frequency identification technology in supply chain management of IKCO (Iran`s biggest auto-manufacturer) based on the Lin framework and evaluated the ranks and weights of these factors, using fuzzy Delphi, Delphi and fuzzy AHP methods. Researcher modified the Lin structure and presented 28 factors and 6 effective dimensions in developing RFID technology in IKCO [8].

3. CONCEPTUAL MODEL

The conceptual model of the research is presented in figure 1.

4. RESEARCH QUESTIONS

- What are the key factors influencing the development of RFID in supply chain of Iran's auto-industry?
- What is the rank of cost dimension in the development of RFID in Iran`s auto-industry?
- What is the rank of technology dimension in the development of RFID in Iran`s auto-industry?
- What is the rank of infrastructure dimension in the development of RFID in Iran`s auto-industry?
- What is the rank of standard dimension in the development of RFID in Iran`s auto-industry?
- What is the rank of security dimension in the development of RFID in Iran`s auto-industry?

5. RESEARCH HYPOTHESIS

- The cost dimension is one of the top priorities in development of RFID technology in the supply chain of the Iran`s auto-industry.
- The technology dimension is one of the top priorities in development of RFID technology in the supply chain of the Iran`s auto-industry.
- The infrastructure dimension is one of the top priorities in development of RFID technology in the supply chain of the Iran`s auto-industry.
- The standard dimension is one of the top priorities in development of RFID technology in the supply chain of the Iran`s auto-industry.
- The security dimension is one of the top priorities in development of RFID technology in the supply chain of the Iran`s auto-industry.
- Every dimension of factors affecting development of RFID technology in the supply chain of the nation`s auto-industry have different effects and priorities.

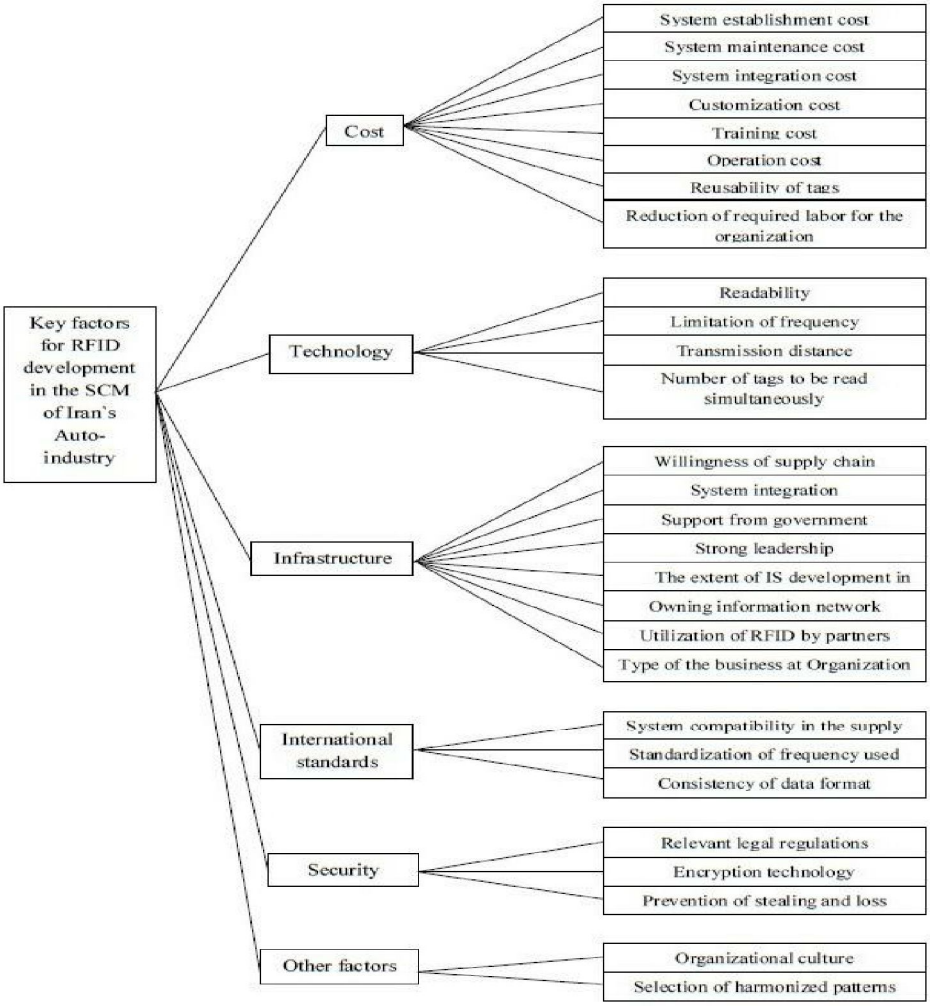

Figure1. Conceptual model of the research [8]

6. RESEARCH METHODOLOGY

This study is an applied research in terms of purpose and is descriptive-survey in terms of data collection. The questionnaire has been used in this study in order to collect data. The questionnaire of this research is based on the standard questionnaire of the based research by Sanayei et al. in 2011, therefore has enough validity. Statistical society of the present study is the society of all the managers and experts in the supply chain of Iran's auto-manufacturers. The sample size in this study is 266, based on Cochran`s formula for determining appropriate sample size [20]. Cronbach`s Alpha is used to determine the reliability of the questionnaire [21]. The coefficient was 0.904 which shows good reliability of the instrument and is much upper than 0.7, indicates high reliability of the questionnaire content. The confirmatory factor analysis was used to evaluate the construct validity of the observed variables. With $\chi 2/df$ of 2.32, RMSEA of 0.07 and all the t-values upper than 1.96, it is possible to say the questions have enough validity to measure the latent variables.

7. DATA ANALYSIS

To validate the dimension analysis of RFID development in auto-industry, we applied SEM (Structural Equation Modeling) in this study. It is a useful technique for testing and estimating causal relations between constructs. The fundamental approach for implementing the SEM analysis is illustrated in figure 2 [21].

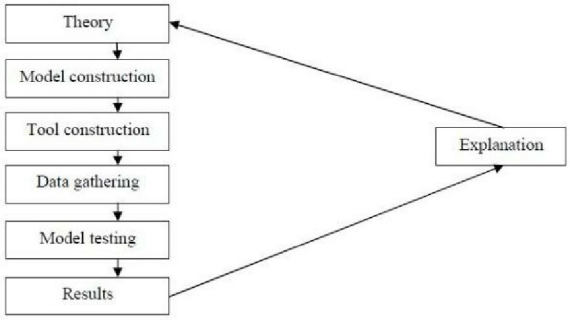

Figure2. SEM method steps [21]

The structural model fit was great with the results shown in table1, indicating a strong predictive validity. $\chi 2/df$ of the study is 2.611. it`s value should be less than 3 and the obtained value shows a good fitness of the model. Root mean square error of approximation (RMSEA) should be less than 0.08, which in the presented model its value is equal to 0.032. Goodness of fit (GFI) and Adjusted Goodness of fit indexes (AGFI) are also 0.91 and 0.89. Figure 3 shows the structural equation model of the research.

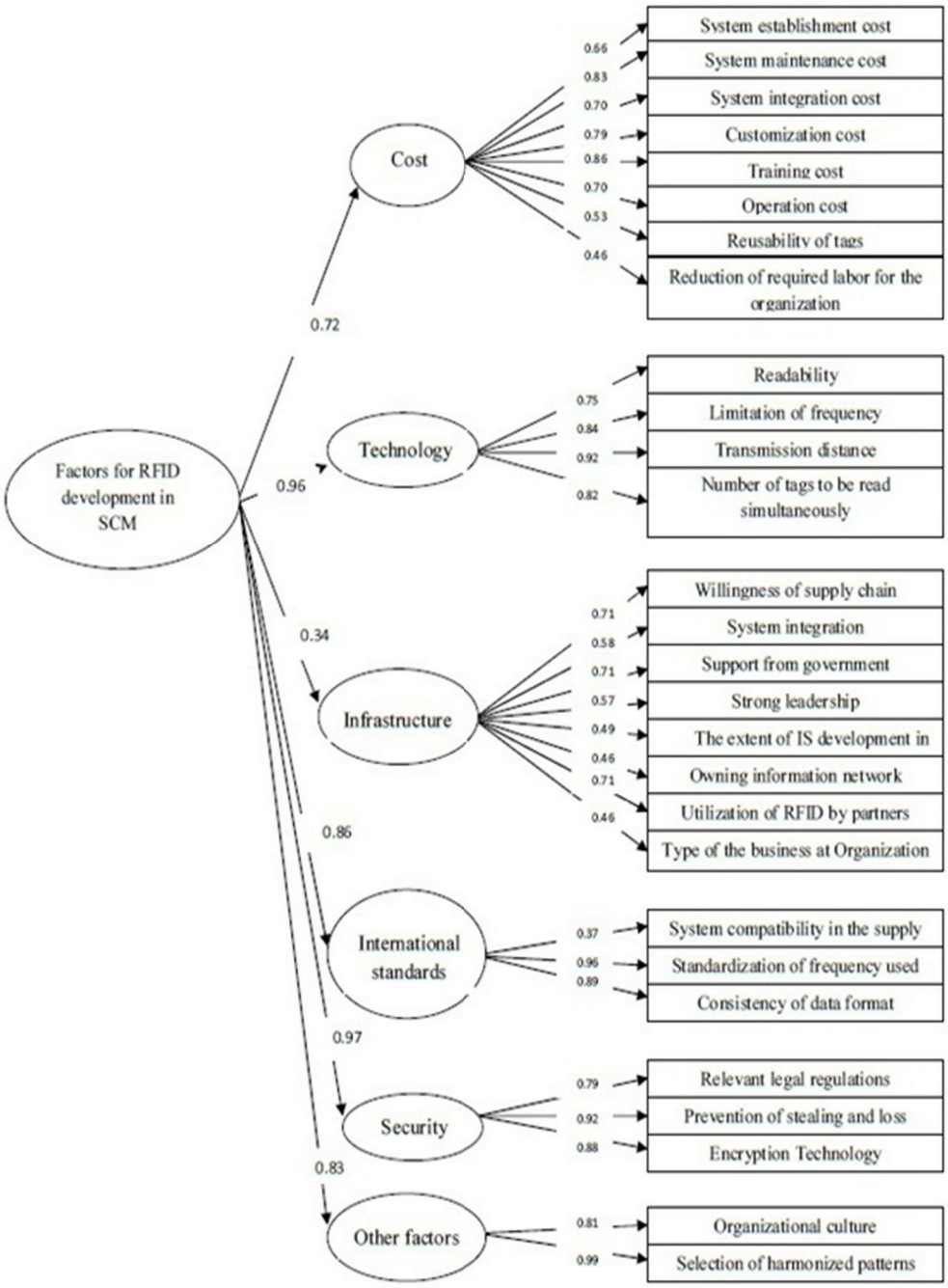

Figure3. Structural equation model

Table1. Indexes of the study

Index	Value
CHI SQUARE	3509.89
DF	1344
CHI SQUARE/DF	2.611
RMSEA	0.032
GFI	0.91
AGFI	0.89

8. HYPOTHESIS TESTING

8.1. First hypothesis

- The cost dimension is one of the top priorities in development of RFID technology in the supply chain of the nation`s auto-industry.

In statistical point of view this hypothesis can be written:

H0: The cost dimension is not one of the top priorities in development of RFID technology in the supply chain of the Iran`s auto-industry.

H1: The cost dimension is one of the top priorities in development of RFID technology in the supply chain of the Iran`s auto-industry.

The results of hypothesis 1 are depicted in table 2, as it`s obvious the standardized coefficient is 0.72 and the t-value is 8.66 which is bigger than 1.96, therefore with 95% confidence it`s possible to say The cost dimension is one of the top priorities in development of RFID technology in the supply chain of the nation`s auto-industry and the first hypothesis is supported.

Table2. Results of hypothesis 1

Course of direction	T value	Standardized Parameter
Cost issues on RFID development	8.66	0.72

8.2. Second hypothesis

- The technology dimension is one of the top priorities in development of RFID technology in the supply chain of the Iran`s auto-industry.

In statistical point of view this hypothesis can be written:

H0: The technology dimension is not one of the top priorities in development of RFID technology in the supply chain of the Iran`s auto-industry.

H1: The technology dimension is one of the top priorities in development of RFID technology in the supply chain of the Iran`s auto-industry.

The results of hypothesis 2 are depicted in table 3 the standardized coefficient is 0.96 and the t-value is 12.62 which is bigger than 1.96, therefore it`s possible to say The technology dimension is one of the top priorities in development of RFID technology in the supply chain of the nation`s auto-industry and the second hypothesis is supported.

Table3. Results of hypothesis 2

Course of direction	T value	Standardized Parameter
Technology issues on RFID development	12.62	0.96

8.3. Third hypothesis

- The infrastructure dimension is one of the top priorities in development of RFID technology in the supply chain of the Iran`s auto-industry.

In statistical point of view this hypothesis can be written:

H0: The infrastructure dimension is not one of the top priorities in development of RFID technology in the supply chain of the Iran`s auto-industry.

H1: The infrastructure dimension is one of the top priorities in development of RFID technology in the supply chain of the Iran`s auto-industry.

The results of hypothesis 3 are depicted in table 4, the standardized coefficient is 0.34 and the t-value is 4.51 which is bigger than 1.96, therefore it`s possible to say The software and hardware infrastructure dimension is one of the top priorities in development of RFID technology in the supply chain of the nation`s auto-industry and the third hypothesis is supported.

Table4. Results of hypothesis 3

Course of direction	T value	Standardized Parameter
Infrastructure issues on RFID development	4.51	0.34

8.4. Fourth hypothesis

- The standard dimension is one of the top priorities in development of RFID technology in the supply chain of the Iran`s auto-industry.

In statistical point of view this hypothesis can be written:

H0: The standard dimension is not one of the top priorities in development of RFID technology in the supply chain of the Iran`s auto-industry.

H1: The standard dimension is one of the top priorities in development of RFID technology in the supply chain of the Iran`s auto-industry.

The results of hypothesis 4 are depicted in table 5, as it`s obvious the standardized coefficient is 0.86 and the t-value is 5.44 which is bigger than 1.96, therefore with 95% confidence it`s possible to say The standard dimension is one of the top priorities in development of RFID technology in the supply chain of the nation`s auto-industry and the fourth hypothesis is supported.

Table5. Results of hypothesis 4

Course of direction	T value	Standardized Parameter
Standard issues on RFID development	5.44	0.86

8.5. Fifth hypothesis

- The security dimension is one of the top priorities in development of RFID technology in the supply chain of the Iran`s auto-industry.

In statistical point of view this hypothesis can be written:

H0: The security dimension is not one of the top priorities in development of RFID technology in the supply chain of the Iran`s auto-industry.

H1: The security dimension is one of the top priorities in development of RFID technology in the supply chain of the Iran`s auto-industry.

The results of hypothesis 5 are depicted in table 6, the standardized coefficient is 0.97 and the t-value is 13.63 which is bigger than 1.96, therefore with 95% confidence it`s possible to say The security dimension is one of the top priorities in development of RFID technology in the supply chain of the nation`s auto-industry and the fourth hypothesis is supported.

Table6. Results of hypothesis 5

Course of direction	T value	Standardized Parameter
Security issues on RFID development	13.63	0.97

8.6. Sixth hypothesis

- Every dimension of factors affecting development of RFID technology in the supply chain of the nation`s auto-industry have different effects and priorities.

In statistical point of view this hypothesis can be written:

Ho: Every dimension of factors affecting development of RFID technology in the supply chain of the nation`s auto-industry does not have different effects and priorities.

H1: Every dimension of factors affecting development of RFID technology in the supply chain of the nation`s auto-industry have different effects and priorities.

The results of the value of the effect of each studying variable are mentioned in table 3.

Table7. results of the value of the effect of each studying variable

Factor	Standard coefficient	T value	Rank
Cost	0.72	8.66	5
Technology	0.96	15.62	2
Infrastructure	0.34	4.51	6
Standard	0.86	5.44	3
Security	0.97	13.63	1
Others	0.83	11.37	4

According to the findings as it`s obvious the effect coefficient of Every dimension of factors affecting development of RFID technology in the supply chain of the nation`s auto-industry is different and their sequence from high to low is the security, technology, international standard, other factors, cost and infrastructures.

9. CONCLUSION

In this paper, the rank and priority of the key dimensions of factors in developing RFID technology in the supply chain of Iran`s auto-industry were examined by the structural equation modeling. These dimensions include cost, infrastructure, security, technology, standard and other factors. The findings indicate that Security and technology dimensions have the greatest influence on the development of RFID technology in the supply chain of Iran's auto-industry. Therefore it is suitable for nation`s auto manufacturers to emphasis more on these effective dimensions and should strengthen these two areas and their factors which are "prevention of stealing and loss", "encryption technology" and "relevant legal regulations" for security dimension and "transmission distance", "limitation of frequency"، "number of tags to be read simultaneously" and "readability" for technology dimension. The standardized coefficient of "prevention of stealing and loss" is the major value among other factors of security dimension and needs much greater attention.

The standard dimension is the third effective dimension in the development of RFID technology in the supply chain of Iran`s auto-industry and the industry practitioners should not neglect its importance among other dimensions. They also have to work on the standardization of the frequency which is used, as the results show that it is the most important factor in this dimension.

The results also show that although at the first glance, the most important and effective dimension seems to be the cost, it is less important than security issue, technology issue and Standard issue and it is not the top priority in RFID implementation and development in the nation`s auto industry.

REFRENCES

1. Miles, R.E., Snow, C.C. (2007). Organization theory and supply chain management: an evolving research perspective. *Journal of Operations Management* 25 (2), 459–463.
2. Patnayakuni, R., Rai, A., Seth, N. (2006). Relational antecedents of information flow integration for supply chain coordination. *Journal of Management Information Systems* 23 (1), 13–49.
3. Kumar, S., Budin, E.M.(2006). Prevention and management of product recalls in the processed food industry: a case study based on an exporter's perspective. Technovation 26 (5/6), 739–750.
4. Ngai, E.W.T., Cheng, T.C.E., Au, S., Lai, K.-H., (2007). Mobile commerce integrated with RFID technology in a container depot. *Decision Support Systems,* 43 (1), 62–76.
5. Lin, L. C.(2009). "An Integrated Framework for the Development of Radio Frequency Identification Technology in the Logistics and Supply Chain Management". *Computers & Industrial Engineering*, Vol. 57, pp. 832-842.
6. Strassner, M., Fleisch, E. (2002). "Segment evaluation automotive- Applications of Auto-ID technology in the automotive industry", M-Lab Report, No. 15, St.Gallen.
7. Lu, B.H., Bateman, R.J., Cheng, K.(2006). "RFID enabled manufacturing: Fundamentals, methodology and applications", *International Journal of Agile Systems and Management*, 1(1), pp. 73-92.

8. Sanayei, Ali., Ghazifard, A.M.(2011). and Fariborz Sobhan-Manesh, "The Factors Influencing the Development of Radio Frequency Identification Technology in Supply Chain Management (Case study: IKCO)", the first conference of management and innovation. Iran, Shiraz.
9. Soon, C.B., Gutierrez, J.A. (2008).Effects of the RFID mandate on supply chain management. *The Journal of Theoretical and Applied Electronic Commerce Research,* 3(1), 81–91.
10. Jones, P., Clarke-Hill, C., Shears, P., Comfort, D., Hillier, D., (2004). Radio frequency identification in the UK: opportunities and challenges. *International Journal of Retail and Distribution Management* 32 (3), 164–171.
11. Min, S., Mentzer, J.T.(2004). Developing and measuring supply chain management concepts. *Journal of Business Logistics,* 25 (1), 63–99.
12. Morton, S.C., Dainty, A.R.J., Burns, N.D., Brookes, N.J., Backhouse, C.J. (2006). Managing relationships to improve performance: a case study in the global aerospace industry. *International Journal of Production Research,* 44 (16), 3227–3241.
13. Krause, D.R., Handfield, R.B., Tyler, B.B. (2007). The relationships between supplier development, commitment, social capital accumulation and performance improvement. *Journal of Operations Management* 25 (2), 528–545.
14. Twist, D.C.(2005). The impact of radio frequency identification on supply chain facilities. *Journal of Facilities Management,* 3 (3), 226–239.
15. Bose, I., Lam, C.Y. (2008). Facing the challenges of RFID data management. *International Journal of Information Systems, and Supply Chain Management* 1 (4), 1–19.
16. Gale,T.,Rajamani,D.,Sriskandarajah,C.(2005).Theimpact ofRFIDonsupplychain performance.Availablefrom http://www.som.utdallas.edu/c4isn/documents/ c4isn-Impact-RFID-SC-Perform.pdf.
17. Kang,Y.,Gershwin,S.B.,(2005).Informationinaccuracyini nventorysystems—stock loss andstockout.*IIETransactions*,37(9),843–859.
18. Özelkan,C.E.,Sireli,Y.,Munoz,M.P.,Mahadevan,S. (2006).A decision modelto analyze costs and benefits of RFID for superior supply chain performance. In: Proceedings of PICMET,Istanbul,Turkey,pp.610–617.
19. Silver, E.A., Pyke, D.F., Peterson, R. (1998) Inventory Management and Production Planning and Scheduling. Wiley.
20. Cochran, G. (1977). Sampling techniques (3rd ed.). New York: john wiley & sons.
21. Houman, H.A. (1387). Structural Equation Modeling with LISREL software application. Tehran: SAMT.