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Developing a model for Agile Pharmaceutical manufacturing: Evidence from Iran

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Abstract: Agility is the fundamental characteristic of a supply chain needed for survival in turbulent markets, where environmental forces create additional uncertainty resulting in higher risk in the supply chain management. Agility further helps providing the right product, at the right time to the consumer. As pharmaceutical distributors play a vital role in health continuum, the purpose of this research is developing a model for manufacturing companies to be agile according to determining basic factors. The present study analyzes the manufacturing part of pharmaceutical supply chain based on SCOR model, used to assess agile supply chains by highlighting their specific characteristics and applicability in production of products. In addition, for making priority of critical factors, TOPSIS algorithm as a common technique of MADM model has been used. In result, several factors are identified as critical factors to being agile in manufacturing. Finally, the paper adds insights into the pharmaceutical supply chain, examining this from multiple perspectives.

Key word: Agile manufacturing, Pharmaceutical industry, Supply chain, Iran

INTRODUCTION

In today's extremely competition-oriented universal market, productive supply chain management (SCM) has a crucial role and is accepted as a key factor for organizational presentation and competitive advantage (Schneller and Smeltzer, 2006; White and Mohdzain, 2009). Over the last two decades, globalization has resulted in a highly competitive business environment. The turbulent market condition in the twenty-first century has heightened the need for more competitive enterprise strategies. Speed, quality, flexibility and responsiveness, which are the key elements of agile capabilities, are necessary to meet the unique needs of customers and markets.

Today's business situation is characterized by an upward level of unpredictability. In this unstable market, firms face aggressive competitive environment due to globalization, technological changes, shorter goods' life cycles, diminished margins, economic downsized markets and more informed and well-informed customers with unique and quickly changing needs. These changing market situations forces organizations to alter the path their supply chains structured and handle in order to be more responsive to these changes. In order to respond to the challenges and demands of today's business environment, firms have been undergoing a revolution in terms of implementing novel operations strategies and technologies (Gunasekaran *et al*., 2008). Companies benefit from having such agile characteristics by forecasting uncertainties and enabling quick changes to achieve greater responsiveness to the requirements in their business (Jackson and Johansson, 2003; Baramichai *et al*., 2007). The pharmaceutical section plays a significant role in the medical and health system. The pharmaceutical market is heavily regulated in many countries because of the unique nature of demand and supply (Yu *et al*., 2010). Considering the important role of agile manufacturing in turbulent environment, so far, there is no study determining factors affecting agile manufacturing in pharmaceutical industry.

Finally, the purpose of this paper is to address this question:

"In Order To Being Agile In Pharmaceutical Manufacturing, Which Critical Factors Should Be Taken Into Account By Companies?"

To answer the question, this article benefits from the fuzzy TOPSIS to quantify critical factors. The remainder of the paper is organized as follows: Section 2 presents the literature on pharmaceutical industry and a review of agile manufacturing. In Section 3 study design and basic factors are developed. Section 4 and 5 present data collection and results ultimately, in section 6 and 7 conclusion and implications are provided.

Literature Review:

2.1. Pharmaceutical Industry Environment:

In pharmaceutical manufacturing, quality standards are very important as good manufacturing practices concentrates particularly on the manufacturing of safe and quality goods (Greene and O'Rourke, 2006). World

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Health Organization (WHO) defines current good manufacturing practices (cGMP) as "that part of quality assurance which ensures that products are consistently produced and controlled to the quality standards appropriate to their intended use and as required by the customer" (A WHO Guide to Good Manufacturing Practice Requirements, 2010).

The pharmaceutical industry is explained as a system of procedures, operations and organizations involved in the discovery, development and production of drugs and medications. The pharmaceutical supply chain (PSC) represents the path through which essential pharmaceutical products are distributed to the end-users at the right quality, at the right place and at the right time (Mehralian *et al*., 2012). The Pharmaceutical Supply Chain is very complicated and greatly responsible to ensure that the appropriate drug, reaches the right people at the right time and in the right situation to fight against sickness and sufferings. This is a highly sensitive supply chain that everything less than 100% customer service level is unacceptable as it directly influence the health and safety. The solution that a lot of Pharmaceutical industries adopt is to bear a vast inventory in the supply chain to ensure close to 100 percent fill rate. However, it is a great war to ensure product availability at an optimum cost unless supply chain processes are streamlined towards customer requirements and demands (Chandrasekaran and Kumar, 2003).

The time to market, R & D productivity (Innovations), drugs life cycle reduction, government regulations, decreasing exclusive patent life, production flexibility, and increasing cost are the main problems that pharmaceutical industries are facing today. The pharmaceutical market is heavily regulated in many countries because of the singular nature of demand and supply for drugs (Garattini *et al*., 2007). In accord with the feature of the competition in drug market, governments must balance both clinical and economic interests (Hakonsen *et al*., 2009). The pharmaceutical section plays a crucial function in the medical and health system. Characterized with its size of total and aging population, quickly increasing economy and increasing prevalence of chronic diseases (like cardiovascular disease, cancer, and chronic respiratory disease) pharmaceutical industry growth has increased at a very fast rate (Mehralian *et al*., 2012).

2.2. Pharmaceutical Supply Chain components:

The pharmaceutical supply chain (PSC) like to other industries begins with the sourcing of active and inactive ingredients for approved products. Dosages are planned and packed into different configurations. Products moved along to company's warehouses, wholesale distributors, retail pharmacies, medicinal organizations (hospital pharmacy), and finally to end- users. The data flow and funds flow start from end customer to producer through different channels (Chandrasekaran and Kumar, 2003). A supply chain is the arrangement of organizations, their facilities, acts, and activities; that are involved in manufacturing and giving a product or service. A typical pharmaceutical supply chain consists of the following members: initially manufacturing, secondary producing, market warehouse/distribution centers, wholesalers, retails/hospitals and patients (Shah, 2004). Previously, under a centrally organized economy, the whole pharmaceutical products were distributed by an owned monopoly firm (first-tier wholesaler) to some regional wholesalers (second-tier wholesalers) who would then deliver the products to local wholesalers (third-tier wholesalers) (Shao, 2006). Among pharmaceutical supply chain components, it has been argued that delivery of medicines has substantial effect on customers' satisfaction (Rossetti *et al*., 2011). Because of the changing economic system; pharmaceutical supply chain has been reformed. Figure 1, exhibits the new pharmaceutical supply chain.

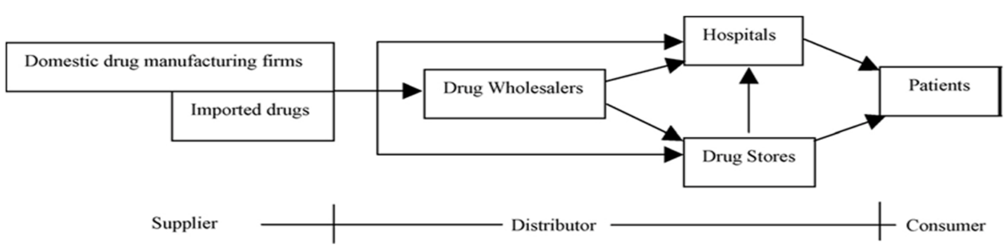

Fig. 1: Pharmaceutical supply chain.

Source: Mehralian *et al*. (2012)

2.3. The Agile Manufacturing:

Supply chain management is accepted as a philosophy of revolutionized businesses by increasing the business competencies and performance of all the members in the supply chain (Ferguson, 2000; Arif Khan *et al*., 2009). Supply chain agility has been receiving very consideration recently as a way for organizations to reply in a quick manner to changing business environment and improve their customer service levels. In order to comprehend this concept, it is important to first establish the definition of the agile companies. Agility has been proposed as a reply to the high levels of intricacy and uncertainty in advanced markets (Christopher and Juttner, 2000). According to Naylor *et al.* (1999), “agility means applying market knowledge and a vital corporation to exploit profitable opportunities in a rapidly changing market place”. The relation between agility and flexibility is extensively discussed in the literature (Christopher, 2000; Swaffordetal, 2006). It has been proposed that the origins of agility lie in flexible manufacturing systems (Gosling *et al*., 2010).

Agile manufacturing can be defined as the capability of surviving and prospering in an environment of continuous and unpredictable change by reacting quickly to the markets [4]. Agile manufacturing is a new expression which is applied to manifest the ability of a producer of goods and services to thrive in the turbulent environments. These changes can exist in markets, in technologies, in business relationships and in all perspectives of the business [6]. Agile manufacturing is a vision of manufacturing that is a natural outcome of lean manufacturing. In the lean manufacturing, the focus is on cost-cutting, but the requirement for firms to become more flexible and responsive to customers cause to development of the agile manufacturing as a separate concept from the lean organization.

The target of an agile enterprise is to enrich/satisfy customers and employees. A firm basically possesses a set of capabilities for making appropriate replies to changes occurring in its business environment. Anyway, the business conditions in which a lot of companies understand themselves are characterized by volatile and unpredictable demand. Agility might, so, be defined as the ability of a firm to reply rapidly to changes in the market and customer demands, strategic advantage by responding to marketplace uncertainty. Ultimately, agility can be obtained by systematically developing and gaining capabilities that can make the supply chain reflect rapidly and diversely to environmental and competitive changes (Khan *et al*., 2006).

Therefore, these firms need a number of distinguishing attributes to promptly deal with the changes inside their environment. Such attributes include four main elements (Sharp *et al*., 1999): responsiveness, competency, flexibility/adaptability and quickness/ speed. The base for agility is the joining of information technologies, staff, business process organization, innovation and facilities into main competitive attributes. The embracing of agile strategies has some benefits for firms, including quick and efficient reaction to changing market requests; the ability to customize products and services delivered to customers, the capability to manufacture and deliver new products in a cost-efficient mode (Swafford *et al*., 2006), decreased producing costs, enhanced customer satisfaction, removal of non-value-added activities and increased competitiveness. Therefore, agility has been advocated as the commerce paradigm of the 21st century and in addition agility is considered the winning strategy for becoming a universal leader in an increasingly competitive market of quickly changing customers’ requirements (Agarwal *et al*., 2006: Ismail *et al*., 2007).

Ultimately, according to Gunasekaran and Yusuf (2002), manufacturing agility can be considered as the capability of a business to:

. cover the changing market needs;

. increase customer service level; and

. Reduce the cost of products, with the goals of being competitive in a global market and enhancing the chance of long-term survival and profitability.

In this paper agile manufacturing is defined as a production model that involves technology, human resources and organization by creating an information and communication infrastructure, flexibility, speed, quality, service and efficiency and making it possible to respond effectively to changes in the business environment.

2.4. Fuzzy TOPSIS:

TOPSIS (technique for order preference by similarity to ideal solution) technique of solving the multi-criteria decision choosing tasks that implies full and complete information on criteria, expressed in numerical form. The method is very useful for solving real problems; it provides us with the optimal solution or the alternative's ranking. In addition to this, it is not so complicated for the managers as some other methods which demand additional knowledge. TOPSIS technique would search among the given alternatives and find the one that would be closest to the ideal solution but farthest from the anti-ideal solution at the same time. Modification of the method aims to set a different manner of determining the ideal and anti-ideal point – through standardization of linguistic attributes' quantification and introduction of fuzzy numbers in description of the attributes for the criteria expresses by linguistic variables (Karimi *et al*., 2011).

Study Design:

In this section we provided a methodology for operationalizing the variables and factors, acquiring the data and determining the reliability of factor grouping. The data used in this study gathered from questionnaire distributed to managers in the Iranian pharmaceutical companies. The pharmaceutical industry is chosen because it has a heavy and complete supply chain and has been increased pressures from the government and the public sector. These types of firms have tried to improve their supply chain performance due to increasing concerns and importance of supply issues, and manufacturers are seeking methods to improve their performance.

The questionnaire was drawn up based on the 12 critical factors listed in Table 1, which presented in previous studies (Tseng and Lin, 2011; Swafford *et al*., 2008; Antonioa *et al*., 2007; Agarwal *et al*., 2007; Christopher, 2000; Sharifi and Zhang, 1999), with 38 questions measuring attitude: the chosen response can be strongly disagree, disagree, no opinion, agree, or strongly agree. In addition to the above questions, information related to the basic profile of the interviewees was requested at the end of the questionnaire. The main sampling targets were senior managers, different department managers and personnel who were involved in decision making.

3.1. Research Model:

Our research model is presented in Figure 2, the key dependent variable of interest, is agility in manufacturing that is expected to be influenced by some independence variables. These variables have related to sub factors, and shown in Table 1, and as a result agility can improve responsiveness, quickness, flexibility and competency of manufacturers.

3.2. Capabilities of Agility:

Agile enterprises require a number of distinguishing capabilities or ‘‘fitness’’ to deal with the change, uncertainty and unpredictability within their business environment. These capabilities consist of four principle elements (Giachetti *et al*., 2003): (1) responsiveness which is the ability to identify changes and respond quickly to them, reactively or proactively, and recover from them; (2) competency which is the ability to efficiently and effectively reach enterprises’ aims and goals; (3) flexibility/adaptability which is the ability to process different processes and achieve different goals with the same facilities; and (4) quickness/speed which is the ability to carry out activity in the shortest possible time. Furthermore, underpinning these fours principles is a methodology to integrate them into a coordinated, interdependent system, and to translate them into strategic competitive capabilities (Sharp *et al*., 1999). These must be taken into account if an organization is to carry out agile enterprise (Tseng and Lin, 2011).

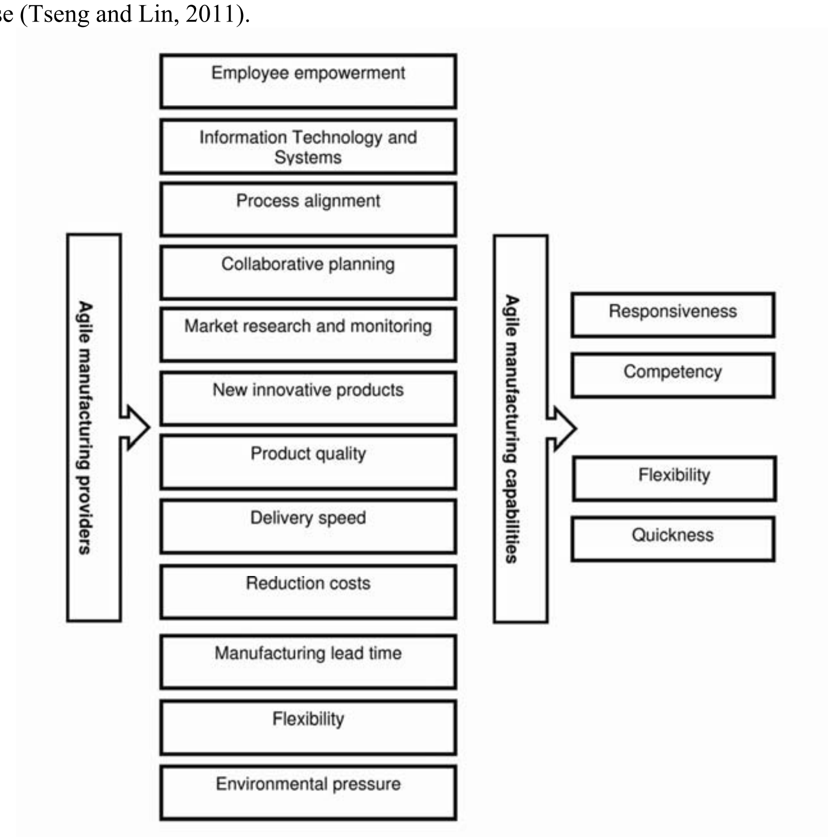

Fig. 2: Research model

Table 1. Agile manufacturing factors.

Factors	Sub- factors	Citations
Employee empowerment	Education and learning	Breu *et al*., (2001); Gunasekaran *et al*.,(2008)
	Innovation and creation	
	People flexibility	
Information Technology and Systems	Skills in IT(information technology)	Agarwal *et al*., (2007); Gunasekaran *et al*.,(2008); Swafford *et al*., (2008); Tseng and Lin, (2011)
	RFID (Radio frequency identification)	
	Exchange of information	
	Collaboration on strategic and operational planning	
	E-commerce	
Process alignment	Co-managed inventory	Christopher, (2000);Braunscheidel, (2005); Agarwal *et al*., (2007); Tseng and Lin, (2011)
	Collaborative product design	
	Synchronous supply	
Collaborative planning	Leverage partners' capabilities	Christopher, (2000); Agarwal *et al*., (2007); Gunasekaran *et al*.,(2008); Tseng and Lin, (2011)
	Focus on core competencies	
	Act as network orchestrator	
Market sensitive	Customer orientation	Christopher, (2000); Agarwal *et al*., (2007); Lin *et al*., (2006); Tseng and Lin, (2011)
	monthly feedback	
	Retain and grow customer relationships	
	Market behaviors	
New innovative products	Fast introduction of new products	Swafford, (2003); Braunscheidel, (2005); Baramichai, (2007);Agarwal *et al*., (2007)
	Technological innovation	
Product quality	Approved quality	Antonioa, (2007); Agarwal *et al*., (2007)
	Performance quality	
Delivery speed	timeliness of delivery	Sharifi and Zhang, (1999); Antonioa, (2007); Agarwal *et al*., (2007); Yeung, (2008)
	Delivery reliability	
Reduction costs	Penalty cost	Patil, (2006); Agarwal *et al*., (2007); Antonioa, (2007); Tseng and Lin, (2011)
	Inventory cost	
Manufacturing lead time	Increase production capacity	Sharifi and Zhang, (1999); Swafford *et al*., (2006); Agarwal *et al*., (2007)
	Reduce setup time	
Flexibility	Supply flexibility	Swafford, (2003); Braunscheidel, (2005); Lin *et al*., (2006); Antonioa, (2007); Tseng and Lin, (2011)
	Manufacture flexibility	
Environmental pressure	Political factor	Sharifi and Zhang, (1999); Braunscheidel, (2005); Tseng and Lin, (2011)
	Economic factors	
	Social factors	

3.3. Reliability and Validity of The Questionnaire:

The internal consistency of a set of measurement items refers to the degree to which items in the set are homogeneous. Internal consistency can be estimated using reliability coefficient such as cronbach's alpha (Saraph *et al*., 1989). In this research cronbach's alpha was calculated 0.92.

The validity of a measure refers to the extent to which it measures what is intended to be measured. Content validity is not evaluated numerically, it is subjectively judged by the researchers (Kaplan, 1987). It can be argued that because the measurement items were based on an extensive review of the literature on agile manufacturing. To gauge the acceptance of the questionnaire, 10 people who qualified in field of manufacturing, participated in a pilot test. The participants suggested adding and omitting some parts of questionnaire. Finally, all the pretest participants expressed strong agreement with the suitability of the questionnaire. The questionnaire was considered finalized after modifying the some questions, then ready to be delivered.

Besides the face validity, using principal components method for extraction, factors with eigenvalues greater than 1 were retained. The Factor analysis (i.e. Pearson's principal component analysis) was tested with and without rotation (i.e. Varimax rotation with Kaiser normalization). The conservative factor loadings of greater than 0.5 were considered at 95% level of confidence (Hair *et al*., 1998).

Data Collection:

Data for this study has been gathered using questionnaire that was distributed to 21 pharmaceutical firms which affiliated to tree large holding companies. In order to understand the viewpoints from key sectors of the pharmaceutical industry, questionnaires were sent to the marketing, sales, information technology (IT), finance, research and development (R&D) and quality assurance and control departments. Accordingly, we choose respondents from managers who had comprehensive knowledge about company's process, products and general pharmaceutical related issues. The number of questionnaires sent out was 210; the number returned was 156, a return rate 72 percent. Except 2 of them, remaining of the returned questionnaires was complete.

Data Analysis And Results:

Data analysis has been done by statistical analysis and Multiple Attribute Decision Making (MADM) algorithm. In statistical analysis we have used t- student tests (one sample t- test), Pearson correlation and for MADM algorithm we applied fuzzy TOPSIS technique. In this section we also used fuzzy TOPSIS technique to prioritize agile manufacturing factors. There are many applications of fuzzy TOPSIS in the literature. Chen *et al*, (2006) presented a fuzzy TOPSIS approach to deal with the supplier selection problem in a supply chain system. Yang and Hung (2007) used TOPSIS and fuzzy TOPSIS methods for a plant layout design problem (Karimi *et al*. 2011).

The TOPSIS method was firstly proposed by Hwang and Yoon in 1981. The basic concept of this method is that the chosen alternative should have the shortest distance from the positive ideal solution and the farthest distance from a negative ideal solution. A positive ideal solution is a solution that maximizes the benefit criteria and minimizes cost criteria (Karimi *et al*., 2011); whereas, a negative ideal solution maximizes the cost criteria and minimizes the benefit criteria. In the classical TOPSIS method, the weights of the criteria and the ratings of alternatives are known precisely and crisp values are used in the evaluation process. However, under many conditions crisp data are inadequate to model real-life decision problems. Therefore, the fuzzy TOPSIS method is proposed, in which the weights of criteria and ratings of alternatives are evaluated by linguistic variables represented by fuzzy numbers to deal with the deficiency in the traditional TOPSIS (Ertugul and KarakaşoGlu, 2008).

This paper presents an extension of the TOPSIS method proposed by Chen *et al*. (2006). The related algorithm can be described as follows (Chen *et al*., 2006).

Step 1: A committee of the decision-makers is formed. Fuzzy rating of each decision maker. $D_k = (k = 1,2,...,k)$ can be represented as triangular fuzzy number $\tilde{R}_k = (k = 1,2,...,;)$ with membership function $\mu_{\tilde{R}_k}(x)$

Step 2: Criteria evaluation is determined.

Step 3: After that, appropriate linguistic variables are chosen for evaluating criteria and alternatives.

Step 4: Then the weight of criteria are aggregated. The aggregated fuzzy rating can be determined by:

$$\tilde{R} = (a, b, c), k = 1,2,..., k.$$

$$\text{where , } a = \min\{a_k\}, b = \frac{1}{k}\sum_{k=1}^{k} b_k, c = \max\{c_k\} \qquad (1)$$

$$a_{ij} = \min_k \{a_{ijk}\}, b_{ij} = \frac{1}{k}\sum_{k=1}^{k} b_{ijk}, c_{ij} = \max_k \{c_{ijk}\} \qquad (2)$$

Then, the aggregated fuzzy weight ($\tilde{w}_{ij}$) of each criterion are calculated by:

$$(\tilde{w}_{ij}) = (w_{j1}, w_{j2}, w_{j3}) \qquad (3)$$

Where

$$w_{j1} = \min_k \{w_{ik1}\}, w_{j2} = \frac{1}{k}\sum_{k=1}^{k} w_{jk2}, w_{j3} = \max_k \{w_{jk3}\} \qquad (4)$$

Step 5: Then the fuzzy decision matrix is constructed.

Step 6: The above matrix is normalized.

Step 7: Considering the different weight of each criterion, the weighted normalized decision matrix is computed by multiplying the importance weights of evaluation criteria and the values in the normalized fuzzy decision matrix.

Step 8: the fuzzy positive ideal solution (FPIS,A*) and fuzzy negative ideal solution (FNIS,A*) are determine by:

$$A^* = (\tilde{V}_1^*, \tilde{V}_2^*, ..., \tilde{V}n^*), \qquad (5)$$

$$A^- = (\tilde{V}_1^-, \tilde{V}_2^-, ..., \tilde{V}_n^-) \qquad (6)$$

$$\tilde{V}_j^* = \max_i \{V_{ij3}\} \text{ and } \tilde{V}_j^- = \min_i \{V_{ij1}\}$$

Where,

$i = 1,2,...,m; \quad j = 1,2,...,n$

Step 9: Then, the distance of each alternative from FPIS and FNIS are calculated by:

$$d_i^* = \sum_{j=1}^{n} d_v(\tilde{V}_{ij}, \tilde{V}_j^*) \quad i = 1,2,...,m \qquad (7)$$

$$d_i^- = \sum_{j=1}^{n} d_v(\tilde{V}_{ij}, \tilde{V}_j^-) \quad i = 1,2,...m \qquad (8)$$

Where $d_v(...)$ is the distance measurement between two fuzzy numbers.

Step 10: A closeness coefficient index (CCl) is defined to rank all possible alternative. The closeness coefficient represents the distance to the fuzzy positive ideal solution (A*) and fuzzy negative ideal solution (A^-) simultaneously. The closeness coefficient of each alternative is calculated by:

$$CC_i = \frac{d_i^- i}{d_i^* + d_i^-}, \ i = 1,2,...,m \qquad (9)$$

Step 11: According to the closeness coefficient, the ranking of the alternative can be determined.

5.1. Correlation Analysis:

We have used Pearson correlation to test the relations among main factors. It means what's the inter correlation among critical factors. The results indicated that these factors have generally correlated together.

5.2. Result of fuzzy TOPSIS:

In order applying fuzzy TOPSIS, We have converted the language terms to fuzzy numbers according table 2.

Table 2: Language term.

Very low	1	(0,0.1,0.2)
Low	2	(0.1,0.25,0.4)
Medium	3	(0.3,0.5,0.7)
High	4	(0.6,0.75,0.9)
Very high	5	(0.8,0.9,1)

As illustrated in table 3, The priorities of basic factors according to fuzzy TOPSIS's results show that the delivery speed has first priority and new innovative products, reduction costs, manufacturing lead time (production cycle time), market sensitive, product quality, environmental pressure, employee empowerment, collaborative planning, flexibility, process alignment and finally information technology and systems are followed.

Table 3: TOPSIS rank of basic factors.

Factors	Ci (rank of TOPSIS)
Delivery speed	0.41818
New innovative products	0.52562
Costs reduction	0.78042
Manufacturing lead time	0.84117
Market sensitivity	0.97026
Product quality	1.05814
Environmental pressure	1.12187
Employee empowerment	1.19107
Collaborative planning	1.22364
Flexibility	1.34731
Process alignment	1.74776
Information technology and systems	2.65316

Discussion:

Agile manufacturing is a new expression which is applied to manifest the ability of a producer of goods and services to thrive in the turbulent environments (Gunasekaran, 1999). In this study all attempts aimed at providing an efficient and optimized model for agility of manufacturers (as a component of supply chain) in pharmaceutical Industry. According to fuzzy TOPSIS's result, 12 main indicators were identified as the most important factors affecting process of agile manufacturing that including: delivery speed, new innovative products, reduction costs, manufacturing lead time (production cycle time), market sensitive, product quality, environmental pressure, employee empowerment, collaborative planning, flexibility, process alignment and finally information technology and systems.

Delivery speed was identified as the first influential factor for agility of manufacture process. It refers to the ability firm to deliver products faster than competitors (Handfild Pannesi, 1992). According to Sharifi and Zhang (1999), this indicator along with sub-indicators (high rate of response to orders and reliability of delivery) will directly increase speed of supply chain. Developing and introducing the new product to the market in order to satisfy customers' need, was assigned as the second factor for agility manufacturing. Furthermore, in order to be competitive and survive in the today market, presenting new and novel products is avoidable for manufacturers. Baramichai (2007) Noticed that the number of new product which presented to the market during the one year and also response to customers need by producing new product, could be considered as an index of innovation. Cost minimization is considered as the third factor affecting the agility in this model. Certainly each business wants to reduce costs because it has many remarkable effects. In the agile manufacturing, we are looking for reducing the costs both inside the organization and even outside the organization that directly or indirectly impact on the finished product's cost (Cooper and Slag Mulder, 1998). According to Agarwal *et al*. (2007) cost reduction can promote accountability of supply chain as well. Another effective factor for agility of manufacture process was related to sensitivity to market and customer requirements which are in consistent with several researches that have demonstrated the ability of this issue to increase responsiveness, flexibility and agility of supply chain (sharifi and Zhang, 1999; Christopher,2000; Gunasekaran *et al*., 2008).

Considering it as a vital factor in pharmaceutical manufacturer, quality was recognized as a another fundamental factor in this study, and it also can be in closed connection with good manufacturing practice (GDP) which has been reinforced by regulatory body to guaranty the quality of drugs until they reach to end-users (Chowdary and George, 2012). Furthermore, according to national drug policy (NDP), quality are generally accepted as an essential factor besides efficacy and safety, almost in every country in the world, so that pharmaceutical manufacturers must take this issue in to account seriously along of drug supply chain (Friedli *et al*., 2010). According to the most of agility definitions, it can be seen that they have concentrated on flexibility directly or indirectly (Christopher, 2000). Studies (Sharifi and Zhang, 1999; Swafford *et al*., 2006; Swafford *et al*., 2008) have stated that flexibility can remarkably promote the responsiveness of supply chain. Process integration was considered as the eleventh effective index on agility in this study. Process integration means collaboration between buyers and suppliers, collaborative product development, public systems and the sharing of information (Christopher, 2000). Sharifi and Zhang (1999) stated that integration of processes along with sub-indices of coordinated management of inventory, cooperation in product design and simultaneous supply, can directly increase eligibility and flexibility of supply chain. Other factors including reduce manufacturing time, IT utilizing and collaborative planning besides aforementioned issues have some potential in order to shaping an agile manufacturing in pharmaceutical sector.

Implications:

During the recent decades, SCM has become a popular agenda for both the pharmaceutical industry and non- pharmaceutical industries. Globalization, outsourcing, single sourcing, just-in-time supply chain management, lean and agile supply chain have made pharmaceutical supply chain more sensitive to environment. To survive and thrive in the 21th century economy, pharmaceutical companies should learn how to encounter ongoing challenges in their environment. This forces pharmaceutical firms to select a new way of operating that gives them ability to be flexible and respond quickly to unpredictable changes. So, to succeed, pharmaceutical firms should be agile, in order to become resilient to unexpected disruptions in their supply chain. Finally, it should be said due to unbelievable relationships between response to consumer's requirements and firm's success (like profitability and corporate social responsibility) firms must extensively pay attention to their supply chain activities.

REFERENCE

Agarwal, A., R. Shankar and M.K. Tiwari, 2006 .Modeling the metrics of lean, agile and leagile supply chain: An ANP- based approach. European journal of Operational Research, 173: 211-225.

Agarwal, A., R. Shankar and M.K. Tiwari, 2007. Modeling agility of supply chain. Industrial Marketing Management, 36: 443-457.

Antonioa, K.W.L., C.M. Richard and E.T. Yama, 2007. The impacts of product modularity on competitive capabilities and performance: An empirical study. International Journal Production Economics, 105: 1-20.

Arif Khan, K., B. Bakkappa, A.M. Bhimaraya and B.S. Sahay, 2009 .Impact of agile supply chains' delivery practices on firms' performance: cluster analysis and validation. Supply Chain Management: An International Journal, 14(1): 41-48.

Baramichai, M., E.W. Zimmers Jr and C.A. Marangos, 2007. Agile supply chain transformation matrix: an integrated tool for creating an agile enterprise. Supply Chain Management: An International Journal, 12(5): 334-348.

Braunscheidel, J.M., 2005. Antecedents of supply chain agility: an empirical investigation, Ph.D. thesis, The State University of New York at Buffalo, Buffalo, NY.

Breu, K., C.J. Hemingway, M. Strathern and D. Bridger, 2001. Workforce Agility: the new employee strategy for the knowledge economy, Journal of Information Technology, 17(1): 21-31.

Chandrasekaran, N. and S. Mohan Kumar, 2003. Pharmaceutical Supply Chain Challenges and Best Practices, (working paper, CII – Institute of Logistics, 20 December. 20).

Chen, C.T., C.T. Lin and S.F. Huang, 2006. A fuzzy approach for supplier evaluation and selection in supply chain management. International Journal of Production Economics, 102: 289-301.

Chowdary, B.V. and D. George, 2011. Improvement of manufacturing operations at a pharmaceutical company: A lean manufacturing approach. Journal of Manufacturing Technology Management, 23(1): 56-75.

Christopher, M. and U. Juttner, 2000. Developing strategic partnerships in the supply chain: a practitioner perspective. European Journal of Purchasing and Supply Management, 6(2): 117-27.

Christopher, M., 2000. The agile supply chain: competing in volatile markets. Industrial Marketing Management, 29(1): 37-44.

Cooper, R. and R. Slag Mulder, 1998. Cost management beyond the boundaries of the firm. Management Accounting, 18-20.

Ertugrul, I. and N. KarakaşoGlu, 2008. Comparison of fuzzy AHP and fuzzy TOPSIS methods for facility location selection. The International Journal of Advanced Manufacturing Technology, 39: 783-795.

Ferguson, B.R., 2000. Implementing supply chain management. Production and Inventory Management Journal, 2(2): 64-70.

Friedli, T., M. Goetzfried and P. Basu, 2010. Analysis of the implementation of total productive maintenance, total quality management, and Just-In-Time in pharmaceutical manufacturing. Journal of Pharmaceutical Innovation, 5: 181-192.

Garattini, L., D. Cornago and P. De Compadri, 2007. Pricing and Reimbursement Ofin-patent drugs in seven European countries: a comparative analysis. Health Policy, 82: 330-339.

Giachetti, R.E., L.D. Martinez, O.A. Saenz and C.S. Chen, 2003. Analysis of the structural measures of flexibility and agility using a measurement theoretical framework. International Journal of Production Economics, 86(1): 47-62.

Gosling, J., L. Purvis and M.M. Naim, 2010. Supply chain flexibility as a determinant of supplier selection. International Journal of Production Economics, 128(1): 11-21.

Greene, A. and D. O'Rourke, 2006. Lean manufacturing practice in a cGMP environment. Pharmaceutical Technology Europe, 18(10): 33-40.

Gunasekaran, A. and Y. Yusuf, 2002. Agile manufacturing: a taxonomy of strategic and technological imperatives. International Journal of Production Research, 40(6): 1357-85.

Gunasekaran, A., 1999. Agile manufacturing: A framework for research and development. International Journal of Production Economics, 62: 87-105.

Gunasekaran, A., K. Lai and T.C.E. Cheng, 2008. Responsive supply chain: A competitive strategy in a networked company. Omega, 36(4): 549.

Hair, J.F.J., R.E. Anderson, R.L. Tatham and W.C. Black, 1998. Multivariate data analysis. (Upper Saddle River, NJ: Prentice-Hall).

Hakonsen, H., A.M. Horn And E.L. Toverud, 2009. Price control as a strategy for pharmaceutical cost containment—what has been achieved in Norway in the period 1994–2004?. Health Policy, 90: 277-285.

Handfield, R.B. and R.T. Pannesi, 1992. An empirical study of delivery speed and reliability. International Journal of Operations and Production Management, 12(2): 58-72.

Ismail, H., I. Raid, J. Mooney, J. Poolton and I. Arokiam, 2007. How small and medium enterprises effectively participate in the mass customization game. IEEE transactions on engineering management, 54(1): 86-97.

Jackson, M. and C. Johansson, 2003. An agility analysis from a production system perspective. Integrated Manufacturing Systems, 14(6): 482-488.

Kaplan, R.M., 1987. Basic Statistics for the Behavioral Sciences. Allyn and Bacon, Boston, MA.

Karimi, A.R., N.S. Mehrdadi, J. Hashemian, Gh.R. Nabi-Bidhendi and R. Tavakkoli-Moghaddam, 2011. Using of the fuzzy TOPSIS and fuzzy AHP method for wastewater treatment process selection. International Journal of academic research, 3(1): 737-745.

Khan, K.A., S.K. Srivastava and B. Bakkappa, 2006. Supply chain agility and organizational performance: a study of selected manufacturing companies in India. (paper presented at the 10th International Conference, Production and Operations Management Society and Indian Institute of Management Ahmedabad, Ahmedabad, December).

Lin, T.C., H. Chue and P.Y. Chu, 2006. Agility index in the supply chain efficiency. International Journal of Production Echonomics, 100(2): 285-299.

Mehralian, G., A. Rajabzadeh, M. Morakabati and H. Vatanpour, 2012. Developing a suitable model for supplier selection based on supply chain risks: An empirical study from Iranian pharmaceutical companies. Iranian journal of pharmaceutical Research, 11(1): 209-219.

Naylor, J.B., M.M. Naim and D. Berry, 1999. Leagility: integrating the lean and agile manufacturing. International Journal of Production Economics, 62: 107-118.

Rossetti, C.L., R. Handfield and K.J. Dooley, 2011. Forces, trends, and decisions in pharmaceutical supply chain management. International Journal of Physical Distribution and Logistics Management, 41(6): 601-622.

Saraph, J.V., P.G. Benson and R.G. Schroeder, 1989. An instrument for measuring the critical factors of quality management. Decision Sciences, 4: 810-829.

Schneller, E.S. and L.R. Smeltzer, 2006. Strategic management of the health care supply chain. (Jossey-Bass, San Francisco, CA).

Shah, N., 2004. Pharmaceutical supply chains: key issues and strategies for optimization. Computers and Chemical Engineering, 28: 929-941.

Shao, X. and J. Ji, 2006. Reconfiguration of pharmaceutical logistics operations in China: an empirical study. Transportation Journal, 45: 52-66.

Sharifi, H. and Z. Zhang, 1999. A methodology for achieving agility in a manufacturing organization:An introduction. International Journal of Production Economics, 62: 7-22.

Sharp, J.M., Z. Irani and S. Desai, 1999. Working towards agile manufacturing in the UK industry. International Journal of Production Economics, 62: 155-169.

Swafford, P., 2003. Theoretical development and empirical investigation of supply chain agility. Ph. D. thesis. The Georgia Institute of Technology, Georgia, USA.

Swafford, P.M., S. Ghosh and N.N. Murthy, 2006. A framework for assessing value chain agility. International Journal of Operations and Production Management, 26(2): 118-140.

Swafford, P.M., S. Ghosh and N.N. Murthy, 2008. Achieving supply chain agility through IT integration and flexibility. International Journal of Production economics, 116: 288-297.

Tseng, Y.H. and C.T. Lin, 2011. Enhancing enterprise agility by deploying agile drivers, capabilities and providers. Information Sciences, 181: 3693-3708.

White, A.D. and M.B. Mohdzain, 2009. An innovative model of supply Chain management: a single case study in the electronic sector. International Journal of Information Technology and Management, 8(1): 69-84.

WHO,. Who expert committee on specifications for pharmaceutical preparations. Technical Report Series, WHO Technical Report Series 957, WHO, Geneva, available at: www.who.int/medicines/publications/TRS957_2010.pdf

Yang, T. and C.C. Hung, 2007. Multiple-attribute decision making methods for plant layout design problem. Robotics and Computer-Integrated Manufacturing, 23: 126-137.

Yeung, A.C.L., 2008. Strategic supply management, quality initiatives, and organizational performance. Journal of Operations Management, 26: 490-502.

Yu, X., C. Li, Y. Shi and M. Yu, 2010. Pharmaceutical supply chain in China: Current issues and implications for health system reform. Health Policy, 97: 8-15.

Yusuf, Y.Y. and E.O. Adeleye, 2002. A comparative study of lean and agile manufacturing with a related survey of current practices in the UK. International Journal of Production Research, 40(17): 4545-4562.