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EVALUATION OF THE EFFECTS OF INDUSTRY 4.0 ON ORGANIZATIONAL AGILITY WITH FUCOM: IMPLEMENTATION IN THE TEXTILE INDUSTRY

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Abstract

The aim of this study is to determine the effect levels on organizational agility abilities as a result of the implementation of Industry 4.0. Organizational agility was examined in terms of four basic criteria: responsiveness, flexibility, quickness and competence in this study. In addition, twelve sub-criteria have been defined in relation to the basic criteria. In order to determine the sub-criteria, the related studies were first examined conceptually and then expert opinions were used. These experts consist of five engineers working in textile companies for the ready-made garment group. In the study, FUCOM was used to determine the effect levels of the criteria. In the results of study, it is thought that Industry 4.0 has the most impact on quickness, followed competence, flexibility and responsiveness among the organizational agility. When all the criteria are evaluated, the three agility capabilities that the Industry 4.0 process has the most impact on businesses are identified as “short operation time”, “operational efficiency”, “product quality”.

Keywords: *Agility, Organizational Agility, Industry 4.0, FUCOM, MCDM*
JEL Classification: *D23, D81, M11*

ENDÜSTRİ 4.0’IN ÖRGÜTSEL ÇEVİKLİK ÜZERİNE ETKİLERİNİN FUCOM İLE DEĞERLENDİRİLMESİ: TEKSTİL ENDÜSTRİSİNDE UYGULAMA

Öz

Bu çalışmanın amacı, tekstil sektöründeki işletmelerde Endüstri 4.0’ın uygulanmasının çeviklik yeteneklerine olan etki düzeylerini belirlemektir. Çalışmada örgütsel çeviklik; cevap verilebilirlik, esneklik, çabukluk ve yetkinlik olmak üzere dört temel kriter açısından incelenmiştir. Ayrıca temel kriterlerle ilişkili olacak şekilde çalışmada on iki alt kriter tanımlanmıştır. Alt kriterlerin belirlenmesi için ilgili çalışmalar önce kavramsal olarak incelenmiş ardından sektördeki uzman görüşlerinden faydalanılmıştır. Bu uzmanlar hazır giyim grubuna yönelik tekstil firmalarında çalışan beş adet mühendisten oluşmaktadır. Çalışmada hem ana hem de alt kriterlerin etki düzeylerini belirleyebilmek amacıyla FUCOM kullanılmıştır. Çalışma sonucunda; Endüstri 4.0’ın işletmelerin örgütsel çeviklik yeteneklerinden en çok çabukluk, ardından yetkinlik, esneklik ve cevap verilebilirlik üzerinde etki ettiği düşünülmektedir. Çalışmadaki tüm alt kriterler değerlendirildiğinde; Endüstri 4.0 sürecinin tekstil sektöründeki işletmeler üzerinde en çok etki ettiği üç çeviklik yeteneği “kısa operasyon zamanı”, “operasyonel verimlilik” ve “ürün kalitesi” olarak belirlenmiştir.

Anahtar Kelimeler: *Çeviklik, Örgütsel Çeviklik, Endüstri 4.0, FUCOM, ÇKKV*
JEL Sınıflandırması: *D23, D81, M11*

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1. Introduction

The rapid development of digital technologies is changing traditional management practices and fundamentally causing great differences in many production activities. One of the most important developments in digitalization in recent years has undoubtedly been experienced with the Industry 4.0 process. Industry 4.0 was formed as a strategic initiative based on the digitalization of production systems (Rojko, 2017). Industry 4.0 technologies have the power to change the competitive environment of companies in the global market by creating differences in economic development, industrial growth and workforce needs (Rüßmann et al., 2015). With the implementation of new technologies and tools, 'competition' has become more difficult and important than ever in the new industrial era. With Industry 4.0, businesses need organizational solutions to keep up with changing business conditions and to catch new opportunities. Industry 4.0 offers opportunities that enable businesses to work integratedly with units inside and outside the company, focus on communication, rationalize decision-making, and act by anticipating possible situations with new technologies.

The implementation of Industry 4.0 technologies has created significant opportunities for businesses by affecting the performance of production systems in many respects. One of the key elements of Industry 4.0 has been the firm's development of organizational agility, which is the ability to detect and respond to changes in the business environment. Numerous studies in various disciplines emphasize organizational agility for successful business (Cho et al., 2022). Studies indicate that organizational agility, identifying and responding to opportunities and threats in uncertain and complex business environments, is the unique ability that determines the success of businesses (Liu & Yang, 2020). Thus, with the constantly developing and changing business conditions, it is seen as a critical role for businesses to be 'agile'. The importance of advanced information and communication technologies with Industry 4.0 has made organizational agility researches a necessity. Industry 4.0 systems expect businesses to respond to complex and continuous changes. This situation necessitated businesses to have “organizational agility” effectively as an important driving force for performance improvement.

The aim of this study, evaluation of the effects of the implementation of Industry 4.0 technologies on the organizational agility capabilities of businesses in the textile sector. In the current literature, it is seen that the effects of the agility capability of the businesses on the Industry 4.0 process are discussed. However, the effects of Industry 4.0 on the agility ability of enterprises have been studied several times as far as is known. For this reason, it is thought that the findings of the study will be important for the current literature and practitioners in the sector. The study was carried out on five cases of similar scale from the ready-made garment industry, and it was decided to use FUCOM for weighting the criteria. The selected businesses are production facilities where Industry 4.0 is newly applied, and it is stated that they are in a process of adaptation.

In the study, firstly, a framework for the concepts of agility and organizational agility is drawn, then the research process and the method used are explained step by step. In the fourth section, the practice and findings on the ready-made garment sector are given. Finally, the conclusion and discussion section took place as the part where the results of the study were shared and suggestions were made in general.

2. Literature Review

Agility is the capacity of businesses to adapt to changing situations. Many frameworks and models analyze agility in a different context, which causes definitional complexity by differing in content and structure of the concept (Žitkienė & Deksnys, 2018). The first definitions of the concept were made in the early 90s and it was seen as a savior solution for businesses to survive in changing environmental conditions (Nafei, 2016). Agility, which is necessary for the success of businesses, has been expressed as the ability to evaluate market opportunities that arise quickly

and unexpectedly, and to rearrange resources quickly and flexibly according to customer needs (Liu & Yang, 2020). The most striking point in general definitions is that businesses are defined as the ability to take action easily and quickly. It is very important for businesses to respond to changing market situations, the behavior of competitors, and the differences in customer expectations and take action. In today's business world, the change power and change capacity of businesses should be seen as a key factor for their sustainability.

Organizational agility has been a concept expressed by many researchers. In general, the concept is examined from the perspective of how businesses interact with changing environmental conditions (Holsapple & Li, 2008; Lu & Ramamurthy, 2011; Nijssen & Paauwe, 2012). Organizational agility is an organizational structure based on understanding the markets that will create competitive advantage, accessing the necessary information for these markets, and trying to gain competitive advantage in products, services and market segmentation (Sambamurthy et al., 2003). Teece et al. (2016) defined the concept as "the capacity of a business to efficiently and effectively direct its resources to high-yield activities that create and maintain value as required by internal and external conditions". Organizational agility is one of the strategies that increase the competitiveness of businesses and enable them to operate for a longer period of time. For this reason, organizational agility can most easily be defined as the ability of businesses to recognize opportunities and to respond quickly to unexpected environmental and technological developments.

Different models and scales of organizational agility have been developed in the literature. In the study of Sharifi & Zhang (1999), which are accepted as the basic dimensions of organizational agility, the dimensions were examined in four categories: responsiveness, flexibility, quickness and competency.

a) Responsiveness: Responsiveness is about the ability of businesses to recognize environmental changes and incorporate new situations into their systems. More clearly, the concept is expressed as the ability to respond quickly and proactively to changes caused by the external environment (Zhang & Sharifi, 2000). In the process of adapting to Industry 4.0, it is related to the fact that businesses can respond to this change by following the developments in the technological field. Responsiveness requires businesses to act reactively in some cases and proactively in others. Sherehiy et al. (2007) studied responsiveness in three sub-dimensions as detecting and predicting change, instant reaction and gaining from change.

b) Flexibility: Flexibility is the capacity of a business to adjust its internal structures and processes in response to changes in the environment (Reed & Blunsdon, 1998). Organizational agility is also expressed as the ability to use different processes and alternatives that lead managers to reach the goal (Shahaei, 2008). Sherehiy et al. (2007) studied flexibility in four sub-dimensions: flexibility in product volume, flexibility in product model/configuration, workforce flexibility, flexibility in organization and organizational matters. Organizational flexibility includes making production systems flexible such as the use of new technologies, the development of information technologies, and the more effective use of computers.

c) Quickness: Quickness is related to the process of implementing the decision by acting quickly against changes (Jain et al., 2008). With the implementation of Industry 4.0, it has been seen that many businesses are rapidly restructuring in terms of organizational and technical aspects. In other words, businesses aimed to respond to customer needs by acting 'fast' without wasting time, not falling behind their competitors. Acting quickly is therefore an important component of organizational agility. Sherehiy et al. (2007) studied quickness in three sub-dimensions: rapid time to market for new products, improving the speed of delivery of products and services, timing and fast operation time.

d) Competency: Competency is the ability of businesses to achieve their goals effectively and efficiently (Sharifi & Zhang, 1999). The concept is also the ability of a business to achieve efficiency

as well as reach its goals (Biçer, 2021). Sherehiy et al. (2007) studied competency in eleven sub-dimensions: strategic vision, appropriate technology, sufficient technological capability, product/service quality, cost effectiveness, high rate of new product introduction, management change, qualified workforce, operational efficiency, internal and external cooperation, and integration.

There are important situations that businesses can follow in order to improve themselves and respond to changes caused by environmental discontinuities characterized by uncertainty and instability (Rigby et al., 2020). The issue of adaptation to technology, which is included in the definitions of organizational agility, has attracted more attention in recent years, especially with revolutionary innovations such as Industry 4.0. Adapting to information technologies makes significant contributions to the agility level and performance development of enterprises. (Khoshlahn & Ardabili, 2016; Ravichandran, 2017).

Along with Industry 4.0, the level of adaptation of businesses to radical changes in technological production systems is seen as one of the critical success factors (Cevik Aka, 2022). In addition, the effects of businesses on organizational agility capabilities in this process should be seen as an important actor. Because with Industry 4.0 technologies, the effects on organizational agility should be taken into account in order for businesses to realize the opportunities and risks that will be affected in many ways such as time, cost, competitiveness, and market share.

Research on the relationship between agility and Industry 4.0 has started slowly in the literature (Akkaya, 2019). In some studies, it has been argued that organizational agility is a result of the implementation of Industry 4.0 technologies (Rane & Narvel, 2019). Agility and the implementation of technologies are carried out together for the successful integration of new industrial era implementations in businesses (Tortorella et al., 2020). Organizational agility is considered as a critical factor that plays a role in the process of adapting to the new technologies developed in the Industry 4.0 process and accordingly to environmental changes. Although agility seems to be an indispensable condition in the success of the process, agility capabilities are also highly affected by the technological developments applied in the new industrialization period. Especially smart production, big data, internet of things, robotic technologies, cyber-physical systems and cloud computing technologies are seen as important technologies that strengthen agility capabilities. Businesses are increasingly seeking the adoption of Industry 4.0 technologies with the expectation that they can improve agility (Mrugalska & Ahmed, 2021).

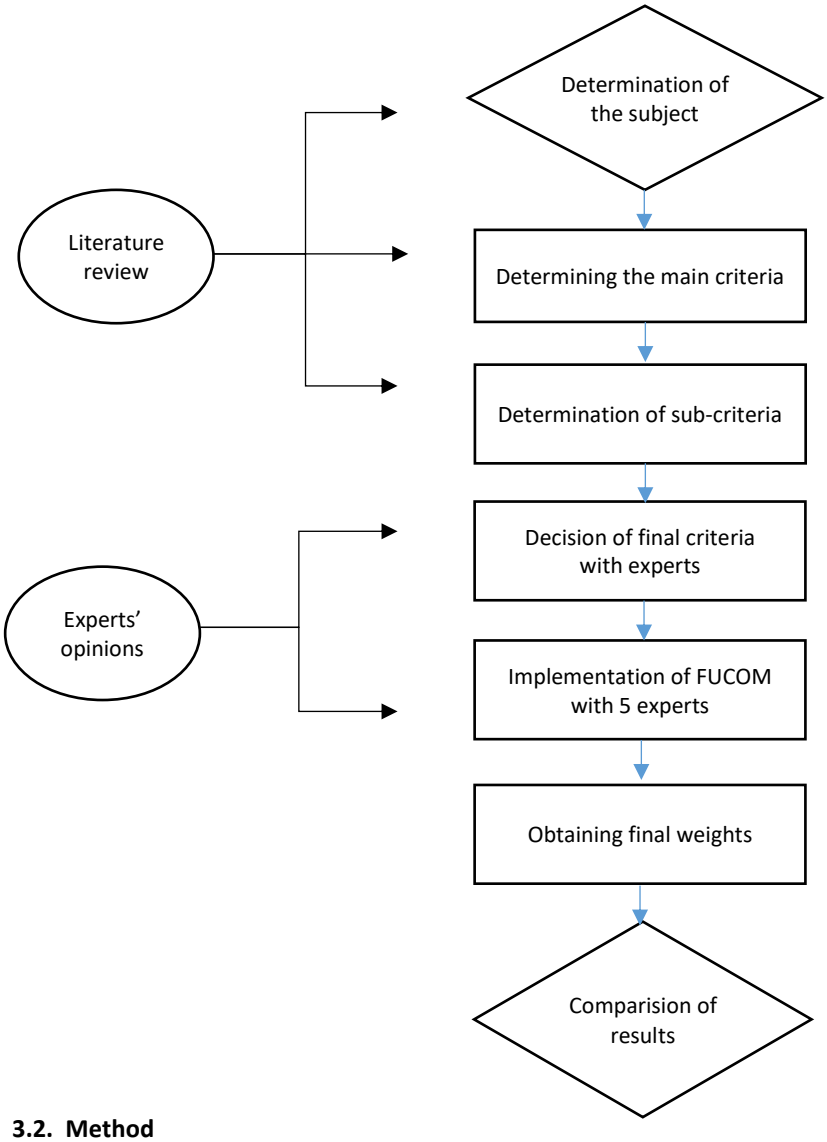
In recent studies, it has been shown that businesses that adopt Industry 4.0 technologies can significantly increase their agility capabilities by using different technologies (Akkaya, 2019; Mrugalska & Ahmed, 2021). However, only a few documents have been found in the literature. For this reason, it can be stated that the research area is quite new. From this point of view, there is a great need for studies examining the effects of industry 4.0 on organizational agility. At the same time, it will be important to carry out applications in different sectors with the fact that applications in various sectors will create different effects. In this study, it is important to examine the effects of the new industrial period on organizational agility in the textile sector in a way that will contribute to the literature. It is also the first application of the relevant literature in the textile sector as far as is known.

3. Methodology

3.1. Research Design

The study started with the determination of the subject as a result of the literature review. The process was carried out in 6 steps in total. Relevant steps are outlined in Figure 1.

Figure 1: **Research Design Steps**



3.2. Method

FUCOM, one of the subjective criteria weighting methods, was used in the study. As a fairly new method, FUCOM was introduced in 2018 by Pamucar et al. Developed by The FUCOM algorithm is based on pairwise comparisons of criteria, where only n−1 comparisons are required in the model, and the model is validated by determining the deviations from the full consistency of the comparisons (Pamucar et al., 2018). Since the weights of the criteria in FUCOM are determined according to the information obtained from the experts, the experts directly affect the result.

The method has been used by different researchers in recent years. Demir and Bircan (2020) used FUCOM to weight the criteria affecting the selection of private school, Sofuoğlu (2020) used to weight the manufacturing method selection criteria, Dalić et al. (2020) used to weight the distribution channel selection criteria, Stević and Brković (2020) used to weight the human resources evaluation criteria and Badi and Kridish (2020) used to weight the selection criteria of the appropriate site for the waste dump. Ayçin and Aşan (2021) used the method to weight the criteria in the selection of business intelligence applications, Ecer (2021) used to weight sustainable

supplier selection criteria, Pamucar et al. (2021) used to weight the critical criteria for sustainable transportation and Ulutas and Karakus (2021) used to weight the textile production facility location selection criteria. On the other hand, Akar (2022) used to the method to evaluate barriers to sustainable manufacturing, Popović et al. (2022) used to evaluate barcode technology application conditions, Isik (2022) used to evaluate performance criteria, Cosansu and Okursoy (2022) used to evaluate financial performance criteria and Demir et al. (2022) used to evaluate sustainable urban mobility policies.

FUCOM was preferred in the study because it needs less comparison, is not complicated, and deviations from consistency can be calculated. Steps of the method: (Pamucar et al., 2018)

Step 1: The criteria are ranked from the most important criteria to the least important criteria (Equation 1).

$$C_{j(1)} > C_{j(2)} > \ldots > C_{j(k)} \quad (1)$$

Step 2: The comparative priorities of the criteria listed in Step 1 are determined by the decision makers as $\phi_{k/(k+1)}$. $\phi_{k/(k+1)}$ shows the advantage of the $C_{j(k)}$ criterion over the $C_{j(k+1)}$ criterion. After each pairwise comparison, the comparative priority vector is obtained (Equation (2)).

$$\phi = (\phi_{1/2}, \phi_{2/3}, \phi_{3/4}, \ldots, \phi_{k/(k+1)}) \quad (2)$$

Step 3: The weight coefficients of the criteria $(w_1, w_2, w_3 \ldots, w_n)^T$ are calculated. In order to accept the final values, it is tested whether the following 2 conditions are met.

Condition 1: The ratio of the weighting coefficients must be equal to the comparative priority of the criteria defined in Step 2, $\phi_{k/(k+1)}$.

$$\frac{w_k}{w_{(k+1)}} = \varphi_{k/(k+1)} \quad (3)$$

Condition 2: The final values of the weight coefficients must satisfy the mathematical transitivity condition: $\phi_{k/(k+1)} \otimes \phi_{(k+1)/(k+2)} = \phi_{(k)/(k+2)}$. This condition also provided $\frac{w_k}{w_{(k+1)}} \otimes \frac{w_{(k+1)}}{w_{(k+2)}} = \frac{w_k}{w_{(k+2)}}$ equality since $\phi_{k/(k+1)} = \frac{w_k}{w_{(k+1)}}$ and $\phi_{(k+1)/(k+2)} = \frac{w_{(k+1)}}{w_{(k+2)}}$ in Equation (3). As a result, Equation (4) is obtained.

$$\frac{w_k}{w_{(k+2)}} = \phi_{k/(k+1)} \otimes \phi_{(k+1)/(k+2)} \quad (4)$$

Full consistency, minimum DFC (χ), occurs only when transitivity is fully adhered to. For this, $\phi_{k/(k+1)} = \frac{w_k}{w_{(k+1)}}$ and $\frac{w_k}{w_{(k+2)}} = \phi_{k/(k+1)} \otimes \phi_{(k+1)/(k+2)}$ conditions must be met. Thus, the condition of maximum consistency is ensured; the DFC value for the values of the weighting coefficients is $\chi = 0$. In order to satisfy the conditions, the attained $(w_1, w_2, \ldots, w_n)^T$ values for the weight coefficients should be $\left|\frac{w_k}{w_{(k+1)}} - \varphi_{k/(k+1)}\right| \leq \chi$ and $\left|\frac{w_k}{w_{(k+2)}} - \varphi_{k/(k+1)} \otimes \varphi_{(k+1)/(k+2)}\right| \leq \chi$ by minimizing the χ value. Thus, the final model is:

$$\min \chi$$

s.t.

$$\left|\frac{w_{j(k)}}{w_{j(k+1)}} - \varphi_{k/k+1}\right| \leq \chi, \forall_j$$

$$\left|\frac{w_{j(k)}}{w_{j(k+2)}} - \varphi_{k/(k+1)} \otimes \varphi_{(k+1)/(k+2)}\right| \leq \chi, \forall_j, \quad (5)$$

$$\sum w_j = 1, \; j = 1,2..n$$

$$w_j \geq 0, \forall_j$$

By solving the model in Equation (5), the final weight values of each criterion $(w_1, w_2, \dots, w_n)^T$ are reached.

4. Implementation & Results

The application was carried out in the textile industry. The main reason for the study to take place in the textile sector is that it is the first application for the relevant literature as stated before. This gap in the literature affected the sector selection of the study. Ready-made garment textile enterprises in the Marmara Region were selected for the implementation. In order to reach the enterprises in the study, firstly, communication was established by e-mail, and then one-on-one interviews were conducted.

Each of the decision makers (experts) in the study consists of engineers who have been working full-time for 7 years or more in their sector. These engineers are the managers of their departments. The most important feature of the experts is that they take an active role in the studies carried out by their businesses for Industry 4.0. Although the study was implemented in a single sector, the decision makers were selected separately from five different ready-made garment businesses.

In the research, 4 main criteria in the agility scale developed by Sharifi & Zhang (1999), 11 sub-criteria in the model of Sherehiy et al. (2007) and a new sub-criteria were proposed and a total of 12 sub-criteria were used. The main criteria are; responsiveness, flexibility, quickness and competency. For the sub-criteria, the opinions of the experts in the applied sectors were evaluated. For the main criterion of responsiveness, Sherehiy et al. (2007) has two sub-dimensions: detecting and predicting change and reacting immediately by incorporating changes into the system. In addition, the ability to meet customer needs, which is associated with responsiveness by many researchers (Kritchanchai & McCarthy, 1999; Liu & Yang, 2020), has been included in the study due to the changing demands and demands of today's consumers. Flexibility criterion; flexibility in product volume, flexibility in model design, and flexibility in organization and organizational issues. Quickness criterion; It has been examined in three sub-dimensions as short delivery time, short operation time and short presentation time. Finally, the competency criteria; product/service quality, operational efficiency and cost effectiveness were examined in three sub-dimensions. In this direction, 4 main and 12 sub-criteria have been defined in total.

The notations of the main criteria in the study are shown as follows:

C_1: Responsiveness; C_2: Flexibility; C_3: Quickness; C_4: Competency

The notations of the sub-criteria in the study are shown as follows:

C_{11}: detecting and predicting change

C_{12}: instant reaction

C_{13}: meeting changing customer demands

C_{21}: flexibility in product volume

C_{22}: flexibility in organizational decision

C_{23}: flexibility in model product configuration

C_{31}: short delivery time

C_{32}: short operation time

C_{33}: short presentation time

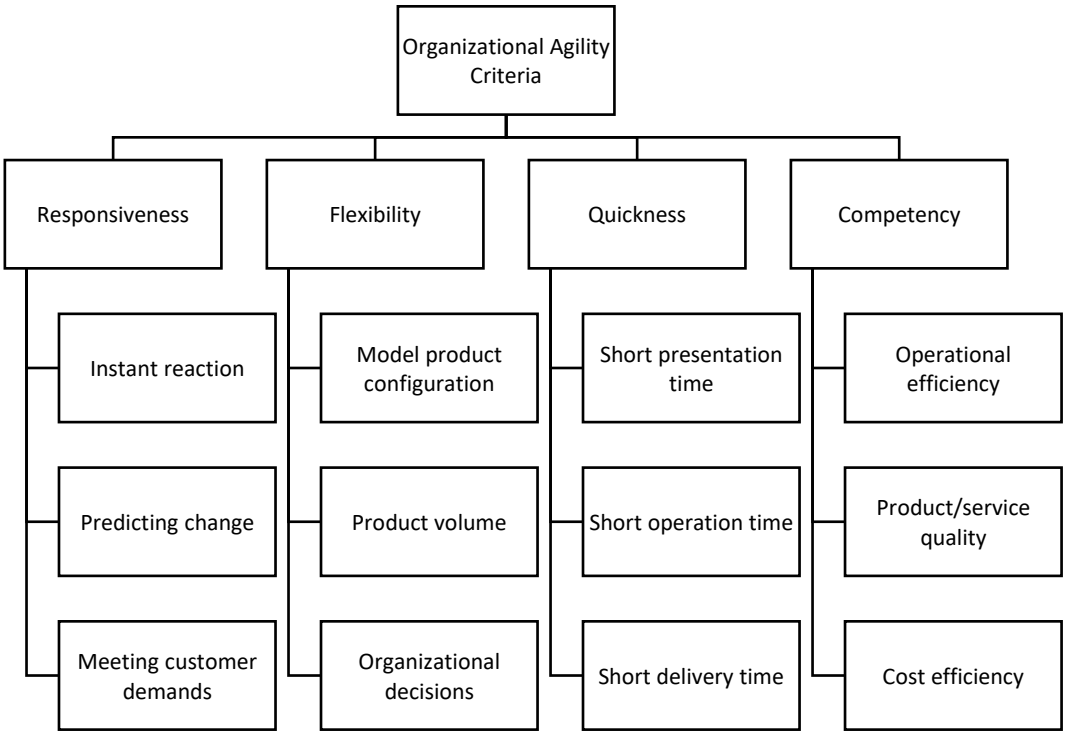
C_{41}: product/service quality

C_{42}: operational efficiency

C_{43}: cost effciency

Figure 2 shows all the criteria included in the study. As shown in Figure 1, expert opinions were used to determine the sub-criteria. Then all the criteria created were weighted by 5 experts in each sector according to FUCOM principles.

Figure 2: **Main Criteria and Sub-Criteria in the Study**



This implementation was carried out with the opinions of five different experts working in different ready-made garment production facilities. The following steps were followed for this process:

Step 1: As a result of the subjective evaluations of the experts, the main criteria and sub-criteria were ranked according to their importance (Table 1).

Table 1: **Ranking of All Criteria according to Priority by Experts**

Experts	Main Criteria	Sub-Criteria (1)	Sub-Criteria (2)	Sub-Criteria (3)	Sub-Criteria (4)
E1	$C_4 > C_3 > C_1 > C_2$	$C_{13}>C_{12}>C_{11}$	$C_{22}>C_{21}>C_{23}$	$C_{32}>C_{33}>C_{31}$	$C_{42}>C_{41}>C_{43}$
E2	$C_3 > C_2 > C_4 > C_1$	$C_{13}>C_{12}>C_{11}$	$C_{22}>C_{21}>C_{23}$	$C_{32}>C_{31}>C_{33}$	$C_{42}>C_{43}>C_{41}$
E3	$C_4 > C_3 > C_2 > C_1$	$C_{13}>C_{11}>C_{12}$	$C_{21}>C_{23}>C_{22}$	$C_{33}>C_{32}>C_{31}$	$C_{41}>C_{42}>C_{43}$
E4	$C_3 > C_4 > C_1 > C_2$	$C_{13}>C_{12}>C_{11}$	$C_{21}>C_{22}>C_{23}$	$C_{31}>C_{32}>C_{33}$	$C_{41}>C_{42}>C_{43}$
E5	$C_3 > C_4 > C_2 > C_1$	$C_{13}>C_{11}>C_{12}$	$C_{22}>C_{21}>C_{23}$	$C_{32}>C_{33}>C_{31}$	$C_{42}>C_{41}>C_{43}$

Step 2: The priority of the best criterion over other criteria was determined by the experts according to the numbers between 1 and 9 (Table 2).

Table 2: **Comparison Scale for Criteria**

Scale	**1**	**3**	**5**	**7**	**9**	**2,4,6,8**
Value Definition	Equal	Medium	Strong	Very Strong	Absolute Superior	Intermediate Values

In this step, according to Table 2, firstly the main criteria and then the sub-criteria are compared in pairs.

Table 3: **Numerical Evaluation of Main Criteria by Experts**

Numerical Evaluation of Main Criteria				
Ranking (E1)	**C_4**	**C_3**	**C_1**	**C_2**
Scoring by E1	**1**	**3**	**4**	**5**
Ranking (E2)	C_3	C_2	C_4	C_1
Scoring by E2	**1**	**2**	**3**	**5**
Ranking (E3)	C_4	C_3	C_2	C_1
Scoring by E3	**1**	**2**	**3**	**4**
Ranking (E4)	C_3	C_4	C_1	C_2
Scoring by E4	**1**	**3**	**4**	**5**
Ranking (E5)	C_3	C_4	C_2	C_1
Scoring by E5	**1**	**2**	**4**	**5**

For E1: $\phi_{4/3} = 3$; $\phi_{3/1} = 4/3 = 1.33$; $\phi_{1/2} = 5/4 = 1.25$

For E2: $\phi_{3/2} = 2$; $\phi_{2/4} = 3/2 = 1.5$; $\phi_{4/1} = 5/3 = 1.67$

For E3: $\phi_{4/3} = 2$; $\phi_{3/2} = 3/2 = 1.5$; $\phi_{2/1} = 4/3 = 1.33$

For E4: $\phi_{3/4} = 3$; $\phi_{4/1} = 4/3 = 1.33$; $\phi_{1/2} = 5/4 = 1.25$

For E5: $\phi_{3/4} = 2$; $\phi_{4/2} = 2=$; $\phi_{2/1} = 5/4 = 1.25$

Table 4: **Numerical Evaluation of Sub-Criteria by Experts**

Ranking (E1)	**Scoring (E1)**	**Ranking (E2)**	**Scoring (E2)**	**Ranking (E3)**	**Scoring (E3)**	**Ranking (E4)**	**Scoring (E4)**	**Ranking (E5)**	**Scoring (E5)**
C_{13}	1	C_{13}	1	C_{13}	1	C_{13}	1	C_{13}	1
C_{12}	3	C_{12}	3	C_{11}	3	C_{12}	5	C_{11}	5
C_{11}	5	C_{11}	4	C_{12}	5	C_{11}	6	C_{12}	7
C_{22}	1	C_{22}	1	C_{22}	1	C_{21}	1	C_{22}	1
C_{21}	3	C_{21}	3	C_{23}	2	C_{22}	2	C_{21}	3
C_{23}	7	C_{23}	5	C_{21}	3	C_{23}	3	C_{23}	5
C_{32}	1	C_{32}	1	C_{33}	1	C_{31}	1	C_{32}	1
C_{33}	3	C_{31}	3	C_{32}	2	C_{32}	2	C_{33}	3
C_{31}	7	C_{33}	5	C_{31}	5	C_{33}	3	C_{31}	5
C_{42}	1	C_{42}	1	C_{41}	1	C_{41}	1	C_{42}	1
C_{41}	3	C_{43}	2	C_{42}	3	C_{42}	2	C_{41}	3
C_{43}	5	C_{41}	3	C_{43}	5	C_{43}	3	C_{43}	5

For each expert, the sub-criteria are compared in pairs and comparison priorities are obtained.

The comparative priorities obtained by Expert1 (E1) for the sub-criteria of responsiveness are as follows:

For E1: $\phi_{C13/12} = 3$, $\phi_{C12/11} = 1.67$; $\phi_{C22/21} = 3$, $\phi_{C21/23} = 2.33$; $\phi_{C32/33} = 3$, $\phi_{C33/31} = 2.33$; $\phi_{C42/41} = 3$, $\phi_{C41/43} = 1.67$

For E2: $\phi_{C13/12} = 3$, $\phi_{C12/11} = 1.33$; $\phi_{C22/21} = 3$, $\phi_{C21/23} = 1.67$; $\phi_{C32/31} = 3$, $\phi_{C31/33} = 1.67$; $\phi_{C42/43} = 2$, $\phi_{C43/41} = 1.5$

For E3: $\phi_{C13/11} = 3$, $\phi_{C11/12} = 1.67$; $\phi_{C22/23} = 2$, $\phi_{C23/21} = 1.5$; $\phi_{C33/32} = 2$, $\phi_{C32/31} = 2.5$; $\phi_{C41/42} = 3$, $\phi_{C42/43} = 1.67$

For E4: $\phi_{C13/12} = 5$, $\phi_{C12/11} = 1.20$; $\phi_{C21/22} = 2$, $\phi_{C22/23} = 1.5$; $\phi_{C31/32} = 2$, $\phi_{C32/33} = 1.5$; $\phi_{C41/42} = 2$, $\phi_{C42/43} = 1.5$

For E5: $\phi_{C13/11} = 5$, $\phi_{C11/12} = 1.20$; $\phi_{C22/21} = 3$, $\phi_{C21/23} = 1.67$; $\phi_{C32/33} = 3$, $\phi_{C33/31} = 1.67$; $\phi_{C42/41} = 3$, $\phi_{C41/43} = 1.67$

Step 3: The weight coefficients of the criteria were calculated. However, it was first tested that the conditions were met.

Condition 1: Equation (3) has been applied and weight coefficient ratios have been reached. For example; For Expert1 (E1):

$\frac{w_4}{w_3} = \varphi_{4/3} = 3$; $\frac{w_3}{w_1} = \varphi_{3/1} = 1.33$; $\frac{w_1}{w_2} = \varphi_{1/2} = 1.25$

$\frac{w_{13}}{w_{12}} = \phi_{C13/12} = 3$, $\frac{w_{12}}{w_{11}} = \phi_{C12/11} = 1.67$

$\frac{w_{22}}{w_{21}} = \phi_{C22/21} = 3$, $\frac{w_{21}}{w_{23}} = \phi_{C21/23} = 2.33$

$\frac{w_{32}}{w_{33}} = \phi_{C32/33} = 3$, $\frac{w_{33}}{w_{31}} = \phi_{C33/31} = 2.33$

$\frac{w_{42}}{w_{41}} = \phi_{C42/41} = 3$, $\frac{w_{41}}{w_{43}} = \phi_{C41/43} = 1.67$

Condition 2: The final values of the weight coefficients, the condition of satisfying the mathematical transitivity condition were checked. Equation (3) is applied for each expert.

For example; The weights of the main criteria for Expert1 (E1) are:

$\frac{w_4}{w_1} = \phi_{4/3} \otimes \phi_{3/1} = 3 \otimes 1.33 = 3.99$ $\frac{w_3}{w_2} = \phi_{3/1} \otimes \phi_{1/2} = 1.33 \otimes 1.25 = 1.66$.

The weights of the sub-criteria for Expert1 (E1):

$\frac{w_{13}}{w_{11}} = \phi_{C13/12} \otimes \phi_{C12/11} = 3 \otimes 1.67 = 5.01$

$\frac{w_{22}}{w_{23}} = \phi_{C22/21} \otimes \phi_{C21/23} = 3 \otimes 2.33 = 6.99$

$\frac{w_{32}}{w_{31}} = \phi_{C32/33} \otimes \phi_{C33/31} = 3 \otimes 2.33 = 6.99$

$\frac{w_{42}}{w_{43}} = \phi_{C42/41} \otimes \phi_{C41/43} = 3 \otimes 1.67 = 5.01$.

The linear program model for the expert (1) was modeled according to Equation (5). A separate model was established for both the weight values of the main criteria and the weight values of the sub-criteria. The model established to reach the weight values of the main criteria according to the data obtained from the Expert1 (E1):

min χ

s.t.

$$\left|\frac{w_4}{w_3} - 3\right| \le \chi, \left|\frac{w_3}{w_1} - 1.33\right| \le \chi, \left|\frac{w_1}{w_2} - 1.25\right| \le \chi, \left|\frac{w_4}{w_1} - 3.99\right| \le \chi, \left|\frac{w_3}{w_2} - 1.66\right| \le \chi,$$

$\sum w_j = 1$, $j=1,2,3,4$; $w_j \ge 0$, $\forall_j$

As a result of solving the model with Excel solver, the weight values of the four main criteria, according to Expert1 (E1);

$w_4 = 0.561$; $w_3 = 0.187$; $w_1 = 0.140$; $w_2 = 0.112$

According to the data received from E1, the model established to reach the weight values of the responsiveness sub-criterion:

min χ

s.t.

$\left|\frac{w_{13}}{w_{12}} - 3\right| \leq \chi$, $\left|\frac{w_{12}}{w_{11}} - 1.67\right| \leq \chi$, $\left|\frac{w_{13}}{w_{11}} - 5.01\right| \leq \chi$,

$\sum w_{ij} = 1$, j=1,2,3 $w_{ij} \geq 0$, $\forall_j$

As a result of solving the model with Excel solver, the weight values of the four main criteria, according to E1;

$w_{13} = 0.632$; $w_{12} = 0.211$; $w_{11} = 0.158$

The models established for all experts were solved with the Excel solver and the weight values for the criteria are shown in Table 5 and Table 6.

Table 5: **Weights of Main Criteria**

	E1	E2	E3	E4	E5	Av.Weights	Ranking
C_1	0.140	0.098	0.120	0.136	0.103	0.119	4
C_2	0.112	0.246	0.160	0.136	0.128	0.156	3
C_3	0.187	0.492	0.240	0.545	0.513	0.395	1
C_4	0.561	0.164	0.480	0.182	0.256	0.329	2

Table 6: **Weights of Sub-Criteria**

	E1	E2	E3	E4	E5	Av.Weights
C_{11}	0.130	0.158	0.217	0.146	0.149	0.160
C_{12}	0.217	0.211	0.130	0.122	0.106	0.157
C_{13}	0.652	0.632	0.652	0.732	0.745	0.683
C_{21}	0.097	0.217	0.182	0.545	0.217	0.252
C_{22}	0.677	0.652	0.545	0.273	0.652	0.560
C_{23}	0.226	0.130	0.273	0.182	0.130	0.188
C_{31}	0.097	0.217	0.118	0.545	0.130	0.221
C_{32}	0.677	0.652	0.294	0.273	0.652	0.510
C_{33}	0.226	0.130	0.588	0.182	0.217	0.269
C_{41}	0.217	0.182	0.652	0.545	0.217	0.363
C_{42}	0.652	0.545	0.217	0.273	0.652	0.467
C_{43}	0.130	0.273	0.130	0.182	0.130	0.170

In Table 5 and Table 6, the weight values of the 4 main criteria and 12 sub-criteria in the study were calculated separately for each expert, and then the average weight values were obtained by taking the averages of the values.

Table 7: **Final Weights of Criteria**

Main Criteria	Sub Criteria	Weights	Ranking
C_1 (0.119)	**C_{11}** (0.160)	0.119 ⊗ 0.160= 0.0190	11
	C_{12} (0.157)	0.119 ⊗ 0.157=0.0186	12
	C_{13} (0.683)	0.119 ⊗ 0.683=0.0812	7
C_2 (0.156)	**C_{21}** (0.252)	0.156 ⊗ 0.252=0.0393	9
	C_{22} (0.560)	0.156 ⊗ 0.560=0.0873	5
	C_{23} (0.188)	0.156 ⊗ 0.188=0.0293	10
C_3 (0.395)	**C_{31}** (0.221)	0.395 ⊗ 0.221=0.0872	6
	C_{32} (0.510)	0.395 ⊗ 0.510=0.2014	1
	C_{33} (0.269)	0.395 ⊗ 0.269=0.1062	4
C_4 (0.329)	**C_{41}** (0.363)	0.329 ⊗ 0.363=0.1194	3
	C_{42} (0.467)	0.329 ⊗ 0.467=0.1536	2
	C_{43} (0.170)	0.329 ⊗ 0.170=0.0560	8

Table 7 shows the final result of the FUCOM implementation made with the experts in the businesses operating in the textile sector. It is seen that the highest effect on the agility capabilities of the businesses in the textile sector in the process of adaptation to Industry 4.0 is "quickness" with a weight ratio of 39.5%, competency with a ratio of 32.9%, and flexibility with a ratio of 15.6%.

According to the four main criteria of organizational agility, the rate of being affected by the responsiveness feature had the lowest weight with 11.9%.

Meeting changing customer demands has been determined as the sub criterion that the new industrial revolution has made the highest contribution to businesses in the textile sector, with a weight ratio of 8.12% within the main criterion of responsiveness. *Flexibility in organizational decision* is the sub criterion that the new industrial revolution has made the highest contribution to the businesses in the textile sector, with a weight ratio of 8.73% within the main criterion of flexibility. *Short operation time* is the sub criterion that the 4th industrial revolution made the highest contribution to businesses in the textile sector, with a weight ratio of 20.14% in the main criterion of quickness. *Operational efficiency* is the sub criterion that the 4th industrial revolution made the highest contribution to businesses in the textile sector, with a weight ratio of 15.36% in the main competency criterion.

5. Conclusion

In this study, it is aimed to determine the effects on organizational agility capabilities as a result of the adoption of Industry 4.0 technologies by the businesses in the textile sector. However, due to the fact that the concept of "organizational agility" has more than one dimension, it is necessary to examine the subject as a whole with its sub-dimensions. In the literature, no study has been encountered in which the effects of the implementation of Industry 4.0 on the agility ability of businesses are directly investigated. For this reason, it is thought that the study has a unique value and its findings will be useful for businesses in similar sectors. In this study, there were 4 main criteria as organizational agility, organizational responsiveness, flexibility, quickness and competency and 12 sub-criteria related to them. In order to reach the weight values of each of the criteria, five experts working in different ready-made garment sectors were interviewed and the final values were reached by applying FUCOM.

As a result of the study, Industry 4.0's organizational agility capabilities of the businesses are the most quickness, then it is thought to have an effect on competency, flexibility and responsiveness. In other words, in terms of businesses operating in the textile sector and in the process of adapting to Industry 4.0, "quickness" is the agility feature where the most opportunities are provided, while the "responsiveness" feature is seen as the situation that has less impact in businesses. When all criteria are evaluated, the agility skill that Industry 4.0 process is most effective on businesses in the textile sector is determined as "short operation time". In the literature, the opportunities that many technologies required by new industrialization will provide to production times are included (Adamik, 2019; Horváth & Szabó, 2019). As a result of Industry 4.0 technologies working with high efficiency and thus eliminating all kinds of unnecessary processes, it has become inevitable to create an advantage in operation time.

The criterion with the second highest weight value (effect ratio) is "operational efficiency". Achieving operational efficiency is one of the key success factors of businesses. The contributions of Industry 4.0 technologies to the productivity of businesses are among the findings of many studies in the literature (Thames & Schaefer, 2016; Horváth & Szabó, 2019; Zielinski, 2019; Pech & Vanecek, 2022). It is stated that the effects of new facility transformations on efficiency were found to be quite successful by the five experts involved in this practice. Thus, by looking at the increase in efficiency, it can be stated that the businesses are able to manage the new process correctly.

The third criterion with the highest weight value is “product quality”. The use of advanced technologies in Industry 4.0 in effective quality control processes has likely created a situation that improves product quality. At the same time, production errors caused by employees are greatly reduced due to the systems that minimize the use of labor in production. It is a topic in many studies that Industry 4.0 improves product quality in businesses (Atzori, 2015; Albers et al., 2016; Cevik, 2019; Masood & Sonntag, 2020). The total weight of the first three criteria with the highest weight in the study is almost equal to the total weight of all criteria. In this case, it is likely that the

production will continue by advanced machines that provide higher efficiency, with less errors and in a shorter time, instead of the labor force (Cevik Aka, 2022). In addition, it can be stated that the effects of short operation time, product quality and operational efficiency will be effective on the total cost in the long periods. However, according to the current study findings, it has been seen that the agility capabilities of the businesses in terms of cost efficiency have not yet developed much.

Another criterion with a high effect level is determined as "short presentation time". In the literature, it has been shown that businesses that have adopted Industry 4.0 offer products to the market in a shorter time (Haddud et al., 2018; Udriyah et al., 2019). Because the advantage that new technologies will provide to the operation time can probably directly affect the presentation time of the product. The fact that the products in the textile sector change periodically depending on external factors such as seasonality requires short presentation time to the market.

The criterion with the fifth highest degree of weight is “flexibility in organizational decisions”. It has become important for businesses to be able to continuously follow, control and operate all their processes, along with all kinds of data provided by new technologies. This has enabled businesses to be flexible and take action in their organizational decisions at both strategic and tactical levels. This finding has been supported by many researchers in the literature (Lasi et al., 2014; Masood & Sonntag, 2020; Pech & Vanecek, 2022; Fragapane et al., 2022; Ramadan et al., 2022).

Finally, the analysis of five expert opinions resulted in the lowest weight value as “instant reaction”. Despite the use of new technologies, the "quick reaction" of businesses to any change has been seen as the criterion that makes the last contribution to organizational agility ability. This result may have emerged specifically for the sector. Because the differences in the textile sector are more predictable than many sectors.

The findings of the study can be seen as a reference for businesses that are preparing or planning a new technological transformation, especially in the textile sector. As a result of the determination of the contributions of Industry 4.0 application to the agility capabilities of the enterprises, it is expected that the enterprises will be able to create more real targets. In this way, it is thought that enterprises can increase their adaptation to the new industrial process. At the same time, it is possible for businesses to act by evaluating the study findings according to their expectations from this process.

Finally, some difficulties were encountered in reaching the experts in this study. The main issue in experiencing this difficulty was that the number of enterprises implementing Industry 4.0 is quite low. Because this situation also affects the knowledge level of the experts who know the process. In addition, the sectoral restriction made the research process difficult at the point of accessing the data. Researchers interested in this field can apply similar work in different sectors. Especially the application can be repeated in the automotive industry. Due to the technological level of the sector, it may be possible to access data more easily. In addition, researchers can expand the scope of the study by adding different agility criteria.

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