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Research Article

A Workforce Efficiency Analysis of Four European Countries: A Micro Level Comparison

Dört Avrupa Ülkesi İşgücü Verimlilik Analizi: Mikro Düzey Bir Karşılaştırma

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Abstract

Workforce efficiency around the world varies based on broad conditions, such as sociocultural, economic, and educational factors. Consequently, comparing workforce efficiencies between countries is difficult. In this study, the workforce efficiency levels of four countries (Turkey, Czech Republic, France, and UK) are measured, compared, and ranked based on data from 2010 and 2019 via the Analytical Hierarchy Process (AHP) and Organization, Rangement Et Synthese De Donnes Relationnels (ORESTE) methodology. To make an equitable comparison, the data from four Toyota automotive manufacturing plants are utilised. Results demonstrate that the Czech Republic is the steadiest country: it earned first-place position for both 2010 and 2019 in workforce efficiency. Additionally, the workforce efficiencies of all countries just after financial crisis (in 2010) was worse than 2019, with the exception of France in 2019. In terms of the ratio between attendance and operation productivity, Turkey in 2010 was the best plant, which reveals that the workforce in Turkey plant during the 2008 financial crisis was managed well comparing the Czech Republic, France, and UK. However, demand reduction was serious, and the total number of employee of plant had difficulty following the production volume.

Keywords: Workforce efficiency, Automotive industry, Analytical hierarchy process, ORESTE

Öz

İşgücü verimliliği, tüm dünyada sosyal, ekonomik ve eğitim düzeyi gibi geniş bir yelpazede çeşitli faktörlere bağlı olarak değişkenlik gösteren bir göstergedir. Bu nedenle, ülkeler arasında karşılaştırmalı bir analiz yapmak zordur. Bu çalışmada, dört ülkenin (Türkiye, Çek Cumhuriyeti, Fransa ve Birleşik Krallık – UK) 2010 ve 2019 yılı işgücü verimlilik düzeyleri AHP (Analitik Hiyerarşi Süreci) ve ORESTE (Organization, Rangement Et Synthese De Donnes Relationnels) yöntemleri ile ölçümlenmiş, karşılaştırılmış ve sıralanmıştır. Rasyonel bir değerlendirme yapabilmek adına, bu dört ülkede faaliyet gösteren Toyota Üretim Tesisleri verileri kullanılmıştır. Elde edilen bulgular, Çek Cumhuriyeti'nin 2010 ve 2019 yıllarında en yüksek işgücü verimlilik düzeyine sahip ve bu süreçte en istikrarlı ülke olduğunu ortaya koymaktadır. Ayrıca, Fransa dışında incelenen tüm ülkelerin 2008 finansal kriz sonrası (2010) işgücü verimlilik oranları 2019 yılı verimlilik oranlarından daha düşük çıkmıştır. Devamsızlık ve operasyonel verimlilik göstergelerinde ise Türkiye, diğer ülkelere kıyasla, 2010 yılında en iyi performansı sergileyen ülke olmuştur ve bu sonuç bu göstergeler bazında bu dönemde işgücünün görece daha iyi yönetildiğinin bir göstergesidir. Diğer yandan bu dönemde Türkiye'de talep çok ciddi oranda

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düşmüş ve toplam çalışan sayısının üretim rakamları ile paralel seyretmesi sürecinde güçlükler yaşanmıştır.

Anahtar Kelimeler: İşgücü verimliliği, Otomotiv endüstrisi, Analitik Hiyerarşi Süreci, ORESTE

1. INTRODUCTION

One of the most desired outcomes of companies is workforce efficiency, which directly affects corporate cost. It is broadly defined as a worker's ratio of output to input, and it has a crucial role for corporations and societies. Jain (2007) defines workforce efficiency as the capacity of labour to produce more product that is of better quality within a specific time and under specific circumstances. The rate of production of a highly efficient operator can, even within a single timeframe, demonstrate that of an inefficient worker.

Irrespective of the importance of efficiency and productivity at both macro and micro levels, investors are sensitive to the efficiency and productivity levels of the country. As Ulengin et al. (2014) emphasise, the labour efficiency influences the industrial competitiveness in a country; therefore, exposing the efficiency level of countries is helpful. However, Kamasheva et al. (2013) imply that it is impossible to be an efficient employee in an inefficient organisation.

One of the key contributors to the national economy (especially for industrialised countries) is the automotive sector. The performance of this sector generally represents the economic condition of the country. The European Automobile Manufacturers Association (2020) represents 6.7% of total European Union employment, which is 14.6 million direct and indirect jobs; 11.5% of all manufacturing jobs (3.7 million) are in the automobile industry.

The aim of this study is to ascertain the workforce efficiency levels of four countries: Turkey, the Czech Republic, France, and UK via determined performance indicators. Regarding the labour market's efficiency and productivity, there are indexes in the macro level that exhibit the countries' efficiency. For instance, the International Labour Organisation (ILO) periodically presents the labour productivity levels of countries. Based on the labour productivity report from 2021, the analysed four countries' generated output value ($) per worker is presented in Figure 1. As portrayed, all the countries analysed in this study increased output per worker between 2010 and 2019. However, how workforce efficiency in manufacturing has changed in these countries is not clear.

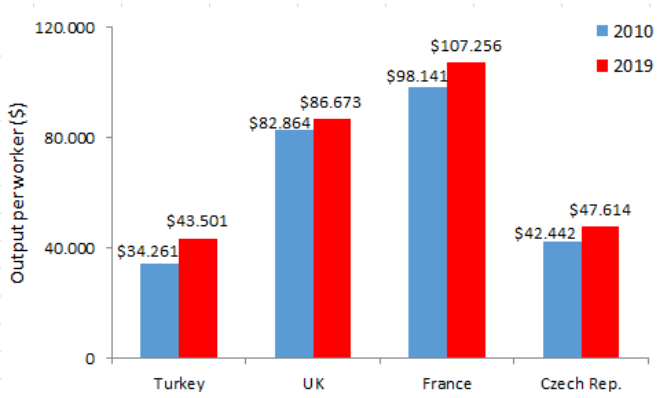

Figure 1. Labour productivity levels of four countries for 2010 and 2019 (ILO, 2020)

However, ILO measures productivity as the output (GDP) produced per employee (or total working hour) in a period. The World Economic Forum also presents labour market efficiency reports and these repots describe the efficient labour markets as the ability to match employees with the most appropriate jobs in line with their skills. Additionally, these type of indexes consider numerous sectors and many organisational levels (strategic, tactical, or operational). Both of these indexes are macro level and provide an idea about the countries' macro level workforce efficiency. In this study, the operational level workforce efficiencies are compared and ranked by the AHP-ORESTE methodology. The countries were selected based on data availability and plant existence. To compare the countries' efficiency levels objectively, data from Toyota Motor Corporation (TMC) production facilities in these countries were utilised. Similar products are produced, and the same management philosophy,

production system, and quality approach apply in these facilities; therefore, comparison and ranking of countries' workforce efficiencies are significant for the manufacturing area.

The structure of this study is as follows. In Section 2, the workforce efficiency measurement studies and country reflections are reviewed. Section 3 presents the methodologies utilised in study. Data structure and variable selection are presented in Section 4. the results are drawn in section 5. In final section, conclusions are presented.

2. LITERATURE REVIEW

Increased market competition and globalisation has made workforce efficiency—which depends on many variables, such as employment guarantees, management approaches, human resources policies, communication, and confidence building—more important than ever before; furthermore, it has become a decisive factor of competitiveness in the world. Higher efficiency implies a lower unitary cost (Fallahi et al., 2010) and better organisational management.

In literature, workforce efficiency levels of countries are generally measured by utilising macro variables, such as the economic growth rate (Song et al., 2013), GDP (Filippini and Tosetti, 2014), employment (Kotulic et al., 2015), capital stock (Ghali and El-Sakka, 2004), and energy utilised (Zhou et al., 2012). On the micro level, there are many variables utilised as indicators of workforce efficiency in manufacturing, such as operational cost (Aguado et al., 2013), absenteeism ratios (Sargent et al., 2003; Zhang et al., 2017), accident rates (Helleno et al., 2017; Swarnakar et al., 2020), quality rates (defect per unit, direct run ratio, first-time quality), produced quantity per employee (Odeggard and Roos, 2014), actual production time, planned versus actual operation time (Calcagnini and Travaglini, 2014), and processed quantity. Calcagnini and Travaglini (2014) utilised the data from four industrialised countries: France, Germany, US, and Italy from 1950 to 2010 by employing the common trends-common cycles approach. The data regarded the labour productivity per hour worked and were calculated by the Bureau of Labour Statistics. The hierarchical structure of the key performance indicators (KPIs) that are utilised in manufacturing systems is defined by Brundage et al. (2017) and Kang et al. (2016). In these studies, Data Envelopment Analysis (DEA) (Zhang et al., 2011; Hu and Wang, 2006; Zhou et al., 2008; Deliktas and Gunal, 2016) and Stochastic Frontier Analysis (SFA) (Piesse and Thirtle, 2000) are generally utilised. However, the comparison of workforce efficiencies of countries by utilising micro level variables in the manufacturing industry has not been studied, probably because of the difficulty in making a fair comparison between countries. In terms of determining the weight of the criteria, many studies (Demirkol, 2021; Sonar and Kulkarnı, 2021; Sedghiyan et al. 2021; Mandavgade et al. 2021; Gnanavelbabu and Arunagiri, 2018; Özcan et al. 2017) utilize AHP methodology.

3. MODEL

3.1 Oreste

ORESTE (Organization, Rangement Et Synthese De Donnes Relationnels) method is first presented by Roubens (1978). His purpose was to come up with a solution to practical necessity problem in ELECTRE regarding criteria weights (Pastijn and Leysen, 1989). The method which is based on several parameters and thresholds uses ordinal information for ranking of alternatives. However the model was advocated and popularized by Pastijn and Leysen (1989).

ORESTE is particularly proper to support the conflicting decisions in absence of crisp numerical values and alternatives' weight (Chatterjee and Chakraborty, 2014, pp. 322). In addition, the antisymmetric part of the outranking relation is not transitive in ELECTRE, this part of the aggregated incomplete relation, obtained after the incomparability analysis, is transitive in ORESTE which means that facing the interpretation of the intransitivity is not a problem for decision maker. Finally, decision making process in ORESTE is very fast since the model uses only ordinal ranking of criteria.

ORESTE method is operated in two steps. While ORESTE I works on process to find out a overall rank order on alternative set, analysis on indifference and incomparability are performed by ORESTE II (Delhaye et. al., 1991, pp. 33-38). In practice, it is difficult to say it is a wide used methodology. However, it may be utilized in different areas as an multi criteria decision making methodology on ranking, selecting the best alternative to select best performer. Jafari (2013) utilized ORESTE on

agriculture to decide and prioritize the risks. To select the most appropriate location, Givescu (2007) ranked the tourism location alternatives via ORESTE. Leeneer and Pastijn (2002) also used ORESTE to select the methodology of immobilizing mine in defence industry. Yerlikaya and Arıkan (2016) analysed the efficiency of small and medium sized companies by ORESTE, AHP and PROMETHEE.

ORESTE I has 8 steps as in Pastijn and Leysen (1989);

Step 1: Select a set of *k* criteria (*cj; j =1,2,…,k*) which generates C sets and describe a set of alternatives *(m)* (a_i; i =1,2,…,m). In here, a complete weak order is defined as a given preference structure on the set of C; S = (I or P) relation is transitive and complete, indifference (I) is symmetric where preference (P) is antisymmetric. For each criterion, weak order is defined as a preference structure on the A set: *Sj = (Pj or Ij)* relation is complete, *Ij* is symmetric and *Pj* is antisymmetric. Obtaining the global preference structure G is the main purpose of this process (Pastijn and Leysen, 1989).

Step 2: To signify alternatives' performance based on criteria, build the decision matrix,

Step 3: Obtain the criterias' weak order demonstrating relative importances utilizing the equation (1);

c_1 P c_2 I c_3 P c_4 ..... c_n (1)

In equation (1), from c_1 to c_4, the importance and prefences of criterion decreases which means that while c_1 specifies the most preferred, c_4 denotes the least prefered criteria (Chatterjee and Chakraborty, 2014, pp. 322).

Step 4: For each criteria, build the complete weak order of the alternatives via equation 2.

c_1 : a_1 P a_2 P a3 ..... :a_m

c_2 : a_1 P a_2 P a3 ..... :a_m

c_3 : a_1 P a_2 P a3 ..... :a_m

.....

c_n : a_1 I a_2 R a3 ..... :a_m (2)

Step 5: Develop criteria and alternatives' Besson rankings. In this step, based on the weak order structure developed in step 4, a Besson rank is determined for each alternative considering its position in weak order structure. In case the three (or more) alternatives stand at the same rank for a specific criterion at the begining, these alternatives' Besson ranks are determined via (1 + 2 + 3) / 3 = 2. The Besson rank of a_i for j criterion is expressed by $r_j(a_i)$ and rc_j denotes the jth criteria's Besson rank (Chatterjee and Chakraborty, 2014, pp. 323).

Step 6: Determine projection distances: which coincide the alternatives' relative position corresponding an arbitrary origin *O*. The projection distance, $d(O,a_i)$, is calculated by using the equation 3 and for non-linear projection way $DR_j(a_j)$ by equation (4)

$d_j(O,a_i)= 0,5\ [rc_j + rj(ai)]$ (3)

$$DR_j(a_j) = \left[0{,}5rc_j^R + 0{,}5rc_j(a_i)^R\right]^{1/R} \quad (4)$$

Regarding the determined projection distances, if a_1 alternative is preferred over a_2 alternative (that is demonstrated as [a_1 P a_2]) for j_{th} criterion, this means that $d_j(a_1) < d_j(a_2)$. The smaller projection distance means the better position for alternatives.

Step 7: Calculate projection ranking (global ranks): Starting from the lowest projection distance, a mean global Besson rank, $r_j(a_i)$, is designated for each projection distance. Again, the smaller $r_j(a_i)$ indicates better position in ranking. In example, $r_1(a_1)$ remains equal or smaller than $r_2(a_2)$ if $DR_1(a_1)$ is smaller than $DR_2(a_2)$. These are called global ranks.

Step 8: Obtain the mean global ranks: By summing up each alternatives' global Besson ranks using equation (5), each alternatives' mean global ranks are obtained.

$$r(a_i) = \sum_{j=1}^{n} r_j(a_i) \quad (5)$$

In the second stage of the ORESTE (ORESTE II), Pastijn and Leysen (1989) introduces incomparability and indifference thresholds which are to build an (I, P, R) framework. While preference (P) intencities are utilized for situations which have contradictions, incomparability (R) renders discrepancies. In addition, the indifference (I) relation will be more rational comparing the the weak order framwork. In order to figure out the intensity of action "a" on action "b", equation (6) is utilized:

$$C'(a,b) = \sum_{j:a\,P_j\,b} \left(r_j(b) - r_j(a)\right) \quad (6)$$

The equation (6) is upper bounded by $(m-1)k^2$. Chatterjee and Chakraborty (2014) presents that *normilizing the* P (which is also *C'(a, b))* by $(m-1)k^2$ yields $0 \leq C(a, b) - C(b, a) \leq 1$ and $0 \leq C(a,b) \leq 1$.

In case of incomparability (have contradictions), β, γ *and* C^* thresholds are calculated by appliying indifference and incomparability test.After calculating the thresholds, the test results are interpreted by the flow seen in figure 1. β should be less than 1/[(m-1)k]. C^*(indifference threshold) may be linked with referene situations and sholud be less than $\frac{d}{2(m-1)}$ as seen on equation (7);

$$C^* < \frac{d}{2(m-1)}, \qquad d = 1, \ldots\ldots, (m-1) \quad (7)$$

Final incomparatibility threshold γ may also be in relation with a reference situation too. If the decision maker is appraising the situation such as (a P b), in this case γ should be lower bounded in double criteria matrix and single criteri matrix as in equation (8) and equation (9) respectively;

$$\gamma < \frac{C(a,b) - C(b,a)}{C(b,a)} = \frac{\left[\left(\frac{k+2}{2}\right) * k - \left(\frac{k-2}{2}\right) * k\right]}{\left[\left(\frac{k-2}{2}\right) * k\right]} = \frac{4}{k-2} \quad (8)$$

$$\gamma < \frac{C(a,b) - C(b,a)}{C(b,a)} = \frac{\left[\left(\frac{k+1}{2}\right) * k - \left(\frac{k-1}{2}\right) * k\right]}{\left[\left(\frac{k-1}{2}\right) * k\right]} = \frac{2}{k-1} \quad (9)$$

In this indifference and the incomparability test, four different situations are observed between two alternatives. So, incomparability test flow between two alternatives is summarized in figure. 2.

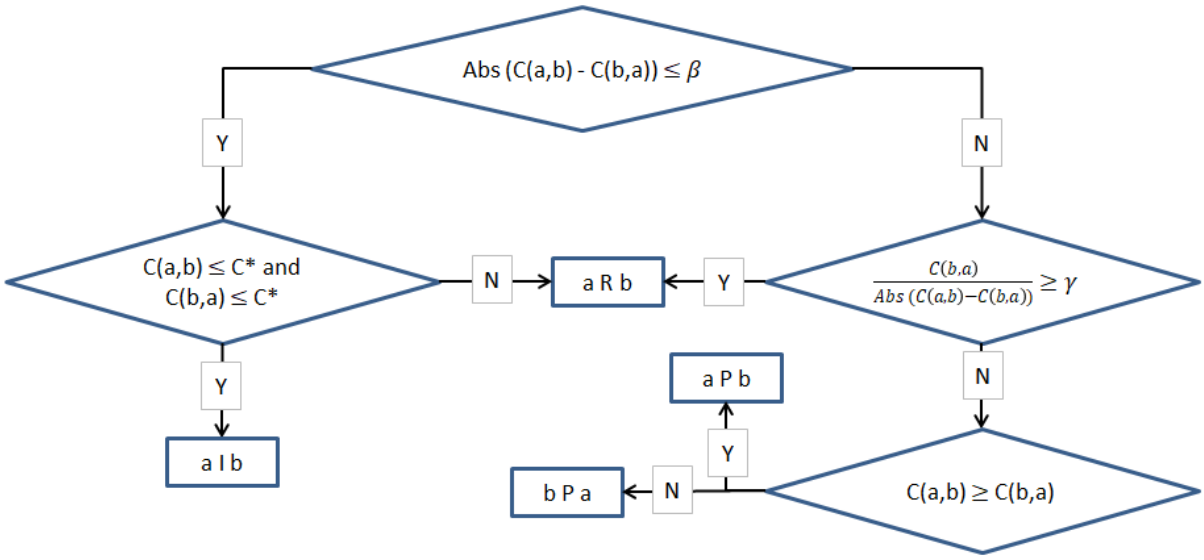

Figure 2. Incomparability test flow (Pastijn and Leysen, 1989)

3.2 AHP

The Analytic Hierarchy Process (AHP), introduced by Saaty, is a type of multi-criteria decision-making approach. Many researchers use the AHP methodology mainly due to the easy to obtain data and good mathematical approach of the method which performs pairwise comparisons described by Saaty (2013) as presented in Table 1.

Table 1. Scale used in pairwise comparison

Intensity of numerical importance	Definition
1	Equal important
3	Moderately more important
5	Strongly more important
7	Very strongly important
9	Extremely more important

The AHP methodology has six main steps. Because of it is a well-known methodology, these steps are presented very briefly in this study and details of the methodology can be found in Saaty (1980). At the first step, the decision problem should be clarified and decompose it into a hierarchy with a specific target. Besides, evaluation criteria and sub-criteria are determined and are set in hierarchy at the bottom. Based on Saaty's pairwise comparison scale, the decision matrix which contains the assessment of each alternatives based on the criteria is established. If the problem has m alternatives and c criteria, the decision matrix is set as in equation (10);

$$D = \begin{bmatrix} d_{11} & d_{12} & \dots & d_{1c} \\ d_{21} & d_{22} & \dots & d_{2c} \\ . & . & . & . \\ . & . & . & . \\ . & . & . & . \\ d_{m1} & d_{m2} & \dots & d_{mc} \end{bmatrix} \quad (10)$$

Here d_{m1} stands for rating of the i_{th} alternative in respect to the j_{th} criteria. In the next step, the methodology searches for a vector which expresses the priority of each alternative for the related criterion. The purpose is to set relative priorities with respect to each of the elements at the next higher

level. So the new form of matrix is set as in equation (11);

$$\begin{bmatrix} w_1/w_1 & w_1/w_2 & \dots & w_1/w_c \\ w_2/w_1 & w_2/w_2 & \dots & w_2/w_c \\ . & . & . & . \\ . & . & . & . \\ . & . & . & . \\ w_c/w_1 & w_c/w_2 & \dots & w_c/w_c \end{bmatrix} \quad (11)$$

Based on criterion, matrix A is generated with a_{ij} which interpreted as the degree of preference of i_{th} criteria over j_{th} criteria**.** In case the comparisons c(c - 1)/2 comparisons in total) are consistent, a_{ij} satisfies the following conditions: $a_{ij} = w_i/w_j = 1/a_{ji}$ and $a_{ii} = 1$. After calculating the inconsistency index (CI) to measure the consistency of decision maker's judgments as seen on equation (12), it is decided to redo the assessment and comparisons or not. If the inconsistency index gets closer to zero, greater consistency is achieved.

$$CI = \frac{(\lambda_{max} - c)}{(c-1)} \quad (12)$$

In next step, comparison matrix is normalized and finally the relative weights of criteria is exposed via calculating the eigenvalues of this matrix as seen on equation (13).

$$A.W = \lambda_{max}.W \quad (13)$$

4. APPLICATION

Countries' workforce efficiency levels are affected by economic, cultural, structural, and social variables. Additionally, the internal dynamics of companies have a crucial role in efficiency. Since there are several internal and external variables affecting workforce efficiency, it is difficult to compare countries. In this study, the workforce efficiencies of four countries are measured based on seven criteria. To make a rational comparison, four Toyota Motor Corporation (TMC) manufacturing plants in Europe were selected. TMC applies the same manufacturing philosophy, production system, and management approaches for all plants; consequently, workforce efficiency and productivity levels of these countries can be measured and compared effectively. Because of these reasons, these four countries are selected and efficiencies are compared.

To determine countries' power against crisis and observe how their workforce efficiency and productivity have changed over time, data from 2010 and 2019 were analysed. Additionally, a combined dataset was analysed separately by considering each year's data as an alternative.

4.1 Data

To determine the workforce efficiency levels of countries, seven criteria were selected: direct production member, maintenance, logistics, office member (white-collar employee), attendance ratio, operational productivity ratio (OPR), and production efficiency (PFF) ratio. OPR is an official corporate KPI that measures the ratio of actual total working time without any line stops and total working time for a specific shift in manufacturing. PFF is also a global KPI for TMC, and it measures cost centre-based (the smallest organisation in the corporation) working time efficiency. It is the ratio of actual total working time of all employees per shift (the data is entered by the group leader for each cost centres), considering breaks, lunchtime, and tempo, to the total standard time provided to employees to achieve the tasks. PFF demonstrates how workforce is utilised efficiently in operations compared to the standards. All the variables were selected in ratio form to allow consideration of different scales of companies. Table 2 presents the descriptive statistics of the data utilized in this study.

Table 2. Descriptive statistics of companies in counties for 2010 and 2019

Corporate Country	Criteria						
	# of Vehicle/Operator	# of Vehicle/MTCE	# of Vehicle/# of Office Member	# of Vehicle/# of Logistics Operator	Attendance (%)	OPR (%)	PFF (%)
Max/Min	**Max**	**Max**	**Max**	**Max**	**Max**	**Max**	**Max**
Turkey2010	60.2	0.0051	294.1	550.1	96.6%	95.4%	0.67%
Turkey2019	76.9	0.0022	517.2	705.9	90.2%	93.8%	0.89%
France2010	80.6	0.0019	705.1	671.7	86.1%	93.1%	0.85%
France2019	84.3	0.0015	893.9	700.8	84.9%	88.0%	0.87%
UK2010	75.2	0.0027	335.2	663.8	95.0%	92.7%	0.73%
UK2019	86.7	0.0018	553.6	766.7	82.7%	93.7%	0.90%
Czech Rep.2010	74.9	0.0037	449.5	730.8	89.8%	94.7%	0.80%
Czech Rep.2019	111.0	0.0019	1043.1	1084.7	82.2%	94.3%	0.81%

4.2 Aim of the Study

The aim of this study is to measure and rank the workforce efficiency levels of manufacturing in countries. Although the study utilised the automotive industry, it is a reference and provides a general idea about workforce efficiency levels of the country in the manufacturing area.

5. RESULTS

Both AHP and ORESTE results were obtained through MS Excel. In this study, two terms were considered and analysed: companies' workforce efficiency statistics after the 2008 financial crisis and their 2019 situation, which represents high market demand and production volume. Additionally, the ORESTE methodology was utilised for both situations: in total, as eight alternatives for four countries, and separately, as four countries for two years. Then the results were compared. First, AHP results are introduced.

5.1 AHP Results

AHP results are an important part of ORESTE input since the weight of the criteria used in ORESTE are determined by AHP. AHP is an easy and efficient way of decision-making. The structure of this problem is well suited for AHP because of the necessity of determining criteria weights. Therefore, calculating the criteria weights via pairwise comparison is considered efficient and effective.

Based on the procedure explained in Section 3.2, comparison matrices were obtained, and the weight of the criteria are presented in Table 3. Six participants, including experts, engineers, and managers working and experienced in the automotive manufacturing industry completed the comparison matrix. According to the results, the most important criterion is PFF, followed by number of vehicles produced per operator. The third most important criterion is OPR, with 11% importance value. These three criteria form 80% of the total weight. These weights were directly utilised in ORESTE as weak orders (weight of the criteria).

Table 3. Comparison matrix of criteria

Criteria	# of Vehicle/ Operator	# of Vehicle/MTCE	# of Vehicle/# of Office Member	# of Vehicle/# of Logistics Operator	Attendance (%)	OPR (%)	PFF (%)
# of Vehicle/Operator	1.00	8.00	4.00	8.00	4.00	1/2	1/7
# of Vehicle/MTCE		1.00	1/4	½	1/6	1/4	1/9
# of Vehicle/# of Office Member			1.00	2.00	1/4	1/3	1/9
# of Vehicle/# of Logistics Operator				1.00	1/6	1/5	1/9
Attendance (%)					1.00	1/2	1/7
OPR (%)						1.00	1/8
PFF (%)							1.00
Weights	**0.22**	**0.02**	**0.05**	**0.03**	**0.1**	**0.11**	**0.47**

5.2 ORESTE Results

In the first step of ORESTE, a weak order structure should be established that considers preference and indifference relationships. Then, Besson ranks of alternatives, which belong to importance relationships based on each criteria, are applied. The Besson ranks of alternatives are presented in Table 4.

Table 4. Besson-ranks

Corporate Country	Workforce					Productivity	
	# of Vehicle/ Operator	# of Vehicle/ MTCE	# of Vehicle/# of Office Member	# of Vehicle/# of Logistics Operator	Attendance (%)	OPR (%)	PFF (%)
Weight of Criteria	**0.22**	**0.02**	**0.05**	**0.03**	**0.1**	**0.11**	**0.47**
Turkey2010	8	1	8	8	1	1	8
Turkey2019	5	4	5	4	3	4	2
France2010	4	5	3	6	5	6	4
France2019	3	8	2	5	6	8	3
UK2010	6	3	7	7	2	7	7
UK2019	2	7	4	2	7	5	1
Czech Rep.2010	7	2	6	3	4	2	6
Czech Rep.2019	1	6	1	1	8	3	5

In Table 4, the Czech Republic in 2019 was the best plant, among others, in number of vehicle produced per operator. However, Turkey in 2010 was the best performer in number of vehicles produced per maintenance operator who is responsible for maintenance for machines and equipments.

In the next step, projection distances are calculated. In this study, $R = 2$ and $\alpha = 0.5$, which means that the effect of the criteria on order structure are 50%. In line with these parameters, total projection distances were calculated and presented in Table 5.

Table 5. Total projection distances

Corporate Country	Workforce					Productivity	
	# of Vehicle/ Operator	# of Vehicle/ MTCE	# of Vehicle/# of Office Member	# of Vehicle/# of Logistics Operator	Attendance (%)	OPR (%)	PFF (%)
Weight of Criteria	**0.22**	**0.02**	**0.05**	**0.03**	**0.1**	**0.11**	**0.47**
Turkey2010	5.7	0.7	5.7	5.7	0.7	0.7	5.7
Turkey2019	3.5	2.8	3.5	2.8	2.1	2.8	1.5
France2010	2.8	3.5	2.1	4.2	3.5	4.2	2.8
France2019	2.1	5.7	1.4	3.5	4.2	5.7	2.1
UK2010	4.2	2.1	4.9	4.9	1.4	5.0	5.0
UK2019	1.4	4.9	2.8	1.4	5.0	3.5	0.8
Czech Rep.2010	5.0	1.4	4.2	2.1	2.8	1.4	4.3
Czech Rep.2019	0.7	4.2	0.7	0.7	5.7	2.1	3.6

Next, global ranks, which are in closed intervals (1 to 56) in this problem, were calculated and presented in Table 6.

Table 6. Global ranks

Corporate Country	Criteria							TOTAL
	# of Vehicle/ Operator	# of Vehicle/ MTCE	# of Vehicle/# of Office Member	# of Vehicle/# of Logistics Operator	Attendance (%)	OPR (%)	PFF (%)	
Weight of Criteria	**0.22**	**0.02**	**0.05**	**0.03**	**0.1**	**0.11**	**0.47**	**-**
Turkey2010	53.0	4.0	53.0	53.0	4.0	4.0	53.0	**224**
Turkey2019	32.0	25.0	32.0	25.0	18.0	25.0	11.0	**168**
France2010	25.0	32.0	18.0	38.5	32.0	38.5	25.0	**209**
France2019	18.0	53.0	11.0	32.0	38.5	53.0	18.0	**224**
UK2010	38.5	18.0	44.0	44.0	11.0	47.5	47.5	**251**
UK2019	11.0	44.0	25.0	11.0	47.5	32.0	4.0	**175**
Czech Rep.2010	47.5	11.0	38.5	18.0	25.0	11.0	42.0	**193**
Czech Rep.2019	4.0	38.5	4.0	4.0	53.0	18.0	32.0	**154**

As seen in Table 6, the Czech Republic in 2019 was the best performer in number of vehicles produced per operator, while Turkey in 2010 was the best in OPR. In total, the most efficient company was the Czech Republic in 2019, followed by Turkey in 2019. As expected, companies' postcrisis workforce efficiencies were lower than performances in 2019. The rankings were considered separately, and the overall rankings are classified in Table 7.

Table 7. Overall ranking based on years

Ranking	**Overall**	**2010**	**2019**
1	Czech Rep.2019	Czech Rep.(193)	Czech Rep.(135)
2	Turkey2019	France (209)	Turkey (168)
3	UK2019	Turkey (224)	UK (174)
4	Czech Rep.2010	UK (250)	France (223)
5	France2010		
6	France2019		
7	Turkey2010		
8	UK2010		

(): Parenthesis shows the ranking values

Table 7 reveals that, generally, the performances of all companies after a crisis (in 2010) were worse than in 2019, with the exception of France in 2019. The performances of the Czech Republic in 2010 and France in 2010 were better than the performance of France in 2019. This means that the performance of the Czech Republic in 2010 and France in 2010 (after the 2008 financial crisis) were better than France in 2019.

To build and exhibit indifference, incomparability, and preference structure, normalised preference intensities of an alternatives matrix were calculated. Total number of $(a\text{-}1)k^2$ calculation, which is equal to 343, were performed, and the normalised intensities matrix is presented in Table 8.

Table 8. Alternatives' normalized intensity matrix

Corporate Country	**Turkey 2010**	**Turkey 2019**	**France 2010**	**France 2019**	**UK 2010**	**UK 2019**	**Czech Rep.2010**	**Czech Rep.2019**
Turkey2010	=	0.163	0.264	0.386	0.188	0.325	0.102	0.284
Turkey2019	0.327	=	0.181	0.264	0.281	0.162	0.175	0.203
France2010	0.308	0.061	=	0.122	0.223	0.101	0.175	0.101
France2019	0.388	0.102	0.080	=	0.277	0.067	0.236	0.083
UK2010	0.114	0.041	0.102	0.198	=	0.182	0.067	0.181
UK2019	0.469	0.143	0.201	0.210	0.401	=	0.277	0.098
Czech Rep.2010	0.192	0.102	0.192	0.325	0.235	0.223	=	0.182
Czech Rep.2019	0.490	0.239	0.257	0.287	0.465	0.159	0.297	=

To exhibit indifference, incomparability, and preference structure among alternatives, the threshold values were calculated as explained in Section 3.1 ($\beta: 0.02;\ \gamma: 0.33;\ and\ C^*: 0.07$). Based on preference intesity, threshold values, and incomparability test results, the alternatives' relation matrix was obtained (Table 9).

Table 9. Relation matrix

Corporate Country	Turkey 2010	*Turkey 2019*	France 2010	France 2019	UK 2010	UK 2019	Czech Rep.2010	Czech Rep.2019
Turkey2010	=	<	<	R	R	<	<	<
Turkey2019	>	=	>	>	>	>	>	R
France2010	>	<	=	R	>	<	R	<
France2019	R	<	R	=	R	<	R	<
UK2010	R	<	<	R	=	<	<	<
UK2019	>	<	>	>	>	=	>	R
Czech Rep.2010	>	<	R	R	>	<	=	<
Czech Rep.2019	>	*R*	>	>	>	R	>	=

The relation matrix and global ranks reveal that, although the Czech Republic in 2019 was in first place and Turkey in 2019 was in second place, the performance of Turkey in 2019 was better than the Czech Republic in 2019 since it had less incomparability (*R*) relation with alternatives. This means that the workforce efficiency of Turkey in 2019 was better than the Czech Republic in 2019. No other major change was observed in ranking considering incomparability test results.

The ORESTE methodology was also applied for 2010 and 2019 separately. Each step of the method was utilised similarly for the two terms; final ranks, ranking values, and relation matrices are presented in Table 10.

Table 10. Final ranks of companies and relation matrix for 2010 and 2019 separately

Ranks (2010)	Company
1	Czech Rep.(86)
2	France (91)
3	Turkey (115)
4	UK (117)

Ranks (2019)	Company
1	Czech Rep. (87)
2	UK (98)
3	Turkey (99)
4	France (122)

Corp. Country	Turkey	France	UK	Czech Rep
Turkey	=	<	=	<
France	>	=	>	<
UK	=	<	=	<
Czech Rep	>	>	>	=

Corp. Country	Turkey	France	UK	Czech Rep
Turkey	=	>	R	<
France	<	=	<	<
UK	R	>	=	<
Czech Rep	>	>	>	=

In Table 10, only the ranks for UK and Turkey in 2019 differ compared to the results presented in Table 7. The performances of these countries were close (ranking values of countries were 98 and 99), and no main superiority was observed as in the relationship matrix; consequently, it was difficult to make an exact ranking for these countries.

Overall results demonstrate that the Czech Republic is the steadiest country: it maintained its position between 2010 and 2019 because it did not lose any volume after the 2008 financial crisis. Additionally,

its production volume increased in that term since the demand for "A" segment passenger cars which is the smallest category of passenger car defined by the European Commission on passenger car classification system, which is what the Czech Republic produces. Although Turkey is one of the worst performers overall, it stands in the first place in maintenance workforce efficiency. This might be the reason for the low automation ratio of the company.

Regarding office (white-collar) and logistics workforce efficiency, the Czech Republic again stands in the first place, and Turkey in 2010 stood in last place. However, the attendance and OPR of Turkey in 2010 was the best. These results indicate that workforce in Turkey plant in the 2008 financial crisis was managed well compared the UK, Czech Republic and France; however, volume reduction was serious, and the number of operators in Turkey could not maintain the production volume.

6. CONCLUSION

There are many labour efficiency and productivity measurements and comparison indexes for countries in the literature at the macro level. However, finding a similar atmosphere (same management philosophy, same production approaches, same measurement methodology, same or similar products manufactured, etc.) for comparison is difficult micro level. The workforce efficiencies of the four counties are compared by only considering the internal dynamics and not purified from macro changes in these countries such as coup attempt in Turkey in 2016, yellow vest protest in France in 2018 and Brexit in 2019. On the other hand, it is not observed a major event which has potential to affect workforce efficiency directly in these plants for the years 2010 and 2019.

On the other hand, the workforce efficiency level of analysed four countries are measured for 2010 and 2019 to see how they are managed 2008 financial crisis in terms of workforce efficiency. The overall and yearly basis analysis exposed the similar results where a fractional difference is obtained in ORESTE II process. The overall results indicate that the Czech Republic was the steadiest country in workforce efficiency for both years, while Turkey achieved second place. However, the Czech Republic location of TMC was the only branch that was not affected by the 2008 financial crisis because it manufactured A segment vehicles. Regarding changes in overall efficiencies determined by checking ranking values, Turkey and UK improved their workforce efficiency statuses, while France has fallen behind.

The other finding is that, although Turkey was second and third place overall for 2010 and 2019, respectively, it stood at first place overall in maintenance workforce efficiency in 2010. This might be the reason for the low automation ratio of the company in 2010 compared to the others.

In crisis management ability, the Czech Republic and France were observed as the best performers that manufacture A and B segment small vehicles. In postcrisis performances regarding workforce efficiency, the Czech Republic, Turkey, and UK were observed as satisfactory performers. The lifelong employment policy of the company might play a crucial role in these results. Considering other financial and operational variables, the countries' performances might be compared and ranked for future studies. Additionally, workforce efficiencies can obtained directly via input-output analyses, such as DEA.

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Araştırma Makalesi

A Workforce Efficiency Analysis of Four European Countries: A Micro Level Comparison

Dört Avrupa Ülkesi İşgücü Verimlilik Analizi: Mikro Düzey Bir Karşılaştırma

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Genişletilmiş Özet

Giriş

İşgücü verimliliği, tüm dünyada sosyal, ekonomik ve eğitim düzeyi gibi geniş bir yelpazede çeşitli faktörlere bağlı olarak değişkenlik gösteren bir göstergedir. Bu nedenle, ülkeler arasında karşılaştırmalı bir analiz yapmak oldukça zordur. Ülkelerin işgücü verimliliği de makro ve mikro pek çok değişkene bağlı olarak değişkenlik gösterir.

Ülkelerin işgücü verimliliklerini rasyonel bir şekilde karşılaştırabilmek için, benzer yönetsel yaklaşıma, benzer ürün/hizmet üretimine ve benzer amaçlar ile üretimin gerçekleştirilmesine ihtiyaç vardır. Bu alanda yapılan çalışmalarda genellikle makro değişkenler kullanılmıştır. Bu çalışmada ise, aynı sektörde benzer kategoride ürünler üreten bir otomotiv üreticisinin, dört farklı ülkedeki(Türkiye, Çek Cumhuriyeti, Fransa ve Birleşik Krallık – UK) işgücü verimlilik düzeylerinden hareketle, 2010 ve 2019 yıllarındaki işgücü verimlilikleri kıyaslanmıştır. Ülkelerin işgücü verimliliklerini ve üretkenliklerini makro düzeyde belirleyen çeşitli endeksler yer almakla birlikte, bu endeksler pek çok sektörü, pek çok makro değişkeni ve pek çok işletmeye ilişkin pek çok farklı yönetsel yaklaşımlar içermektedir. Dolayısı ile ülkeler arasında üretim endüstrilerinde işgücü verimliliklerini doğrudan karşılaştırmak zordur (farklı yaklaşımlar, farklı kültürler, farklı endüstriler, farklı makine-teknoloji kullanımı, farklı otomasyon düzeyleri vb dolayısı ile). ILO'nun yayınlamış olduğu işgücü üretkenlik endeksi (2021) rakamlarına bakıldığında (Şekil 1) Çek Cumhuriyeti'nin çalışan başına yaratmış olduğu gayri safi milli hasılanın, Fransa ve İngiltere'nin yaklaşık yarısı kadar olduğu; fakat bunun doğrudan işgücü verimliliğine yansıtılmasının doğru olmayacağı söylenebilir.

Yöntem

Bu çalışmada, dört ülkenin (Türkiye, Çek Cumhuriyeti, Fransa ve Birleşik Krallık – UK) 2010 ve 2019 yılı işgücü verimlilik düzeyleri AHP (Analitik Hiyerarşi Süreci) ve ORESTE (Organization, Rangement Et Synthese De Donnes Relationnels) yöntemleri ile ölçümlenmiş, karşılaştırılmış ve sıralanmıştır. ORESTE yöntemi, Roubens (1978) tarafından geliştirilmiş ve uygulamada çok sıklıkla kullanılan bir yöntem değildir. Bu yöntemde alternatifler kriter bazında diğer bir alternatife üstünlüğüne bağlı olarak sıralandığı basit bir sıralama yöntemidir. Farklı özelliklere sahip kriterin bulunduğu alternatiflerin değerlendirilmesinde oldukça kullanışlı olması dolayısı ile bu yöntem, pek çok farklı alanda kullanılabilmektedir. Rasyonel bir değerlendirme yapabilmek adına, bu dört ülkede faaliyet gösteren Toyota Üretim Tesisleri verileri kullanılmıştır.

Çalışmada AHP yöntemi ile sıralamada kullanılacak olan kriter ağırlıkları belirlenmiştir. AHP, kalitatif ve kantitatif faktörlerin birleştirilerek, bir seçim sürecinde en uygun alternetifi bulmada kullanılan bir çok kriterli karar verme yöntemidir. AHP modeli çok sayıda ve farklı uygulamalarda kullanım alanı

bulmuş ve başarılı bir şekilde uygulanmıştır. AHP, matematiksel modellerle çözülmesi güç, karmaşık problemleri basit bir şekilde ele alarak, karar sürecinde en uygun alternatifin bulunmasını kolaylaştırır. Basitliğine, kullanım kolaylığına ve esnekliğine ek olarak AHP'nin güçlü ve popüler bir karar verme aracı olarak yer bulmasındaki diğer bir etken ise, aynı karar çerçevesinde kalitatif ve kantitatif kriterleri birleştirebilme kabiliyetidir. Çalışma kapsamında, alanında uzman, mühendis ve yöneticilerden oluşan altı kişilik bir ekip, kriterlere ilişkin göreli karşılaştırmalar yapmıştır. Bu karşılaştırma sonuçlarına bağlı olarak elde edilen kriter ağırlıkları, ORESTE yönteminde ihtiyaç duyulan ağırlıkları oluşturmuştur. Sekiz aşamalı olarak yürütülen ve ORESTE ve ORESTE II süreçleri ile elde edilen çıktılar doğrultusunda, kurumların ve ülkelerin işgücü verimlilik sıralamaları yapılmıştır.

Bulgular

AHP yöntemi ile elde edilen kriter ağırlıkları, tablo A'da görülmektedir. Bu kriterler içerisinde önem ağırlığı en yüksek kriterin, PFF olduğu görülmektedir. Yaklaşık %50 ağırlığa sahip olan bu kriter, değerlendiriciler tarafından işgücü verimliliğinin en belirgin göstergesi olarak kabul edilmiştir. PFF kriterinden sonraki en güçlü işgücü verimlilik göstergesi ise operatör başına üretilen araç sayısı göstergesidir (%22). Üçüncü en önemli kriter ise, üretimin kesintiye uğramaksızın devam durumunu ifade eden OPR (%) kriteridir. Tablo A'da görüldüğü üzere belirlenmiş olan yedi kriterin ilk üçü, toplam kriter ağırlığının %80'ini oluşturmaktadır.

Tablo A. Kriter ağırlıkları

	Araç Sayısı / Operatör	Araç Sayısı/Bakım Çalışanı Sayısı	Araç Sayısı / Ofis Çalışanı (Beyaz Yaka) Sayısı	Araç Sayısı / Lojistik Operatör Sayısı	Devamsızlık (%)	OPR (%)	PFF (%)
Kriter Ağırlıkları	**0.22**	**0.02**	**0.05**	**0.03**	**0.1**	**0.11**	**0.47**

Elde edilen bulgular, Çek Cumhuriyeti'nin 2010 ve 2019 yıllarında en yüksek işgücü verimlilik düzeyine sahip ve bu süreçte en istikrarlı ülke olduğunu ortaya koymaktadır (Tablo B).

Tablo B. 2010 ve 2019 yılları için genel sıralama

Sıralama	Genel	2010	2019
1	Çek Cum. 2019	Çek Cum. (193)	Çek Cum. (135)
2	Türkiye 2019	Fransa (209)	Türkiye (168)
3	UK 2019	Türkiye (224)	UK (174)
4	Çek Cum. 2010	UK (250)	Fransa (223)
5	Fransa 2010		
6	Fransa 2019		
7	Türkiye 2010		
8	UK 2010		

Global dizilimde (Tablo C) kriter bazlı olarak yapılan analizlerde ise, operatör başına üretkenlik ve lojistik faaliyetlerki işgücü verimliliğinde Çek Cumhuriyeti (2019) ve Birleşik Krallık (2019)'ın ilk iki sırayı paylaştığı görülmektedir. Beyaz yaka çalışan sayısında ise Çek Cumhuriyeti (2019) ve Fransa (2019)'un en verimli ülkeler olduğu söylenebilir. Devamsızlık kriterine bağlı olarak elde edilen bulgular ise, Türkiye (2010) ve UK (2010)'un bu alanda en iyi performans gösteren ülke olduklarını göstermektedir. Bu alandaki ilginç bulgulardan birisi, devamsızlık konusunda en iyi performans gösteren ilk dört ülke içerisindeki üç ülkenin 2010 yılına ait olmasıdır. Kriz dönemi ve hemen sonrasında yaşanan bu durum, kriz dinamiklerine bağlı olarak gelişmiş olabilir. OPR ve PFF'de ise ilk iki sırayı

alan ülkeler sırası ile Türkiye (2010) ve Çek Cumhuriyeti 2010 ile Birleşik Krallık (2019) ve Türkiye (2019)'dur.

Tablo C. Global dizilim

Ülke	Kriter							TOPLAM
	Araç Sayısı / Operatör	Araç Sayısı/Bakım Çalışanı Sayısı	Araç Sayısı / Ofis Çalışanı (Beyaz Yaka) Sayısı	Araç Sayısı / Lojistik Operatör Sayısı	Devamsızlık (%)	OPR (%)	PFF (%)	
Kriter Ağırlığı	**0.22**	**0.02**	**0.05**	**0.03**	**0.1**	**0.11**	**0.47**	**-**
Türkiye 2010	53.0	4.0	53.0	53.0	4.0	4.0	53.0	**224**
Türkiye 2019	32.0	25.0	32.0	25.0	18.0	25.0	11.0	**168**
Fransa 2010	25.0	32.0	18.0	38.5	32.0	38.5	25.0	**209**
Fransa 2019	18.0	53.0	11.0	32.0	38.5	53.0	18.0	**224**
UK 2010	38.5	18.0	44.0	44.0	11.0	47.5	47.5	**251**
UK 2019	11.0	44.0	25.0	11.0	47.5	32.0	4.0	**175**
Çek Cum. 2010	47.5	11.0	38.5	18.0	25.0	11.0	42.0	**193**
Çek Cum. 2019	4.0	38.5	4.0	4.0	53.0	18.0	32.0	**154**

Diğer yandan, Fransa dışında incelenen tüm ülkelerin 2008 finansal kriz sonrası (2010) işgücü verimlilik oranları 2019 yılı verimlilik oranlarından daha düşük çıkmıştır (Tablo D). Devamsızlık ve operasyonel verimlilik göstergelerinde ise Türkiye, 2010 yılında en iyi performansı sergileyen ülke olmuştur ve bu sonuç bu göstergeler bazında bu dönemde işgücünün iyi yönetildiğinin bir göstergesidir. Diğer yandan bu dönemde Türkiye'de talep çok ciddi oranda düşmüş ve toplam çalışan sayısının üretim rakamları ile paralel seyretmesi sürecinde güçlükler yaşanmıştır.

Table D. Firma ve ülkelerin 2010 ve 2019 yılları işgücü verimlilik değerleri bazında sıralamaları ve ilişki matrisleri

Sıralama (2010)	Şirket
1	Çek Cum.(86)
2	Fransa (91)
3	Türkiye (115)
4	UK (117)

Sıralama (2019)	Şirket
1	Çek Cum. (87)
2	UK (98)
3	Türkiye (99)
4	Fransa (122)

Ülke	Türkiye	Fransa	UK	Çek Cum.
Türkiye	=	<	=	<
Fransa	>	=	>	<
UK	=	<	=	<
Çek Cum.	>	>	>	=

Ülke	Türkiye	Fransa	UK	Çek Cum
Türkiye	=	>	R	<
Fransa	<	=	<	<
UK	R	>	=	<
Çek Cum.	>	>	>	=

Tartışma

Çalışmada izlenen metodoloji, benzer ürünler üreten ve aynı çalışma kültürü ve yönetsel yaklaşımlar ile faaliyetlerini sürdüren dört farklı tesis işgücü verimlilik göstergelerinin karşılaştırmalı analizi bazlıdır. Diğer yandan, işgücü verimlilik oranları sektöre göre değişkenlik gösterebilir. Bu süreçte farklı performans göstergeleri kullanılabilir. Bu oranlar, kurumların mevcut altyapıları ile (otomasyon oranı ve makina-ekipman kullanım düzeyleri gibi) ilintili olarak değişiklik gösterebilir. Bu çalışmada bir karar kriteri olarak belirlenmiş olan PFF kriteri, kurumların otomasyon düzeylerine bağlı olarak ortaya çıkabilecek işgücü verimlilik farklılıklarını ortadan kaldırdığı (hesaplama mantığı, otomasyon düzeyini de göz önünde bulundurduğu için) için, elde edilen sonuçların makine, teknoloji kullanımı ve otomasyon gibi işgücü verimliliğini doğrudan ve önemli ölçüde etkileyebilecek kriterlerden arındırılmış sonuçlar olduğu söylenebilir. Gelecek çalışmalarda, benzer bir yaklaşım ile farklı değişkenler de sürece katılmak sureti ile farklı süreçler için ülke karşılaştırmaları yapılabilir.