Mühendislik Bilimleri ve Tasarım Dergisi
10(3), 1054 – 1065, 2022
e-ISSN: 1308-6693

Journal of Engineering Sciences and Design
DOI: 10.21923/jesd.947773

Araştırma Makalesi Research Article

APPLICATION OF LABOR PRODUCTIVITY ANALYSIS IN TROUSERS SEWING LINE

Meral İŞLER[1], Mehmet KÜÇÜK[2*]

[1]Selçuk University, Faculty of Architecture and Design, Fashion Design Department, Konya
[2]Ege University, Engineering Faculty, Textile Engineering Department, İzmir

Keywords
Clothing Production,
Kurosawa Model,
Labor Productivity,
Lost Time.

Abstract
In order not to lose their market share in global markets where borders have disappeared, to gain competitive advantage, and to increase their profitability, businesses have increased their work on efficiency values to use their scarce resources effectively. Considering that global economies, of which importance is frequently mentioned today, are composed of national economies, and national economies are constituted by the economies of enterprises operating in that nation, it becomes evident how important they are. Improving the economies of businesses operating in countries is possible by minimizing unnecessary activities in production activities with various efficiency studies and reducing production-related costs. In this study, the workforce efficiency in a clothing company manufacturing trousers was analyzed. In this context, data was collected from the sewing line of a garment company operating on trouser production in Izmir, and the data obtained was evaluated with the labor productivity model with rates from Kurosawa's productivity models. As a result of this research, it has been determined that the losses expected to be eliminated entirely after getting used to the production of the relevant product are still visible and even more than they should be.

KONFEKSİYON ÜRETİMİNDE İŞGÜCÜ VERİMLİLİK ANALİZİNİN PANTOLON DİKİM HATTINDA UYGULANMASI

Anahtar Kelimeler
Konfeksiyon Üretimi,
Kurosawa Modeli,
İşgücü Verimliliği,
Kayıp Süre.

Öz
İşletmeler, sınırların ortadan kalktığı global pazarlarda sahip oldukları pazar paylarını kaybetmemek, yeni pazarlarda söz sahibi olabilmek, rekabet avantajı sağlamak ve karlılıklarını arttırabilmek için ellerinde bulundurdukları kıt kaynakları etkin bir şekilde kullanabilme özelliklerini gösteren verimlilik değerleri üzerine gösterdikleri önemi ve yaptıkları çalışmaları arttırmıştır. Günümüzde öneminden sıklıkla söz edilen küresel ekonomiler, küresel ekonomileri ulusal ekonomilerin, ulusal ekonomileri de o ulusta faaliyet gösteren işletmelerin ekonomilerinin oluşturduğu düşünüldüğünde, ne derece önemli oldukları ortaya çıkmaktadır. Ülkelerin ekonomileri içerisinde faaliyet gösteren işletmelerin ekonomilerinin iyileştirilmesi ise üretim aktiviteleri içerisindeki gereksiz faaliyetlerin çeşitli verimlilik çalışmaları ile minimize edilerek, üretim kaynaklı maliyetlerinin düşürülmesiyle mümkün olmaktadır. Bu çalışmada pantolon üretimi yapan bir konfeksiyon firmasındaki işgücü verimliliği analiz edilmiştir. Bu kapsamda İzmir'de pantolon üretimi üzerine faaliyet gösteren bir konfeksiyon firmasının dikim bandından veri toplanmış ve elde edilen veriler Kurosawa'nın verimlilik modellerinden oranlarla işgücü verimliliği modeli ile değerlendirilmiştir. Gerçekleştirilen bu araştırmanın sonucunda, ilgili ürünün üretimine alışıldıktan sonra tamamen ortadan kaldırılması beklenen kayıpların hala görüldüğü ve hatta olması gerekenden daha fazla olduğu tespit edilmiştir.

* İlgili yazar / Corresponding author: mehmet.kucuk@ege.edu.tr, +90-232-311-2794

Alıntı / Cite

İşler, M., Küçük, M., (2022). Application of labor productivity analysis in trousers sewing line, Journal of Engineering Sciences and Design, 10(3), 1054-1065.

Yazar Kimliği / Author ID (ORCID Number)	Makale Süreci / Article Process	
M. İşler, 0000-0002-9654-4664	**Başvuru Tarihi / Submission Date**	04.06.2021
M. Küçük, 0000-0002-0017-5762	**Revizyon Tarihi / Revision Date**	08.11.2021
	Kabul Tarihi / Accepted Date	06.04.2022
	Yayım Tarihi / Published Date	30.09.2022

1. Introduction

Productivity is a concept that is influenced by various factors such as labor, capital, raw material, energy, environmental condition, quality of inputs and outputs, occupational safety and etc. (Güner, 2010).

Companies have the opportunity to determine their weaknesses and strengths while they have a road map and control tool by measuring the productivity level which can vary depending on the different factors. In addition, the usage of the resources provides information about the future of the company as well as the ability to compare with the other companies. The results of the productivity measurement activities, the necessary decisions and precautions are taken rationally by working in the light of scientific data (Özkan, 2010). All the companies desire to reduce the costs, keep strong in the market and have the competitive capacity. They know that not only finding the materials, labor or machine cheaper, the main point of the cost reduction is possible with the appropriate productivity applications (Atilla, 2008).

In the companies, productivity is an indicator that shows the efficiency level of the capital, material, labor, machine, land, building etc. used during the manufacturing process. As is known, there are some other production factors besides the labor force. These inputs have very close relation with each other individually or collectively. Increasing or decreasing of each inputs alone or with other inputs affects the production level (Doğan and Aydın, 1991). Productivity level placements applications have been handled by a large number of researchers and many productivity assessments have been made in the literature so far (Kalaoğlu and Sarıçam, 2007; Tanuwidjaja and Thangavelu, 2007; Ahuja and Khamba, 2009; Cabral and Mollick, 2011; Holl, 2016). Japanese scientist Dr. Kazukiyo Kurosawa is one of the researchers known for their productivity measurement models. Kurosawa's method and some examples of the studies are given below.

In an M.Sc. thesis which was prepared Pekel in 2001, the relation between motivation and productivity was examined through the employees of the State Airports Authority (Pekel, 2001). In 2005, Kurosawa et al. was checked the impacts of the training on productivity with a survey of manufacturing companies in Japan. They evaluate the impacts of the Off-the-Job Trainings and On-the-Job Trainings on the productivity (Kurosawa et al., 2005). Tangen was analyzed the productivity and the performance relation in a manuscript which was performed in 2005. In this study, he clarified the meaning of five terms which are productivity, performance, profitability, efficiency and effectiveness and showed the interrelation of them (Tangen, 2005). In 2007, Kahya and Polat examined design of a new productivity management system in a company's Mechanical Works Workshop using the WPMR model (Workshop Productivity Management by Ratio). They designed a system which records daily data in the system systematically and provide productivity analysis on request. As a result of this study, they made some recommendations for the applicability of the system (Kahya and Polat, 2007). In a study conducted by Konuk and Önder in 2008, they focused on the points to be taken into consideration in the determination and increase of productivity in boron mining. For this purpose, they used the AIPR model (Total Productivity Model) and argued that the efficiency in this area decreased year by year (Konuk and Önder, 2008). Another study was generated by Kim et al. in 2010 and this study proposes the Productivity Achievement Ratio (PAR), which is a productivity evaluation indicator which assists the selection of the management items for construction productivity enhancement. The results of this study indicate that the PAR can aid construction practitioners in achieving more balanced and effective productivity management (Kim et al., 2011). In 2011, Tor conducted a survey for determining the demographic factors that had an impact on productivity. The surveys were carried out by the employees of a selected firm and the results showed that age, professional seniority, year of service, occupational plan and working reasons had an impact on productivity (Tor, 2011). In a study which was conducted by Özkan et al. in 2011, the AIPR Model was used for productivity analysis in a wire manufacturing company. Within the scope of this study, the factors that have effect on the overall productivity of the company were obtained (Özkan et al., 2011). In 2013 Akçakoca et al. used WPMR system to evaluate the labor productivity in Turkey. The conclusion of this study was that labor productivity was found to be lower than should be expected (Akçakoca et al., 2006). In a study conducted by Uçmuş and Kaçar in 2015 at a congress about productivity, labor productivity was investigated in a battery company. They concluded that the key factor in increasing productivity is the labor force and it is extremely necessary to shift the planned production period so that the enterprise can use own production resources (particularly the labor force) efficiently (Uçmuş and Kaçar, 2015).

Apparel and productivity have always been an interesting topic. Studies in this area are shown below. In 2012, in a study, how the ergonomic regulations in the company affect the productivity was examined. However, an application study was not carried out in the study (Arslan, 2012). In a study that was held in 2016, a pants manufacturing company was examined with work study method. This study was calculated the unproductive times in the line with the help of chronometer technique (Kumaş et al., 2016). In the study in 2017, productivity was calculated by taking into account only the number of operators, machines and customers, using the data envelopment method (Doğan and Ersoy, 2017). Unal was calculated the standard times of each processes of a suit jacket with digital chrometers. In the selected company, the production due time and productivity of the orders with the same model was estimated with the determined standard unit times (Unal, 2018). In another study about the productivity and clothing sector, the financial productivity of an enterprise examined by using financial data was calculated (Balkan, 2019). In a master of science thesis in 2019, the line balancing techniques were examined with appropriate algorithms for clothing companies to setup the manufacturing lines more productively (Demirbaş, 2019).

After the literature reviews, no study has been found that demonstrates the efficient and inefficient periods of the factors (operator, management, foreman and rare part) that are involved in the production of clothing sector until the last day of production (not just the first day or the total time).

The purpose of the Kurosawa WPMR (workshop productivity management by ratio) model is to reveal the responsibilities of each operator, foreman, and the management in the use of the workforce. This system philosophy is based on the understanding and awareness that time and labor resources are extremely important. According to this model, time seems to be the most fundamental element in increasing not only labor productivity but also raw material and capital productivity. Therefore, the WPMR system should be the preferred model for the general efficiency understanding especially for labor-intensive sectors (Prokopenko, 1998). After the reviews of the researches in the literature, it has been observed that there is no study applied to the apparel industry with the Kurosawa productivity model. In this study, it was aimed to measure labor productivity in a clothing company. In this direction, the data of a production line of a clothing company operating in Izmir were collected and analyzed with the help of Kurosawa WPMR model.

2. Material and Method

2.1. Material

Measuring the productivity level of the clothing industry is difficult because besides the labor-intensive and dynamic structure, the duration time of the processes and the remodeling time is too short. In this study, the WPMR model was applied in a pants production line which constitutes the densest and the most crowded part of the clothing companies. The application of the study was carried out in a sports pants manufacturer which has a single shift working in Izmir. The company works 5 days in a week and 540 minutes daily apart from legally determined breaks. 540 daily working minutes include 30 minutes of lunch break and 2 times 15 minutes breaks as the planned administrative stops. For this reason, all calculations have been made over 480 minutes, excluding planned stops. The data were collected in the line for 10 days (2 weeks) time. Data from the company were obtained by the observation method. In addition to the observation method, recording forms such as productivity, maintenance, and production numbers used by the planning department of the enterprise were also used. To evaluate the efficiency, the data on the first day when the product entered the line was taken, and the data were randomly evaluated on the 7th day from the following days for comparison. Each operation was evaluated separately by recording the loss (depending on the management, the foreman and the operator) and the effective working hours. Data collection was carried out with the help of daily transaction record forms. Each operator's data were analyzed and included in the measurement. The operation steps of the determined trousers, the technical drawing (Figure 1) and the standard time of each process are given in Table 1.

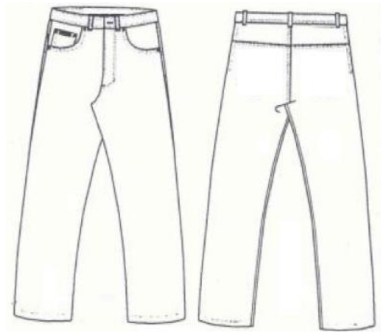


Figure 1. The Technical Drawing of the Determined Trousers

Table 1. The Operation Steps and the Standard Times of the Trousers

Processes	Machine	Std Time (min)
1- Front piece and pocket bag overlock	3 thread overlock machine	0,37
2- Pocket seam	Lockstitch Machine	0,48
3- Top stitch pocket mouth	Lockstitch Machine	0,35
4- Left fly bottom overlock	3 thread overlock machine	0,22
5- Left fly side overlock	3 thread overlock machine	0,19
6- Attaching zipper to fly	Lockstitch Machine	0,29
7- Left fly seam to front + edge stitching	Lockstitch Machine	0,46
8- Fly side overlock	3 thread overlock machine	0,34
9- Closed Fly seam + edge stitching	Lockstitch Machine	0,38
10- Front taping	Lockstitch Machine	0,31
11- Fly edge stitch	Lockstitch Machine	0,52
12- Pocket bag seam	5 thread overlock machine	0,31
13- Back dart seam	Lockstitch Machine	0,42
14- Back interlining dart seam	Lockstitch Machine	0,43
15- Interlining the center back	3 thread overlock machine	0,32
16- Center back seam (edge stitch)	Lockstitch Machine	0,26
17- Back interlining bottom hem overlock	3 thread overlock machine	0,20
18- Front interlining bottom hem overlock	3 thread overlock machine	0,22
19- Side seam	5 thread overlock machine	1,32
20- Sewing the Crotch	5 thread overlock machine	1,15
21- Fusing the fusible interlining to the waistband	Iron	0,40
22- Folding the waistband	Iron	1,11
23- Combining the waistband	Lockstitch Machine	0,58
24- Waistband and belt loop seam	Lockstitch Machine	1,43
25- Topstitch waistband	Lockstitch Machine	1,12
26- Belt loop + waistband seam + bartacking	Lockstitch Machine	2,20
27- Hem bottom	Lockstitch Machine	1,30
TOTAL		**17,08**

2.2. Method

There may be many reasons for productivity losses in the clothing industry, but in most businesses in this industry, the losses are thought to be caused by the operator. In the research, in order to determine the effect of other units on productivity besides the operator, Kurosawa's WPMR model was used to evaluate the sewing line productivity of the clothing business.

Within the scope of this method, the losses encountered during the production processes are categorized as caused by management, foreman, operator and rare parts. The reasons for the losses in each class are considered within the examples given below.

- The losses arising from the management are maintenance and repair, cleaning, practice and etc.
- The losses arising from the operators are coming to work late, reworking the waste product, time given to visitors and etc.
- The losses arising from the foreman are missing parts, materials or defects, misdirections, wrong production schedule, etc.
- The losses arising from the rare parts are missing or incorrect performance of tasks (such as control, tracking, parts feeding).

In the WPMR model, it is designed to measure workforce productivity by determining the planned working hours and not working hours, and the days and times that cannot be worked for some reason although they should be worked on the plan. In the model, productivity controls are obtained daily, evaluations and measures are obtained weekly and analyzes are prepared. The responsibility of each employee is determined by comparing the analyzes prepared with the operating standards. In addition, while taking precautions regarding labor productivity, the structure of the labor input (man-hour structure) should be determined well in order to determine the employee's responsibility correctly (Figure 2). The man-hour structure diagram in the WPMR model was given in Figure 2. The detailed explanations of the symbols that were used in the diagram was given below.

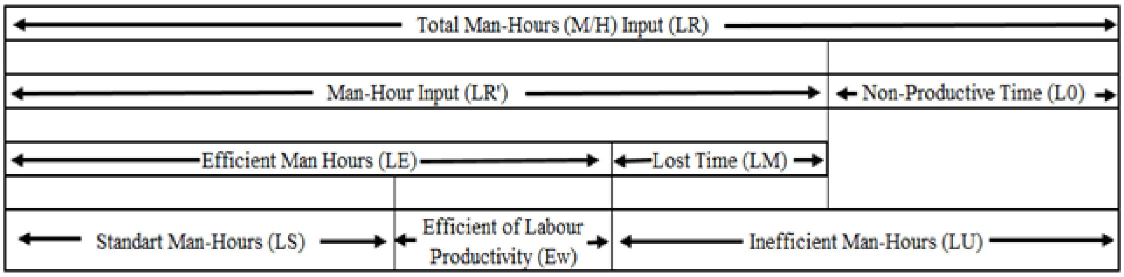


Figure 2. Flow diagram of man-hour structure (Ahuja and Khamba, 2009)

LE = LR- LU (1)
LR = The total man-hours
LR' = The man-hour input
LE = Efficient man-hours
LS = Q * Standard time (2)
LS = Standard man-hours
Q = The outputs
LU = LOY +LOU+ LOO + LOS (3)
LU = Inefficient man-hours
LOY = The total stopping time arising from the management (maintenance and repair, cleaning, practice and etc.)
LOU = The total stopping time arising from the foreman (defects, missing pieces and etc.)
LOO = The total stopping time arising from the operator
LOS = The total stopping time arising from the rare parts

The labor productivity was shown below according to the given symbols above;

Labor Productivity (PL) = LS/ LE (4)
The labor productivity in the responsibility of the management
(POY) = LE/(LE+LOY) (5)
The labor productivity in the responsibility of the foreman
(POU) = LE/(LE+ LOu) (6)
The labor productivity in the responsibility of the operator
(POO) = LE/ (LE+LOO) (7)
The labor productivity in the responsibility of the rare parts
(POS) = LE/ (LE+LOS) (8)
The ratio between the efficient man-hours and the total man-hours
(PE) = LE/LR (9)
General Proses Productivity (PG) = LS/ LR (10)

The effective and the lost times of the production line were determined with the help of these formulas and the labor force analysis was performed with the WPMR Model.

3. Findings

In line with the information obtained from the daily data record forms, since the number of processes is high, the first day that the product enters the production line and one of the days after the operators get used to the manufacturing of the product is chosen randomly (7th day) and the data of that day are given as an example (Table 2 and Table 3). Times in the tables are evaluated in minutes.

Table 2. The time obtained for all processes on the day the product enters the production line (minutes)

Process	Std Time (min)	Data 1st Day															
		The Outputs (Q)	The Total Man - Hours (L_R)	Efficient Man - Hours (L_E)	Std Man - Hours (L_S)	Mgmt (L_{OY})	Foreman (L_{OU})	Operator (L_{OO})	Rare (L_{OS})	Inefficient Man - Hours (L_U)	Labor Productivity ($P_L=L_S/L_E$)	P_{OY}	P_{OU}	P_{OO}	P_{OS}	P_E	P_G
1-Front piece and pocket bag overlock	0,37	980	480	420	362,60	16	19	18	7	60	0,86	0,96	0,96	0,96	0,98	0,88	0,76
2-Pocket seam	0,48	712	480	409	341,76	20	22	21	8	71	0,84	0,95	0,95	0,95	0,98	0,85	0,71
3-Top stitch pocket mouth	0,35	993	480	412	347,55	22	21	17	8	68	0,84	0,95	0,95	0,96	0,98	0,86	0,72
4-Left fly bottom overlock	0,22	1210	480	431	266,20	13	11	16	9	49	0,62	0,97	0,98	0,96	0,98	0,90	0,55
5-Left fly side overlock	0,19	1405	480	441	266,95	8	13	12	6	39	0,61	0,98	0,97	0,97	0,99	0,92	0,56
6-Attaching zipper to fly	0,29	1108	480	427	321,32	14	14	18	7	53	0,75	0,97	0,97	0,96	0,98	0,89	0,67
7-Left fly seam to front + edge stitching	0,46	760	480	425	349,60	16	9	22	8	55	0,82	0,96	0,98	0,95	0,98	0,89	0,73
8-Fly side overlock	0,34	1036	480	433	352,24	19	8	14	6	47	0,81	0,96	0,98	0,97	0,99	0,90	0,73
9-Closed Fly seam + edge stitching	0,38	1002	480	422	380,76	26	9	16	7	58	0,90	0,94	0,98	0,96	0,98	0,88	0,79
10-Front taping	0,31	1050	480	414	325,50	22	11	19	14	66	0,79	0,95	0,97	0,96	0,97	0,86	0,68
11-Fly edge stitch	0,52	710	480	420	369,20	21	13	17	9	60	0,88	0,95	0,97	0,96	0,98	0,88	0,77
12-Pocket bag seam	0,31	1065	480	421	330,15	18	14	18	9	59	0,78	0,96	0,97	0,96	0,98	0,88	0,69
13-Back dart seam	0,42	880	480	433	369,60	14	8	17	8	47	0,85	0,97	0,98	0,96	0,98	0,90	0,77
14-Back interlining dart seam	0,43	833	480	433	358,19	16	9	15	7	47	0,83	0,96	0,98	0,97	0,98	0,90	0,75
15-Interlining the center back	0,32	998	480	437	319,36	14	8	13	8	43	0,73	0,97	0,98	0,97	0,98	0,91	0,67
16-Center back seam (edge stitch)	0,26	1030	480	428	267,80	20	12	14	6	52	0,63	0,96	0,97	0,97	0,99	0,89	0,56
17-Back interlining bottom hem overlock	0,20	1265	480	432	253,00	19	12	6	11	48	0,59	0,96	0,97	0,99	0,98	0,90	0,53
18-Front interlining bottom hem overlock	0,22	1210	480	418	266,20	23	12	14	13	62	0,64	0,95	0,97	0,97	0,97	0,87	0,55
19-Side seam	1,32	417	480	420	550,44	21	9	16	14	60	1,31	0,95	0,98	0,96	0,97	0,88	1,15
20-Sewing the Crotch	1,15	498	480	431	572,70	24	7	8	10	49	1,33	0,95	0,98	0,98	0,98	0,90	1,19
21-Fusing the fusible interlining to the waistband	0,40	850	480	436	340,00	17	9	8	10	44	0,78	0,96	0,98	0,98	0,98	0,91	0,71
22-Folding the waistband	1,11	550	480	424	610,50	23	9	11	13	56	1,44	0,95	0,98	0,97	0,97	0,88	1,27
23-Combining the waistband	0,58	670	480	415	388,60	18	11	22	14	65	0,94	0,96	0,97	0,95	0,97	0,86	0,81
24-Waistband and belt loop seam	1,43	370	480	425	529,10	18	14	11	12	55	1,24	0,96	0,97	0,97	0,97	0,89	1,10
25-Topstitch waistband	1,12	445	480	425	498,40	19	9	13	14	55	1,17	0,96	0,98	0,97	0,97	0,89	1,04
26-Belt loop + waistband seam + bartacking	2,20	390	480	420	858,00	22	11	14	13	60	2,04	0,95	0,97	0,97	0,97	0,88	1,79
27-Hem bottom	1,30	510	480	432	663,00	18	7	11	12	48	1,53	0,96	0,98	0,98	0,97	0,90	1,38

The data of the 1st day the product entered the line is shown in Table 2. According to this, taking into consideration the first operation "Front piece and pocket bag overlock", the daily production volume of this operation is 980 pieces. The standard man-hour (Ls) of the operation in question is 362.60 min. Losses arising from the management (LOY) are 16 min., losses arising from the foreman (LOU) 19 min., operators' losses (LOO) 18 min., and rare parts losses (LOS) are 7 min. With the sum of these losses, it is seen that the total inefficient hours (LU) is 60 minutes.

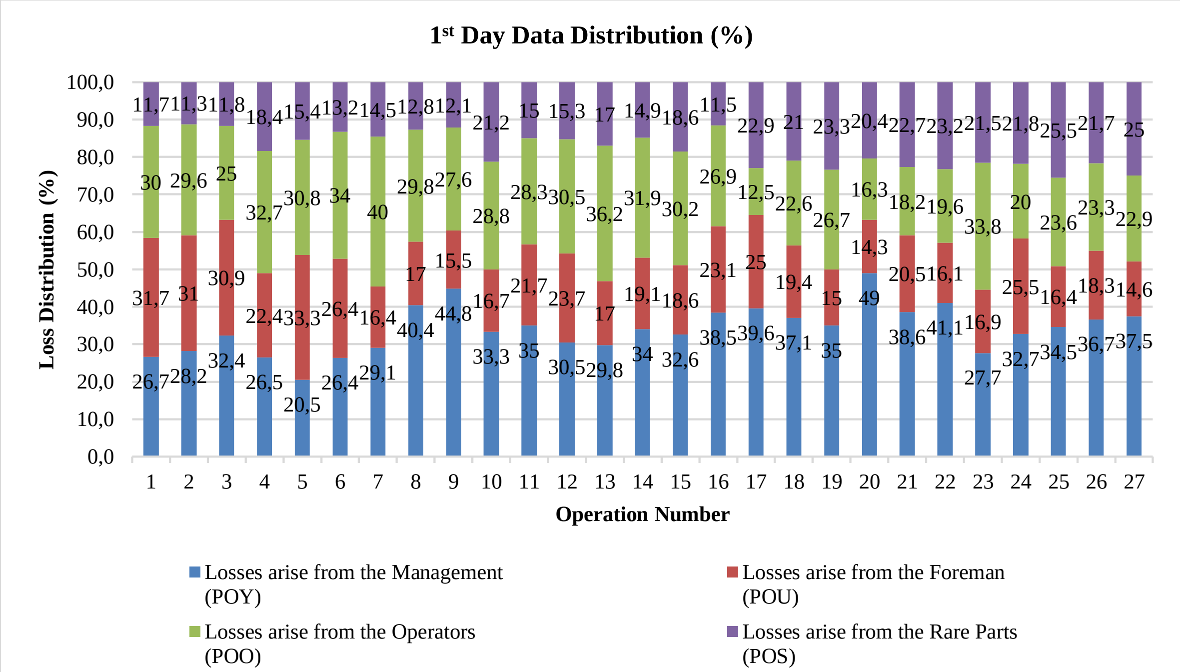


Figure 3. The distribution of the data obtained in the 1st day

As can be seen in Figure 3, the distribution of all lost times detected on the first day arise from the management, foreman, operator and rare parts were calculated. In this way, the losses of the first day could be calculated separately with the help of Kurosawa's WPMR model and it was determined from which unit they mostly originated. When all operations are examined on the day the product enters the line, the management losses are between 20.5% and 49%, the losses caused by the foreman between 14.3% and 33.3%, the operator losses between 12.5% and 40%, and the rare parts losses are between 11.3% and 25.5%. Since the first day that the product enters the line, the operators' adaptation process to the operations, the occurrence of malfunctions in the line setup, more frequent managerial stops of the line, it can be considered as an expected situation to be high. With the efficiency analysis application, on the first day the product enters the line, problematic operations can be detected more easily and it will be easier to determine which unit should be investigated first in order to prevent losses.

Table 3. The time obtained for all processes on the 7th day from the production line (minutes)

Process	Std Time (min)	Data 7th Day															
		The Outputs (Q)	The Total Man - Hours (L_R)	Efficient Man - Hours (L_E)	Std Man - Hours (L_S)	Mgmt (L_{OY})	Foreman (L_{OU})	Operator (L_{OO})	Rare (L_{OS})	Inefficient Man - Hours (L_U)	Labor Productivity ($P_L=L_S/L_E$)	P_{OY} L_E/L_E+L_{OY}	P_{OU} L_E/L_E+L_{OU}	P_{OO} L_E/L_E+L_{OO}	P_{OS} L_E/L_E+L_{OS}	P_E L_E/L_R	P_G L_S/L_R
1-Front piece and pocket bag overlock	0,37	1130	480	450	418,10	8	7	10	5	30	0,93	0,98	0,98	0,98	0,99	0,94	0,87
2-Pocket seam	0,48	845	480	443	405,60	6	11	14	6	37	0,92	0,99	0,98	0,97	0,99	0,92	0,85
3-Top stitch pocket mouth	0,35	1078	480	446	377,30	8	10	12	4	34	0,85	0,98	0,98	0,97	0,99	0,93	0,79
4-Left fly bottom overlock	0,22	1364	480	453	300,08	7	5	11	4	27	0,66	0,98	0,99	0,98	0,99	0,94	0,63
5-Left fly side overlock	0,19	1456	480	454	276,64	7	5	10	4	26	0,61	0,98	0,99	0,98	0,99	0,95	0,58
6-Attaching zipper to fly	0,29	1320	480	451	382,80	9	6	7	7	29	0,85	0,98	0,99	0,98	0,98	0,94	0,80
7-Left fly seam to front + edge stitching	0,46	882	480	447	405,72	6	12	10	5	33	0,91	0,99	0,97	0,98	0,99	0,93	0,85
8-Fly side overlock	0,34	1120	480	459	380,80	5	5	8	3	21	0,83	0,99	0,99	0,98	0,99	0,96	0,79
9-Closed Fly seam + edge stitching	0,38	1123	480	456	426,74	6	7	6	5	24	0,94	0,99	0,98	0,99	0,99	0,95	0,89
10-Front taping	0,31	1325	480	451	410,75	9	5	9	6	29	0,91	0,98	0,99	0,98	0,99	0,94	0,86
11-Fly edge stitch	0,52	869	480	452	451,88	7	6	8	7	28	1,00	0,98	0,99	0,98	0,98	0,94	0,94
12-Pocket bag seam	0,31	1326	480	453	411,06	5	10	8	4	27	0,91	0,99	0,98	0,98	0,99	0,94	0,86
13-Back dart seam	0,42	1010	480	451	424,20	5	7	11	6	29	0,94	0,99	0,98	0,98	0,99	0,94	0,88
14-Back interlining dart seam	0,43	974	480	453	418,82	5	7	12	3	27	0,92	0,99	0,98	0,97	0,99	0,94	0,87
15-Interlining the center back	0,32	1086	480	452	347,52	7	8	9	4	28	0,77	0,98	0,98	0,98	0,99	0,94	0,72
16-Center back seam (edge stitch)	0,26	1214	480	456	315,64	7	5	8	4	24	0,69	0,98	0,99	0,98	0,99	0,95	0,66
17-Back interlining bottom hem overlock	0,20	1415	480	451	283,00	8	9	7	5	29	0,63	0,98	0,98	0,98	0,99	0,94	0,59
18-Front interlining bottom hem overlock	0,22	1397	480	462	307,34	5	4	6	3	18	0,67	0,99	0,99	0,99	0,99	0,96	0,64
19-Side seam	1,32	465	480	454	613,80	6	5	10	5	26	1,35	0,99	0,99	0,98	0,99	0,95	1,28
20-Sewing the Crotch	1,15	571	480	455	656,65	6	6	10	3	25	1,44	0,99	0,99	0,98	0,99	0,95	1,37
21-Fusing the fusible interlining to the waistband	0,40	1163	480	463	465,20	5	3	9	0	17	1,00	0,99	0,99	0,98	1,00	0,96	0,97
22-Folding the waistband	1,11	602	480	454	668,22	9	7	10	0	26	1,47	0,98	0,98	0,98	1,00	0,95	1,39
23-Combining the waistband	0,58	742	480	448	430,36	8	7	10	7	32	0,96	0,98	0,98	0,98	0,98	0,93	0,90
24-Waistband and belt loop seam	1,43	403	480	443	576,29	9	8	12	8	37	1,30	0,98	0,98	0,97	0,98	0,92	1,20
25-Topstitch waistband	1,12	475	480	444	532,00	7	9	14	6	36	1,20	0,98	0,98	0,97	0,99	0,93	1,11
26-Belt loop + waistband seam + bartacking	2,20	408	480	444	897,60	7	11	10	8	36	2,02	0,98	0,98	0,98	0,98	0,93	1,87
27-Hem bottom	1,30	532	480	451	691,60	8	7	9	5	29	1,53	0,98	0,98	0,98	0,99	0,94	1,44

The data belonging to the 7th day of the product chosen randomly in the band are shown in Table 3. When the first operation "Front piece and pocket bag overlock" was examined again on the 7th day, it was seen that the daily production number of this operation increased to 1130 pieces. The standard man-hour (Ls) is 418.10 min. on this day of the operation. Losses arising from the management (LOY) are 8 min., losses arising from the foreman (LOU) 7 min., operators' losses (LOO) 10 min., and rare parts losses (LOS) are 7 min. With the sum of these losses, it is seen that the total inefficient hours (LU) is 10 min.

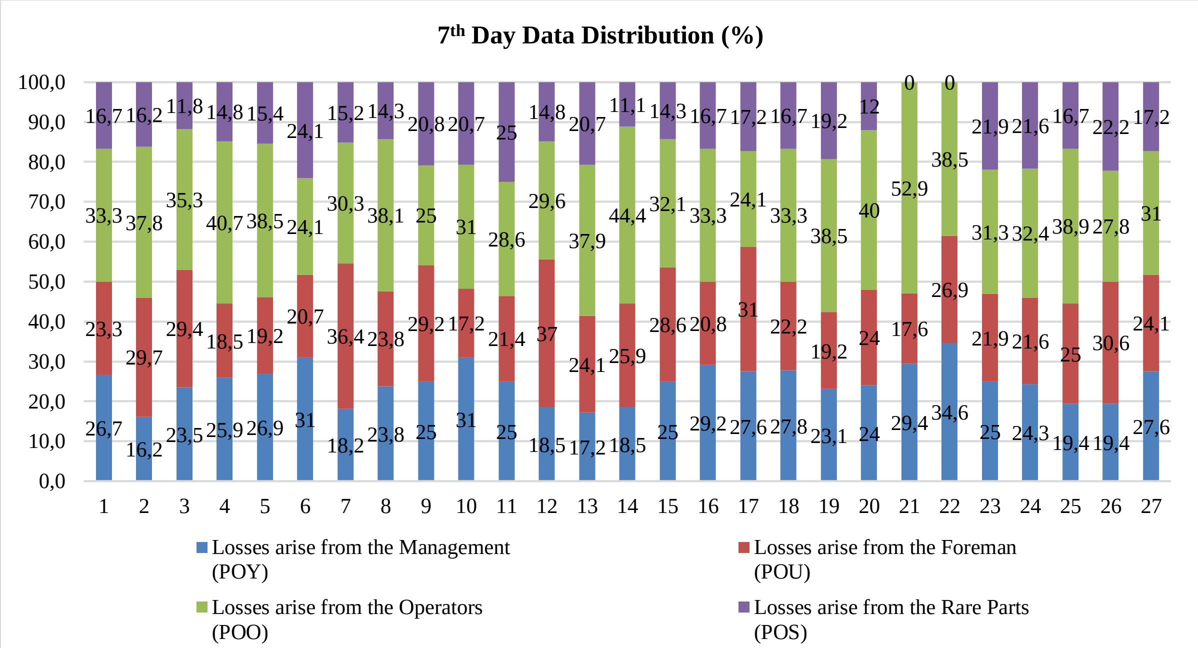


Figure 4. The distribution of the data obtained in the 7th day

When all the operations belonging to the 7th day shown in Figure 4 are examined and it is seen that the total loss in operations is between 16.2% and 34.6% belonging to management, between 17.2% and 37% losses belonging to foreman, between 24.1% and %52.9 belonging to operators, and between 0% and 24.1% belonging to rare parts. If these lost times are examined by Kurosawa's labor force method, on the 7th day, it can be determined which unit will be investigated and studied first in order to prevent these losses.

When the 7th day data of the production in the line is examined, the rare parts losses were zeroed in only two processes. In all other processes, all types of losses (managerial, operator induced, foreman, and rare parts losses) appear to exist. The expected situation after the product gets used to the line is the disappearance of the managerial, rare parts and foreman-related losses and the reduction of the losses caused by the operators.

The comparison of the "Inefficient man-hours (LU)" obtained after the product gets used to the line (7th day) and the day the product enters the line is shown below (Figure 5).

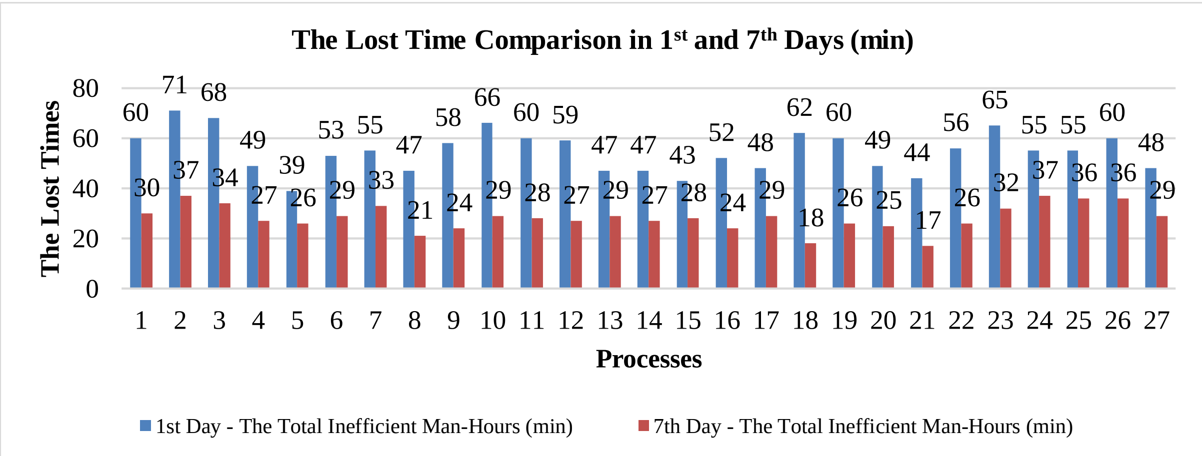
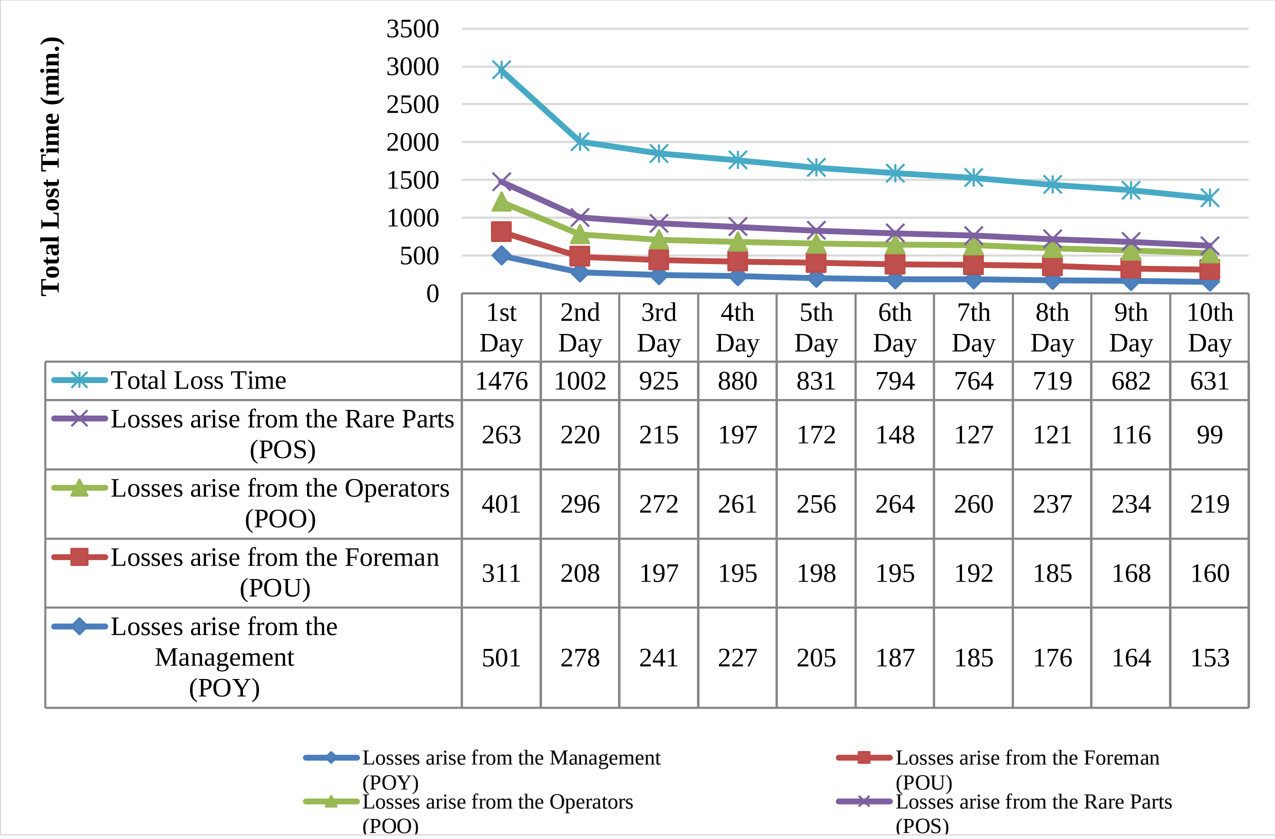


Figure 5. The total lost times in 1st and 7th days

In the comparisons, it is seen that the values for the 7th day are lower than the first day, and this is an expected result. However, although the units of the factory have had enough time to get used to the product, different lost times were measured for each operation on the 7th day as well. All production activities of the order completed within the scope of 10 days and the distribution of the losses caused by the management, foreman, operators and rare parts is shown below (Figure 6).



	1st Day	2nd Day	3rd Day	4th Day	5th Day	6th Day	7th Day	8th Day	9th Day	10th Day
Total Loss Time	1476	1002	925	880	831	794	764	719	682	631
Losses arise from the Rare Parts (POS)	263	220	215	197	172	148	127	121	116	99
Losses arise from the Operators (POO)	401	296	272	261	256	264	260	237	234	219
Losses arise from the Foreman (POU)	311	208	197	195	198	195	192	185	168	160
Losses arise from the Management (POY)	501	278	241	227	205	187	185	176	164	153

Figure 6. The distribution of the lost times within 10 days

Total loss times of all operations in the sewing band decreased by 49% on the 7th day and 57% on the 10th day compared to the 1st day. While 72% of the lost time on the first day is the sum of management, foreman and rare parts losses, 65% of the lost time in all operations on the 10th day consists of management, foreman and rare parts losses. Despite the increase in productivity, the high ratio of management, foreman losses and rare parts losses to total losses is remarkable.

4. Conclusion

In today's economic conditions, market conditions mostly determine the product's price, not companies. In this case, companies should be able to offer the product that can create demand in market conditions at the demanded price. The businesses may not be able to interfere with market conditions and external factors. However, they have the opportunity of providing a competitive advantage compared to other businesses by reducing their internal costs.

Measuring labor productivity is an essential element for clothing companies. Labor productivity is a factor that directly affects deadlines, operating profitability, and production costs. Although companies make use of the daily production tracking forms and the operator's daily production control charts in calculating labor productivity, the losses are still not clearly expressed. Therefore, the resulting productivity losses may not be analyzed correctly, the productivity losses caused by the management are hung on the operator, and the productivity losses caused by the operator on the foreman and wrong results are likely to be obtained, accordingly.

Kurosawa model is one of the methods that can be used to achieve the primary reason behind the loss of efficiency. Since there is no similar application in the literature regarding the clothing industry, a sample study of the Kurosawa model was conducted on an order. Within the scope of the study, the data coming from the 1st and 7th day of trouser production in the company were compared. In order to obtain more systematic results regarding the productivity of the production and to determine whether the problems in the system arises from managerial reasons or caused by certain operations or operators, regular monitoring should be carried out by recording all orders entering the line. In productivity analysis, the increase in productivity compared to the beginning can be perceived as a satisfactory result.

In this study, it is clearly seen that although the productivity has increased on the 7th day compared to the first day, there were still losses (in the 7th day) which were expected to be eliminated. These losses that were seen in the 7th day were close to the first day losses especially for some operations, but they did not decrease the total productivity owing to the other losses that were reduced during the production. So these hidden losses can easily be decipherable with the help of this model. A single product was considered to improve the applicability of this method in the clothing industry. By applying the method to different products and different manufacturing lines, the effects of different factors on productivity can also be evaluated.

In the study, the productivity factor was calculated on the basis of lost time both on the basis of the enterprise and on the basis of the business units, unlike the previous studies in the literature. For this reason, the unit causing the inefficiency could be determined and all the inefficiency reasons were not put on the operators' back.

Now, where even the smallest cost reduction is of great importance, the importance of methods that will easily determine which product has a problem in which operation and from which unit (management, operator, foreman or rare parts) this problem arises becomes more relevant. Besides, while it is a typical result that the productivity increases day by day and decreases the losses after the product enters the production line in classical productivity analyzes, in this model, even though the productivity increases day by day, it will play an important role to see where the decreasing losses are caused and to take measures to minimize them.

Considering the start and end days of the order, there is a significant decrease in the losses due to the stoppages. This leads many managers to focus on operator activities, preventing them from investigating the source of losses. In general, companies spend their time on increasing the efficiency of the operation-operator productivity. They attribute the increase in operation-operator efficiencies to the increase in overall efficiency. However, besides the operation-operator efficiencies in the manufacturing sector, the management, foreman, and rare part efficiencies also affect the whole process as explained in the method and were proven in Figure 6. This is the point that has been determined by the study and is the main point to be emphasized. Since the study is the first application in clothing production, it is thought that it will contribute to closing this gap in the literature. In further studies, the causes of foreman, management and rare part losses, which have an effect on productivity as well as the operator, will be investigated with different methods.

Conflict of Interest

No conflict of interest was declared by the authors.

References

Ahuja, I. P. S. And Khamba, J. S., 2009, Investigation of Manufacturing Performance Achievements Through Strategic Total Productive Maintenance Initiatives, Int. J. Productivity and Quality Management, vol. 4, no 2, pp.129–152.

Akçakoca, H., Aykul, H., Taksuk, M., Ediz, I. G. And Dixon-Hardy, D. W., 2006, Labour Productivity Model (WPMR System) and its Application to the Stripping Area of Garp Lignite Enterprise in Turkey, Mining Technology, vol. 115:1, pp.12-23, DOI: 10.1179/174328606X98321.

Arslan, A., 2012. Hazır giyim işletmelerinin ergonomik olarak düzenlenmesinin çalışma verimliliği ve kalite üzerindeki etkisi. Verimlilik Dergisi , (4) , 35-46 . Retrieved from https://dergipark.org.tr/tr/pub/verimlilik/issue/21762/233925.

Atilla, F., 2008, Üretim Yönetiminde Verimlilik Sırları: Yöneticilere İpuçları, Sistem Yayıncılık, İstanbul.

Balkan, D., 2019. Tekstil Sektöründe Verimlilik Ölçümü ve Bir Uygulama, Tekstil ve Mühendis, 26: 113, 79-85 DOI: doi.org/10.7216/1300759920192611309.

Cabral, R. And Mollick, A. V., 2011, Intra-Industry Trade Effects on Mexican Manufacturing Productivity Before and After NAFTA, The Journal of International Trade & Economic Development: An International and Comparative Review, vol. 20:1, pp. 87-112, DOI: 10.1080/09638190902836014.

Demirbaş, Z. A., 2019, Examination of Appropriate Algorithms for Apparel Industry in Assembly Line Balancing, MSc. Thesis, Tekirdağ Namık Kemal University Graduate School of Natural and Applied Sciences Department of Textile Engineering.

Doğan, A. And Aydin, İ., 1991, İmalatçı Kamu Kuruluşlarında Maliyet ve Verimlilik Karşılaştırmaları, Milli Prodüktivite Merkezi Yayınları, Ankara.

Doğan, N. And Özgür, E. Y., 2017. Efficiency Measurement: A Case Study of A Firm in The Textile Sector, Hitit University Journal of Social Sciences Institute, Year 10, Issue 1, June 2017, pp. 35-44.

Güner, M., 2010. Tekstil ve Konfeksiyonda İş Etüdü, Ege Üniversitesi Basımevi, İzmir.

Holl, A., 2016. Highways and Productivity in Manufacturing Frms, Journal of Urban Economics, vol. 93, pp.131-151.

Kahya, E. And Polat, O., 2007. The Implementation of Workshop Productivity Management by Ratios (WPMR) to a Mechanical Workshop in a Company, Verimlilik Dergisi, no 2, pp. 9-36.

Kalaoğlu, F. And Sariçam, C., 2007. Analysis of Modular Manufacturing System in Clothing Industryby Using Simulation, FIBRES & TEXTILES in Eastern Europe, vol. 15, No. 3 (62), July / September.

Kim, T. W., Lee, H. S., Park, M. And Yu, J. H., 2011. Productivity Management Methodology Using Productivity Achievement Ratio, KSCE Journal of Civil Engineering vol. 15(1), pp. 23-31, DOI 10.1007/s12205-011-0983-5.

Konuk, A. And Önder, S., 2008. Productivity and Rentability at the Boron Mine Enterprice, Eng&Arch.Fac. Eskisehir Osmangazi University, Vol. XXI, No:1.

Kumaş, Z., Sabir, E. C. And Duru Baykal, P., 2016. The Using of Work Study Technique for Process Productivitiy of Apparel Plant, Çukurova University Journal of the Faculty of Engineering and Architecture, 31(1), pp. 175-189.

Kurosawa, M., Ohtale, K. And Ariga, K., 2005. Productivity, Training, and Human Resource Management Practices, Disentangling Complex Interactions Using A Survey of Japanese Manufacturing Firms, Kyoto University.

Özkan, S., 2010. Etkin Verimlilik Ölçme ve Değerlendirme Yöntemi Olarak Kazukiyo Kurusawa Modelinin Bir Üretim İşletmesinde Uygulanabilirliğine Yönelik Çalışma, Yüksek Lisans Tezi, Dumlupınar Üniversitesi, Sosyal Bilimler Enstitüsü, Kütahya.

Özkan, A., Aydoğdu, A., Korkmaz, M. And Yahyaoğlu, G., 2011. Strategic Cost Management – Target Cost – Applied Study Directed to Applicability of Kazukiyo Kurusawa AIPR Model as an Effective Productivity Assessment and Evaluation Method in A Cable Production Firm, Akademik Bakış Dergisi, Sayı: 25.

Pekel, H. N., 2001. İşletmelerde Motivasyon-Verimlilik İlişkisi Devlet Hava Meydanları İşletmesi Antalya Havalimanı Çalışanları Arasında Bir Örnek Olay Araştırması, Yüksek Lisans Tezi, Süleyman Demirel Üniversitesi Sosyal Bilimler Enstitüsü, İşletme Anabilim Dalı.

Prokopenko, J., 1998. Verimlilik Yönetimi, MPM Yayınları, No: 476, Ankara.

Tangen, S., 2005. Demystifying Productivity and Performance, International Journal of Productivity and Performance Management, vol. 54, no 1, pp.34-46, doi: 10.1108/17410400510571437.

Tanuwidjaja, E. And Thangavelu, S., 2007. Structural Changeand Productivity Growth in the Japanese Manufacturing Industry, Global Economic Review: Perspectives on East Asian Economies and Industries, vol. 36:4, pp. 385-405, DOI: 10.1080/12265080701694603.

Tor, S. S. ,2011. The Demographic Factors, In Organisations, That Are Effecting The Job Satisfaction And Productivity: One Exercise Of A Company In Food Industry In Karaman, Thesis of Master, Department of Business Administration.

Uçmuş, E. And Kaçar, S., 2015. Bir Akü Firmasında İşgücü Verimlilik Analizi, 5. Ulusal verimlilik kongresi, Ankara, 6-7 Ekim.

Ünal, C., 2018. Takım Elbise Ceket Üretiminde İş Akışı ve Standart Birim Sürenin Belirlenmesi, SETSCI Conference Indexing System, Volume 3, 487-490.