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Research Article

Application of FAHP Methodology to Rank Productivity-Affecting Factors in Blanket Factory: A Case Study

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Blanket factory as a textile industry is one of the manufacturing sectors in Ethiopia; however, the sector productivity is the main issue of the business owners. For the reason of improving the productivity of the sector, factors affecting productivity should be identified and prioritized since improvement is capital intensive measurement. In this research, a FAHP methodology has been developed to prioritize the identified productivity-affecting factors of the blanket factory. Productivity problem is sourced from different factors. However, the concept of productivity-affecting factors has been considered in previous literature, its integration with productivity of the blanket factory and the FAHP methodology has not been studied. For the sake of filling this gap, this research has been conducted using the following main steps: at the beginning, productivity-affecting factors have been identified from previous literature. Then, as there are many productivity-affecting factors in different manufacturing sectors, the list of potential productivity-affecting factors has been investigated to check which factors are most common in the blanket factory. Finally, a FAHP model has been applied to prioritize productivity-affecting factors. According to this model, the result showed that skilled employee and on and off job training, production process line balancing, and better technology and manufacturing system are the most important factors of productivity problem in the blanket factory. Based on the normalized weight, these factors scored 35.92%, 22.94%, and 17.06%, respectively. As the main implications, the research procedure and obtained results using the developed methodology can help industry managers, operation managers and practitioners, business owners, academicians, and researchers to determine productivity-affecting factors so that they can provide possible solutions to the blanket factory.

1. Introduction

Textile industry is one of the manufacturing industries' sector in Ethiopia which created huge employment opportunities. Blanket factory, namely, Debre Berhan blanket factory (DBBF) P.L.C. is the one among the textile industries that produces blanket as number one in the country. The factory is located in Debre Berhan city and at present, the main product line is blanket, kuta, and polyester bed cover, and from the byproducts, mattress and pillow are produced. The factory is working as a lion share in the market. The customers are publics and organizations such as local institutions, NGOs and UN agencies in Ethiopia, disaster relief organization, defense forces and police, prisoners, hospital, and other institutions within Ethiopia. As a mission, they stated as providing quality products to customers with affordable price and supplying various blankets with different quality parameters, sizes, weights, and designs to expand the market size.

The production process of the company contains sequences of operations such as sorting, pulling, cutting, ramming, dyeing, squeezing, drying, blending, carding and spinning, yarning, warping, weaving, and finishing to convert raw material such as wool and acrylic fiber into a blanket [1]. In the operation, first, the wool and acrylic fiber is sorted, followed by pulling and cutting process to get the pulled material. Then, the pulled material is processed in the ramming machine. Based on the color requirement, it goes to the dyeing process, then dried to remove some moisture contents. Then, it goes to pulling and sucker machines, after that, it goes to the temporary storage space. Then, using carding and spinning machines, it changes into a yarn. In the weaving section, the yarn changed into rolls of cloth, then this cloth is passed through the mending section to cut off the unwanted part of the blanket. Finally, hard blanket is passed through the raising machine to become a soft blanket, then it goes to the finishing section. Figures 1 and 2 show the brief process description as well as the products of the factory, respectively.

The factory is old in history which produces its product with facilities as it has during its establishment. During my visit of the case company for advising the internship placed students of my department, the researcher has discussed with the management staffs that they have productivity problems and have observed activities those may hinder the productivity. Inadequate productivity is the burning issue which minimizes the overall performance of many companies in the globe. This is also true for most of the textile industries in Ethiopia. For DBBF P.L.C. to sustain in the market with competitive domains, to create incremental employment opportunities, to deliver quality products to its current huge customers, and to reach new customers in the potential market, there should be an improvement in the productivity.

As parts of today's competitive business environment, the essence of productivity is getting more attention in developing countries [2]. With this regard, identifying productivity-affecting factors, developing a model to prioritize the factors, and providing solutions to overcome the productivity problems is a challenge of every manufacturing industry which needs to be addressed.

There are various causes affecting productivity, and there are many techniques to determine the importance of one factor over the others. These techniques have been generally categorized under multicriteria decision-making (MCDM) and the different types of MCDM techniques have been applied in previous studies [3]. Among them, analytical hierarchy process (AHP) is the well-known which is the deterministic technique that cannot capture the uncertainty and fuzziness of the decision-making environment [4]. Judgements of decision-makers using linguistic variables cannot be addressed using AHP, rather fuzzy analytical hierarchy process (FAHP) has been suggested to consider the uncertainty and fuzziness of decision-makings [5–7]. Many studies have been conducted using FAHP [8]. As this research object to prioritize productivity-affecting factors, the application of FAHP can be justified as it prioritizes factors in different decision-making levels suing pairwise comparison matrix, considering the judgment of decision-makers as linguistic expressions. Intrinsic complexity of considering fuzzy values in decision-making and the successful application of FAHP in previous studies justify to use this methodology for productivity problem.

1.1. Objectives of the Study. The main objectives of the study are as follows:

(i) To identify productivity-affecting factors from previous literature and then to filter which investigated factors are most common in blanket factory since there are many productivity-affecting factors in different manufacturing sectors from the literature

(ii) To develop a FAHP model and prioritize the identified productivity-affecting factors

1.2. The Scope of the Study. This research is limited to textile industry especially blanket factory; however, the methodology and results can be applied to other manufacturing industries. It suggests the novel methodology to identify the factors affecting productivity and prioritize them using the MCDM tool in which the continuous improvement of productivity is started from identifying and prioritizing them.

1.3. Contribution of the Study. This study focused on assessing the productivity-affecting factors and since every improvement initiation cannot be applied at the same time due to resource constraints, it is also important to prioritize the factors according to their effect weight. Therefore, by considering DBBF P.L.C. as a case company, identifying the critical factors affecting productivity of the factory, prioritizing them for continuous improvement is an important procedure to bring the sector more competent in the market. In general, from theoretical and practical point of view, this research contributes to the literature world for the sake of the authors' and readers' knowledge such as academicians and industry practitioners such as operations managers and no similar research is conducted especially in the developing countries.

The remaining sections of this paper are organized as follows: literature review has been provided in Sections 2, development of the proposed model in Sections 3, and Section 4 shows the result and discussion of the research. Finally, in Section 5 the conclusion part including limitations of the study, benefit of the research, and future extensions of the study have been summarized.

2. Literature Review

Due to globalization, every manufacturing industry will face the business competition from both local and global market. One of the solutions to be competitive in the market is improving productivity by considering prominent factors that affect the productivity of the sector. By doing this, one can sustain in the business and can compete in the available market. Sustainable production system management through handling productivity-affecting factors is important for both the business owner and the shop floor workers, those involved in the production system [9]. Thus, it is important to identify and prioritize the factors to develop an effective productivity improvement plan [10]. Therefore, identifying productivity-affecting factors and developing MCDM model to prioritize them to focus on the improvement areas is the aim of this study. MCDM is one of the approaches to prioritize the best factors out of the available options while these options are identified based on a variety of criteria or comparing alternatives/factors against each other using pairwise comparison matrix [11, 12].

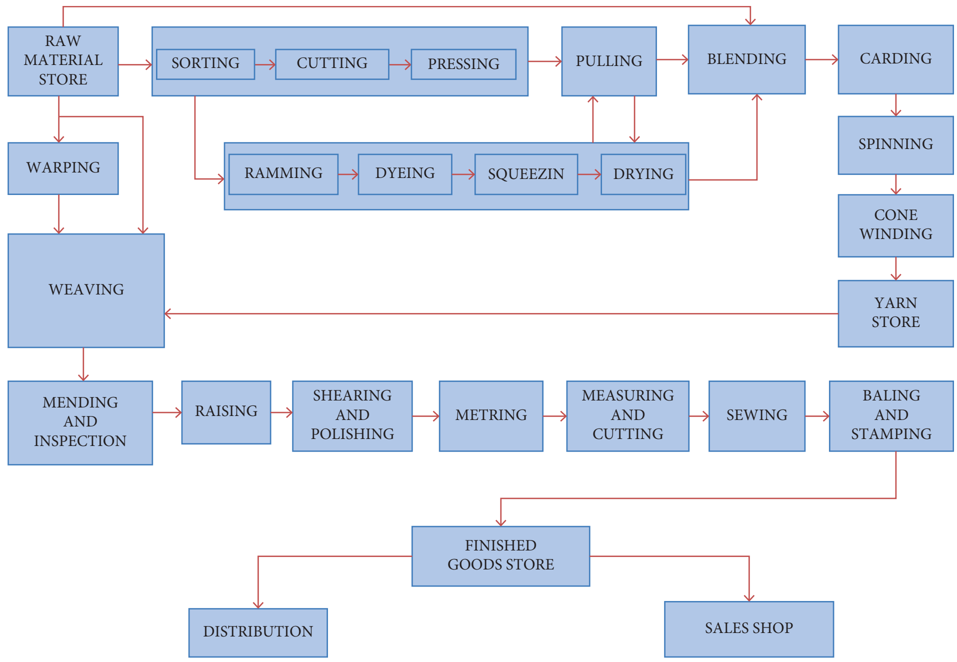

Figure 1: Work flow of the DBBF P.L.C.

Figure 2: Main products of the company.

There are numerous factors identified from previous studies those affect the sustainability, growth, and performance (effectiveness, efficiency, and productivity) of certain organizations. Labor quality is one of the significant enabler for improving productivity in the industrial sector [13] and also the sector's growth is affected by the firm's size as well as loan interest rate that is linked in the long term [14]. Technology in terms of selection and advancement will have an impact on the grow of certain sectors [15]. Additionally, efficient labors, smart machines, and minimized energy utilization can assist the application of a smart sustainable manufacturing framework [16]. Minimizing cost, various aspects of transportation logistics, and reduced energy can have an impact to develop sustainable biofuel supply chain and growth in the sector [17]. The research conducted by [18] depicted that an imperfect item due to machine breakdown have an impact on the effectiveness of multi-warehouse. On the other hand, productivity improvement can be achieved by paying attention for motion study that can improve the existing system productivity levels [19, 20], applying the best facility lay out, reducing set up times in the production system, set up of workers output target, reducing idle time [21], improving line balancing problems [22, 23], and incorporating advanced technology, implementing good management style, following better industrial policy and legislation [24], following capacity building through training [25, 26], motivating workers [27], etc. Also, job satisfaction, organizational responsibility, and absenteeism are the productivity-affecting factors [28]. These identified factors have been summarized in Table 1.

The AHP, FAHP, TOPSIS, and other methodologies are the most often employed techniques among MCDM techniques to prioritize the alternatives [29–34]. AHP has been employed to rank factors for productivity to enhance operations and production activities of the firm [35]. In the other way, the combination of DEA and AHP has been employed to rank factors affecting the efficiency in the area of management, human resource, financing, and customer [36]. The research conducted in water and waste water company in Qazvin employed MCDM techniques such as T-test and MADM to rank factors affecting human resource productivity [37]. Failure mode prioritization is employed to prioritize risks [38]. Critical management strategies of the construction industry have been prioritized using partial least squares structural equation modelling for the sake of improving the productivity [39]. The combination of MCDM techniques like ANP and DIMATEL to prioritize factors affecting accounting actions [40]. Critical success factors of process management have been prioritized to increase their level of impact using AHP [41]. The

Table 1: Factors of productivity.

Authors	Findings
San et al. [13]	Labor quality has been identified as an important factor to change the levels of productivity in Taiwanese manufacturing industries which will have management and policy implication
Chaudhuri et al. [14]	The results show common firm-specific factors and some industry-specific factors. Capital, investment, and labor productivity are a significant productivity-affecting factors depending on the nature of the industries
Liu and Li [15]	Input growth such as labor and capital and technical progress are important factors to output/efficiency (performance) change
Sarkar et al. [16]	The application of a smart sustainable manufacturing framework can be assisted through efficient labors, smart machines, and minimized energy utilization
Sarkar et al. [17]	The development of sustainable biofuel supply chain and growth resulted of minimizing cost, different aspects of transportation logistics, and energy reduction
Panwar et al. [18]	Imperfect item due to machine breakdown have an impact on the effectiveness of multiwarehouse
Shantideo and Shahare [19]	The application of work study methods improves the practices in the industry and ascertain and rectify production process and production rate problems
Duran et al. [20]	The application of work and time study in all manufacturing and service sectors as a scientific approach raises the efficiency of utilization of the factors of production
Sarkar et al. [21]	Application of queuing models improves productivity through optimizing the waiting or idle time
Parvez et al. [22]	Overall productivity can be improved by considering cycle time of process, total work load on station, identifying bottleneck activities, and redesigning the layout by line balancing with proper industry policy and legislation
Shumon et al. [23]	Effective layout model that solves bottleneck process through balancing process with advanced technology increased the efficiency by 21% and labor productivity by 22%
Gosnell et al. [24]	Identifying management practices and desire for deeper managerial engagement supported with better policy and legislation rigorously examine the determinants of productivity amongst skilled labor
Jeni et al. [25]	Employee’s job performance and productivity can be improved through training and development which improves the staff member’s knowledge, skills, behavior, and attitudes
Yimam [26]	Employee’s performance can be improved through training design, training needs assessment, training delivery style, and training evaluation
Guedes et al. [27]	Operational performance and productivity are positively associated with the level of motivation of the team and implementation of TPM
Kottawatta [28]	Job performance and productivity are strongly correlated with job satisfaction, less absenteeism, organizational commitment, and job involvement

study conducted in construction industry to prioritize construction equipment productivity-affecting factors has employed the structural equation modelling [42].

However, the AHP methodology that incorporates the fuzzy sets [33] and the uncertainties circumstances [34] has become recent concerns of the researcher and gives a better result. So, for choosing a supplier, one can suggest fuzzy logic and this fuzzy logic has been suggested to order communicate preferences in the language [43], while others may advocate AHP methodology [44]. To implement the FAHP methodology for problem solving, the triangle membership functions should be developed to get the pairwise comparison matrix for further decision analysis [45]. Then, comparison ratio of the fuzziness has been identified using triangular membership function [46] and this popular technique is also used by Chang [47]. In the MCDM methodology, during the factor evaluation process, the decision-makers are required to express their choices in terms of the number scales. This is because to capture all possible perceptions related with the subjective response and the lost objective answers to make a better decision [48–51]. FAHP methodology such as AHP can be applied in alone or with combination of other MCDM tools to solve industrial problems. The combination of the fuzzy TOPSIS and FAHP as new methodology have been applied to rate the failure modes [52]. The other MCDM tool, namely, fuzzy decision-making trial and evaluation laboratory (DEMATEL) has been introduce to find the key elements in the supply chain supplier selection problem [53]. In summary, the FAHP methodology can be applied both in service and manufacturing sectors such as banking, supply chain management, and renewable energy [54–60]. The summary of the previous literature is given in Table 2. Identification of productivity-affecting factors in blanket factory is not purely reviewed in the previous literature; in addition to this, prioritizing the factors affecting the textile industries such as blanket factory's productivity in developing countries such as Ethiopia is neglected. To fill this gap, this research is conducted to identify and prioritize productivity-affecting factors of the blanket factory. Summary of related literature has been shown in Table 2.

In general, according to the review of the previous literature which is clearly discussed in the literature review section, a better model that captures the fizziness and uncertainty of decision-making environment is important especially for developing countries such as Ethiopia. To be realistic and more reliable in the decision-making process having subjectivity and fuzziness of the evaluation process, applying fuzzy logic is important. In addition, the decision-making tool and MCDM methodology based on linguistic evaluations will help the business owners to get a better result in terms of prioritizing factors and improving the productivity step by step which is crucial for the blanket industry's competitiveness, survival, and growth. In other way, a MCDM technique is required to prioritize the productivity-affecting factors as the importance of them can help industry managers, operation managers and practitioner, business owners, academicians, and researchers to provide possible solutions to the industry problems. Therefore, a FAHP is applied to prioritize the productivity factors of the blanket factory seems to be the first, so that it fills the gap and contributes to be best of readers' and academicians' knowledge.

3. Materials and Methods

The DBBF P.L.C. in Debre Berhan city, Ethiopia, has been selected and visited to conduct the study. The study is conducted from March 23, 2022 to November 17, 2022. In this section, the different steps of the study have been discussed. Figure 3 displays the flowchart of the research methodology. This figure indicates how most often used productivity-affecting factors from literature review of previous studies were utilized in pair wise comparison analysis to conduct the study. Then, each step has been clearly discussed.

3.1. Idea Generation, Review of Previous Studies, and Gap Identification. In this research, a FAHP model has been developed to prioritize the most important productivity-affecting factors of the blanket factory. According to the review of the related literature in this area, the researcher has realized that the concept is not investigated. Hence, this step helps to identify the most important factors of productivity-affecting factors.

3.2. Extracting the Potential Productivity-Affecting Factors. The review of the literature related with productivity-affecting factors has been indicated in Table 1. In this table, labor quality such as skilled labor, capital and technical progress, application of work and time study, technological advancement, less absenteeism, optimizing waiting, set up time and idle time in production process, effective facility layout and balance of process, implementing good management style, following better industrial policy and legislation, training and development, level of motivation of the team, job satisfaction, organizational responsibility, and absenteeism are the most important productivity-affecting factors. As the productivity-affecting factors for various manufacturing industries varies, the list of potential productivity-affecting factors has been investigated to check which factors are the most common in the blanket factory.

3.3. The FAHP Model Development. In the recent decades, most decisions have been made in the environment where there is insufficient information with uncertainty to predict what the future looks like. Furthermore, a decision-maker's needs for evaluating the options and criteria are invariably ambiguous and have multiple meanings because qualitative attribute evaluation by humans is inherently unique and inaccurate. However, to capture the decision-makers subjective preferences, AHP model integrated with fuzzy set extension provides better results in the decision making process. Therefore, FAHP methodology is used to compute the relative weights using a scale of relative importance [61]. In this phase, the detail steps that the researcher follows to develop the FAHP model for ranking productivity-affecting factors are clearly elaborated.

3.3.1. Define the Problem. Using FAHP method, this study aims to assess and rank the factors affecting blanket production. The model is validated by putting to the test the propositions using a comparison of six factors from well-known Ethiopian blanket factory-DBBF P.L.C. The researcher with the emphasis on the factory's goal has planned to prioritize the most important factors of their output. First, the DBBF P.L.C. is surveyed and the factors for the decision are established by a review of previous literature and other first-hand sources such as the case company experts and respected personnel. Accordingly, six productivity-affecting factors, including A1: skilled employee and on and off job training; A2: management style and employee motivation; A3: operational plan, policy, and legislation; A4: better technology and manufacturing system; A5: production process line balancing; and A6: time and motion study, are used to guide the study's methodology. The problem's primary objective is designated as productivity at the top of the hierarchy. Six productivity-affecting factors that must be ranked are located on the second level.

3.3.2. Create the Pairwise Comparison Matrix. In this step the relative pairwise comparison matrix or the relative importance of different productivity-affecting factors with respect to the goal has been conducted. This is performed with the help of the scale of relative importance [61] as shown in Table 1 below. The questionnaire that contained the factors paired comparison matrix were filled out after group discussion on the dominance of one factor over the other have been decided. Here, a group decision has been made to enhance the reliability of the data in pairwise comparison matrix form for further mathematical computations in the evaluation process. A pairwise comparison matrix has been constructed as a technique input to

Table 2: Summary of related literature.

Authors	Findings
Kumar et al. [35]	The ranking of factors enhance productivity, categorization of the factors into four perspectives, and hierarchy of perspective and action plan as a final outcome of the paper using AHP
Jelodar [36]	The ranking of factors affecting performance (efficiency) in the areas of management, personnel, finance, and customers were segmented and obtained results were ranked using DEA and AHP
Nasrollahi and Zarepour [37]	Analyzing the data using T-test and MADM methods, and then factors affecting productivity of human resource in water and wastewater company in Qazvin have been prioritized using AHP
Aneset al. [38]	The prioritizing failures modes using the so-called risk priority number to improve reliability using FMEA
Hwang [39]	Prioritizing critical management strategies can help the construction industry to improve productivity using partial least squares structural equation modelling
Mohammad et al. [40]	Factors affecting accounting action has been identified and prioritized using the ANP and DIMATEL
Aylin [41]	Critical success factors have been prioritized using AHP to increase their impact on process management
Chandra et al. [42]	Various construction equipment productivity constraints/factors have been identified and quantified using structural equation modelling to improve construction equipment productivity

determine the weights of productivity-affecting factors while using the FAHP method. Considering the general steps in the evaluation process, the detail FAHP method which is applied in this research to rank productivity-affecting factors is presented in Figure 3. In this step, normalizing the pairwise comparison matrix and determining the factors weight have also been performed. Table 3 shows the scale of relative importance with their respective linguistic variables which helps to assign fuzzy weights during pairwise comparison.

3.3.3. Checking Consistency. To check the consistency of the matrix, first we need to determine the weighted sum value of each factor; once it is completed for each factor, the largest Eigen value of a matrix, $\lambda_{\max}$, has been calculated from the summation of products between each element of Eigen vector and the sum of columns of the reciprocal matrix to determine the consistency index (CI) and consistency ratio (CR) as follows:

$$\mathrm{CI} = \frac{\lambda_{\max} - n}{n - 1}, \tag{1}$$

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}}, \tag{2}$$

where n is the number of compared elements in the matrix and RI is the consistency index of randomly generated pairwise matrix and is associated with the number of compared element which have been shown in Table 4.

If the value of CR does not exceed 0.1, one can assume that the matrix is reasonably consistent. So, continue with the process of decision-making using FAHP otherwise acceptable, if it will not exceed 0.1. Otherwise, the whole process should be revised. If the pair wise comparison matrix of the crisp number is consistent, then the pairwise comparison matrix of the fuzzy number of that crisp number matrix is also consistent [46].

3.3.4. Set Up Triangular Fuzzy Numbers (TFNs). In this step, fuzzy pairwise comparison matrix has been developed. The triangular part called membership function that contains the three real values called fuzzy values is generally represented as $A = (l, m, u)$ [61], where l is the lower, m is the middle, and u is the upper ends of the triangle in the X-axis. However, to convert the reciprocal number into fuzzy numbers, equation (3) should be applied. The value between 0 and 1 indicates the degree to which an element belongs to the set A [63, 64]. The fuzzy number A will not contain any members if x1 and $x > u$ [11]. Finally, equation (4) displays the pairwise contribution matrix, where d_{ij}^{k} denotes the kth decision-maker's preference of i^{th} factor over j^{th} factor using TFNs.

$$\widetilde{A}^{-1} = (l, m, u)^{-1} = \left(\frac{1}{u}, \frac{1}{m}, \frac{1}{l}\right), \tag{3}$$

$$\widetilde{A^{k}} = \begin{bmatrix} \widetilde{d_{11}^{k}} & \cdots & \widetilde{d_{1n}^{k}} \\ \vdots & \ddots & \vdots \\ \widetilde{d_{n1}^{k}} & \cdots & \widetilde{d_{nn}^{k}} \end{bmatrix}. \tag{4}$$

3.3.5. Calculate the Weight Value of the Fuzzy Vector. In this step, we need to determine the very important calculations to get the weights of factors as a basis for ranking the productivity-affecting factors:

(a) Determine the fuzzy geometric mean value, $\widetilde{r}_i$

Using equation (5), it is possible to determine the fuzzy geometric mean of each factor.

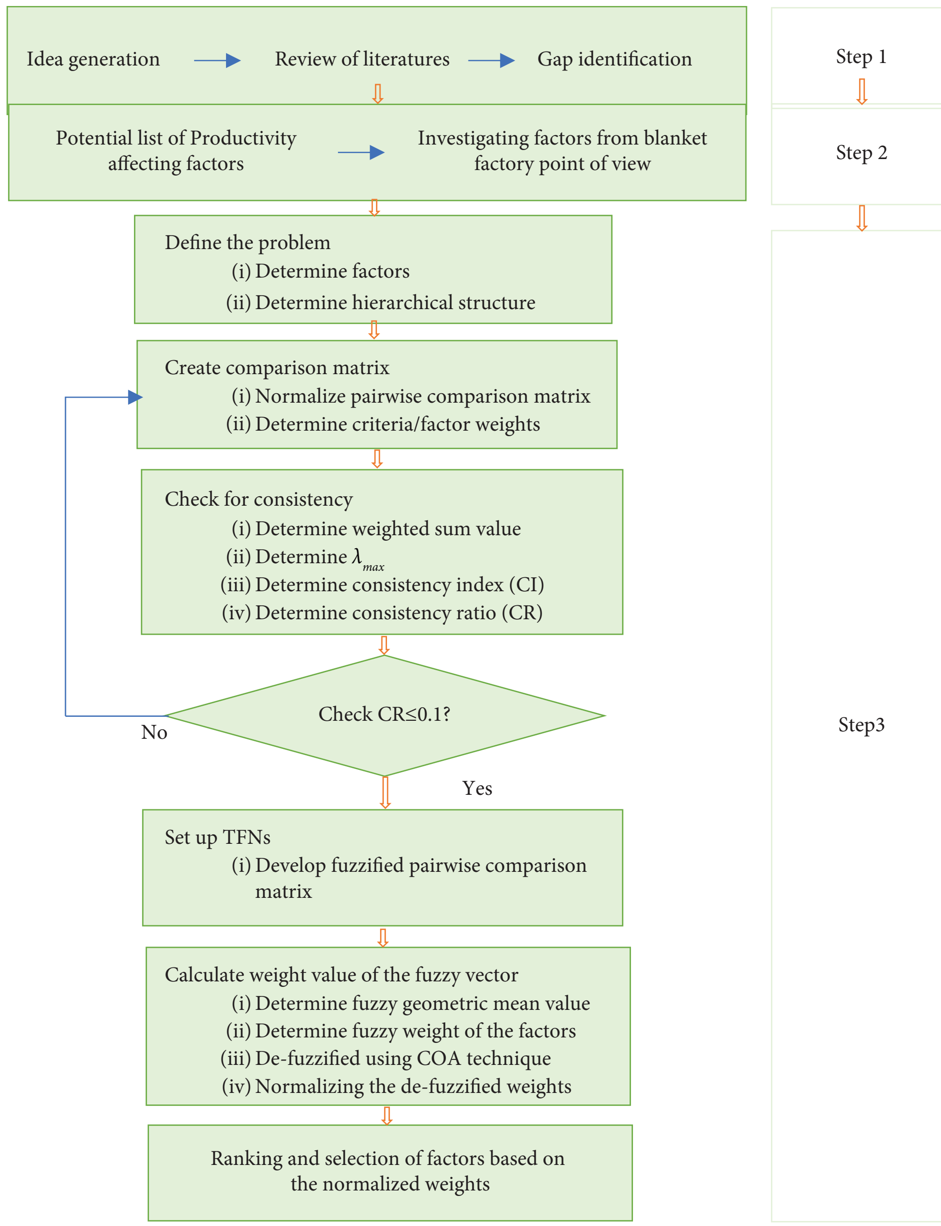

Figure 3: Flow chart of the research methodology.

Table 3: Scale of relative importance.

Saaty scale/intensity of importance	Definition/linguistic variables
1	Equally importance
3	Moderately importance
5	Strong importance
7	Very strong importance
9	Extremely importance
2, 4, 6, 8	Intermediate values

$$\tilde{r}_i = \left(\prod_{j=1}^{n} \tilde{d}_{ij} \right)^{1/n}. \tag{5}$$

(b) Determine the fuzzy weight of productivity-affecting factors, $\widetilde{W}_i$

Using equation (6), fuzzy weight of each factor have been determined.

$$\widetilde{W}_i = \tilde{r}_i \otimes \left(\tilde{r}_i \oplus \tilde{r}_2 \oplus \ldots\ldots\ldots \oplus \tilde{r}_n\right)^{-1}. \tag{6}$$

(c) Defuzzification using center of area (COA)

Using COA technique in equation (7), we defuzzified the fuzzy numbers to get crisp numeric value [66].

$$M_1 = \frac{lw_i + mw_i + uw_i}{3}. \tag{7}$$

(d). Normalizing the defuzzified weights

In most cases, the total of the factors weight is more than one which is not acceptable. So, the weights are

Table 4: Randomly generated RI matrix [62].

n	1	2	3	4	5	6	7	8	9	10	11	12	13
RI	0.001	0.001	0.58	0.89	1.12	1.24	1.33	1.40	1.45	1.49	1.51	1.54	1.56

generally normalized to get the weight total as one. In this case, we applied equation (8) to get normalized weight for final ranking and selection.

$$N_i = \frac{M_i}{\sum_{i=1}^{n} M_i}. \quad (8)$$

4. Result and Discussion

The required information is gathered, and detail analysis has been conducted using the research methodology shown in Figure 3.

As it was clearly defined in the methodology part as step one, the goal of the hierarchy is defined as improving productivity and factors affecting the productivity from the literature and inputs from the company management personnel, the data have been collected in summarized form in accordance with six by six matrix. The first-hand data have been collected in the form of crisp numerical value from the respondents which have been seen in Table 5.

Table 5: The first-hand data collected from the case company.

Factors	A1	A2	A3	A4	A5	A6
A1	1	4	6	3	1/2	5
A2	¼	1	2	1/3	1/5	2
A3	1/6	1/2	1	1/3	1/5	1/4
A4	1/3	3	3	1	1/3	2
A5	2	5	5	3	1	5
A6	0.2	1/2	4	1/2	1/5	1
Sum	3.947	14	21	8.16	2.43	15.25

To determine the factors weight, first we need to determine normalized weight of each factor. For this, the crisp numeric value at each column has been divided by the total sum of the respective column and the result is shown in Table 6.

Table 6: Normalized pairwise comparison matrix.

Factors	A1	A2	A3	A4	A5	A6	Factor weights
A1	0.2534	0.2857	0.2857	0.3676	0.2058	0.3279	0.2877
A2	0.0633	0.0714	0.0952	0.0404	0.0823	0.1311	0.0806
A3	0.0423	0.0357	0.0476	0.0404	0.0823	0.0164	0.0441
A4	0.0836	0.2143	0.1429	0.1225	0.1358	0.1311	0.1384
A5	0.5067	0.3571	0.2381	0.3676	0.4115	0.3279	0.3682
A6	0.0507	0.0357	0.1905	0.0613	0.0823	0.0656	0.081

After the weight of the factor has been determined, the next is about the consistency ratio of the data. To do this, first, the weighted sum value of the factors and the maximum Eigen value have been determined. Then, using equation (1), the consistency index has been determined. Finally, using equation (2) and Table 4 (to refer the number of compared elements), the consistency ratio is determined to check whether the value exceed 0.1 or not and the result is shown in Table 7.

Once the consistency ratio of the first-hand data has been checked which is consistent, the equivalent fuzzy data in matrix form is assumed to be consistent. So, using Table 8, equations (3) and (4), and Figure 4, the fuzzy comparison matrix has been developed and is shown in Table 9.

The lower, middle, and upper points of the fuzzy geometric mean of each productivity-affecting factor have been computed using Equation (5). For instance, to get the lower point of the skilled employee and on and off job training's fuzzy geometric mean, one can multiply the lower point of this factor raw wise and take the sixth root of the product, i.e., $\widetilde{r_1} = (1 * 3 * 5 * 2 * 1/3 * 4)^{1/6} = 1.8493$. Similar procedure has been applied to get the middle and upper points of the fuzzy geometric mean of each factor. The result is shown in Table 10.

The lower, middle, and upper points of the fuzzy weights of the factors have been computed using equation (6). For this, first, add up the lower point of the fuzzy geometric mean of the factors, then take the reciprocal of it. Follow the same procedure for middle and upper points. Then, put them in an increasing order as shown in Table 10. For instance, the fuzzy weight of skilled employee and on and off job training shown in Table 11 is computed as $\widetilde{W_1} = (1.8493 * 0.096, 2.3761 * 0.1239, 3.0717 * 0.1648) = (0.1776, 0.2945, 0.5062)$.

Once we get the fuzzy weight of each factor, the defuzzified weight have been computed using equation (7). In this step, the center of area technique has been applied to get the average of the lower, middle, and upper point of each factor. For instance, the defuzzified weight of skilled employee and on and off job training which is shown in Table 12 is computed as $M_1 = (0.1776 + 0.2945 + 0.5062)/3 = 0.3261$.

In most cases, the sum of the defuzzified weight of the factors may not be exactly 1. In such a case, normalizing the weight of the factors is mandatory to the sum of the weights of the six factors are assumed to be 1. In this case, as shown in Table 12, the sum is 0.9079. Then, using equation (8), the defuzzified weight of each factor has been divided by 0.9079 and the results are shown in Table 13. Hence, the productivity-affecting factors have been ranked based on this result.

Based on the normalized result shown in Table 13, the factors called skilled employee and on and off job training and production process line balancing are ranked first and second, respectively. Likewise, better technology and manufacturing system, management style and employee motivation, time and motion study, and operational plan, policy, and legislation have taken the next priorities. Figure 5 clearly visualizes the weight of the factors as the defuzzified and normalized weights.

Table 7: Consistency ratio.

Criteria weights	0.2877 A1	0.0806 A2	0.0441 A3	0.1384 A4	0.3682 A5	0.081 A6	Criteria weights	Weighted sum value	CI=(λmax-n)/(n-1)	CR (Validation, is the value ≤ 0.1?)
A1	0.2877	0.3226	0.2648	0.4151	0.1841	0.405	0.2877	1.8793		
A2	0.0719	0.0806	0.0883	0.0457	0.0736	0.162	0.0806	0.5221		
A3	0.048	0.0403	0.0441	0.0457	0.0736	0.0203	0.0441	0.2721	0.074894343	0.0603 (yes)
A4	0.0949	0.2419	0.1324	0.1384	0.1215	0.162	0.1384	0.8912		
A5	0.5754	0.4032	0.2207	0.4151	0.3682	0.405	0.3682	2.3876		
A6	0.0575	0.0403	0.1765	0.0692	0.0736	0.081	0.081	0.49820		

Table 8: Fuzzy scale of relative importance.

Saaty scale/intensity of importance	Definition/linguistic variables	TFNs
1	Equally importance	(1, 1, 1)
3	Moderately importance	(2, 3, 4)
5	Strong importance	(4, 5, 6)
7	Very strong importance	(6, 7, 8)
9	Extremely importance	(9, 9, 9)
2	Intermediate values	(1, 2, 3)
4		(3, 4, 5)
6		(5, 6, 7)
8		(7, 8, 9)

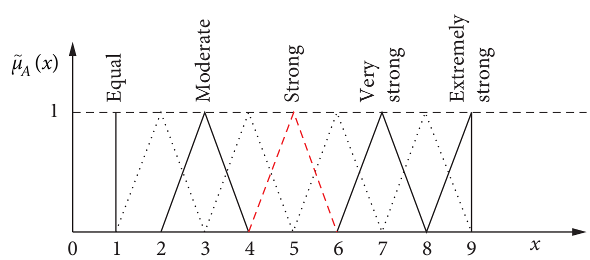

Figure 4: A triangular fuzzy numbers [65].

Table 9: Set up TFNs to develop fuzzy comparison matrix.

	A1	A2	A3	A4	A5	A6
A1	(1, 1, 1)	(3, 4, 5)	(5, 6, 7)	(2, 3, 4)	(1/3, ½, 1)	(4, 5, 6)
A2	(1/5, ¼, 1/3)	(1, 1, 1)	(1, 2, 3)	(1/4, 1/3, 1/2)	(1/6, 1/5, 1/4)	(1, 2, 3)
A3	(1/7, 1/6, 1/5)	(1/3, 1/2, 1)	(1, 1, 1)	(1/4, 1/3, 1/2)	(1/6, 1/5, 1/4)	(1/5, 1/4, 1/3)
A4	(1/4, 1/3, 1/2)	(2, 3, 4)	(2, 3, 4)	(1, 1, 1)	(1/4, 1/3, 1/2)	(1, 2, 3)
A5	(1, 2, 3)	(4, 5, 6)	(4, 5, 6)	(2, 3, 4)	(1, 1, 1)	(4, 5, 6)
A6	(1/6, 1/5, 1/4)	(1/3, 1/2, 1)	(3, 4, 5)	(1/3, 1/2, 1)	(1/6, 1/5, 1/4)	(1, 1, 1)

Table 10: Fuzzy geometric mean of productivity-affecting factors.

Factors	Fuzzy geometric mean, $\tilde{\mathbf{r}}_\mathbf{i}$		
	l	m	u
A1	1.8493	2.3761	3.0717
A2	0.4503	0.6368	0.8492
A3	0.2711	0.334	0.4503
A4	0.7937	1.122	1.5131
A5	2.245	3.0142	3.7063
A6	0.4582	0.5848	0.8238
Sum	6.0676	8.0679	10.4144
Reciprocal of the sum	0.1648	0.1239	0.096
Increasing order	0.096	0.1239	0.1648

Table 11: Computation of the fuzzy weights of the factors.

Factors	Fuzzy weight $(\widetilde{\mathbf{W}}_i)$		
	l	m	u
A1	0.1776	0.2945	0.5062
A2	0.0432	0.0789	0.1400
A3	0.026	0.0414	0.0742
A4	0.0762	0.1391	0.2494
A5	0.2156	0.3736	0.0355
A6	0.044	0.0725	0.1358

Table 12: Computation of the nonfuzzy weight of the factors.

Factors	Nonfuzzy weights
Skilled employee and on and off job training	0.3261
Management style and employee motivation	0.0874
Operational plan, policy, and legislation	0.0472
Better technology and manufacturing system	0.1549
Production process line balancing	0.2082
Time and motion study	0.0841
Sum	0.9079

Table 13: Normalized weight of the factors.

Factors	Normalized weights	Ranking
Skilled employee and on and off job training	0.3592	1
Management style and employee motivation	0.0962	4
Operational plan, policy, and legislation	0.052	6
Better technology and manufacturing system	0.1706	3
Production process line balancing	0.2294	2
Time and motion study	0.0926	5
Sum	1	

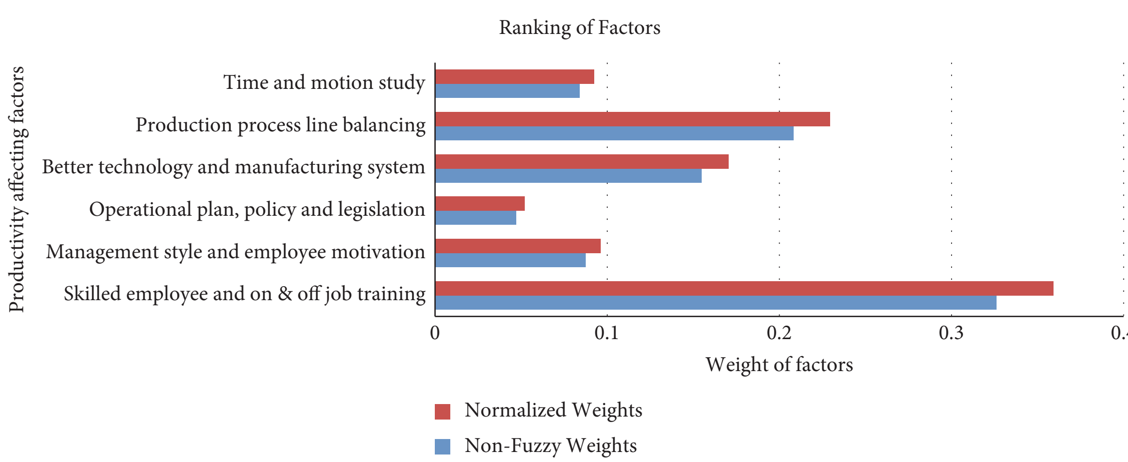

Figure 5: Weight comparison of each factor for ranking.

5. Conclusions

This research applied the FAHP model to prioritize productivity-affecting factors of blanket factory. This research has been conducted using the following main steps: at the beginning, productivity-affecting factors have been identified from previous literature. Then, as there are many productivity-affecting factors in different manufacturing sectors, the list of potential productivity-affecting factors has been investigated to check which factors are most common in blanket factory. Finally, a FAHP model has been applied to prioritize productivity-affecting factors. The result showed that skilled employee and on and off job training, production process line balancing, better technology and manufacturing system, management style and employee motivation, time and motion study, and operational plan, policy, and legislation are the most important productivity-affecting factors in the blanket factory, respectively.

5.1. Benefits of the Study. As an important scientific contribution, the ranked productivity-affecting factors shown in Table 13 can be more considered by industry managers, operation managers and practitioners, business owners, academicians, and researchers before productivity improvement process. Skilled employee and on and off job training are the most important factor to be considered by the management staff and business owners as the problem related with it might causes serious productivity problems during and after the production process. Following this, it is important for the business owners make line balancing in production processes so that it reduces the bottlenecks and nonvalue adding activities. Thirdly, better technology and manufacturing system has been considered as an important factor to improve productivity. Unable to advance technology in regular time interval might result in not competing and sustaining in the business. It is important for the business owners to employ the right management style and employee motivation mechanisms for the level of increasing the satisfaction as well as productivity of the workers. Futhermore, problems related with time and motion study should be considered to remove wasteful motion and to complete tasks more quickly. Lastly, operational plan, policy, and legislation problems should be considered as an important factor of productivity so as to set organizational goals and define the outcomes to measure daily tasks against it. Hence, as theoretical implication, the result of this research is considered by academician and researchers to examine the productivity-affecting factors and the management as well as the business owners can address the problems with proper investment attention. Even if the main productivity-affecting factors have been addressed in this research, there is a prominent limitation that will be addressed in future researches. The limitation is insufficient knowledge of what productivity is and how it is related with different factors as the concept is not well considered in developing countries such as Ethiopia. So, considering productivity-affecting factors in developing countries will provide tremendous result for business owners and the community. Therefore, as a research implication the prioritizing of factor can be examine in other manufacturing sectors as practical implication managers can examine these factors in the industry that they work to solve productivity related problems.

5.2. Future Extensions of the Study. In the future, the developed research procedure can be applied to rank productivity-affecting factors of other manufacturing industry sectors. In addition to this, other MCDM tools can be employed to be compare the result with a FAHP methodology, one can apply AHP software to determine and validate the results of the consistency ratio accuracy and other computations.

Data Availability

The data sets are taken from the case company called Debre Berhan blanket factory (DBBF) P.L.C to support the finding of the current study and are available from the corresponding author on reasonable request.

Conflicts of Interest

The author declares no conflicts of interest.

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