**Research Paper**

# Understanding the drivers of marker efficiency for improved fabric utilization in apparel production: an analytical approach

**Md. Taslim[1], Mohammad Tanvirul Hasnat[2*]**
[1]General Manager, Sterling Denims Ltd. Kohinoor Gate, Nayarhat, Savar, Dhaka 1350, Bangladesh.
[2*]Sr. Trainer, Sterling Denims Ltd. Kohinoor Gate, Nayarhat, Savar, Dhaka 1350, Bangladesh.

**Article Info**

***Article History:***
Received: 27 September 2025
Revised: 07 December 2025
Accepted: 13 December 2025
Published: 30 January 2026

***Keywords:***
Pearson Correlation Coefficient
Marker Efficiency
Marker Length
Marker Width

**ABSTRACT**

Purpose: This study aims to investigate and identify the critical factors that exert a statistically significant influence on marker efficiency, with the ultimate goal of optimizing fabric utilization and minimizing material wastage in readymade garment (RMG) production.
Methods: A quantitative research approach was utilized, analyzing primary data from 56 woven markers collected across three factories. The analysis employed Pearson Correlation Coefficients for relationship assessment, one-tailed hypothesis testing to confirm directional impact, and Multiple Linear Regression (MLR) followed by an ANOVA Test to assess the collective predictive power of the independent variables.
Results: The MLR model predicting Marker Efficiency was statistically significant Prob (F-statistic = 0.000), explaining 32.72% (R2) of the variance. The Hypothesis Testing confirmed a statistically significant positive impact from Marker Length (r =0.4901), the strongest correlation). Marker Pieces (r = 0.3536). Functional Area (r = 0.3515). In contrast, Marker Width was found to have no statistically significant linear relationship (p = 0.1861). An almost perfect positive correlation was observed between Marker Efficiency and Fabric Utilization (r=0.9985).

*Corresponding Author:*
Mohammad Tanvirul Hasnat
Sr. Trainer, Sterling Denims Ltd. Kohinoor Gate, Nayarhat, Savar, Dhaka-1350, Bangladesh.
Email: tanvirulhasnat397@gmail.com

# 1. INTRODUCTION

The textile industry is one of the most dynamic and fast-expanding sectors, contributing greatly to business growth and economic development. In the face of rising global competition, it presents vast scope for researchers and industry professionals to introduce innovative solutions and technologies that can effectively tackle existing challenges [1]. The readymade garments (RMG) sector is the largest industrial industry in Bangladesh, playing a vital role in the national economy through its significant contribution to GDP, foreign currency earnings, and employment opportunities. Throughout the last five years, RMG consistently accounted for more than 81% of the country's total exports, underscoring its dominant role in the national economy which is described in Table 1. The RMG industry in Bangladesh provides employment to millions of local workers, making it the country's largest single source of jobs. Both foreign exchange earnings and employment opportunities in the RMG sector are growing steadily each year [2].

Table 1. Bangladesh RMG Export Growth in the Last Five Years

| Year | Export of RMG in Million USD | Total Export of Bangladesh in Million USD | % Of RMG's to Total Export |
|---|---|---|---|
| 2020-21 | 31456.73 | 38758.31 | 81.16 |
| 2021-22 | 42613.15 | 52082.66 | 81.82 |
| 2022-23 | 38142.1 | 46430.71 | 82.15 |
| 2023-24 | 36151.31 | 44469.74 | 81.29 |
| 2024-25 | 39346.97 | 48283.93 | 81.49 |

In most cases, woven garment factories rely heavily on imported fabrics, which leads to a significant outflow of foreign currency to the countries that supply these materials. It is noted that 10–15% unavoidable wastage occurs during cutting and marker making. While larger pattern pieces generally improve marker efficiency and reduce fabric usage, in the case of extremely large sizes (such as 3XL), marker efficiency tends to decline even though fabric consumption rises [3]. Textile waste can generally be divided into two main types: pre-consumer waste and post-consumer waste. Pre-consumer waste refers to the material discarded during the production process, such as fabric edges, cuttings, and leftover scraps generated on factory floors while manufacturing garments. Post-consumer waste, on the other hand, comes from products that have already been used, including discarded clothing, towels, bed linens, carpets, rugs, upholstery, and other household textile items [4]. This study is focused on pre-consumer waste in the RMG industry aims to find out a way to reduce the wastage. Marker efficiency plays a crucial role in determining the amount of fabric wasted during garment production. A marker refers to the layout plan of pattern pieces on the fabric, designed to make the best possible use of the material. Higher marker efficiency means the patterns are arranged more compactly, allowing for maximum fabric utilization and reducing leftover scraps. Conversely, poor marker efficiency results in more gaps between pattern pieces, leading to greater fabric waste and increased production costs. Therefore, optimizing marker efficiency is essential for achieving cost-effective and sustainable apparel manufacturing. If we want to optimize the marker efficiency, we must focus on factors that affect marker efficiency. This study is focused on those factors.

### Problem Statement

Approximately 60–70% of global fabric production is consumed in apparel manufacturing, while the rest is utilized in areas such as home furnishings and industrial textiles [5]. Marker making is very important because raw material cost is from 50–60 % of the total cost in apparel industry. It means that if we can save 2 % of the fabric, we can increase 1% profit margin [6].

According to EEA (European environment Agency) worldwide cloth end up wasting is anticipated of between sprout through 25% among 2023 - 24 which is described in Figure 1 but also mid - century. Solely 20% of both the end up wasting would be gathered, and indeed the percentage of what had to be used in textile and apparel seems to be recirculated in to the new stuff is amazingly drop which is shown in Figure 1 (less than 1% of usable reusable material) [7].

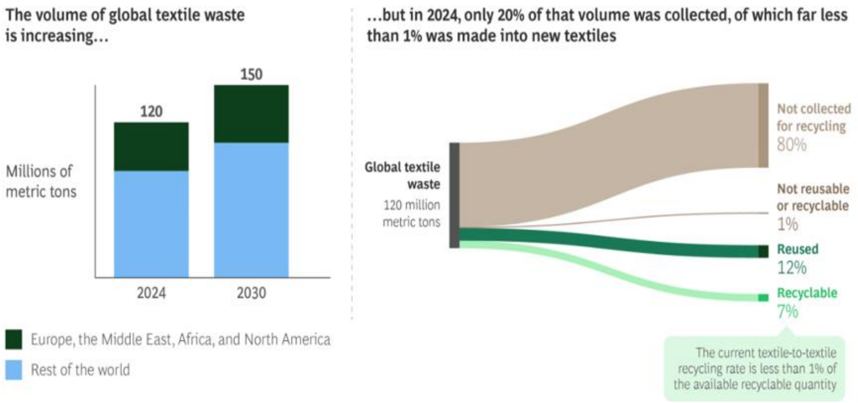


Figure 1. Global Textile Waste and Recycling

### Signiface of the Research

The study is significant in understanding the which impact marker efficiency & cost in garment manufacturing. Research Aim is t o identify the factors that impact of marker efficiency & increase fabric utilization by reducing fabric wastage.

## 2. RELATED WORK

### 2.1. Marker Efficiency Across Garments Sizes

Marker efficiency and fabric use vary by garment size. From XS to XL efficiency improves slightly, but fabric consumption still increases because the patterns get bigger. For XXL efficiency drops again and fabric use rises sharply, showing that this size needs much more material. The mixed-size marker performs the best overall, reaching an efficiency of 89.05%, making it one of the most effective layout options [8]. We have also found the same higher efficiency on mixed sizes & the lowest efficiency on a single size.

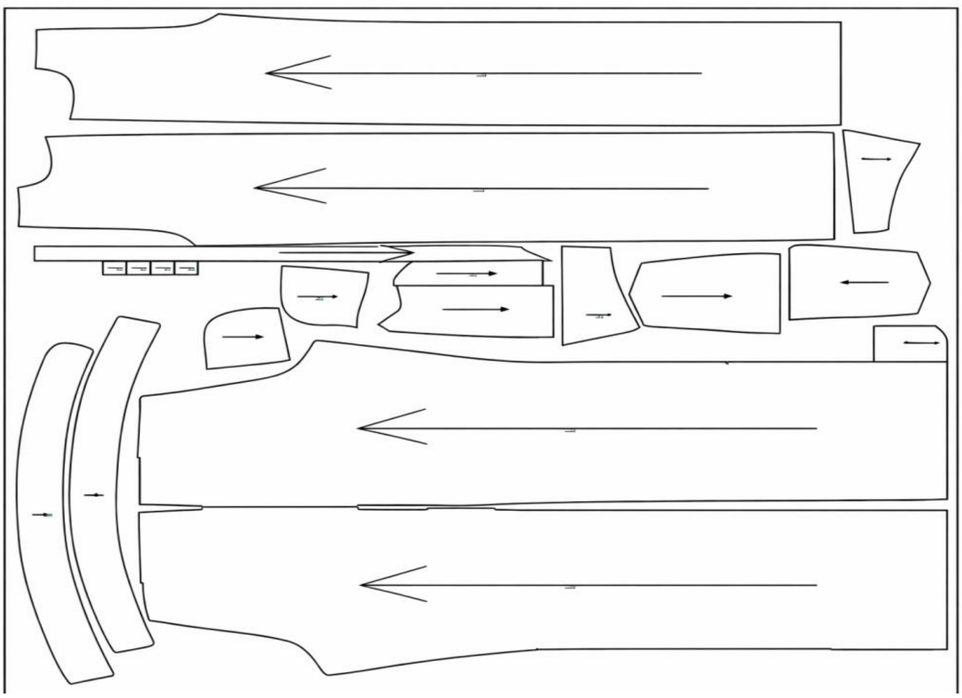

Figure 2. Marker Making for 1 Size Garment

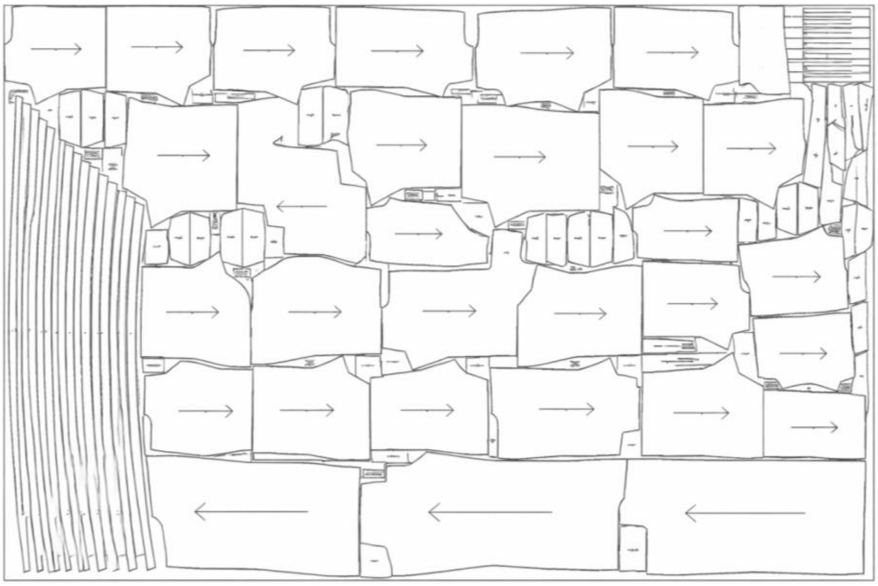

Figure 3. Marker Making for a Combination of 10 Sizes Garment

We also found the significant improvement in marker efficiency from 77.8% which is showed in Figure 2 for a single garment size to 90.7% for a 10-size combination demonstrates a crucial principle in apparel manufacturing fabric utilization which is shiwed in Figure 3. This substantial gain of over 16 percentage points is achieved through advanced pattern nesting, where the varying shapes and contours of multiple sizes interlock more tightly, dramatically minimizing the wasted fabric area in the cutting marker. This optimized layout is vital for large-scale production, directly translating to considerable material cost savings and enhanced sustainability by reducing textile scrap.

### 2.2. Marker Efficiency Across Fabric Width, Style and Size Combination

Marker efficiency varied significantly depending on fabric width, size-combination and style-combination. Combining multiple sizes in one marker (multi-size marker) led to higher marker efficiencies than single-size markers in many cases. There was also a significant interaction effect between these two variables. Fabric width matters: some widths gave better efficiencies, indicating that choosing optimum usable width is a relevant decision [9].

### 2.3. Marker Efficiency Across Fabric Shrinkage

A study on Mans shirt found that fabric shrinkage and the ratio of garment sizes included in a marker have a clear impact on how efficiently fabric can be used. As shrinkage percentages increased, marker efficiency improved, meaning the pattern pieces were arranged more effectively on the fabric. The effect on fabric consumption, however, was not linear: when shrinkage was set at 2% in both length and width, the amount of fabric required per shirt increased, but at 3% shrinkage the consumption dropped again. The results also showed that different size combinations produced noticeable variations in both efficiency and consumption, indicating that selecting the right size ratio is important for minimizing fabric waste in shirt production [10]. H. Bilgiç and P. D. Baykal showed that A weak positive correlation between fabric width and marker efficiency (Pearson coefficient 0.367). A weak positive correlation for the total number of patterns vs. efficiency (Pearson coefficient 0.356), and a moderate positive correlation for the number of small patterns vs. efficiency (Pearson coefficient 0.548) [11].

## 3. METHODOLOGY

### 3.1. Conceptual Framework

The proposed relationships between several factors (independent variables) and the outcome of Marker Efficiency which is illustrated & described with Figure 4.

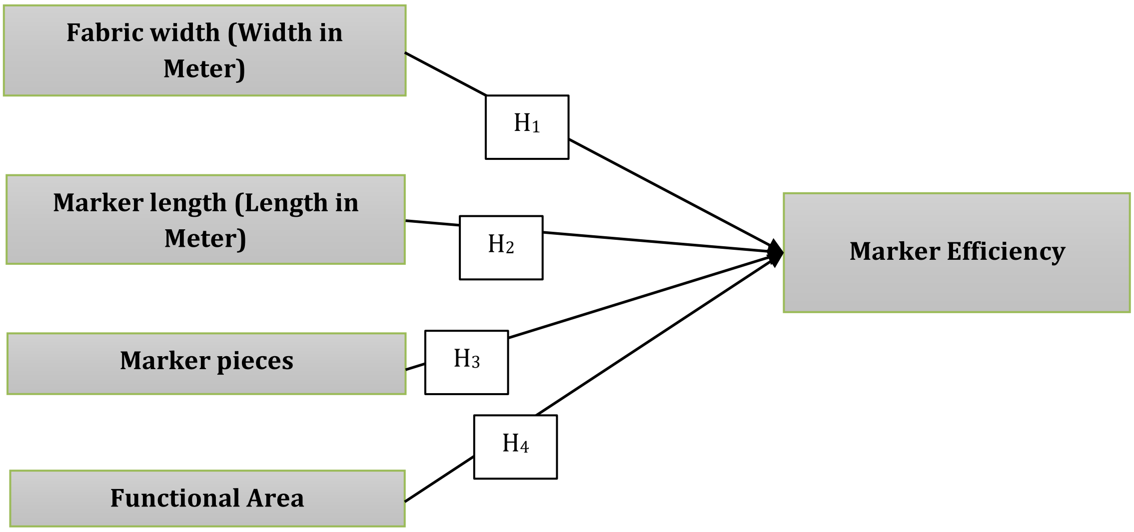


Figure 4. Proposed a Conceptual Framework for the Study

### 3.2. Hypotheses Development

H1: Alternative Hypothesis: There is a positive impact of Fabric width on Marker efficiency & Fabric Utilization.

H0: Null Hypothesis: There is no impact of fabric width on Marker Efficiency & fabric utilization.

H2: Alternative Hypothesis: There is a positive impact of Marker Length on Marker efficiency & Fabric Utilization.

H0: Null Hypothesis: There is no impact of Marker Length on Marker efficiency & Fabric Utilization.

H3: Alternative Hypothesis: There is a positive impact of Marker pieces on Marker efficiency & Fabric Utilization.

H0: Null Hypothesis: There is no impact of Marker pieces on Marker efficiency & Fabric Utilization.

H4: Alternative Hypothesis: There is a positive impact of functional area on Marker efficiency & Fabric Utilization.

H0: Null Hypothesis: There is no impact of functional area on Marker efficiency & Fabric Utilization.

### 3.3. Data Collection

Primary data collection has been selected as the data type that the present research study is using in investigating and collecting data from three different factories in Bangladesh related with woven bottom item only. The author collected a combination of 56 markers from different buyers. The makers range from 1 to 30 pieces which is employed in Table 2.

Table 2. Date Collection

| | Buyer | Style | Marker Pieces | Functional Area ($M^2$) | Plies | Length in Meter | Width in Meter | Total Functional Area (M2) | Total Lay Area (M2) | Marker Efficiency | Fabric Utilization % | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ARDENE | DP-520-MID RIPED HEM | 12 | 17.54 | 101 | | 11.32 | 1.71 | 1771.91 | 1959.48 | 90.67 % | 90.43 % | 109.40 |
| 2 | ARDENE | DP-512-LIGHT | 15 | 25.26 | 100 | | 15.93 | 1.71 | 2526.44 | 2730.48 | 92.73 % | 92.53 % | 119.01 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | EURODESH | 02318148 GT-28''-P2-BLUE | 10 | 16.08 | 72 | | 13.39 | 1.36 | 1157.83 | 1309.68 | 88.50 % | 88.41 % | 111.74 |
| 4 | EURODESH | 02318148 GT-28''-P2-BLUE | 10 | 15.92 | 60 | | 13.09 | 1.38 | 955.27 | 1087.54 | 87.91 % | 87.84 % | 95.54 |
| 5 | COSTCO | WHARF-CHARCOAL | 22 | 25.52 | 202 | | 19.13 | 1.48 | 5154.97 | 5716.23 | 90.33 % | 90.18 % | 379.35 |
| 6 | COSTCO | WHARF-BLACK STRIP | 17 | 19.70 | 180 | | 15.60 | 1.46 | 3546.90 | 4099.93 | 86.61 % | 86.51 % | 378.66 |
| 7 | EURODESH | 02318148GT-28''-P-2 | 10 | 16.08 | 68 | | 13.50 | 1.35 | 1093.21 | 1235.82 | 88.51 % | 88.46 % | 105.94 |
| 8 | EURODESH | 02318148GT-30''-BLUE | 5 | 8.03 | 99 | | 6.45 | 1.41 | 794.92 | 900.39 | 88.38 % | 88.29 % | 74.82 |
| 9 | EURODESH | 02318148GT-30''-BLUE | 5 | 8.09 | 104 | | 6.71 | 1.37 | 841.13 | 956.53 | 88.20 % | 87.94 % | 84.13 |
| 10 | EURODESH | 02318148GT-30''-BLUE | 5 | 8.02 | 71 | | 6.71 | 1.37 | 569.09 | 653.02 | 87.41 % | 87.15 % | 61.19 |
| 11 | SIPLEC | EFCTTBP TDENS LIM STONE | 16 | 11.02 | 98 | | 7.59 | 1.63 | 1080.29 | 1209.89 | 89.45 % | 89.29 % | 79.72 |
| 12 | ARDENE | DP 512-F4 | 10 | 16.81 | 48 | | 10.69 | 1.71 | 806.81 | 880.02 | 91.84 % | 91.68 % | 42.70 |
| 13 | ARDENE | DP-512-F4 | 10 | 16.75 | 52 | | 10.74 | 1.70 | 871.20 | 950.79 | 91.72 % | 91.63 % | 46.77 |
| 14 | EURODESH | 02318148GT-30'' | 6 | 9.31 | 113 | | 7.61 | 1.38 | 1052.49 | 1189.98 | 88.60 % | 88.45 % | 99.32 |
| 15 | EURODESH | 02318148GT-30'' | 10 | 16.77 | 95 | | 13.68 | 1.37 | 1593.46 | 1782.26 | 89.49 % | 89.41 % | 137.65 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 | ARDENE | DP-512-F4 | 7 | 11.50 | 73 | | 7.32 | 1.71 | 839.25 | 915.56 | 92.02% | 91.67% | 44.51 |
| 17 | ARDENE | DP-512-F4 | 12 | 19.99 | 92 | | 12.64 | 1.71 | 1838.80 | 1993.21 | 92.35% | 92.25% | 90.06 |
| 18 | COLINS | 1019142-32'' | 12 | 21.43 | 116 | | 15.51 | 1.52 | 2485.59 | 2729.91 | 91.30% | 91.05% | 160.99 |
| 19 | EURODESH | 02318148GT-30''-BLUE | 8 | 13.05 | 75 | | 11.01 | 1.35 | 978.95 | 1111.72 | 88.47% | 88.06% | 98.62 |
| 20 | ARDENE | DP-512-F4-MID | 12 | 19.87 | 57 | | 12.57 | 1.73 | 1132.38 | 1237.82 | 91.68% | 91.48% | 61.05 |
| 21 | COLINS | 1019142-32''-MID TROY | 13 | 23.12 | 127 | | 16.70 | 1.52 | 2936.07 | 3218.88 | 91.25% | 91.21% | 186.35 |
| 22 | COLINS | 1019141-32''-MID TROY | 14 | 23.22 | 125 | | 17.02 | 1.52 | 2902.04 | 3228.42 | 90.03% | 89.89% | 215.06 |
| 23 | EURODESH | 02318148GT-30'' | 12 | 19.73 | 89 | | 16.61 | 1.35 | 1755.99 | 1990.27 | 88.41% | 88.23% | 174.03 |
| 24 | COLINS | 1048831-32''-DARK PARIS | 11 | 16.43 | 102 | | 12.51 | 1.45 | 1676.21 | 1847.35 | 90.83% | 90.74% | 118.21 |
| 25 | COLINS | 1019135-32''-LIGHT TROY | 12 | 21.07 | 125 | | 15.29 | 1.52 | 2633.24 | 2900.76 | 90.90% | 90.78% | 176.27 |
| 26 | COLINS | 1047569-32''-MID TROY | 12 | 18.87 | 117 | | 13.72 | 1.52 | 2207.43 | 2435.48 | 90.70% | 90.64% | 150.27 |
| 27 | COLINS | 1019135-30''-LIGHT TROY | 5 | 8.44 | 96 | | 6.16 | 1.52 | 810.70 | 897.40 | 90.57% | 90.34% | 57.13 |
| 28 | COSTCO | WHARF-CHARCOAL | 12 | 13.74 | 203 | | 10.35 | 1.48 | 2789.28 | 3108.76 | 89.84% | 89.72% | 215.93 |
| 29 | COLINS | 1047569-32''-MID TROY | 8 | 12.64 | 100 | | 9.23 | 1.52 | 1264.45 | 1401.23 | 90.37% | 90.24% | 90.13 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 30 | COLINS | 1019135-34''-LIGHT TROY | 10 | 18.88 | 106 | | 13.68 | 1.52 | 2001.03 | 2200.38 | 91.03% | 90.94% | 131.35 |
| 31 | COLINS | 1019140-32''-NAVY TROY | 7 | 11.43 | 115 | | 8.36 | 1.52 | 1314.40 | 1458.48 | 90.13% | 90.12% | 94.93 |
| 32 | COSTCO | WHARF-KHAKI | 11 | 12.81 | 206 | | 9.96 | 1.47 | 2639.70 | 3021.68 | 87.43% | 87.36% | 259.29 |
| 33 | COLINS | 1019135-32''-LIGHT TROY | 7 | 11.83 | 88 | | 8.66 | 1.52 | 1041.18 | 1156.76 | 90.35% | 90.01% | 76.16 |
| 34 | COLINS | 1048741-28''-MID PARIS | 5 | 5.91 | 95 | | 4.67 | 1.44 | 561.91 | 637.62 | 88.54% | 88.13% | 52.72 |
| 35 | COLINS | 1048831-30''-DARK PARIS | 5 | 7.57 | 87 | | 6.05 | 1.40 | 658.62 | 734.73 | 90.02% | 89.64% | 54.48 |
| 36 | COLINS | 1048831-34''-DARK PARIS | 9 | 14.85 | 78 | | 11.33 | 1.44 | 1157.94 | 1273.69 | 91.18% | 90.91% | 80.30 |
| 37 | COLINS | 1019135-32''-LIGHT TROY | 12 | 21.13 | 130 | | 15.46 | 1.52 | 2747.00 | 3049.36 | 90.20% | 90.08% | 199.23 |
| 38 | COLINS | 1019141-34''-MID TROY | 9 | 16.01 | 100 | | 11.73 | 1.52 | 1601.21 | 1780.93 | 90.01% | 89.91% | 118.42 |
| 39 | H&M | BEPPE LOOSE - JUDE WASH | 30 | 26.77 | 100 | | 18.08 | 1.62 | 2676.54 | 2928.38 | 91.40% | 91.40% | 155.53 |
| 40 | H&M | Indiana Wide HW - CAROL | 15 | 28.00 | 100 | | 19.33 | 1.57 | 2800.47 | 3043.99 | 92.00% | 92.00% | 154.64 |
| 41 | H&M | LOOSE BARREL | 17 | 14.52 | 100 | | 10.19 | 1.54 | 1452.50 | 1565.19 | 92.80% | 92.80% | 73.33 |
| 42 | H&M | BEPPE LOOSE - COAST WASH | 30 | 26.12 | 106 | | 17.68 | 1.63 | 2769.02 | 3046.23 | 90.90% | 90.90% | 170.53 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 43 | H&M | Indiana Wide HW - Rinse HM | 15 | 26.40 | 84 | | 18.21 | 1.59 | 2217.26 | 2428.54 | 91.30% | 91.30% | 133.09 |
| 44 | H&M | STRAIGHT LOOSE | 10 | 17.55 | 100 | | 11.89 | 1.63 | 1754.60 | 1932.38 | 90.80% | 90.80% | 109.36 |
| 45 | H&M | MADISON HW SKINNY JEANS | 18 | 24.23 | 120 | | 19.23 | 1.44 | 2907.28 | 3311.26 | 87.80% | 87.80% | 281.49 |
| 46 | H&M | FLARE 5PKT SOFT - DK | 23 | 20.36 | 120 | | 16.74 | 1.36 | 2442.93 | 2729.53 | 89.50% | 89.50% | 210.91 |
| 47 | H&M | SKINNY KNIT - LT | 30 | 23.92 | 136 | | 19.76 | 1.35 | 3253.33 | 3635.01 | 89.50% | 89.50% | 282.19 |
| 48 | H&M | SKINNY KNIT - MID | 30 | 23.79 | 128 | | 19.43 | 1.36 | 3045.21 | 3379.81 | 90.10% | 90.10% | 246.23 |
| 49 | H&M | SKINNY KNIT - DK | 30 | 24.15 | 136 | | 19.46 | 1.37 | 3284.56 | 3629.35 | 90.50% | 90.50% | 251.38 |
| 50 | H&M | FLARE 5PKT SOFT - MID | 23 | 20.07 | 120 | | 16.64 | 1.35 | 2408.10 | 2687.61 | 89.60% | 89.60% | 207.63 |
| 51 | H&M | FRANK RELAXED - JOCKE | 16 | 14.33 | 128 | | 10.62 | 1.51 | 1834.10 | 2053.86 | 89.30% | 89.30% | 145.41 |
| 52 | H&M | FRANK RELAXED - RINSE | 18 | 14.28 | 107 | | 10.62 | 1.51 | 1528.04 | 1716.90 | 89.00% | 89.00% | 124.96 |
| 53 | H&M | FRANK RELAXED - DANIL | 20 | 18.07 | 120 | | 12.57 | 1.61 | 2168.23 | 2433.48 | 89.10% | 89.10% | 164.45 |
| 54 | H&M | AMICALLIGHT | 1 | 1.91 | 12 | | 1.32 | 1.71 | 22.945112 | 27.12 | 84.60% | 84.60% | 2.44 |
| 55 | H&M | AMICALLIGHT | 1 | 1.80 | 12 | | 1.31 | 1.71 | 21.648785 | 26.96 | 80.30% | 80.30% | 3.10 |
| 56 | H&M | AMICALLIGHT | 1 | 1.91 | 12 | | 1.32 | 1.71 | 22.960663 | 27.24 | 84.30% | 84.30% | 2.49 |

## 4. RESULTS AND DISCUSSION

Descriptive Statistics often referred to as exploratory statistics in specific contexts provide an ideal framework for organizing and distilling numerical data into meaningful summaries [12]. We use decriptive statistics for collected data to simplify, organize, and summarize the data set is shown in Table 3.

Table 3. Descriptive Analysis of Recorded Data

| | Marker Efficiency % | Total Functional Area (m2) | Length in Meter | Width in Meter | Fabric Utilization % | Total Wastage (m) |
|---|---|---|---|---|---|---|
| count | 56 | 56 | 56 | 56 | 56 | 56 |
| mean | 0.897 | 1792.84 | 12.197 | 1.513 | 0.895 | 134.831 |
| std | 0.022 | 1020.91 | 4.841 | 0.124 | 0.022 | 83.307 |
| min | 0.803 | 21.649 | 1.31 | 1.346 | 0.803 | 2.436 |
| 25% | 0.885 | 1025.62 | 9.09 | 1.394 | 0.884 | 78.832 |
| 50% | 0.901 | 1715.41 | 12.541 | 1.518 | 0.9 | 118.313 |
| 75% | 0.909 | 2634.86 | 16.097 | 1.614 | 0.909 | 174.589 |
| max | 0.928 | 5154.97 | 19.761 | 1.727 | 0.928 | 379.347 |

### 4.1. Correlation Analysis

The Pearson Correlation Coefficient is a statistical metric used to quantify the magnitude and orientation of the straight-line relationship that exists between two distinct variables. The resulting value ranges from -1 to +1, where the extremes indicate a perfect linear association (positive or negative), and a value of -1 signifies the absence of any linear link. From the analysis based on the real data set, the grab transportation system has a strong positive correlation interms of the two variables of interest studied [13]. The Pearson correlation method involves constructing a linear regression line that best represents the relationship between two variables. The resulting coefficient (r), serves as a metric for how closely the individual observations cluster around this central trend line [14]. In the current study, we have found below Pearson Correlation Coefficient (r) value by using SPSS which we described in Table 4.

Table 4. Correlation Analysis of 56 Data Set

| Variable | Pearson Correlation Coefficient (r) |
|---|---|
| Length in meter | 0.4901 |
| Marker Pieces | 0.3536 |
| Total Functional Area (m2) | 0.3515 |
| Width in meter | 0.1216 |

Length in meter (0.4901) exhibits the strongest positive correlation. This suggests that as the marker length increases, the marker efficiency tends to increase. This is a moderate relationship, meaning length is a significant factor, but not the only determinant.

Marker Pieces (0.3536) and Total functional area (0.3515) both show a moderate positive correlation. This indicates a slight tendency for higher efficiency as the number of marker pieces and the total functional area increase.

Width in meter (0.1216) shows a very weak positive correlation. This suggests that marker width, within the scope of this data, has a negligible linear impact on the marker efficiency.

The correlation analysis between marker efficiency and Fabric Utilization reveals an extremely strong, positive linear relationship which is shown in Table 5.

Table 5. Correlation between Marker Efficiency and Fabric Utilization

| Statistic | Value |
|---|---|
| Pearson Correlation Coefficient (r) | 0.9985 |

The Pearson correlation coefficient of 0.9985 is extremely close to +1. This means almost a perfect positive linear correlation between marker efficiency and fabric utilization. The positive value means that as the marker efficiency increases, the fabric utilization % also increases by an almost identical proportion, and vice versa.

### 4.2. Hypothesis Test

In Carver's view, the primary function of a statistical hypothesis test is to generate a p-value a specific calculation used to decide whether a set of results is statistically significant or merely a product of random variation [15]. Based on the data from the sheet and using a one-tailed Pearson correlation test with a significance level of alpha (α) = 0.05, here is the hypothesis test conclusion for each factor's impact on Marker Efficiency % is shown in Table 6.

Table 6. Hypothesis Test

| Hypothesis ID | Independent Variable | Pearson's r | P-Value (One-Tailed) | H0 Conclusion (α=0.05) | Interpretation |
|---|---|---|---|---|---|
| H1 | Fabric Width (Width in meter) | 0.1216 | 0.1861 | Fail to Reject H0 | The positive correlation is not statistically significant. We cannot conclude that increasing fabric width has a positive impact. |
| H2 | Marker Length (Length in meter) | 0.4901 | 0.0001 | Reject H0 | There is a significant positive impact of Marker Length on Marker Efficiency. |
| H3 | Marker Pieces | 0.3536 | 0.0038 | Reject H0 | There is a significant positive impact of the number of Marker Pieces on Marker Efficiency. |
| H4 | Functional Area | 0.3515 | 0.004 | Reject H0 | There is a significant positive impact of Functional Area on Marker Efficiency. |

H1 (Fabric Width): The null hypothesis (Ho: There is no impact) is not rejected. The observed positive relationship is too weak to be considered statistically significant.
H2 (Marker Length/Length in Meter): The null hypothesis is rejected. There is strong evidence to support the alternative hypothesis that Marker Length has a positive impact on Marker Efficiency.
H3 (Marker Pieces): The null hypothesis is rejected. There is strong evidence to support the alternative hypothesis that Marker Pieces has a positive impact on Marker Efficiency.
H4 (Functional Area): The null hypothesis is rejected. There is strong evidence to support the alternative hypothesis that Functional Area has a positive impact on Marker Efficiency.

### 4.3. Model Fit Measures

The model uses Length in meter, Width in meter, Total Functional Area, and Marker Pieces to predict Marker Efficiency which is shown in Table 7.

Table 7. Model Fit Measures

| Measure | Value | Interpretation |
|---|---|---|
| R-squared | 0.3272 | 32.72% of the variability in marker efficiency % is explained by the four independent variables. |
| Adjusted R-squared | 0.2745 | After adjusting for the number of predictors in the model (4), the explained variance is 27.45%. |

### 4.4. ANOVA Test

Commonly used in factorial research, ANOVA is essentially a version of the General Linear Model. In these types of studies, conditions are grouped by specific factors, and each factor is further divided into multiple levels or categories [16]. The ANOVA Test (using the F-statistic) assesses the overall significance of the regression model. Null Hypothesis (H0): All regression coefficients are zero (i.e., the model has no predictive power). Alternative Hypothesis (HA): At least one regression coefficient is not zero (i.e., the model has predictive power) which is shown in Table 8.

Table 8. ANOVA Test

| Statistic | Value |
|---|---|
| F-statistic | 6.2018 |
| Prob (F-statistic) | 0.0004 |
| Degrees of Freedom (Regression) | 4 |
| Degrees of Freedom (Residual) | 51 |

Since the Prob (F-statistic) (0.0004) which is shown in Table 8 is much less than the standard significance level of alpha = 0.05, we reject the Null Hypothesis (H0). The regression model is statistically significant, meaning the four independent variables collectively provide a reliable prediction of Marker Efficiency.

The findings of this study establish the vital role of marker efficiency in optimizing fabric utilization [17]. A positive correlation exists, indicating that enhanced fabric utilization directly leads to a substantial reduction in material wastage [18]. Consequently, this research focused on identifying and analyzing the specific factors that exert a significant impact on marker efficiency. The current analysis indicates a statistically significant positive relationship between marker length (Length in meter) and marker efficiency. This finding is supported by a Pearson Correlation Coefficient (r) of 0.4901, which confirms the tendency for marker efficiency to increase as the marker length increases. Both the number of Marker Pieces of (0.3536) and the Total Functional Area of (0.3515) exhibited a moderate positive correlation with marker efficiency. This statistically consistent finding suggests a tendency for marker efficiency to rise proportionally with an increase in either the count of marker pieces or the overall functional area [19]. No significant linear relationship was observed between marker width and marker efficiency as the most commonly used width of fabric was used in the collected marker.

## 5. CONCLUSION

The findings of this research emphasize that marker efficiency plays a crucial role in maximizing fabric usage and minimizing waste within garment production. The analysis shows that marker length has a strong and statistically significant positive effect on marker efficiency, while the number of marker pieces and the total functional area also contribute moderately to improving efficiency levels [20]. These results suggest that thoughtful adjustments to marker layout and dimensions can lead to better material utilization. On the other hand, marker width shows no meaningful linear relationship with efficiency, which may be due to the uniform fabric widths used in the samples. In summary, the study highlights the importance of deliberate marker planning as a practical approach to boosting operational efficiency and reducing fabric waste in the apparel industry.

### Acknowledgments

Based on the results of this study, it is recommended that apparel manufacturers place greater emphasis on optimizing marker length, marker piece count, and functional area when planning marker layouts, as these factors directly contribute to improved marker efficiency and reduced fabric waste. Production teams should consider adopting advanced marker-making software and layout techniques that enable more effective arrangement of pattern pieces, particularly for markers with higher complexity or larger piece counts. Since marker width does not significantly influence efficiency due to standardized fabric widths, efforts should instead focus on refining layout strategies rather than altering fabric width selections. Regular monitoring of marker performance, combined with training for cutting room personnel on best practices for marker planning, can help sustain higher efficiency levels. By integrating these improvements into routine operations, garment manufacturers can enhance material utilization, reduce overall production costs, and strengthen their competitiveness in the industry. Finally, width wise booking with esurient, fabric diameter adjustment, both vertical & horizontal both side cuttable fabric can increase marker efficiency significantly

### Funding Information

No sponsor was involved for this research, all the cost beared by the authors themselves.


### Author Contributions Statement

| Name of Author | C | M | So | Va | Fo | I | R | D | O | E | Vi | Su | P | Fu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Md. Taslim | ✓ | ✓ | ✓ | ✓ | | ✓ | | ✓ | ✓ | ✓ | ✓ | | | |
| Mohammad Tanvirul Hasnat | ✓ | ✓ | | | | ✓ | ✓ | ✓ | | | ✓ | ✓ | ✓ | |

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

### Conflict of Interest Statement

The authors declare that they have no financial conflicts of interest related to this research. However, corresponding author and co-author are the employee of the organization from where the sample data has been congregated.

### Informed Consent

The protection of privacy is a legal right that must not be breached without individual informed consent. In cases where the identification of personal information is necessary for scientific reasons, authors should obtain full documentation of informed consent, including written permission from the patient prior to inclusion in the study. Incorporate the following (or a similar) statement: We have obtained informed consent from all individuals included in this study.

### Ethical Approval

There was no involvement of using people or animals, & the research followed all national rules and institutional policies, and it was approved by affiliated organizations of the authors.

### Data Availability

Data supporting the conclusions of this article are available from the authors upon reasonable request. The materials used in the experiments, including reagents and software tools, can be found in the supplementary files attached to this publication. For any request for data please contact Md. Taslim

(Corresponding author) by email: taslim7@ymail.com or Mohammad Tanvirul Hasnat (Corresponding author) by email: tanvirulhasnat397@gmail.com

## REFERENCES

[1] M. T. Hasnat, M. Taslim, and M. M. Hasan, 'Testing potentiality of copper particles as antimicrobial agent by kirby bauer test to inhibit the activity of various microorganisms when applied to fabrics especially medical wear', International Journal of Agriculture and Animal Production, no. 51, pp. 59-70, June 2025. doi.org/10.55529/ijaap.51.59.70
[2] M. Z. Haider, 'Competitiveness of the Bangladesh Ready-made Garment Industry in Major International Markets', Asia-Pacific Trade and Investment Review, vol. 3, no. 1, pp. 3-5, 2007.
[3] 'Study of Fabric Waste Generated in the Woven Garments Industries in Bangladesh', International Journal of Scientific & Engineering Research, vol. 11, no. 11, pp. 198-199.
[4] S. A. Jain, 'Waste Management in Textile and Fashion Industry', Textile Learner, 2022.
[5] M. M. Islam, M. I. H. Mondal, and F. Ahmed, 'Study on prawn shell waste into chitosan and its derivatives as value added products for cellulosic fibres', Res. J. Text. Appar., vol. 21, no. 2, pp. 134-145, June 2017. doi.org/10.1108/RJTA-01-2017-0002
[6] M. Islam, "Important Factors of Marker Efficiency," Textile Learner , 2023
[7] Spinning Textile Waste into Value. 2025.
[8] M. N. Haque, 'Impact of Different Sorts of Marker Efficiency in Fabric Consumption', International Journal of Textile Science, 2016.
[9] V. L. K. W. A. S. Kizilirmak, 'Reducing fabric consumption: By improving marker efficiency', M, pp. 126-130, 2020.
[10] H. Y. A. A. Almetwally, 'nfluencing fabric shrinkage and different size ratios on marker making efficiency and fabric consumption rate for men's shirt', International Design Journal, vol. 8, pp. 55-60, 2018. doi.org/10.21608/idj.2018.85867
[11] H. A. P. Baykal, 'The effects of width of the fabric, fabric and model type on the efficiency of marker plan in terms of apparel, "', Textile and Apparel, vol. 26, pp. 314-320, 2016.
[12] L. J. Marshall, 'An introduction to descriptive statistics: A review and practical guide', Radiography, vol. 16, no. 4, pp. 1-7, 2010. doi.org/10.1016/j.radi.2010.01.001
[13] B. L. A. A. F. I. A. Friday Zinzendoff, Breakdown Analysis of Pearson Correlation. IOP Publishing Ltd, 2020, pp. 6-7.
[14] est for Significance of Pearson's Correlation Coefficient', International Journal of Innovative Mathematics, pp. 15-16, 2018.
[15] L. L. Eberhardt, 'What Should We Do about Hypothesis Testing?', The Journal of Wildlife Management, vol. 67, no. 2, pp. 241-247, 2003. doi.org/10.2307/3802765
[16] "Analysis of Variance (ANOVA)," Brain Mapping, pp. 477-481, 2015. doi.org/10.1016/B978-0-12-397025-1.00319-5
[17] V. L. K. A. S. K. Widanalage, 'Reducing fabric consumption: by improving marker efficiency', International Journal of Engineering Research & Technology (IJERT).
[18] R. M. P. M. Janarthanan, 'REDUCTION OF FABRIC CONSUMPTION, BY INCREASING FABRIC UTILIZATION & MINIMIZING WASTAGE IN GARMENT SECTOR', nternational Research Journal of Engineering and Technology (IRJET), vol. 7, no. 7, pp. 890-903, 2020.
[19] M. A. R. Nilanto, M. N. Islam, S. Morsalin, M. S. Ahmed and S. A. Khan, "INVESTIGATION OF MARKER EFFICIENCY COMBINING DIFFERENT SIZE GARMENTS AND USING DIFFERENT WIDTH MATERIALS.," onnecting you to content on EBSCOhost.
[20] N. Haque, 'Impact of Different Sorts of Marker Efficiency in Fabric Consumption', International Journal of Textile Science, pp. 97-109, 2016.

**How to Cite:** Md. Taslim, Mohammad Tanvirul Hasnat. (2026). Understanding the drivers of marker efficiency for improved fabric utilization in apparel production: an analytical approach. Journal of Production, Operations Management and Economics (JPOME), 6(1), 1-15. https://doi.org/10.55529/jpome.61.1.15

**BIOGRAPHIES OF AUTHORS**

| | |
|---|---|
|  | **Md. Taslim**, over 25 years of experience in the Ready-Made Garment (RMG) sector, with a diverse background spanning industry setup, automation implementation & practice with operational leadership. He began his career in marketing, working closely with American and European buyers, which enabled him to travel to more than 15 countries, gaining deep insights into global apparel markets. Currently, he serves as the Head of Operations at Sterling Group, Bangladesh, where he plays a key role in driving efficiency and innovation across the organization. Md. Taslim holds a postgraduate degree in Physics from National University, Bangladesh. Email: taslim7@ymal.com |
|  | **Mohammad Tanvirul Hasnat**, is a Textile Engineer with a Bachelor's degree from the University of Dhaka, Bangladesh. He is currently serving at Sterling Group, Bangladesh, where he focuses on sustainable apparel manufacturing with proper optimization of company's assets. He is a certified Six Sigma Black Belt and has completed the Black Belt level of the Setting Transformation Blueprint Program in collaboration with Textile Talent Hunt. With a strong passion for sustainability and continuous improvement, he is dedicated to driving innovation and operational excellence in the textile and apparel industry. Email: tanvirulhasnat397@gmail.com |