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The Impact of Marker Parameters on Fabric Consumption for Jeans

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Abstract

Fabric Consumption refers to the average amount of fabric required for a garment. Understanding the factors affecting fabric consumption is essential to finding solutions for material savings in industrial garment production, thereby reducing product costs. This is particularly significant in jeans production. This study examines the impact of fabric width, the number of garments per marker layout, and the number of jeans components on marker length, marker efficiency, and fabric consumption using Bayesian Model Averaging (BMA) in R software. The results indicate significant multivariate linear relationships between the marker layout parameters and marker length as well as fabric consumption (R^2 = 0.9736 and 0.602, respectively). When the fabric width increases and the number of garment components decreases, both marker length and fabric consumption for jeans are reduced.

Keywords: Marker length; Jeans; Fabric Consumption; Fabric Width; Marker Making

Introduction

Fabric Consumption plays a crucial role in the garment industry. During production, fabric consumption is considered a core factor that directly impacts production costs, product prices, and the economic efficiency of businesses [1]. Fabric consumption not only determines the amount of raw material required but also has an effect on waste generation and the sustainability of the production process. It is affected by various factors such as product design, fabric surface characteristics, fabric width, and pattern layout. Researching the factors influencing fabric consumption not only helps in identifying solutions to reduce garment production costs but also provides a foundation for designing and using fabric more efficiently. For this reason, numerous studies have been conducted on fabric consumption.

Ming-Hsiu Chen and Hsin-Hui Hsu focused their research on optimizing pattern layout to minimize fabric waste in garment production. Their optimization model utilized computational algorithms to improve fabric cutting efficiency, reducing waste and production costs [2]. Ravi K. Gupta conducted studies on waste reduction techniques and material optimization, particularly in denim garment production. Computer-Aided Design (CAD) technology is widely applied to automate the pattern-making and marker-making processes, enhancing efficiency in production [3]. Other studies combined CAD tools and digital technologies to automate pattern-making processes using software systems to create patterns based on specific size parameters. This approach not only saves time but also enhances accuracy in production planning [4]. The impact of marker layout parameters on fabric consumption for T-shirts in industrial garment production has also been identified [5]. Fabric wastage during spreading has a significant effect on production costs in garment manufacturing. Fabric wastage during spreading correlates with marker length, ply length, number of fabric layers, and roll length, as determined by high-correlation multivariate linear models [6]. Phạm Thị Huyền et al. researched and proposed a method for determining fabric consumption for men's shirts using the Marker Making V6R2 software. Patterns, grading, and marker layouts for five shirt sizes on five types of fabric with different widths were carried out. A multivariate linear regression model was established between fabric consumption, fabric width, shirt size, and marker efficiency. This model enables precise calculations of the fabric required for production [7]. The effect of T-shirt structure on marker efficiency has also been studied. T-shirts with different designs were laid out on five fabric widths to determine suitable constructions that minimize fabric waste and reduce costs in industrial garment production [8].

However, understanding the factors influencing fabric consumption in the production of jeans, a globally popular industrial garment, remains limited. This study aims to clarify the effects of denim fabric width, the number of products on marker, and the number of jeans components on marker length and fabric consumption for jeans. These findings provide a foundation and suggestions for reducing material waste, improving economic efficiency, and advancing towards more sustainable production in garment industry.

Methods

Five styles of jeans were selected for this study, with the basic design shown in Figure 1. Styles b, c, d, and e were modified from style a.

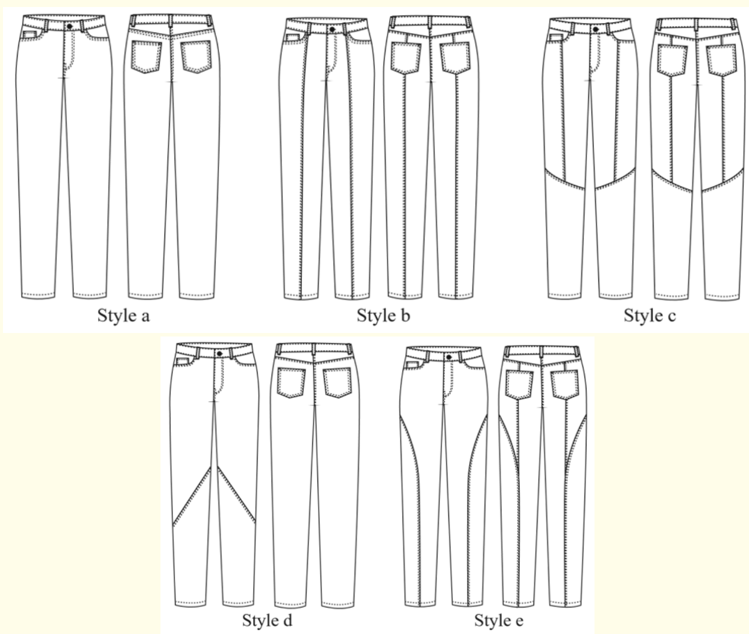

Figure 1: Five Styles of Jeans Selected for the Experiment.

The basic dimensions of the five jeans styles are identical and are presented in Table 1. The technical patterns were designed for size 32, with grading for other sizes performed using the Lectra-ModarisV7R2 software.

S. No	Description	29	30	31	32	33	34	35
1	Waist relaxed	77.5	80	82.6	85.1	87.6	90.7	92.7
2	Waistband width	4.1	4.1	4.1	4.1	4.1	4.1	4.1
3	Low hip 3-point measurement, 3 inches from the front crotch seam	96.5	99.1	101.6	104.1	106.7	109.2	111.8
4	Thigh 1 inch from crotch point	55.2	56.8	58.4	60	61.6	63.2	64.8
5	Knee 14 inches down front rise seam	37.8	38.7	39.7	40.6	41.6	42.5	43.5
6	Leg opening part	36.2	36.8	37.5	38.1	38.7	39.4	40
7	Fly "J" stitch length – width	11.4 x 3.5	12.7 x 3.5	12.7 x 3.5	14 x 3.5	14 x 3.5	15.2 x 3.5	15.2 x 3.5
8	Belt loop length-width	6.4 x 1.27	6.4 x 1.27	6.4 x 1.27	6.4 x 1.27	6.4 x 1.27	6.4 x 1.27	6.4 x 1.27
9	Pocket opening width – height Top	11.4 x 5.7	11.4 x 5.7	12.1 x 5.7	12.1 x 5.7	12.1 x 5.7	12.7 x 7	12.7 x 7
10	Coin pocket width- height top edge	6.4 x 9.5	6.4 x 9.5	7 x 10.2	7 x 10.2	7 x 10.2	7.6 x 10.8	7.6 x 10.8
11	Back pocket depth - width	14.6 x 11.4	14.6 x 11.4	15.9 x 12.7	15.9 x 12.7	15.9 x 12.7	17.1 x 14	17.1 x 14
Unit: cm								

Table 1: Basic Dimensions of Experimental Jeans.

To determine the impact of marker layout parameters, including fabric width, the number of products on the layout, and the number of jeans components on the marker length, efficiency, and fabric consumption for jeans, 175 experiments were established with the following condition parameters:

- Fabric width (kr) was selected at 5 values: 1.5m; 1.55m; 1.6m; 1.65m; 1.7m.
- The number of components in the selected jeans styles (ct) were 16, 20, 24, 18, 22 pieces respectively for the 5 styles. The number of products on the marker (sp) corresponding to each jeans style was 3, 4, 5, 6, 7 products. The marker layouts were created for jeans sizes as follows: the 3-product marker layout includes sizes 30, 31, and 32; the 4-product marker layout has two variations, with the first including sizes 30, 31, 32, and 33, and the second including sizes 31, 32, 33, and 34. The 5-product marker layout consists of sizes 30, 31, 32, 33, and 34. The 6-product marker layout also has two variations, with the first including sizes 29, 30, 31, 32, 33, and 34, and the second including sizes 30, 31, 32, 33, 34, and 35. Lastly, the 7-product marker layout includes sizes 29, 30, 31, 32, 33, 34, and 35, corresponding to different jeans styles and fabric width values.

175 markers were created automatically using MarkerManager V6R2 and MarkerMaking V6R2 software to obtain the marker length (L), efficiency (h) [9], and fabric consumption (dm) for the jeans was determined by the formula:

$$dm = L / sp \quad (1)$$

Where, *dm* is fabric consumption for jeans (m), *L* is marker length (m) and *sp* is number of products on the marker.

Bayesian Model Averaging was used to identify the optimal model that represents the relationship between fabric width, the number of products on the marker, and the number of jeans components with marker length, efficiency, and fabric consumption for jeans using R software. The Bayesian Information Criterion (BIC) and the R-squared coefficient (R^2) were used to evaluate and select the optimal model [10]. BIC is a measure that balances model complexity (number of variables) and the optimality of the model through the Residual Sum of Squares (RSS):

$$BIC = n\ log(RSSp) + p\ logn \qquad (2)$$

Where, *n* is sample size; *p* is number of input variables in the model. A lower BIC value indicates a better model. The model with fewer variables that explains the most data is considered the optimal one.

Results

Effect of Lofout Parameters on Monker Length

The marker lengths ranged from 2.52m to 8.13m, with a mean value of 5.33m and a standard deviation of 1.433m. The 95% Confidence Interval (CI) for the pattern length is (2.89; 8.44)m. The experimental data was analyzed using BMA on R software, resulting in the optimal model:

$$L = 4.7242 - 0.0344*kr+0.0392*ct+1.057*sp \qquad (3)$$

R2 = 0.9736 and BIC = -620.79, the model's probability is 1.

The residuals of the model ranged from -0.442 to 0.578, with a mean value of -0.046, indicating that the model's error is negligible.

The efficiency of the marker layouts ranged from 80.36% to 89.21%, with a mean value of 85.20%, a standard deviation of 1.96%, and a 95% CI of (81.35; 89.05)%. No significant linear relationship was found between efficiency and the marker layout paraeters.

Effect of Layout Layout Parameters on Fabric Consumption for Jeans

The fabric consumption for the experimental jeans ranged from 0.93m to 1.23m, with an average value of 1.066m and a standard deviation of 0.069m. The 95% Confidence Interval (CI) for fabric consumption is (0.93; 1.2) m. The experimental data were analyzed using BMA in R software, and two optimal models were obtained:

Model 1:

$$dm = 2.0015 - 0.0068*kr + 0.0079*ct \qquad (4)$$

R2 = 0.602, BIC = -150.9; the model's probability is 0.906

Model 2:

$$dm = 2.0115 - 0.0068*kr + 0.0079*ct - 0.0020*sp \qquad (5)$$

R2 = 0.603 và BIC = -146.4; the model's probability is 0.094

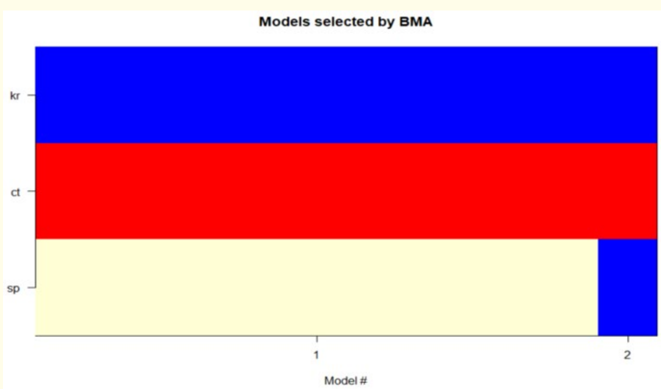

Figure 2: BMA Plot of Optimal Models.

Model 1 was chosen as the optimal model because the statistical indicators of the two models differ little, and the probability of model 1 is significantly higher than that of model 2. For model 1, the residual values range from -0.078 to 0.083, with a median value of -0.008. This indicates that the model error is negligible.

Discussions

The optimal model showing the relationship between the length of the marker layout and the condition parameters has a Multiple R-squared (R^2) = 0.9736. This means that the variations in fabric width, the number of components on the jeans, and the number of jeans on the layout explain 97.36% of the variation in the marker length. The marker length is inversely proportional to fabric width and the number of jeans components, and directly proportional to the number of products on the marker. The Adjusted R-squared value of 0.9732 indicates that the model is affected by the number of independent variables, and the p-value < 2.2e-16 shows that the model is statistically significant. This confirms that the three variables, fabric width (kr), number of jeans components (ct), and number of products on the layout (sp), all have a significant impact on marker length.

The regression coefficient for fabric width (kr) is -0.0342, which indicates that when the fabric width increases by 1 cm, the marker length decreases by 0.0342 m, assuming the number of products (sp) and jeans components (ct) remains constant; p-value = 2e- 16 confirms that the effect of fabric width is statistically significant. The regression coefficient for the number of jeans components (ct) is 0.0392, meaning that when the number of details on the jeans increases by 1, the marker length increases by 0.0392 m, assuming the fabric width (kr) and number of products (sp) remain constant; p-value = 3.07e-09 confirms that the number of details also has a significant effect on marker length. The regression coefficient for the number of products on the layout (sp) is 1.0573, indicating that when one more pair of jeans is added to the layout, the marker length increases by 1.0573 m, assuming the fabric width (kr) and number of jeans components (ct) remain constant; p-value = 2e-16 confirms that the number of jeans on the layout significantly affects the marker length. The marker length increases when fabric width decreases, the number of jeans components increases, and the number of jeans on the layout increases within the study range. However, the number of jeans on a layout cannot be increased too much, as the actual length of the fabric laying table will not support the quality requirements, and fashion trends have an effect on the number of jeans components.

The efficiency of the marker layouts does not vary much, as the MarkerMaking V6R2 automatic layout software uses the same principle for arranging the components of the jeans. The relationship between efficiency and these parameters may be more complex than linear.

The optimal model showing the relationship between the fabric consumption for jeans and the condition parameters has a Multiple R-squared (R^2) = 0.602. This means that the variations in fabric width and the number of jeans components explain 60.2% of the variation in the fabric consumption for jeans. Fabric consumption for jeans is inversely proportional to fabric width and directly proportional to the number of components on a pair of jeans. The Adjusted R-squared value of 0.5973 indicates that the model is affected by the number of independent variables, and the p-value < 2.2e-16 confirms that the model is statistically significant. This demonstrates that fabric width and the number of jeans components significantly affect the fabric consumption for jeans.

The regression coefficient for fabric width is -0.0068, which means that when the fabric width increases by 1 cm, the fabric consumption for jeans decreases by 0.0068 m, assuming the number of jeans components remains unchanged. The p-value = 2e- 16 shows that the effect of fabric width is statistically significant. The regression coefficient for the number of jeans components is 0.0079, indicating that when the number of d jeans components increases by 1, the fabric consumption increases by 0.0079 m, assuming the fabric width remains unchanged. The p-value = 1.79e-10 shows that the number of jeans components also has a significant impact on fabric consumption. Fabric consumption decreases when fabric width increases and the number of details on the jeans decreases within the research range. However, fabric width cannot be increased indefinitely due to the limitations of the denim production process, and fashion trends have an effect on the number of jeans components.

Conclusions

The relationship between marker length, fabric consumption and fabric width, number of jeans components, and the number of products on the marker layout has been established. These three factors significantly impact the pattern length. When fabric width increases and the number of jeans components and the number of products on the marker layout decrease, the marker length also decreases within the scope of the study.

Fabric width and the number of jeans components also have a significant effect on fabric consumption. When fabric width increases and the number of jeans components decreases, fabric consumption decreases. The number of products on the marker layout does not show a significant impact on fabric consumption. However, when the number of products on the layout is low and the pattern length is short, fabric waste at the fabric roll's starting point tends to be higher.

To reduce fabric consumption for jeans, it is advisable to increase fabric width, increase the number of products on the layout, and decrease the number of jeans components. However, it is important to balance fashion trends with cost-reduction strategies when mass-producing garments.

Research limitation

The extent to which fabric consumption variability is explained by the variation in fabric width, the number of jeans components, and the number of products on the layout is limited. This suggests that it might be beneficial to explore a non-linear model that better captures the relationship between fabric consumption and the layout parameters. Such a model could potentially offer more accurate predictions and deeper insights into how these factors impact fabric usage.

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