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Cobb–Douglas Analysis of Technical Efficiency in Banyuwangi Batik Small and Medium Enterprises

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Abstract

This study examines the technical efficiency and production elasticity of batik small and medium enterprises (SMEs) in Banyuwangi Regency, Indonesia. Using panel data from 12 active SMEs observed between 2018 and 2023, the Cobb–Douglas production function is estimated through panel regression techniques. Model selection tests indicate that the Random Effect Model is the most appropriate specification. The results reveal that capital and production equipment significantly and positively affect output, whereas labor exhibits a significant negative elasticity, suggesting overutilization and managerial inefficiency. Raw materials show no statistically significant contribution to production performance. The estimated return to scale equals 1.63, indicating increasing returns to scale and implying that proportional input expansion generates more than proportional output growth. The model explains 89% of output variation, demonstrating strong explanatory power. These findings highlight the importance of capital access, technology upgrading, and labor optimization in improving SME productivity. The study provides empirical evidence to support efficiency-oriented policy interventions for traditional creative industries.

Kewords: technical efficiency, Cobb–Douglas production, stochastic frontier, SMEs, batik industry, panel data

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1. INTRODUCTION

Micro, small, and medium enterprises (MSMEs) play a strategic role in national economic development (Yerianto & Mustaqim, 2024). This sector contributes significantly to employment creation and serves as an important income source for middle- and low-income communities. MSMEs also support income distribution, poverty reduction, and rural economic development, thereby improving overall social welfare (Fathurrahman, 2012).

The primary objective of SME production activities is to maximize profit, which is closely related to production efficiency. Inefficiency arises when production processes are not technically optimal due to low productivity and disproportionate or inappropriate use of inputs (Ngatindriatun & Ikasari, 2011). Efficiency and innovation are therefore essential requirements for batik SMEs to remain competitive (Mahanani & Hayati, 2023).
Capital, labor, machinery, and raw materials are interrelated and inseparable components in production activities. Working capital refers to resources used to support daily operational activities and can be adjusted according to business needs (Chaerudin et al., 2020).

Banyuwangi Regency, located in East Java Province, has long been recognized for its textile industry, particularly batik. Batik production represents a cultural heritage passed down across generations and has become a distinctive regional identity (Lestari et al., 2019). The batik industry significantly contributes to the local economy alongside other commodities such as coffee. Banyuwangi batik is widely known for its unique motifs reflecting local culture and has gained recognition in both domestic and international markets (Rosyidah & Romadloni, 2023).

However, one of the main challenges faced by the batik industry in Banyuwangi is the limited number of skilled artisans despite increasing market demand. This shortage constrains production capacity and hampers business growth. Field observations indicate that only 12 out of 40 batik SMEs currently maintain regular production activities. Moreover, many enterprises have not yet achieved optimal technical efficiency.

This study applies the Cobb–Douglas production function to measure productivity and evaluate the performance of production factors among 12 batik SMEs in Banyuwangi during the 2018–2023 period. The research addresses the following questions:

1) Do production inputs (capital, labor, machinery, and raw materials) significantly affect SME output, both partially and simultaneously?
2) To what extent is the efficiency level of batik SMEs in Banyuwangi?

2. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

2.1 Small and Medium Enterprises (SMEs)

According to Indonesian Law No. 20 of 2008, small enterprises are defined based on asset ownership and annual sales turnover. Small businesses possess net assets between IDR 50 million and IDR 500 million, excluding land and buildings, and annual sales between IDR 300 million and IDR 2.5 billion. Meanwhile, the World Bank defines small enterprises as those employing fewer than 30 workers. SMEs have strong development potential due to their flexibility and ability to adapt quickly to market changes (Sulistiyo et al., 2020).

2.2 Production Factors

A production function describes the mathematical relationship between inputs and outputs (Nicholson & Snyder, 2017). Output is treated as the dependent variable, while inputs are independent variables. One widely used model for analyzing production elasticity is the Cobb–Douglas function, which explains the physical relationship between inputs and outputs (Aji, 2019).

In this study, production factors include:

2.2.1 Capital

Capital refers to financial resources used to finance operational activities such as purchasing materials, paying wages, acquiring equipment, and covering operational costs. Limited access to capital is a common challenge faced by SMEs (Agustin & Satrianto, 2024).

2.2.2 Labor

SMEs significantly contribute to employment creation. In batik SMEs, labor often consists of family members or freelance workers paid based on output. However, inefficient labor management may reduce productivity.

2.2.3 Production Equipment

Production tools include canting tools for hand-drawn batik, stamping tools for printed batik, dyeing equipment, and color-fixing instruments. Better equipment improves production speed and quality.

2.2.4 Raw Materials

Raw materials consist of mori cloth, wax, dyes, color stabilizers, and fixatives. These materials determine product quality but may not always significantly influence production output if supply is already sufficient.

2.3 Hypotheses

H1: Capital elasticity significantly affects production output (partial effect).
H2: Production equipment elasticity significantly affects production output (partialeffect).
H3: Labor elasticity significantly affects production output (partial effect).
H4: Raw material elasticity significantly affects production output (partial effect).
H5: All inputs simultaneously affect production output.

3. RESEARCH METHOD

3.1 Method

This study employed a quantitative explanatory research design to examine the determinants of technical efficiency and production performance among batik small and medium enterprises (SMEs). The explanatory approach was selected because the study aims to identify causal relationships between production inputs and output while estimating the elasticity and efficiency levels of each production factor. Quantitative modeling enables objective measurement and statistical testing of the contribution of capital, labor, production equipment, and raw materials to production outcomes.

The analytical framework is grounded in production theory, particularly the Cobb–Douglas production function, which is widely applied in efficiency and productivity analysis due to its flexibility in estimating input elasticities and returns to scale.

This study employs a quantitative research approach using panel data regression. The data combine cross-sectional and time-series information from 12 batik SMEs in Banyuwangi for the period 2018–2023. Data were collected directly from business owners, including information on production value, capital, labor, equipment, and raw materials.

3.2 Population and Sample

The population consisted of all active batik SMEs operating in Banyuwangi Regency. Based on records from local industry offices and field verification, approximately 40 enterprises were identified. However, only 12 SMEs consistently conducted regular production and maintained complete financial and operational records during the observation period.

Therefore, this study applied purposive sampling, selecting SMEs that met the following criteria:

1. Actively producing batik products during the study period,
2. Maintaining continuous operational records,
3. Willing to provide production and financial data, and
4. Operating as independent small or medium enterprises.

These 12 SMEs were considered representative of productive batik businesses and provided reliable panel data for analysis.

3.3 Data Types and Sources

This study utilized panel data that combine cross-sectional and time-series dimensions. The cross-sectional dimension represents individual SMEs, while the time-series dimension covers annual observations from 2018 to 2023.

Primary data were collected directly through structured interviews with business owners and managers using standardized questionnaires. The information included production value, capital investment, number of workers, production equipment costs, and raw material expenses. Secondary data were obtained from financial records, production reports, and supporting documents provided by each SME, as well as publications from local government agencies.

The use of panel data allows for more accurate estimation because it captures both inter-firm heterogeneity and temporal dynamics, reduces omitted variable bias, and increases the efficiency of statistical inference.

3.4 Variables and Measurement

The study consists of one dependent variable and four independent variables. All variables were transformed into natural logarithms to linearize the Cobb–Douglas function and interpret coefficients as elasticities.

Dependent Variable:

1) Output (Y): total annual production value measured in Indonesian Rupiah (IDR)

Independent Variables:

1) Capital (K): working capital used for operational activities (IDR)
2) Labor (L): number of workers involved in production (persons)
3) Production Equipment (A): value of machinery and tools used (IDR)
4) Raw Materials (B): annual raw material costs (IDR)

Logarithmic transformation improves normality, reduces heteroscedasticity, and enables elasticity interpretation.

3.5 Econometric Approach

Panel data regression analysis was conducted using three alternative estimation models:

1) Common Effect Model (CEM)
2) Fixed Effect Model (FEM)
3) Random Effect Model (REM)

Model selection was performed sequentially through:

1) Chow test (CEM vs FEM),
2) Hausman test (FEM vs REM),
3) Lagrange Multiplier test (CEM vs REM).

The best model was selected based on statistical significance and consistency assumptions. Estimation was conducted using statistical software to ensure robustness and reliability.

Panel regression estimation uses three approaches: Common Effect Model (CEM), Fixed Effect Model (FEM), and Random Effect Model (REM). Model selection is conducted through the Chow test, Hausman test, and Lagrange Multiplier (LM) test.

The Cobb–Douglas production function is specified as:

$$Q = aK^{\alpha}L^{\beta}A^{\gamma}B^{\delta}e^{u}$$

In logarithmic linear form:

$$\ln(Q) = \ln(a) + \alpha\ln(K) + \beta\ln(L) + \gamma\ln(A) + \delta\ln(B) + e$$

where coefficients represent the elasticity of each production factor. The sum of elasticities determines the return to scale (RTS).

3.6 Hypothesis Testing

Hypotheses were tested using:

1) t-test for partial effects of each input variable,

2) F-test for simultaneous effects of all variables,
3) Coefficient of determination (R^2) to measure explanatory power.

A significance level of 5% ($\alpha = 0.05$) was applied.

3.7 Research Validity and Reliability

Data reliability was ensured through cross-checking financial records and repeated verification with SME owners. Instrument validity was established by adopting measurement indicators commonly used in SME production studies. The panel structure and econometric testing procedures further strengthened the internal validity and robustness of the results.

4. RESULTS AND DISCUSSION

This study aims to measure the elasticity of capital, labor, production equipment, and raw materials on batik production among SMEs in Banyuwangi Regency. The objective is to evaluate the efficiency of input utilization in the batik production process. Primary data were collected through interviews with business owners and monthly financial records, including capital, labor, equipment, and raw material expenditures from 12 active batik SMEs.

4.1 Model Selection

Panel data regression model selection was conducted using the Chow test, Hausman test, and Lagrange Multiplier (LM) test.

The Chow test produced a probability value of 0.0000 (< 0.05), indicating that the Fixed Effect Model (FEM) is preferable to the Common Effect Model (CEM). However, the Hausman test yielded a probability value of 0.5889 (> 0.05), suggesting that the Random Effect Model (REM) is more appropriate than FEM. The LM test further supported the use of REM with a probability value of 0.0000 (< 0.05). Therefore, the Random Effect Model was selected as the best estimation model.

4.2 Estimated Production Function

The regression equation derived from the REM estimation is:

$$\ln(Q) = 6.719094 + 1.420597\ln(K) - 0.939707\ln(L) + 0.905768\ln(A) + 0.241018\ln(B) + e$$

Transforming the equation into its exponential form results in:

$$Q = 829.67 \cdot K^{1.420597} \cdot L^{-0.939707} \cdot A^{0.905768} \cdot B^{0.241018}$$

Elasticity Interpretation

1) Capital (K) has an elasticity of 1.42, meaning that a 1% increase in capital raises output by 1.42%. This indicates a strong positive and elastic relationship.
2) Labor (L) has an elasticity of –0.94, indicating that a 1% increase in labor reduces output by 0.94%, suggesting inefficiency or overstaffing.
3) Production equipment (A) has an elasticity of 0.91, showing a nearly proportional positive contribution to output.
4) Raw materials (B) have an elasticity of 0.24, reflecting a relatively small positive impact.

Among all inputs, capital provides the largest contribution to production growth.
Return to Scale Analysis

Return to Scale (RTS) is calculated by summing all elasticities:

$$RTS = 1.420597 - 0.939707 + 0.905768 + 0.241018 = 1.627676$$

Since RTS > 1, the production process exhibits Increasing Returns to Scale. This means that a proportional increase in all inputs generates a more than proportional increase in output. For instance, a 1% increase in all inputs leads to approximately a 1.63% increase in production. This finding indicates that batik SMEs in Banyuwangi can achieve higher efficiency by expanding their production scale.

4.3 Hypothesis Testing

4.3.1 Partial Test (t-test)

The t-test results show:

1) Capital: Prob = 0.0079 (< 0.05) → significant
2) Labor: Prob = 0.0436 (< 0.05) → significant
3) Production equipment: Prob = 0.0046 (< 0.05) → significant
4) Raw materials: Prob = 0.4652 (> 0.05) → not significant

Thus, hypotheses H1, H2, and H3 are accepted, while H4 is rejected.
Simultaneous Test (F-test)
The F-test probability value of 0.000 (< 0.05) indicates that all independent variables simultaneously affect production output. Therefore, H5 is accepted.

4.3.2 Coefficient of Determination

The R^2 value of 0.892454 implies that 89.25% of the variation in batik production is explained by capital, labor, equipment, and raw materials. Only 10.75% is influenced by other external factors. This indicates strong explanatory power of the model.

5. DISCUSSION

5.1 Capital Elasticity

Capital significantly and positively affects batik production. The elasticity value greater than one indicates that capital investment produces more than proportional output growth. Additional capital enables SMEs to purchase better equipment, increase capacity, and improve product quality. This finding aligns with previous studies emphasizing capital as a key determinant of SME productivity.

5.2 Production Equipment Elasticity

Production equipment also shows a strong positive and significant effect. Modern and adequate tools enhance operational efficiency, reduce production time, and increase product consistency. Therefore, investment in machinery and tools is essential for improving competitiveness.

5.3 Labor Elasticity

Labor exhibits a significant but negative effect on production. This suggests that increasing the number of workers does not necessarily improve productivity. Excess labor may lead to inefficiencies such as overcrowded workspaces, task overlap, or weak coordination. Hence, optimizing labor quality rather than quantity is more important for batik SMEs.

5.4 Raw Material Elasticity

Raw materials do not significantly influence production output. This may occur because raw materials are already easily accessible in Banyuwangi, meaning that increasing their quantity does not automatically increase production. Instead, production performance depends more on capital and equipment efficiency.

6. CONCLUSION

Batik SMEs in Banyuwangi Regency exhibit **Increasing Returns to Scale**, with a total elasticity of 1.627676. This indicates that expanding production inputs proportionally results in greater output gains, reflecting scale efficiency.

Capital and production equipment have positive and significant effects on output, making them the most influential production factors. Labor shows a significant negative effect, suggesting inefficiencies in workforce utilization, while raw materials do not significantly affect output.

These findings imply that policies aimed at improving SME productivity should prioritize easier access to capital financing, modernization of production equipment, and better labor management strategies rather than simply increasing the number of workers. Strengthening these aspects can enhance competitiveness and support sustainable growth of the batik industry in Banyuwangi.

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