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Clustering Analysis of Indonesian Batik Export Destination Countries Using X-Means Algorithm

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Abstrak (Bahasa Indonesia)

Batik merupakan salah satu warisan budaya Indonesia yang memiliki nilai ekonomi tinggi karena menjadi produk ekspor unggulan. Dalam beberapa tahun terakhir, nilai ekspor batik mengalami variasi yang cukup signifikan setiap tahunnya. Penelitian ini dilakukan untuk menganalisis data ekspor batik Indonesia menggunakan algoritma X-*Means* sebagai pengembangan dari penelitian sebelumnya yang menggunakan metode peramalan. Perbedaan dalam penelitian ini terletak pada pendekatan yang digunakan. Jika peramalan menekankan pada prediksi di masa mendatang, algoritma X-*Means* digunakan untuk melihat pola klasterisasi dari data yang ada. Data yang digunakan berasal dari dataset ekspor batik 2010-2021 yang diperoleh dari *Kaggle* dan Sentra Batik dan Kerajinan Indonesia. Pengolahan data dilakukan menggunakan aplikasi *RapidMiner* dengan beberapa uji klaster untuk mengetahui hasil terbaik. Hasil penelitian menunjukkan bahwa pengujian dengan 3 klaster menghasilkan nilai *Davies-Bouldin Index (*DBI*)* sebesar 0,029. Nilai DBI yang rendah menunjukkan bahwa hasil klasterisasi sangat baik dan terdapat jarak antar klaster yang jelas. Dari hasil ini, negara-negara dengan nilai ekspor batik tertinggi adalah Amerika Serikat dan Jerman, sementara negara-negara dengan nilai ekspor terendah adalah Slovenia dan Portugal. Hasil ini membuktikan bahwa algoritma X-*Means* dapat digunakan untuk menganalisis pola ekspor batik Indonesia secara efektif.

Abstract (English)

Batik is one of Indonesia's cultural heritages that has high economic value because it is a leading export product. In recent years, the value of batik exports has varied considerably each year. This study was conducted to analyze Indonesian batik export data using the X-Means algorithm as a development of previous studies that used forecasting methods. The difference in this study lies in the approach used. While forecasting emphasizes future predictions, the X-Means algorithm is used to see the clustering patterns of existing data. The data used comes from the 2010-2021 batik export dataset obtained from Kaggle and the Indonesian Batik and Handicraft Center. Data processing was carried out using the RapidMiner application with several cluster tests to determine the best results. The results showed that the test with 3 clusters produced a Davies-Bouldin Index (DBI) value of 0.029. A low DBI value indicates that the clustering results are very good and there is a clear distance between clusters. From these results, the countries with the highest batik export values were the United States and Germany, while the countries with the lowest exports included Slovenia and Portugal. These results prove that the X-Means algorithm can be used to analyze Indonesian batik export patterns effectively.

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1. Introduction

Batik is a globally recognized Indonesian cultural heritage and has made a significant contribution to the Indonesian economy through export activities (Yulianto et al., 2023). The batik industry encompasses not only art and culture but also serves as a livelihood for many businesses, from small artisans to large corporations (Suhartini Suhartini, Nina Aini Mahbubah, n.d.). Several regions, such as Pekalongan, Yogyakarta, and Solo, have long been centers of batik production, actively supplying both domestic and international markets (Wulaningrum & Hasmarini, 2023). Export activities play a crucial role because they not only help increase state revenue through foreign exchange but also expand the market reach for domestic businesses (Ginting et al., 2024). Through export activities, Indonesian batik products can be more widely known internationally and become a cultural identity that can compete with textile products from other countries (Faradila et al., 2024). Furthermore, export activities also contribute to job creation, improving public welfare, and strengthening Indonesia's position in international trade (Algusri et al., 2025). Therefore, maintaining stability and increasing export value is crucial for maintaining Indonesia's economic value going forward (Wijayanti et al., 2025).

However, in reality, the value of Indonesian batik exports is not always stable (Pramono et al., 2023). Data from recent years shows erratic increases and decreases due to various factors such as the Covid-19 pandemic, global competition, changes in market demand, and the lack of data-driven marketing strategies (Suhairi et al., 2024). Previous research only predicted export trends using forecasting methods, without considering the patterns of export destination countries based on their shared characteristics (Ningtyas & Azmiyanti, 2025). Understanding export destination countries is crucial because each country has different characteristics, needs, and trade policies (Faradila et al., 2024). By recognizing market patterns and potential in each destination country, businesses can adjust production, pricing, and promotional strategies to better target their target market. The government can also utilize this information to develop more efficient export policies, expand potential markets, and increase the competitiveness of batik products in the global market (Sayekti & Irawanto, 2023).

This study aims to segment batik export destination countries to increase export efficiency and expand batik market share using a data mining approach. Segmentation divides data into groups so that each group has similar characteristics. This method ensures that the resulting information is more focused and easier to analyze. Data mining is the process of processing and analyzing large amounts of data to discover important patterns that are not immediately visible (Hapsari & Indriyani, n.d.). One technique in data mining is clustering, which groups data based on similar characteristics. In this study, the algorithm used was X-Means, a development of the K-Means algorithm (Putra et al., 2022). The difference is that X-Means not only divides data into groups but can also automatically determine the number of groups based on the quality of the clustering results (Tanti & M Basysyar, 2024).

Several previous studies have demonstrated that the X-Means algorithm is capable of producing good clustering results (Putra et al., 2022), successfully obtaining a DBI value of 0.13 in student interest grouping, indicating fairly good clustering results. Other previous studies have also shown that X-Means has more accurate results than K-Means, with an accuracy of up to 92% (Afdilla & Hasibuan, 2024). Furthermore, a study using X-Means for sales data obtained a silhouette value of 0.68, indicating a clear distance between groups (Tanti & M Basysyar, 2024). Based on the results of previous research, the X-Means algorithm is considered suitable for use in this study because it can group data without having to determine the number of clusters from scratch and produces more structured results. Therefore, the study analyzed Indonesian batik export data from 2010–2021 using the X-Means algorithm, expanding on previous research that only used forecasting methods. To measure the performance of the X-Means algorithm, the researchers used the DBI value as an indicator of clustering quality, where the smaller the DBI value, the better the resulting cluster (Putra et al., 2022). It is hoped that the results of this study can provide more detailed information regarding export destination countries with high, medium, and low values, so that they can be taken into consideration in determining the future development strategy for Indonesian batik exports.

2. Materials and Methods

This study employed a quantitative research design using data mining techniques with a clustering approach to segment Indonesian batik export destination countries based on their export value patterns during 2010–2021 (Hapsari & Indriyani, n.d.). The research aimed not only to

identify countries with high, medium, or low export categories but also to provide strategic insights for enhancing batik market penetration internationally, in line with government efforts to boost non-oil and gas exports through cultural products (Faradila et al., 2024; Sayekti & Irawanto, 2023). The primary variable analyzed was the annual batik export value (in USD) per destination country.

Data were collected from two sources: (1) the *"Indonesian Batik Export 2010–2021"* dataset from Kaggle, and (2) supplementary data from the Indonesian Batik and Handicraft Center. The 12-year timeframe was selected to capture export fluctuations influenced by external factors such as the Covid-19 pandemic and shifting global market demands (Pramono et al., 2023; Suhairi et al., 2024). Unlike previous studies that focused solely on forecasting future export trends (Ningtyas & Azmiyanti, 2025), this research adopted a clustering approach to reveal hidden patterns among destination countries based on shared export characteristics—a critical step for developing targeted export strategies (Yulianto et al., 2023).

The methodological framework followed six sequential stages, as illustrated in Figure 1.

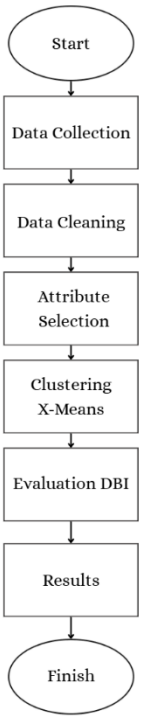

Figure 1. research methods

2.1 Data Collection

In this stage, researchers collected data on Indonesian batik exports from 2010–2021. The collected data contained a list of countries and their export values in USD. This stage was conducted to ensure all necessary information was available and ready for analysis.

2.2 Data Cleaning

The collected data was then cleaned to ensure there were no blank values, duplicate data, or formatting errors. Data cleaning was carried out to ensure that the clustering results were not affected by invalid data. This process also included adjusting attribute types and adding country IDs.

2.3 Attribute Selection

In this stage, researchers selected the attributes used in the clustering process. Only relevant attributes, such as country IDs and export values, were included, ensuring a more focused analysis process and more accurate results.

2.4 X-Means Clustering

Once the data was prepared, the clustering process was performed using the X-Means algorithm. This algorithm is used to group countries based on similar export values. The research conducted several experiments with the number of clusters to find the best results.

2.5 Evaluation (DBI)

The clustering results were then evaluated using the DBI. The DBI value is used to measure cluster quality, with a lower value indicating better clustering results. In this study, three clusters produced the lowest DBI value and was considered the best result.

2.6 Results

At this stage, the researchers interpreted the clustering results. Countries were grouped into high, medium, and low export groups based on the best cluster value obtained. These results formed the basis for the research conclusions and recommendations.

3. Results and Discussions

3.1 Clustering Results

The X-Means algorithm was applied to the Indonesian batik export dataset (2010–2021) containing 157 destination countries. Three configurations were tested (k = 3, 5, and 7) and evaluated using the Davies-Bouldin Index (DBI). Lower DBI values indicate better clustering quality with clear separation between groups (Putra et al., 2022).

Table 1. X-Means Clustering Performance Comparison

K	DBI Value	Total Clusters	Cluster Composition (Number of countries)
3	0.029	3	Cluster 0: 155 Cluster 1: 1 (United States) Cluster 2: 1 (Germany)
5	0.287	5	Cluster 0: 148 Clusters 1–3: 1 country each (US, Germany, UK) Cluster 4: 6
7	0.288	7	Cluster 0: 146 Clusters 1–4 & 6: 1 country each Cluster 5: 6

As shown in Table 1, the configuration with $k = 3$ produced the lowest DBI value (0.029), which is significantly below the 0.1 threshold for high-quality clustering (Putra et al., 2022). This confirms that the 3-cluster solution provides the clearest separation of export patterns. In contrast, configurations with $k = 5$ and $k = 7$ yielded substantially higher DBI values (0.287 and 0.288, respectively), indicating fragmented and less meaningful cluster structures.

Figure 2. Cluster Distribution with $k = 3$

Figure 2 visually confirms the extreme imbalance in cluster distribution under the optimal 3 cluster model. The detailed composition of each cluster is as follows:

- **Cluster 0 (155 countries / 98.7% of destinations)**
  Countries with low and unstable annual batik export values. Examples include Slovenia (2011), Portugal (2014), Belgium (2016), Dominican Republic (2017), Russia & Bolivia (2015), India & Norway (2019), and Maldives (2021) (Faradila et al., 2024). These markets collectively contribute less than 40% of total export value despite representing the vast majority of destination countries.
- **Cluster 1 (1 country) United States** – the largest and most stable market for Indonesian batik throughout 2010–2021, consistently contributing the highest export value annually (Wulaningrum & Hasmarini, 2023).
- **Cluster 2 (1 country) Germany** – the second-largest market with relatively stable demand compared to other European destinations (Yulianto et al., 2023).

3.2 Discussion

The clustering results presented in Table 1 and Figure 2 reveal an extreme concentration in Indonesia's batik export market: two countries (United States and Germany) dominate the export landscape, while 155 other countries collectively represent a long tail of low-value markets. This finding has three strategic implications supported by existing literature:

First, Indonesia's batik export sector faces high vulnerability to external shocks in the US and German markets. Economic downturns, trade policy changes, or shifts in consumer preferences in these two countries could significantly impact national batik export revenue (Pramono et al., 2023; Suhairi et al., 2024). This concentration risk underscores the urgent need for market diversification strategies to reduce dependency on these two dominant markets.

Second, the 155 countries in Cluster 0 represent untapped potential for market expansion. Although each country contributes minimally to total exports individually, their collective market size is substantial. Targeted promotion, particularly in countries showing intermittent demand spikes within Cluster 0 (e.g., Japan, Singapore, Australia) could gradually shift them toward higher-value segments (Sayekti & Irawanto, 2023). This approach aligns with government efforts to expand non-oil and gas exports through cultural products like batik (Faradila et al., 2024).

Third, this study demonstrates that clustering provides complementary insights compared to forecasting approaches used in previous research (Ningtyas & Azmiyanti, 2025). While forecasting predicts *future values*, clustering as demonstrated in Table 1 reveals *structural patterns* among

destination countries. This segmentation enables policymakers and exporters to: (1) prioritize retention strategies for high-value markets (US, Germany), (2) design tailored entry strategies for emerging markets within Cluster 0, and (3) allocate promotional resources more efficiently based on cluster characteristics (Hapsari & Indriyani, n.d.).
These findings directly support the research objective stated in the introduction: providing data-driven recommendations to enhance batik's international visibility and support government efforts to expand Indonesia's cultural exports (Yulianto et al., 2023). By identifying the extreme market concentration revealed in Figure 2, this study offers concrete evidence for policymakers to develop targeted interventions that reduce export vulnerability while expanding batik's global footprint.

4. Conclusion

This study successfully analyzed Indonesian batik export patterns from 2010 to 2021 using the X-Means clustering algorithm. Among the three tested configurations (k = 3, 5, and 7), the model with three clusters produced the lowest DBI value of 0.029, confirming it as the optimal configuration for segmenting export destination countries. The clustering results revealed an extreme market concentration: 155 countries (98.7% of destinations) were grouped into Cluster 0 with low and unstable export values, while only two countries formed high-value clusters the United States (Cluster 1) and Germany (Cluster 2).
This finding has three concrete societal impacts:
First, for batik artisans and SMEs, the identification of two dominant markets (US and Germany) provides clear guidance for production planning and quality standardization. Artisans in batik centers such as Pekalongan, Yogyakarta, and Solo can prioritize designs and motifs that align with the preferences of these stable markets, thereby increasing their income stability and reducing production waste.
Second, for government export policy, this study offers data-driven evidence to support two strategic actions:

1. Market retention: Strengthen bilateral trade agreements with the US and Germany to protect Indonesia's position as the "global home of batik".
2. Market diversification: Target selected countries within Cluster 0 that show intermittent demand spikes (e.g., Japan, Singapore, Australia) through cultural diplomacy and digital promotion, reducing overreliance on two markets and mitigating vulnerability to external shocks.

Third, for national economic resilience, reducing export concentration aligns with Indonesia's goal to expand non-oil and gas exports through cultural products. By transforming batik from a niche craft into a globally recognized cultural brand, this research contributes to job creation, foreign exchange earnings, and the preservation of intangible cultural heritage—directly benefiting communities dependent on the batik industry.

Above all, the X-Means algorithm proved effective for uncovering structural patterns in export data that forecasting methods cannot reveal. More importantly, this study transforms raw export data into actionable intelligence for artisans, businesses, and policymakers ultimately supporting Indonesia's vision to elevate batik as a sustainable driver of economic growth and cultural diplomacy on the global stage.

5. References

Algusri, J., Sandri, S. H., Ardi, H. A., & Alfarizal, G. (2025). *Peningkatan Daya Saing Womenpreneur Batik melalui Inovasi , Ekspor , dan Pemasaran Digital UMKM Gerai Kembang Setaman Pekanbaru*. *5*(1), 120–124.

Faradila, F., Hasni, |, Rayadiani, | Sefiani, & Tarman, |. (2024). Persepsi Eksportir Dalam Mendorong Produktivitas Ekspor: Studi Kasus Cirebon, Padang, Manggarai Barat Dan Tangerang. *Trade Policy Jounal*, *3*(5), 35–44.

Ginting, D. B. (2022). *STRATEGI RUMAH BATIK ANDALAN DALAM MELAKUKAN EKSPOR BATIK BONO KE TIONGKOK TAHUN 2016-2019*. *9*, 1–15.

Hapsari, R. K., & Indriyani, T. (n.d.). *CV . LUMINARY PRESS INDONESIA*.

Herdawani Afdilla, & Hasibuan, W. R. (2024). Analysis and Comparison of the Performance of K-Means Algorithm and X-Means Algorithm in Disease Type Clustering in Mitra Medika Hospital. *Journal of Artificial Intelligence and Engineering Applications (JAIEA)*, *4*(1), 580–587. https://doi.org/10.59934/jaiea.v4i1.696

Ningtyas, F. Y. P. U., & Azmiyanti, R. (2025). Analisis Forecasting Tren Ekspor Batik Indonesia: Prediksi Penurunan Pendapatan Di Amerika & Eropa Serta Peluang

Pertumbuhan Di Asia Melalui Business Intelligence. *Jurnal Sistem Informasi Dan Bisnis Cerdas*, *18*(2), 172–185.

Ningtyas, F. Y. P. U., & Azmiyanti, R. (2025). Analisis Forecasting Tren Ekspor Batik Indonesia: Prediksi Penurunan Pendapatan Di Amerika & Eropa Serta Peluang Pertumbuhan Di Asia Melalui Business Intelligence. *Jurnal Sistem Informasi Dan Bisnis Cerdas*, *18*(2), 172–185.

Ningtyas, F. Y. P. U., & Azmiyanti, R. (2025). Analisis Forecasting Tren Ekspor Batik Indonesia: Prediksi Penurunan Pendapatan Di Amerika & Eropa Serta Peluang Pertumbuhan Di Asia Melalui Business Intelligence. *Jurnal Sistem Informasi Dan Bisnis Cerdas*, *18*(2), 172–185.

Pramono, R. A., Trisnapradika, G. A., Adhy, B. B., Fatimah, G., Prawesty, D., Sutrisno, H., & Putra, R. P. (2023). *PENYULUHAN PENINGKATAN EKSPOR BATIK MENUJU PASAR GLOBAL*. *4*(November), 212–218.

Putra, P. H., Hasibuan, A., & Marpaung, E. A. (2022). Analisis Klasifikasi Metode X-Means Pada Minat dan Bakat Anak Dimasa Pandemi. *SITEKIN: Jurnal Sains, Teknologi Dan Industri*, *19*(2), 424–429. https://ejournal.uin-suska.ac.id/index.php/sitekin/article/download/17889/7834

Putra, P. H., Hasibuan, A., & Marpaung, E. A. (2022). Analisis Klasifikasi Metode X-Means Pada Minat dan Bakat Anak Dimasa Pandemi. *SITEKIN: Jurnal Sains, Teknologi Dan Industri*, *19*(2), 424–429. https://ejournal.uin-suska.ac.id/index.php/sitekin/article/download/17889/7834

Sayekti, P., & Irawanto, R. (2023). *Etiket Era Baru Berbasis Muatan Lokal untuk Produk Unggulan " Batik Heritage Laweyan " Siap Ekspor*. *5*(02), 141–153.

Suhairi, S., Lestari, A., Zahra, A., Lubis, S. Z. K. A., & Rozi, Y. F. (2024). Strategi Dan Kebijakan Ekspor Impor Atau Perdagangan Internasional Terhadap Pertumbuhan Ekonomi. *Jurnal Minfo Polgan*, *12*(2), 2643–2647. https://doi.org/10.33395/jmp.v12i2.13342

Suhairi, S., Lestari, A., Zahra, A., Lubis, S. Z. K. A., & Rozi, Y. F. (2024). Strategi Dan Kebijakan Ekspor Impor Atau Perdagangan Internasional Terhadap Pertumbuhan Ekonomi. *Jurnal Minfo Polgan*, *12*(2), 2643–2647. https://doi.org/10.33395/jmp.v12i2.13342

Suhartini, S., Mahbubah, N. A., & Basjir, M. (2021). Marketing Strategy Design Based on Information Technology in Batik Small and Medium-Sized Enterprises in Indonesia. *Eastern-European Journal of Enterprise Technologies*, *6*(13–114), 39–48. https://doi.org/10.15587/1729-4061.2021.244137

Suhartini, S., Mahbubah, N. A., & Basjir, M. (2021). Marketing Strategy Design Based on Information Technology in Batik Small and Medium-Sized Enterprises in Indonesia. *Eastern-European Journal of Enterprise Technologies*, *6*(13–114), 39–48. https://doi.org/10.15587/1729-4061.2021.244137

Tanti, T., & M Basysyar, F. (2024). Implementasi Algoritma X-Means Untuk Mengelompokan Penjualan Barang Di Ciledug Store. *JATI (Jurnal Mahasiswa Teknik Informatika)*, *8*(2), 1608–1613. https://doi.org/10.36040/jati.v8i2.9026

Tanti, T., & M Basysyar, F. (2024). Implementasi Algoritma X-Means Untuk Mengelompokan Penjualan Barang Di Ciledug Store. *JATI (Jurnal Mahasiswa Teknik Informatika)*, *8*(2), 1608–1613. https://doi.org/10.36040/jati.v8i2.9026

Wijayanti, A., Damayanti, R., Al-shami, S. A., & Pawenang, S. (2025). *Pemberdayaan UMKM Batik Melalui Literasi Keuangan Sebagai Strategi Menuju Pasar Ekspor*. *3*, 377–384.

Wulaningrum, A., & Hasmarini, I. (2023). Analisis Ekspor Batik Indonesia ke Amerika Serikat Pada Tahun 2000-2020. *Economics and Digital Business Review*, *4*(2), 231–239.

Wulaningrum, A., & Hasmarini, I. (2023). Analisis Ekspor Batik Indonesia ke Amerika Serikat Pada Tahun 2000-2020. *Economics and Digital Business Review*, *4*(2), 231–239.

Yulianto, I., Mahfudz Sidik, P., & Roesli, M. (2023). Manifestasi Slogan Â€Œglobal Home of Batikâ€ Sebagai Strategi Peningkatan Ekspor Batik Indonesia. *Jurnal Perspektif Bea Dan Cukai*, *7*(1), 101–130. https://doi.org/10.31092/jpbc.v7i1.2116

Yulianto, I., Mahfudz Sidik, P., & Roesli, M. (2023). Manifestasi Slogan Â€Œglobal Home of Batikâ€ Sebagai Strategi Peningkatan Ekspor Batik Indonesia. *Jurnal Perspektif Bea Dan Cukai*, *7*(1), 101–130. https://doi.org/10.31092/jpbc.v7i1.2116