A STATISTICAL APPROACH TO DETERMINING TARGETED SUBSIDY AMOUNTS BASED ON ENERGY CONSUMPTION IN INDONESIA

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Abstrak: Subsidi energi merupakan kebijakan penting pemerintah untuk memastikan akses energi yang terjangkau bagi masyarakat, terutama kelompok maysrakat pra-sejahtera. Namun, penentuan besaran subsidi seringkali tidak tepat. Penelitian ini mengusulkan pendekatan statistik berbasis *Probability Density Function* (PDF) dan *Cumulative Distribution Function* (CDF) untuk menganalisis pola konsumsi energi masyarakat yang meliputi listrik, bahan bakar minyak (BBM), dan gas. Metode ini bertujuan untuk mengidentifikasi distribusi konsumsi energi di berbagai kelompok masyarakat guna memungkinkan klasifikasi penerima subsidi yang lebih akurat. Analisa PDF digunakan untuk mengevaluasi probabilitas konsumsi energi pada rentang tertentu, sementara CDF digunakan untuk menentukan ambang batas konsumsi yang menjadi dasar penetapan nilai subsidi, dengan memanfaatkan tiga variabel energi (listrik, BBM, dan gas) konsumsi BBM mencatatkan prosentase terbesar, yakni 60-70% dari total konsumsi energi pada masyarakat kategori non-sejahtera, dengan rata-rata pengeluaran total antara 330 ribu hingga 480 ribu per bulan. Subsidi dapat diarahkan secara langsung dalam bentuk cash untuk kebutuhan energi, sehingga meningkatkan efisiensi alokasi subsidi oleh PLN dan Pertamina.

Kata kunci : subsidi energi, konsumsi energi, PDF, CDF, alokasi subsidi

Abstract: Energy subsidies are an important government policy to ensure affordable energy access for the public, especially for underprivileged groups. However, determining the appropriate subsidy amount is often inaccurate. This study proposes a statistical approach based on the Probability Density Function (PDF) and Cumulative Distribution Function (CDF) to analyze energy consumption patterns in society, covering electricity, fuel (BBM), and gas. This method aims to identify the distribution of energy consumption across different social groups to enable more accurate classification of subsidy recipients. The PDF analysis is used to evaluate the probability of energy consumption within a specific range, while the CDF is utilized to determine the consumption threshold that serves as the basis for setting subsidy values. Using three energy variables (electricity, fuel, and gas), fuel consumption accounts for the largest percentage, ranging from 60-70% of total energy consumption among non-affluent households, with an average total expenditure between 330,000 to 480,000 per month. Subsidies can be directly allocated in the form of cash for energy needs, thereby improving subsidy allocation efficiency by PLN and Pertamina.

Keywords : energy subsidies, energy consumption, PDF, CDF, subsidy allocation

A. Introduction

Energy subsidies represent a crucial government policy aimed at guaranteeing that the community has access to affordable energy. According to the Minister of Finance Regulation, subsidies aim to encourage economic growth by providing support to vulnerable groups in society (Ministry Of Finance Republic Of Indonesia, 2023) . With the existence of subsidies, it is expected that the community can reduce the burden of energy costs, thereby improving quality of life and productivity (Bambang Handriyanto & Lukmandono, 2023). The subsidies provided must be targeted effectively, so that the allocation of the government budget can be carried out efficiently and effectively. This aligns with the Indonesia President's program to implement budget efficiency across all ministries and agencies (Elyada Christi Octavia, 2025), making the determination of subsidy amounts crucial in promoting this goal. Additionally, the allocation of substantial subsidies for several sectors is managed by state-owned enterprises

(SOEs) such as PLN (State Owned Electricity Company) and Pertamina (State Owned oil and Gas Corporation) Indonesia.

The determination of appropriately targeted subsidies cannot be overlooked, especially in the context of government budget management. Currently, focusing on subsidy determinations is a strategic step to enhance budget usage efficiency. The Integrated Social Welfare Data (DTKS) collected by the Ministry of Social Affairs includes various categories, such as poor families, vulnerable groups, and those in need (Widyaningsih et al., 2023). However, this data collection process needs to be refined to encompass all eligible groups for subsidies, ensuring that no one is overlooked.

Previous research has shown that many studies have not focused on analyzing the monthly consumption values of subsidy recipients. Most research has concentrated on macroeconomic aspects without considering the direct impact on community energy consumption (Maisarah et al., 2024), (Yanto & Yunus, 2021). Therefore, it is essential to conduct a more in-depth analysis of monthly energy consumption patterns, particularly in the context of the subsidies provided. The most demonstrable micro category in determining subsidies is the level of community consumption itself, including the routine needs of the community, which can serve as a measure (Soleh Akbarudin Romadhon et al., 2024). In this context, accurate calculations to determine subsidy amounts become crucial. This research will refer to several relevant references to calculate subsidies based on three main components: electricity, fuel oil (BBM), and gas. In the state budget (APBN), the energy subsidy expenditure item consists of BBM and LPG subsidies as well as electricity subsidies (Fiscal Policy Agency, 2022). A subsidy calculation table will be prepared to provide a clear picture of subsidy fund allocation, allowing for analysis of whether these subsidies are effective in improving community welfare.

The analytical method used in this study involves a statistical approach based on Probability Density Function (PDF) and Cumulative Distribution Function (CDF). PDF is used to evaluate the distribution of energy consumption across various community groups, while CDF serves to determine the consumption threshold that becomes the basis for setting subsidy values. With this approach, it is hoped to gain a better understanding of community energy consumption patterns and the effectiveness of the allocated subsidies (Samsul Anwar et al., 2023)

B. Methods

This study employs a quantitative approach with a statistical analysis design based on the Probability Density Function (PDF) and Cumulative Distribution Function (CDF). This approach is chosen to analyze the energy consumption patterns of the community and the effectiveness of subsidies, as well as to obtain the appropriate subsidy amounts. The research aims to demonstrate that the PDF and CDF methods are highly suitable for determining the value of existing subsidies.

The population in this study includes all Indonesian citizens categorized as pre-prosperous, utilizing actual electricity billing data from the State Electricity Company (PLN) specifically for electricity consumption data, comprising over 1 million confidential data points that only display the results. Meanwhile, the sample for other energy usage consists of 500 samples distributed throughout Indonesia

Data is collected through questionnaires and secondary data from the Ministry of Social Affairs. The questionnaire is designed to gather information on energy consumption, including monthly electricity payment data, fuel oil (BBM) purchase data, and gas purchase data. Data collection is conducted through surveys and secondary data collection from energy usage reports, such as electricity data from customer accounts. Data analysis utilizes PDF to evaluate the distribution of energy consumption across various community groups based on electricity tariff categories. CDF will be used to determine the consumption threshold that serves as the basis for setting subsidy values.

PDF is a function that describes the relative probability of a continuous random variable. PDF provides information about the likelihood of values taken by the random variable within a

certain range. Mathematically, for a continuous random variable X, PDF is expressed as f(x) (Mendenhall & Beaver, 2019). The main properties of PDF are:

$$f(x) \geq 0 \; For \; All \; of \; x \quad (1)$$

The area under the PDF curve across the entire range of values for X is 1, resulting in the following equation:

$$\int_{-\infty}^{\infty} f(x)dx = 1$$

$$P\,(a \leq X \leq b) = \int_{a}^{\infty b} f(x)dx = 1 \quad (2)$$

CDF is a function that provides the probability that the random variable X will be less than or equal to a certain value x. CDF accumulates the probabilities from the PDF. Mathematically, for a continuous random variable X, CDF is expressed as F(x). CDF is defined as:

$$F(x) = P(X \leq x) = \int_{-\infty}^{x} f(t)dt \quad (3)$$

The main properties of CDF are:

F(x) is non-decreasing : $F(x1) \leq F(x2) \; jika \; x1 < x2,$

And Limited CDF : $\lim_{x \to -\infty} F(x) = 0 \; dan \; \lim_{x \to -\infty} F(x) = 1$ (4)

C. Results and Discussion

To categorize the community members who will receive subsidies, categories are based on electricity subscription data. This is feasible because each household has its own electricity tariff. The categorization for each surveyed community is shown in the following graphs: Fig.1 for electricity cost usage, Fig.2 for the number of gas cylinders in kilograms, and Fig. 3 for the number of litters.
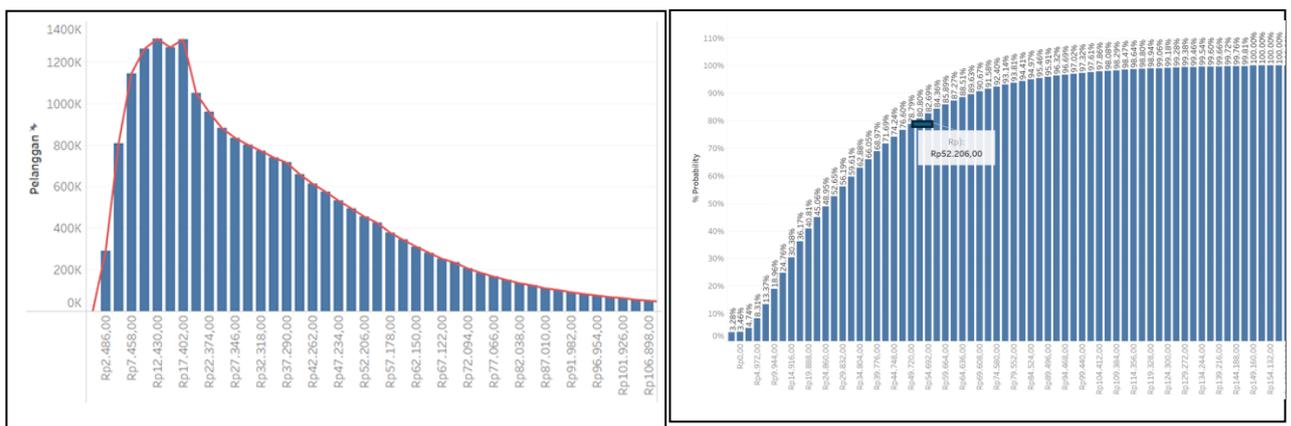

Fig 1. The PDF graph (left) and the CDF graph (right) show the electricity costs paid by customers with a tariff of 450-900 VA.

In Fig.1, the consumption value is dominated by amounts ranging from Rp 12,430 to Rp 17,402, which exhibit a non-normal distribution. To assess the best possible outcome for the realization figures, the probability indicated on the CDF graph at Rp 54,692 (109 kWh) with a CDF probability of 80% is used. The 80% figure is considered favorable as it remains within the middle range. The cumulative variance proportion reaches between 70% and 80%. This

indicates that this percentage is deemed sufficient to represent significant information within the data (Pendi, 2021).
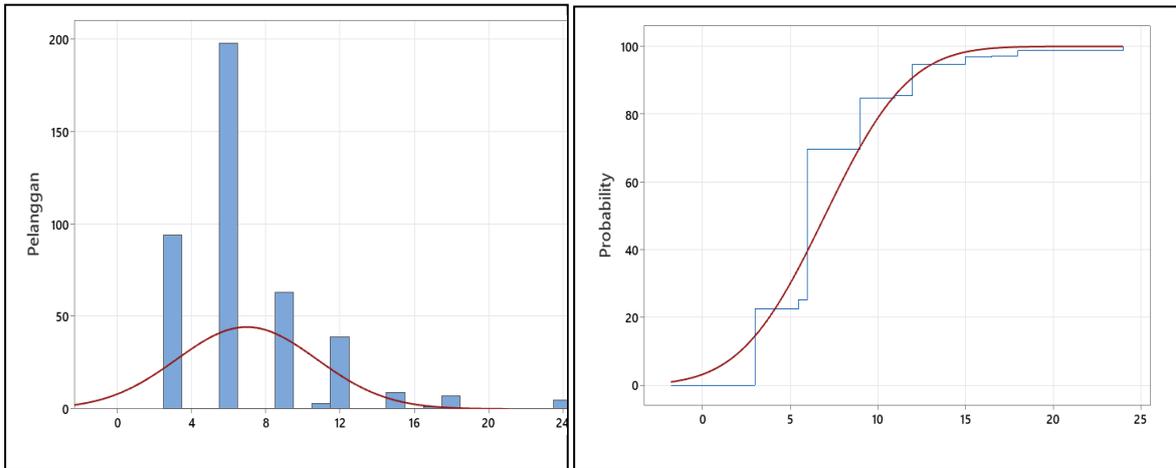

Fig 2. The PDF graph (left) and the CDF graph (right) show the number of kilograms of gas cylinders for customers with a tariff of 450-900 VA.

In Fig 2, the amount of gas cylinders used is at 6.5 kg per month, which exhibits a normal distribution. To assess the best possible outcome for the realization figures, the probability indicated on the CDF graph at 10.5 kg per month with a CDF probability of 80% is used.
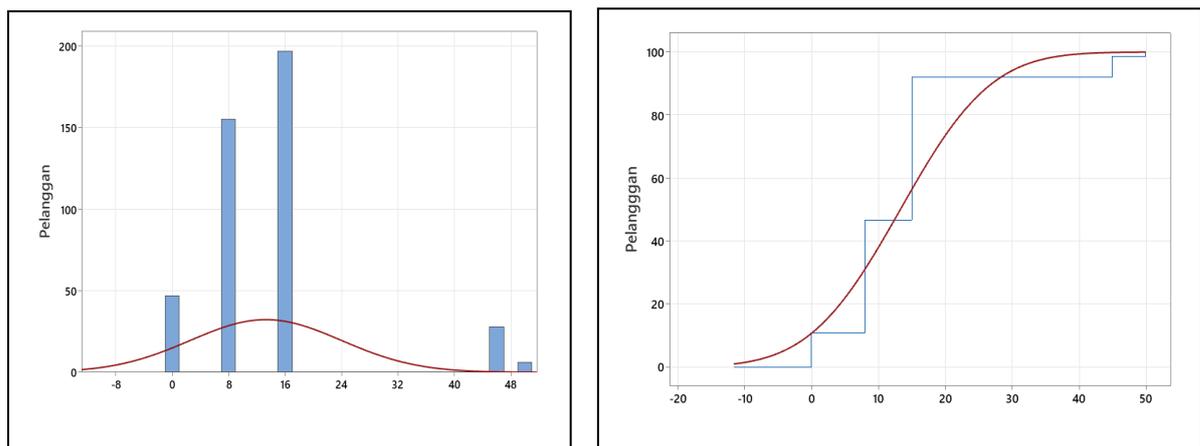

Fig 3. The PDF graph (left) and the CDF graph (right) show the number of liters of fuel for customers with a tariff of 450-900 VA.

In Fig 3, the amount of fuel used is at 16 liters per month, which exhibits a non-normal distribution. To assess the best possible outcome for the realization figures, the probability indicated on the CDF graph at 22 liters of fuel per month with a CDF probability of 80% is used. To validate this, realization data from the Ministry of Finance from 2020 to 2022, specifically for electricity consumption in several countries, is utilized (KEMENKEU, 2022).

Table 1. Average Electricity Consumption in Various Countries

Groups	Consumption per Capita per Year (kWh)	Consumption per Household per Year (kWh)	Tariff Group Equivalent
Low-income countries (*Afghanistan Somalia, MAdagaskar, Palestina, Senegal, Korea Utara*)	196	784 s.d 980	R1-450 VA to R1-1300 VA

Lower-middle-income countries (*Afrika Selatan, Peru, Kosovo, Paraguay, Palau, Mogolia, Dominika*)	1,071	4,284 s.d 5,355	R1-2200 VA to R3-6600 VA beyond
Upper-middle-income countries (*German, Belgia, Australia, Malta, Finlandia*)	4,994	19,976 s.d 24,970	R3-6600 VA beyond

From the average consumption data for low-income communities presented in Table 1, the annual electricity consumption for this demographic ranges between 784 kWh and 980 kWh, which translates to an average monthly usage of approximately 65.4 kWh to 81.67 kWh. Meanwhile, based on the results of the CDF (Cumulative Distribution Function) analysis, the estimated electricity cost for low-income households is around Rp 54,692 per month for 132 kWh of consumption. This discrepancy arises due to the non-normal distribution of electricity consumption within this group, which suggests that the fundamental electricity needs of low-income communities can be reasonably capped at Rp 54,692 per month. This figure is significant as it indicates that the maximum limit for subsidized electricity still accommodates communities whose consumption falls below this threshold, aligning with the findings reported by the Ministry of Finance. In the context of different tariff schemes, the subsidized electricity tariff is currently set at Rp 415/kWh, whereas the economic electricity tariff—reflecting the actual cost of electricity production without government intervention—stands at Rp 1,842/kWh. Beyond electricity, the cost structure of other essential energy sources also reveals substantial differences between subsidized and non-subsidized rates. For instance, the subsidized price of liquefied petroleum gas (LPG) is Rp 5,000 per kilogram, whereas the economic price is significantly higher at Rp 14,250 per kilogram. Similarly, the subsidized fuel price is set at Rp 10,000 per liter, while the economic fuel price reaches Rp 12,400 per liter. These disparities highlight the crucial role of government subsidies in ensuring that essential energy resources remain affordable for low-income households, preventing excessive financial burdens and enabling equitable access to basic energy needs across different socio-economic groups

Table 2. Basic Needs Data Before and After Subsidy and Energy Usage Percentage

Parameter	Electricity (kWh)	Gas (kG)	Fuel (Litter)	Electricity (Rp)	Gas (Rp)	Fuel (Rp)	Electricity Percentage	Gas Percentage	Fuel Percentage	Monthly Expenditure (Rp)
Society Basic Needs Data After PDF CDF Analysis	132	10.5	22	Rp54.962	Rp52.500	Rp220.000	16.78%	16.03%	67.18%	Rp327.462
Economic Values				Rp243.952	Rp149.625	Rp272.800	36.61%	22.45%	40.04%	Rp666.377
Energy Subsidy				Rp188.990	Rp97.425	Rp52.800	-	-	-	Rp338.915

Based on Table 2, the government has the capacity to allocate direct cash assistance, known as the Energy Cash Transfer, amounting to Rp 338,915 based on the latest data from 2024. This allocation is intended to help low-income households manage their energy expenses by covering part of the costs associated with electricity, gas, and fuel consumption. The table highlights several important insights regarding the distribution and utilization of these energy resources. One key observation is that the portion of LPG gas usage is the smallest compared to other energy sources such as electricity and fuel. Despite this, the subsidy allocation for LPG gas, as determined by the Ministry of Energy and Mineral Resources (KESDM), remains relatively high. This discrepancy presents an "anomaly" in the subsidy allocation mechanism, as it indicates a mismatch between government funding and actual consumer needs.

Ideally, government subsidies should be designed to reflect real consumption patterns so that financial assistance is allocated efficiently to areas where it is most needed. However, the data in Table 2 suggests that the current distribution of subsidies may not be fully aligned with the actual consumption behavior of low-income households. For instance, while LPG usage remains lower than other energy types, its subsidized allocation remains disproportionately high. This situation may lead to inefficiencies in subsidy spending, where funds intended to assist low-income households may not be reaching them in an optimal manner.

Additionally, the table reveals that the proportion of household expenditure allocated to different energy types is uneven. Fuel consumption dominates household spending at approximately 67.18% of the total monthly expenditure on energy, while electricity and LPG gas account for 16.78% and 16.03%, respectively. This suggests that fuel remains a primary necessity for many households, possibly due to its essential role in daily transportation and cooking needs. However, the imbalance in subsidy allocation raises concerns about whether the existing government policies adequately address the actual financial burden of low-income consumers.

Another notable issue is the ongoing shortage of LPG gas, which has been attributed to regulatory inefficiencies and policies that do not effectively target the communities most in need. According to KESDM (2023), these shortages are likely exacerbated by misdirected subsidies, leading to supply-demand imbalances in the market. If subsidy allocations continue to be misaligned with real consumption trends, there is a risk that energy assistance programs will fail to achieve their intended objectives, ultimately placing an additional financial strain on low-income communities.

Thus, while the government's allocation of Rp 338,915 in Energy Cash Transfers represents a significant effort to assist vulnerable populations, there is a need for a more precise and data-driven approach in subsidy distribution. Ensuring that energy subsidies are tailored to actual usage patterns can help minimize inefficiencies, prevent supply shortages, and improve the overall effectiveness of social assistance programs. The findings presented in Table 2 highlight the importance of continuous policy evaluation and reform to ensure that energy subsidies truly benefit those who need them most.

D. Conclusion

Energy subsidies serve as a critical policy instrument that plays a strategic role in improving community welfare and fostering sustainable economic growth. By reducing the financial burden of essential energy costs for lower-income households, subsidies help enhance the purchasing power of the public, ensuring that basic energy needs such as electricity, gas, and fuel remain affordable. However, for these subsidies to be truly effective, their implementation must be carefully designed to maximize their impact while maintaining fiscal responsibility. One of the key considerations in subsidy policy is ensuring the effectiveness and efficiency of budget allocation. Without a well-targeted approach, subsidies can lead to unintended consequences, such as benefiting higher-income groups that do not require financial assistance or creating market distortions that result in resource misallocation. Consequently, the determination of subsidy amounts becomes a crucial aspect of the government's broader effort to ensure that financial assistance is directed toward the groups that genuinely need it.

This study underscores the necessity of conducting a more detailed and data-driven analysis of community energy consumption patterns to refine the subsidy framework. Traditional approaches to subsidy allocation often rely on broad income classifications or assumptions about energy needs, which may not always reflect actual consumption behaviors. Instead, a more precise methodology is required to establish thresholds and allocation strategies that are fair and effective. In this regard, the use of statistical methods such as the Probability Density Function (PDF) and Cumulative Distribution Function (CDF) provides valuable insights into how energy consumption is distributed across different segments of society. By analyzing these distributions, policymakers can identify consumption benchmarks that serve as reliable references for determining subsidy eligibility. For instance, understanding the variations in

electricity, gas, and fuel usage among different income brackets enables the government to design a subsidy system that is not only more equitable but also responsive to the real needs of the population.

In conclusion, energy subsidies play a fundamental role in supporting economic stability and improving living standards, particularly for low-income households. However, their effectiveness hinges on the precision of budget allocation and the ability to tailor subsidy schemes to actual consumption patterns. By leveraging analytical methods such as PDF and CDF, policymakers can gain deeper insights into energy usage trends, enabling them to refine subsidy policies in a way that is both equitable and efficient. Moving toward a bundled energy subsidy approach, rather than channeling subsidies through individual state-owned enterprises, presents a more practical and transparent solution that ensures financial assistance reaches those who need it most. Ultimately, a well-designed subsidy framework that integrates electricity, gas, and fuel into a unified model will contribute to more effective energy management, fiscal sustainability, and inclusive economic development.

References

Bambang Handriyanto, & Lukmandono. (2023). Strategi Menentukan Harga Pokok Produksi yang Kompetitif Menggunakan Metode Activity Based Costing di PT. XYZ Food. *JATI UNIK*.

Elyada Christi Octavia. (2025). *EFISIENSI ANGGARAN 2025: KEBIJAKAN PRABOWO DAN DAMPAKNYA TERHADAP PNS SERTA EKONOMI NASIONAL*. Fakultas Ekonomi Bisnis UNESA.

Fiscal Policy Agency. (2022). *Wajah Subsidi Energi di Masa Depan*. https://anggaran.kemenkeu.go.id/in/post/wajah-subsidi-energi-di-masa-depan

KOMPAS. (2025). *Aturan Baru Penjualan Elpiji 3 Kg yang Bikin Gaduh*. https://nasional.kompas.com/read/2025/02/04/06352841/aturan-baru-penjualan-elpiji-3-kg-yang-bikin-gaduh-pemerintah-janji-ubah?page=all

Maisarah, U., Farisha, M., & Rizal, Y. (2024). *Pengaruh Subsidi Energi dan Konsumsi Listrik Terhadap Pertumbuhan Ekonomi di Indonesia*.

Mendenhall, & Beaver. (2019). *Introduction to Probability & Statistics*.

Ministry Of Finance Republic Of Indonesia. (2023). *Peraturan Menteri Keuangan Nomor 166 Tahun 2023 tentang Tata Cara Penyediaan Anggaran, Penghitungan, Pembayaran, dan Pertanggungjawaban Dana Subsidi Jenis Bahan Bakar Minyak Tertentu dan Liquefied Petroleum Gas Tabung 3 Kilogram*.

Pendi. (2021). ANALISIS REGRESI DENGAN METODE KOMPONEN UTAMA DALAM MENGATASI MASALAH MULTIKOLINEARITAS Pendi INTISARI. *Bimaster*.

Samsul Anwar, Afriyani, & Putri Shalihatul. (2023). Visitor Behavior in The Library Of Syiah Kuala University Based on Theoir Visiting Time Duration. *Eksakta - Jurnal Ilmu MIPA*.

Soleh Akbarudin Romadhon, Sakinah, N. F., Dina Azwa Bella, Husna Roihatil, Jannah, & Bintis Tianatud Diniati. (2024). Analisis Pengaruh Pendapatan Masyarakat, Tabungan, Pendidikan, Inflasi, dan Subsidi Terhadap Tingkat Konsumsi Masyarakat (Studi Kasus diIndonesia Periode1993-2023). *ECODIG*.

Widyaningsih, D., Ruhmaniyati, & Toyamah, N. (2023). URGENSI MEMUTAKHIRKAN DATA TERPADU THE URGENCY OF SUSTAINABLE AND HIGH-QUALITY UPDATE OF INTEGRATED POVERTY DATA: LESSONS LEARNED FROM CASE STUDIES IN SIX INDONESIAN REGIONS. *Jurnal Ekonomi Dan Pembangunan*, *31*(2). https://doi.org/10.55981/jep.2023.1013

Yanto, B. H., & Yunus, Y. (2021). Evaluasi Penentuan Kelayakan Pemberian Subsidi Listrik dengan Metode MFEP. *Jurnal Informatika Ekonomi Bisnis*, 109–114. https://doi.org/10.37034/infeb.v3i3.91