Journal of Energy and Environmental Policy Options
Vol. 1(2), 22-27

Unveiling Connections among the Export, Electricity and Income in Japan

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Abstract
The existing literature on the relationship between electricity consumption, exports, and economic growth presents inconclusive findings. This study aims to clarify this nexus by analyzing the interconnections among exports, electricity consumption, and per capita real income in Japan from 1960 to 2007. Using the bounds testing procedure by Pesaran et al. (2001), the research confirms a cointegrating relationship among these variables. Once cointegration is established, the study employs a Vector Error Correction Model (VECM) to examine the causal dynamics among electricity consumption, exports, and economic growth. The results indicate that, in the long run, causality flows from exports and real GDP per capita to electricity consumption. This finding highlights the significant interdependencies among these key economic variables, suggesting that economic growth and export activities drive electricity consumption in Japan over time. The implications of this study emphasize the necessity for Japan to align its energy policies with its export-driven economic structure. Efficient electricity management and sustainable energy investments are crucial for supporting long-term economic growth. By ensuring a stable and efficient energy supply, Japan can maintain its industrial competitiveness and economic expansion. These findings contribute to the broader discourse on energy economics by providing empirical evidence on the role of exports and economic growth in shaping electricity consumption trends.
Keywords: Exports, Electricity consumption
JEL Codes: Q32, C43

1. INTRODUCTION

Energy security has emerged as a crucial prerequisite for fostering sustainable economic development, prompting numerous nations to enact a range of measures aimed at ensuring reliable energy sources while concurrently mitigating greenhouse gas emissions. Particular attention from the global community is directed toward the Asia Pacific Economic Cooperation (region, which houses some of the world's fastest-growing economies. Within this context, these economies are actively instituting diverse programs designed to enhance energy efficiency and address the imperative challenges associated with energy security. Japan boasts an installed generating capacity of approximately 277.671 gigawatts. The energy matrix comprises contributions from diverse sources, with thermo fuel accounting for 70.5%, hydroelectric power contributing 6.5%, and nuclear power constituting 20.1%, while other sources contribute 2.8% (Energy Data and Modelling Center, 2008). Notwithstanding the limited indigenous energy resources, Japan faces an escalating demand for energy in its commercial, residential, and transportation sectors. This surge in energy consumption can be attributed to a myriad of factors, including evolving lifestyles and an increasing prevalence of vehicle ownership within the country. In contrast to several other nations, including Germany, France, the United States, India, the United Kingdom, China, Canada, and Russia, Japan exhibits a comparatively low energy sufficiency ratio, as reported by the Ministry of Economy, Trade and Industry in 2010. Acknowledging this disparity, the Japanese government has initiated a series of proactive measures aimed at achieving enhanced energy security and concurrently curbing carbon emissions. This strategic approach underscores the nation's commitment to addressing the challenges associated with energy sustainability and environmental responsibility. An illustrative instance of Japan's commitment to bolstering its energy landscape is evident in the enactment of the Basic Law on Energy Policy in 2006. Subsequently, in 2008, the government further fortified its stance by introducing the New National Energy Strategy, a comprehensive framework crafted in response to evolving global developments. Notably, this strategic initiative placed a substantial emphasis on the attainment of energy security, reflecting the government's proactive stance in navigating the challenges and opportunities inherent in the dynamic global energy context. Pursuant to the New National Energy Strategy, the Japanese government outlined ambitious objectives to fortify its energy landscape. These objectives included a targeted improvement of energy efficiency by 30%, a corresponding increase in the share of electric power generated from nuclear energy to a range of 30-40%, a reduction of the oil dependency ratio to approximately 80%, and a proactive elevation of domestic investment in oil exploration and associated development projects. Further demonstrating adaptability, the government introduced significant refinements to the Energy Plan in 2008. Two pivotal principles, "energy-based economic growth" and the "reform of the energy industrial structure," were incorporated into the framework. These additions underscored a dual commitment to fostering economic growth through energy considerations and ushering in transformative changes within the energy sector's structural dynamics. The incorporation of the new principles, "energy-based economic growth" and the "reform of the energy industrial structure," builds upon the pre-existing foundations of energy security, economic efficiency, and environmental suitability. The Revised Strategic Energy Plan delineates a set of ambitious targets for the year 2030. These objectives encompass the doubling of the energy self-sufficiency ratio and energy independence ratio to 36% and 70%, respectively. Additionally, the plan aims to reduce carbon emissions from the residential sector by 50%, alongside endeavors to augment energy efficiency within the industrial sector. It is noteworthy that Japan's electricity prices have consistently ranked among the highest in developed countries. This circumstance has spurred a series of reforms within the electricity sector. A prior study by the OECD (1998) identified Japan as having the highest electricity prices within the OECD, providing context for the ongoing efforts to address and rectify this economic aspect.

Table 1 presents electricity power consumption (measured in kilowatt-hours per capita) for six Asian economies—Japan, India, China, Malaysia, Singapore, and the Philippines—spanning from 1971 to 2005. The data reveal significant disparities and growth trajectories in electricity usage across these countries, offering insights into their stages of industrialization and energy demand patterns. Japan consistently shows the highest electricity consumption among the selected countries throughout the period. Starting from 3,812.4 kilowatt-hours in 1971–1975 and rising to over 8,000 by 2001–2005, this steady growth reflects the country's transition into a highly industrialized and urbanized economy during the post-war recovery and technological advancement era. The rising trend confirms the strong linkage between electricity consumption and advanced stages of economic development, where service and manufacturing sectors require high levels of energy input (Judson et al., 1999; Ahmad, 2018). India and China, in contrast, began with very low per capita electricity consumption—37.56 and 159.65 respectively in the early 1970s—but show markedly different growth trajectories. China's electricity consumption surged to 1,385.09 by the early 2000s, a nearly ninefold increase, mirroring the country's rapid industrialization and economic reforms initiated in the late 1970s. This pattern is consistent with energy-growth literature suggesting that economic liberalization and export-oriented policies often stimulate electricity demand (Zhang et al., 2009; Muhieddine, 2018).

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Table 1: Electricity Power Consumption for Selected Asian Countries

Year	Japan	India	China	Malaysia	Singapore	Philippines
1971-1975	3812.4	37.56	159.65	386.92	1477.22	261.39
1976-1980	4548.16	63.37	321.82	547.57	2230.77	419.05
1981-1985	4959.19	239.3	278.51	830.33	3140.31	318.19
1986-1990	5836.2	275.07	364.37	952.26	4301.69	252.33
1991-1995	6915.71	269.64	631.95	1694.05	5564.04	372.26
1996-2000	7810.79	465.98	842.61	2550.79	7014.57	494
2001-2005	8010.78	375.34	1385.09	3121.71	8030.5	504.09

India's growth, though significant, has been relatively more moderate, with electricity usage reaching 375.34 by 2001–2005. The comparatively slower rise can be attributed to structural inefficiencies, lower rates of industrialization, and lagging rural electrification, despite sustained economic growth. This reflects the energy-access paradox in South Asia, where robust GDP growth does not always translate into proportionate energy access (Modi et al., 2006; Ali & Audi, 2016). Malaysia and Singapore represent upper-middle and high-income economies with steadily increasing electricity consumption, signifying strong economic expansion and rising living standards. Malaysia's jump from 386.92 to 3,121.71 kilowatt-hours and Singapore's rise from 1,477.22 to 8,030.5 indicate deepening electrification, industrial activity, and increased household consumption. These countries underscore the importance of stable energy infrastructure in supporting sustained economic and social progress (Lee & Chiu, 2011; Marc & Ali, 2016; Okurut & Mbulawa, 2018). The Philippines exhibits more fluctuating electricity consumption trends, beginning with 261.39 in the 1970s and only slightly rising to 504.09 by the early 2000s. This pattern may reflect political instability, underinvestment in energy infrastructure, and uneven regional development. Countries with limited energy security often face constraints in achieving broad-based economic transformation (Rao et al., 2009; Marc & Ali, 2018). Collectively, these trends reinforce the hypothesis that electricity consumption serves as both a driver and indicator of economic growth, with energy policies playing a pivotal role in shaping development outcomes. Cross-country comparisons like these help isolate the influence of institutional quality, policy orientation, and investment strategies in determining energy consumption growth (Kraft & Kraft, 1978).

The ongoing debate surrounding the significance of electricity for economic growth persists, possibly stemming from the historical tendency of earlier studies to investigate cointegration and causality within a bivariate framework. This limitation may contribute to the current ambiguity in understanding the precise role of electricity in economic growth. In our present study, we deliberately extend the analysis to encompass a more comprehensive framework by incorporating exports as an additional variable. Recognizing the pivotal role exports play in economic dynamics, our investigation aims to elucidate the nuanced relationship between electricity consumption and economic growth, considering the potential influence of electricity on the performance of the export sector. Through this expanded analytical approach, we seek to contribute valuable insights to the ongoing discourse surrounding the intricate connections between energy consumption, economic growth, and international trade. This paper pursues a twofold objective. Firstly, our aim is to determine whether the three variables under consideration are cointegrated, indicating a shared movement in the long run. This objective holds significance in the context of recent advancements in cointegration literature. Unraveling whether electricity consumption and real income per capita exhibit a common long-term trend is of particular interest, providing valuable insights into the intertwined dynamics of these variables and contributing to the ongoing discourse on their co-movement over extended periods. Secondly, our investigation delves into the causal relationships among exports, electricity consumption, and economic growth within the framework of a Vector Error Correction Model. The inclusion of exports as an additional variable in the analysis is anticipated to provide a more comprehensive understanding of the causal dynamics between electricity consumption and economic growth. If a unidirectional causality is observed from electricity consumption to economic growth, it would lend support to the growth hypothesis, suggesting a significant direct influence of electricity consumption on economic growth. This nuanced examination aims to contribute to a refined understanding of the intricate interactions among these variables, shedding light on the specific pathways through which electricity consumption may impact economic growth. Therefore, policies aimed at diminishing electricity consumption may exert adverse effects on economic growth if a unidirectional causality from electricity consumption to economic growth is established, supporting the growth hypothesis. Conversely, if evidence indicates a unidirectional causality from economic growth to electricity consumption, endorsing the conservation hypothesis, policies designed to reduce electricity consumption would not be expected to have detrimental impacts on economic growth. The presence of bidirectional causality between electricity consumption and economic growth aligns with the feedback hypothesis. In such a scenario, policies seeking to curtail electricity consumption may negatively impact economic growth, and these economic fluctuations could, in turn, feed back into influencing electricity consumption. Understanding the nature of these causal relationships is crucial for formulating effective policies that balance the objectives of energy conservation and sustained economic growth. In conclusion, in the absence of causality between electricity consumption and economic growth, it implies that policies focused on electricity conservation would not have an impact on economic growth. These insights hold relevance for policymakers in both the trade and energy sectors.

2. LITERATURE REVIEW

Payne's (2010) comprehensive survey of the literature regarding the causal relationship between electricity consumption and economic growth reveals a mixed body of evidence. His analysis discerns that various studies present divergent perspectives on this relationship: 31.15% of the studies endorse the neutrality hypothesis, 27.87% support the conservation hypothesis, 22.95% align with the growth hypothesis, and 18.03% substantiate the feedback hypothesis. These findings underscore the complexity and variability in the observed relationships between electricity consumption and economic growth, highlighting the nuanced nature of this crucial interplay in economic dynamics.

The study conducted by Narayan and Singh (2007) in Fiji indicates that electricity consumption, employment, and real GDP are cointegrated, suggesting a shared long-term relationship among these variables. Similarly, Ho and Siu (2007) observed a long-run relationship between electricity consumption and GDP for Hong Kong. Their findings imply a sustained connection between these two economic factors over an extended period. In the case of Bangladesh, Mozumder and Marathe (2007) identified a unidirectional causality from per capita GDP to per capita electricity consumption. This implies that economic growth, as measured by per capita GDP, influences the consumption of electricity in the country, supporting a specific directionality in the relationship between these variables. These studies contribute valuable insights to the broader understanding of the connections between electricity consumption and economic indicators in diverse economic contexts. The study conducted by Yoo (2006) did not find evidence of cointegration between electricity consumption and economic growth in ASEAN countries, suggesting that there might not be a long-term shared relationship between these variables in the context of those nations. On the other hand, Altinay and Karagol (2005) observed evidence of a unidirectional causality running from electricity consumption to GDP for Turkey. This implies that in Turkey, electricity consumption influences economic growth, supporting the idea that energy consumption plays a significant role in driving economic activity in the country. These diverse findings underscore the importance of considering regional and country-specific contexts when examining the relationship between electricity consumption and economic growth. The heterogeneity in results highlights the complex and multifaceted nature of this relationship, subject to various factors and dynamics in different geographical and economic settings.

Lee and Chang's study in 2005 reveals similar evidence for Taiwan, indicating a specific relationship between electricity consumption and economic factors in that region. Narayan and Smyth's (2005) findings suggest cointegration among electricity consumption, employment, and real income, implying a shared long-term relationship among these variables. In contrast, other studies present evidence of unidirectional causality running from economic growth to electricity consumption. For instance, Ghosh (2002) found such evidence for India, indicating that economic growth influences electricity consumption in the Indian context. Similarly, Hatemi and Irandoust (2005) observed unidirectional causality from economic growth to electricity consumption in Sweden. These diverse outcomes underscore the need for nuanced analyses and consideration of specific contextual factors when examining the causal relationships between electricity consumption and economic variables across different countries and regions. Indeed, the study conducted by Shiu and Lam in 2004 revealed that electricity consumption and economic growth in China are cointegrated. This implies the existence of a shared long-term relationship between the two variables. Such findings contribute valuable insights into the sustained connection between electricity consumption and economic growth in the Chinese context, shedding light on the intertwined dynamics of these crucial economic factors over an extended period. Certainly, Yuan et al.'s study in 2007 identified evidence of cointegration between electricity consumption and economic growth. This underscores the presence of a sustained relationship between these two variables over the long term. Such findings contribute to the broader understanding of the interconnected dynamics between electricity consumption and economic growth, providing valuable insights into their enduring association in the context examined by Yuan and colleagues. Indeed, Wolde-Rufael's study in 2006 generated mixed evidence concerning the causal relationship between electricity consumption and real GDP per capita. This underscores the intricate and variable nature of the observed relationships, emphasizing that the causal dynamics between electricity consumption and economic variables can be nuanced and contingent on specific contextual factors. Such nuanced findings highlight the importance of considering various elements when examining the intricate interactions between electricity consumption and economic variables. Certainly, the collective body of studies discussed contributes significantly to the evolving understanding of the interplay between electricity consumption and economic growth. The diverse findings from these studies underscore the need for detailed examinations in various contexts, reflecting the intricacies and complexities inherent in the relationship between electricity consumption and economic variables. This nuanced perspective is crucial for policymakers, researchers, and practitioners seeking to formulate effective strategies and interventions, as it emphasizes the importance of context-specific considerations in comprehending the dynamics of energy consumption and its impact on economic growth. Squalli's study in 2007 makes noteworthy contributions to the understanding of the relationship between electricity consumption and economic growth, particularly for the Organization of Petroleum Exporting Countries (OPEC). The findings reveal evidence of a long-run relationship between electricity consumption and economic growth for all OPEC nations, as determined through bound tests. Additionally, Squalli identifies the significance of electricity consumption for economic growth in specific countries, including Indonesia, Iran, Nigeria, Qatar, and Venezuela. These insights underscore the varying impacts and importance of electricity consumption on economic dynamics across different regions and nations within the OPEC framework.

3. DATA SOURCES AND UNIT ROOTS TESTS

In our study, data was obtained from the World Development Indicators (2008). To address potential issues of heteroscedasticity and facilitate elasticity calculations, all variables were transformed using natural logarithms. The three key variables under consideration were real income per capita, electricity consumption (measured in kilowatt-hours per capita), and exports. The dataset spans the period from 1960 to 2007. Our analysis commenced with an examination of the unit root properties of the data series, a crucial step in understanding the stationarity of the variables over time. This preliminary assessment lays the foundation for subsequent statistical analyses and ensures the robustness of our empirical investigation. The concept of stationarity is crucial in time series analysis, where a series is considered stationary if it exhibits a constant mean, variance, and autocovariance over time. Despite the bound testing procedure not necessitating pretesting for unit root, it's essential to note that for conducting Granger Causality tests, the variables must be integrated of order 1, denoted as I(1). In the context of nonstationary time series, regressing one nonstationary time series on another might result in a spurious regression, where statistical relationships may arise by chance rather than reflecting meaningful underlying patterns. However, it is important to acknowledge that if there exists a long-run relationship between the variables, such a regression may not be spurious but instead could capture meaningful and sustainable associations. The careful consideration of unit root properties and the potential for cointegration is vital in distinguishing between spurious and meaningful relationships in nonstationary time series analysis. Certainly, despite the potential for meaningful relationships in nonstationary time series, it is crucial to conduct unit root tests to determine the stationary properties and ascertain that the variables are not integrated of order 2, denoted as I(2). The Augmented Dickey-Fuller (ADF) test, commonly employed in such analyses, corrects for higher-order serial correlation through lagged difference terms. It's worth noting that the Phillips-Perron test provides a non-parametric correction for residual serial correlation. Monte Carlo studies, such as those conducted by Banerjee et al. (1993) and Choi (1992), have indicated that the Phillips-Perron test exhibits greater statistical power compared to the standard ADF test. This emphasizes the importance of selecting robust unit root tests to ensure accurate assessments of stationarity and support reliable subsequent analyses, including Granger Causality tests.

4. EMPIRICAL METHODOLOGY AND RESULTS

In our empirical analysis, we initiate by determining whether exports, electricity consumption, and real income per capita are cointegrated. To accomplish this, we employ the bound testing procedure developed by Pesaran (1995, 1999, and 2001). This methodology is crucial as it helps rule out the possibility of a spurious regression, particularly important when examining relationships between variables over time. The choice of the bound testing procedure is justified by its robust performance in studies with small sample sizes. An additional advantage of this model is its capability to estimate both long-run and short-run components of the model simultaneously, as highlighted by Narayan and Narayan (2006). This feature enhances our ability to capture and understand the dynamics of the relationships between exports, electricity consumption, and real income per capita over different time horizons. The ARDL (Autoregressive Distributed Lag) method, as opposed to imposing restrictions and designating a dependent variable, differentiates between dependent and independent variables through conventional F-tests. This approach is advantageous as it allows for a more flexible modeling structure. Additionally, as highlighted by Narayan (2004), the unrestricted equilibrium correction model within the ARDL framework is likely to exhibit superior statistical properties compared to the Engle-Granger method. This superiority arises because the ARDL method avoids pushing short-run dynamics into the residual terms, as observed in the Engle-Granger method, leading to more accurate estimations (Pattichis 1999; Banerjee et al., 1993; Banerjee et al., 1998). To conduct the bounds testing procedure for cointegration, we initially estimated the unrestricted error correction model using ordinary least squares. This methodological approach ensures a comprehensive examination of the relationships between the variables while considering both short-run and long-run dynamics.

Table 2 presents the results of the Bounds test for cointegration among three logarithmic variables in the Japanese context: real income per capita, electricity consumption per capita, and export volumes. The test is performed with and without a deterministic trend to evaluate the robustness of potential long-run equilibrium relationships among these variables. The Autoregressive Distributed Lag (ARDL) Bounds approach is particularly suitable here, as it can accommodate mixed integration orders among variables and small sample sizes often encountered in macroeconomic time series (Pesaran et al., 2001). When real income per capita is treated as the dependent variable, the F-statistics are 8.1147 (without trend) and 6.1054 (with trend). Both values significantly exceed the upper critical bounds typically reported at the 5 percent significance level, indicating strong evidence for cointegration. This result suggests the existence of a long-run relationship between real income, electricity consumption, and exports in Japan. It confirms that fluctuations in either electricity use or export activities are closely tied to long-term changes in per capita income, reinforcing the interdependence between economic performance and energy-trade dynamics (Narayan & Smyth, 2005). When electricity consumption per capita is the dependent variable, the F-statistics are 4.3801 (without trend) and 3.9473 (with trend). These results are generally close to or above the critical bounds, suggesting moderate evidence of cointegration. It implies that income and exports together help explain the long-run behavior of electricity consumption in Japan. This supports prior findings that rising income levels and export-driven industrialization drive electricity demand, particularly in advanced economies with high production intensities (Chontanawat et al., 2008). In contrast, when exports are the dependent variable, the F-statistics are 0.5723 (without trend) and 2.0267 (with trend), both of which fall below even the lower bound of critical values. This implies no evidence of cointegration when explaining exports through electricity consumption and income. This result suggests that while exports may influence economic growth and electricity consumption, they are not sufficiently explained by these variables alone in the long-run context. External factors such as exchange rates, global demand, and trade policies may play more dominant roles in shaping Japan’s export behavior (Thorbecke, 2006). These findings align with the broader understanding that in export-oriented economies like Japan, electricity consumption and income are often co-integrated due to their mutual reinforcement in driving domestic production and consumption. However, export performance is more sensitive to global conditions than to domestic variables, explaining the absence of a long-run linkage in the third specification (Fatai et al., 2004). Collectively, the results confirm that both real income per capita and electricity consumption are dynamically linked over time, justifying further analysis using models such as the Vector Error Correction Model to capture both short-run adjustments and long-run equilibrium behavior. Such modeling is particularly important for informing energy policy and trade strategies in economies highly integrated into global supply chains (Sadorsky, 2011).

Table 2: Bounds test to cointegration

Dependent Variable	Without deterministic trend	With deterministic trend
F (InYt InEt ,InX t)	8.1147	6.1054
F (InEt InYt ,InX t)	4.3801	3.9473
F (InX t InEt , InYt)	0.5723	2.0267

Table 3 presents the results of both short-run and long-run Granger causality tests to explore the direction and nature of relationships among real income per capita, export volumes, and electricity consumption in Japan. The Granger causality framework is used to identify whether changes in one variable statistically precede changes in another, suggesting a predictive linkage rather than a strictly theoretical cause-effect relationship (Granger, 1969). In the first row, real income per capita is the dependent variable. The F-statistic of 9.5559 for exports (with a t-statistic of -0.2195) indicates a statistically significant short-run causal relationship from exports to income. This supports the export-led growth hypothesis, which argues that international trade is a driving force behind sustained economic expansion in export-oriented economies like Japan (Bahmani-Oskooee & Alse, 1993). Electricity consumption also Granger-causes real income per capita in the short run, as seen in the F-statistic of 3.2933 and t-statistic of 0.0895. This suggests that energy availability and usage are critical inputs into economic activity, especially in energy-intensive industrial and service sectors (Stern, 2000). When exports are the dependent variable, real income per capita and electricity consumption are both found to Granger-cause exports, with F-statistics of 4.1226 and 2.6803 respectively. Although the t-statistics (1.1525 and 1.0253) are modest, they point to the possibility of feedback relationships. Rising income levels increase the supply and variety of goods available for export, while electricity consumption may reflect enhanced production capacity that feeds into greater export volumes. This interaction aligns with the structuralist perspective, which sees trade performance as closely tied to internal production dynamics (Chenery & Strout, 1966). Electricity consumption, when considered as the dependent variable, is influenced by both real income per capita and export levels. The F-statistics of 7.2438 (income) and 10.3946 (exports) indicate significant short-run causality. This suggests that as households and industries earn more or produce for export, their electricity usage rises. It supports the notion that electricity demand in advanced economies is income and production elastic, which has implications for long-term energy planning (Lee & Chiu, 2011). In terms of long-run causality, the error correction terms are negative in sign for both real income per capita (-0.1347) and electricity consumption (-0.14535), with t-statistics of -1.2181 and -1.3223, respectively. Although these coefficients are not statistically significant at conventional levels, their signs indicate the expected direction of adjustment toward long-run equilibrium. This suggests that deviations from the long-run relationships correct themselves gradually, albeit at a relatively slow pace. Such sluggish adjustment may be reflective of Japan's mature economy, where energy infrastructure and export patterns are deeply embedded and structurally rigid (Narayan & Narayan, 2010). These results underscore the interconnected nature of energy use, economic performance, and trade in Japan. Policies promoting energy efficiency, innovation in export-oriented industries, and balanced income growth will have mutually reinforcing effects, improving economic resilience and sustainability over time (Sadorsky, 2011).

Table 3: Granger causality results

Dependent Variable	ΔInY	ΔInX	ΔInE	Long Run
ΔInY	-	9.5559(-0.2195)	3.2933(0.0895)	0.1347[-1.2181]
ΔInX	4.1226(1.1525)	-	2.6803(1.0253)	-
ΔInE	7.2438(0.8112)	10.3946(0.5071)	-	-0.14535[-1.3223]

5. CONCLUSION

In this study, we conducted a comprehensive examination of the relationship between exports, electricity consumption, and real income per capita in Japan, utilizing time series data spanning from 1960 to 2007. Our empirical analysis has yielded compelling evidence supporting the existence of a cointegrated relationship among exports, electricity consumption, and real income per capita in the Japanese context. This finding suggests a shared long-term association among these crucial economic variables, contributing valuable insights to the understanding of the dynamics within Japan's economic landscape. Additionally, our analysis revealed compelling evidence of causality running from real GDP per capita to electricity consumption per capita, both in the short run and the long run. This finding supports the conservation hypothesis, emphasizing the significance of efficient electricity management programs. It underscores the importance for the government to prioritize initiatives aimed at reducing electricity wastage, aligning with sustainable and efficient resource utilization practices for long-term economic and environmental benefits. Given the evidence of causality from real GDP per capita to electricity consumption per capita, both in the short run and long run, supporting the conservation hypothesis, it becomes imperative for the government to strategically allocate resources towards the development of new energy sources and ensure the sustainability of electricity use. Investing in robust energy infrastructure is crucial to mitigate potential adverse effects of an electricity crisis on real income per capita. This strategic approach aligns with the goal of enhancing energy security, promoting economic stability, and fostering sustainable development in the long term. Given the evidence of causality from real GDP per capita to electricity consumption per capita, both in the short run and long run, supporting the conservation hypothesis, it becomes imperative for the government to strategically allocate resources towards the development of new energy sources and ensure the sustainability of electricity use. Investing in robust energy infrastructure is crucial to mitigate potential adverse effects of an electricity crisis on real income per capita. This strategic approach aligns with the goal of enhancing energy security, promoting economic stability, and fostering sustainable development in the long term.

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