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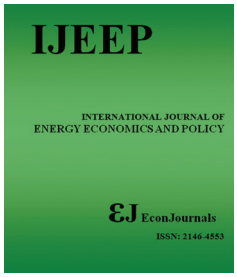

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Energy Consumption and Generation Diversity

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ABSTRACT

This study investigates whether generation diversity in population can influence energy consumption. Using a panel data of 37 OECD countries over the years 1980-2021, it is found that apart from the size of population by age, generation diversity can influence the electric consumption per head of OECD countries. Specifically, an increase in generation diversity decreases the electric consumption. High generation diversity can lead to a smaller household, where energy consumption can be more efficiently managed. High generation diversity can also lead to high income variation that results in diversity in energy source consumption. Moreover, younger generations, concerning over environmental issues and energy conservation, can influence older generations to conserve more energy through bandwagon effect. This study shows that generation diversity is an important dimension in population structure that can influence electricity consumption. Hence, generation diversity needs to be considered in planning for energy management strategies.

Keywords: Generation Diversity, Energy Consumption, Electricity Consumption, OECD
JEL Classifications: J1, Q4

1. INTRODUCTION

The world energy consumption is growing. International Energy Agency (IEA, 2021) reports that there is a rise in electricity demand in 2021 with almost half of the increase come from fossil fuels, which threatens the increase in CO_2 emissions to record levels in 2022. Even though different countries use different types of energy, and regardless of the source of energy, demand for energy is increasing with the global population, that is expected to increase by 2 billion over the next 2 decades. With an improvement in standards of living, IEA estimated that by 2040, electricity generation is expected to increase by 52%. Estiri (2015), Mohamed and Bodger (2005), Druckman and Jackson (2008), and Egelioglu et al. (2001), among others, show a positive relationship between economic and social factors with energy consumption. Apart from the population size, population structure also influences the energy consumption. It has been established that as population ages, the consumption behavior of population changes, and therefore, energy consumption would also be affected. Estiri and Zagheni (2019), among others, show that the U.S. energy use rises with age, starting when young adults leave the family home in their early 20s. Energy consumption remains flat until individuals reach 30s and then climbs to a peak in their mid-50s. Energy consumption among 55-64 shows a slow growth, where it increases rapidly after the age 70. A study in Japan also confirms such patterns (Inoue et al., 2022).

Therefore, as the world enters aging/aged society, this demographic shift may pose a significant challenge to finding the energy supply to satisfy the growing demand for energy. United Nation predicts that the growth of world population between 2000 and 2050 to be around 0.86%, which was reduced from 1.77% during 1950-2000. Life expectancy increases due to a better healthcare and social welfare. However, at the same time, there is a low fertility rate due not only to economic incentives, but also the lifestyle of the new generation. This trend leads to an increase in the proportion of senior population. Across OECD member countries, the share of population aged 65 and over is projected to rise from 17.3% in 2019 to 26.7% by 2050.[1] Moreover, the share of population aged 80 and over is expected to increase from 4.6% to 9.8% over the same period. Due

1 https://www.oecd-ilibrary.org/sites/9989e95c-en/index.html?itemId=/content/component/9989e95c-en

to different activities and behaviors of population in different age group, their energy consumption behavior differs. Estiri and Zagheni (2019) find that older population consume more energy even after controlling for wealth, local climate, and home size in the US. Other studies find similar results in many countries around the world (Pais-Magalhães et al., 2022; Inoue et al., 2022; Jo et al., 2020; Mohamed and Bodger, 2005; Liddle, 2013). However, Hasanov and Mikayilov (2017) found that the working age population (aged 15-64) is the group that contributes to more energy consumption in Azerbaijan. Garau et al. (2013) find that a pronounced aging population leads to a reduction in energy use. Ota et al. (2018) find that aging society in Japan reduces the total electricity demand but does not affect gas demand. Therefore, based on the literature, we can presume that population structure in the form of population age does have an influence on energy consumption regardless of the data used and estimation models. However, none of the existing studies directly analyze the impact of another aspect of population structure, the coexistence of different generation on energy consumption.

Apart from age differences, different generation population might have influence over the energy consumption behavior. In sociology and psychology literature, studies confirm that due to the social and historical events that shape the social consciousness and perspective of an individual, there are distinct cohorts of population (generation) that shared the same characteristics, attitudes, and values but differ from other generations. Because of the differences in lifestyles of each generation, when there are many generations living together (high generation diversity), the level of energy consumption might differ from the time when there is a low generation diversity. Is there an economy of scale in energy consumption when many generations are coexisted in a society as what found in the study at the household level? (Ironmonger et al., 1995)[2]

Therefore, the aim of this study is to analyze whether generation diversity has any impact on energy consumption. Just as it is important to understand population characteristics on energy consumption, knowing whether generation diversity has any impact and in which direction can help guide a plan to supply energy as well as planning for sustainable energy consumption in the future.

The rest of the paper is organized as followed. Section 2 provides information on generation differences in energy consumption. Section 3 described data and methodology. Results are presented in Section 4, and conclusion is in Section 5.

2. GENERATION DIFFERENCES IN ENERGY CONSUMPTION

In defining each generation, the literature generally uses the year that they were born. Even though minor variations exist, we can summarize each generation in Table 1.

Table 1: Lists of generations

Generations	Years Born
Greatest generation	1901–1927
Silent generation	1928–1945
Baby boomer	1946–1964
Generation X	1965–1980
Generation Y	1981–1996
Generation Z	1997–2012

The Pew Research Center (2015, 2019)

Generational cohort theory discussed by researchers in anthropology, sociology, and psychology suggests that people in each cohort exhibit similar characteristics, preferences, and values toward different aspects of life, and each cohort thinks and behaves differently. Not only people of different age group usually have different aspects of life, but their thoughts or how people feel about a given issue is also shaped by their historical and life events when they grow up (Becton et al., 2014; The Pew Research Center, 2015).

Beaman (2020) summarizes studies by BC Hydro, a Canadian electric company, that finds similarity in energy use patterns by generation cohort, and strong differences between generations. Baby boomers were part of the peak in fertility that began in 1949, after the end of World War II. Baby boomers, despite rapid change in the current media platforms and devices, are traditionalists, prefer the use of traditional electric devices as opposed to new technological devices that consume less energy, like to live in larger homes, more likely to prepare home-cooked meals, and therefore results in higher energy usage. Beaman (2020) states that BC Hydro finds that average Baby Boomer in a single-family home consumes twice the amount of energy as a millennial (Generation Y).

Generation X is defined by the relatively low birth rates compared to the Baby Boom generation. Nimngern (2018) and Francis and Hoefel (2018) describe Baby Boomer generation's behavior as idealism, revolutionary, collectivist, serious, and hard working. Generation Xs are competitive, confidence, individualistic, and interested in technology. Being a frugal generation, they commonly seek ways to save money and therefore more receptive to adopt more energy-conscious lifestyle. Generation Ys are globalist, questioning, and oriented to self. They grew up with technology and therefore are technology-able. They care for environment, green energy, and sustainability. They are more likely to live in smaller homes to reduce carbon footprint along with being less financially established and are twice more likely to adopt solar technology than the Baby Boomers (Beaman, 2020). However, their desire or convenience can also increase energy usage. Generation Zs grew up with technology. They are highly connected to the internet. However, there is still inconclusive evidence of Generation Zs' energy habits. However, with the increasing climate change, and energy sustainability needs, they are expected to consume less energy than other generations.

Since each generation has different views on what is important in life, their energy consumption can differ. When this generation coexist in a society, the energy consumption can be affected.

3. GENERATION DIVERSITY INDEX

To quantify the level of generation diversity at a point in time, we need a measure that can capture the complexity of generational differences. Even though the proportions of population in different

2 Ironmonger et al. (1995) finds significant economies of scale in energy use are found in Australian households.

generations can describe demographic information of a community, these proportions are still not able to account for the diversity of number of generations that change over time. Therefore, we need a measure that not only consider the number of generations, and the size of each generation, but also how they compared to one another.

Harnphattananusorn and Puttitanun (2022) generate generation diversity indices that measure the intensity of generation diversity in OECD countries, which consider the number of generations, the absolute size of each generation, and the relative size of each generation compared to others in the labor force in each period. They follow methods that Biologists measure the diversity of different species in a community using biodiversity indices.[3] In this paper, we use one of the generation diversities, the Shannon index, that is better account for when there can be differences in the size of each generation in a community, which is calculated using the following formula:

$$HS = -\sum_{i=1}^{s} p_i ln p_i$$

Where p_i is the proportion of individuals found in the i^{th} generation compared to the size of the population. The higher the value of Shannon index is associated with higher generation diversity.

4. DATA AND EMPIRICAL MODEL

To explore the relationship between generation diversity and electricity consumption, we use the data of 37 OECD countries over the years 1980-2021 collected from the World Development Indicator dataset. The data on the number of each OECD country's population born in different years over the years 1980-2021 is used to calculate the generation diversity index (Shannon Index). Apart from the generation diversity, we also control for the size of population at different age (Estiri and Zagheni (2019) and Inoue et al. (2022)) and consumer price index as shown in equation (1).

$$\begin{aligned} lelccon_{it} = a_0 + 1cpi_{it} + HSindex_{it} + la1014_{it} + la1519_{it} \\ + la2024_{it} + la2529_{it} + la3034_{it} + la3539_{it} \\ + la4049_{it} + la5054_{it} + la5559_{it} + la6064_{it} \\ + la6569_{it} + la7074_{it} + la7579_{it} + e_{it} \end{aligned} \quad (1)$$

and

$$e_{it} = \alpha_i + \varepsilon_{it} \quad (2)$$

where $lelccon_{it}$ is the Electric power consumption (kWH per capita) in logarithmic form of country i in year t, $lcpi_{it}$ is the consumer price index of country i in year t, $HSindex_{it}$ is the generation mix index of country i in year t, la denote the natural log of population in different age range, for example $la1014_{it}$ is the size of population with age between 10 to 14 of country i in period t, and e_{it} is the error term. It is assumed that e_{it} is uncorrelated with the controlled variables, αi is the country-specific effects, and ε_{it} is the common stochastic error term.

Due to the nature of our data set, the appropriate estimation method used in this study is a panel regression analysis. We focused on two models: fixed effect and random effect models. The assumption that distinguishes the fixed effect model from the random effect model is whether in equation (2) is correlated with the set of explanatory variables or not. We use the Hausman test (Hausman, 1978) to determine whether the fixed or random effect model is more appropriate.

Table 2 shows the descriptive statistics of the variables used in the model. Overall, the average value of the electric power consumption in logarithmic form is 8.605 with the minimum usage being 6.208 and the maximum at 10.905.

5. RESULTS

The estimation result is shown in Table 3. Based on the Hausman test, the fixed effect model is the appropriate estimation technique for equation 1 and our data set. Based on Table 3, we can see that older population significantly consume more electricity compared to younger population, which supports the results found in Estiri and Zagheni (2019), Jo et al. (2020), and Inoue et al. (2022). As for the variable of interest, the generation diversity, it significantly reduces the electric consumption per person at the 5% level of significant. The reasons why generation diversity leads to a reduction in energy consumption may come from several factors. Because of the differences in lifestyles of each generation, high generation diversity can lead to a smaller household living separately, where energy management[4] can be easily monitored, controlled, and conserved as compared to a larger household. Therefore, energy consumption is more efficient with smaller household under a high generation diversity society. This result supports Abrahão and Souza (2021) that shows household with fewer people consumes less energy per person. Moreover, a high level of generation diversity can lead to an increase in income variation (Fatahi et al., 2017)[5] that results in diversity in energy source consumption. Those with lower income might choose to consume energy from different sources compared to those with higher income. Hence, the electricity consumption can be lower because population switches to use other energy alternatives. Additionally, younger generations are more concern over the environmental issues and energy conservation, their behaviors might induce and influence older generations to conserve more energy through bandwagon effect[6]. Older generations might be pressured to reduce their energy consumption and learn how to conserve more energy from younger generations. This result holds after controlling for age differences, which suggests that generation diversity is another important factor that we should consider when determining the impact of demographic structure on energy consumption.

3 These biodiversity indices consider the relative abundances of different species as well as species equitability.

4 Energy management is the process of tracking and optimizing energy consumption to conserve energy usage (https://www.enertiv.com/resources/faq/what-is-energy-management).

5 See Fatahi et al. (2017) finds that income variation has a negative impact on electricity consumption in Iran.

6 Bandwagon effect is when people take certain actions primarily because others are doing so. The phenomenon is observed in various fields, such as economics, politics, finance, and psychology.

Table 2: Descriptive statistics

Variable	Mean	SD	Min	Max	Observations
leleccon					
overall	8.605	0.771	6.208	10.905	N=1464
between		0.715	6.861	10.187	n=37
within		0.280	6.965	9.540	T=39.568
lcpi					
overall	3.997	1.502	-7.766	5.752	N=1498
between		0.719	1.236	4.581	n=37
within		1.318	-5.662	8.512	T=40.486
HSindex					
overall	1.204	0.075	0.977	1.345	N=1554
between		0.012	1.170	1.218	n=37
within		0.074	1.012	1.348	T=42
la1014					
overall	13.616	1.556	9.940	16.888	N=1554
between		1.569	9.989	16.791	n=37
within		0.121	13.119	13.942	T=42
la1519					
overall	13.647	1.552	9.945	16.916	N=1554
between		1.566	9.996	16.818	n=37
within		0.148	13.021	13.992	T=42
la2024					
overall	13.680	1.540	9.942	16.954	N=1554
between		1.556	10.004	16.825	n=37
within		0.095	13.389	13.943	T=42
la2529					
overall	13.702	1.523	9.837	16.988	N=1554
between		1.538	10.001	16.856	n=37
within		0.127	13.218	14.012	T=42
la3034					
overall	13.702	1.515	9.701	16.964	N=1554
between		1.528	9.960	16.849	n=37
within		0.137	13.076	14.060	T=42
la3539					
overall	13.677	1.513	9.480	16.942	N=1554
between		1.524	9.906	16.813	n=37
within		0.163	12.969	14.114	T=42
la4044					
overall	13.630	1.511	9.268	16.942	N=1554
between		1.518	9.822	16.752	n=37
within		0.197	12.930	14.155	T=42
la4549					
overall	13.569	1.510	9.252	16.937	N=1554
between		1.513	9.735	16.677	n=37
within		0.222	12.916	14.192	T=42
la5054					
overall	13.493	1.507	9.236	16.923	N=1554
between		1.509	9.649	16.598	n=37
within		0.234	12.818	14.169	T=42
la5559					
overall	13.404	1.502	9.194	16.897	N=1554
between		1.503	9.544	16.505	n=37
within		0.234	12.708	14.147	T=42
la6064					
overall	13.274	1.502	9.024	16.847	N=1554
between		1.502	9.407	16.382	n=37
within		0.245	12.474	14.090	T=42
la6569					
overall	13.118	1.502	8.878	16.713	N=1554
between		1.501	9.240	16.228	n=37
within		0.250	12.416	13.925	T=42
la7074					
overall	12.925	1.500	8.665	16.508	N=1554
between		1.499	9.036	16.024	n=37
within		0.248	12.170	13.724	T=42
la7579					
overall	12.646	1.501	8.397	16.136	N=1554
between		1.497	8.772	15.759	n=37
within		0.267	11.683	13.568	T=42

Authors' calculations

Table 3: The impact of generation diversity on electric consumption

leleccon	Fixed effect
lcpi	0.027***
	(0.005)
HSindex	–0.169**
	(0.068)
la1014	–0.654***
	(0.061)
la1519	0.229**
	(0.091)
la2024	–0.338***
	(0.099)
la2529	0.109
	(0.104)
la3034	0.055
	(0.102)
la3539	0.170*
	(0.093)
la4044	0.325***
	(0.085)
la4549	0.114
	(0.082)
la5054	0.024
	(0.079)
la5559	0.113
	(0.070)
la6064	–0.008
	(0.058)
la6569	–0.019
	(0.048)
la7074	0.016
	(0.043)
la7579	0.279***
	(0.038)
constant	3.288***
	(0.623)

*, ** and ***statistical significance at 10%, 5% and 1% levels, respectively

6. CONCLUSION

This study investigates the relationship between generation diversity and electricity consumption using 37 OECD countries data over the years 1980-2021. We find that generation diversity leads to a reduction in electricity consumption per person. This might be due to several reasons. High generation diversity can lead to a smaller household living separately, where energy consumption can be more efficiently managed as compared to a larger household. High generation diversity can lead to high income variation that results in diversity in energy source consumption. Additionally, younger generations who can be more concern over the environmental issues and energy conservation, influence older generations to conserve more energy through bandwagon effect. This result shows that generation diversity is an important factor that can influence the electricity consumption. Hence, this paper provides additional evidence supporting existing literature that population structure needs to be considered in energy management strategies.

REFERENCES

Abrahão, K.C., de Souza, R.V. (2021), What has driven the growth of Brazil's residential electricity consumption during the last 19 years?

An index decomposition analysis. Ambiente Construido, 21(2), 7-39.
Beaman, M. (2020), Generational Power: From Boomers to Gen Z. Available from: https://www.hydroottawa.com/en/blog/generational-power-boomers-gen-z
Becton, J.B., Walker, H.J., Jones-Farmer, A. (2014), Generational differences in workplace behavior. Journal of Applied Social Psychology, 44, 75-189.
Druckman, A., Jackson, T. (2008), Household energy consumption in the UK: A highly geographically and socio-economically disaggregated model. Energy Policy, 36(8), 3177-3192.
Egelioglu, F., Mohamad, A., Guven, H. (2001), Economic variables and electricity consumption in Northern Cyprus. Energy, 26(4), 355-362.
Estiri, H. (2015), A structural equation model of energy consumption in the United States: Untangling the complexity of per-capita residential energy use. Energy Research and Social Science, 6, 109-120.
Estiri, H., Zagheni, E. (2019), Age matters: Ageing and household energy demand in the United States. Energy Research and Social Science, 55, 62-70.
Fatahi, S., Baharipour, S., Rezaee, E. (2017), Evaluation of the effects of population structure of electricity consumption (Case study comparing electricity consumption provinces west and east on the country). Quality and Productivity, 5(2), 1-13.
Francis, T., Hoefel, F. (2018), "True Gen" Generation Z and its Implications for Companies. Marvin Bower: McKinsey and Company Article.
Garau, G., Lecca, P., Mandra, G. (2013), The impact of population aging on energy use: Evidence from Italy. Economic Modelling, 35, 970-980.
Harnphattananusorn, S., Puttitanun, T. (2022), Generation mix and GDP growth in OECD countries. Heliyon, 8(9), e10508.
Hasanov, F.J., Mikayilov, J.I. (2017), The impact of age groups on consumption of residential electricity in Azerbaijan. Communist and Post Communist Studies, 50(4), 339-351.
Hausman, J.A. (1978), Specification tests in econometrics. Econometrica, 46, 1251-1271.
Inoue, N., Matsumoto, S., Mayumi, K. (2022), Household energy consumption pattern changes in an aging society: The case of Japan between 1989 and 2014 in retrospect. International Journal of Economic Policy Studies, 16, 67-83.
International Energy Agency. (2021), World Energy Outlook 2021. Available from: https://www.iea.blob.core.windows.net/assets/4ed140c1-c3f3-4fd9-789a4e14a23c/worldenergyoutlook2021.pdf
Ironmonger, D.S., Aitken, C.K., Erbas, B. (1995), Economies of scale in energy use in adult-only households. Energy Economies, 17(4), 301-310.
Jo, H.H., Jang, M., Kim, J. (2020), How population age distribution affects future electricity demand in Korea: Applying population polynomial function. Energies, 13(20), 5360.
Liddle, B. (2013), Population, affluence, and environmental impact across development: Evidence from panel cointegration modeling. Environmental Modelling and Software, 40, 255-266.
Mohamed, Z., Bodger, P. (2005), Forecasting electricity consumption in New Zealand using economic and demographic variables. Energy, 30(10), 1833-1843.
Nimngern, S. (2018), Available from: https://www.edoc.mrta.co.th/HRD/Attach/1566372710_1.pdf [Last accessed on 2022 Oct 27]. (Article in Thai).
Ota, T., Kakinaka, M., Kotani, K. (2018), Demographic effects on residential electricity and city gas consumption in the aging society of Japan. Energy Policy, 115, 503-513.
Pais-Magalhães, V., Moutinho, V., Robaina, M. (2022), Is an ageing population impacting energy use in the European Union? Drivers, lifestyles, and consumption patterns of elderly households. Energy Research and Social Science, 85, 102443.
The Pew Research Center. (2015), The Whys and hows of Generations Research. Available from: https://www.pewresearch.org/politics/2015/09/03/the-whys-and-hows-of-generations-research [Last accessed on 2022 Oct 27].
The Pew Research Center. (2019), Defining Generations: Where Millennials end and Generation Z Begins. Available from: https://www.pewresearch.org/fact-tank/2019/01/17/where-millennials-end-and-generation-z-begins [Last accessed on 2022 Oct 27].