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Demographic effects on residential electricity and city gas consumption in the aging society of Japan

Toru Ota[a], Makoto Kakinaka[b], Koji Kotani[c,d,e,f,*]

[a] Toho Gas, Japan
[b] Graduate School for International Development and Cooperation, Hiroshima University, Japan
[c] Research Institute for Future Design, Kochi University of Technology, Japan
[d] School of Economics and Management, Kochi University of Technology, Japan
[e] Urban Institute, Kyusyu University, Japan
[f] College of Business, Rikkyo University, Japan

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ABSTRACT

Japan has been confronted with two demographic forces, declining fertility rates and lengthening life spans, which give rise to the increasing ratio of the elderly (aging society), the decline in population and the prevalence of nuclear families. This study empirically analyzes the demographic effects on residential electricity and city gas consumption in Japan. Our analysis presents the following main results. First, the aging of the society decreases the electricity demand but does not affect the city gas demand significantly. Second, the decrease in population with the prevalence of nuclear families increases the electricity demand but decreases the city gas demand. The direction of the demand for each alternative depends on the balancing of the first and second effects. Third, the analysis also shows clear results about the own- and cross-price effects. Ongoing energy market reforms for price suppression would increase energy demand with possible substitutability between the two energy sources. Our case study of Japan is also applicable to other countries that will have just started to experience the similar demographic pattern of an aging society with energy market deregulation.

1. Introduction

Japan has been facing critical demographic issues of an aging society (see, e.g., Muramatsu and Akiyama, 2011). According to the Statistics Bureau of the Ministry of Internal Affairs and Communication, the proportion of the Japanese population aged 65 or above reached 25.97%, while those aged 14 or below declined to 12.77% in 2014. Although most developed countries have experienced aging in their societies, its speed in Japan, which currently has the highest proportion of elderly citizens in the world, has been tremendous. The “super-aged society” in Japan originates from a continuous decline in fertility and marriage rates along with a long life expectancy, changes in norms and development of medical technology (Fig. 1). In addition, the number of households has surpassed the decline in the average number of members per household, and the majority of households are elderly (Fig. 2). The trend of an aged society is expected to continue in the future. The Statistics Bureau now estimates that 31.60% of the population will be aged 65 or above, while only 10.32% will be aged 14 or below in 2030.

Demographic changes affect various macroeconomic conditions. Recent research has contributed to understanding possible links between demographic and environmental processes in the field of environmental demography. One crucial issue is a possible effect on residential energy demand since the demographic features of an aged society, such as fewer household members and leisure-rich environments, could affect consumption patterns for households (Yamasaki and Tominaga, 1997). For example, an aging society inspires a large proportion of households to spend more time at home rather than on activities outside the home due to elderly people's preferences for a sedentary lifestyle. Under such circumstances, the government has discussed future plans related to long-term power supply configurations, i.e., the balance between electricity, city gas and other energy resources with the consideration of various aspects, such as energy efficiency, patterns of energy demandand the importance of carbon reduction.[1] This issue has attracted much attention from the general public, particularly since the Great East Japan Earthquake and tsunami in 2011 damaged the nuclear power plants in Fukushima. Thus, an

* Corresponding author at: School of Economics and Management, Kochi University of Technology, Japan.
E-mail address: kojikotani757@gmail.com (K. Kotani).

[1] Many studies emphasize the important roles of energy efficiency, carbon emission reduction, and renewable energy investment in maintaining environmental sustainability. For recent studies, see, e.g., Meng et al. (2016), Wang et al. (2016), Su and Ang (2017) and Zeng et al. (2017a, 2017b).

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Nomenclature

EUIL	Electric Utility Industry Law
GEU	General Electricity Utilities
IPP	Independent power producer
JPEX	Japan Electric Power Exchange
PPS	Power producer and supplier
UN	United Nations

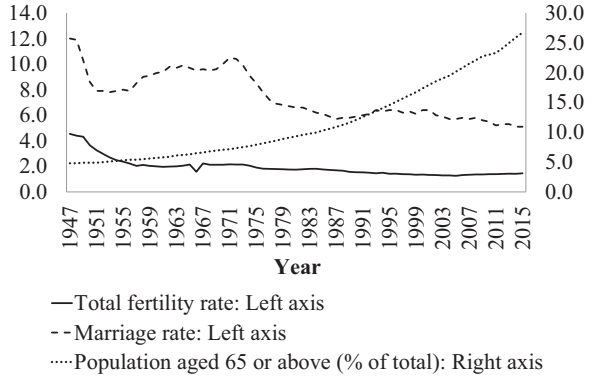

Fig. 1. Demographic changes in Japan. Total fertility rate is the average number of children born to a woman over her lifetime, which is multiplied by 1000. Marriage rate is the annual number of marriage notifications for the whole population, which is multiplied by 1000. Population aged 65 or above (% of total) is the percentage of the population aged 65 or above of the total population. The data are taken from the Statistics Bureau in the Ministry of Internal Affairs and Communications.

examination of how patterns of the residential demand for each energy resource relate to the ongoing aging of the society is necessary to plan and adopt appropriate energy policies.

Many empirical studies have examined the roles of demographic factors, such as the population, age structure, household size and urbanization, on energy and/or environmental issues (Liddle, 2014).[2] Among them, some works discuss the effects of demographic changes, particularly in age structure, on energy consumption. For instance, York (2007a) examines demographic effects in 14 EU countries and report that an increase in the proportion of the elderly population is associated with increased energy consumption. A study of York (2007b) over 14 Asian countries shows that the proportion of the population in the productive age range has a positive effect on energy use. In addition, Liddle and Lung (2010) suggest a U-shaped lifecycle with respect to energy intensity in OECD countries, with a relatively energy-intensive lifestyle during the early adulthood and retirement-age periods as well as a relatively energy non-intensive lifestyle during the middle-age period. Liddle (2011) also shows the U-shaped effect of age structure on residential electricity consumption for over 22 OECD countries in the sense of the positive impact for young and old cohorts and the negative impact for the middle cohort. Moreover, based on micro-level analyses mainly at the household level, some studies argue that different micro-demographic processes could cause various patterns of residential energy consumption (see, e.g., Pachauri, 2004; Brounen et al., 2012; Jingchao and Kotani, 2012; Fu et al., 2014; Valenzuela et al., 2014; Elnakat et al., 2016).

Concerning the case of Japan, few empirical studies have focused on

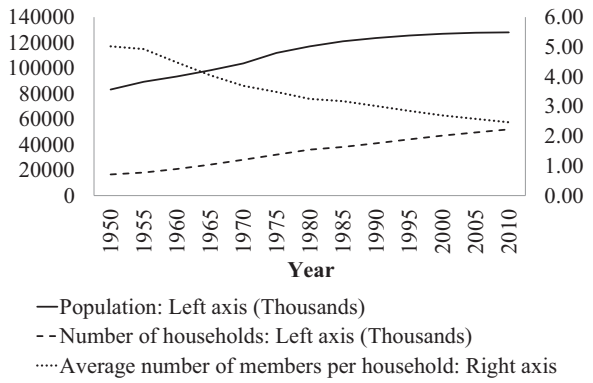

Fig. 2. Population is the number of households and the average number of members per household in Japan. The data are taken from the Statistics Bureau, Ministry of Internal Affairs and Communications.

the demographic effects on energy issues in relation to the rapid aging of the society, although many studies on energy policy issues related to energy production and consumption in Japan exist (Takase and Suzuki, 2011; Lu et al., 2016). As an initial study on demographic effects in Japan, Yamasaki and Tominaga (1997) discuss the evolution of the aging society and its effects on residential energy demand in Japan by examining the factors that determine the energy demand of elderly households and predict future residential energy consumption. However, their study summarizes current aging trends of demography and energy use but does not employ an empirical analysis in a scientific manner. Different from the previous studies, our study attempts to analyze demographic effects on residential energy consumption by employing econometric methods.[3] In addition, the Agency of Natural Resources and Energy of Japan reports that in 2011, the proportions of electricity and city gas to total residential energy consumption amounted to 50.6% and 20.7%, respectively. These two main industries have competed with each other, particularly in urban regions. The gradual liberalization has intensified the competition between the two industries, which decreases energy prices through efficient corporate management. The novelty of our study is the empirical examination of the roles of ongoing demographic issues in determining the residential energy demands for electricity and city gas, taking into account their substitutability. The analysis of such an issue is important for understanding the current and future paths of energy demands and for designing a sound energy policy in Japan.

Our empirical study employs a panel data analysis with the prefecture level data of residential electricity and city gas consumption and several demographic variables capturing the aging of Japanese society during the five periods (every five years from 1990 to 2010). Our analysis presents the following main findings. First, the aging of the society decreases the electricity demand but does not affect city gas demand significantly. Second, the shrinking population with the decline in the household size and the prevalence of nuclear families consisting of only the elderly increases the electricity demand but decreases the city gas demand. The overall impact of the aging of the society with the increase of nuclear families on the demand for each alternative depends on the balancing of the first and second effects. Third, concerning non-demographic effects, our analysis also shows clear results about the own- and cross-price effects, which provides important policy implications for the deregulation processes. Ongoing energy market reforms for price suppression would increase the energy demand with the possible substitutability between the two energy sources. Our case study of Japan could also be applied to other countries that will have

[2] See, e.g., Dietz and Rosa (1997), Yamasaki and Tominaga (1997), O'Neill and Chen (2002), Shi (2003), Cole and Neumayer (2004), Liddle (2004, 2013, 2015), Fan et al. (2006), Martinez-Zarzoso et al. (2007), Roberts (2008), York (2008), Kronenberg (2009), Jorgenson and Clark (2010, 2012), Jorgenson et al. (2010), Poumanyvong and Kaneko (2010), Martinez-Zarzoso and Maruotti (2011), Fang et al. (2012), Okada (2012), Zhu et al. (2012), Knight et al. (2013) and Honjo and Fujii (2014).

[3] Relevant studies may include the work of Honjo and Fujii (2014) that evaluates the impacts of demographic, meteorological and economic changes on emissions by examining household emissions in the 47 prefectures of Japan.