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ABSTRACT

This study aims to investigate the economic growth concerning electricity consumption in the demographic transition of population ageing. The direction of the framework was to expand the basic neoclassical growth model. The investigation discussed the relationship between electricity consumption and economic growth; population ageing on electricity consumption; and population ageing on economic growth. Demographic transition alters the consumption structure within the population, which potentially affects economic growth. Meanwhile, electricity consumption is core to the development process. Investigation of electricity consumption and population ageing seems crucial in the production sector. The proposed model can be used in ways that give us new insights into the relationship between energy and population growth, especially in developing countries. The developed framework is primarily focused on the linkages between electricity consumption and economic growth. This study was lacking in real data application and further work will be implemented. This paper is among the first to contribute to the debate on electricity consumption and economic growth from a population ageing perspective. It has the value of enlightening the complexities of the economic system and the current social changes of the global demographic transition.

Keywords: energy consumption; neoclassical production function; population ageing; sustainability

INTRODUCTION

There are numerous research and literature that focus on the relationship between energy especially electricity consumption and economic growth. The increase in the number of studies is mainly due to the rise in global demand for the energy consumption (i.e., oil and gas). The upsurge in this demand can be linked to the rapidly growing economies (Salahuddin et al., 2018). Economic growth leads to an increase in electricity consumption especially due to industrialization, urbanization, and improved standard of living. Furthermore, rising price of crude oil, ever-growing of emission level and climate change have added the momentum to the deliberation of the economic growth (Lawal et al., 2020). U.S. Energy Information Administration (2022) highlighted that economic output and energy consumption specifically electricity consumption positively correlate with each other. Karanfil and Li (2015) stated that the nexus between electricity consumption and economic growth are highly dependent on the country's income level as well as regional differences. The influence of energy consumption in the model of an economic growth was first established around 1970s after the oil crisis in 1973. Energy plays a vital role in the economic growth of a nation whereby almost all production of goods require energy to process the raw materials (Azam et al., 2015). Since then, the relationship between energy consumption and economic growth has become a major focus in the economic literature (Aslan, 2014; Tang et al., 2016; Hayat et al., 2018; Danlami et al., 2019).

The real economic system greatly depends on the physical energy consumption (i.e., electricity) as well as on the capital and labour. According to Barro and Sala-i-Martin (1995), technological progress can always be expressed as labour-augmenting and consistent with the existence of a steady state in the production function. Sardadvar (2011) highlighted that labour-augmenting is also known as *Harrod-neutral*. If the technological progress evolves to capital-augmenting, it is defined as *Solow-neutral*. A progress is considered to be *Hicks-neutral* when the technological progress acts as a direct multiplication between increasing scale factors with the production function. In addition, the study mentioned that aggregate output increases with population and technological progress. One of the issues related to the population is the ageing process that is taking place worldwide. In most developed countries, the average age of people in the labour market has been gradually increasing (Dixon, 2003). According to Balsalobre-lorente et al. (2021), population ageing may contribute to the shortage of the labour supply which will undermine the potential of an economic growth.

Mačiulytė-Šniukienė et al. (2019) discussed that the direct economic impact of population ageing is through labour force. Despite numerous forethoughts that discussed labour in the context of population ageing and economic growth, the interrelated focus on electricity consumption within the same context is still lacking. In an economic growth model, technology innovation can be substituted by energy. Thus, the main aim of this study is to propose a new model of the economic growth with respect to the energy particularly electricity consumption in the context of population ageing. The neoclassical production function will be employed as a basic model for this study. This paper contributes to the new insight towards an economic growth model in the context of ageing nations, intending to complete several gaps from the previous studies including the future of energy consumption arising from economic activities and the fundamental role of the demographic development along with technology. This paper is divided into several main sections. Section 2 provides overview of production factors include electricity consumption, the relationship between population ageing, electricity consumption and economic growth. In Section 3, research methodology is explained. Model development is discussed in Section 4. Lastly, Section 5 provides the concluding statements.

LITERATURE REVIEW

Overview of the production factors: Electricity consumption

The complexity of the relationship between energy consumption and economic growth has attracted a lot of debate over the past years which was initiated by the seminal work of Kraft and Kraft (1978). The role of energy in the economic growth has always been clearly highlighted in the empirical studies either for a single country or multiple countries simultaneously. However, the empirical evidence was still considered to be controversial and has sparked a lot of argument in the topic of economic growth. Based on the traditional neoclassical growth model, energy is introduced as an intermediate input next to the basic factors of labour and capital contributing to the economic growth both directly or indirectly (Balsalobre-Lorente et al., 2018). Higher economic growth requires greater energy consumption which will in turn promotes more energy efficiency applications. Instead of energy in general, a study carried out by Azam et al. (2021) discovered a stable long run relationship between electricity consumption and economic growth. Churchill and Ivanovski (2020) investigated the dynamics of electricity consumption and economic growth which highlighted that electricity consumption, labour, and capital have significant positive impact on the economic growth. Hamdi et al. (2014) in their study found electricity consumption, foreign direct investment and capital significantly influenced the GDP growth while labour was assumed to be constant and was not included in the empirical analysis.

Azam et al. (2015) showed that energy consumption has significant long run relationship with the GDP. Besides, Dogan (2015) examined the short and long run estimation as well as the relationship between electricity consumption and economic growth for Turkey. The other variables included in the model estimation were capital and labour. The results indicated that all variables were co-integrated. Electricity consumption, capital, and labour have statistically significant positive effects on the economic growth. Osman et al. (2016) also investigated the energy-growth nexus that included the GDP, electricity consumption, and capital in the model estimation. Labour was excluded due to the data limitation. Based on the study, a long-run equilibrium relationship existed among the variables and has a positive relationship with the GDP as expected. In general, most of the previous studies that focused on energy or electricity consumption were based on the neoclassical growth framework. Electricity consumption positively give impact on the economic growth. Most of the studies included labour and other several production factors in the model estimation. In the relationship between electricity consumption and economic growth, mostly element of demographic transition was overlooked which is visibly indispensable in the production process. Population ageing tend to alters the labour force which means it will probably impact the energy-growth relationship.

Population ageing and electricity consumption

The global demand of electricity continues to increase with the growth of modern economics and lifestyles. In addition, the industrialisation process promotes electricity consumption to continue hike up. It was pointed out by York (2007) that population size and age structure have clear effects on energy consumption. There are also different in the allocation of private consumption expenditure across various sectors includes consumption of energy or electricity among household. Romanach et al. (2017) mentioned that older people greatly rely on electric appliances particularly air conditioners to achieve thermal comfort. The situation prompts the elderly to resort high electricity consumption and creates potential loss of adapting low-cost measures. Population ageing affects consumption structure in which special requirements exist from older people (Li and Li, 2014). They have different expectation in terms of spending and consumption especially in leisure activities, services, and goods. Deutsch and Timpe (2013) stated that consumer behaviour and socio-demographic seems as a push-factor for energy consumption. Different age group have varying lifecycle demands including the way people live in their dwellings, awareness towards energy efficiency measures, and income

level. According to Barnicoat and Danson (2015), the elderly tend to spend longer in homes thus demonstrates alteration in consumption which changes the use of energy-intensive mix.

Valenzuela et al. (2014) focused on small geographic areas of Texas in their study about demographic, socio-economic and housing characteristics on household energy consumption. The age factor was considered in the study and found that elderly-led households consume less energy compare with non-elderly households. Study done by Ota et al. (2018) provides useful detailed description of the ageing on electricity consumption. The result was concluded that population ageing decreases the electricity consumption with several other determinants was also considered in the empirical investigation. In addition, the study highlighted that household size influence the demand for electricity. Nevertheless, contradict finding shows in study done by Otsuka (2017) which mentioned that ageing society have a limited relationship with electricity savings. This means that electricity savings is not possible or ageing population tend to have high electricity consumption. Aslam and Ahmad (2018) also found that population ageing implies increased in the energy demand. In addition, electricity expenditure is almost linearly increasing with age. Similarly, Kim et al. (2019) investigate the impact of the population age structure on electricity demand found increase in youth and people aged 65 to 80 raises the electricity demand in short and long term while no strong relationship among people aged over 80. Study by Estiri and Zagheni (2019) evaluated the age in energy consumption profile highlighted that there is a slight decrease in energy consumption between ages 60 and 80. Meanwhile, in the oldest cohort (i.e., people age above 80) shows an increasing concave micro-profile.

In general, most of the past studies take into account age factor with other determinants to investigate the impact on energy or electricity consumption. However, the main focus is on demographic variables itself not due to the situation of population ageing. Population ageing is accelerating in recent years and puts high pressure on economic growth indirectly via electricity consumption which is vital to investigate. Prior works existed mostly applied household level data in the empirical works. Since electricity is also crucial for economic growth in the long term, exploration on demographic transition of ageing in energy-growth relationship at aggregate level also require vigorous attention. In keeping more closely with population ageing, the suitable variables will be used as a proxy. The electricity consumption tends to change as there are alteration in the population age structure which will redirect the contribution on the economic growth.

Population ageing and economic growth

Population ageing presents many challenges to the government spending, labour force and energy consumption which is caused by dramatic reduction in birth rate and high life expectancy. In general, York (2007) highlighted that the changes of the age structure in a population correspond to higher energy consumption. Moreover, the demographic transition is likely to influence the economic structure of production and consumption. With reference to the production aspect, Maestas et al. (2016) simulated that predominantly, the increase in the population ageing proportion can reduce the economic growth which may be driven by the shift in the share of labour force. Note that as population ageing progressed, the growth rate of the effective labour supply declined as shown in Table 1 except for high income countries which showed inverse relationship. In addition, Figure 1 illustrates the trend of the labour force participation rate according to the age group from the year 1990 to 2019. High income countries rose in labour force participation rate for all age groups except for group 15 to 24. Upper middle-income countries have increased in the labour force participation rate of working age of 55 to 64 while another group showed declining pattern. Nonetheless, participation rate for age 15 to 24 reduced for countries of all income groups implying that lower fertility rate impacted the ageing process.

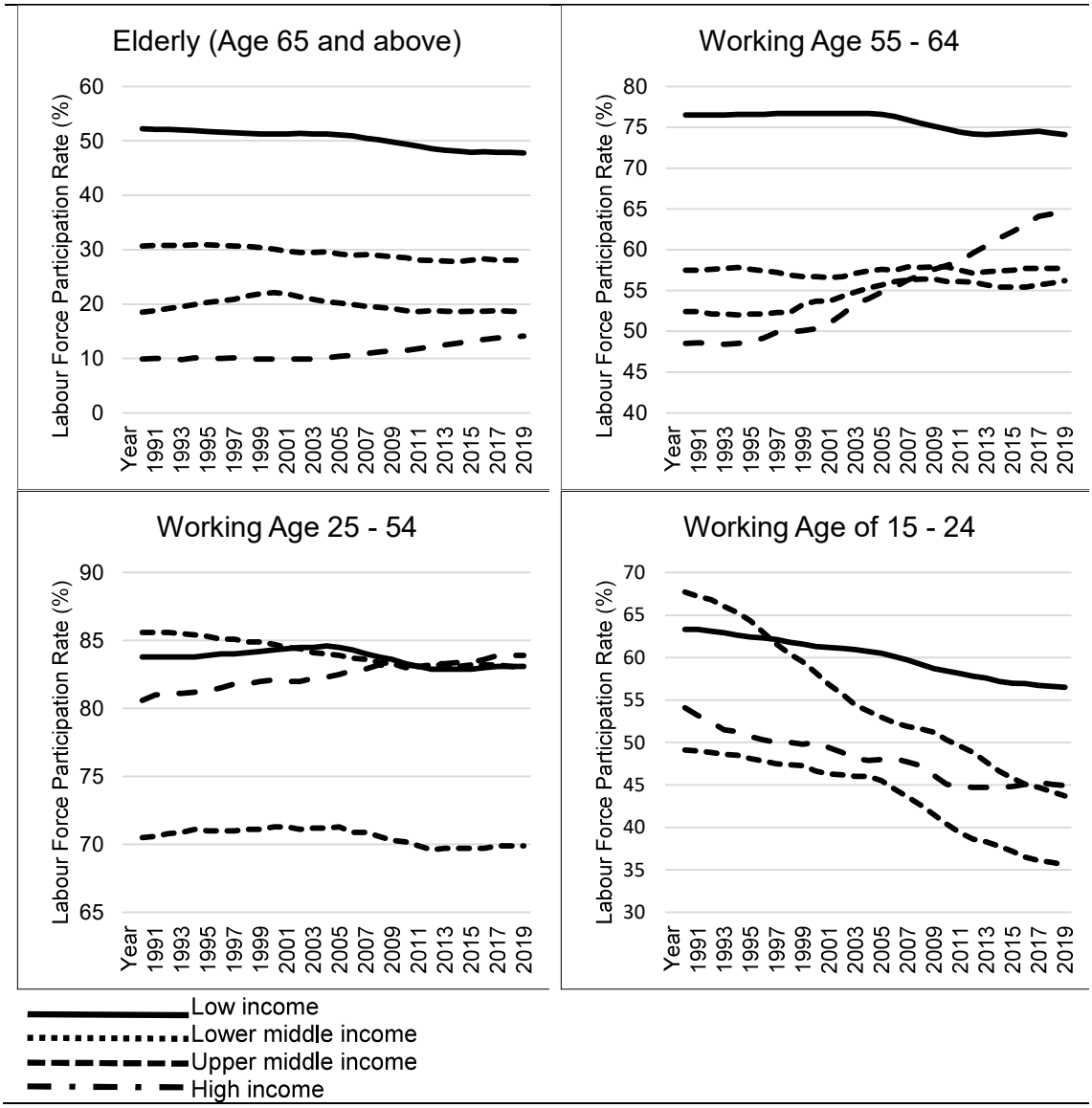
Table 1: Percentage of population age ≥ 65 and labour force participation rate according to

countries' income group

	High Income				Upper Middle Income			
Year	1990	2000	2010	2018	1990	2000	2010	2018
PA (%)	12.2	13.66	15.33	17.98	5.69	6.84	8.05	10.14
L (%)	69.95	70.86	71.53	73.29	76.13	74.50	71.33	71.28
	Lower Middle Income				Low Income			
Year	1990	2000	2010	2018	1990	2000	2010	2018
PA (%)	3.99	4.46	4.89	5.53	3.09	3.16	3.28	3.40
L (%)	62.10	61.89	59.94	59.05	75.95	75.49	73.64	73.03

Notes: PA is population ages 65 and above (% of total population), L is labour force participation rate (% of total population ages 15-64)
Source: World Development Indicator (2019)

Figure 1: Trend of labour force participation rate among countries divided into four income groups according to the age group



Notes: Labour force participation rate is defined as the labour force as a percent of working-age population
Source: International Labour Organisation Statistics (ILOSTAT) (2019)

Marešová, et al. (2015) stated that economic prosperity is highly dependent on the size and quality of the labour force. Shortage of the labour supply leads to a higher wage which will then promote innovation in investment and capital stock accumulation (i.e., physical and human capital) to ensure economic growth. Kolasa and Rubaszek (2016) in their study discussed the ageing scenario under non policy changes. Other glaring problem of population ageing within the labour supply, another related issue is aggregate consumption which alters the economic structure. Choi and Shin (2015) explored the effects of population ageing on economic growth without discussing about electricity consumption in the context of the study. Simulation results concluded that population ageing may significantly undermine the economic growth potential. Further, Maestas et al. (2016) also investigated the impact of ageing on the per capita output without acknowledging electricity consumption in the model.

The aggravating impact of population ageing on the economic growth can be initially minimised when the elderly or post retirement community are absorbed into the labour sector. When older people work longer hours, they tend to alter the consumption pattern which may lead to different level of economic dependency crucial for higher economic growth. Since the slower growth of labour force is inevitable in an ageing nation, the impact of ageing through labour needs to be investigated in the energy-growth nexus. Taking accounts of labour and population ageing in a production side will provide a closer look on how to improve the plan for a sustainable future. Most studies so far have ignored the impact of population ageing in the energy-growth relationship. This study shows that both energy consumption and labour market are important when considering the impact of population ageing on economic growth.

RESEARCH METHODOLOGY

This study was based on a review of the existing literatures on a few specific topics related to electricity consumption, economic growth and population ageing. Due to population ageing, there are greater need to sustain economic growth by knowing that the impact of electricity consumption is vital. The relationship between electricity consumption and economic growth previously has been studied and there may not sufficient relevant literature on the effect of demographic transition of ageing. A model of neoclassical economic growth was extended and previous literature were used to clarify and support. This study devised a conceptual framework for analysing economic growth with consideration of electricity consumption and demographic transition. The econometric technique was used to present a model of economic growth. In order to proceed with econometric analysis, this study plan to utilise panel ARDL econometric approach with consideration of several countries according to the demographic dividend status by World Bank classification.

DISCUSSION AND MODEL DEVELOPMENT

Electricity consumption affects an economic growth directly and indirectly as a complement to the other input factors of production such as capital and labour in the production side. The existence and importance of electricity to the economic growth can be proved by the majority of the country-specific and cross-countries studies. Electricity consumption positively influences the economic growth. Normally, labour is assumed as a constant variable in economic growth model and was not thoroughly discussed. However, in regards to the demographic transition of ageing, labour force inevitably indicates the possibility of inconsistency. The neoclassical growth framework has been used extensively in the energy-

growth studies which will be initiated as a basic model to explore energy-growth relationship in the demographic transition.

Electricity consumption, Economic growth and Demographic Transition

The economic growth is highly dependent on an uninterrupted energy supply which resulted in sharp increase of electricity demand. Investment in energy infrastructure is vital to ensure sufficient electricity supply combined with better innovation to curb wastage and stimulate long term economic growth especially in the population ageing. The transition of ageing may boost or harm economic growth with regards to the electricity sector as well as labour force. Many past studies have discussed that higher numbers of older population causes shrinkage in the labour force. The reduction in the share of the working-age population is considered as a demographic burden which possibly to have a downward effect on the economic growth. Pertinent to the electricity consumption in the population ageing, longer life expectancy influences the consumption pattern. Electricity can be considered as an intermediate good in the production side. It is required to produce goods and services specifically generated from a combination of the production factors which affect the economic growth.

Population consumes goods and services and at the same time supplies production factors (i.e., labour and capital) to the economic system. Non-working population specifically the elderly tends to spend more time as consumer. In general, rather than being involved in any production of economic activities, comprehensive discussion with respect to electricity consumption and population ageing on economic growth found that these two elements were previously discussed in separate strands by the past researchers. Thus, the next section proposes a new conceptual model for economic growth via the combination of electricity consumption and the element of ageing via labour under the same framework.

Development of the model

According to the past literatures, study related to energy or electricity consumption and economic growth prominently utilised neoclassical growth theory (Ghali and El-Sakka, 2004; Hamdi et al., 2014; Adebola and Shahbaz, 2015; Sriyana, 2019). Mainstream economic growth model highlighted that the economy output fundamentally is produced from two input factors which are capital and labour (Solow, 1956). Barro and Sala-i-martin (1992) mentioned that convergence is also predicted by the neoclassical growth model with exogenous technological progress in a closed economy. If technology is similar, the capital market tends to speed up the convergence of production. The main objective of this study is to investigate the economic growth concerning electricity consumption in the demographic transition of population ageing. Thus, the basic theoretical framework is extended and modified to achieve the objective of this study. The framework underlines the relationship according to the augmented neoclassical growth theory. The general form of model specification using Cobb-Douglas production function is given in the following way:

$$Y = AK^{\alpha}L^{1-\alpha}e^{u} \tag{1}$$

Y is output, *A* represent technology, while *K* and *L* stand for capital and labour respectively. Error term, *e* assumed to have normal distribution. According to Solarin and Al-Mulali (2018), technology can be determined by the function of energy consumption, and foreign direct investment. Respective to the demographic transition of ageing, this study assumed that the focus needs to be centered on the component of labour because changes of the age structure probably impact the labour supply.

Gruescu (2007) introduced a new indicator in the economic growth model with respect to the

population ageing known as dependency ratio to substitute labour. In addition, the inclusion of the dependency ratio is appropriately representing the age structure of the population (Uddin et al., 2016; Li & Zhou, 2019; Bawazir et al., 2020). Therefore, from equation (1), this study substituted technology, *A* with electricity consumption, *ELC* and foreign direct investment, *FDI*. Meanwhile, old age dependency ratio, *OADR* substituted the labour, *L* expressed in the equation (2) as:

$$\ln Y_{it} = \alpha_0 + \beta_1 \ln ELC_{it} + \beta_3 K_{it} + \beta_2 FDI_{it} + \beta_4 OADR_{it} + \varepsilon_{it} \quad (2)$$

It was assuming that the electricity consumption *(ELC)*, foreign direct investment *(FDI),* old age dependency ratio *(OADR*) and gross capital formation *(K)* have cumulative effects on economic growth. Y_{it} is the per capita real GDP, α_0 represent country specific fixed effect, ELC_{it} is the per capita electricity consumption, FDI_{it} is the foreign direct investment, K_{it} is gross capital formation, $OADR_{it}$ is old age dependency ratio and ε_{it} is the random error term. The subscript of *i=1,2….N* refers to each country and *t=1,2…..T* for time period. Long-run elasticities estimates are represented by the β in the equation. The formulation of *OADR* is shows in the equation (3).

$OADR =$ [People age 65 and above / Working age population (15 - 64)] x 100 (3)

According to equation (2), electricity consumption was expected to have a positive relationship with per capita real GDP. Each increase in the electricity consumption level posits that the per capita GDP will increase shows good indicator of economic growth. This assumption has been supported by many empirical studies such as Churchill and Ivanovski (2020), Lawal et al. (2020) and Azam et al. (2021). Foreign direct investment and gross capital formation also expected to have positive relationship with economic growth (Tang et al., 2016). The relationship between old age dependency ratio and economic growth is uncertain either positively or negatively related. Bawazir et al. (2020) found old age dependency ratio is positively affect the economic growth. Meanwhile, Uddin et al. (2016) proved dependency ratio is negatively impacted the economic growth.

CONCLUSION

The current and future demographic trends have inspired this research to review and explore the impact of demographic transition in electricity and economic growth relationship. Based on the past literature and empirical findings, the role of electricity consumption in economic growth is very important and cannot be neglected. The model framework developed in this study were based on the basic neoclassical growth theory. Taking the demographic transition phenomenon globally, both labour force and consumption of electricity are the focus in this new framework. The salient point in this study is to explore the importance of production factors in terms of powering the economic growth by measures of electricity consumption and overcoming population ageing issues within the labour force. It has to be emphasized that most governments have attempted to solve the demographic issues by introducing a series of public policies in order to assure economic growth. One of the suggestions to enable and empower the labour sector is reemployment of older workers by legally binding the appropriate policies and practices like flexible work systems and age-friendly workplace. Investment in human capital formation through educational and training programme was also discussed to secure economic growth in demographic transition. However, the proposed model focuses more on linking the electricity consumption and ageing impact through labour factor. All of these considerations are crucial for a sustainable economy and society. This study lack of intention in investigating the impact of human capital investment on economic growth.

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REFERENCES

Adebola, S., & Shahbaz, M. (2015). Natural gas consumption and economic growth : The role of foreign direct investment , capital formation and trade openness in Malaysia. *Renewable and Sustainable Energy Reviews*, *42*, 835–845.

Aslam, M., & Ahmad, E. (2018). Impact of ageing and generational effects on household energy consumption behavior: Evidence from Pakistan. *Energies*, *11*(8).

Aslan, A. (2014). Causality between electricity consumption and economic growth in Turkey: An ARDL bounds testing approach. *Energy Sources, Part B: Economics, Planning and Policy*, *9*(1), 25–31.

Azam, A., Rafiq, M., Shafique, M., Zhang, H., Ateeq, M., & Yuan, J. (2021). Analyzing the relationship between economic growth and electricity consumption from renewable and non-renewable sources: Fresh evidence from newly industrialized countries. *Sustainable Energy Technologies and Assessments*, *44*, 100991.

Azam, M., Khan, A. Q., Bakhtyar, B., & Emirullah, C. (2015). The causal relationship between energy consumption and economic growth in the ASEAN-5 countries. *Renewable and Sustainable Energy Reviews*, *47*, 732–745.

Balsalobre-lorente, D., Shahbaz, M., Roubaud, D., & Farhani, S. (2018). How economic growth, renewable electricity and natural resources contribute to CO2 emissions? *Energy Policy*, *113*(November 2017), 356–367.

Balsalobre-lorente, D., Sinha, A., Driha, O. M., & Shujaat, M. (2021). Assessing the impacts of ageing and natural resource extraction on carbon emissions : A proposed policy framework for European economies. *Journal of Cleaner Production*, *296*, 126470.

Barnicoat, G., & Danson, M. (2015). The ageing population and smart metering: A field study of householders' attitudes and behaviours towards energy use in Scotland. *Energy Research and Social Science*, *9*, 107–115.

Barro, R. J., & Sala-i-martin, X. (1992). Convergence. *Journal of Political Economy*, *100*(2), 223–251.

Barro, R. J., & Sala-i-Martin, X. (1995). *Technological Diffusion, Convergence, and Growth* (Issue 116).

Bawazir, A. A. A., Aslam, M., & Osman, A. F. Bin. (2020). Demographic change and economic growth: empirical evidence from the Middle East. *Economic Change and Restructuring*, *53*(3), 429–450.

Choi, K.-H., & Shin, S. (2015). Population aging, economic growth, and the social transmission of human capital: An analysis with an overlapping generations model. *Economic Modelling*, *50*, 138–147.

Churchill, S. A., & Ivanovski, K. (2020). Electricity consumption and economic growth across Australian states and territories. *Applied Economics*, *52*(8), 866–878.

Danlami, A. H., Aliyu, S., & Danmaraya, I. A. (2019). Energy production , carbon emissions and economic growth in lower-middle income countries. *International Journal of Social Economics*, *46*(1), 97–115.

Deutsch, M., & Timpe, P. (2013). The effect of age on residential energy demand. *Eceee*

Summer Study Proceedings, 2177–2188.

Dixon, S. (2003). Implications of population ageing for the labour market. *Labour Market Trends*, *111*(2), 67–76.

Dogan, E. (2015). The relationship between economic growth and electricity consumption from renewable and non-renewable sources: A study of Turkey. *Renewable and Sustainable Energy Reviews*, *52*, 534–546.

Estiri, H., & Zagheni, E. (2019). Age matters : Ageing and household energy demand in the United States. *Energy Research & Social Science*, *55*, 62–70.

Ghali, K. H., & El-Sakka, M. I. . (2004). Energy use and output growth in Canada : a multivariate cointegration analysis. *Energy Economics*, *26*, 225–238.

Gruescu, S. (2007), *Population Ageing and Economic Growth: Education Policy and Family Policy in a Model of Endogenous growth*, Physica-Verlag Heidelberg, New York.

Hamdi, H., Sbia, R., & Shahbaz, M. (2014). The nexus between electricity consumption and economic growth in Bahrain. *Economic Modelling*, *38*, 227–237.

Hayat, F., Khan, A. A., & Ashraf, M. A. (2018). Energy planning and sustainable development of Pakistan. *International Journal of Energy Sector Management*, *13*(1), 24–44.

International Labour Organization Statistics ILOSTAT (2019), Labour force participation rate. Date of access: 05/09/2019. https://www.ilo.org/global/statistics-and-databases/lang--en/index.htm

Karanfil, F., & Li, Y. (2015). Electricity consumption and economic growth: Exploring panel-specific differences. *Energy Policy*, *82*(1), 264–277.

Kim, J., Jang, M., & Shin, D. (2019). Examining the role of population age structure upon residential electricity demand: A case from Korea. *Sustainability (Switzerland)*.

Kolasa, A., & Rubaszek, M. (2016). The effect of ageing on the European economies in a life-cycle model. *Economic Modelling*, *52*, 50–57.

Kraft, J., & Kraft, A. (1978). On the relationship between energy and GNP. *Journal of Energy and Development*, *3*, 401–403.

Lawal, A. I., Ozturk, I., Olanipekun, I. O., & Asaleye, A. J. (2020). Examining the linkages between electricity consumption and economic growth in African economies. *Energy*, *208*, 118363.

Li, S., & Zhou, C. (2019). What are the impacts of demographic structure on CO2 emissions? A regional analysis in China via heterogeneous panel estimates. *Science of the Total Environment*, *650*(2019), 2021–2031.

Li, Z., & Li, H. (2014). Analysis of the Impact of Population Aging on the Household Consumption. *International Journal of Business and Social Science*, *5*(61), 102–107.

Mačiulytė-Šniukienė, A., Matuzevičiūtė, K., & Ruplienė, D. (2019). Evaluating the Impact of Ageing Population on Labour Market. *Contemporary Issues in Business, Management and Economics Engineering' 2019*, *May*.

Maestas, N., Mullen, K. J., & Powell, D. (2016). The Effect of population aging on economic growth, the labor force and productivity. In *RAND Working Paper* (Issue WR-1063-1).

Marešová, P., Mohelská, H., & Kuča, K. (2015). Economics Aspects of Ageing Population. *Procedia Economics and Finance*, *23*, 534–538.

Osman, M., Gachino, G., & Hoque, A. (2016). Electricity consumption and economic growth in the GCC countries: Panel data analysis. *Energy Policy*, *98*, 318–327.

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.

Otsuka, A. (2017). Determinants of efficiency in residential electricity demand: stochastic frontier analysis on Japan. *Energy, Sustainability and Society*, *7*(1), 31.

Romanach, L., Hall, N., & Meikle, S. (2017). Energy consumption in an ageing population: exploring energy use and behaviour of low-income older Australians. *Energy Procedia*, *121*, 246–253.

Salahuddin, M., Alam, K., Ozturk, I., & Sohag, K. (2018). The effects of electricity consumption, economic growth, financial development and foreign direct investment on CO2 emissions in Kuwait. *Renewable and Sustainable Energy Reviews*, *81*(June 2017), 2002–2010.

Sardadvar, S. (2011). Neoclassical Growth Theory and Standard Models Thoughts. In *Economic Growth in the Regions of Europe* (Vol. 1, pp. 9–22).

Solarin, S. A., & Al-Mulali, U. (2018). Influence of foreign direct investment on indicators of environmental degradation. *Environmental Science and Pollution Research*, *25*(25), 24845–24859.

Solow, R. M. (1956). A Contribution to the Theory of Economic Growth. *Oxford Journals*, *70*(1), 65–94.

Sriyana, J. (2019). Dynamic effects of energy consumption on economic growth in an emerging economy. *International Journal of Energy Economics and Policy*, *9*(4), 283–290.

Tang, C. F., Tan, B. W., & Ozturk, I. (2016). Energy consumption and economic growth in Vietnam. *Renewable and Sustainable Energy Reviews*, *54*, 1506–1514.

Uddin, G. A., Alam, K., & Gow, J. (2016). Population age structure and savings rate impacts on economic growth: Evidence from Australia. *Economic Analysis and Policy*, *52*(December), 23–33.

U.S. Energy Information Administration (2022), Annual Energy Outlook 2022 with Projections to 2050, Date of access: 01/08/2022. https://www.eia.gov/outlooks/aeo/.

Valenzuela, C., Valencia, A., White, S., Jordan, J. A., Cano, S., Keating, J., Nagorski, J., & Potter, L. B. (2014). An analysis of monthly household energy consumption among single-family residences in Texas, 2010. *Energy Policy*, *69*, 263–272.

World Development Indicator (2019), DataBank. Date of access: 21/11/21. https://databank.worldbank.org/source/world-development-indicators

York, R. (2007). Demographic trends and energy consumption in European Union Nations, 1960-2025. *Social Science Research*, *36*(3), 855–872