DEMOGRAPHIC DETERMINANTS OF ENERGY CONSUMPTION IN EU COUNTRIES

Is energy consumption dependent on demographic processes?

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Abstract
It is a fact that EU countries are facing an unprecedented demographic future. The combination of very low fertility in the long term and the continued increase in life expectancy will inevitably lead to population ageing and population shrinking. However, several questions lead us to the decoupling thesis: (i) Is economic growth in developed countries happening despite demographic decline?; (ii) What is the impact of demographic processes on economic growth and energy consumption?, and (iii) How much pressure do demographic processes place on energy consumption? The paper examines these research questions to investigate the potential correlation between individual components of demographic trends and energy consumption in general. It is essential to keep in mind that demographic changes can affect not only macro variables, such as aggregate consumption, but also their composition. The European Union Member States differ in the direction, size, intensity and structure of demographic processes. Given the different demographic trends among EU countries, different magnitudes of their impact on energy consumption can be expected. The data and research show that the impact of certain demographic processes on energy consumption cannot be ignored, and that demographic changes are affecting the level and structure of energy consumption. A common EU country process is the process of population ageing. All projections indicate the growing impact of an ageing population, which will create additional obstacles to reduce future energy consumption. The dominant demographic processes in the EU are driving the increase in energy consumption and thus making it more difficult to decouple economic growth from environmental impacts.

Keywords: demography, energy consumption, population ageing, European Union

JEL classification: J11, 013, Q41

Introduction

Population, development and environment are in constant interaction. Raising awareness of the depletion of natural resources and the importance of sustainable development is very important. Population growth and changes in its structures have increased the pressures on the environment around the world. The assumption is that population growth puts pressure on natural resources and diminishes the chances of sustainable economic development. Economic history gives us examples of the importance of matching the growing needs of the population with natural resources. The Industrial Revolution was a response to the lack of supply of certain natural resources, whereas today, technological development offers answers to many challenges. However, the current environmental crisis is very complex and the issue of the imbalance of available natural resources and the demand for them is very challenging in the growing economies of the world.

From a demographic perspective, we divide the world into two large groups of countries: developing countries and developed countries. It is estimated that the first group is now inhabited by over 83% of the world population (UN, 2019). The trend of continued growth in the share of developing countries (Asia, Africa, Latin America) in the world's total population is estimated at one percentage point per decade. It is therefore clear that the key to global sustainable development lies in the creation of sustainable policies of balanced production and efficient (energy) consumption in developing countries.

When we speak of economic development, energy consumption and resources in developed countries, there is a different logic of interactions with demographic processes. Countries with the highest standards of living today are also countries of demographic depression. Unlike developing countries, the western world is wrapped in the fate of declining fertility, and a shrinking and ageing population. These dominant demographic trends in Europe carry with them implications such as overburdened pension and health systems, imbalances in the labour market, lack of care for the elderly, etc. These are major challenges that require long-term strategies, as are demographic trends. In addition to these implications, the goal is to shed light on the demographic background of the energy sector. Economic growth and development are energy dependent. Do demographic trends place additional pressures on the energy resources needed for economic development?

In certain conditions of economic and social development, the characteristics of individual population structures determine the structure of consumption. Also, the characteristics of the population indirectly determine the volume of production necessary to produce goods and services. However, energy consumption in the developed world is most often explained by several dominant economic determinants associated with economic development and modernization. The level of each country's energy consumption is explained by the level and structure of its economic activity or production, and the strength of its economy expressed as the gross domestic product. In addition to the economic determinants of energy consumption, demographic processes are increasingly being included in energy consumption analysis. Social and demographic determinants are often overlooked in the literature on energy efficiency, perhaps due to the lack of detailed microeconomic data. In order to improve energy consumption projections and provide strong energy policy measures, a better understanding of the demographic determinants of energy consumption is needed. Population projections are critical for predicting future resource requirements and matching production to energy demand.

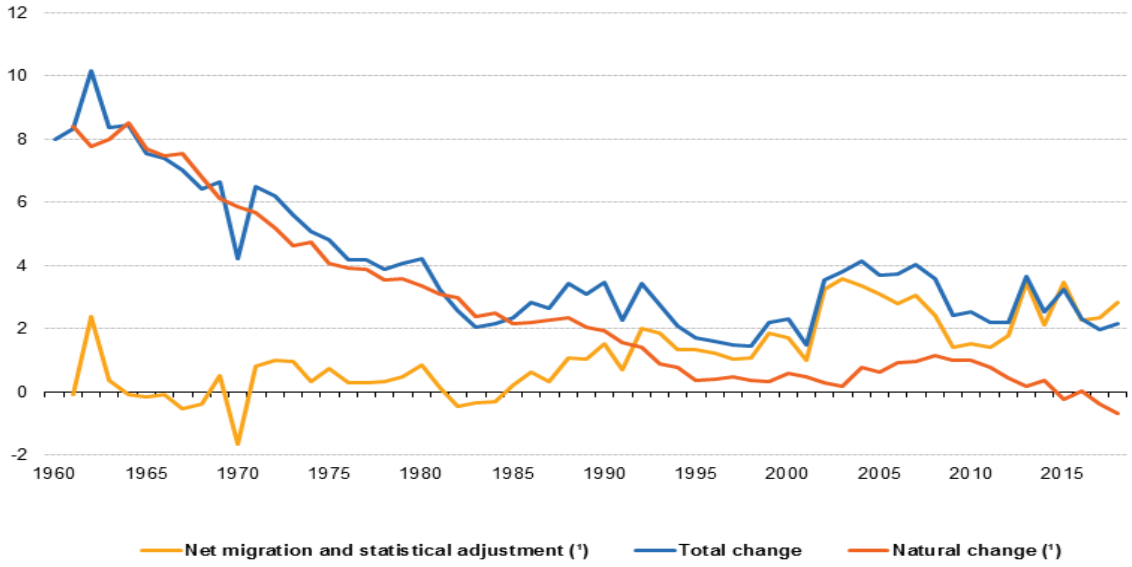
Demographic decline in European Union

The fact is that EU countries are facing an unprecedented demographic future. The combination of very low fertility in the long term and a continued increase in life expectancy will inevitably lead to population ageing and population shrinking. Demographic decline is a decrease in the total population over a certain period and within a specific geographical area. Although the overall EU-28 area is not yet declining, some countries have recorded total and natural depopulation for many years (Figure 1). It is important to show

how the European Union Member States differ in their demographic processes. It can often be heard that demographic processes and changes are identical across Europe. However, a demographic and statistical comparison of individual aggregate and partial demographic processes across countries shows that identical processes can only be discussed when it comes to the long-term direction of these processes. When it comes to short- and medium-term changes, the analysis shows that they are not identical. They vary by country in their direction, size, intensity and structure (Wertheimer-Baletić, 2017).

The numbers best show just how dramatically Europe is ageing. The median age in the EU-28 has increased from 38.3 years in 2001 to 43.1 in 2018, an increase of 4.8 years in just 17 years. This means that half of the EU-28's population was older than 43.1 years, while half was younger. The Irish population remains the youngest with an average age of 37 years. In contrast, the oldest population is in Italy, with an average age of 46.3 years. In Croatia, the average citizen is 43.7 years old. According to the Eurostat projection, Italy will be the first country to reach a median age of 50 years by 2029. The proportion of people over 80 in the EU-28 population is expected to double (from 5.4% of the population in 2016 to 11.4% in 2050) (EPRS, 2019). Life expectancy at the EU level increased by more than 10 years compared to the early 1960s, with women still living longer than men on average.

Figure 1. Population change by component (annual crude rates), EU-28 Total, 1960-2018.

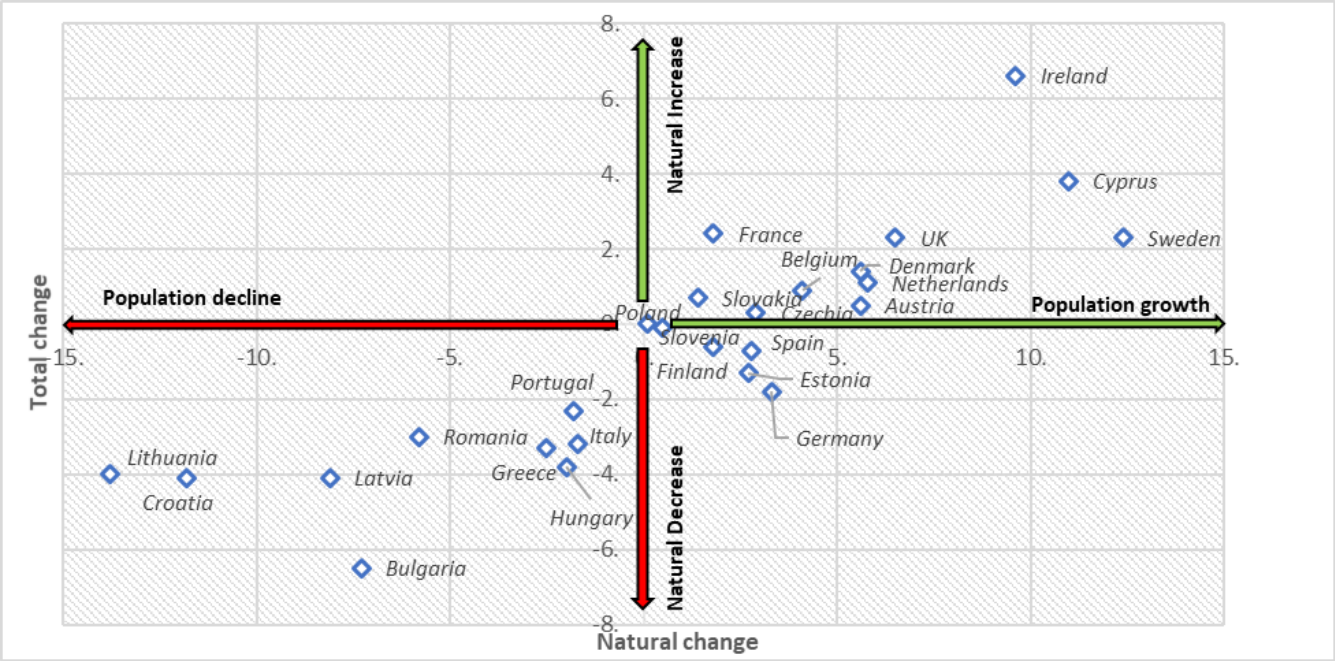


Source: Eurostat; Population and population change statistics, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=demo_gindandlang=en (25.10.2019)

Figure 1 clearly shows the most important demographic processes from 1960 to the present. Total depopulation caused by fertility decline was a continuous process in the latter half of the 20th century. At the same time, immigration gradually increased until the early 2000s, when its volume changed the trend of the total population of EU countries towards gradual growth. Today, many EU countries can attribute their population growth largely or exclusively to immigration. However, migration on its own will not be enough to reverse the trends of population decline in the EU. Not all countries contribute equally to population growth or decline across Europe, as already stated.

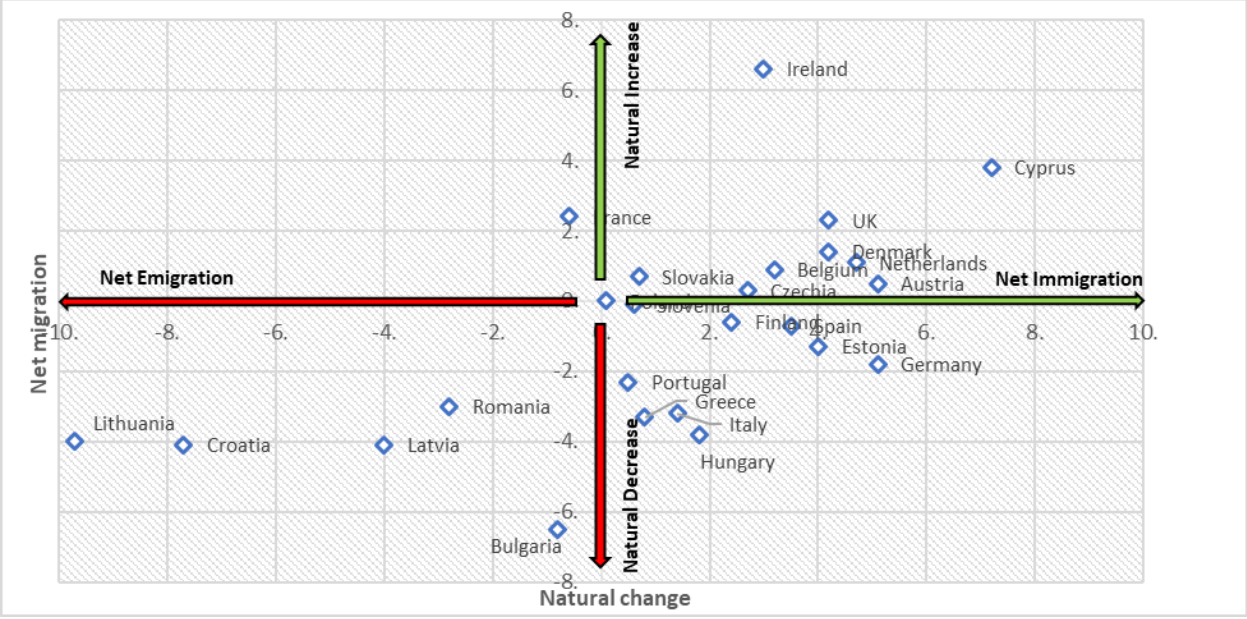
If we look at the processes of total population change, natural growth and migration at the national level, then there is a great difference in the demographic perspective (Fig. 2, Fig. 3).

Figure 2. Total and natural change in European Union countries, 2017.



Source: authors' calculation based on Eurostat database; Population (Demography, Migration and Projections)

Figure 3. Natural change vs net migration in European Union countries, 2017.



Source: authors' calculation based on Eurostat database; Population (Demography, Migration and Projections)

Figures 2 and 3 clearly illustrate that not all countries in Europe have the same demographic trends or future. By comparing the crude rates of total population change, according to Eurostat data for 2018, ten EU Member States experienced population decline. Of these ten countries, five recorded a population

decline due to both natural decline and emigration - Latvia, Bulgaria, Croatia, Romania and Lithuania, making these countries the demographically most vulnerable and fastest shrinking countries in the world. The reasons for these catastrophic demographic trends should be examined on a country-by-country basis. However, very low fertility and mass emigration in these countries, combined with access to free movement, has resulted in massive-scale depopulation. The process of emigration brings multiple losses to a country as emigration is made up of people of working and fertile age. Besides the immediate reduction of this contingent, they also bring with them children as well as future unborn children.

The main economic result of such unfavourable demographic processes is seen in the stagnation and decline of the working-age population. In addition to the decline, there is also an ageing workforce: a shift in the composition of the workforce from relatively young to relatively old workers (Akrap et al., 2018). In addition to a shortage of workers, there are clear negative economic consequences such as a tendency to increase taxes, increased government spending on health care and pensions (Strmota, 2017).

Given the different demographic trends among the EU countries, it is expected that their impacts on energy consumption will also vary in magnitude.

Impact of demographic changes on energy consumption – research analysis

In order to link demographic processes with the energy sector, an overview of the most important empirical research is given below in Table 1. The table outlines relevant research focusing on demographic change and the impact of demographic processes on energy consumption.

Table 1. List of demographic variables relevant for energy consumption analysis

Demographic variable	Energy demand reflection	Source
Total population	↑ P ↑ D_{energ}	(Brounen et al., 2012; York, 2007)
Fertility	↓N (TFR) ↓ P ↓ D_{energ} ↓N (TFR) ↑ P_{65+} ↑ D_{energ}	(Warner and Jones, 2018; York, 2007)
Population ageing	↑P_{65+} ↑ $D_{energ\ rezid}$ ↑P_{65+}	(Attanasio et al., 2007; Hamza and Gilroy, 2011; Kronenberg, 2009; Romanach et al., 2017)
Family type / household composition	↑ P ↑ D_{energ} Children ↑ D_{energ}	(Brounen et al., 2012; Garau et al., 2013)
Urbanization	↑ D_{energ} ; ↓ $D_{energ\ PER\ CAPITA}$	(Güneralp et al., 2017; Mirkovic and Alawadi, 2017; Sadorsky, 2018)

Source: Various scientific papers, in period 2006.-2018.: Abbreviations: P- population; N- birthrate; TFR- total fertility rate; P_{65+} – population 65+; D_{energ}- demand for energy; $D_{energ\ rezid}$ - residential demand

Total population change

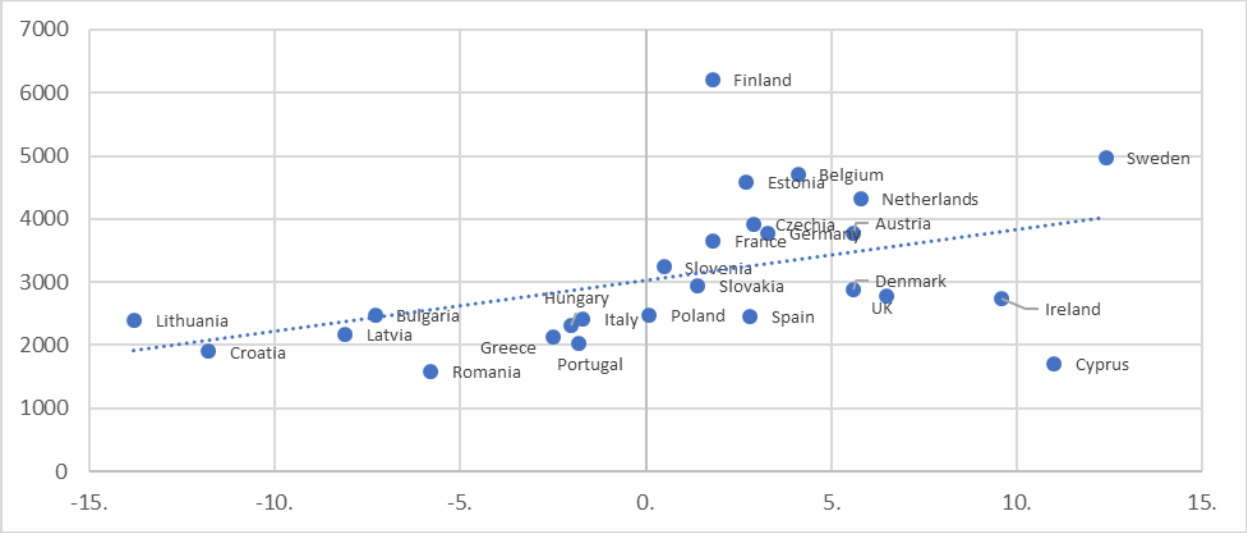
Total population change is a basic indicator of a country's demographic development. The impact of population, its rise or fall, is often logically correlated with economic variables. When it comes to consumption, then a positive correlation is logical and demonstrable. Global energy consumption is undoubtedly a function of population growth and decline, and their correlation is positive. Every person added to the world's population requires energy to prepare food, to provide clothing and shelter, and to fuel economic life. Each increment in demand is another claim on energy resources (and creates problems of what to do with the by-products of energy use), forcing further global adjustments in the use of energy.

Environmental experts believe that the expected decline in Europe's population may not necessarily be an adverse outcome, since a fall in housing also means less pressure on the ecosystem and natural resources (Ehrlich and Ehrlich, 2005). The degradation of the environment is caused by our intensive use of resources, which has dramatically increased our standard of living over the past decades. While there are fears that

population growth will threaten sustainable development (Malthusianism), it is crucial to use resources efficiently so they can be spread across the entire growing and ageing world population.

However, when it comes to per capita spending, then the logic is a little different. Empirical studies of per capita energy consumption show a very important link between household demographic characteristics and economies of scale in household energy consumption (Brounen et al., 2012). In this sense, an additional person in the household means a decrease in energy consumption per capita.

Figure 4. Total population change vs final energy consumption-energy use p.c.[1], by EU countries, 2017.



Source: authors' calculation based on Eurostat database; Eurostat: Population (Demography, Migration and Projections)/ Final energy consumption by sector

Figure 4 shows the change in total population compared to total energy consumption per capita in 2017. Countries that have reported total population growth have on average higher levels of energy consumption per capita than countries with depopulation. There is a certain correlation between the degree of economic development, energy consumption and population movement.

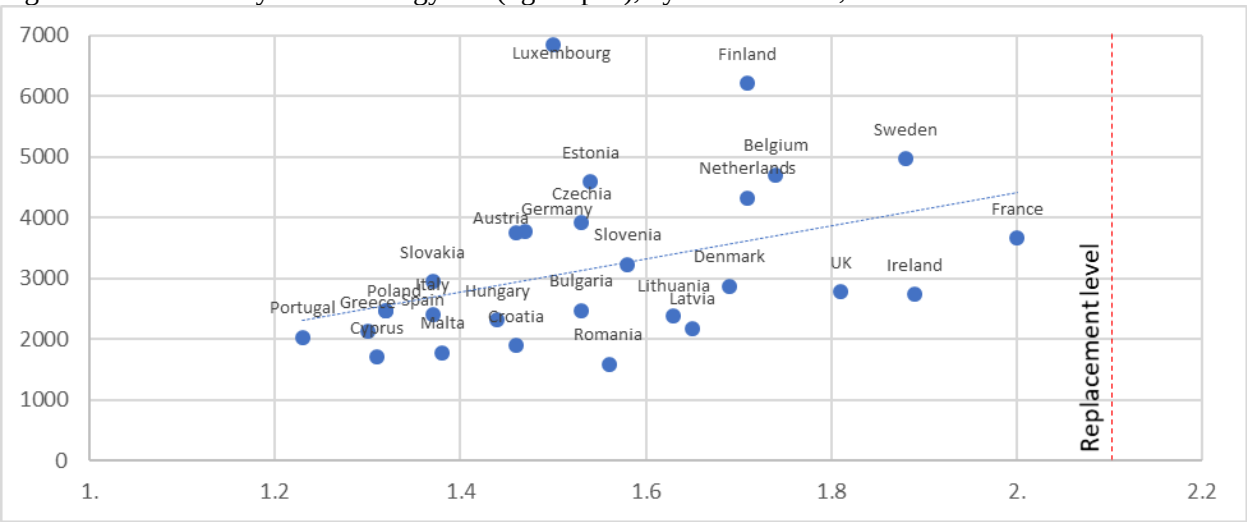
Fertility

An important assumption underlying the theory of demographic transition is the close correlation of changes in the components of natural population movement (birth rate/fertility and mortality) with the factors of economic, social and cultural development of a country. The decline in fertility is the dominant process of the very well-known theory of demographic transition (Lesthaeghe, 2014; van de Kaa, 2002). According to the theory, fertility decline is an irreversible process and the result is an inevitable long-term increase in the proportion of the old population. The total fertility rate in all EU countries today is below the replacement level of 2.1 children per woman (Fig. 5). In the context of the theory of demographic transition, as one of the components of the modernization of society that influenced the decline in fertility, energy consumption could be considered as an indicator of the stage of demographic transition.

[1] Final energy consumption covers the energy consumption of end-users, such as industry, transport, households, services and agriculture. It excludes consumption of the energy sector itself and losses occurring during transformation and distribution of energy (e.g. power plants, district heating plants, oil refineries, coke ovens, blast furnaces). It also excludes all non-energy use of energy carriers (e.g. natural gas used for producing chemicals, oil-based lubricants, bitumen used for road surfaces). Quantities delivered to international aviation and international marine bunkers are also excluded from the final energy consumption (*Eurostat, Final energy consumption by sector*, https://ec.europa.eu/eurostat/web/energy/data/main-tables).

A continued decline in fertility means a further natural decline and intensification of the ageing population. It would be interesting to investigate which process has a stronger impact on energy consumption: the decrease in the population due to natural decline, or the increase in the proportion of the elderly.

Figure 5. Total fertility rate vs energy use (kg oil p.c.), by EU countries, 2014.



Source: authors' calculation based on Eurostat and The World Bank database; World Development Indicators; Eurostat, Fertility indicators.

Figure 5 shows the correlation between fertility and total energy consumption across EU countries. At first, the correlation may appear to be slightly positive. According to previous studies, lower fertility points to countries with poorer age structure and a higher proportion of older people, which may affect the country's economic activity and indirect energy consumption. Although we cannot directly link fertility and the energy sector in developed countries, there is certainly an indirect influence due to population ageing.

Population ageing

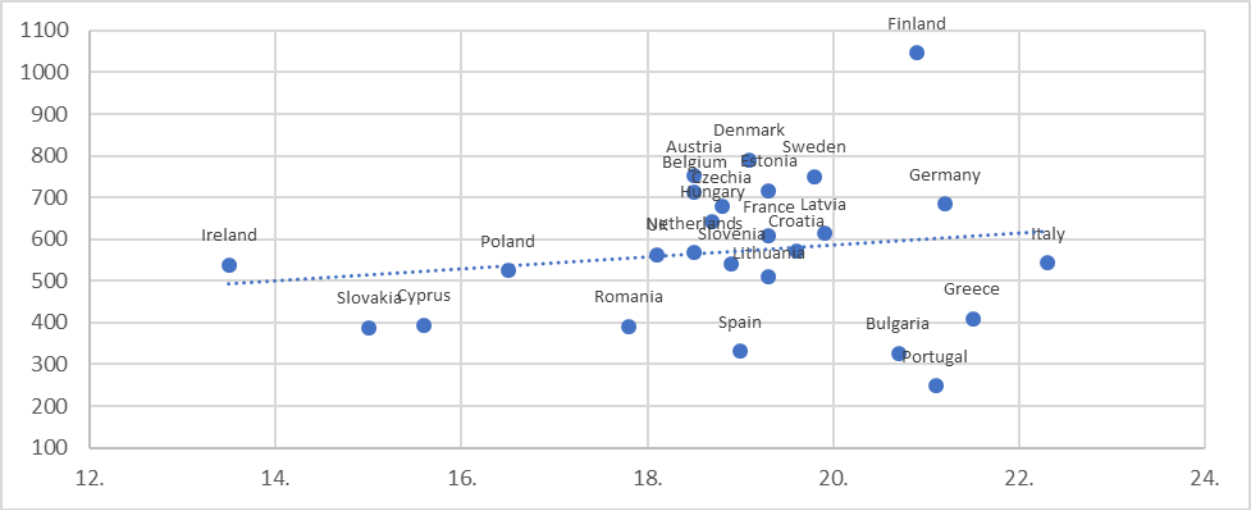
With the global trend of population ageing, economic challenges in society are increasing, and one such challenge is the change in the volume and structure of energy consumption. The most studied component of demographic development in terms of energy consumption is population ageing. In general, most papers dealing with the link between demographic processes and the energy sector focus on population ageing and its implications for demand and production (Hamza and Gilroy, 2011; Garau et al., 2013; Romanach et al., 2017). From the perspective of most economists, a country with a higher proportion of elderly population is usually associated with decreasing productivity, lower savings and higher government spending (Attanasio et al., 2007; Ludwig et al., 2012; Nagarajan et al., 2016). Recent papers have also examined the role of ageing on the structural transformation of economies, noting that the consumption pattern shifts towards goods that are more relevant for the elderly, housekeeping, health and leisure services (Aiyar and Ebeke, 2016).

The population with a higher proportion of elderly consumes more energy than the younger population. Older people have smaller households (higher consumption per capita) and use less energy-efficient products. Also, older people are less prone to change in terms of switching to energy-efficient appliances (York, 2007).

The supply-side composition of the economy shifts in tandem, with the service sector growing relative to manufacturing (Siliverstovs et al., 2011).

In more detail, some papers state that the ageing of the population changes the structure of energy consumption. Findings show that demographic change tends to increase the consumption of energy for heating purposes and to reduce the consumption of motor vehicle fuels. Furthermore, changes in the structure of household consumption also affect sectoral production. In the ageing economy, the output of the sector refined petroleum products and other fuels are reduced, while the output of the sector electricity and district heat is increased (Kronenberg, 2009).

Figure 6. Population 65+ (% of total population) vs energy use (kg of oil per capita), by EU countries, 2017.



Source: authors' calculation based on Eurostat and The World Bank database; World Development Indicators; Eurostat, Population (Demography, Migration and Projections)

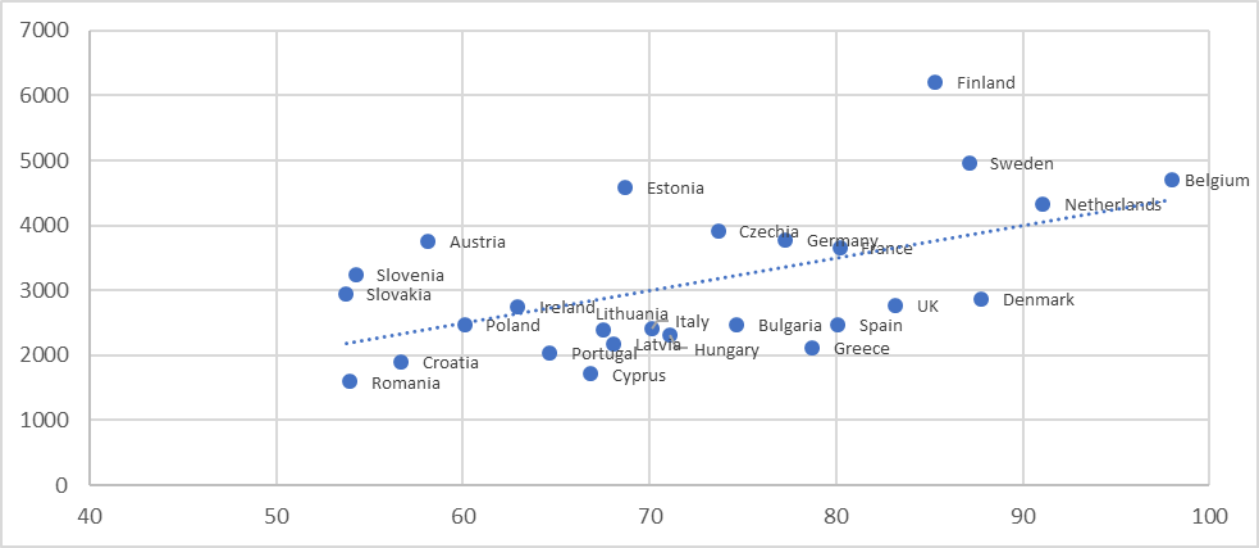
Cross-sectional data across EU countries do not show a significant trend, so we cannot conclude that countries in the European Union with a higher proportion of elderly consume more energy per capita (Figure 6). The discrepancy can be explained by the nature of the data. The papers reviewed explored individual countries and trends in consumption over time. On the other hand, a panel study was conducted on a group of economically heterogeneous countries. European Union countries are relatively homogeneous regarding the ageing process.

Urbanization

In addition to studying the number, change and population structure, demography deals with the distribution of the population. According to UN estimates, more than half of the world's population lives in urban areas today, and by 2050 this proportion will increase to 68% of the world's population (UN, World Urbanization Prospects, 2019).

Cities consume the vast majority (60–80%) of energy production worldwide and account for roughly an equivalent share of global CO_2 emissions (OECD, 2010). According to many energy and environmental experts, cities are a major battleground in humanity's fight to save energy and combat climate change. Urbanization leads to more economic activity and energy use. On the other hand, economies of scale and energy-efficient transportation and infrastructure can reduce energy use, making it difficult to predict the overall impacts of urbanization on energy intensity.

Figure 7. Urban population (% of total) vs energy use (kg of oil per capita), by EU countries, 2017.



Source: authors' calculation based on Eurostat and The World Bank database; World Development Indicators; Eurostat, Population (Demography, Migration and Projections)

A good illustration of the correlation between urbanization and energy consumption are two countries with similar needs and geographical context, but different population distribution in cities (Fig.7). Denmark's urban areas are denser than Finland's by a factor of four, and people in Denmark consume 2.5 times less energy than the Finns (OECD, 2010). This example shows us that the urbanization indicator always needs to be further analysed, since the distribution of the population within cities can make a significant difference in influencing energy consumption. Increasing density could significantly reduce energy use in urban areas (Güneralp et al., 2017; Mirkovic and Alawadi, 2017; Sadorsky, 2018).

Conclusions

Demographic changes are affecting the level and structure of energy consumption, though demographic trends affect EU regions in different ways, and therefore there is no single description of all demographic trends. A review of the literature showed increasing interest in exploring the impact of demographic change on economic processes. Energy consumption is one of the indicators of the level of development of the country. Given the different demographic trends among EU countries, it is expected that their impact on energy consumption will be of varying magnitude.

Demographic projections of EU countries clearly point to a further trend of deterioration in age structure and an increase in the proportion of the elderly. Accordingly, the ageing trend of society will create additional obstacles to reducing future energy consumption.

Although cities consume most of the energy production in the world, urbanization processes have the potential to reduce energy consumption per capita due to increased energy efficiency, better infrastructure and better transportation to serve the higher population density.

In terms of decoupling, the dominant demographic processes in the EU are driving the increase in energy consumption and thus making it more difficult to decouple economic growth (welfare) from environmental impacts.

A review of the literature to date showed that certain regularities need to be investigated beyond aggregate indicators. Given that there is aggregate variables may show autocorrelation, the most appropriate analysis would be to investigate the relationship between individual consumer demographic characteristics and energy consumption indicators. Such research would require access to energy service provider data and, where necessary, modification of existing databases.

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