Analysing an Energy Sectoral Specialisation Pattern in Southern European Union Countries

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Abstract. Exploring the sectoral energy structure of Southern European Union (EU) countries of the Mediterranean region, the paper investigates the changes that have occurred in the distribution of the major energy end-use sectors in comparison to the EU average. To that end, the indices of sectoral specialisation were calculated, and then the behavioural pattern of energy users was analysed. The results indicate a relatively low sectoral heterogeneity of final energy consumption in the sample of interest, meaning that the structure of energy end-use sectors seems to show a rather comparable development trend and is quit homogeneous compared to the EU average. The degree of economic specialisation has become gradually lower over time. The stability of this trend is confirmed by using regression in Galton’s sense. The marginal values of the sectoral specialisation index suggest that the existing homogeneity in the sectoral structure is mainly related to the level of development, geographical proximity and spill-over effect as well as the size of an economy. Indeed, countries such as Malta and Cyprus were found to have a higher degree of specialisation than Italy or France.

1. Introduction
To become a low-carbon economy, each of the European Union (EU) regions and member countries should be committed to the accomplishment of the 2030 and the 2050 energy and environmental targets [1, 2]. This is also true when Southern EU countries of the Mediterranean region, which are in the focus of this paper, come into question. The development of the Energy Union should ensure a secure, affordable and climate-friendly energy in every EU member country [3, 4]. Hence, it should contribute to the increasing energy integration of Southern EU countries and together with other integration processes, which are present in the whole EU, result in changes in the sectoral allocation and macroeconomic dynamics of the member countries.

Sectoral specialisation is commonly defined as a degree to which a local or regional economy specialises in one or more economic sectors compared to the reference economy which is usually the regional or the national economy. Understanding the changes that occur in the pattern of sectoral specialisation is of particular importance to policy authorities and competitiveness. Indeed, a high degree of sectoral specialisation can trigger asymmetric shocks and affect macroeconomic performance, the potential for growth and development and the distribution of welfare [5–7]. Dimaian et al. [8] provided evidence that this is also true for Southern EU countries. Sectoral specialisation has been studied in particular in the field of international trade and specialisation (see e.g., [5, 9]) and several papers have already covered the EU [10-16]. It is usually considered in terms of employment
or value-added generated in selected sectors of the economy, but to our knowledge, few studies have considered it in terms of energy end-use sectors (e.g., [17]).

Although energy and environmental policies in Southern EU countries vary from country to country, they share similar regional challenges such as heavy dependence on imported fossil fuels and an underdeveloped grid infrastructure or opportunities such as huge renewable energy potentials (see [18-21]). Hence, knowing what is going on with sectoral final energy consumption may be beneficial for them and the EU energy and environmental policies. Exploring the sectoral energy structure of Southern EU countries of the Mediterranean region, the paper investigates the changes that have occurred in the distribution of the major energy end-use sectors compared to the EU economy over the period 1998-2016. To that end, the indices of sectoral specialisation were calculated on the basis of Eurostat data on final energy consumption, and then the corresponding behavioural pattern of energy users was analysed.

The results of the analysis contribute to the literature in two ways. First, the paper captures changes that occurred in the energy end-use sectors of Southern EU countries, which have not been the subject of the analysis with respect to this topic so far. Second, it confirms the stability of a gradually decreasing specialisation trend in final energy consumption by applying Galtonian regression.

The paper is organised as follows. The next section gives an overview of the development of the major energy end-use sectors over the period of interest. Section 3 briefly introduces the methods applied, while Section 4 provides calculations and reviews sectoral specialisation and reallocation in Southern EU countries using the EU-28 as a benchmark. Section 5 concludes the paper and provides directions for further research.

2. Development in final energy consumption in Southern EU countries

The EU may be divided into regions based on their climate, geographical, historical, cultural and economic criteria. However, since there are neither clear criteria nor definitions for doing that, some countries are classified into two or more regions. Depending on the definition, nine countries may be considered to be part of Southern EU Europe, i.e., Croatia, Cyprus, France, Greece, Italy, Malta, Portugal, Slovenia and Spain. One should note that Portugal is not a Mediterranean country since it does not have any coastline in the Mediterranean Sea. However, we included that country in the analysis as many other authors [19, 21] since it has so much in common with other Mediterranean countries (e.g., weather and climate, Latin script, landscape or architecture).

According to the Eurostat database of population and energy [22, 23], Southern EU countries account for about 39% of the EU population and consume about 37% of its final energy demand. It is therefore worth investigating what is happening with energy consumption therein. On average, this group of countries reduced its energy consumption by 0.2% each year over the last twenty years. Figure 1 graphically presents the development in final energy consumption for the entire group of countries and the major energy end-use sectors in the period under consideration.
Final energy consumption in Southern EU countries declined by 3.03% between 1998 and 2016, i.e., from 404.5 million tonnes of oil equivalent (TOE) in 1998 to 392.3 million TOE in 2016 (Table 1). For the purpose of comparison, final energy consumption in the EU-28 decreased more slowly, by 1.74%, from 1,127.5 million TOE in 1998 to 1,107.8 million TOE in 2016.

Table 1. Average final energy consumption in the period 1998-2016.

| Country   | Average final energy consumption | Per capita average final energy consumption |
|-----------|----------------------------------|--------------------------------------------|
|           | Million TOE | Standard deviation | Minimum | Maximum | Annual rate of change in average share, in % | TOE per capita | Standard deviation | Minimum | Maximum |
| EU-28     | 1,139.84    | 38.51             | 1,063.14 | 1,194.42 | -0.10                                      | 2.29 | 0.10 | 2.09 | 2.41 |
| Greece    | 18.98       | 2.05              | 15.28    | 22.06    | -0.50                                      | 1.73 | 0.18 | 1.39 | 2.00 |
| Spain     | 86.14       | 7.61              | 72.16    | 98.12    | 0.75                                       | 1.95 | 0.18 | 1.70 | 2.24 |
| France    | 153.47      | 5.80              | 141.34   | 161.51   | -0.23                                      | 2.42 | 0.16 | 2.14 | 2.63 |
| Croatia   | 6.73        | 0.46              | 6.00     | 7.40     | 0.56                                       | 1.56 | 0.12 | 1.33 | 1.72 |
| Italy     | 125.99      | 7.28              | 113.32   | 137.15   | -0.20                                      | 2.15 | 0.16 | 1.86 | 2.37 |
| Cyprus    | 1.77        | 0.13              | 1.55     | 1.97     | 0.71                                       | 2.30 | 0.22 | 1.87 | 2.54 |
| Malta     | 0.47        | 0.06              | 0.36     | 0.58     | 1.68                                       | 1.15 | 0.10 | 0.92 | 1.29 |
| Portugal  | 17.58       | 1.21              | 15.77    | 19.01    | -0.05                                      | 1.68 | 0.11 | 1.52 | 1.81 |
| Slovenia  | 5.40        | 2.64              | 4.42     | 16.26    | -6.47                                      | 2.36 | 0.10 | 2.21 | 2.61 |
| Total/average Share, in % | 416.53 | 0.00             | 370.20   | 464.08   | -0.17                                      | 1.92 | 0.15 | 1.66 | 2.13 |

The data source for calculation: [22, 23]

However, countries belonging to this group vary substantially not only in terms of size, population or level of economic development achieved, but also in terms of energy system and energy landscape, including energy consumption behaviours, practices and trajectories [20]. Table 1 provides basic statistics related to final energy consumption in this group of countries. It confirms the existence of heterogeneity in final energy consumption between countries of interest. In general, compared to the EU-28, Southern EU countries consumed less energy per capita (2.29 vs. 1.92 TOE per capita, respectively). Thereby, Malta and France consumed the least and the most energy per capita, respectively. Final energy consumption in the industry, agriculture/forestry and “other” sectors declined over the period of interest. In contrast, it increased in the other sectors (see Figure 1 and Table 2). The lowest share of industry was found in Malta (10.2%), while the highest one was found in Portugal (31.06%). It decreased in all countries except in Slovenia. A drop in industrial energy consumption, which was also observed in the EU-28, has been a synergistic result of multiple causes. Among them, the economic transition towards less energy-intensive manufacturing industries, innovation in and implementation of new energy-efficient and energy-saving technologies are particularly important, in addition to factors such as energy/environmental regulation which are important for all sectors (see [24-26]).
Households and industry account for about 23% of total final energy consumption. Among them, the share of households went from the lowest value in Cyprus (15.35%) to the highest value in Croatia (37.72%). Household final energy consumption is influenced by the use of more energy-efficient household appliances and energy efficiency innovations in residential buildings [24, 26]. However, their consumption led to the rebound effect in the period observed, which is not seen when looking at the EU-28 in that period [17]. Transport is the largest energy consuming sector. It accounts for about 40% of total final energy consumption, with the largest share (56.65%) and the lowest share (28.34%) in Malta and Croatia, respectively. The rebound effect also occurred in that sector. An increase in the number of private cars and a growing demand for passenger and freight transport followed upgrades in fuel and vehicle efficiency and transport infrastructure [26]. As supported by data in Table 2, a downward trend in final energy consumption in Southern EU countries is not present everywhere; Greece, France, Italy, Portugal and Slovenia experienced an average decrease in energy consumption between 1998 and 2016.

### Table 2. Average shares and annual rates of change in final energy consumption in the period 1998-2016.

| Average share, in % | Annual rate of change in average share, in % |
|---------------------|---------------------------------------------|
| Industry Transport Households Agriculture/Forestry Services Industry Transport Households Agriculture/Forestry Services |
| Greece 20.18 40.11 25.35 4.35 9.48 -1.46 0.03 0.58 -6.97 3.51 |
| Spain 27.93 41.70 16.79 3.00 9.87 -1.69 -0.05 0.96 0.41 3.03 |
| France 22.19 32.47 26.72 2.66 14.14 -1.29 0.34 0.49 0.77 0.46 |
| Croatia 20.38 28.34 37.72 3.27 9.88 -2.02 1.58 -0.55 -0.95 1.85 |
| Italy 27.12 33.63 25.17 2.25 11.48 -1.69 -0.09 1.07 -0.42 2.21 |
| Cyprus 17.85 53.30 15.35 1.55 10.18 -4.36 0.00 3.45 9.62 4.33 |
| Malta 10.02 56.65 15.94 0.60 15.64 -1.21 -0.82 -0.49 97.94 4.92 |
| Portugal 31.06 39.01 16.52 2.50 10.44 -1.63 0.87 -0.03 -5.05 2.65 |
| Slovenia 27.31 32.77 23.44 1.48 10.69 7.11 9.08 7.58 6.95 4.50 |
| Average 22.67 39.78 22.56 2.40 11.31 -1.53 0.19 0.65 -0.28 1.46 |

Note: The remaining % to 100% of the sum of the average shares refers to the “other” sectors. The annual rate of change in average share for Malta in agriculture/forestry is calculated for the period 2005-2016; for the “other” sector. The data source for calculation: [22, 23].

In general, the data follows the overall trend in final energy consumption observed over time across the EU-28 – a transition from the industrial to the service sector. Fernandez Gonzales et al. [27], Odyssee and Mure [24], EEA [26, 28] or Bertoldi et al. [25] provided further information on this trend. Only in Slovenia, energy consumption in industry increased more than in the service sector. As already pointed out by Borozan [17], changes in sectoral composition are obviously taking place all the time, and sectoral reallocations and adjustments have been a permanent features of the EU and its member states over the last 20 years. They have been gradual, as already observed by Melachroinos [10], Ezcurra et al. [11], Marelli [12] or ECB [14] that explored economic specialisation in terms of employment and value-added. Russu [13] revealed the transformation that occurred with respect to technology, required qualifications and sector growth intensity as well. He demonstrated that sectors with high technology and skill levels and high and medium-high sectoral growth rates increased significantly in most EU countries in 2005 compared with 1995.

### 3. Methods and data
Sectoral specialisation of a country indicates a degree of specialisation in the sectoral structure between the country itself and the reference economy, the EU-28 in our case. As highlighted by Krugman [5], if the country is becoming more integrated, a rise in sectoral specialisation and steady diverging patterns may occur. This is because they can benefit from trade opportunities and comparative advantages [5]. Following Melachroinos [10], we calculated the index of sectoral specialisation (SS) using expression (1):

$$SS' = \frac{1}{2} \sum \left[ \left( \frac{E_i^j}{E_i} \right) - \left( \frac{E_i^j}{E_j} \right) \right]$$

where $E_i^j$ and $E_i$ stand for final energy consumption in year $t$ ($t = 1998, \ldots, 2016$) at the national level and final energy consumption for a sector $i$ ($i = 1, \ldots, 5$) in a country $j$ ($j = 1, \ldots, 9$) in year $t$, respectively. $E_i^j$ denotes final energy consumption of all sectors in a country $j$ in year $t$. According to Eurostat, which is the data source, final energy consumption refers to total energy consumed by energy end-use sectors (industry, transport, households, services, agriculture /forestry and “other” sectors), excluding energy which is used by the energy sector itself. The value of the sectoral specialisation index ranges between 0 and 1. It will take the value of zero if a country $j$ has a sectoral structure identical to the rest of the EU-28. It will take the value of 1 if a country $j$ has no sectors in common with the rest of the EU-28. In the first case, the country is unspecialised, while in the second one, it exhibits a strong sectoral specialisation.

To investigate how stable the sectoral specialisation pattern has been over the period of interest, we followed Guerrieri and Iammarino [29] and adopted the Galtonian regression model. The model is presented as follows:

$$SS_{ijt} = \alpha + \beta SS_{ijt-1} + e_{ijt},$$

where $t$ refers to the average sectoral specialisation (SS) for the period 2008-2016, $t-1$ refers to the average sectoral specialisation for the previous period 1998-2007, while $i$ and $j$ denote respectively an energy end-use sector and a member country of interest. The key parameter is $\beta$; its estimated value provides information on the dynamics and the structure of sectoral energy specialisation. If the estimated $\beta$ is equal to one, the existing sectoral specialisation pattern is stable. However, if it is less than or greater than one, the existing structure of specialisation weakens or strengthens, respectively. When $\beta$ is less than zero, a reversal of the original specialisation pattern occurs. The model was estimated using the robust standard error.

4. Sectoral specialisation in Southern countries

Figure 2 graphically illustrates the average values of indices of sectoral specialisation per Southern EU country calculated by using expression (1).

Over the whole period under consideration, the average values of the sectoral specialisation indices oscillate between 0.0345 (in Slovenia) and 0.3567 (in Malta). They suggest that the homogeneity in the sectoral distribution of final energy consumption in Southern EU countries is quite high. In other words, the structure of final energy consumption sectors in this group of countries seems to have a fairly comparable development path and is quite homogenous. This result is consistent with Ezcurra et al. [11], Marelli [12] and ECB [14] as well as Borozan [17], who found that the economic structure of the EU is quite homogenous when employment, value-added or energy consumption are considered. The lowest values of this index are found in Italy, France and Slovenia, and the highest values are found in Malta and Cyprus. Such a distribution of specialisation is expected considering geographical proximity and the related spill-over effect as well as the size of the economy and the level of economic development reached. Namely, as observed by Borozan [17], the values of indices suggest that larger and more developed countries are on average less specialised with regards to the EU average, while
smaller and less developed countries as well as geographically peripheral countries are relatively more specialised. A plausible explanation lies in the fact that larger countries, such as France or Italy, have a more diversified sectoral structure, are more developed and are able to achieve economies of scale for a larger number of economic activities [17].

![Figure 2. Evolution of the indices of sectoral specialization](image)

Note: The index values were multiplied by 100. This algebraic manipulation does not change the meaning.

Looking at the growth dynamics of the index values, a reduction in the level of economic specialisation can be observed. Namely, the average annual growth rate accounts for -1.79% in the period considered. This holds for each Southern EU country, whereby the greatest decline in specialisation was recorded in Italy (-3.89%), while the smallest one were recorded in Slovenia and Malta (-0.90% and -0.76%, respectively). The gradual change in the initial specialisation pattern is confirmed by running the Galtonian regression model represented by expression (2). The estimated $\beta$, which is 0.932 and statistically significant at the 0.01 level, confirms a very slow decline in the degree of specialisation in Southern EU countries. Bearing in mind the potentially negative effects of strong specialisation (e.g., economic vulnerability to exogenous shocks or unfavourable effects on growth and development potential as well as welfare distribution), Marelli [12] pointed out that more developed regions generally have a lower and further decreasing degree of specialisation. Likewise, Armstrong and Read [6-7] demonstrated that small countries that are highly specialized in tourism are particularly sensitive to economic crises or global warming. From this point of view, the observed trend in Southern EU countries can be characterised as positive. Gadea-Rivas et al. [16] revealed that sectoral composition has a significant impact on economic fluctuations and that a similar sectoral composition can explain, in particular, the synchronisation that occurred between European regions after the Great Recession.

5. Conclusion

Contemporary environmental, social and economic trends such as climate change, changes in energy behavioural practices or innovations in more energy-efficient, energy-saving and clean energy technologies as well as integration processes have caused sectoral restructuring of the economy in EU member countries.

The present paper explores the sectoral energy structure of Southern EU countries of the Mediterranean region in relation to the EU average from 1998 to 2016. To that end, a brief overview of the sectoral changes in final energy consumption in this group of countries was provided, and then the indices of sectoral specialisation were calculated and the corresponding behavioural pattern of the energy end-use sector was analysed. The selected Southern EU countries account for about 39% of the EU population and consume about 37% of its final energy demand. Although a decreasing trend in final energy consumption was observed for both Southern EU countries and the EU-28, the former
reduced its energy consumption at a slightly faster pace than the latter. However, Southern EU countries consumed less energy per capita than the EU-28 in the period observed. The results show that final energy consumption declined in the industry, agriculture/forestry and “other” sectors under the period of consideration, while it increased in the other sectors. This is a consequence of current trends in the non-residential sectors (e.g., economic transition to less energy-intensive manufacturing industries and services, and innovation and adoption of new energy-efficient and energy-saving technologies), and the residential sector (e.g., the rebound effect triggered by the use of more energy-efficient household appliances and energy efficiency innovations in residential buildings).

The results also indicate a mild decrease in economic specialisation in terms of energy consumption across the sample of interest, meaning that the structure of final energy consumption sectors seems to show a fairly comparable trend across them. In relation to the EU average, it is rather homogeneous. Over time, a decrease in economic specialisation has become gradually lower, which is confirmed by employing Galtonian regression. The marginal values of the specialisation index indicate that dissimilarities may be related to the level of economic development, geographical proximity and spill-over effect as well as the size of the economy. Indeed, countries such as Malta and Cyprus were found to have higher degrees of specialisation than Italy or France. Further research is needed to verify the results obtained for a longer period, each major end-user sector and a deeper disaggregation of the data. In addition, the driving forces of economic specialisation should be investigated in order to better understand the changes that occur over time.

6. References

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