Electricity Bill Price Prediction

Analysis based on European Union integration level

Francesco Cabras

Dipartimento di Matematica
Università degli Studi di Trento
Italy
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Introduction

Electricity bills are among the most important expenses for families around the world, at least for the lucky households that have access to it. In distinct countries the price of electricity of course is different, and it is not only always easy to acknowledge which are the reasons behind these gaps. One could think that the key factor is in the supply: how much it costs to actually source energy, getting electricity and especially distribute it among households. In recent years many countries around the world have gone through liberalization of their electricity markets: the result is that consumers can choose among different suppliers, and may decide to modify the profile of their demand to reduce their costs [7]. This means that the demand of electricity has become more elastic. Another trend that has gone through in recent years has been the increase in the renewable sources of energy. To measure the effect of such changes on the price of the good is the main aim of this document. The first idea is to have a look at the amount spent by households aroung the world for their electricity bills. In *Figure 1* the countries are colored on the basis of the price of electricity, measured in US dollars per kWh [1].

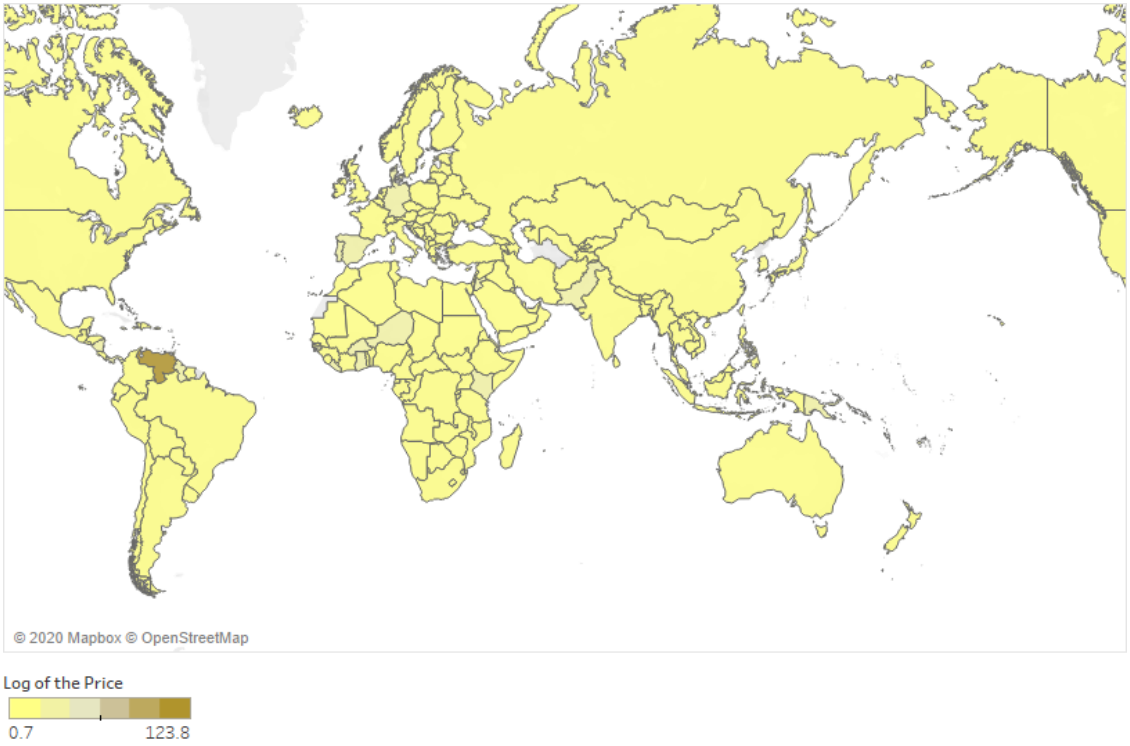

Figure 1: The more expensive electricity is, the more intense the red color.

[1] World Bank data, 2020

The more intense the red color, the more expensive electricity is. Interestingly, the country which appears as the most intensely red-colored is among the ones that has the easiest access to resources for getting electricity: **Venezuela**.The reason behind this finding is that in recent years this country has been suffering from exceptional inflation: the take-home message, however, is that the political and macro-economical frameworks are extremely important for the final price of this good.

Apart from South America, also in Africa some results are quite interesting: looking at the pale color of countries like South Sudan or Somalia, which are among the poorest in the world, the reader may think that to wealthier country consistently should correspond higher electricity price, given that there is no sky-high inflation. If however, for instance, bordering countries as Algeria and Niger countries are considered, this simple hypothesis does not work: the former has an electricity price of 2.1 dollars per kWh and a gdp per capita of 4,114.72 dollars. In the latter, instead, electricity price corresponds to 21.3 dollars per kWh (10 times with respect to Algeria) but the gdp is merely 413.98 dollars (almost one tenth with respect to Algeria). Since inflation is not really a problem in Niger, this is a hint that the link between economic development and electricity price is not that elementary. The particular problem with Niger is its extremely low electrification rate: only one in seven Nigeriens have access to modern electricity services, and just four percent of rural residents have access through the national utility. The country's total energy consumption per capita is 44 kWh of electricity. It is the second lowest energy consumption per capita in West Africa, behind Guinea Bissau, and the ninth lowest in the world.

Access to Electricity

While the whole share of Algeria inhabitants has access to the grid, this is not the case for Niger, where only part of the relatively wealthier urban population does. This explains why the price is not related with the gross domestic product per capita: since only the wealthy population can afford to have access to the grid, the prices can be kept higher. In this case a loop is entered, since prices are also high because network costs are shared among few people, and network costs are the most important component in the final electricity price paid by households. In *Figure 2* it is showed how electricity price (in dollars per kWh) is related to population share having grid access, for countries with no universal electricity service.

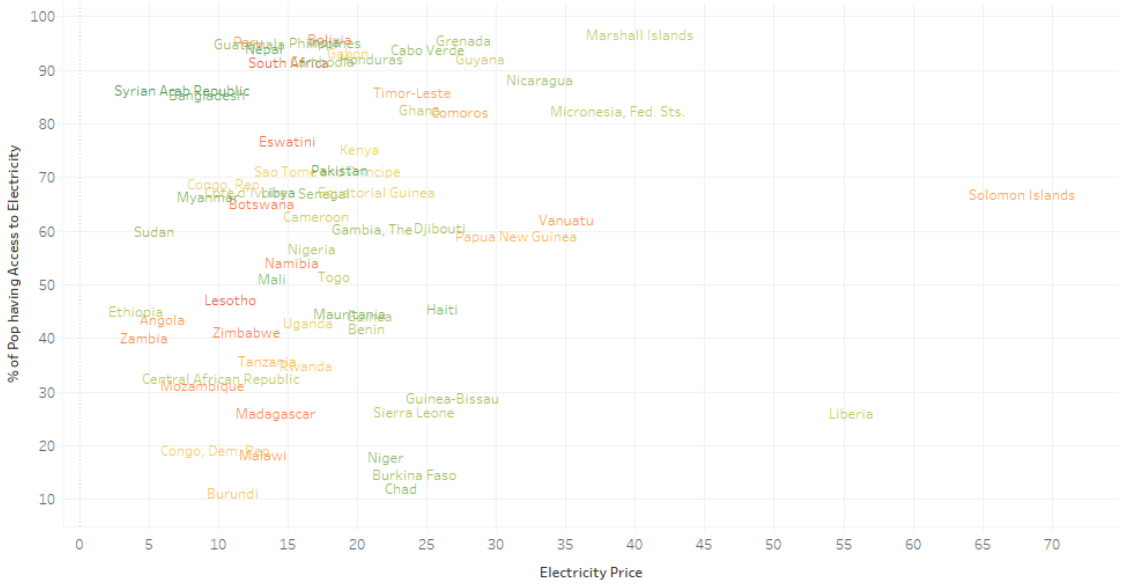

Figure 2: The more southern the country, the redder the color.

Although the countries providing little electricity access to its population also have low gross domestic product, prices are not that low with respect to wealthier and more electricity-intensive countries. In *Figure 3* it is represented how countries with little grid access are concentrated in Africa: in recent years, Asian countries (especially India) have made important steps forward in this sense.

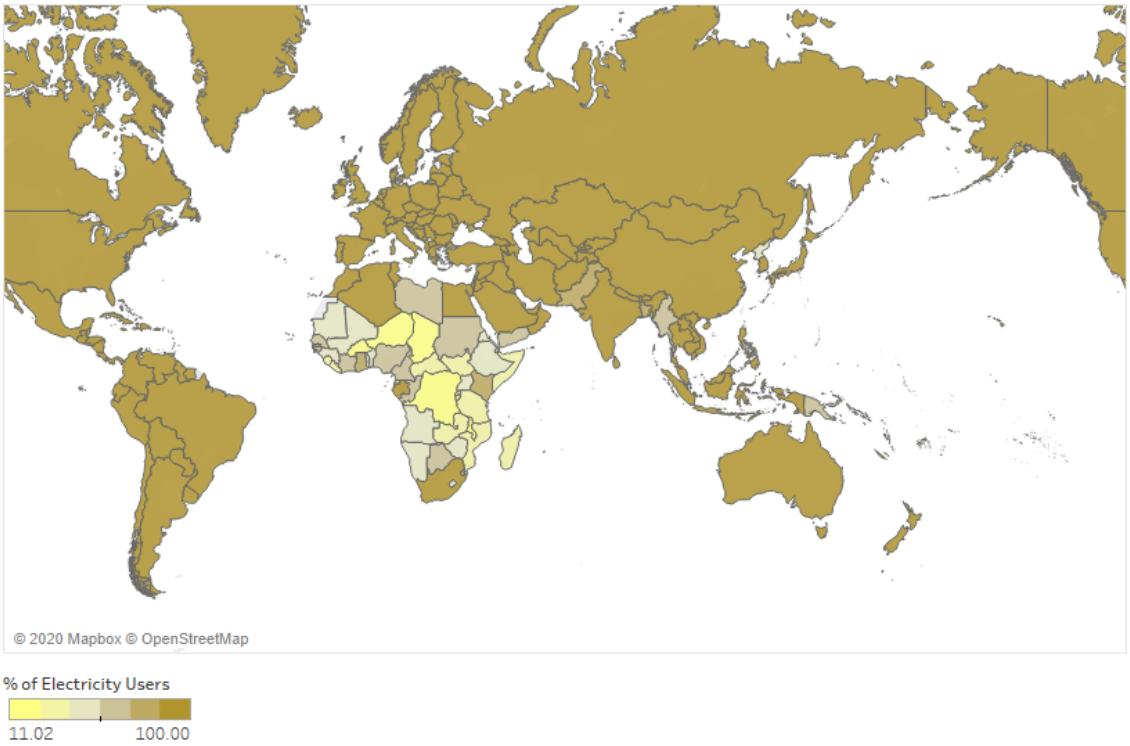

Figure 3: Share of population having grid access.

Production

Access to electricity is linked to production and consumption patterns inside a country. Electricity is not freely available in nature, so it must be "produced" (that is, transforming other forms of energy to electricity). Apart from a slight decrease during the 2008 crisis years, electricity production has been increasing constantly in recent years, with China having overcome United States as the main producer.

Table 1 illustrates which are the main electricity generators, with most recent data available. It is interesting to notice the leap of China which was able to increase its generation by five times of the amount it was producing in 2000, with an average increase of 5 percent per year. The United States also increased its production, but not at the pace of China. India was only the 7_{th} biggest producer in 2000, and also was able to climb the rankings quite fast in order to allow for its economy to grow. Japan, instead, saw its production decrease in the same time period.

Country	Production (2000)	Production (2019)
China	1,356	7,482
United States	4,053	4,385
India	570	1,614
Russia	878	1,122
Japan	1,068	1,013
Canada	606	649

Table 1: Major Electricity Producers (in KwH), Enerdata.

If the focus shifts to European countries, Germany and France turn out being the two major producers in the continent, followed by the United Kingdom. European situation is illustrated in *Figure 4*.

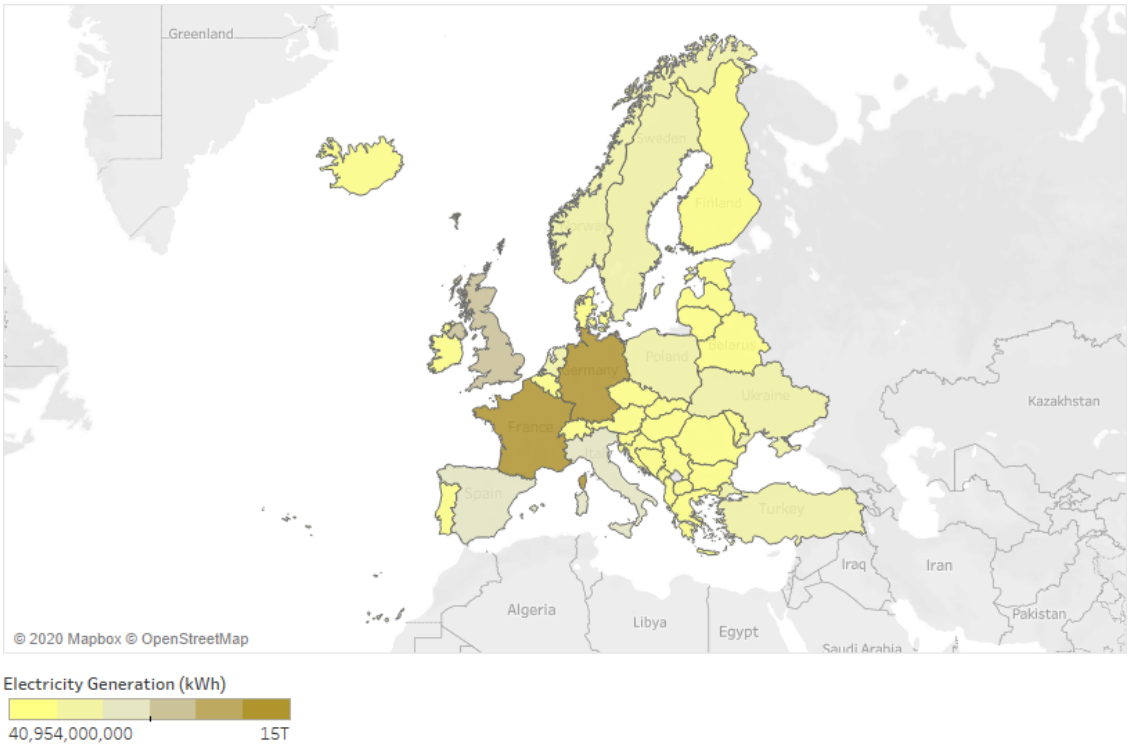

Figure 4: European countries and corresponding electricity generation capacity.

Consumption

Since the major costs associated with electricity is actually the way of transporting it from one place to another, most of the electricity produced in one country actually remains inside that country until it is consumed. This explains why the major electricity producers are also the major electricity consumers. However, there are still marginal differences among these rankings. *Table 2* shows which are the principal electricity consumers in the world.

Country	Consumption (2000)	Consumption (2019)
China	1,138	6,510
United States	3,590	3,865
India	376	1,230
Russia	693	922
Japan	986	918
South Korea	263	553

Table 2: Major Electricity Producers (in KwH), Enerdata.

Also in this case, the behavior of Asiatic countries is the most interesting. China, India and South Korea have experience a major boost in their electricity consumption while Japan decreased its value in the last 20 years. China is the country which consumes (and produces) the largest share of electricity because it is also the most populated. Data regarding consumption per capita represented in *Table 3* can result be even more interesting.

Country	kWh consumption per Capita
Iceland	53,832
Norway	23,000
Bahrain	19,597
Kuwait	15,591
Canada	15,588
Finland	15,520

Table 3: Countries with highest consumption per capita values, World Bank data.

There are certain countries that are particularly ill-suited for the existence of individuals, and a large amount of energy has to be consumed in order to improve their well-being. It is the case of Iceland and Norway, where temperatures are very low and during winter months sunlight is available only for few hours. Or it is the case of Bahrain or Kuwait where contrarily it is simply too hot.

Figure 5 also shows how European countries with highest consumption per capita are located in the North, where temperatures are lowest.

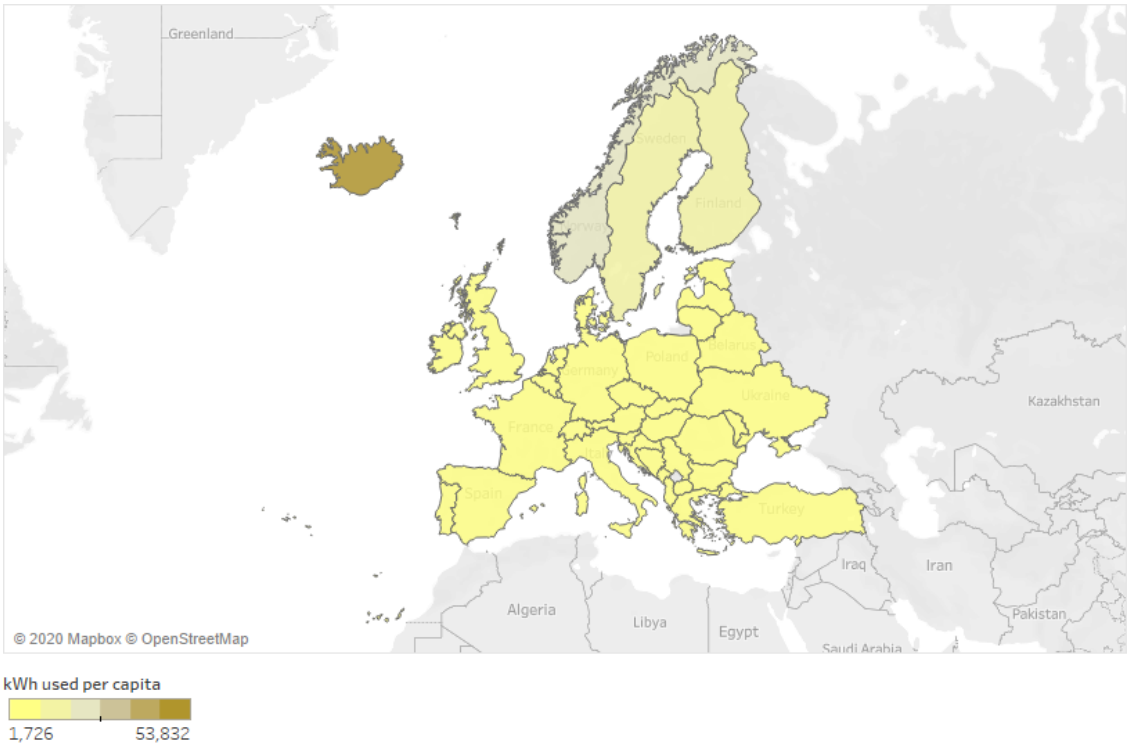

Figure 5: European countries and corresponding consumption per capita values, World Bank data.

European Union Electricity Market

Electricity is not an easily tradable product, as it needs hundreds of legal rules and technical standards to be agreed upon before it can become freely marketable. Electric power is, after all, not more than a flow of electrons inside metallic wires of a massive, interconnected network. That is the reason why, for decades, electricity was considered to be an "anti-market" product, best suited to non-competitive markets like natural monopolies. [4] Furthermore, the particular characteristics of electricity, such as non-storability and the continuous balance between demand and supply, supported the State intervention. The fact that this market is inclined to be a monopoly resulted in efficiencies, where State subsidies have been the rule to maintain a stable industry. [3] Nevertheless, there is one region in the world that has tried to overcome these "anti-market" barriers to create an extremely vast electricity market. That region is identifiable as the European Union.

The European Union because is a unique case of a large extended market in which member countries can exchange goods. Liberalization of the economic markets and convergence are two of the main objectives in the Union. In particular, European electricity market liberalization represents the world's most large-scale cross-jurisdiction reform of the electricity sector involving integration of national markets. To reach such a big achievement took several years of time, and there are specific reasons why this process took so long:

- The objective of this project is to open up national monopolies' market spaces to foreigners, which of course is a radical project that inevitably leaves some parties unsatisfied. One of the risks of market concentration is that big incumbents try to build barriers in order to maintain their position and to foreclose the entrance of more efficient market actors. [9]

- In the last 25 years there has been no wave of disruptive technological innovation to challenge the incumbent energy giants.
- the national arrangements that had been developed between industry players and public authorities could not be easily merged at the EU level into a common scheme.

Creating a market that is actually free, however, is not an easy matter, and that's why there are still wide differences in the amounts households from different member countries pay for electricity. Although the pace of the liberalization is steady, the integrated European electricity market is yet to be achieved.

Taxation

Taxes account for a sizable share of the final prices consumers pay for energy around the EU and can have a strong impact on consumption patterns, the type of energy consumed and their use. There is disagreement among European countries for much households should pay in their bills, and the consequence is wide differences in tax rates. Belgium, Ireland, Germany and Denmark are the member states where electricity is the most expensive. However, these four countries present different tax rates: Belgium and Ireland citizens pay a high price because electricity is actually expensive excluding taxes and levies while Germany and especially Denmark pay such a high price precisely because of taxes and levies. This behavior is well represented with *Figure 2*, where household electricity prices are plot both including and excluding taxes and levies. Prices are lowest in Bulgaria and Hungary, whose inhabitants pay one third of the amounts Danish citizens pay in their bills.

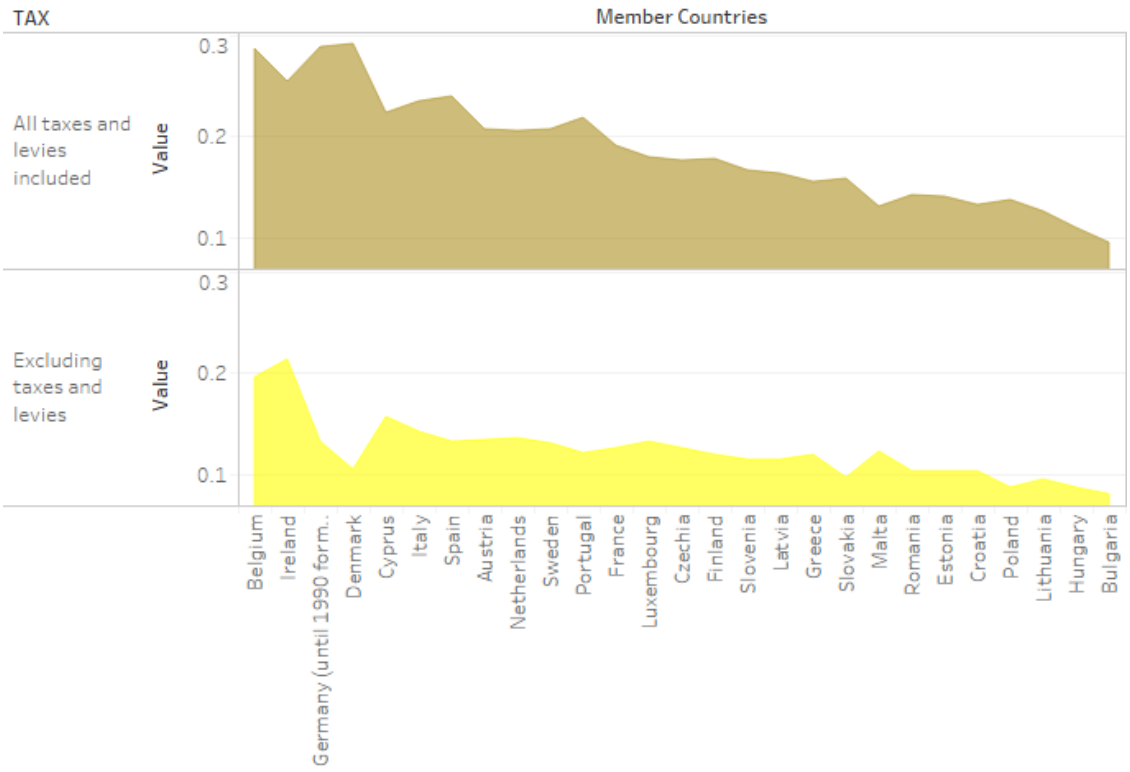

Figure 6: 2019 (second semester) data, electricity prices.

The average final price paid by European households is 21.7 cents per KwH including taxes and 12.8 cents per KwH excluding taxes, which make up an average of around 6 cents of taxes per KwH. Over time, also taxes tend to change: in the second semester of 2007 the price paid by European households fell with respect to the first semester by 3 cents, while the the electricity price itself decreased only by a cent. This means that most of the drop was due to a decrease in taxes. *Figure 3* shows how electricity prices for European citizens changed over time, on average.

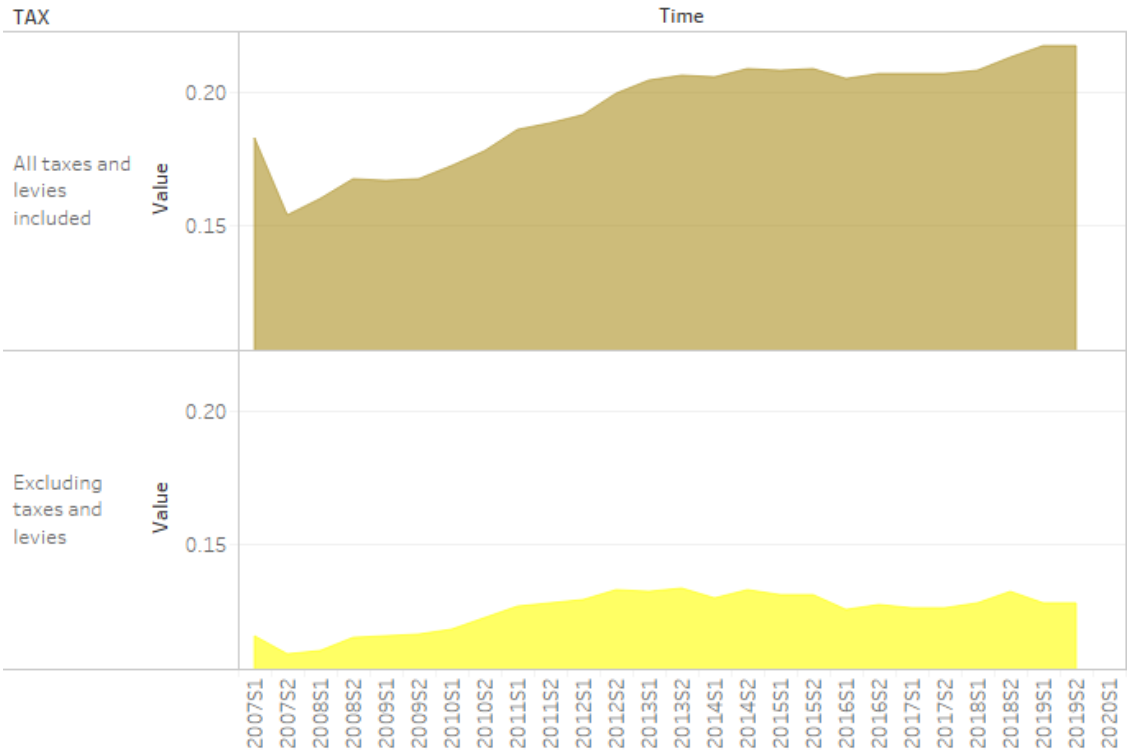

Figure 7: 2019 (second semester) data, electricity prices.

Inflation

As all other commodities, the price of electricity tends to increase over time at a similar pace with respect to inflation. The average increase in prices in a given country is an obvious cause for electricity price surge. The levels of inflation are over time converging, as it should be for such a tied market, and the pace of such convergence became even more steady after the global financial crisis. [2] The body which is charge for controlling the inflation level in the Euro area is the European Central Bank, and the primary objective of its monetary policy is to maintain price stability. The ECB aims at inflation rates of below, but close to, 2% over the medium term. The ECB failed to keep inflation under this level for the first years of the 21th century, before the 2008 financial crisis, but after this the inflation level dropped and never got back to such high levels. Such inflation target was highly debated in recent times, especially after the Federal Reserve has relaxed the same 2% target.

As it is possible to discern from *Figure 4*, the inflation level and the electricity price tend to show a similar trend. The average level of prices in 2015 is used as a benchmark and is denoted by a 100 in the

plot. Interestingly, however, the electricity price has had its peak in 2012, while inflation continued being positive until now.

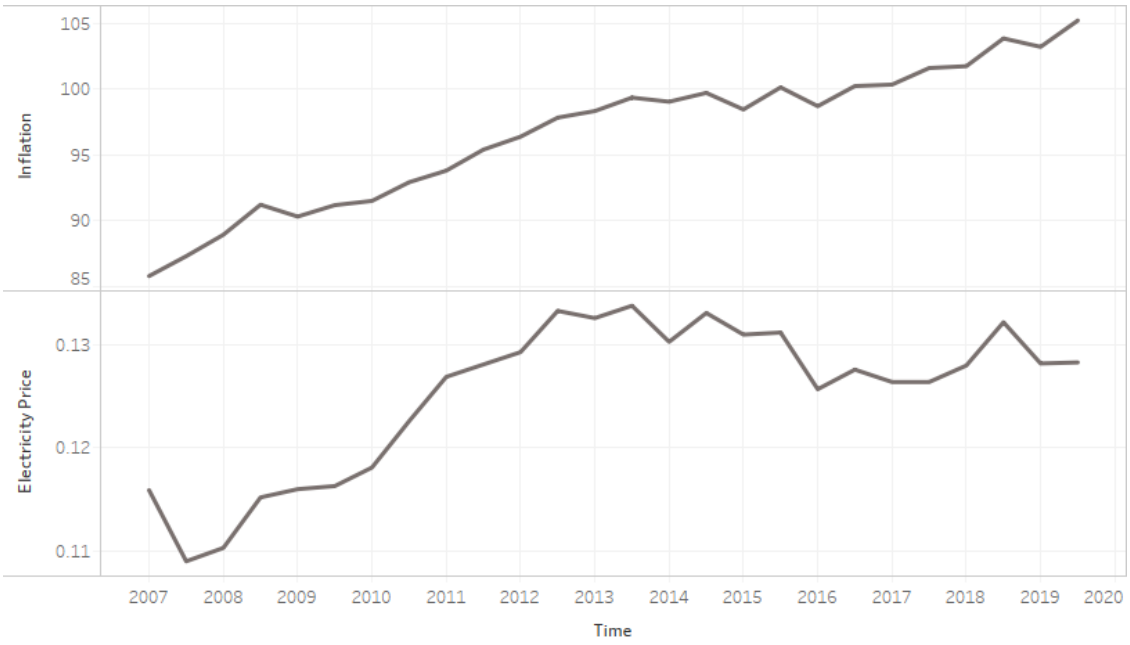

Figure 8: Price of electricity and inflation level in the European Union .

The behavior of inflation depends both on structural and on short-term factors. The inflation rate over long periods is determined by the extent to which the rate of money growth (which is controlled by the ECB or by national central banks in non-euro countries) exceeds the growth rate of real output. Short-run fluctuations are instead due to demand shocks, e.g. sizable increases in government spending, and supply shocks, e.g. sharp rises in the oil price. [1]

Market Concentration

The directive 2003/54/EC requires that all non-household customers can freely choose their electricity by 1 July 2004, with successive full market opening including all household customers within three years. Most of the European Union electricity market is now at least formally, open to competition; this was not the case a few decades ago. However, most national electricity market are still dominated by relatively few companies and small consumers seem quite resistant to switching supplier. [5]

The European Union is fighting monopolies in the electricity sector for the simple reason that the market price is supposed to be higher with respect to a situation of competition. In *Figure 2* the average of the biggest supplier share in the EU member countries markets is plot against the average electricity price over. It is possible to notice how, most notably, the average concentration in EU markets tends to decrease over time, with the share of the biggest supplier going from 60 to 50% of the market from 2000 to 2020. In theory, such an increase in competition should be accompanied with a decrease in the price of the good: yet, in last 20 years, the price instead of falling has been rising from 0.08 to 0.11 dollar cents per KwH. Although there are too many confounding elements at stake, in the first place inflation, the relationship between the two variables shall not be so elementary, and needs further investigation.

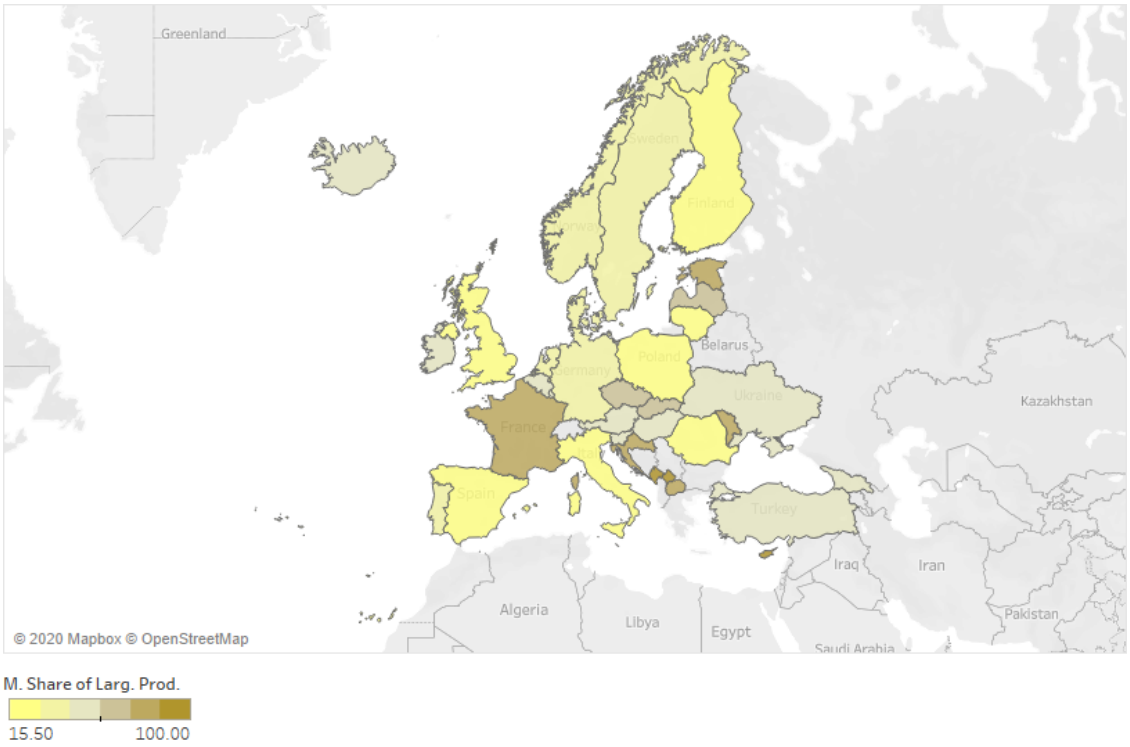

Figure 9: Average of biggest supplier share in the market plot against average electricity price.

In any case, *Figure 2* also demonstrates how, although the liberalization process has led to the disintegration of national monopolies, it did not lead to a disruptive fall in concentration within the sector. With an average value of the biggest supplier market share of 50% the European situation is quite far from the internal market and open competition. There still exist different national and regional markets with the presence of incumbents as main actors in each electricity market. Despite liberalization, the level of concentration is hence quite high. In *Figure 3*, the focus is on the biggest European markets over the last 20 years: Germany, Spain, France and Italy. It is interesting how notice how they all experienced a slight decrease in market concentration, but with France starting from a concentration value that stands out with respect to the others, with the most important supplier having a market share of 90%.

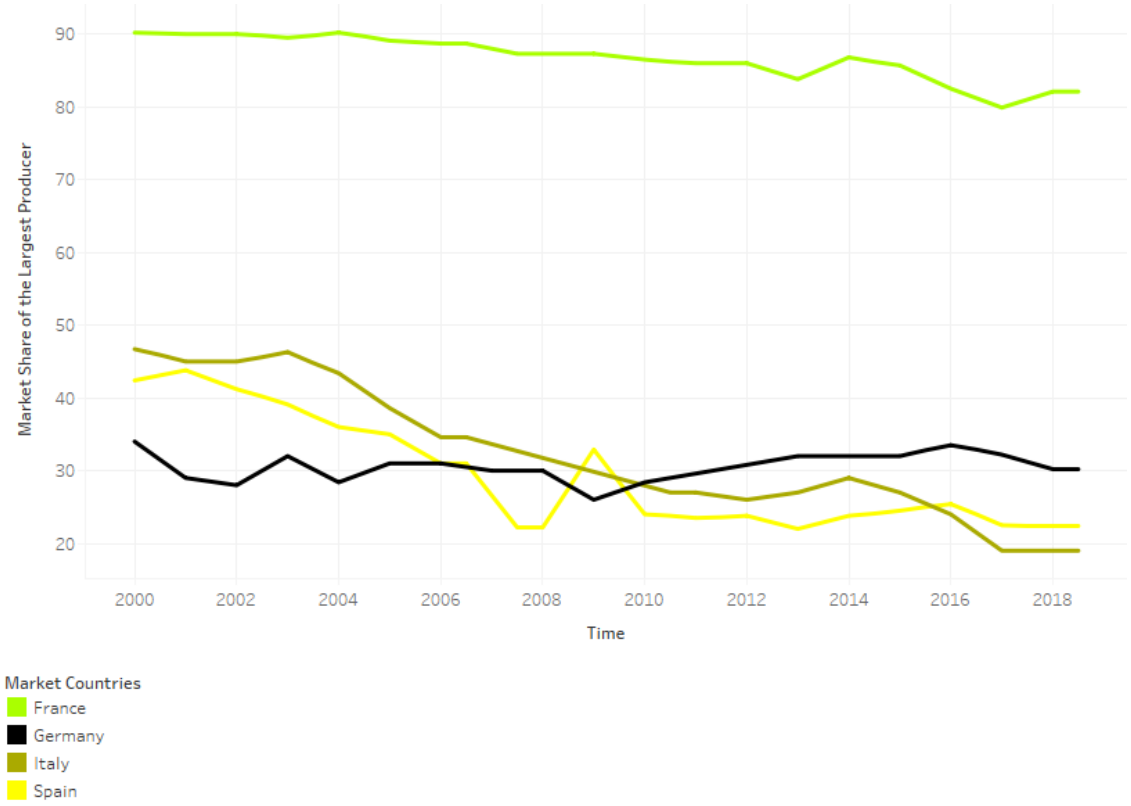

Figure 10: Average of biggest supplier share in the market plot for Germany, Spain, France and Italy.

One final note of caution: in this section the market share of the biggest supplier in the market was used as a proxy for market liberalization. The higher the share, the more the market is concentrated. However, looking at the largest supplier is a bit limiting and it is used only because data are available from Eurostat. A market in which only two suppliers share the whole market is completely different from one in which the biggest supplier controls half of the market and the rest of it is controlled by very little providers. Yet, the largest supplier market share variable value would be the same.

Gross Domestic Product

The wealth and the productive capacity of a country are closely related to the consumption patterns of its citizens. Economic development stimulates greater demand for electricity in the long-run: the gross domestic product has an effect primarily on the quantity of electricity consumed. [6] Whether there is an effect not only on the quantity used but also on the price of the good is a more debated topic: [8] employs annual data for Malaysia from 1970 to 2008 to examine this causal relationship but found that there is no causal relationship between prices and economic growth. *Figure 11* shows differences in GDP per capita, in US dollars. [2]

[2]World Bank data

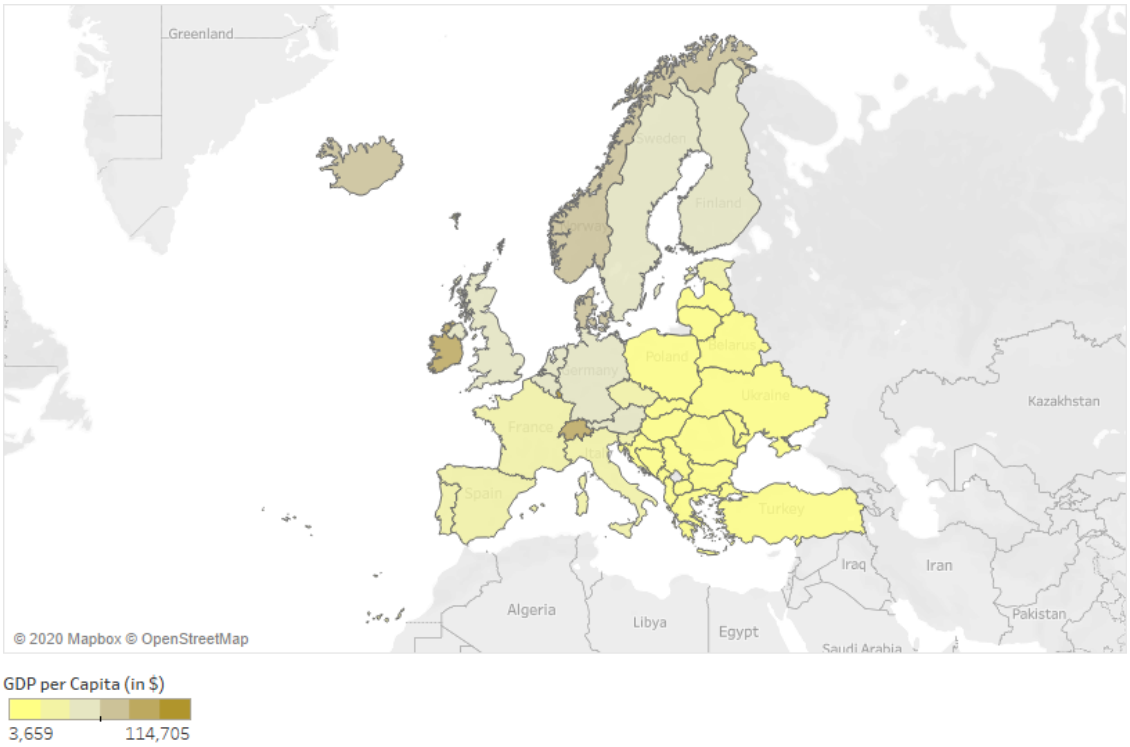

Figure 11: Gross Domestic Product per capita for European countries (in Dollars).

Belgium, Ireland, Germany and Denmark are the European member countries for which electricity is the most expensive, and also corresponds to high GDP areas. In the last 20 years GDP tended to increase for European countries, even if the economic crisis incurred in the end of the first decade slowed down the growth process. Also the electricity price has tended to increase, although at different paces and more irregularly with respect to the Gross Domestic Product.

Figure 12 shows the behavior of real GDP per capita and electricity price (taxes excluded) for France and Germany, the two major economies in the European Union. In this case inflation has been taken into account and in fact the absolute GDP values are not comparable with *Figure 11*. Electricity is cheaper in France with respect to Germany by quite a significant amount, and Gross Domestic Product is also lower. For both countries there have been increase in the values of the two parameters, although with considerable less regularity when it comes to electricity price.

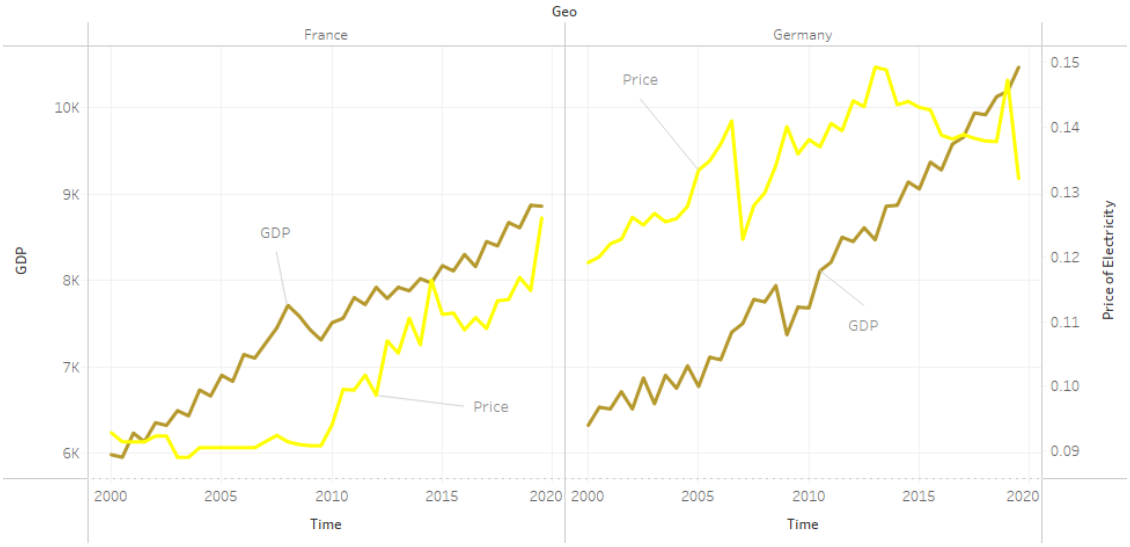

Figure 12: GDP per capita and Electricity Price over time for France and Germany.

Methodology & Results

Static Model

Dynamic Model

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