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Does the overweight epidemic cause energy consumption? A piece of empirical evidence from the European region

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Abstract: The effect of the overweight epidemic on energy consumption and environmental degradation was investigated for a panel of thirty-one countries from Europe from 1990 to 2016. The quantile via moments approach was used and revealed that the overweight epidemic increases the consumption of energy and carbon dioxide (CO2) emissions. It does this in two ways. First, overweight increases the consumption of processed foods from multinational food corporations, fast-food chains and multinational supermarket chains. This process impacts the multinational food corporations and farm production positively to attend to the demand for processed foods. This increase impacts the consumption of energy from non-renewable energy sources. Second, overweight reduces physical activities as well as outdoor activities, which increases the intensive use of home appliances and motorised transportation and consequently stimulates the consumption of energy and thus CO2 emissions rise.

Keywords: Energy consumption; Environmental degradation; European countries; Health; Overweight & Obesity; CO2 emissions.

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1. Introduction

This article explores the linkage from the overweight epidemic to energy consumption and carbon dioxide emissions. That connection is its infancy, laking the rock-solid foundations that allow second-generation research. In accordance, we have based the empirical research in economic principles to construct a model that provides an accurate explanation of why the overweight epidemic can impact energy consumption and carbon dioxide emissions.

Energy consumption and carbon dioxide (CO2) emissions, according to Bianco et al. [1], are the biggest concerns in Europe. Several targets and strategies have been adopted to reduce the consumption of non-renewable energy sources and by this means mitigate CO2 emissions.

The consumption of primary energy in the European region increased by 9.2%. Whereas in 1990 this consumption was 1,641 million tonnes of oil equivalent (Mtoe), in 2004 it was already 1,789 Mtoe. However, between 2005 to 2016, this consumption decreased by 10.8%, reaching 1,598 Mtoe in 2016 [2] (see **Figure 1**, below).

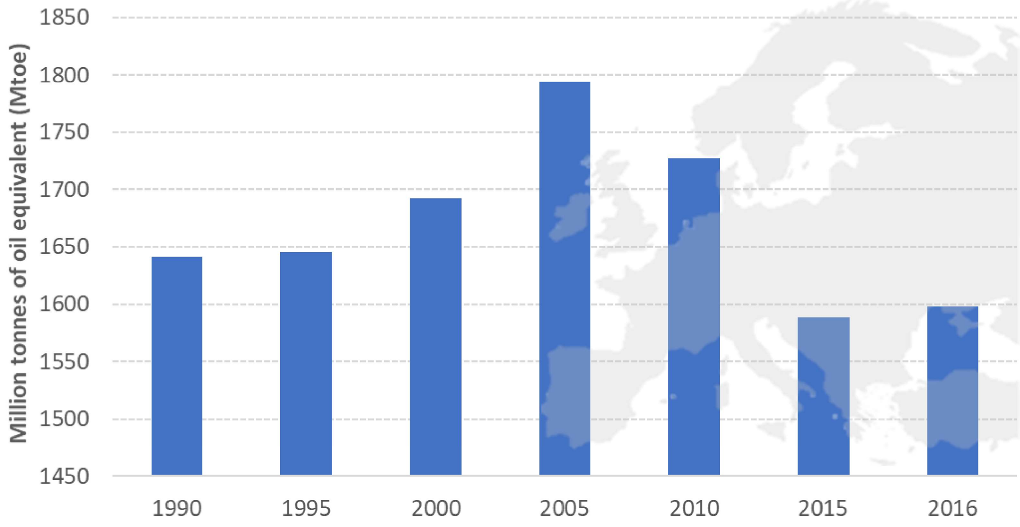

Figure 1. Consumption of primary energy in the European region between 1990-2016. The authors created this graph with the database from IEA [3].

The economic recession and energy efficiency improvements that increase the share of renewable energy sources in the energy matrix, as well as the change in climate conditions, were the causes for this decrease in the consumption of primary energy between 2005 to 2016 for most European region countries.

CO2 emissions in the European region followed the same trend of energy consumption. Indeed, between 1999 to 2006, these emissions remained relatively unchanged within the 28 European countries. From 2008 CO2 emissions started falling, but at a modest pace. Nevertheless, there is an exception. Emissions dropped sharply in 2009 due to the economic crisis that impacted industrial activity strongly and consequently, the fall in energy consumption. However, in 2015, these emissions experienced a slight increase when compared to 2014. Indeed, in 2017 they were down by 22% when compared with the levels of the year 1990. This decrease represents an absolute reduction of 1,240 million tonnes of CO2 -equivalents [2,4].

Several drivers have influenced the increase in energy consumption and consequently emissions of CO2 in the European region (e.g., economic growth, globalisation, trade, financial liberalisation, urbanisation, population growth, energy prices, and so on). Nevertheless, the literature has missed a possible connection between the increase in energy consumption, CO2 emissions and health, such as people's overweight (and obesity) problem. Overweight is a chronic disease and a significant risk factor for people with many other diseases. Indeed, it puts substantial pressure on individuals and health systems globally [5]. This chronic disease has increased substantially over the past three decades. In 2014, over 600 million adults or 13% of the total adult population were classified as overweight or obese worldwide. Of these 600 million overweight adults, 11% were men, and 15% were women [5]. In the European region, it looks no different. It is estimated that 51.6% of the total adult population (18 and over) can be classified as overweight. This disease has tripled since the late 1980s. In 1985, the share of adults that were overweight or obese was 44.5%, and in 2016 this value reached 58.2% (see **Figure 2,** below).

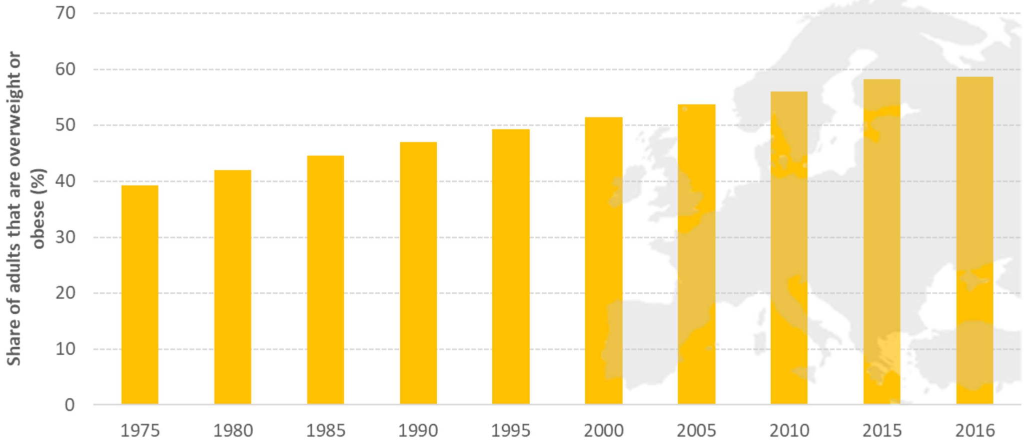

Figure 2. Share of adults that are overweight or obese (%) in Europe, from 1975 to 2016. Being overweight is defined as having a body mass index (BMI) greater than or equal to 25. Obesity is defined by a BMI greater than or equal to 30. BMI is a person's weight in kilograms divided by his or her height in metres squared. The authors created this graph with the database from Our World in Data [6].

This chronic disease is one of the world's largest health problems. It hits the richest countries, regardless of the income level of individuals [7]. This problem is caused by several factors, such as environmental, social, economic, genetic, physiological, and political factors that have interacted to varying degrees over time [8]. Alongside other factors, the urbanisation, lifestyles and globalisation process, as well as technological progress, have been promoting the development of overweight or obesity [9,10,11,38]. Indeed, the increase in weight caused by the above-mentioned factors contributes to making people less physically active. Consequently, they demand more energy from motor vehicles and modern household appliances. Indeed, as overweight and obese people use motor vehicles as a mode of transportation to move around and modern household appliances, this behaviour helps to reduce the physical effort that would otherwise be spent. It can be concluded that this behaviour of using motor vehicles and modern household appliances contributes to weight gain due to individuals' lower caloric expenditure.

We will focus the research on the impact of the overweight epidemic on the consumption of energy, and identify possible consequences for the environment. The link of the overweight epidemic to CO2 emissions will be assessed. The following research questions were formulated. **Can the overweight epidemic increase energy consumption in the European region? Can an overweight epidemic increase CO2 emissions and, consequently, have a negative impact on the environment?** A good starting point for an analysis of these phenomena is to choose a group of countries that have experienced fast, economical, social and environmental transformations but were similar enough to be handled as a panel. The thirty-one countries of the European region between 1990 to 2016 are well-positioned for this task. This group of countries shares common features like economic growth, consumption of energy, urbanisation, and a process of globalisation. Moreover, this group of countries has had a rapid increase in the overweight epidemic in the last thirty years. It is expected that the relationships between energy consumption and the overweight evolve in a nonlinear way. It is well known that when a human being becomes overweight, several physical habilities decrease more than proportionally. The quantiles econometric technique is well suited to capture this pattern between overweight and the explanatory variables. Therefore, to answer the research questions, a quantile via moments approach (**QvM**), that is a quantile regression for panel data (**QRPD**), developed by Machado and Silva [12], will be used as the methodological approach.

Therefore, this study is innovative for the literature as it assesses three crucial aspects: (i) the link between health, non-renewable energy consumption and the environment; (ii) a recent econometric technique; and (iii) a group of countries where the topics were less apprised. **First**, it examines the effect of the overweight epidemic on energy consumption and its consequences for CO2 emissions. This topic is not explored by the literature and opens a new line of investigation in the literature related to energy and health. **Second**, it uses quantile via moments as a methodology approach. This econometric technic is new and little explored by literature. **Finally**, it addresses the countries from the European region, bearing in mind that this region is not outlined in the literature in general regarding this topic of study.

Moreover, empirical research results also contribute to the literature for several additional reasons. It can help policymakers develop more initiatives to reduce the overweight epidemic and consequently, the consumption of energy and environmental degradation. New lines of investigation regarding the link between energy and health will be rooted in the empirical findings of this research and added to the literature.

This study is organised as follows. **Section 2** presents the data and the methodology approach. **Section 3** presents results and a brief discussion. **Section 4** presents the conclusions and policy implications.

2. Data and methodological approach

This section presents the data and methodological approach that will be used in this study. The annual data was collected from 1990 to 2016 for thirty-one countries from the European region (e.g., **Austria**, **Belgium**, **Bulgaria**, **Croatia**, **Czech Republic**, **Denmark,** **Estonia**, **Finland**, **France**, **Germany**, **Greece**, **Hungary**, **Iceland**, **Ireland**, **Italy**, **Latvia**, **Lithuania**, **Luxembourg**, **Malta**, the **Netherlands**, **Norway**, **Poland**, **Portugal**, **Republic of Cyprus**, **Romania**, **Slovakia**, **Slovenia**, **Spain**, **Sweden**, **Turkey**, and the **United Kingdom**). The time-series began in 1990 due to the data availability for the variable gross domestic product (GDP) per capita and purchasing power parity (PPP) (constant 2011 international $). Data were available for all countries from 1990 to 2016 at World Bank Data Open [13]. The variables which were chosen to perform this investigation are:

Table 1. Description of variables, source and summary statistics

Description of variables			Summary statistics				
Variable	**Definition**	**Source**	**Obs**	**Mean**	**Std Dev**	**Min**	**Max**
LogSAO	Share of adults that are overweight [(1)]	Our World in Data [6]	837	4.0223	0.0936	3.7447	4.2484
LogEPC_PC	Electric power consumption (kWh per capita)	World Bank Open Data [13]	837	8.6612	0.6543	6.8348	10.9573
LogGDP_PC	GDP per capita, PPP (constant 2011 international $)	World Bank Open Data [13]	837	10.1968	0.5097	8.3262	11.4913

Note(1): Being overweight is defined as having a body-mass index (BMI) greater than or equal to 25. BMI is a person's weight in kilograms divided by his or her height in metres squared.

LogUP	Urban population (% of the total population). This variable is a proxy of urbanisation.	World Bank Open Data [13]	837	4.2613	0.1729	3.8694	4.5841
LogCO2_PC	CO2 emissions (kg per capita 2011 PPP $ of GDP).	World Bank Open Data [13]	837	-1.3097	0.4425	-2.6267	0.2197
LogKOFEcGI	Economic globalisation index in de facto [2].	KOF Globalisation Index [14]	829	4.2589	0.1940	3.4512	4.5386
LogKOFSoGI	Social globalisation index in de facto [3]	KOF Globalisation Index [14]	829	4.3180	0.1617	3.6536	4.5246

Notes: The Stata command *sum* was used; "**Log**" denote variables in natural logarithms; Obs. denotes the number of observations in the model; Std.-Dev. denotes the Standard Deviation; Min. and Max. denote Minimum and Maximum, respectively.

All variables used in this study were transformed into natural logarithms. Moreover, the variables **LogEPC_PC**, **LogGDP_PC**, and **LogCO2_PC** were used in per capita values to control for the disparities between the variables in the model that result from population growth over time [15]. That is, the per capita values allow us to control for population growth over time and within countries [16]. The summary statistics of variables obtained with the Stata command *sum* indicate that the variables **LogSAO**, **LogEPC_PC**, **LogGDP_PC**, **LogUP**, and **LogCO2_PC** have 837 observations. However, the variables such as **LogKOFEcGI** and **LogKOFSoGI** have 829 observations each. This is due to the existence of zeros in data in the early 1990s in some countries of the European region (e.g., Czech Republic, Estonia, Slovakia, and Slovenia).

As mentioned before, this study will use the **QvM** model approach developed by Machado and Silva [12]. According to developers, this model is an alternative for quantile regression, as this approach allows the use of methods that are valid in the estimation of conditional means. That is, those with differencing out individual effects in panel data models. Also, Machado and Silva [12] add that this model can provide information on how the regressors affect the entire conditional distribution as well as the fact that it can be adapted to estimate in the presence of cross-sectional models with endogenous variables. That is, this method is not based on the

Notes[2]: This variable measures trade and financial globalisation. Trade globalisation is determined based on trade in goods and services, and financial globalisation includes foreign investment in various categories.
Notes[3]: This variable measures interpersonal contact flows of information and cultural proximity. Interpersonal contact is measured within the de facto segment concerning international telephone connections, tourist numbers, and migration. Flows of information are determined within the de facto segment concerning international patent applications, international students and trade in high-technology goods. Cultural proximity is measured in the de facto segment via trade in cultural goods, international trademark registrations and the number of McDonald's restaurants and IKEA stores.

estimation of conditional means, but on moment conditions that identify conditional means under exogeneity.

This model can identify the same structural quantile function. It enables this method to be used for non-linear models and is much more straightforward, especially in models with multiple endogenous variables [12]. Therefore, it was by these advantages that this study opted to use this model as the methodology approach. Therefore, the **QvM** model is constructed around the following **Equation (2.1)**:

$$Y_{it} = a_i + X'_{it}\beta + (\delta_i + Z'_{it}\gamma)U_{it}\ , \qquad \textbf{(2.1)}$$

where $\{(Y_{it}, X'_{it})'\}$ from a panel of n individuals i = 1,…, n over T time-periods with $P\{\delta_i + Z'_{it}\gamma > 0\} = 1$. Additionally, the parameters $(\alpha_1, \delta_i), i = 1, \dots, n$, capture the individual i fixed effects and Z is a k-vector of known differentiable (with probability 1) transformations of the components of X with element l given by $Z_l = Z_l(X),\quad l = 1, \dots, k$. The sequence $\{X_{it}\}$ is *i.i.d.* for any fixed i and independent across t. U_{it} are *i.i.d.* (across i and t), statistically independent of X_{it}, and normalised to satisfy the moment condition $E(U) = 0\ \wedge E(|U|) = 1$ [12].

Before the realisation of the **QvM** model, it is necessary to verify the proprieties of variables that will be used in this study. To this end, some **preliminary tests** will be applied such as **(a)** variance inflation factor (VIF) to check for the existence of multicollinearity between the variables [17]; **(b)** cross-section dependence (CSD) test to identify the presence of cross-sectional dependence (CSD) in the panel data [18]; **(c)** the panel unit root test (CIPS-test) [24] for the presence of unit roots; **(d)** the Westerlund cointegration test to identify the presence of cointegration between the non-stationary variables [19, 20]; and **(e)** the Hausman test to identify heterogeneity, i.e. whether the panel has random effects (RE) or fixed effects (FE).

After the model regression, it is also necessary to apply some **post-estimation test**s to identify if the model is adequate. To this end, the Wald test [21] to verify the global significance of the estimated models will be computed. The conceptual framework (**Figure 3,** in the **Appendix**), highlights the methodological approach that will be used in the **QvM** model approach. Furthermore, all estimations and testing procedures will be accomplished using **Stata 15.0**.

3. Results and discussion

This section will present the empirical results of preliminary tests, **QvM** model regression, and the post-estimation test and also a brief discussion of results. To identify the level of multicollinearity between the variables in the panel data, the VIF-test was computed. This test calculates the variance inflation factor of all variables that will be used in each model. The results of this test were obtained with the **Stata** command *estat vif*, and they indicate that the VIF-values from the **Model I** (that identify the effect of the overweight epidemic on the consumption of energy), and **Model II** (that identify the effect of the overweight epidemic on CO2 emissions) are low. At the same time, for the mean VIF, the values are lower than the usually accepted benchmark of 10 (see **Table 2**, in the **Appendix**).

After identifying the presence of low multicollinearity between the variables of each model, it is necessary to check the presence of cross-sectional dependence in the panel data. To do this, the CSD-test was computed. The null hypothesis of the CSD-test is the presence of cross-section independence CD~N(0,1). The results of this test obtained with the **Stata** command *xtcd*, indicate the null hypothesis is not rejected, thus indicating that all variables used in this study have the presence of cross-sectional dependence (see **Table 3**, in the **Appendix**). The presence of CSD in these variables may be an indication that the selected countries of this study share the same characteristics [22].

With variables that have long periods, it is crucial to verify the order of integration of the variables. For this, the panel unit root test (CIPS-test) was computed. The null hypothesis of this test is that all series have a unit root. The results of this test, obtained with the **Stata** command *multipurt*, show that some of the variables are on the borderline between the I(0) and I(1) orders of integration, such as **LogEPC_PC**, **LogCO2**, **LogKOFEcGI**, and **LogKOFSoGI**, while the variables **LogSAO**, **LogGDP_PC**, and **LogUP** are I(1) (see **Table 4**, in the **Appendix**). However, the non-stationarity of some variables (e.g., **LogSAO**, **LogGDP_PC**, and **LogUP**) is an indication of potential "spurious correlation" [16] among them. In the presence of this phenomenon, it is recommended to compute the Westerlund cointegration test, to verify the cointegration between the variables which are not stationary (this test requires that all variables be I(1), and their null hypothesis is non-cointegration). The results of this test, obtained with the **Stata** command *xtwest*, show that the null hypothesis of Westerlund cointegration test cannot be rejected. That is, this test indicates the presence of non-cointegration in the variables which are I(1) (see **Table 5**, in the **Appendix**).

After identifying the non-presence of cointegration in the non-stationary variables, it is necessary to identify whether individual effects are present in the panels. The Hausman test was performed to this end. This test will compare the random effects estimator (RE) with fixed effects (FE). The null hypothesis of this test is that the difference in coefficients is not systematic, where the random effects are the most sustainable estimator [15]. However, the **QvM** model approach requires the model to have fixed effects, as mentioned in the section before. Therefore, the results of the Hausman test, obtained with the **Stata** command *hausman*, indicate that the null hypothesis of this test should be rejected in both models, as the results of this test are statistically significant at the 1% level (see **Table 5**, in the **Appendix**). Thus, the fixed effects estimator is the most appropriate for the accomplishment of this analysis.

The next step after the realisation of preliminary tests is to carry out the **QvM** model regression. The **25th**, **50th**, and **75th** quantiles were respectively calculated to assess non-linearities of the impact of the overweight epidemic on the consumption of energy, as mentioned before. Indeed, these quantiles were utilised in order to simplify the exhibition of results. Moreover, in the previous analyses, several quantiles were utilised, and we realise that does not have lost of information, where all independent variables pointed to the same effect on the dependent variable. This model does not allow us to perform causalities between the variables; it only allows the effect in the quantiles to be observed. **Table 6** shows the results of the **QvM** model regression.

Table 6. Estimations for the consumption of energy

Independent variables	Model I (Dependent variable LogEPC_PC)		
	Quantiles		
	25th	50th	75th
LogSAO	0.7129***	0.9196***	1.1352***
LogGDP_PC	0.2759***	0.1547***	0.5138
LogUP	0.7283***	0.6233***	0.0283
Obs	837	837	837
F / Wald test	Chi2(3) = 361.69 ***	Chi2(3) = 456.79***	Chi2(3) = 171.53***

Notes: The Stata command *xtqreg* was used; *** denotes statistically significant at the 1% level; "**Log**" denotes variables in natural logarithms. The Stata command *testparm* was used to perform the Wald test.

The results of **QvM** model regression obtained with the **Stata** command *xtqreg* indicate that in the **25th**, **50th** and **75th** quantiles the overweight epidemic encourages the consumption of energy in the European region. The **25th** and **50th** quantiles also indicate that economic growth and urbanisation processes increase the consumption of energy. Most of the results of this estimation are statistically significant at the 1% level. Additionally, the Wald test that verifies the global significance of the estimated model was computed after the estimation of each quantile. The null hypothesis of the Wald test is that all the coefficients are equal to zero. The result from the post-estimation test indicates that the null hypothesis cannot be rejected, indicating that the estimator of this study is adequate. It should be recalled that the results of the Wald test were obtained with the **Stata** command *testparm*.

The results of **QvM** model for the consumption of energy also reveal that we are in the presence of a **non-linear** phenomenon. This non-linearity can be seen on looking for the values of the estimated coefficients that change as we go up (or down) in the quantiles' regression. We found a behaviour that deserves to be analysed. As we go up in the quantiles, overweight sharply increases pace as it contributes to the consumption of energy. In other words, for situations where the consumption of energy is high, an increase in overweight leads to an increase in energy consumption that is more expressive than where energy consumption is low. For both economic growth and urbanisation, the 75th quantile was revealed to be statistically non-significant. These two variables also showed that their contribution to energy consumption declines as we go up from the 25th quantile to the 50th. Moreover, the results from the Model I showed to be robust same in the presence of shocks in the model.

Therefore, if the overweight epidemic increases the consumption of energy, then we can formulate the following research question. **Does an overweight epidemic increase CO2 emissions and consequently impact the environment adversely?** This study carries out another **QvM** model regression to identify the possible effect of the overweight epidemic on CO2 emissions to answer this question. **Table 7** shows the results of the **QvM** model regression.

Table 7. Estimations for CO2 emissions

Independent variables	Model II (Dependent variable LogCO2_PC)		
	Quantiles		
	25th	50th	75th
LogSAO	1.5972***	1.4482***	1.3409***
LogEPC_PC	0.2145***	0.2591***	0.2912***
LogGDP_PC	-0.4877***	-0.5356***	-0.5701***
LogUP	0.5218*	0.4875**	0.4628**
Trend	-0.0388***	-0.0366***	-0.0351***
Obs	837	837	837
F / Wald test	Chi2(4) = 150.67 ***	Chi2(4) = 401.66***	Chi2(4) = 325.10***

Notes: The Stata command *xtqreg* was used; *** denotes statistically significant at the 1% level; "**Log**" denotes variables in natural logarithms. To perform the Wald test, the Stata command *testparm* was used.

The results of the **QvM** model regression indicate that in the **25th**, **50th** and **75th** quantiles, the overweight epidemic increases CO2 emissions. Moreover, the consumption of energy and urbanisation process has the same effect. Indeed, they encourage environmental degradation by increasing emissions of CO2. However, economic growth decreases emissions of CO2 in the European region. Consequently, the results of the **QvM** model regression answer the question regarding the effect of the overweight epidemic on CO2 emissions. The Wald test verifies the global significance of the estimated model, indicating that the estimator of this study is adequate.

The results of the **QvM** model estimation for CO2 emissions also reveals that we are in the presence of **non-linear** behaviour. Indeed, the values of the estimated coefficients vary as we go up (or down) in the quantiles' regression. As we go up the quantiles, the overweight epidemic decreases the pace at which it contributes to the deterioration of the environment. An identical pattern was found for the urbanisation process, but it is statistically significant at the 5% level, and only for the quantiles **50th** and **75th** nevertheless. By other words, when the environment degradation intensifies, the contribution of urbanisation to this deterioration falls. Regarding the consumption of energy as we go up the quantiles, their contribution to the deterioration of the environment increases its pace. Conversely, as we go up the quantiles, economic growth contributes more and more to improving environment quality. Finally, a word about the trend in our analysis. As we go up the quantiles, the tendency is for its contribution to improving the quality of the environment to decrease, although at a very slight pace. Moreover, the results from the Model II showed to be robust same in the presence of shocks in the model.

After identifying that the overweight epidemic in European region increases the consumption of energy and the environmental degradation by emissions of CO2, the question remains: **What are the explanations for these phenomena**? The possible explanation for these phenomena under analysis is complex. There are several drivers behind that. Therefore, before pointing out a possible explanation for the positive effect of overweight on the consumption of energy and CO2 emissions, in order to understand this phenomenon it is necessary to identify drivers that can cause the overweight epidemic. Several drivers, such as economic growth, urbanisation and globalisation, have been identified as causing this epidemic problem and consequently, the consumption of energy and emissions of CO_2.

Economic growth has been related to an increase in the levels of non-communicable diseases across the world. Among them, overweight and obesity have gained prominence. The development caused by economic growth has effects on dietary changes. According to Gerbens-Leenes et al. [23], and Roskam et al. [24], socio-economic groups experience the process of income transition from lower to high income caused by economic development and tend to consume fatty foods and energy-dense animal food sources. Consequently, income contributes to increasing overweight and obesity levels, except for countries where the home production of food is prevalent. Butzlaff [25] and Monteiro et al. [26] add that in developed countries, the upper-middle-income group have high levels of overweight and obesity. Conversely, for high-income groups, the overweight and obesity levels are lower, due to the preference shift towards healthier foods and by the financial capacity to buy them. Thus, according to nutrition transition theory, the initial income increase allows the intake of food with higher energy-caloric, which contributes to a rise in overweight and obesity.

Furthermore, Costa-Font and Mas [27] further added that lower economic inequality caused by higher economic development also impacts overweight and obesity rates. In countries with high economic growth but low income, food insecurity underscores the risk of overweight and obesity, due to food consumption in the stage following higher income. According to Sullivan et al. [28], nutritional deficits are followed by an excess of caloric consumption. Therefore, economic growth is associated with overweight and obesity, both with its contemporaneous and future effects on food consumption.

The process of globalisation has also encouraged changes in almost all aspects of humankind's behaviour ranging from cultural to social and economic issues. The process of globalisation has several dimensions such as economic, social and political, which have evolved at different speeds. Economic and social globalisation has made a substantial contribution to the progressive path for overweight and obesity. According to Fox et al. [9] and Popkin [11], one of the main features of economic globalisation is precisely the change in food systems that it provokes. The food chain extension, caused by economic globalisation, enables economies of scale in food production processes. These processes enabled a diet rich in energy-caloric foods, with high contents of sugar and salt. Indeed, this kind of food is less expensive and thus more accessible to lower-income classes. Globalisation also offers a ready supply of processed foods by multinational food corporations, fast-food chains and multinational supermarket chains. Moreover, according to the same authors, globalisation has a complementary effect on the demand side of food systems. The socio-economic dimension of globalisation has increased people's time constraints and consequently reduced the consumption of homemade food. As a side effect, it increases the consumption of processed food from multinational food corporations, fast-food chains and multinational supermarket chains.

Furthermore, economic globalisation also impacts on people's energy-caloric expenditure. This impact occurs due to the penetration of new technologies made available by the increase in trade and economic liberalisation. These new technologies reduce people's need for physical activity. Indeed, innovations in technology have evolved along a path that allows labour-saving behaviours in industrial sectors and the home appliances have become more accessible as well as the use of motorised transportation [29,30]. Social globalisation promotes the use of individual transportation, communication, and other activity-sparing systems [30].

Social globalisation also impacts how the food is distributed, marketed and consumed. Thus, the process of social globalisation encourages extensive exposure to global eating practices or Westernisation of food consumption. A clear example of Westernisation of food consumption is McDonaldisation or Cocalisation that encourages the consumption of food with higher energy-caloric content, contributing to an increase in overweight and obesity [9,23]. In short, the overweight and obesity epidemic is stimulated by both economic and social globalisation, via economic growth that facilitates the process of nutrition transition.

The process of urbanisation also participates in the increase in the overweight and obesity epidemic. The energy-caloric food expended as the process of urbanisation has been moving side by side with economic development and globalisation, and that consequently affects food production, access and consumption. According to Reardon et al. [31], the process of urbanisation allows better food accessibility due to the presence of supermarkets, fast-food chains, multinational supermarkets offering a ready supply of processed foods, the decline of farm stands, and open markets with healthier foods. Urban areas lead to the exposure of people to mass media marketing of food and beverages that can influence a change in traditional diets [32].

Moreover, Kjellstrom et al. [33], and Lindstrom [34] add that urban areas require less energy-caloric expenditure related to commuting and leisure activities. Thus, more travelling by car and less walking or biking for transportation or leisure contribute to overweight and obesity. Pirgon and Aslan [35] and Brug et al. [36] point out that neighbourhoods that are densely populated require less energy-caloric expenditure due to the limited recreational space for outdoor activities, and more leisure time spent on sitting and screen-viewing leisure activities.

According to Fox et al. [9], Kjellstrom et al. [33] and Bell et al. [37], the process of urbanisation is also related to a higher proportion of manufacturing and service sector jobs. This higher proportion translates into less energy-calories expended on daily work activities for individuals, and consequently leads to fewer active jobs, such as farming. Therefore, the urbanisation process can be seen as a critical driver of overweight and obesity trends.

Moreover, these explanations also help to understand the effects of other variables in **models I** and **II**. Indeed, to confirm these explanations about the positive effect of economic growth, globalisation (e.g., economic and social) and urbanisation on the overweight epidemic, a complementary analysis was made. The results of preliminary tests of this model indicate the presence of low-multicollinearity and the presence of fixed-effects (see **Tables 2** and **6** in the **Appendix**). **Table 8** shows the results of the **QvM** model regression.

Table 8. Estimations for overweight epidemic

Independent variables	Model III (Dependent variable LogSAO)		
	Quantiles		
	25^{th}	50^{th}	75^{th}
LogGDP_PC	0.1089***	0.0943***	0.0750***
LogUP	1.0727***	1.0652***	1.0553***
LogKOFEcGI	0.1314***	0.1033***	0.0661*
LogKOFSoGI	0.1308***	0.1790***	0.2429***
Obs	829	829	829
F / Wald test	Chi2(4) = 2936.60 ***	Chi2(4) = 3206.06***	Chi2(4) = 1011.50***

Notes: The Stata command *xtqreg* was used; *** and * denote statistically significant at the 1% and 10% levels; "**Log**" denotes variables in natural logarithms. The Stata command *testparm* was used to perform the Wald test.

The results of the **QvM** model estimation for the overweight epidemic confirms the explanations regarding the positive effect of economic growth, economic and social globalisation and urbanisation on the overweight epidemic, specifically for the European region. Additionally, the Wald test validates the global statistical significance of the estimated model, indicating that the estimator of this study is adequate to perform the analysis.

The results of the **QvM** model estimation for the overweight epidemic reveals that we are in the presence of **non-linear** behaviour. As we go up the quantiles, economic growth decreases the pace at which it contributes to the overweight epidemic. An identical pattern was found for the process of urbanisation and economic globalisation. However, it should be noted that for economic globalisation, the 75^{th} quantile only is statistically significant at the 10% level. Conversely, the social globalisation strongly intensifies its pace as it contributes to the overweight epidemic as we go up the quantiles. Moreover, the results from the Model III showed to be robust same in the presence of shocks in the model.

Therefore, the overweight epidemic encourages the consumption of energy via an increase in the consumption of processed foods from multinational food corporations, fast-food chains and multinational supermarket chains, and as well food production in farms. This will impact the multinational food corporations and farm production positively to attend the demand for processed foods. This increase will impact the consumption of energy from non-renewable energy sources. Another possible explanation for these phenomena is related to the capacity of overweight to reduce physical activities as well outdoor activities, thus increasing the intensive use of home appliances and motorised transportation, as well as screen-viewing leisure activities. All this has a positive effect on the consumption of energy and consequently on the environment with the increase in CO2 emissions. **Figure 4** summarises the possible explanation of these phenomena based on the literature above.

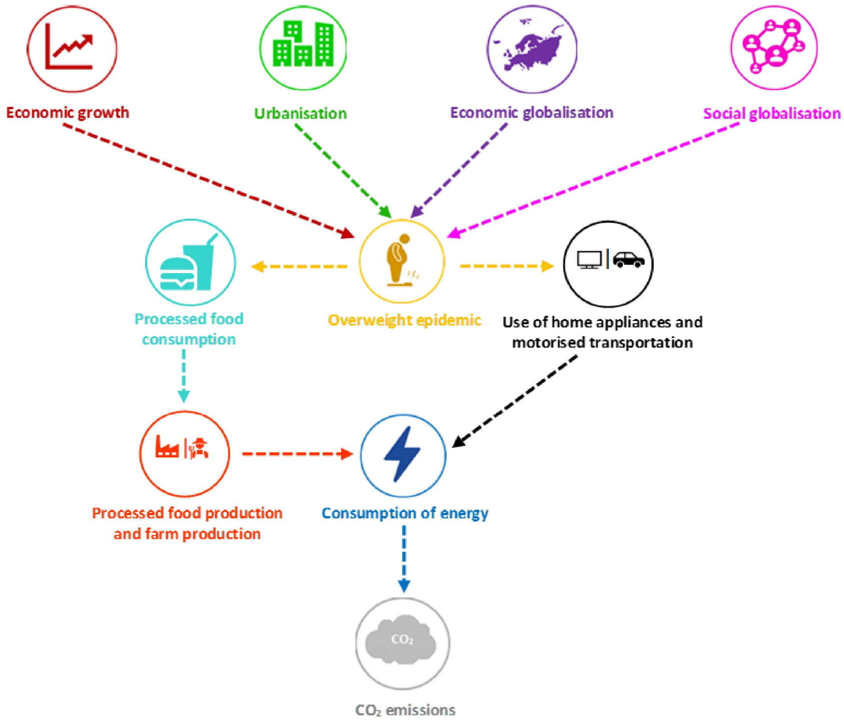

Figure 4. Summary of a possible explanation of these phenomena. Figure created by the authors.

Moreover, **Figure 5** in the **Appendix** evidences the possible relationship between the variables based on the results from **models I**, **II**, and **II**. It should be remembered that the main objective of this study is to identify the effect of the overweight epidemic on the consumption of energy and the consequences for the environment. The study used CO2 emissions to reach the objective. For this reason, in this study we opted not to carry out a causality check between the variables, although theoretical support exist for a causal relationship between them as some literature stresses.

4. Conclusions and policy implications

As we already know, this study investigated the effect of the overweight epidemic on the consumption of energy as well as on environmental degradation (CO2 emissions) in a panel of thirty-one European countries for the period from 1990 to 2016. The **QvM** model was used in this study to realise the respective investigation, and the methodology choice proved adequate for this kind of study. Indeed, this is possible only due to the research objectives of this study. We opted to use an unusual structure and approach (e.g., availability of Stata commands and didactic figures) to simplify the investigation and understanding for readers, as well as the replication of this study in another group of countries and a different context, and also to be more instructive.

The results of preliminary tests indicated the presence of a low multicollinearity level in the models, cross-sectional dependence in the variables that were used, stationarity in some variables, non-cointegration in the non-stationary variables, and fixed effects in all models.

Moreover, the regression models pointed out to be robust same in the presence o shocks in the models.These results were shown to be promising and adequate to advance with the **QvM** model regression to answer the research questions of this study. The **QvM** model regression indicated that the overweight epidemic increases the consumption of energy and CO2 emissions. That is, these results obtained the models **I** and **II** can answer the research questions that arose in this study. The main research question of this study is as follows: **What are the possible explanations regarding the positive effect of the overweight epidemic on the consumption of energy and CO2 emissions**? The overweight epidemic increases the consumption of energy and CO2 emissions in two ways. First, the increase in overweight results from the consumption of processed foods from multinational food corporations, fast-food chains and multinational supermarket chains. This will contribute to multinational food corporations and farms increasing their production to attend demand for processed foods. In parallel, this increase will impact the consumption of energy from non-renewable energy sources. Second, overweight reduces physical activities as well outdoor activities and increases the intensive use of home appliances and motorised transportation. Thus, the consumption of energy increases, as do CO2 emissions. This empirical evidence leads to a supplemental research question. **What can be done to reverse the positive impact of the overweight epidemic on the consumption of energy and CO2 emissions in the European region**?

To reverse this problem, policymakers in the European region need to restrict the sale of processed food with a high content of sugar and fat close to schools and hospitals, as well as restricting access to unhealthy food through taxation. Furthermore, policymakers should launch public health campaigns that are backed by the media, as already occurs with tobacco consumption. An overhaul of the regulatory system that allows industry-sponsorships in these sectors is also advised to revert their huge influence on markets and mindsets.

Lawmakers and governments in the European region should encourage teachers in schools to emphasise the need to practise physical activity, and the importance of a healthy and balanced diet, instead of banning products and restricting choices. Furthermore, they need to support more self-regulatory industry initiatives in reducing sugar and calorie intake. These actions can deliver quick results, particularly in schools, as well as remove the regulatory hurdles that limit improvements such as the stipulation that sweeteners can only be used in processed foods that contain less than 30% calories. The influence of corporate lobby groups from multinational food corporations on the European region needs to be reduced by lawmakers and governments in order to put health first. They need to encourage food sector to produce and deliver foods that are enjoyable, affordable, nutrient-rich and have the least possible impact on the environment.

All these policy implications need to be based on three spheres. First, the social determinants of health that include employment, education and housing. Second, the environmental determinants of health, such as air pollution. Third, the commercial determinants of health, such as lifestyle diseases.Therefore, all these policy recommendations will reduce the problem of the overweight epidemic in the European region and consequently, the consumption of energy and CO2 emissions.

However, this problem is not limited to reducing the overweight problem. It is also necessary to change the way of producing and consuming energy. Although the European region has several initiatives to reduce the consumption of fossil fuels, for example with the introduction of renewable energy and CO2 emissions targets, which have indeed produced satisfactory results, it is necessary to do much, much more.

Policymakers need to encourage the development of more renewable energy policies to increase the production and consumption of this kind of energy source, as well as technological development. It is necessary to develop mechanisms to reduce the tariff barriers on products and technologies that improve energy efficiency and that produce green energy. This could reduce the prices of these products and technologies for households and industries or firms (mainly the big processed food producers and farms) and facilitate their acquisition. Indeed, the increase in energy efficiency (in systems related to transport, production sectors, infrastructure, and buildings) needs to be a priority for European governments and cannot be put aside. Therefore, all these policy recommendations will accelerate the process of the energy transition and contribute to reducing CO2 emissions.

This study will contribute to the literature and to policymakers and governments, in that it will help to develop more initiatives to reduce the overweight epidemic in the European region and accelerate the process of the energy transition to reduce the consumption of fossil fuels, and consequently, CO2 emissions. Finally, the empirical findings of this study will open a new topic of investigation in the literature about the relationship between energy consumption, environmental degradation, and obesity.

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Appendix

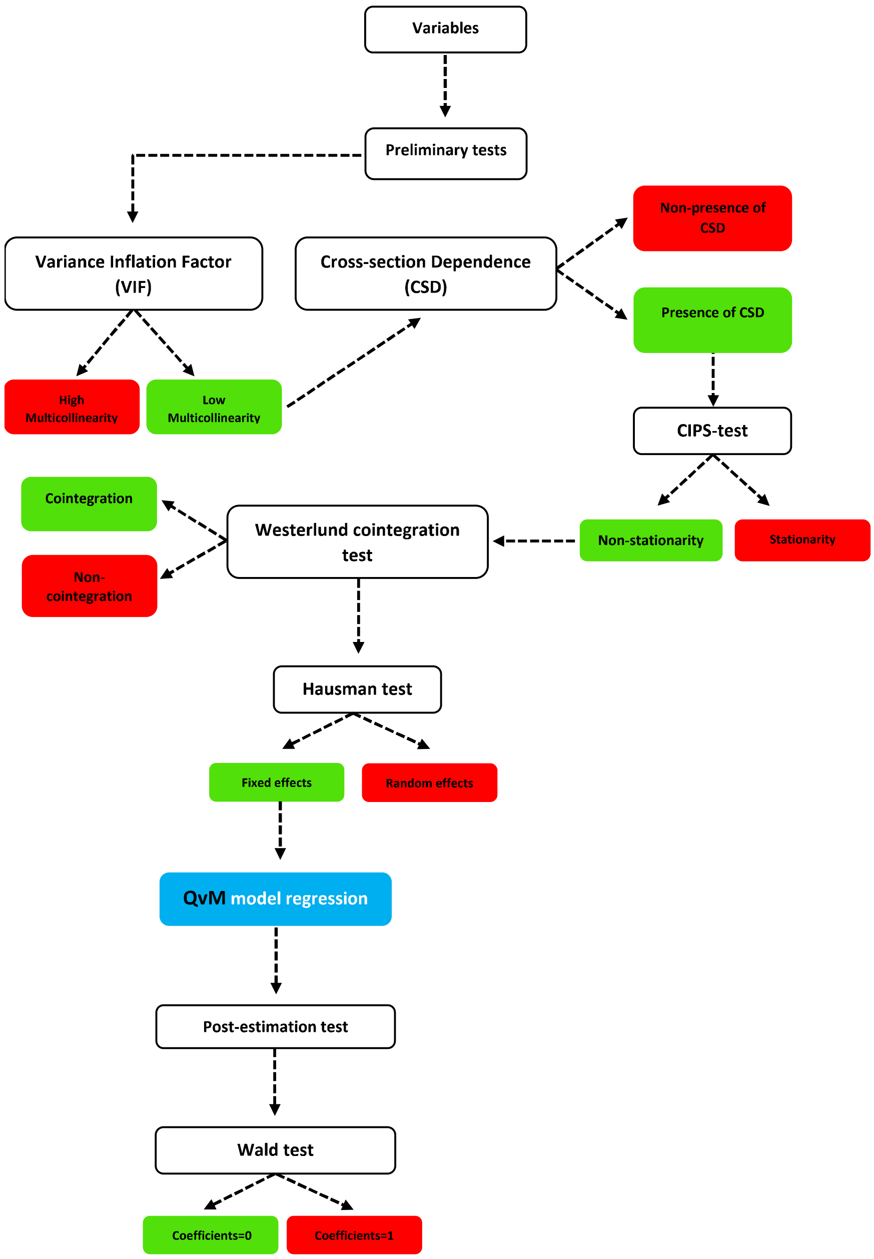

Figure 3. The conceptual framework.

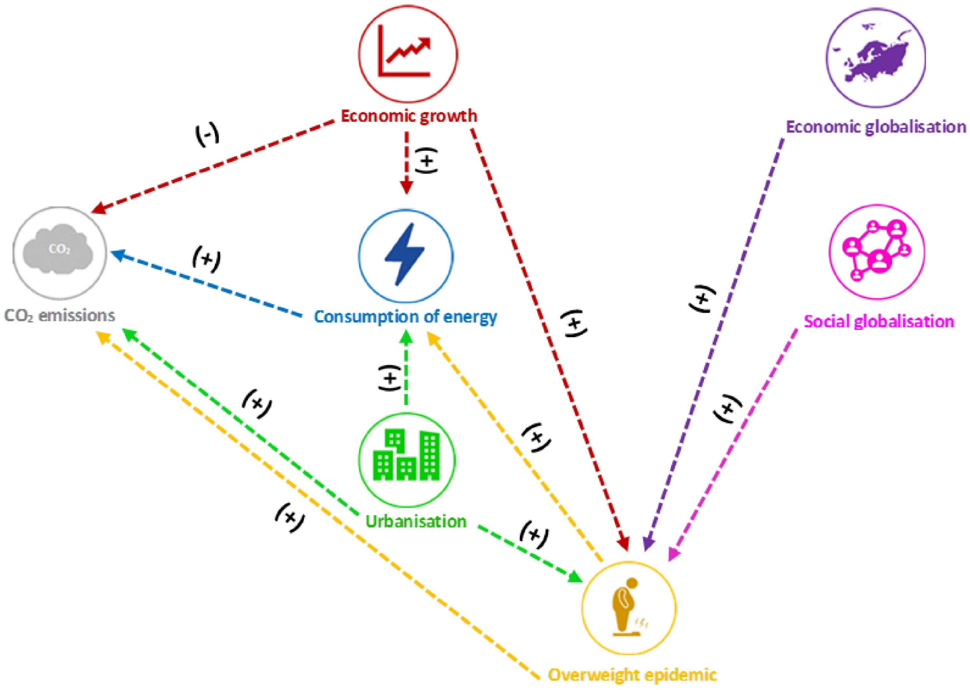

Figure 5. The relationship between the variables. This figure was created by the authors.

Table 2. VIF-test

Variables	VIF	1/VIF
Model I (Dependent variable LogEPC_PC)		
Variables	**VIF**	**1/VIF**
LogSAO	**1.15 < 10**	0.8706
LogGDP_PC	**1.31 < 10**	0.7639
LogUP	**1.44 < 10**	0.6955
Mean VIF	**1.30 < 6**	
Model II (Dependent variable LogCO2_PC)		
LogSAO	**1.21 < 10**	0.8279
LogEPC_PC	**2.46 < 10**	0.4063
LogGDP_PC	**2.17 < 10**	0.4600
LogUP	**1.70 < 10**	0.5892
Mean VIF	**1.88 < 6**	
Model III (Dependent variable LogSAO)		
LogEPC_PC	**2.61 < 10**	0.3824
LogGDP_PC	**3.78 < 10**	0.2648
LogUP	**1.54 < 10**	0.6488
LogKOFEcGI	**3.15 < 10**	0.3169
LogKOFSoGI	**5.07 < 10**	0.1971
Mean VIF	**3.23 < 6**	

Notes: The Stata command *estat vif* was used. "Log" denotes variables in natural logarithms.

Table 3. Pesaran CD-test

Variables	CD-test	p-value	Corr	Abs (corr)
LogSAO	111.29	0.000 ***	0.993	0.993
LogEPC_PC	59.11	0.000 ***	0.528	0.631
LogGDP_PC	102.00	0.000 ***	0.910	0.910
LogUP	25.51	0.000 ***	0.228	0.821
LogCO2	92.89	0.000 ***	0.837	0.848
LogKOFEcGI	95.79	0.000 ***	0.863	0.863
LogKOFSoGI	106.75	0.000 ***	0.962	0.962

Notes: The Stata command *xtcd* was used; "Log" denotes variables in natural logarithms; *** denotes statistical significance at the 1% level.

Table 4. Panel Unit Root test (CIPS-test)

Variables	Panel Unit Root test (CIPS) (Zt-bar)		
	Without trend		With trend
	Lags	Zt-bar	Zt-bar
LogSAO	1	2.233	1.215
LogEPC_PC	1	-9.274 ***	-7.240 ***
LogGDP_PC	1	-1.209	0.292
LogUP	1	0.006	0.838
LogCO2	1	-4.523 ***	-1.016
LogKOFEcGI	1	-2.264 **	0.550
LogKOFSoGI	1	-6.887 ***	-4.001 ***

Notes: The Stata command *multipurt* was used; The null for CIPS test is: series have unit root; the lag length (1) and trend were used in this test; *** and ** denotes statistically significant at the 1% and 5% levels; "Log" denote variables in natural logarithms.

Table 5. Westerlund cointegration test

Statistics	Value	Z-value	P-value	P-value robust
Gt	-1.588	6.230	1.000	0.990
Ga	-4.597	6.862	1.000	1.000
Pt	-6.562	6.845	1.000	1.000
Pa	-4.710	4.759	1.000	0.970

Notes: The Stata command *xtwest* (with the constant and trend option) were used. Bootstrapping regression with 100 reps; H_0: No cointegration; H_1 Gt and Ga test the cointegration for each country individually, and Pt and Pa test the cointegration of the panel.

Table 6. Hausman test

Variables	(b) Fixed	(B) Random	(b-B) Difference	Sqrt(diag(V_b-V-B)) S.E.
Model I (Dependent variable LogEP_PC)				
LogSAO	0.9189	0.7553	0.1635	0.0410
LogGDP_PC	0.1551	0.1954	-0.0402	0.0089
LogUP	0.6236	0.8813	-0.2576	0.0822
Chi2 (3)	**24.84***			
Model II (Dependent variable LogCO2_PC)				
LogSAO	-2.0672	-1.8225	-0.2447	0.0603
LogEPC_PC	0.2867	0.2523	0.0344	0.0119
LogGDP_PC	-0.6921	-0.7288	0.0366	0.0108
LogUP	1.7015	1.2855	0.4159	0.1060
Chi2 (4)	**21.82***			
Model III (Dependent variable LogSAO)				
LogEPC_PC	0.0631	0.0118	0.0513	0.0050
LogGDP_PC	0.0776	0.0104	0.0672	0.0041
LogUP	0.9648	0.4700	0.4947	0.0308
LogKOFEcGI	0.0880	0.0598	0.0281	0.0047
LogKOFSoGI	0.1779	0.4111	-0.2332	0.0116
Chi2 (5)	**597.55***			

Notes: The Stata command *hausman* (with the options, sigmamore) was used; *** denotes statistically significant at the 1% level; "Log" denote variables in natural logarithms.

Response to Editor

Dear Professor Isabel Soares
Subject Editor
Energy

We would like to thank you for the opportunity to revise the manuscript once more. We tried to incorporate the reviewer's suggestions and preserve what had already been evaluated by prior reviewers. In our opinion, the manuscript has been improved and could be now achieved maturity.

Yours sincerely,
Matheus Koengkan
José Alberto Fuinhas

Response to Reviewer #1

Dear Professor,

We would like to thank you for your careful reading of the paper as well as for your useful and valuable comments and suggestions. We believe that your comments motivated us to improve the quality of our paper. The following are the responses to your queries/comments.

Yours sincerely,

Reviewer comment (R.C.): *A major shortcoming of this paper is that the authors do not provide a theory to explain why the overweight epidemic should affect energy consumption or even carbon dioxide emissions. How does the overweight epidemic translate into an action that affects energy use? These are some questions that need to be addressed in order for the reader to understand why the authors are examining this question and why they should care. The paper reads very much like an exploratory data analysis rather than a well-motivated research paper. For me, this is a major limitation of the paper.*

Reply: We disagree. There are several levels at which applied research materialises. The relationship between excess weight and energy consumption is in the first stages of investigation and as such, at this stage, is recommended by good practices that we begin by verifying what is commonly called, in researcher slang, the anecdotal evidence. This does not mean that the paper is not well-motivated research. Indeed, some authors (Wang et al., 2020) are working in the relationship between energy consumption and overweight. The manuscript was upgraded, clarifying the readers about this point.

(R.C): *In the Introduction, you need to connect the state of the art to your paper goals. Please follow the literature review by a clear and concise state of the art analysis. This should clearly show the knowledge gaps identified and link them to your paper goals. Please reason both the novelty and the relevance of your paper goals.*

Reply: Thank you for the useful guidance. The Introduction section was improved following your advice.

(R.C.) *In addition, the literature review is far from complete. The author(s) need to carefully identify the limitations of prior work, and explain how your study addresses these limitations. Therefore, delve into how they did it, what they find, and what they missed. Otherwise, you are merely replicating their work, which adds no real value as far as our understanding is concerned.*

Reply: Thank you for the remarks. The literature supporting the manuscript was upgraded.

(R.C.): *The paper lacks clear theoretical foundations and consequently the empirical test is not formulated in the context of existing theories. The authors would benefit from a tighter link to the theoretical literature on the subject.*

Reply: Thank you so much for your comment. Unfurtenelly, our investigation could not benefit from theoretical literature that approaches this topic by the simple reason that this does not exist. Indeed, we were severely constrained by the unavailability of structured theory on the theme. We had only some usable pieces of the puzzle from other papers that have researched, for example, the links between economics and health, globalisation, urbanisation, and environmental degradation. Moreover, were just these established relationships that were used in our investigation to support the empirical results found.

(R.C.): *The model is quite technical and does not explain the reason of why should we care about the nonlinear properties of the relationship between the overweight epidemic, energy consumption, and environmental degradation.*

Reply: Thank you for the insight. The manuscript now includes a concise explanation of the reasoning of the use of nonlinearities.

(R.C.): *Although authors argue that the quantile via moments (QvM) approach has some advantages as compared to previously used methods, why it is particularly suitable and appropriate for your research should be at least explained. The lack of definition and justification for this method gives the investigation the appearance of a technical exercise.*

Reply: Thank you so much for your comment. We disagree with your comment, as mentioned before, this is conceptual, empirical research, that is, this investigation was not explored before, as well as is the first time that this methodology is used for this kind of investigation. Therefore, this study is a kick-off for other investigations that approach this topic and methodology that are coming, as well as will help develop new theoretical literature on the subject.

(R.C.): *Further problems, such as unaccounted variables that affect energy consumption and carbon dioxide emissions and simultaneously affect the overweight epidemic or are* *themselves affected by the overweight epidemic, may obfuscate the measurement of the direct effect and need to be discussed.*

Reply: Thank you for the remark. Now, this point was clarified in the paper, and its discussion was deepened.

(R.C.): *In section 2, why these specific variables are being taken? There should be a citation for the variables being used.*

Reply: Thank you so much for your comment. However, it does not exist a conceptual framework, which indicates (or suggests) the variables that should be used in our investigation. We based our approach in the literature that links causal relationships between economics and health, globalisation, urbanisation, and environmental degradation. This literature was cited in the manuscript, allowing us to justify the effect of overweigh pandemic on the consumption of energy. Please, note that our investigation is empirical and does not exist similar research where we can confront/confirm our results. Moreover, the results found have economic soundness and was in accordance with the scarce literature available.

(R.C.): *In section 3, the authors only report the estimated results of the 25th, 50th, and 75th quantiles and this implies many missed opportunities for this paper. We do not know what happens for other conditional quantiles.*

Reply: Thank you so much for your comment. We opted to show the estimates of the 25^{th}, 50^{th}, and 75^{th} of the QvM model in order to keep the exhibition of results simple. During model estimation, several quantiles were utilised, and we realise that no important information was lost. All estimated coefficients of independent variables pointed to the same effect on the dependent variable (see the results below). That is, the inclusion of new quantiles does not add anything to the investigation.

Table 1. Estimations for the consumption of energy

Independent variables	**Model I (Dependent variable LogEPC_PC)**		
	Quantiles		
	10^{th}	**100^{th}**	**125^{th}**
LogSAO	0.5636**	0.5636**	0.5915**
LogGDP_PC	0.3635***	0.3635***	0.3471***
LogUP	0.8041**	0.8041**	0.7899**
Obs	837	837	837
F / Wald test	Chi2(3) = 205.31 ***	Chi2(3) = 205.31***	Chi2(3) = 227.88***

Notes: The Stata command *xtqreg* was used; *** denotes statistically significant at the 1% level; "**Log**" denotes variables in natural logarithms. The Stata command *testparm* was used to perform the Wald test.

Table 2. Estimations for CO2 emissions

Independent variables	Model II (Dependent variable LogCO2_PC)		
	Quantiles		
	10th	**100th**	**125th**
LogSAO	1.7364**	1.7364**	1.7110**
LogEPC_PC	0.1730*	0.1730*	0.1806**
LogGDP_PC	-0.4430***	-0.4430***	-0.4511***
LogUP	0.5537	0.5537	0.5479
Trend	-0.0408***	-0.0408***	-0.0404***
Obs	837	837	837
F / Wald test	Chi2(4) = 60.83 ***	Chi2(4) = 60.83***	Chi2(4) = 70.47***

Notes: The Stata command *xtqreg* was used; *** denotes statistically significant at the 1% level; "**Log**" denotes variables in natural logarithms. The Stata command *testparm* was used to perform the Wald test.

Table 3. Estimations for overweight epidemic

Independent variables	Model III (Dependent variable LogSAO)		
	Quantiles		
	10th	**100th**	**125th**
LogGDP_PC	0.1188***	0.1188***	0.1171***
LogUP	1.0777***	1.0777***	1.0769***
LogKOFEcGI	0.1504***	0.1504***	0.1471***
LogKOFSoGI	0.0981*	0.0981*	0.1038**
Obs	829	829	829
F / Wald test	Chi2(4) = 1638.15 ***	Chi2(4) = 1638.15***	Chi2(4) = 1819.65***

Notes: The Stata command *xtqreg* was used; *** and * denote statistically significant at the 1% and 10% levels; "**Log**" denotes variables in natural logarithms. The Stata command *testparm* was used to perform the Wald test.

(R.C.): *The paper lacks robustness tests. The authors should consider whether the empirical results are robust. For example, whether country-specific factors change the relationships between the overweight epidemic and energy consumption or even carbon dioxide emissions?*

Reply: Thank you so much for your comment. However, the robustness check had been made, with the inclusion of dummies' variables, such as ID2011 that represents a shock that occurred in 2011 in European countries. The shock that occurred in 2011 is related to the European debt crisis. Moreover, another dummy variable was used, such as Malta2013, that reflect the effect of the European debt crisis in Malta in the year 2013. The inclusion of dummies' variables to check the robustness is used by several authors, such as Fuinhas et al. (2017). Indeed, you can see the results after the inclusion of dummy variables below (Tables 4, 5 and 6).

Table 4. Estimations for the consumption of energy

Independent variables	Model I (Dependent variable LogEPC_PC)		
	Quantiles		
	25th	50th	75th
LogSAO	0.7175***	0.9218***	1.1359***
LogGDP_PC	0.2742***	0.1543***	0.0286
LogUP	0.7339***	0.6308***	0.5228
IDMALTA2013	-0.1337**	-0.1999***	-0.2693***
Obs	837	837	837
F / Wald test	Chi2(3) = 359.19 ***	Chi2(3) = 450.06***	Chi2(3) =169.72***

Notes: The Stata command *xtqreg* was used; *** denotes statistically significant at the 1% level; "**Log**" denotes variables in natural logarithms. The Stata command *testparm* was used to perform the Wald test.

Table 5. Estimations for CO2 emissions

Independent variables	Model II (Dependent variable LogCO2_PC)		
	Quantiles		
	25th	50th	75th
LogSAO	1.6083***	1.4526***	1.3375***
LogEPC_PC	0.2157***	0.2588***	-0.5703***
LogGDP_PC	-0.4868***	-0.5348***	0.2906***
LogUP	0.5130***	0.4860**	0.4660***
Trend	-0.0389***	-0.0367***	-0.0350***
IDMALTA2013	0.1299***	0.0165	-0.0673**
Obs	837	837	837
F / Wald test	Chi2(4) =149.89 ***	Chi2(4) = 399.27 ***	Chi2(4) = 325.18***

Notes: The Stata command *xtqreg* was used; *** denotes statistically significant at the 1% level; "**Log**" denotes variables in natural logarithms. The Stata command *testparm* was used to perform the Wald test.

Table 6. Estimations for overweight epidemic

Independent variables	Model III (Dependent variable LogSAO)		
	Quantiles		
	25th	50th	75th
LogGDP_PC	0.1091***	0.0943***	0.0755***
LogUP	1.0700***	1.0634***	1.0552***
LogKOFEcGI	0.1335***	0.1058***	0.0710***
LogKOFSoGI	0.1218***	0.1715***	0.2343***
ID2011	0.0183**	0.0163**	0.0138
Obs	829	829	829
F / Wald test	Chi2(4) = 2841.40 ***	Chi2(4) = 3764.41***	Chi2(4) = 1468.55 ***

Notes: The Stata command *xtqreg* was used; *** and * denote statistically significant at the 1% and 10% levels; "**Log**" denotes variables in natural logarithms. The Stata command *testparm* was used to perform the Wald test.

Indeed, how as you see the results of three models indicate that the methodology approach is robust in the presence of shocks.

References

Fuinhas J.A., Marques A.C., Koengkan M., (2017). Are renewable energy policies upsetting carbon dioxide emissions? The case of Latin America countries. Environmental Science and Pollution Research, Vol. 24, pages: 15044–15054. doi: *https://doi.org/10.1007/s11356-017-9109-z*

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