Impacts of Paris agreement, fossil fuel consumption and net energy imports on CO2 emissions: A panel data approach for three West European countries

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Research Article

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Posted Date: August 9th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-161029/v1

Impacts of Paris agreement, fossil fuel consumption, and net energy imports on CO_2 emissions: A panel data approach for three West European countries

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Abstract

Global warming is a growing concern and carbon dioxide (CO_2) emissions are the primary accelerator of global warming in the world. Since global warming is threatening the lives of all mankind and species, the Paris agreement was conceived to avert the negatives of climate change and it was adopted by the majority of countries. This paper seeks to examine the impacts of the Paris agreement, fossil fuel consumption, and net energy imports on CO_2 emissions of Germany, France, and Spain in the post-Paris agreement with Panel datasets from 1995 to 2019 using both fully modified OLS (FMOLS) and dynamic OLS (DOLS). The purpose of this study is to analyze how the Paris agreement has changed the amount of CO_2 emissions in 3 industrialized countries in western Europe. The findings of the two methods indicate that net energy import and three fossil fuel consumption parameters have meaningful positive effects on CO_2 emissions. Key findings suggest that based on FMOLS results the Paris agreement has a very negligible, though negative impact around 0.0087 on carbon dioxide emissions. While according to DOLS results it still has a negative, but also meaningless impact. Based on statistics, oil consumption has the most to do with carbon dioxide emissions, which is followed by gas and coal consumption, thereby substitution with fewer pollutant energies, such as renewable energies can help CO_2 emissions mitigation.

Keywords: West European countries, CO_2 emissions, Paris agreement, FMOLS, DOLS

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1. Introduction

In recent decades, due to population growth and industrialization utilizing fossil fuels has increased significantly. Global greenhouse gas (GHG) emissions need to be declined (Metz et al., 2007), and human activities are mostly responsible for the sharp increase in GHG emissions over the last 150 years. Greenhouse gases are the dominant factors of global warming through producing greenhouse gas effect by tricking heat into Earth's atmosphere. Among all greenhouse gases, carbon dioxide (CO_2) is considered the chief source of global warming (Shaojian Wang et al., 2014) with maximum heat-trapping compared to other dangerous GHG in the atmosphere (Kalmaz et al., 2019) and (Ozturk et al., 2010).

Based on reports (energy outlook, etc.), since energy is a vital factor of production which plays a crucial role as an input for business development during the process of production (Ahmad et al., 2017), employing fossil fuels such as coal, oil and other similar fuels are the primary source of the constant growth of CO_2 amount (Caglar, 2020) and environmental challenge (Menyah et al., 2010). CO_2 emissions are proven to be the first factor of climate change (Haug et al., 2019), and human activities are the critical contributor of carbon dioxide emissions globally (Li et al., 2019). And, it is argued that carbon dioxide emissions growth rates lead to many serious health issues (Maibach et al., 2021), which affect the quality of life (Martins et al., 2019), and have significant negative impacts on the environment (Jebli, 2016). Therefore, CO_2 mitigation has received particular attention from many scientists, researchers, and organizations to find a way to decline CO_2 emissions. Multiple research on global warming has induced governments to decline dependency on fossil fuels (Michalski, 2019). For declining pollutant emissions a great range of policy instruments will need to be planned (Mousavi et al., 2017). For instance, the World Bank has put so much effort into declining the pollution rate and the World Bank's efforts are mostly centered on increasing countries to employ clean energy generation instead of fossil fuel by offering financial inducements (Kahia et al., 2019), or researchers believe that we should correct and change our energy consumption pattern and shifting to alternative fuels (Ciupăgeanu et al., 2017) and (Abas et al., 2017). After long and continuous warnings of scientists even after the Kyoto protocol in 1997 and the Copenhagen Climate change conference in 2009, the Paris agreement was adopted by almost every nation at the conference of Parties 21 (COP 21) in December 2015 (Sandiumenge Torres, 2020), and it is believed as the first truly worldwide climate change deal (Liu et al., 2020) to prevent constant growth of global carbon dioxide emissions which based on reports from IEA (2019) it is estimated to reach further 40,000 Million Kilotons (see Figure 1).

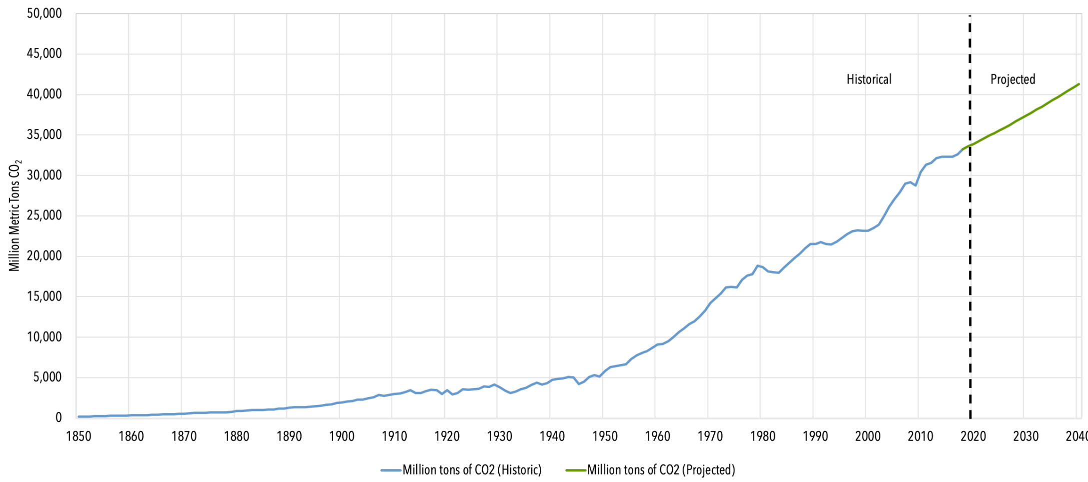

Figure 1. Global carbon dioxide emissions

The majority of countries have adopted the Paris Agreement deal, and this has made this agreement very critical. And, it has attracted many researchers' attention. The Paris agreement on climate change seeks to prevent rising temperature continuously in the world. In other words, this agreement is trying to decline global greenhouse gas emissions to limit the global temperature rise in this century to 2 degrees Celsius above pre-industrial levels, while practicing means to restrict the increase to 1.5 degrees (Ferreira et al., 2019) and (Rose et al., 2017), It is also believed that this agreement is a landmark in a multilateral climate change, because it gathered mostly all nations together for a common goal and to undertake determined efforts to combat climate change (UNFCC, 2015). Furthermore, it is claimed that the environmental integrity of international carbon market mechanisms is ensured by Paris agreement because of presenting a novel context (Schneider et al., 2019)

European countries have been traditionally considered as international leaders on climate change and environmental issues (Oberthür et al., 2017), also as a whole, EU countries are among the biggest energy consumers and are considered the main GHG emitters in the world (Liobikienė et al., 2017). Thereby, European developed countries have made notable investments in using technologies to increase energy efficiency by consuming renewable energy that is introduced as one of alternative energy (Duarte et al., 2018), and with the hope of reducing greenhouse emissions (Menyah et al., 2010). Germany, France, and Spain are chosen for this study, firstly because they are among the first countries which have adopted this agreement on the first day, and as three industrialized European imported-energy-dependent countries that rely on energy imports. Secondly, energy consumption in these countries is relatively high and carbon dioxide emissions are produced by energy consumption (Shahbaz et al., 2020) which is mainly being used by transportation and industries in these countries. For instance, in France, transport makes up for more than 40 percent of carbon dioxide emissions and it is followed by industry-related emissions account for more than 22 percent (ClimateTransparency, 2020). And, in Germany and Spain transport accounts for the main share in the energy related CO_2 emissions from the transport sector. Germany, France, and

Spain like other energy-dependent countries; their challenge is how to increase sectoral energy supplies to have more safe and cheap energy (Luqman et al., 2019) to reduce CO_2 emissions.

Germany has been specifically chosen for this study since Germany's energy industries are in charge of the largest share in 2019 (CLEW, 2021). Based on Germany Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (BMU, 2020), Germany's climate action plan, as the long-term target is to become largely greenhouse gas-neutral by 2050 which is the main Paris agreement goal to globally achieve carbon neutrality in the second half of the century, and Germany's mid-term aim to cut greenhouse gas emissions in Germany by at least 55 percent by 2030. Also, France and Spain pledged to reduce GHG emissions based on the Paris agreement goal and they joined the carbon neutrality target by 2050.

It is worth noting that the majority of CO_2 emissions by these countries are because of utilizing fossil fuels used by transportation in France (ClimateTransparency, 2018), and or it's been stated that in Germany as Europe's biggest emitter of carbon dioxide, coal is a very essential resource in Germany, also in Spain utilization of fossil fuels, especially oil consumption for energy production and industrial production is considerably high (Piłatowska et al., 2020) (see Figure 2 and Figure 3).

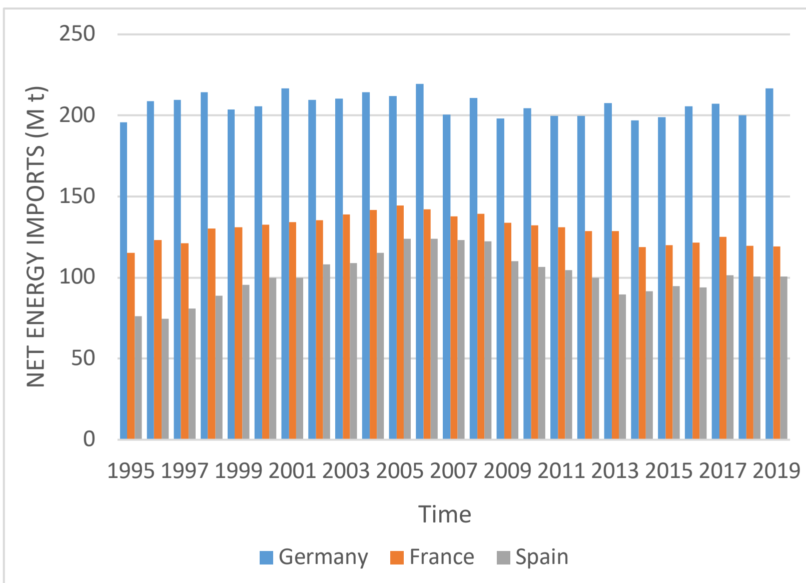

Figure 2. Net Energy Imports of Germany, France and Spain over the period 1995-2019

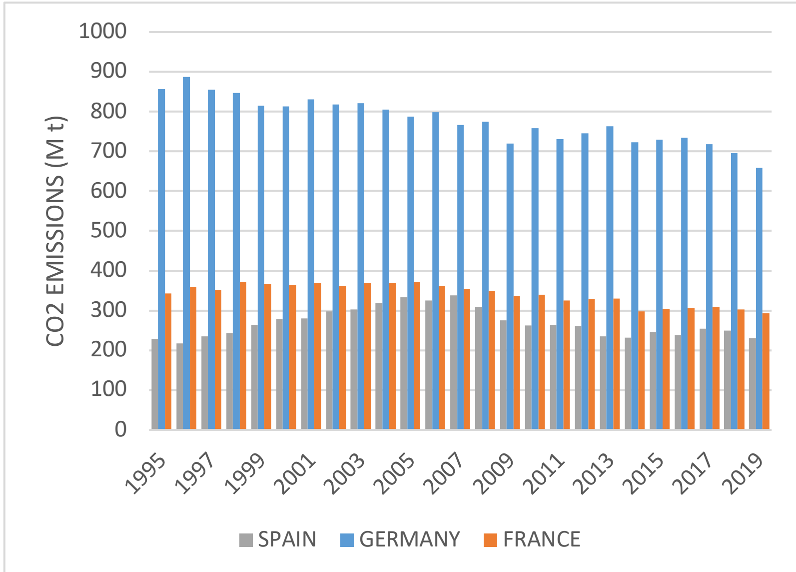

Figure 3. CO_2 Emissions of Germany, France and Spain over the period 1995-2019

This paper aims to fill the gap by examining the impacts of the Paris agreement, net energy imports, and energy consumption on CO_2 emissions from 1995 to 2019 in Germany, France, and Spain by using FMOLS and DOLS methods. These three countries are prominent members of the European Union dependent on oil imports. Based on BP (Petroleum, 2020), countries mentioned above have negligible oil reserves, though they have colossal petroleum corporations. Therefore, these three countries are reasonable examples to study whether they have reduced their CO_2 emissions for the fact that they are well developed to shift their technology to less-pollutant resources. In other words, they are selected to investigate whether they have reduced net energy imports and fossil fuel consumptions as well ever since they have adopted the Paris agreement. For reaching a comprehensive conclusion, both FMOLS and DOLS are taken for the long-run study. To our best knowledge, there is no such study that uses these three countries together and investigates the Paris agreement, net energy imports, and fossil fuel consumption impacts on carbon dioxide emissions.

The remainder of the paper is structured as follows: Section 2 explains literature reviews and in Section 3 the methodology is described. Section 4 covers the empirical analysis and the results. Finally, Section 5 concludes the paper.

2. Literature review

Numerous studies have been conducted to investigate the linkage between CO_2 emissions and other essential macroeconomics such as energy consumption, economic growth, economic output, and the like in various regions and countries. Since energy is deliberated to be the lifeline of an economy and recognized as one of the most crucial and strategic commodities (Sahir et al., 2007), therefore many researchers have conducted notable research on this subject (see Table 1).

Kahia et al. (2019), study 12 countries of MENA[4] region, FDI[5] inflows, renewable energy and international trade cause carbon dioxide decreases, whilst economic growth leads to degradation of the environment. Saidi et al. (2020), analyze the impact of nuclear and renewable energy on CO_2 emissions in 15 countries of OECD and they suggest a mixture of renewable and nuclear energy consumption reduce emissions of carbon dioxide. Khan et al. (2019) investigate the influence of energy consumption, financial development, trade, FDI, economic growth, and innovation on carbon dioxide emissions in Pakistan. Siddique et al. (2020), analyze the impact of energy consumption and urbanization on CO_2 emissions in south Asia, both energy consumption, and economic growth have a significant negative impact on the environment. Bekun et al. (2019), explore the nexus between carbon dioxide emissions, renewable and non-renewable energy in 16 European countries, their study affirms that non-renewable and economic growth increase emissions. Bhattacharya et al. (2017), study 85 developed and developing countries and found growth in renewable energy consumption has a negative impact on CO_2 emissions. Saboori et al. (2013), examine the relationship between carbon dioxide emissions, energy consumption, and economic growth in ASEAN[6] countries, their findings imply that energy consumption and CO2 emissions are extremely interconnected to each other.

Menyah et al. (2010) investigate the impacts of nuclear energy and renewable energy on carbon dioxide emissions in the USA, based on the results nuclear energy consumption can be helpful for CO_2 mitigation, however, there is no sign of significant contribution of renewable energy consumption to help CO_2 emissions reduction.

Table 1. Summary of some former studies

Authors	Sample	Period	Methodology	Main findings
Kahia et al. (2019)	12 of MENA countries	1980-2012	PVAR approach	Economic growth causes environmental degradation, and FDI, renewable energy and international trade lead to decreases
Saidi et al. (2020)	15 of OECD countries	1990-2018	FMOLS and VECM	Nuclear energy investment reduces CO_2 in Canada, Netherlands, Japan, Switzerland, Czech Republic and the UK, and renewable energy in other selected countries will reduce CO2

[4] The Middle East and North Africa countries
[5] Foreign direct investment
[6] Association of Southeast Asian Nations

Khan et al. (2019)	Pakistan	1971-2016	Dynamic ARDL	In short-run; energy consumption, urbanization, economic growth, financial development and the like have a positive effect on CO2 emissions while trade, innovation and foreign direct investment have a negative effect on emissions Whilst, in the long-run; Energy consumption, financial development, trade, FDI, and the like have a positive effect on CO2 emissions in Pakistan while urbanization, economic growth and innovation have a negative effect on CO_2
Siddique et al. (2020)	South Asia	1983-2013	Panel Co-integration and Granger causality approach	energy consumption and economic growth have a significant negative impact on the environment
Bekun et al. (2019)	16 of EU countries	1996-2014	PMG-ARDL model	non-renewable and economic growth increase carbon dioxide emissions
Bhattacharya et al. (2017)	85 developed and developing countries	1991-2012	System GMM and FMOLS	Rise in renewable energy consumption has a significant positive effect on economic output and a negative impact and CO_2 emissions
Menyah et al. (2010)	USA	1960-2007	Modified Granger causality test	Nuclear energy consumption is effective for CO_2 mitigation
Saboori et al. (2013)	ASEAN countries	1971-2009	ARDL and VECM	Carbon emissions increase in respect to energy consumption increase

In the former studies, various econometric and statistical approaches are used and, based on the methods, samples, and period, the results are varied. In our study, the novelty is examining the impacts of the Paris agreement, net energy imports, and energy consumption, and at the same time in Germany, France, and Spain by utilizing Panel data and well-known econometrics methods FMOLS and DOLS.

3. Methodology, Data and Model

As the prior studies assert, econometric tools are the frequent methods to evaluate the energy consumption on CO_2 emissions. And from econometric, Panel data, ARDL, and VECM technique DOLS and FMOLS are the primary methods of evaluation. Some of the studies (SS Wang et al. (2011), Bloch et al. (2012), Saboori et al. (2013)) suggest the VECM method to examine the impact of fossil fuel consumption on CO_2 emissions although a considerable number of the studies reveal the cointegration among the mentioned parameters. It means that there is a significant probability to divulge both short-run and long-run impacts on CO_2 emissions. Moreover, some of the prior studies apply different methods to locate the impacts on CO_2 emissions. It seems to be a preferable way to determine the impact more precisely.

3.1 Methodology

This research aims to determine the Paris Agreement's impact on carbon dioxide emissions in three chosen European countries. The data will be examined in two forms of Panel FMOLS[7] and DOLS[8]. Despite traditional and usual cross-sectional and time-series studies, Panel data studies not only increase freedom of offering policy implications, but also decline collinearity among explanatory variables, therefore improving the accuracy and effectiveness of estimations (Hassan et al., 2011). The reasons behind selecting two various models aim to investigate the Paris Agreement, net energy imports, and fossil fuel consumption (crude oil, natural gas, and coal consumption) effects on the CO_2 emissions in diverse views. In the case of the non-stationary parameters and the existence of the cointegration among the parameters, FMOLS and DOLS are excellent methods to explicate the relationships. Fully-Modified Ordinary Least Square is an econometric tool, which is applicable specifically for semi-parametric models. It can demonstrate the long-run relationships precisely since it can resolve heteroscedasticity and auto-correlation, which the existence of these two situations leads to questioning the results of the model (Pedroni, 2001).

Fully modified OLS is applicable for cointegrated relationships. However, in the presence of multicollinearity, DOLS can achieve better results since it is eliminating endogeneity in the model (Månsson et al., 2018). Both of these models are superior to the Simple Ordinary Least Squares, especially in resolving heteroscedasticity and auto-correlation, but these models operate based on different methods. A comparison between these models may lead us to understand these impacts better (See Figure 4).

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[7] Fully Modified Ordinary Least Squares

[8] Dynamic Ordinary Least Squares Model

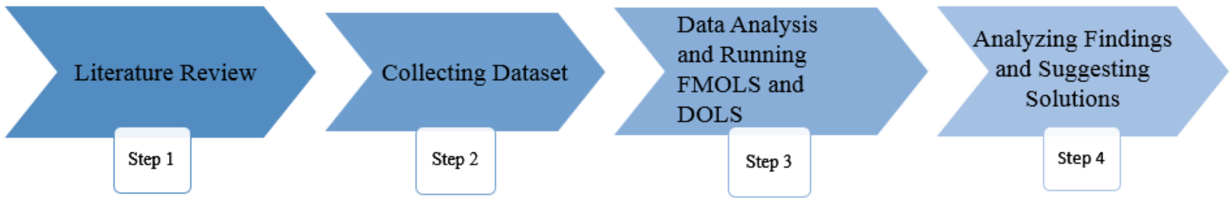

Figure 4. Methodology diagram summary

3.2 Data

In this paper, we have evaluated how the Paris agreement, fuel consumption, and net fuel exports in three developed European countries such as Germany, France, and Spain have influenced carbon dioxide emissions based on utilizing panel FMOLS and DOLS. We exploited annual data from 1995 to 2019 for three Western European countries, including Germany, France, and Spain. First and foremost, CO_2 emissions data is gathered from the average of the BP and IEA's CO_2 emissions data. We applied the net energy import of these countries based on the percentage of energy requisite, which they have to fulfill their required energy. This data is also extracted from the IEA. The most important sources of fossil fuels are crude oil, natural gas, and coal. The data of crude oil, natural gas, and coal usage are collected for the listed countries from the BP Statistics 2020. Paris Agreement is enhanced to the model as a dummy variable to distinguish it into before and after the Paris agreement.

In this study, first, the Paris agreement on carbon dioxide emission in each of the three European countries will be studied, and then, the Paris agreement's impact will be examined on the whole of these countries. For our modeling, we used four parameters, including CO_2 emissions, net energy imports, oil consumption, natural gas consumption, coal consumption, and the Paris Agreement. Where Paris Agreement is a dummy variable, and the parameters consist of 75 observations. In *Table 2*, the characteristics of the data will be demonstrated.

Table 2. Descriptive stats

Data Characteristic					
Variables	**Ln(CO_2)**	**Ln(NEI)**	**Ln(OC)**	**Ln(GC)**	**Ln(CC)**
Mean	6.06	4.94	4.48	3.47	3.17
Median	5.89	4.88	4.49	3.60	2.79
Maximum	6.80	5.39	4.92	3.80	4.51
Minimum	5.44	4.32	4.06	2.09	1.61
Std. Dev.	0.46	0.31	0.25	0.36	0.91
Skewness	0.52	0.09	0.13	-2.16	0.43
Kurtosis	1.60	1.80	1.89	7.35	1.60
Jarque-Bera	9.56	4.58	4.04	117.53	8.46
Probability	0.01	0.10	0.13	0.00	0.02
Observations	75	75	75	75	75

3.3 Model

All of the parameters are transformed into the natural logarithm form to have a dynamic review. Dynamic reviews have superior advantages in a time-series study since they can provide more accurate information about the impact of a parameter (Beck et al., 2011). Moreover, the natural logarithm occasions the data to become normal. Natural logarithm changes the data into the trend. It would be useful to demonstrate the impact more precisely. And confusing coefficient numbers will be omitted in this method. The coefficients' inferences are easier to understand since the percentage of changes will be demonstrated. And consequently, the carbon dioxide emission function is demonstrated in Equation 1.

$$Ln(CO2)_{in} = \beta_0 + \beta_1 Ln(NEI)_{in} + \beta_2 Ln(OC)_{in} + \beta_2 Ln(GC)_{in} \beta_2 Ln(CC)_{in} PA + \beta_4 Ln(CC)_{in} + \beta_5 PA + \varepsilon \quad (1)$$

$CO2_{in} = The\ total\ amount\ of\ \ carbon\ dioxide\ released\ by\ country\ i\ at\ the\ year\ n$

$NEI_{in} = Net\ Energy\ Import\ of\ the\ country\ i\ at\ the\ year\ n$

$OC_{in} = The\ amount\ of\ crude\ oil\ that\ consume\ by\ country\ i\ at\ the\ year\ n$

$GC_{in} = The\ amount\ of\ natural\ gas\ consume\ by\ country\ i\ at\ the\ year\ n$

$CC_{in} = The\ amount\ of\ coal\ that\ consume\ by\ country\ i\ at\ the\ year\ n$

$n = Number\ of\ the\ country\ 1\ to\ 3$

$t = year\ from\ 1995\ to\ 2019$

$PA = Paris\ Agreement$

As mentioned before, PA is a dummy variable to divide the time into prior-agreement and post-agreement. In the following Table 3, a summary of the parameters is presented.

Table 3. Variables Explanation

Parameters	Abbreviation	Measurements	Sources
CO_2 Emissions	CO2	Million Tons	BP, IEA
Net Energy Imports	NEI	Percentage	IEA
Coal Consumption	CC	Million Oil Barrels Equivalent	BP
Oil Consumption	OC	Million Oil Barrels	BP
Gas Consumption	GC	Million Oil Barrels Equivalent	BP
Paris Agreement	PA	-	-

In this study, we examine the Paris agreement's impact on carbon dioxide emissions by these countries separately as panel data form in different relative and appropriate models. This study aims to scrutinize the Paris Agreement impact from varied perspectives to reach a reliable answer to our question. FMOLS and DOLS can give us a precise perspective of these impacts.

4. Results and Inferences

To estimate the best model for the parameters, the next step is to test whether the data is stationary or not. This would be helpful to estimate more precisely and avoid statistical issues that make the estimation invalid like collinearity within and among the parameters. Moreover, due to the probability that CO_2, net energy imports, and fossil fuel consumption have a downward trend, a stationary trend should be applied with a time trend to examine this probability. In this step, we apply Levin, Lin, and Chu t-test, lm, Pesaran and Shi w-test, and ADF[9]-Fisher Chi-squared test. The main goal of all of the tests is to examine whether the parameter has a unit root or not. All the Test functions are based on the following equation.

(2)

$$\Delta y_{it} = \phi_i + \rho_i y_{i,t-1} + \sum_{k=1}^{n_i} \Delta y_{i,t-j} + \varepsilon_{it} + \alpha\tau_{i,t}$$

$i = 1,2,3$

$t = 1,2,3,\dots,25$

Where y_{it} donates to the parameter and n and t are the number of the cross-sections and periods, respectively. Δ represents the first difference of the parameter. n_i shows the number of the lag, and ε_{it} is the distributed random variables. Finally, $\alpha\tau$ is the linear trend. The following Tests examined whether ρ_i is zero or not.

In this examination, the null hypothesis asserts that the parameter has a common unit root process, while the alternative hypothesis claims otherwise. The results in *Table 4* suggest that each parameter becomes stationary after the first difference, hence the probability of these exams is less than 0.05.

Table 4. unit root test

Panel unit root test: Summary							
Parameter	Levin, Lin & Chu	Probability	lm, Pesaran and Shin	Probability	Augmented Dickey-Fuller	Probability	Test result after the difference
Ln(CO_2)	-7.93	0.00	-7.82	0.00	53.37	0.00	I(1)
Ln(NEI)	-7.96	0.00	-8.17	0.00	55.26	0.00	I(1)
Ln(OC)	-3.88	0.00	-4.94	0.00	35.53	0.00	I(1)
Ln(GC)	-6.82	0.00	-7.09	0.00	49.88	0.00	I(1)
Ln(CC)	-1.41	0.07	-3.92	0.00	26.02	0.00	I(1)

The next step is to clarify the cointegration among the parameters. It is important since when all of the parameters are stationary at level 1 then the regression estimation is not valid for them unless they are cointegrated. (Hill et al., 2018) If cointegration exists between the parameters, the model has a long-run relationship and regression is valid. The cointegrated equation is based on the error term of the equations, if the error term is stationary then the model is cointegrated. Therefore, the cointegration equation is achieved from the below equation:

(3)

[9] Augmented Dickey-Fuller

$$\hat{e}_{it} = \delta \hat{e}_{i,t-1} + \sum_{k=1}^{\delta} \theta_j \Delta \hat{e}_{i,t-1} + \mu_{it} + \gamma T_{i,t}$$

$i = 1, 2, 3$

$t = 1, 2, 3, \dots, 25$

Where $\hat{e}$, i, and t are donated as residual of the CO_2 equation, cross-section, and periods, respectively. μ and T are the constant and the trend of the cointegration equation. This test aims to evaluate whether δ is zero or not. Kao Residual Cointegration Test (1999) is highly applicable to determine cointegration in the equation, especially when trend assumption is examined in the cointegration test. The results of the test are represented in Table *5*.

Table 5. Cointegration test

Kao Residual Cointegration Test		
Null Hypothesis: No cointegration		
Trend assumption: No deterministic trend		
Automatic lag length selection based on SIC with a max lag of 5		
User-specified bandwidth: 25 and Parzen Kernel		
ADF	t-statistic	Probability
	-5.48	0.00
Residual variance		HAC variance
0.00		0.00

The Kao residual cointegration test suggests that strong cointegration exists between parameters since the probability of the test is below 0.01, therefore, the Kao cointegration test demonstrates that the model is not spurious. Also, the result claims that parameters have stable long-run relationships. To find the long-run, the model is evaluated by a panel FMOLS model and a panel DOLS.

4.1 FMOLS Model

As mentioned in the previous section, the best model for examination is Fully-Modified OLS since it can evaluate an accurate estimation and avoid problems that make the estimation unreliable. Unit root test and cointegration test demonstrate that cointegration regression like FMOLS and DOLS are suitable estimations. To verify the FMOLS, heteroscedasticity test should apply first to demonstrate whether the heteroscedasticity exists in the model or not. In the case of the existence of heteroscedasticity, FMOLS can remove it from the model. Based on the heteroscedasticity tests in Table *6* and Table *7*, it exists in both the cross-sections and periods of the model. The essence of the heteroscedasticity will violate the validity of the estimation.

Table 6. Panel Cross-section Heteroscedasticity LR Test

Panel Cross-section Heteroscedasticity LR Test			
Likelihood ratio	Value	df	Probability
	25.98	3	0

Table 7. Panel Period Heteroscedasticity LR Test

Panel Period Heteroscedasticity LR Test			
Likelihood ratio	Value	df	Probability
	219.93	3	0

when the difference between the sections of a panel is significant, The F-limer test is applied and cannot be covered by weighting methods simply. F-limer Test examines the ratio of the variance between the sections of the panel. If the difference was significant, the panel should have been estimated by a fixed-effect or random effect estimator. In Table *8* the results of the F-limer test are demonstrated. The null hypothesis, which asserts the sections does not have considerable differences from each other, cannot be rejected by the test. Therefore, the estimation should be based on the pooled estimation, which means FMOLS is suitable for modeling.

Table 8. F-limer Test

F-limer Test			
Effects Test	**Statistic**	**d.f.**	**Probability**
F-limer	1.35	(2,64)	0.27
Cross-section Chi-square	2.97	2	0.23

The next important problem of an FMOLS estimation is the variance inflation factor (VIF). VIF determines the importance of multi-collinearity in the regression. Its tests show that how much of the variance of a parameter's coefficient is increased for the collinearity. VIF test is described in Equation 4.

$$VIF_i = \frac{1}{1 - R_i^2} \tag{4}$$

Where VIF_i is the variance inflation factor of parameter i and R_i^2 is the coefficient determination of the parameter i. If the VIF coefficient places between one and ten, the collinearity does not have a significant impact on the estimation. Consequently, the estimate is creditable. The results of the VIF test are depicted in Table *9*.

Table 9. Variance Inflation Factor of FMOLS model

Variable	Coefficient Variance	Un-centered VIF Coefficient
Ln(NEI)	0.00082	6.93
Ln(OC)	0.00030	3.67
Ln(GC)	0.00007	4.73
Ln(CC)	0.00003	2.68
PA	0.00001	1.58

The coefficients of the VIF test suggest that collinearity is not an issue for our FMOLS estimation since all of the coefficients are less than ten.

According to the outcomes, the most appropriate model is FMOLS since it can resolve heteroscedasticity and is used as a pooled model, with consideration of the unit root and cointegration test outcomes. FMOLS has considerable advantages over other long-run estimation methods. Not only it can be applicable even in the existence of the serial correlation, but also it can be used to cover within and between dimensions of the equation. (Erdal et al., 2020) The within dimensions equation, which is achieved from the unit root test, is presented in Equation 5.

$$\varphi_{FMOLS} = 3^{-1} \sum_{i=1}^{3} \left[\sum_{t=1}^{25} (X_{it} - \acute{X_\iota})^2 \right]^{-1} \left[\sum_{t=1}^{25} (X_{it} - \acute{X_\iota})\, \acute{Y}_{it} - 25\acute{r}_\iota \right] \tag{5}$$

Where $\varphi_{FMOLS} = 3^{-1} \sum_{i=1}^{3} \varphi_{FMi} . \varphi_{FMi}$ is the FMOLS estimator for each parameter. r is considered as the residual of the equation.

We exploited FMOLS based on the weighted pooled model to exterminate the heteroscedasticity within the cross-sections and use long-run covariance based on the efficient lag of the Schwarz criteria to resolve heteroscedasticity in the periods of the equation. The coefficients of the FMOLS model are demonstrated in *Table 10*.

Table 10. FMOLS Parameters' coefficients

Variable	Coefficient	Standard Error	t-statistic	Probability
Ln(NEI)	0.1163	0.0287	4.05581	0.0001***
Ln(OC)	0.5652	0.0175	32.3489	0.0000***
Ln(GC)	0.1326	0.0087	15.2640	0.0000***
Ln(CC)	0.1331	0.0058	22.9878	0.0000***
PA	-0.0087	0.0031	-2.8433	0.0060***

* Rejection of null hypothesis at a 10% level of significance
** Rejection of null hypothesis at a 5% level of significance
***Rejection of null hypothesis at a 1% level of significance

For net energy import and fossil fuels consumptions, the coefficients suggest a logical outcome. As it is predictable, these four parameters have substantial positive effects on CO_2 emissions. If net energy imports improve one percent, the CO_2 emissions increase by 0.12 percent. Crude oil consumption has the most influence on the CO_2 emissions, one percent increase in the usage of crude oil will release 0.56 percent CO_2 in the atmosphere. Natural gas and coal consumption have near the same influence on CO_2 emissions. A one percent increase in the usage of any of them will improve the CO_2 emissions by 0.13 percent. The Paris agreement hurts the CO_2 emissions even though it is not significant. The existence of the Paris agreement reduces CO_2 emissions by 0.01 percent. The characteristics of the FMOLS model are demonstrated in Table 11. Based on the results, the independent parameters can interpret the CO_2 emissions parameter by 0.99 percent. Also Adjusted R-squared is standing at a high rate, which is quite acceptable. And all of the other stats are desirable for the estimation. Most of the results of the FMOLS model are predictable. As it is expected, fossil fuel consumption (crude oil, natural gas, and coil consumption) affects CO_2 emissions positively. It means that fossil fuel consumption is one of the primary reasons for increasing CO_2 emissions in these countries. However, the Paris Agreement impact is believed to be more efficient than the outcomes' suggestion. Although Paris Agreement has a negative effect on CO_2 emissions, this effect is not significant, roughly -0.01 percent. In the next section, the DOLS method will be exploited to examine the validity of the FMOLS model.

Table 11. FMOLS Model Characteristics

R-squared	0.999009	**Mean dependent var**	6.061837
Adjusted R-squared	0.998901	**S.D. dependent var**	0.451725
S.E. of regression	0.014978	**Sum squared resid**	0.014357
Long-run variance	0.000053		

4.2 DOLS model

In the second model, we try to evaluate the mentioned independent parameters on CO_2 emissions in Germany, France, and Spain. In this section, we investigate a Dynamic Ordinary Least Squares model to determine and verify the impact of the net energy import, Crude oil consumption, natural gas consumption, coal consumption, and the Paris agreement on CO_2 emissions. Then, we use the Impulse Response diagram to determine the shock of the Paris agreement on CO_2 emissions. Finally, we evaluate the variance decomposition chart to locate how much of the CO_2 emission coefficient is determined by the Paris agreement in the future.

Unit root tests and cointegration tests suggest that there is a cointegrated long-run equation among the non-stationary parameters. Therefore, we applied FMOLS estimation to locate the effects of the mentioned parameters on CO_2 emissions. However, for validation of the FMOLS model, we apply the DOLS model as well. The DOLS equation is demonstrated in Equation 6.

$$\varphi_{DOLS} = \sum_{i=1}^{3} \left[\sum_{t=1}^{25} Z_{it} \acute{Z}_{it} \right]^{-1} \left[\sum_{t=1}^{25} Z_{it}\, \acute{Y}_{it}^{+} \right] \tag{6}$$

Where $Z_{it} = \left[X_{it} - \bar{X}_i, \Delta X_{i,t-w}, \dots, \Delta X_{t+w}\right]$ is $2(w+1) \times 1$ vector regressors.

As the F-limer test suggests in the previous section the model is based on the pooled estimation. Just like the FMOLS modeling, heteroscedasticity and auto-correlation are two important factors that hurt the reliability of the DOLS model. Heteroscedasticity and auto-correlation are resolved by DOLS, while multi-collinearity is still a problem. VIF test is applied to examine the multi-collinearity in the parameters. the results are demonstrated in Table *12*.

Table 12. Variance Inflation Factor of DOLS model

Variable	Coefficient Variance	Un-centered VIF Coefficient
Ln(NEI)	0.00246	4.52
Ln(OC)	0.00348	2.57
Ln(GC)	0.00029	2.03
Ln(CC)	0.00006	1.62
PA	0.00001	1.07

Just like the FMOLS model all of the VIF coefficients are less than ten, therefore, multi-collinearity is not hurting the reliability of the model. The previous examinations determine DOLS model is valid. Consequently, DOLS coefficients are demonstrated in Table *13*.

Table 13. DOLS Parameters' coefficients

Variable	Coefficient	Standard Error	t-statistic	Probability
D(Ln(NEI))	0.147260	0.049573	2.970599	0.0042***
D(Ln(OC))	0.374833	0.059025	6.350380	0.0000***
D(Ln(GC))	0.215004	0.016986	12.65795	0.0000***
D(Ln(CC))	0.123584	0.007874	15.69542	0.0000***
PA	-0.000244	0.002269	-0.107545	0.9147

* Rejection of null hypothesis at a 10% level of significance
** Rejection of null hypothesis at a 5% level of significance
***Rejection of null hypothesis at a 1% level of significance

The outcomes of the DOLS model are in favor of the FMOLS mostly. Net energy import and three fossil fuel consumption parameters have substantial positive effects on CO_2 emissions. If net energy imports improve one percent, the CO_2 emissions increase by 0.15 percent. Crude oil consumption has the most significant impact on CO_2 emissions, a one percent increase in the usage of crude oil will increase CO_2 emissions by 0.37 percent. If consumption of natural gas increase by one percent, CO_2 release in the air will be empowered by 0.22 percent. Finally, an enhancement in coal consumption usage by one percent will improve the CO_2 emissions by 0.12 percent. The Paris agreement does not hurt the CO_2 emissions since its coefficient is not significant. The characteristics of the DOLS model are demonstrated in Table *14*. Based on the results the independent parameters can interpret the CO_2 emissions parameter by 0.91 percent. Also Adjusted R-squared is placing at a reliable rate. And all of the other stats are desirable for the estimation. The DOLS outcomes champion the FMOLS results. Fossil fuel consumption, which is consisted of crude oil, natural gas, and coal consumption affects CO_2 emissions positively. Just like the FMOLS model, crude oil is the most effective of all fossil fuels. The Paris Agreement has reduced CO_2 emissions even though this impact is not significant.

Table 14. DOLS Model Characteristics

R-squared	0.912530	**Mean dependent var**	-0.005050
Adjusted R-squared	0.902963	**S.D. dependent var**	0.041955
S.E. of regression	0.013069	**Sum squared resid**	0.010932
Long-run variance	0.000137		

The impact of the Paris agreement is extracted by the models. Both models suggest that the effect of the Paris agreement on carbon dioxide emissions is not considerable, albeit the FMOLS coefficient is significant at a low value as it is observable in the following *Figure 5*. All in all, it seems that the Paris agreement does not reduce carbon dioxide as environmentalists' envisaging. Furthermore, both models suggest that net energy imports influence CO_2 emissions positively. Both models estimate net energy import coefficients roughly as same as each other although the DOLS coefficient is higher than the FMOLS estimation. Oil Consumption is the major reason for the increase in CO_2 emissions demonstrated by both of the models. Gas consumption affects the CO_2 emissions positively in both models, however, the DOLS coefficient is more significant than the FMOLS model. Finally, coal consumption causes an improvement in CO_2 emissions in both models and just like the net energy import, both models estimate roughly the same coefficient.

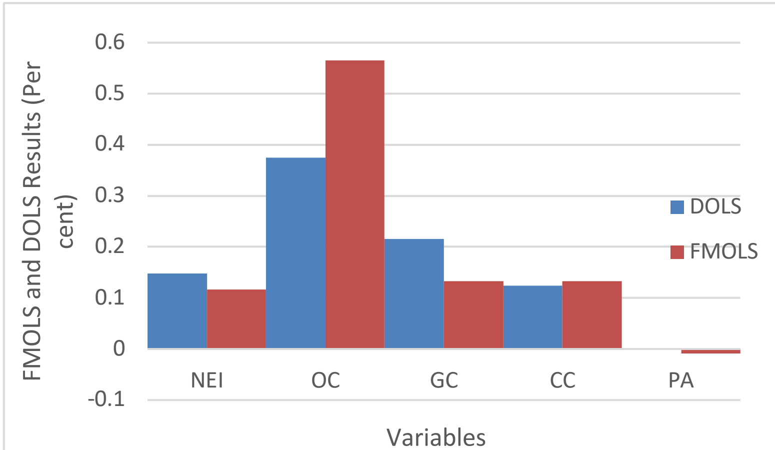

Figure 5. Graphical results of FMOLS and DOLS models

5. Conclusion

Global warming has turned into a global increasing challenge for sustainable growth in recent years. And CO_2 emissions are the major sources of raising this concern. Scientists believe that now it is time to put an end to further greenhouse gas emissions by cutting the use of fossil fuels. Consequently, countries reached a brand new global agreement to face the global warming challenge. In December 2015, In Paris, they decided to reduce CO_2 emissions as a global effort to maintain the temperature of the world which is known as the Paris agreement.

In this study, we have examined the Paris agreement, net energy import, and consumption of three major fossil fuel impacts on CO_2 emissions in three major European countries, including Germany, Spain, and France. We employed FMOLS and DOLS methods to evaluate the effects precisely. The results suggest that the impact of the Paris agreement is negligible. According to the FMOLS model, the Paris agreement reduces CO_2 emissions by roughly 0.01 percent. Although the impact based on the DOLS model is negative, its t-statistics determine that the impact is meaningless. For consumption of three major fossil fuels and net energy import effects on the CO_2 emissions, the results are as it is expected to be because any increase in the parameters will end up growing in CO_2 emissions in both models. It is worth mentioning that the most important factor in the CO_2 emissions is crude oil consumption that has the largest impact in both models.

Finally, since the Paris agreement is an important international deal that was adopted by almost every country and this has made the importance of this deal multiple. It seems that the Paris agreement is less effective than it was hoped to be, especially when three major European countries have conducted less effort to reduce carbon dioxide emissions. Nevertheless, it just took five years from the agreement and it needs to pass more times to determine a more precise long-run effect of the agreement. Moreover, as this study suggests, the most important factor for CO2 emissions is crude oil consumption. Reducing crude oil consumption will end in a substantial reduction in CO2 emissions. Consequently, based on the below expectation of the Paris agreement performance, we suggest that reducing crude oil consumption and substituting crude oil with fewer polluting fuels such as renewable energy would be a suitable step in controlling CO2 emissions. Our findings can warn countries and policymakers from 2015 to 2019 they were not prosperous and they should undertake practical plans and pay their contribution in reducing carbon dioxide emissions. For future studies, we suggest extending the period of data and employing forecasting models for comparing the results.

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