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The Analysis of CO2 Emissions in European Union by Means of Fourier Development

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Abstract: In this article, it will carry out an analysis on the regularity of CO2 emissions of all Union European countries. The research method consists in adjusting the statistical data with the help of Fourier series development and determining the periodicity of the phenomenon. Determining the possible periodicity facilitates the adjustment of the causes that lead to cyclization and therefore the mitigation of possible unwanted effects.

Keywords: cycle; Fourier; periodicity; interpolation

JEL Classification: C65, E17

1. Introduction

In the literature, the economic cycle designates the fluctuations which accompany the evolution of a nation or, sometimes, it simply is associated with the increasing and decreasing of an economy. Throughout history, many states were faced and have experienced economic fluctuations.

Given the complexity of economic phenomena, in practice there are as many types of economic cycles or economic fluctuations. It can say that almost any segment of the economic life is subject to the fluctuations that, sometimes, may include periods of more than a year.

A more comprehensive approach to the problem of an indicator cycle requires knowledge of all aspects of the market economy or social life.

Over time, many economists have attempted, through analysis of available statistical data, to develop specific models of foresights of changes taking place in the economy to come to the aid of the decision-makers to act according to actual economic conditions.

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2. Mathematical Considerations on the Fourier Development

Let a function f:R→R, with f and f' piecewise continous on R and periodic with period T, therefore f(x+T)=f(x) ∀x∈R.

Considering Fourier series associated with the function f: $F(x)=\frac{a_0}{2} + \sum_{m=1}^{\infty}\left(a_m \cos\frac{2m\pi x}{T} + b_m \sin\frac{2m\pi x}{T}\right)$ it has the following:

Lemma 1 ([2]) $\int_{-\frac{T}{2}}^{\frac{T}{2}} F(x)\cos\frac{2n\pi x}{T}dx=\frac{a_n T}{2}$, n≥0, $\int_{-\frac{T}{2}}^{\frac{T}{2}} F(x)\sin\frac{2n\pi x}{T}dx=\frac{b_n T}{2}$, n≥1.

From Fourier series expression, it is observed that F(x+T)=F(x) ∀x∈R so its sum is also a periodic function of period T.

The Dirichlet's theorem (Spiegel, 1974) states that in the conditions above, the Fourier series converges punctually to f in the points of continuity and to $\frac{f(x+0)+f(x-0)}{2}$ in the discontinuity points.

Considering the partial sum of order n corresponding to the series of function F, the n-th Fourier polynomials are:

$Fn(x)=\frac{a_0}{2} + \sum_{k=1}^{n}\left(a_k \cos\frac{2k\pi x}{T} + b_k \sin\frac{2k\pi x}{T}\right)$

It is obvious also that Fn(x)=Fn(x+T) ∀x∈R.

The Fourier polynomials have the property of approximating the function through one periodical with the observation that the absolute error tends to fall (due to the convergence points) with the rise of n.

Due to the existence of an important number of cyclical phenomena in many scientific fields, it intend, below, to approximate their development by means of Fourier polynomials of degree conveniently chosen.

In the case of the discretized phenomenons, it put the problem in the generation of functions that will pass through a series of data points. A very useful tool is the Lagrange interpolation polynomial. Therefore, considering a set of data (xi,yi), i=$\overline{1, k+1}$, the Lagrange interpolation polynomial has the form:

$Ln(x)=\sum_{i=1}^{k+1} \frac{(x-x_1)...(x-x_{i-1})(x-x_{i+1})...(x-x_n)}{(x_i-x_1)...(x_i-x_{i-1})(x_i-x_{i+1})...(x_i-x_n)} y_i$

and is the polynomial of minimum degree (k) passing through the data points.

It will demonstrate, first, the following:

Lemma 2 ([2]) Let $f(x) = ax + b$∈R[X]. Then:

$\int f(x)\cos\frac{2n\pi x}{T}dx = a\frac{T}{2n\pi}x\sin\frac{2n\pi x}{T} + b\frac{T}{2n\pi}\sin\frac{2n\pi x}{T} + a\left(\frac{T}{2n\pi}\right)^2\cos\frac{2n\pi x}{T}$, n≥1

$\int f(x)\cos\frac{2n\pi x}{T}dx = a\frac{x^2}{2} + bx$, n=0

$\int f(x)\sin\frac{2n\pi x}{T}dx=-a\frac{T}{2n\pi}x\cos\frac{2n\pi x}{T} - b\frac{T}{2n\pi}\cos\frac{2n\pi x}{T} + a\left(\frac{T}{2n\pi}\right)^2\sin\frac{2n\pi x}{T}$, n≥1.

3. The Discrete Data Analysis using Fourier Development

Consider a discrete data set: Y=(y1,...,yn) and the points $(k, y_k)_{k=\overline{1,n}}$. In the following, we consider, for a given T, a sequence of the form: $(s, y_s)_{s=\overline{p,p+T-1}}$ and it will build the corresponding Lagrange interpolation polynomial of degree 1 on each pair of consecutive pairs, where the independent variable would be the sequence number of the corresponding date. The result will be a piecewise function continous on every point.

We will determine the truncation of the Fourier development corresponding to the interpolation polynomial for a number of terms and then the obtained function will be calculated at all points $(k)_{k=\overline{1,n}}$ obtaining the set of values: $(\widetilde{y_k})_{k=\overline{1,n}}$. We will then calculate the average error: $\varepsilon = \frac{\sum_{k=1}^{n}|y_k - \widetilde{y_k}|}{n}$ and we will retain that value of T for which the error is minimal.

For the periodic function to be defined in the range: $\left[-\frac{T}{2}, \frac{T}{2}\right]$, we will consider the points: $\left(\frac{T(2s-2p+1-T)}{2(T-1)}, y_s\right)_{s=\overline{p,p+T-1}}$. For a pair of consecutive points, corresponding to s and s+1, we will consider the interpolation polynomial of degree 1 which passing through: $\left(\frac{T(2s-2p+1-T)}{2(T-1)}, y_s\right)$ and $\left(\frac{T(2s-2p+3-T)}{2(T-1)}, y_{s+1}\right)$, $s = \overline{p, p+T-2}$.

We have ([2]): $gs(x) = \frac{(T-1)(y_{s+1}-y_s)}{T} x + \frac{(2s-2p+3-T)y_s - (2s-2p+1-T)y_{s+1}}{2} =$

Now, if we decompose the integrals on $\left[-\frac{T}{2}, \frac{T}{2}\right]$ after gs, we obtain ([2]):

$\frac{a_0}{2} + \sum_{m=1}^{\infty}\left(a_m \cos\frac{2m\pi x}{T} + b_m \sin\frac{2m\pi x}{T}\right)$ where:

$a_0 = \frac{2}{T-1}\sum_{s=p}^{p+T-2}(y_s + y_{s+1})$,

$a_n = \frac{1}{n\pi}\sum_{s=p}^{p+T-2} \sin\frac{n(2s-2p+3-T)\pi}{T-1}y_{s+1} - \sin\frac{n(2s-2p+1-T)\pi}{T-1}y_s + \frac{(T-1)(y_{s+1}-y_s)}{nT\pi}\left(\cos\frac{n(2s-2p+3-T)\pi}{T-1} - \cos\frac{n(2s-2p+1-T)\pi}{T-1}\right)$, n≥1,

$b_n = -\frac{1}{n\pi}\sum_{s=p}^{p+T-2} \cos\frac{n(2s-2p+3-T)\pi}{T-1}y_{s+1} - \cos\frac{n(2s-2p+1-T)\pi}{T-1}y_s - \frac{(T-1)(y_{s+1}-y_s)}{nT\pi}\left(\sin\frac{n(2s-2p+3-T)\pi}{T-1} - \sin\frac{n(2s-2p+1-T)\pi}{T-1}\right)$, n≥1.

After this, we will compute the set of values: $(\widetilde{y_k})_{k=\overline{1,n}}$ for abscissas $\frac{T(2s-2p+1-T)}{2(T-1)}$, s=$\overline{1,n}$ and ordinates $(y_k)_{k=\overline{1,n}}$.

4. The Analysis of CO2 Emissions

Considering an indicator Ik, k=$\overline{1,m}$, we first compute the growth rate (in percents): rk=$\frac{I_k - I_{k-1}}{I_{k-1}}$, k=$\overline{2,m}$.

After, we will compute the accelerations of the indicator: ρk=rk-rk-1, k=$\overline{3,m}$.

We then obtain that: rk=r2+$\sum_{j=3}^{k}\rho_j$, k=$\overline{3,m}$.

We will then consider the pairs of elements (k,ρk), k=$\overline{3,m}$. For these pairs, we will analyze the Fourier polynomials Fn for n=$\overline{8,20}$ as in the previous section and we will retain that expression for which the

mean deviation is minimal. The forecast will be made using the last value of the adjusted growth rate rFourier,m according to the formula: Ik=Ik-1(1+ rFourier,m/100).

5. The Analysis of CO2 Emissions Cyclicity

The following analysis will study the CO2 emissions for the period 1970-2020. The calculations revealed that the best approximation by Fourier polynomials is relative to the growth rate.

5.1. Austria

Table 1. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	4,8547	1988	-14,4006	2004	-5,5379
1973	-0,6737	1989	9,0842	2005	-1,2191
1974	-11,5471	1990	6,2155	2006	-3,3874
1975	-0,8737	1991	-0,5509	2007	-1,0527
1976	12,7492	1992	-14,7317	2008	3,1437
1977	-11,1559	1993	7,8351	2009	-8,2053
1978	6,0105	1994	0,6224	2010	17,5210
1979	4,9008	1995	4,1102	2011	-11,0155
1980	-22,2312	1996	1,1224	2012	-2,2130
1981	22,3922	1997	-7,1282	2013	5,6117
1982	-11,3429	1998	1,7485	2014	-6,7016
1983	0,5318	1999	-3,2057	2015	7,5899
1984	8,4369	2000	3,2663	2016	-1,4913
1985	-4,6623	2001	6,1331	2017	3,4692
1986	-1,4085	2002	-4,7445	2018	-7,8747
1987	7,9067	2003	5,1876		

Source: https://unctadstat.unctad.org and own calculations

By analysing the data set (k,ρk), corresponding to the period [1972,2018], we found that the minimum average absolute error 5,8671 is obtained applying Fourier Analysis for T=18 for the range of years: [1975,1992].

The optimal number of Fourier series terms is 11 being specified in the table 2.

Table 2.

a_0	-1,1090						
a_1	0,1183	b_1	-1,3531	a_2	-0,0604	b_2	0,6382
a_3	0,1468	b_3	-0,6619	a_4	-0,0322	b_4	0,6850
a_5	-0,0373	b_5	-0,3915	a_6	0,3978	b_6	-0,4432
a_7	-0,3818	b_7	-0,5128	a_8	0,0943	b_8	0,5150
a_9	-0,0745	b_9	0,0786	a_{10}	0,1871	b_{10}	0,0146
a_{11}	-0,1183	b_{11}	-0,3516	a_{12}	-	b_{12}	-
a_{13}	-	b_{13}	-	a_{14}	-	b_{14}	-
a_{15}	-	b_{15}	-	a_{16}	-	b_{16}	-
a_{17}	-	b_{17}	-	a_{18}	-	b_{18}	-
a_{19}	-	b_{19}	-	a_{20}	-	b_{20}	-

The recalculated values of CO2 emissions are:

Table 3. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	-1,1976	1988	-0,8512	2004	-2,8038
1973	-2,3884	1989	-1,1976	2005	-0,8512
1974	-4,0556	1990	-2,3884	2006	-1,1976
1975	0,3789	1991	-4,0556	2007	-2,3884
1976	0,5583	1992	0,3789	2008	-4,0556
1977	1,8097	1993	0,5583	2009	0,3789
1978	1,1977	1994	1,8097	2010	0,5583
1979	-1,4210	1995	1,1977	2011	1,8097
1980	2,4960	1996	-1,4210	2012	1,1977
1981	-0,9748	1997	2,4960	2013	-1,4210
1982	-0,0891	1998	-0,9748	2014	2,4960
1983	0,4908	1999	-0,0891	2015	-0,9748
1984	-1,1429	2000	0,4908	2016	-0,0891
1985	-1,0575	2001	-1,1429	2017	0,4908
1986	-0,3759	2002	-1,0575	2018	-1,1429
1987	-2,8038	2003	-0,3759		

The comparative graphs of the evolution of CO2 emissions accelerations and their recomputing after the Fourier regression is:
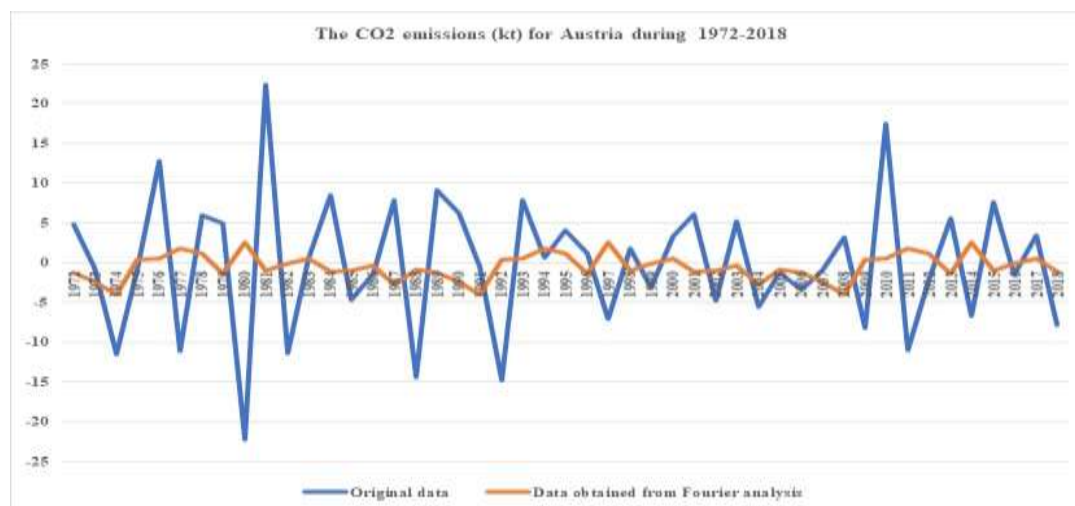
The Fourier analysis for the period 1972-2018

Figure 1.

Based on this analysis, and using the growth rate (in percents) corresponding to -20,3045, the forecast of CO2 emissions for the next 5 years is:

Year	CO2 emissions (kt)
2019	50351,617
2020	40127,973
2021	31980,189
2022	25486,771
2023	20311,810

5.2. Belgium

Table 4. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	10,9159	1988	-2,9131	2004	-5,4763
1973	-1,5145	1989	9,7593	2005	-1,7093
1974	-8,7737	1990	-5,3613	2006	1,2187
1975	-7,0731	1991	2,5338	2007	-1,9648
1976	16,1812	1992	-5,6843	2008	5,9741
1977	-9,1238	1993	-0,5460	2009	-9,0268
1978	9,9814	1994	6,3265	2010	13,6120
1979	-4,1129	1995	-4,6374	2011	-17,0601
1980	-6,7399	1996	4,5466	2012	9,5993
1981	-4,8196	1997	-6,6118	2013	2,3759
1982	3,1210	1998	4,7272	2014	-8,4139
1983	-8,3289	1999	-5,6409	2015	12,2664
1984	17,2754	2000	4,7984	2016	-6,5145
1985	-4,6317	2001	-0,6285	2017	-0,7189
1986	-0,6295	2002	-7,2330	2018	2,3979
1987	1,7657	2003	10,5241		

Source: https://unctadstat.unctad.org and own calculations

By analysing the data set (k,ρk), corresponding to the period [1972,2018], we found that the minimum average absolute error 5,1499 is obtained applying Fourier Analysis for T=8 for the range of years: [2007,2014].

The optimal number of Fourier series terms is 8 being specified in the table 5.

Table 5.

a_0	0,1181						
a_1	-0,0942	b_1	1,6396	a_2	-0,3281	b_2	-0,0325
a_3	-1,3656	b_3	1,9531	a_4	0,7681	b_4	0,2224
a_5	0,0525	b_5	0,5556	a_6	0,0026	b_6	-0,3439
a_7	-	b_7	0,2861	a_8	0,0015	b_8	-0,2447
a_9	-	b_9	-	a_{10}	-	b_{10}	-
a_{11}	-	b_{11}	-	a_{12}	-	b_{12}	-
a_{13}	-	b_{13}	-	a_{14}	-	b_{14}	-
a_{15}	-	b_{15}	-	a_{16}	-	b_{16}	-
a_{17}	-	b_{17}	-	a_{18}	-	b_{18}	-
a_{19}	-	b_{19}	-	a_{20}	-	b_{20}	-

The recalculated values of CO2 emissions are:

Table 6. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	1,9104	1988	1,6826	2004	2,4566
1973	-3,3557	1989	-3,9398	2005	1,7384
1974	1,6826	1990	2,4566	2006	-0,0791
1975	-3,9398	1991	1,7384	2007	1,9104
1976	2,4566	1992	-0,0791	2008	-3,3557
1977	1,7384	1993	1,9104	2009	1,6826
1978	-0,0791	1994	-3,3557	2010	-3,9398
1979	1,9104	1995	1,6826	2011	2,4566
1980	-3,3557	1996	-3,9398	2012	1,7384
1981	1,6826	1997	2,4566	2013	-0,0791

1982	-3,9398	1998	1,7384	2014	1,9104
1983	2,4566	1999	-0,0791	2015	-3,3557
1984	1,7384	2000	1,9104	2016	1,6826
1985	-0,0791	2001	-3,3557	2017	-3,9398
1986	1,9104	2002	1,6826	2018	2,4566
1987	-3,3557	2003	-3,9398		

The comparative graphs of the evolution of CO2 emissions accelerations and their recomputing after the Fourier regression is:

The Fourier analysis for the period 1972-2018

Figure 2.

Based on this analysis, and using the growth rate (in percents) corresponding to -2,0232, the forecast of CO2 emissions for the next 5 years is:

Year	CO2 emissions (kt)
2019	91578,915
2020	89726,090
2021	87910,752
2022	86132,142
2023	84389,516

5.3. Bulgaria

Table 7. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	-2,0915	1988	-4,8583	2004	-11,2465
1973	1,1037	1989	4,1120	2005	2,9663
1974	-0,4745	1990	-14,5640	2006	0,7928
1975	-1,0111	1991	-5,1294	2007	5,1770
1976	-2,4513	1992	14,3859	2008	-12,3756
1977	3,8266	1993	6,9171	2009	-9,1894
1978	3,2613	1994	-4,8415	2010	18,4866
1979	-9,9378	1995	6,0481	2011	6,3718
1980	0,6713	1996	-1,5096	2012	-19,9074
1981	5,7898	1997	-3,7459	2013	-2,5860
1982	8,4952	1998	-2,1395	2014	17,7987
1983	-11,9213	1999	-7,2244	2015	-0,2270
1984	-3,5798	2000	10,2437	2016	-12,4262
1985	5,8084	2001	8,7670	2017	12,1113
1986	-0,2693	2002	-12,0993	2018	-12,1179
1987	-2,1035	2003	15,2858		

Source: https://unctadstat.unctad.org and own calculations

By analysing the data set (k,ρk), corresponding to the period [1972,2018], we found that the minimum average absolute error 6,3179 is obtained applying Fourier Analysis for T=15 for the range of years: [1996,2010].

The optimal number of Fourier series terms is 8 being specified in the table 8.

Table 8.

a_0	2,5021	c					
a_1	-0,0764	b_1	2,5544	a_2	0,1276	b_2	-1,4770
a_3	-0,4372	b_3	1,5145	a_4	0,2125	b_4	-1,5192
a_5	-0,0049	b_5	0,4234	a_6	-0,6094	b_6	-0,5987
a_7	-0,1963	b_7	0,4601	a_8	-0,3428	b_8	-0,3677
a_9	-	b_9	-	a_{10}	-	b_{10}	-
a_{11}	-	b_{11}	-	a_{12}	-	b_{12}	-
a_{13}	-	b_{13}	-	a_{14}	-	b_{14}	-
a_{15}	-	b_{15}	-	a_{16}	-	b_{16}	-
a_{17}	-	b_{17}	-	a_{18}	-	b_{18}	-
a_{19}	-	b_{19}	-	a_{20}	-	b_{20}	-

The recalculated values of CO_2 emissions are:

Table 9. The evolution of the accelerations (percents) of CO_2 emissions during the period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	0,1164	1988	1,9946	2004	2,3542
1973	-1,0526	1989	-0,0759	2005	2,2297
1974	1,9946	1990	2,3542	2006	3,7397
1975	-0,0759	1991	2,2297	2007	2,2013
1976	2,3542	1992	3,7397	2008	3,1281
1977	2,2297	1993	2,2013	2009	7,7598
1978	3,7397	1994	3,1281	2010	1,3539
1979	2,2013	1995	7,7598	2011	-3,5439
1980	3,1281	1996	1,3539	2012	-2,5550
1981	7,7598	1997	-3,5439	2013	-0,1353
1982	1,3539	1998	-2,5550	2014	0,1164
1983	-3,5439	1999	-0,1353	2015	-1,0526
1984	-2,5550	2000	0,1164	2016	1,9946
1985	-0,1353	2001	-1,0526	2017	-0,0759
1986	0,1164	2002	1,9946	2018	2,3542
1987	-1,0526	2003	-0,0759		

The comparative graphs of the evolution of CO_2 emissions accelerations and their recomputing after the Fourier regression is:
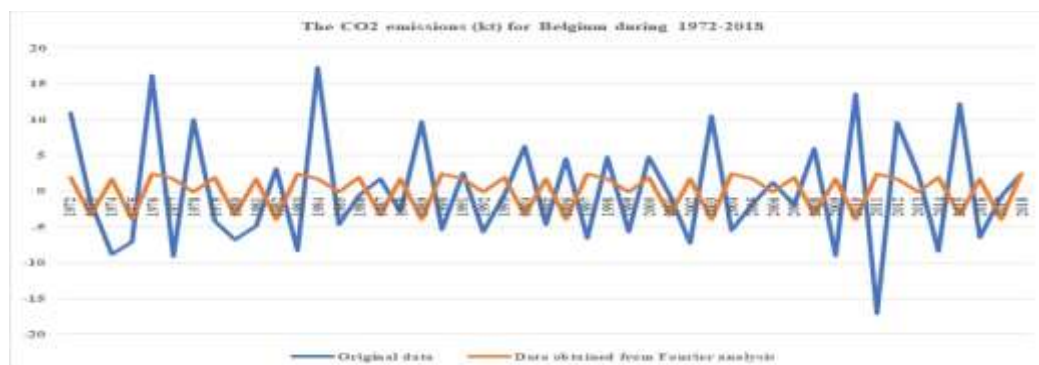
The Fourier analysis for the period 1972-2018

Figure 3.

Based on this analysis, and using the growth rate (in percents) corresponding to 60,8817, the forecast of CO2 emissions for the next 5 years is:

Year	CO2 emissions (kt)
2019	66170,643
2020	106456,456
2021	171268,956
2022	275540,407
2023	443294,092

5.4. Cyprus

Table 10. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	17,0889	1988	-16,0579	2004	-10,0549
1973	-23,6631	1989	4,9731	2005	2,8474
1974	-26,9839	1990	-0,1237	2006	-1,1857
1975	25,8776	1991	6,1569	2007	2,8888
1976	21,5873	1992	-4,0836	2008	-1,8366
1977	-16,1111	1993	-2,3124	2009	-4,5607
1978	-3,1135	1994	-0,5703	2010	-1,7820
1979	1,6993	1995	-6,4101	2011	0,9483
1980	-0,0815	1996	8,3991	2012	-3,5672
1981	-11,8662	1997	-4,7459	2013	-2,0969
1982	6,8337	1998	3,3390	2014	14,9162
1983	-1,9233	1999	-0,8305	2015	-5,3550
1984	2,8401	2000	-0,1516	2016	5,0128
1985	-5,2565	2001	-5,7981	2017	-3,3593
1986	16,8372	2002	4,5776	2018	-3,0568
1987	1,9332	2003	6,6853		

Source: https://unctadstat.unctad.org and own calculations

By analysing the data set (k,ρk), corresponding to the period [1972,2018], we found that the minimum average absolute error 6,0908 is obtained applying Fourier Analysis for T=17 for the range of years: [1991,2007].

The optimal number of Fourier series terms is 9 being specified in the table 11.

Table 11

a_0	**-1,5706**						
a_1	**0,0740**	b_1	**0,6505**	a_2	**-0,0641**	b_2	**-0,3728**
a_3	**-0,1553**	b_3	**0,3628**	a_4	**-0,1303**	b_4	**-0,3125**
a_5	**0,0402**	b_5	**-0,1454**	a_6	**0,0152**	b_6	**-0,1829**
a_7	**0,1063**	b_7	**0,3792**	a_8	**0,0540**	b_8	**-0,0894**
a_9	**0,0643**	b_9	**-0,0881**	a_{10}	**-**	b_{10}	**-**
a_{11}	**-**	b_{11}	**-**	a_{12}	**-**	b_{12}	**-**
a_{13}	**-**	b_{13}	**-**	a_{14}	**-**	b_{14}	**-**
a_{15}	**-**	b_{15}	**-**	a_{16}	**-**	b_{16}	**-**
a_{17}	**-**	b_{17}	**-**	a_{18}	**-**	b_{18}	**-**
a_{19}	**-**	b_{19}	**-**	a_{20}	**-**	b_{20}	**-**

The recalculated values of CO_2 emissions are:

Table 12. The Evolution of the Accelerations (Percents) of CO_2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	**0,1030**	**1988**	**0,1030**	**2004**	**0,1030**
1973	**-0,1765**	**1989**	**-0,1765**	**2005**	**-0,1765**
1974	**0,6029**	**1990**	**0,6029**	**2006**	**0,6029**
1975	**-1,0400**	**1991**	**-1,0400**	**2007**	**-1,0400**
1976	**-2,0654**	**1992**	**-2,0654**	**2008**	**-2,0654**
1977	**-1,5342**	**1993**	**-1,5342**	**2009**	**-1,5342**
1978	**-1,9569**	**1994**	**-1,9569**	**2010**	**-1,9569**
1979	**-0,4876**	**1995**	**-0,4876**	**2011**	**-0,4876**
1980	**-1,5088**	**1996**	**-1,5088**	**2012**	**-1,5088**
1981	**-0,6456**	**1997**	**-0,6456**	**2013**	**-0,6456**
1982	**-0,9826**	**1998**	**-0,9826**	**2014**	**-0,9826**
1983	**-0,7809**	**1999**	**-0,7809**	**2015**	**-0,7809**
1984	**-1,1363**	**2000**	**-1,1363**	**2016**	**-1,1363**
1985	**-0,0476**	**2001**	**-0,0476**	**2017**	**-0,0476**
1986	**0,2294**	**2002**	**0,2294**	**2018**	**0,2294**
1987	**-1,1376**	**2003**	**-1,1376**		

The comparative graphs of the evolution of CO_2 emissions accelerations and their recomputing after the Fourier regression is:
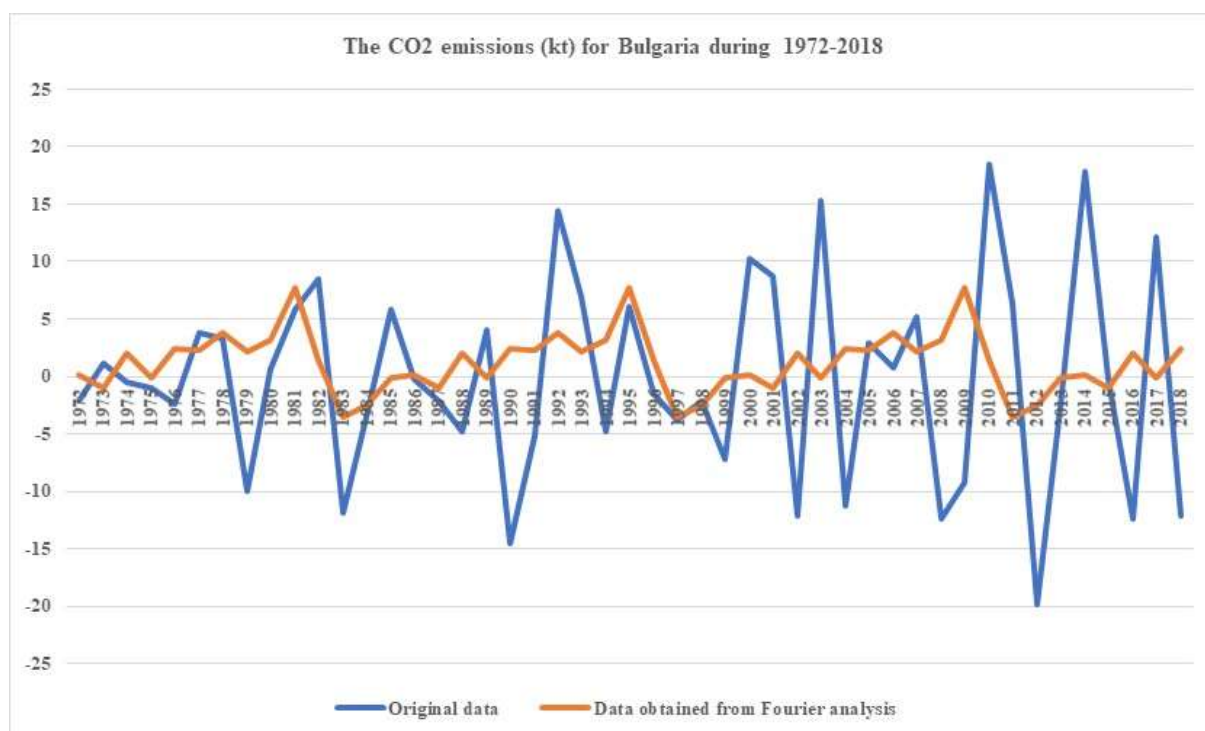
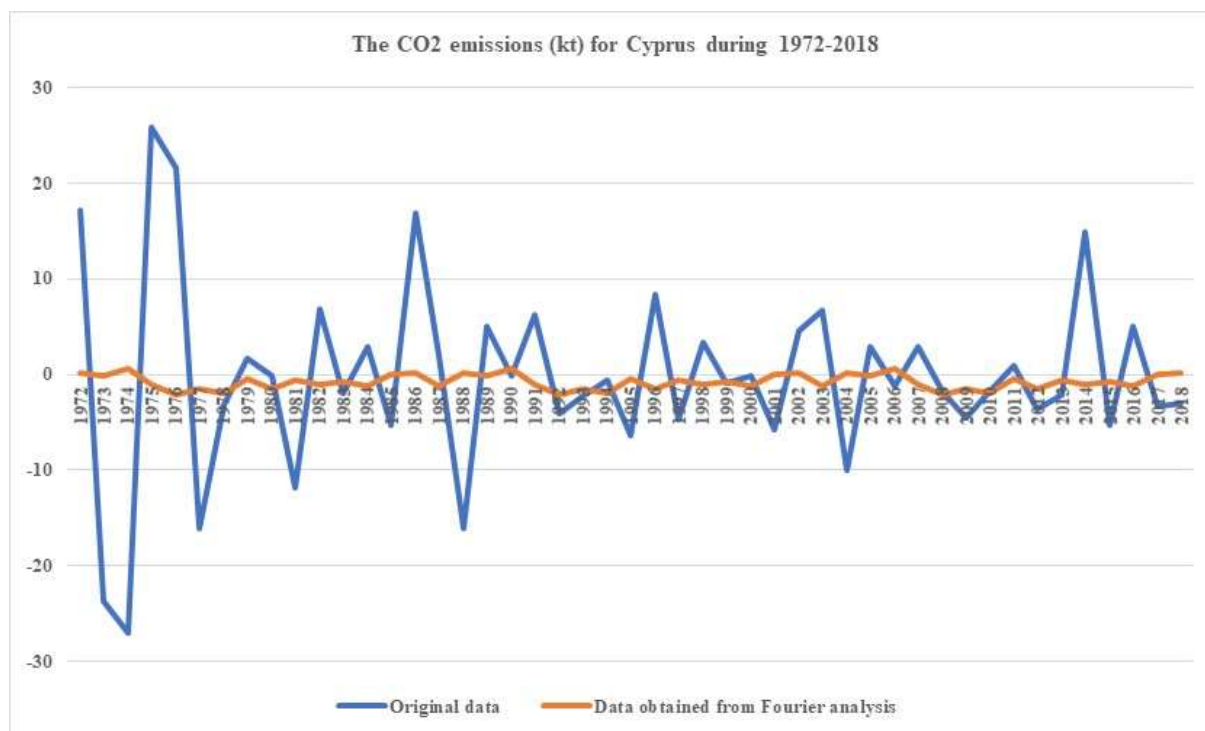The Fourier analysis for the period 1972-2018

Figure 4

Based on this analysis, and using the growth rate (in percents) corresponding to -26,0189, the forecast of CO_2 emissions for the next 5 years is:

Year	CO2 emissions (kt)
2019	5348,834
2020	3957,126
2021	2927,525
2022	2165,815
2023	1602,294

5.5. Czech Republic

Table 13. The evolution of the accelerations (percents) of CO2 emissions during the period 1992-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	-	1988	-	2004	-3,0315
1973	-	1989	-	2005	-3,3325
1974	-	1990	-	2006	3,2868
1975	-	1991	-	2007	2,0124
1976	-	1992	6,8388	2008	-6,8156
1977	-	1993	-0,3396	2009	-1,7318
1978	-	1994	-2,4313	2010	8,5177
1979	-	1995	5,1639	2011	-5,0720
1980	-	1996	0,8693	2012	-0,8438
1981	-	1997	-2,7848	2013	-0,7192
1982	-	1998	-3,1653	2014	1,2609
1983	-	1999	-1,1572	2015	4,1245
1984	-	2000	15,8834	2016	0,6287
1985	-	2001	-10,3876	2017	-1,3174
1986	-	2002	-3,0490	2018	-1,4533
1987	-	2003	6,9915		

Source: https://unctadstat.unctad.org and own calculations

By analysing the data set (k,ρk), corresponding to the period [1992,2018], we found that the minimum average absolute error 2,9752 is obtained applying Fourier Analysis for T=8 for the range of years: [2005,2012].

The optimal number of Fourier series terms is 8 being specified in the table 14.

Table 14

a_0	-1,5139						
a_1	0,0972	b_1	-0,7362	a_2	0,8652	b_2	1,1772
a_3	0,3255	b_3	-0,1312	a_4	-0,1831	b_4	0,4841
a_5	-0,1384	b_5	-0,1687	a_6	-0,0027	b_6	0,2275
a_7	-1,5139	b_7	-0,1822	a_8	-0,0015	b_8	0,1510
a_9	0,0972	b_9		a_{10}	-	b_{10}	-
a_{11}	-	b_{11}	-	a_{12}	-	b_{12}	-
a_{13}	-	b_{13}	-	a_{14}	-	b_{14}	-
a_{15}	-	b_{15}	-	a_{16}	-	b_{16}	-
a_{17}	-	b_{17}	-	a_{18}	-	b_{18}	-
a_{19}	-	b_{19}	-	a_{20}	-	b_{20}	-

The recalculated values of CO_2 emissions are:

Table 15. The Evolution of the Accelerations (Percents) of CO_2 Emissions during the Period 1992-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	-	1988	-	2004	-1,9311
1973	-	1989	-	2005	-0,3633
1974	-	1990	-	2006	0,7605
1975	-	1991	-	2007	-1,4742
1976	-	1992	0,7605	2008	-0,7730
1977	-	1993	-1,4742	2009	0,9197
1978	-	1994	-0,7730	2010	-2,4372
1979	-	1995	0,9197	2011	-1,9311
1980	-	1996	-2,4372	2012	-0,3633
1981	-	1997	-1,9311	2013	0,7605
1982	-	1998	-0,3633	2014	-1,4742
1983	-	1999	0,7605	2015	-0,7730
1984	-	2000	-1,4742	2016	0,9197
1985	-	2001	-0,7730	2017	-2,4372
1986	-	2002	0,9197	2018	-1,9311
1987	-	2003	-2,4372		

The comparative graphs of the evolution of CO_2 emissions accelerations and their recomputing after the Fourier regression is:

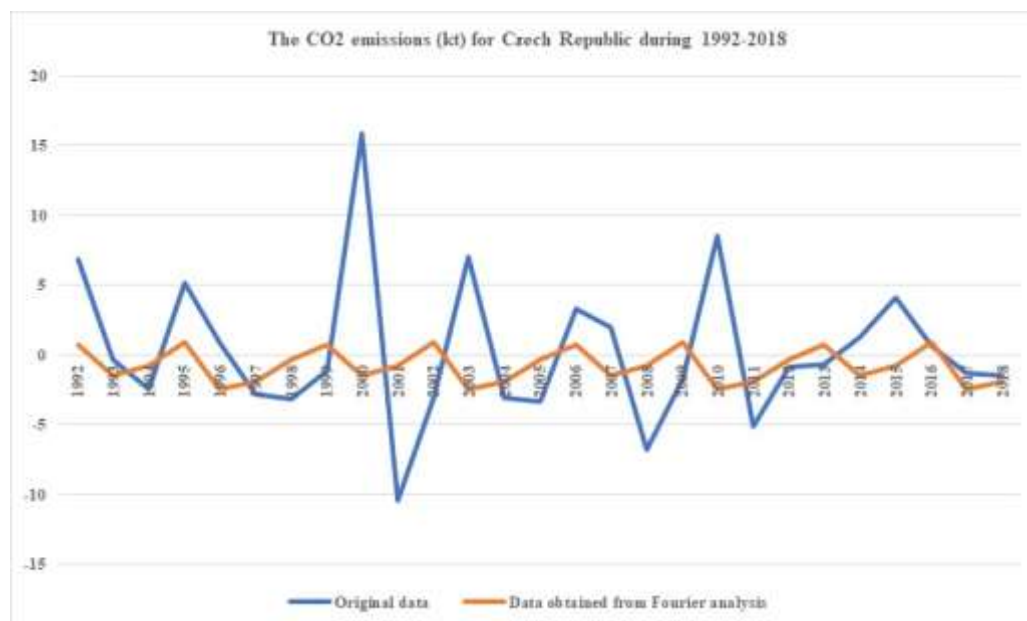The Fourier analysis for the period 1992-2018

Figure 5

Based on this analysis, and using the growth rate (in percents) corresponding to -20,8311, the forecast of CO_2 emissions for the next 5 years is:

Year	CO2 emissions (kt)
2019	81132,289
2020	64231,541
2021	50851,404
2022	40258,497
2023	31872,209

5.6. Germany

Table 16. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1992-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	-	1988	-	2004	-2,2836
1973	-	1989	-	2005	-0,3942
1974	-	1990	-	2006	3,7680
1975	-	1991	-	2007	-5,2483
1976	-	1992	-1,8481	2008	4,5129
1977	-	1993	3,6064	2009	-7,7114
1978	-	1994	-0,6197	2010	12,1600
1979	-	1995	0,9521	2011	-8,6416
1980	-	1996	3,7077	2012	5,2612
1981	-	1997	-6,9252	2013	0,4895
1982	-	1998	2,6371	2014	-7,4788
1983	-	1999	-2,5604	2015	5,8154
1984	-	2000	3,0590	2016	-0,0016
1985	-	2001	2,4910	2017	-2,6529
1986	-	2002	-3,7883	2018	-1,0939
1987	-	2003	2,0942		

Source: https://unctadstat.unctad.org and own calculations

By analysing the data set (k,ρk), corresponding to the period [1992,2018], we found that the minimum average absolute error 3,1622 is obtained applying Fourier Analysis for T=13 for the range of years: [2003,2015].

The optimal number of Fourier series terms is 17 being specified in the table 17.

Table 17.

a_0	0,4634						
a_1	0,0298	b_1	0,6018	a_2	0,1702	b_2	-0,2187
a_3	-0,0038	b_3	0,2089	a_4	0,1524	b_4	-0,4606
a_5	0,5431	b_5	0,3849	a_6	0,3406	b_6	-0,1211
a_7	0,2771	b_7	-0,0185	a_8	0,0381	b_8	-0,0210
a_9	-0,0004	b_9	0,0844	a_{10}	0,0068	b_{10}	-0,0784
a_{11}	0,0002	b_{11}	0,0671	a_{12}	-	b_{12}	-0,0605
a_{13}	0,0002	b_{13}	0,0551	a_{14}	0,0035	b_{14}	-0,0489
a_{15}	-0,0002	b_{15}	0,0471	a_{16}	0,0095	b_{16}	-0,0628
a_{17}	0,0470	b_{17}	0,0635	a_{18}	-	b_{18}	-
a_{19}	-	b_{19}	-	a_{20}	-	b_{20}	-

The recalculated values of CO_2 emissions are:

Table 18. The Evolution of the Accelerations (Percents) of CO_2 Emissions during the Period 1992-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	-	1988	-	2004	-0,6927
1973	-	1989	-	2005	0,0937
1974	-	1990	-	2006	-0,9744
1975	-	1991	-	2007	0,4573
1976	-	1992	-0,6927	2008	-0,9446
1977	-	1993	0,0937	2009	1,8459
1978	-	1994	-0,9744	2010	-0,7426
1979	-	1995	0,4573	2011	1,2128
1980	-	1996	-0,9446	2012	0,7959
1981	-	1997	1,8459	2013	-0,2359
1982	-	1998	-0,7426	2014	1,9051
1983	-	1999	1,2128	2015	0,0597
1984	-	2000	0,7959	2016	-0,6927
1985	-	2001	-0,2359	2017	0,0937
1986	-	2002	1,9051	2018	-0,9744
1987	-	2003	0,0597		

The comparative graphs of the evolution of CO_2 emissions accelerations and their recomputing after the Fourier regression is:

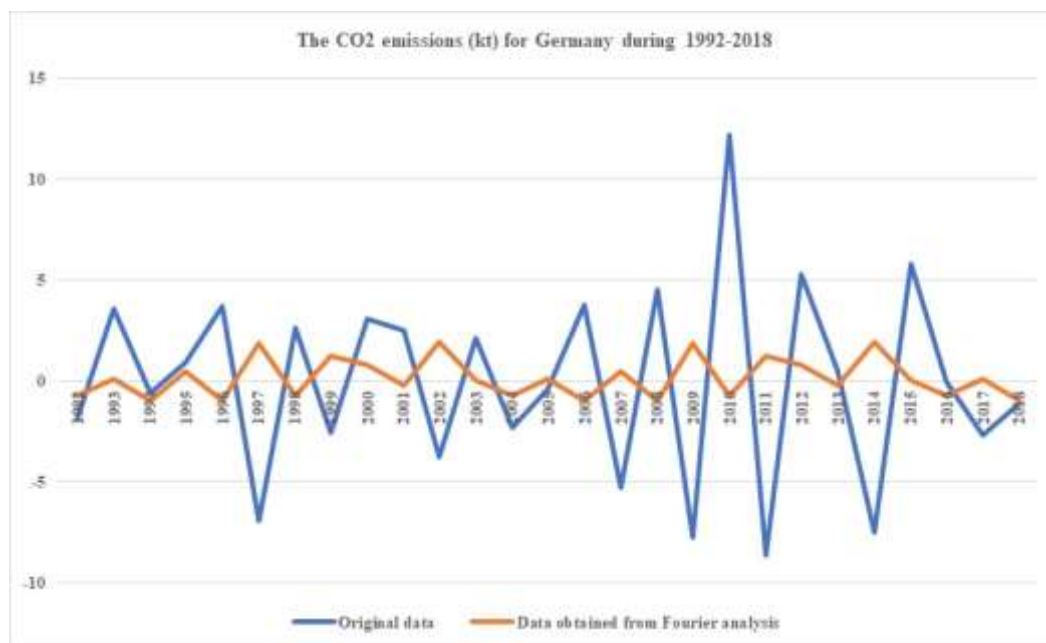The Fourier analysis for the period 1992-2018

Figure 6

Based on this analysis, and using the growth rate (in percents) corresponding to 3,9870, the forecast of CO_2 emissions for the next 5 years is:

Year	CO2 emissions (kt)
2019	737829,360
2020	767246,616
2021	797836,739
2022	829646,490
2023	862724,495

5.7. Denmark

Table 19. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	12,6375	1988	-4,5912	2004	-19,1140
1973	-5,1574	1989	-5,9282	2005	2,4670
1974	-6,4327	1990	18,2243	2006	22,5121
1975	8,3376	1991	13,6969	2007	-24,0579
1976	6,5385	1992	-29,5677	2008	2,1209
1977	-4,9624	1993	13,1177	2009	1,6930
1978	-4,0276	1994	2,5785	2010	5,0549
1979	4,2578	1995	-11,7527	2011	-11,1701
1980	-7,2514	1996	27,5047	2012	-0,7606
1981	-10,0402	1997	-35,3994	2013	15,9574
1982	17,8956	1998	6,8235	2014	-15,1876
1983	-10,2379	1999	1,5926	2015	4,5150
1984	7,9227	2000	-2,8079	2016	11,3379
1985	16,7443	2001	9,6242	2017	-11,0918
1986	-20,0583	2002	-1,9214	2018	5,9442
1987	0,9948	2003	9,6882		

Source: https://unctadstat.unctad.org and own calculations

By analysing the data set $(k, \rho k)$, corresponding to the period [1972,2018], we found that the minimum average absolute error 9,2640 is obtained applying Fourier Analysis for T=15 for the range of years: [1983,1997].

The optimal number of Fourier series terms is 9 being specified in the table 20.

Table 20.

a_0	-2,0181						
a_1	0,2753	b_1	-0,2434	a_2	0,1890	b_2	-0,1259
a_3	0,0446	b_3	-1,1538	a_4	0,0953	b_4	0,0962
a_5	0,1192	b_5	-1,8537	a_6	0,5999	b_6	0,4925
a_7	-0,0771	b_7	-0,0500	a_8	0,3374	b_8	-0,2005
a_9	0,0368	b_9	0,5117	a_{10}		b_{10}	
a_{11}		b_{11}		a_{12}		b_{12}	
a_{13}		b_{13}		a_{14}		b_{14}	
a_{15}		b_{15}		a_{16}		b_{16}	
a_{17}		b_{17}		a_{18}	-	b_{18}	-
a_{19}		b_{19}	-	a_{20}	-	b_{20}	-

The recalculated values of CO_2 emissions are:

Table 21. The Evolution of the Accelerations (Percents) of CO_2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	-0,6722	1988	-1,4418	2004	0,6113
1973	-1,2617	1989	1,2646	2005	-4,3028
1974	-1,4418	1990	0,6113	2006	0,3759
1975	1,2646	1991	-4,3028	2007	-0,8931
1976	0,6113	1992	0,3759	2008	-2,4868
1977	-4,3028	1993	-0,8931	2009	1,7493
1978	0,3759	1994	-2,4868	2010	-5,3706
1979	-0,8931	1995	1,7493	2011	-0,1861
1980	-2,4868	1996	-5,3706	2012	1,3811
1981	1,7493	1997	-0,1861	2013	-2,8937
1982	-5,3706	1998	1,3811	2014	-0,6722
1983	-0,1861	1999	-2,8937	2015	-1,2617
1984	1,3811	2000	-0,6722	2016	-1,4418
1985	-2,8937	2001	-1,2617	2017	1,2646
1986	-0,6722	2002	-1,4418	2018	0,6113
1987	-1,2617	2003	1,2646		

The comparative graphs of the evolution of CO_2 emissions accelerations and their recomputing after the Fourier regression is:

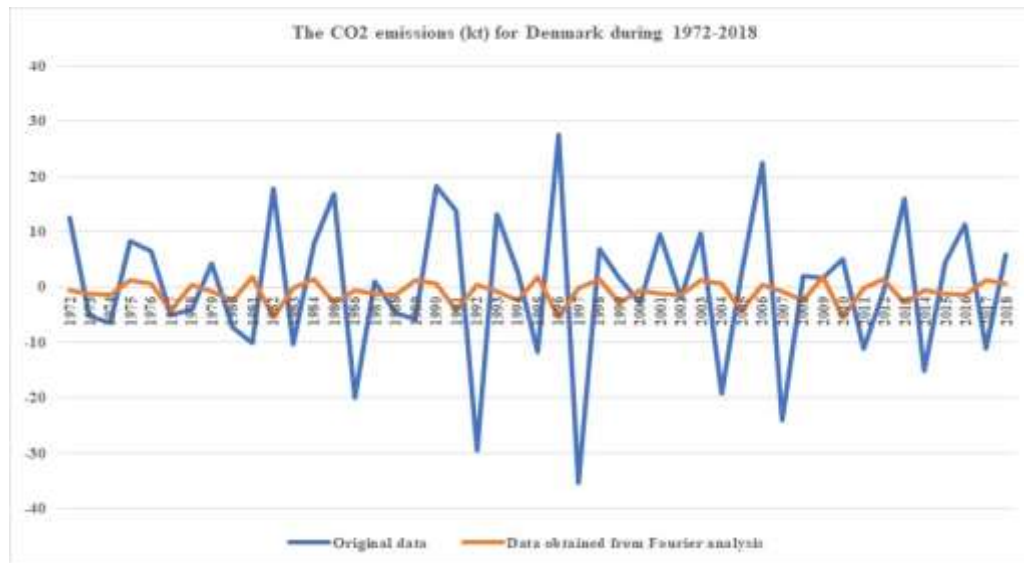The Fourier analysis for the period 1972-2018

Figure 7

Based on this analysis, and using the growth rate (in percents) corresponding to -51,9930, the forecast of CO_2 emissions for the next 5 years is:

Year	CO2 emissions (kt)
2019	16024,737
2020	7692,995
2021	3693,176
2022	1772,983
2023	851,156

5.8. Euro Area

Table 22. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1992-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	-	1988	-	2004	-1,6370
1973	-	1989	-	2005	-0,7988
1974	-	1990	-	2006	-0,2777
1975	-	1991	-	2007	-0,7623
1976	-	1992	-3,3842	2008	-0,7747
1977	-	1993	0,7294	2009	-5,3794
1978	-	1994	2,0111	2010	10,0809
1979	-	1995	2,0294	2011	-6,2990
1980	-	1996	0,2714	2012	2,5042
1981	-	1997	-3,3121	2013	-0,7455
1982	-	1998	2,6954	2014	-3,3685
1983	-	1999	-2,1912	2015	7,5181
1984	-	2000	1,2821	2016	-2,3346
1985	-	2001	1,0826	2017	0,3020
1986	-	2002	-1,6194	2018	-2,3317
1987	-	2003	1,9559		

Source: https://unctadstat.unctad.org and own calculations

By analysing the data set (k,ρk), corresponding to the period [1992,2018], we found that the minimum average absolute error 1,9936 is obtained applying Fourier Analysis for T=8 for the range of years: [2005,2012].

The optimal number of Fourier series terms is 8 being specified in the table 23.

Table 23.

a_0	-2,0181						
a_1	0,2753	b_1	-0,2434	a_2	0,1890	b_2	-0,1259
a_3	0,0446	b_3	-1,1538	a_4	0,0953	b_4	0,0962
a_5	0,1192	b_5	-1,8537	a_6	0,5999	b_6	0,4925
a_7	-0,0771	b_7	-0,0500	a_8	0,3374	b_8	-0,2005
a_9	0,0368	b_9	0,5117	a_{10}		b_{10}	
a_{11}		b_{11}		a_{12}		b_{12}	
a_{13}		b_{13}		a_{14}		b_{14}	
a_{15}		b_{15}		a_{16}		b_{16}	
a_{17}		b_{17}		a_{18}	-	b_{18}	-
a_{19}		b_{19}	-	a_{20}	-	b_{20}	-

The recalculated values of CO_2 emissions are:

Table 24. The evolution of the accelerations (percents) of CO_2 emissions during the period 1992-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	-	1988	-	2004	0,0824
1973	-	1989	-	2005	-0,3844
1974	-	1990	-	2006	-0,3565
1975	-	1991	-	2007	-0,4490
1976	-	1992	-0,3565	2008	-1,3612
1977	-	1993	-0,4490	2009	1,8259
1978	-	1994	-1,3612	2010	-1,6409
1979	-	1995	1,8259	2011	0,0824
1980	-	1996	-1,6409	2012	-0,3844
1981	-	1997	0,0824	2013	-0,3565
1982	-	1998	-0,3844	2014	-0,4490
1983	-	1999	-0,3565	2015	-1,3612
1984	-	2000	-0,4490	2016	1,8259
1985	-	2001	-1,3612	2017	-1,6409
1986	-	2002	1,8259	2018	0,0824
1987	-	2003	-1,6409		

The comparative graphs of the evolution of CO_2 emissions accelerations and their recomputing after the Fourier regression is:

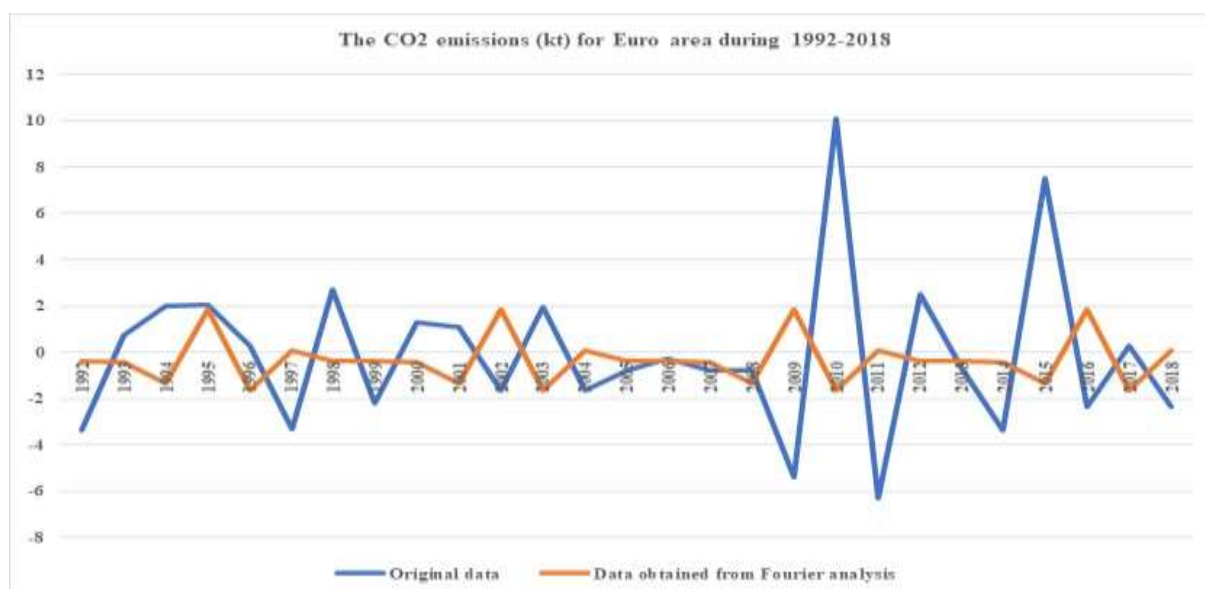The Fourier analysis for the period 1992-2018

Figure 8.

Based on this analysis, and using the growth rate (in percents) corresponding to -8,7504, the forecast of CO2 emissions for the next 5 years is:

Year	CO2 emissions (kt)
2019	2014261,920
2020	1838005,945
2021	1677173,073
2022	1530413,720
2023	1396496,398

5.9. Spain

Table 25. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	2,6498	1988	4,0570	2004	3,4138
1973	-5,5705	1989	9,6136	2005	-0,8512
1974	4,3166	1990	-19,0266	2006	-6,9402
1975	-6,5422	1991	8,4843	2007	6,2623
1976	4,3432	1992	1,2779	2008	-12,3793
1977	-10,6487	1993	-10,8030	2009	-2,7074
1978	3,8689	1994	10,9265	2010	6,3591
1979	-0,8459	1995	0,5598	2011	5,3741
1980	3,9031	1996	-9,6612	2012	-2,2904
1981	-9,1139	1997	12,4004	2013	-7,9608
1982	4,8516	1998	-4,9833	2014	9,0725
1983	-3,6634	1999	5,5605	2015	7,1157
1984	-0,4869	2000	-3,2318	2016	-9,9672
1985	4,0336	2001	-4,8851	2017	10,2522
1986	-6,4965	2002	5,5879	2018	-8,5788
1987	5,5657	2003	-4,2028		

Source: https://unctadstat.unctad.org and own calculations

By analysing the data set (k,ρk), corresponding to the period [1972,2018], we found that the minimum average absolute error 5,3376 is obtained applying Fourier Analysis for T=6 for the range of years: [1991,1996].

The optimal number of Fourier series terms is 8 being specified in the table 26.

Table 26.

a_0	-1,7110						
a_1	1,0242	b_1	2,0629	a_2	2,0578	b_2	-2,4364
a_3	-0,9146	b_3	0,8840	a_4	-0,0640	b_4	-0,9774
a_5	-	b_5	0,7081	a_6	-0,0284	b_6	-0,5490
a_7	-0,1680	b_7	0,5602	a_8	0,1286	b_8	-0,4009
a_9		b_9		a_{10}		b_{10}	
a_{11}		b_{11}		a_{12}		b_{12}	
a_{13}		b_{13}		a_{14}		b_{14}	
a_{15}		b_{15}		a_{16}		b_{16}	
a_{17}		b_{17}		a_{18}	-	b_{18}	-
a_{19}		b_{19}	-	a_{20}	-	b_{20}	-

The recalculated values of CO_2 emissions are:

Table 27. The Evolution of the Accelerations (Percents) of CO_2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	-6,4058	1988	1,7252	2004	0,3909
1973	1,7252	1989	0,3909	2005	-1,2846
1974	0,3909	1990	-1,2846	2006	1,2968
1975	-1,2846	1991	1,2968	2007	-6,4058
1976	1,2968	1992	-6,4058	2008	1,7252
1977	-6,4058	1993	1,7252	2009	0,3909
1978	1,7252	1994	0,3909	2010	-1,2846
1979	0,3909	1995	-1,2846	2011	1,2968
1980	-1,2846	1996	1,2968	2012	-6,4058
1981	1,2968	1997	-6,4058	2013	1,7252
1982	-6,4058	1998	1,7252	2014	0,3909
1983	1,7252	1999	0,3909	2015	-1,2846
1984	0,3909	2000	-1,2846	2016	1,2968
1985	-1,2846	2001	1,2968	2017	-6,4058
1986	1,2968	2002	-6,4058	2018	1,7252
1987	-6,4058	2003	1,7252		

The comparative graphs of the evolution of CO_2 emissions accelerations and their recomputing after the Fourier regression is:

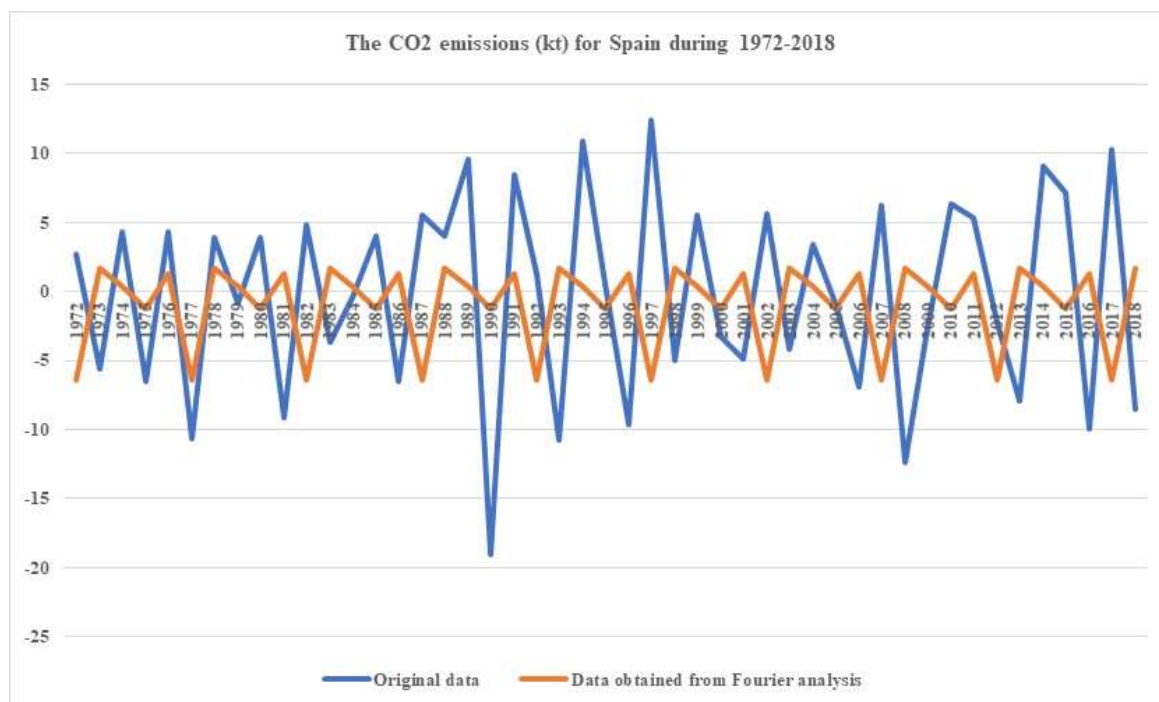The Fourier analysis for the period 1972-2018

Figure 9.

Based on this analysis, and using the growth rate (in percents) corresponding to -33,1270, the forecast of CO2 emissions for the next 5 years is:

Year	CO2 emissions (kt)
2019	172759,708
2020	115529,600
2021	77258,109
2022	51664,815
2023	34549,812

5.10. Estonia

Table 28. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1992-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	-	1988	-	2004	-12,7223
1973	-	1989	-	2005	0,6472
1974	-	1990	-	2006	-8,3666
1975	-	1991	-	2007	32,1059
1976	-	1992	-13,7197	2008	-32,7802
1977	-	1993	1,2104	2009	-10,3478
1978	-	1994	20,5588	2010	44,4099
1979	-	1995	-6,8265	2011	-30,5994
1980	-	1996	15,2664	2012	-2,6398
1981	-	1997	-8,2462	2013	21,3983
1982	-	1998	-1,1788	2014	-21,5014
1983	-	1999	-3,1323	2015	-6,6095
1984	-	2000	4,0191	2016	15,5703
1985	-	2001	5,6714	2017	2,2039
1986	-	2002	-5,9837	2018	-5,7455
1987	-	2003	16,0694		

Source: https://unctadstat.unctad.org and own calculations

By analysing the data set (k,ρk), corresponding to the period [1992,2018], we found that the minimum average absolute error 10,5742 is obtained applying Fourier Analysis for T=8 for the range of years: [2004,2011].

The optimal number of Fourier series terms is 8 being specified in the table 29.

Table 29

a_0	-3,7569						
a_1	0,2310	b_1	-0,5283	a_2	-4,7772	b_2	2,8665
a_3	-3,4236	b_3	-0,2372	a_4	1,9258	b_4	0,3243
a_5	0,7644	b_5	0,1657	a_6	-0,0064	b_6	0,1888
a_7		b_7	-0,1495	a_8	-0,0036	b_8	0,1227
a_9		b_9		a_{10}		b_{10}	
a_{11}		b_{11}		a_{12}		b_{12}	
a_{13}		b_{13}		a_{14}		b_{14}	
a_{15}		b_{15}		a_{16}		b_{16}	
a_{17}		b_{17}		a_{18}	-	b_{18}	-
a_{19}		b_{19}	-	a_{20}	-	b_{20}	-

The recalculated values of CO_2 emissions are:

Table 30. The Evolution of the Accelerations (Percents) of CO_2 Emissions during the Period 1992-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	-	1988	-	2004	-2,3116
1973	-	1989	-	2005	-2,3355
1974	-	1990	-	2006	5,7065
1975	-	1991	-	2007	-8,5618
1976	-	1992	5,7065	2008	-4,0517
1977	-	1993	-8,5618	2009	7,3002
1978	-	1994	-4,0517	2010	-8,8950
1979	-	1995	7,3002	2011	-2,3116
1980	-	1996	-8,8950	2012	-2,3355
1981	-	1997	-2,3116	2013	5,7065
1982	-	1998	-2,3355	2014	-8,5618
1983	-	1999	5,7065	2015	-4,0517
1984	-	2000	-8,5618	2016	7,3002
1985	-	2001	-4,0517	2017	-8,8950
1986	-	2002	7,3002	2018	-2,3116
1987	-	2003	-8,8950		

The comparative graphs of the evolution of CO_2 emissions accelerations and their recomputing after the Fourier regression is:

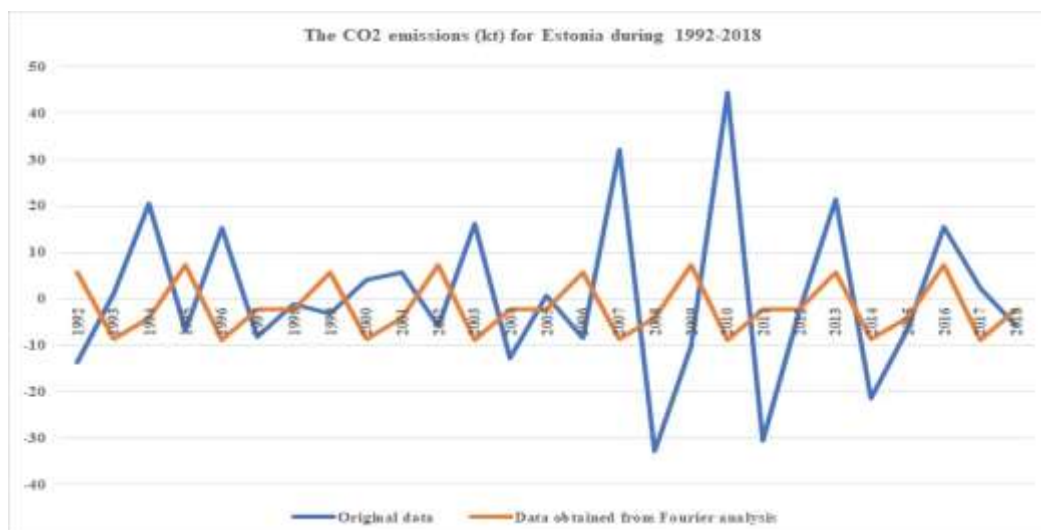The Fourier analysis for the period 1992-2018

Figure 10

Based on this analysis, and using the growth rate (in percents) corresponding to -50,2601, the forecast of CO_2 emissions for the next 5 years is:

Year	CO2 emissions (kt)
2019	**7958,384**
2020	**3958,492**
2021	**1968,950**
2022	**979,354**
2023	**487,130**

5.11. European Union

Table 31. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	**2,9424**	**1988**	**-3,7899**	**2004**	**-2,5629**
1973	**0,2530**	**1989**	**4,6389**	**2005**	**-0,7107**
1974	**-6,1319**	**1990**	**-10,6716**	**2006**	**0,7832**
1975	**-1,7395**	**1991**	**6,5044**	**2007**	**-1,3731**
1976	**10,2705**	**1992**	**-2,1517**	**2008**	**-1,0944**
1977	**-9,1896**	**1993**	**1,4671**	**2009**	**-5,1481**
1978	**4,7680**	**1994**	**1,4117**	**2010**	**10,1321**
1979	**-0,3679**	**1995**	**1,9696**	**2011**	**-5,7840**
1980	**-4,6867**	**1996**	**1,2707**	**2012**	**1,1369**
1981	**-5,1432**	**1997**	**-4,8422**	**2013**	**-0,5143**
1982	**3,9081**	**1998**	**1,7270**	**2014**	**-2,4228**
1983	**0,5593**	**1999**	**-1,3688**	**2015**	**6,8826**
1984	**1,5200**	**2000**	**1,8163**	**2016**	**-1,7857**
1985	**1,9840**	**2001**	**1,4555**	**2017**	**0,5235**
1986	**-2,5194**	**2002**	**-1,8635**	**2018**	**-2,6746**
1987	**2,8888**	**2003**	**2,9149**		

Source: https://unctadstat.unctad.org and own calculations

By analysing the data set (k,ρk), corresponding to the period [1972,2018], we found that the minimum average absolute error 2,8207 is obtained applying Fourier Analysis for T=8 for the range of years: [2007,2014].

The optimal number of Fourier series terms is 10 being specified in the table 32.

Table 32.

a₀	0,1679						
a_1	-0,0147	b_1	1,6360	a_2	-0,3785	b_2	-1,1983
a_3	-0,6272	b_3	1,4210	a_4	0,3528	b_4	-0,3116
a_5	0,0606	b_5	0,5192	a_6	0,0004	b_6	-0,4483
a_7	-	b_7	0,3627	a_8	0,0002	b_8	-0,3033
a_9	0,0187	b_9	0,2786	a_{10}	0,0564	b_{10}	-0,3056
a_{11}		b_{11}		a_{12}		b_{12}	
a_{13}		b_{13}		a_{14}		b_{14}	
a_{15}		b_{15}		a_{16}		b_{16}	
a_{17}		b_{17}		a_{18}	-	b_{18}	-
a_{19}		b_{19}	-	a_{20}	-	b_{20}	-

The recalculated values of CO_2 emissions are:

Table 33. The Evolution of the Accelerations (Percents) of CO_2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	0,6780	1988	1,2073	2004	0,8319
1973	-3,4517	1989	-1,7237	2005	1,0709
1974	1,2073	1990	0,8319	2006	1,9750
1975	-1,7237	1991	1,0709	2007	0,6780
1976	0,8319	1992	1,9750	2008	-3,4517
1977	1,0709	1993	0,6780	2009	1,2073
1978	1,9750	1994	-3,4517	2010	-1,7237
1979	0,6780	1995	1,2073	2011	0,8319
1980	-3,4517	1996	-1,7237	2012	1,0709
1981	1,2073	1997	0,8319	2013	1,9750
1982	-1,7237	1998	1,0709	2014	0,6780
1983	0,8319	1999	1,9750	2015	-3,4517
1984	1,0709	2000	0,6780	2016	1,2073
1985	1,9750	2001	-3,4517	2017	-1,7237
1986	0,6780	2002	1,2073	2018	0,8319
1987	-3,4517	2003	-1,7237		

The comparative graphs of the evolution of CO_2 emissions accelerations and their recomputing after the Fourier regression is:

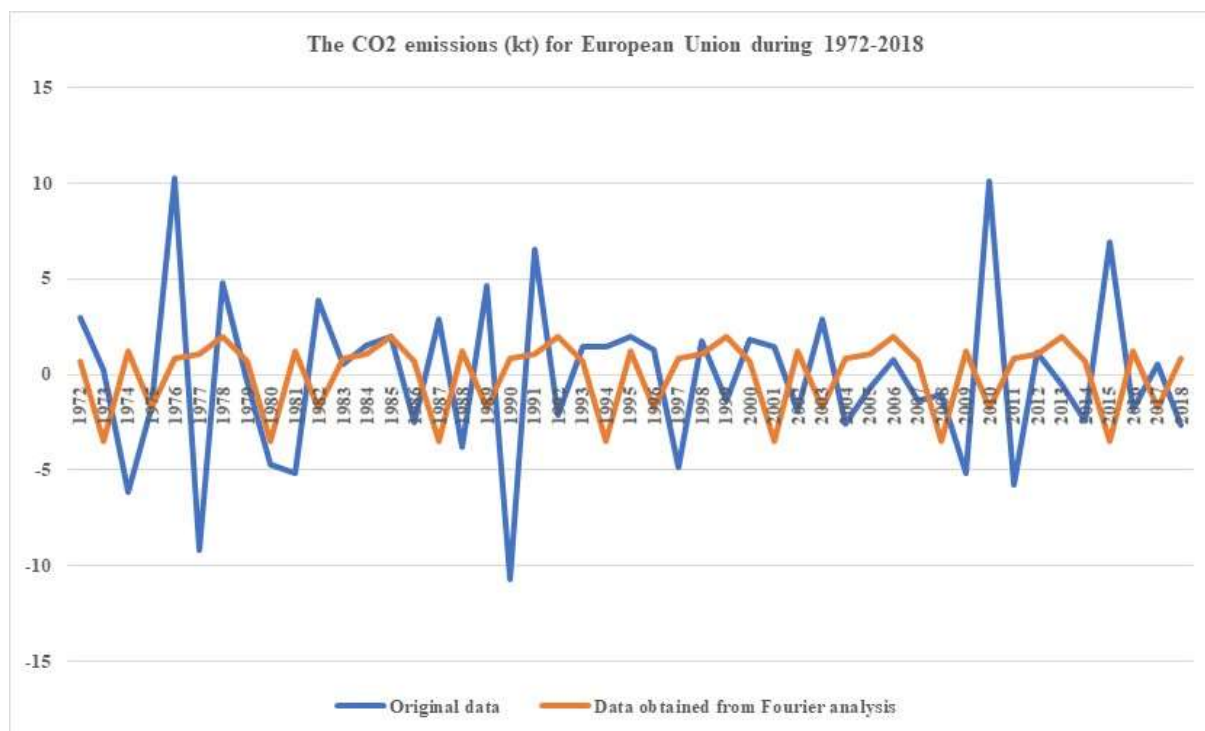The Fourier analysis for the period 1972-2018

Figure 11

Based on this analysis, and using the growth rate (in percents) corresponding to 3,9762, the forecast of CO2 emissions for the next 5 years is:

Year	CO2 emissions (kt)
2019	2985156,702
2020	3103852,503
2021	3227267,886
2022	3355590,512
2023	3489015,502

5.12. Finland

Table 34. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	8,3560	1988	-17,6032	2004	-18,6558
1973	3,0136	1989	10,2552	2005	-12,4357
1974	-17,3123	1990	2,9904	2006	38,8995
1975	4,2385	1991	-2,7116	2007	-23,7087
1976	12,4725	1992	-6,2143	2008	-10,0999
1977	-13,2979	1993	7,4267	2009	8,5877
1978	5,4401	1994	9,8454	2010	19,7886
1979	1,2885	1995	-18,5100	2011	-27,2619
1980	2,5392	1996	17,9604	2012	1,4911
1981	-18,7663	1997	-14,6694	2013	11,9378
1982	-4,7943	1998	-2,4097	2014	-9,6081
1983	12,8612	1999	4,1992	2015	0,7938
1984	5,1299	2000	-1,1681	2016	13,9849
1985	15,9071	2001	13,3662	2017	-12,6560
1986	-10,1628	2002	-7,0243	2018	9,0456
1987	0,7379	2003	9,1891		

Source: https://unctadstat.unctad.org and own calculations

By analysing the data set (k,ρk), corresponding to the period [1972,2018], we found that the minimum average absolute error 9,3696 is obtained applying Fourier Analysis for T=11 for the range of years: [2004,2014].

The optimal number of Fourier series terms is 9 being specified in the table 35.

Table 35.

a_0	1,6821						
a_1	-0,4299	b_1	3,3309	a_2	1,0736	b_2	-1,8827
a_3	1,0148	b_3	-1,6187	a_4	-0,0192	b_4	-0,3765
a_5	1,1309	b_5	0,8422	a_6	-0,0085	b_6	-1,0024
a_7	0,1864	b_7	1,1567	a_8	0,0671	b_8	-0,5403
a_9	-0,0053	b_9	0,4788	a_{10}		b_{10}	
a_{11}		b_{11}		a_{12}		b_{12}	
a_{13}		b_{13}		a_{14}		b_{14}	
a_{15}		b_{15}		a_{16}		b_{16}	
a_{17}		b_{17}		a_{18}	-	b_{18}	-
a_{19}		b_{19}	-	a_{20}	-	b_{20}	-

The recalculated values of CO2 emissions are:

Table 36. The evolution of the accelerations (percents) of CO2 emissions during the period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	5,6131	1988	1,2336	2004	0,0571
1973	3,0157	1989	3,8510	2005	3,1244
1974	0,0571	1990	-2,5101	2006	-5,8432
1975	3,1244	1991	2,8939	2007	-3,0253
1976	-5,8432	1992	5,6131	2008	1,2336
1977	-3,0253	1993	3,0157	2009	3,8510
1978	1,2336	1994	0,0571	2010	-2,5101
1979	3,8510	1995	3,1244	2011	2,8939
1980	-2,5101	1996	-5,8432	2012	5,6131
1981	2,8939	1997	-3,0253	2013	3,0157
1982	5,6131	1998	1,2336	2014	0,0571
1983	3,0157	1999	3,8510	2015	3,1244
1984	0,0571	2000	-2,5101	2016	-5,8432
1985	3,1244	2001	2,8939	2017	-3,0253
1986	-5,8432	2002	5,6131	2018	1,2336
1987	-3,0253	2003	3,0157		

The comparative graphs of the evolution of CO2 emissions accelerations and their recomputing after the Fourier regression is:

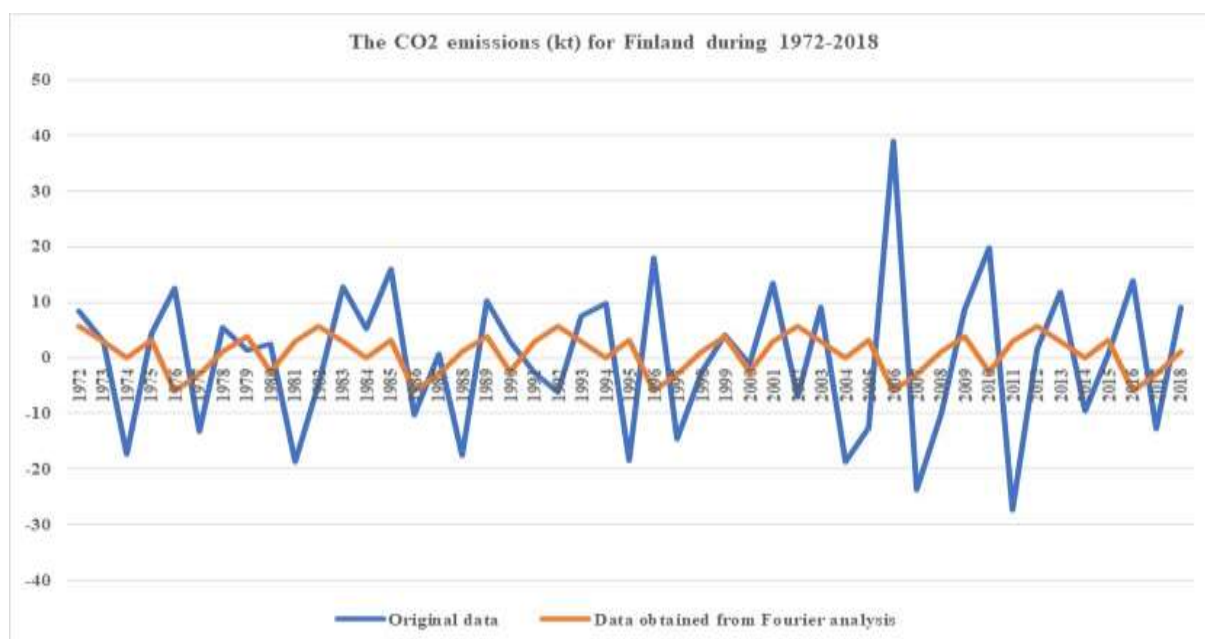The Fourier analysis for the period 1972-2018

Figure 12

Based on this analysis, and using the growth rate (in percents) corresponding to 38,2792, the forecast of CO_2 emissions for the next 5 years is:

Year	CO2 emissions (kt)
2019	61340,653
2020	84821,364
2021	117290,304
2022	162188,094
2023	224272,399

5.13. France

Table 37. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	-1,3787	1988	0,7066	2004	-1,2330
1973	3,5055	1989	6,3544	2005	0,4648
1974	-10,8547	1990	-13,6860	2006	-3,1805
1975	-7,0568	1991	15,5048	2007	0,0826
1976	23,5804	1992	-9,9335	2008	1,0434
1977	-18,0247	1993	-2,0290	2009	-2,7053
1978	10,0935	1994	3,7443	2010	5,1810
1979	-0,5941	1995	3,7091	2011	-5,3221
1980	-9,1014	1996	2,1867	2012	4,9810
1981	-5,5290	1997	-6,8480	2013	-0,7503
1982	6,1089	1998	8,5339	2014	-9,6249
1983	0,6453	1999	-7,7582	2015	11,5027
1984	-0,8134	2000	1,1520	2016	-1,2617
1985	2,9833	2001	1,4392	2017	0,4619
1986	-2,7071	2002	-2,4797	2018	-3,1902
1987	1,7017	2003	3,0374		

Source: https://unctadstat.unctad.org and own calculations

By analysing the data set (k,ρk), corresponding to the period [1972,2018], we found that the minimum average absolute error 4,8235 is obtained applying Fourier Analysis for T=17 for the range of years: [1972,1988].

The optimal number of Fourier series terms is 9 being specified in the table 38.

Table 38.

a_0	-0,9829						
a_1	-0,0648	b_1	0,8604	a_2	-0,2258	b_2	-0,3225
a_3	-0,0109	b_3	0,6018	a_4	-0,1232	b_4	-0,3496
a_5	-0,2925	b_5	0,7294	a_6	0,4075	b_6	0,0439
a_7	-0,0660	b_7	-0,2634	a_8	-0,2262	b_8	-0,1134
a_9	-0,0399	b_9	0,3385	a_{10}	-	b_{10}	-
a_{11}	-	b_{11}	-	a_{12}	-	b_{12}	-
a_{13}	-	b_{13}	-	a_{14}	-	b_{14}	-
a_{15}	-	b_{15}	-	a_{16}	-	b_{16}	-
a_{17}	-	b_{17}	-	a_{18}	-	b_{18}	-
a_{19}	-	b_{19}	-	a_{20}	-	b_{20}	-

The recalculated values of CO2 emissions are:

Table 39. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	-0,1852	1988	-0,1852	2004	-0,1852
1973	-2,7341	1989	-2,7341	2005	-2,7341
1974	-1,9985	1990	-1,9985	2006	-1,9985
1975	0,8503	1991	0,8503	2007	0,8503
1976	-2,6124	1992	-2,6124	2008	-2,6124
1977	0,0562	1993	0,0562	2009	0,0562
1978	-1,0780	1994	-1,0780	2010	-1,0780
1979	-1,3495	1995	-1,3495	2011	-1,3495
1980	-1,1333	1996	-1,1333	2012	-1,1333
1981	0,2149	1997	0,2149	2013	0,2149
1982	0,0768	1998	0,0768	2014	0,0768
1983	-0,1799	1999	-0,1799	2015	-0,1799
1984	0,5673	2000	0,5673	2016	0,5673
1985	0,0038	2001	0,0038	2017	0,0038
1986	0,6218	2002	0,6218	2018	0,6218
1987	1,0165	2003	1,0165		

The comparative graphs of the evolution of CO2 emissions accelerations and their recomputing after the Fourier regression is:

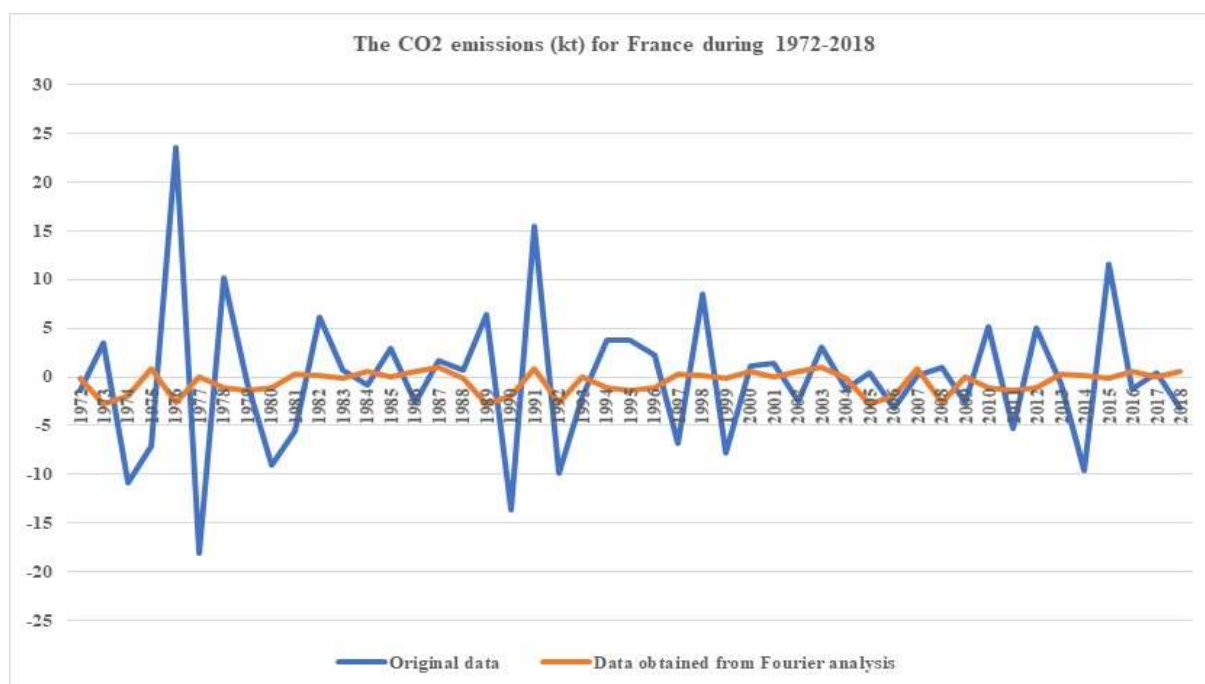The Fourier analysis for the period 1972-2018

Figure 13.

Based on this analysis, and using the growth rate (in percents) corresponding to -19,2715, the forecast of CO2 emissions for the next 5 years is:

Year	CO2 emissions (kt)
2019	250226,059
2020	202003,744
2021	163074,592
2022	131647,672
2023	106277,191

5.14. Greece

Table 40. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	-1,5851	1988	-0,2249	2004	-4,1166
1973	4,4888	1989	1,9918	2005	2,4724
1974	-20,7877	1990	-7,1730	2006	-3,3293
1975	10,1156	1991	-1,6720	2007	4,8110
1976	3,0556	1992	2,8481	2008	-7,3238
1977	-0,8575	1993	-3,2277	2009	-1,9079
1978	-7,2267	1994	2,2152	2010	-1,9107
1979	4,3793	1995	1,8006	2011	4,0978
1980	-6,4164	1996	-3,9973	2012	-1,8153
1981	-1,6406	1997	1,3049	2013	-4,2268
1982	4,1884	1998	2,8151	2014	5,4593
1983	3,6992	1999	-3,7135	2015	1,8283
1984	-3,7915	2000	7,7679	2016	0,5086
1985	3,4951	2001	-5,8017	2017	1,6308
1986	-8,6416	2002	-2,2865	2018	-2,1857
1987	9,7691	2003	3,7578		

Source: https://unctadstat.unctad.org and own calculations

By analysing the data set (k,ρk), corresponding to the period [1972,2018], we found that the minimum average absolute error 3,7242 is obtained applying Fourier Analysis for T=7 for the range of years: [1983,1989].

The optimal number of Fourier series terms is 9 being specified in the table 41.

Table 41.

a_0	0,6048						
a_1	0,7013	b_1	-0,3021	a_2	0,3893	b_2	1,0342
a_3	1,1427	b_3	-0,3588	a_4	0,0973	b_4	0,1451
a_5	0,0281	b_5	-0,2462	a_6	-	b_6	0,1794
a_7	0,0143	b_7	-0,1380	a_8	0,0243	b_8	0,1655
a_9	0,1270	b_9	-0,1196	a_{10}	-	b_{10}	-
a_{11}	-	b_{11}	-	a_{12}	-	b_{12}	-
a_{13}	-	b_{13}	-	a_{14}	-	b_{14}	-
a_{15}	-	b_{15}	-	a_{16}	-	b_{16}	-
a_{17}	-	b_{17}	-	a_{18}	-	b_{18}	-
a_{19}	-	b_{19}	-	a_{20}	-	b_{20}	-

The recalculated values of CO_2 emissions are:

Table 42. The evolution of the accelerations (percents) of CO_2 emissions during the period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	2,0260	1988	-0,1364	2004	2,8266
1973	-1,5964	1989	-1,1999	2005	-0,1054
1974	2,8266	1990	2,0260	2006	-0,1364
1975	-0,1054	1991	-1,5964	2007	-1,1999
1976	-0,1364	1992	2,8266	2008	2,0260
1977	-1,1999	1993	-0,1054	2009	-1,5964
1978	2,0260	1994	-0,1364	2010	2,8266
1979	-1,5964	1995	-1,1999	2011	-0,1054
1980	2,8266	1996	2,0260	2012	-0,1364
1981	-0,1054	1997	-1,5964	2013	-1,1999
1982	-0,1364	1998	2,8266	2014	2,0260
1983	-1,1999	1999	-0,1054	2015	-1,5964
1984	2,0260	2000	-0,1364	2016	2,8266
1985	-1,5964	2001	-1,1999	2017	-0,1054
1986	2,8266	2002	2,0260	2018	-0,1364
1987	-0,1054	2003	-1,5964		

The comparative graphs of the evolution of CO_2 emissions accelerations and their recomputing after the Fourier regression is:

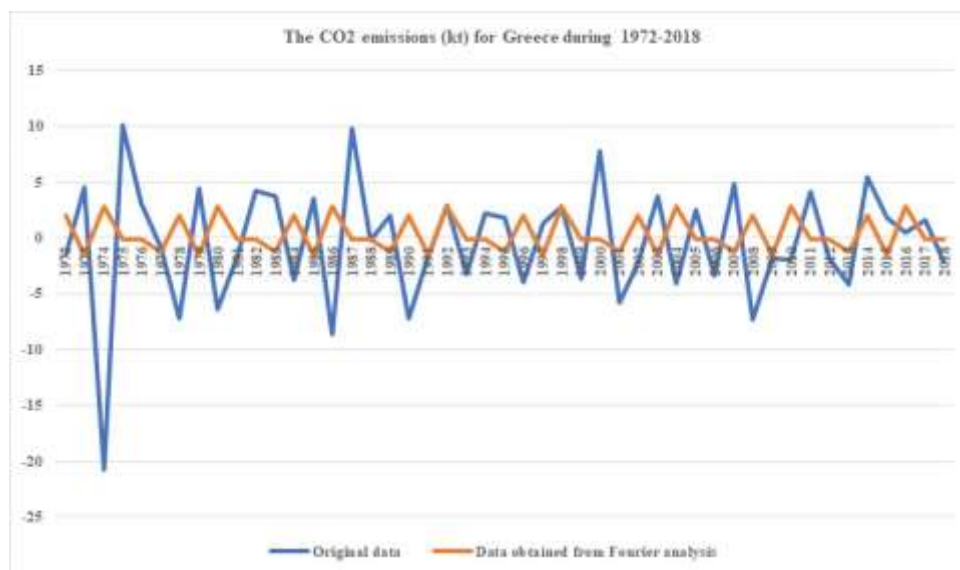The Fourier analysis for the period 1972-2018

Figure 14.

Based on this analysis, and using the growth rate (in percents) corresponding to 30,8145, the forecast of CO_2 emissions for the next 5 years is:

Year	CO_2 emissions (kt)
2019	85408,787
2020	111727,078
2021	146155,218
2022	191192,218
2023	250107,144

5.15. Croatia

Table 43. The Evolution of the Accelerations (Percents) of CO_2 Emissions during the Period 1992-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	-	1988	-	2004	-8,8719
1973	-	1989	-	2005	4,0191
1974	-	1990	-	2006	-1,0068
1975	-	1991	-	2007	5,1756
1976	-	1992	30,2930	2008	-10,8982
1977	-	1993	1,2872	2009	-1,5077
1978	-	1994	-7,8036	2010	2,2994
1979	-	1995	8,1044	2011	2,0740
1980	-	1996	-4,2332	2012	-6,1400
1981	-	1997	11,5369	2013	5,8928
1982	-	1998	-2,8189	2014	-1,7025
1983	-	1999	-8,1118	2015	6,1888
1984	-	2000	-2,7017	2016	-0,5220
1985	-	2001	8,8563	2017	1,6289
1986	-	2002	-0,7462	2018	-8,3364
1987	-	2003	0,9332		

Source: https://unctadstat.unctad.org and own calculations

By analysing the data set (k,ρk), corresponding to the period [1992,2018], we found that the minimum average absolute error 3,5661 is obtained applying Fourier Analysis for T=5 for the range of years: [2003,2007].

The optimal number of Fourier series terms is 8 being specified in the table 44.

Table 44.

a_0	-1,6972						
a_1	1,4393	b_1	-0,2933	a_2	-1,6282	b_2	0,3225
a_3	0,1599	b_3	-0,2541	a_4	-	b_4	0,1612
a_5	0,0576	b_5	-0,1149	a_6	-0,1809	b_6	0,1075
a_7	0,0294	b_7	-0,0993	a_8		b_8	0,0806
a_9		b_9		a_{10}	-	b_{10}	
a_{11}	-	b_{11}	-	a_{12}	-	b_{12}	-
a_{13}	-	b_{13}	-	a_{14}	-	b_{14}	-
a_{15}	-	b_{15}	-	a_{16}	-	b_{16}	-
a_{17}	-	b_{17}	-	a_{18}	-	b_{18}	-
a_{19}	-	b_{19}	-	a_{20}	-	b_{20}	-

The recalculated values of CO_2 emissions are:

Table 45. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1992-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	-	1988	-	2004	1,0153
1973	-	1989	-	2005	-0,9715
1974	-	1990	-	2006	0,9057
1975	-	1991	-	2007	-4,3438
1976	-	1992	1,0153	2008	1,0153
1977	-	1993	-0,9715	2009	-0,9715
1978	-	1994	0,9057	2010	0,9057
1979	-	1995	-4,3438	2011	-4,3438
1980	-	1996	1,0153	2012	1,0153
1981	-	1997	-0,9715	2013	-0,9715
1982	-	1998	0,9057	2014	0,9057
1983	-	1999	-4,3438	2015	-4,3438
1984	-	2000	1,0153	2016	1,0153
1985	-	2001	-0,9715	2017	-0,9715
1986	-	2002	0,9057	2018	0,9057
1987	-	2003	-4,3438		

The comparative graphs of the evolution of CO2 emissions accelerations and their recomputing after the Fourier regression is:

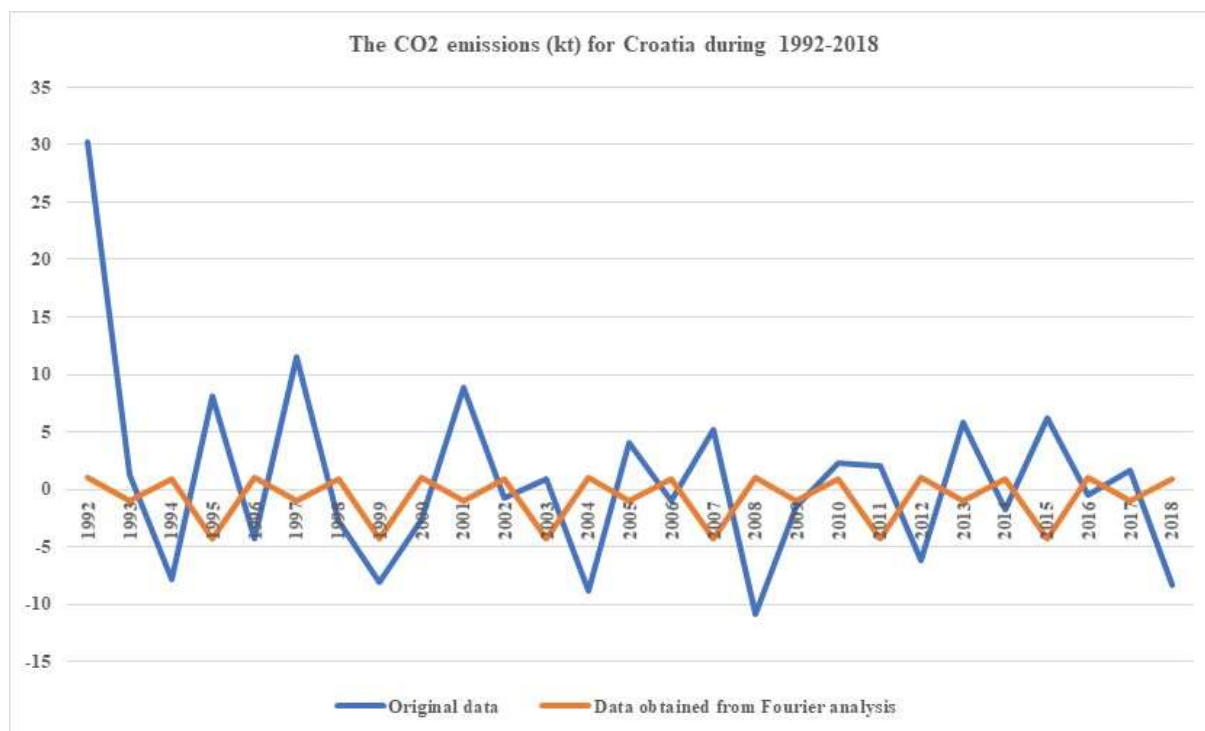The Fourier analysis for the period 1992-2018

Figure 15.

Based on this analysis, and using the growth rate (in percents) corresponding to -19,4163, the forecast of CO2 emissions for the next 5 years is:

Year	CO2 emissions (kt)
2019	13360,777
2020	10766,609
2021	8676,132
2022	6991,548
2023	5634,048

5.16. Hungary

Table 46. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	1,2490	1988	-8,3846	2004	-7,8336
1973	5,0223	1989	4,5307	2005	2,3974
1974	-3,8241	1990	-8,6163	2006	-0,1310
1975	0,3217	1991	7,1378	2007	-1,9915
1976	4,3967	1992	-5,8903	2008	1,3440
1977	-2,1464	1993	10,8024	2009	-8,2459
1978	2,0022	1994	-1,6829	2010	9,8705
1979	-8,2099	1995	0,4220	2011	-2,1095
1980	2,9519	1996	2,3992	2012	-5,3926
1981	-1,0100	1997	-4,3080	2013	1,2707
1982	0,5707	1998	3,1462	2014	5,8289
1983	2,3166	1999	0,3448	2015	7,0873
1984	-0,6834	2000	-6,6405	2016	-4,2327
1985	-7,1521	2001	8,7209	2017	2,1181
1986	2,2457	2002	-4,2470	2018	-4,9975
1987	4,0566	2003	5,8638		

Source: https://unctadstat.unctad.org and own calculations

By analysing the data set (k,ρk), corresponding to the period [1972,2018], we found that the minimum average absolute error 3,6530 is obtained applying Fourier Analysis for T=8 for the range of years: [1998,2005].

The optimal number of Fourier series terms is 10 being specified in the table 47.

Table 47.

a_0	-0,9326						
a_1	0,2799	b_1	-0,4313	a_2	0,0683	b_2	-0,3729
a_3	-0,1544	b_3	0,9523	a_4	0,0869	b_4	0,6019
a_5	-0,0109	b_5	-0,1021	a_6	-0,0078	b_6	0,0175
a_7	-	b_7	-0,0216	a_8	-0,0044	b_8	0,0233
a_9	-0,0034	b_9	0,0053	a_{10}	0,0139	b_{10}	-0,0751
a_{11}	-	b_{11}	-	a_{12}	-	b_{12}	-
a_{13}	-	b_{13}	-	a_{14}	-	b_{14}	-
a_{15}	-	b_{15}	-	a_{16}	-	b_{16}	-
a_{17}	-	b_{17}	-	a_{18}	-	b_{18}	-
a_{19}	-	b_{19}	-	a_{20}	-	b_{20}	-

The recalculated values of CO_2 emissions are:

Table 48. The evolution of the accelerations (percents) of CO_2 emissions during the period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	1,5919	1988	0,8148	2004	-0,0633
1973	-1,2318	1989	-2,2251	2005	-0,4206
1974	0,8148	1990	-0,0633	2006	-1,7301
1975	-2,2251	1991	-0,4206	2007	1,5919
1976	-0,0633	1992	-1,7301	2008	-1,2318
1977	-0,4206	1993	1,5919	2009	0,8148
1978	-1,7301	1994	-1,2318	2010	-2,2251
1979	1,5919	1995	0,8148	2011	-0,0633
1980	-1,2318	1996	-2,2251	2012	-0,4206
1981	0,8148	1997	-0,0633	2013	-1,7301
1982	-2,2251	1998	-0,4206	2014	1,5919
1983	-0,0633	1999	-1,7301	2015	-1,2318
1984	-0,4206	2000	1,5919	2016	0,8148
1985	-1,7301	2001	-1,2318	2017	-2,2251
1986	1,5919	2002	0,8148	2018	-0,0633
1987	-1,2318	2003	-2,2251		

The comparative graphs of the evolution of CO_2 emissions accelerations and their recomputing after the Fourier regression is:

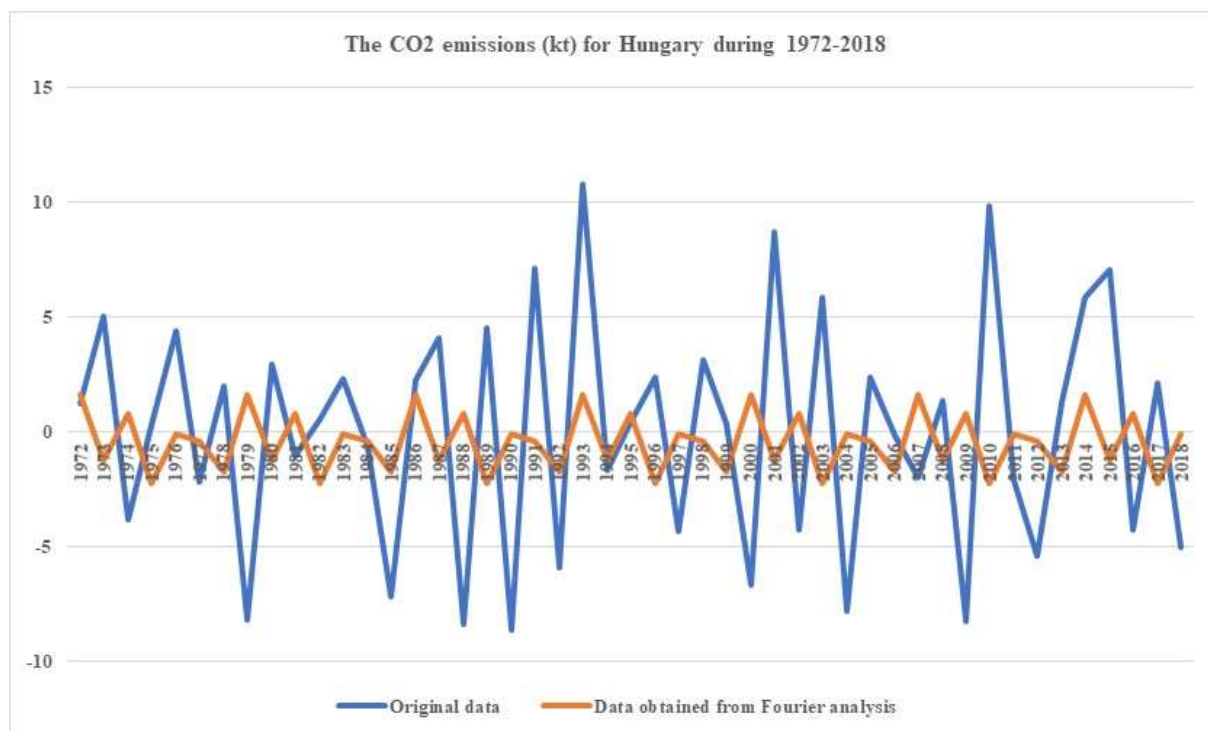The Fourier analysis for the period 1972-2018

Figure 16.

Based on this analysis, and using the growth rate (in percents) corresponding to -21,7307, the forecast of CO_2 emissions for the next 5 years is:

Year	CO2 emissions (kt)
2019	36309,128
2020	28418,901
2021	22243,275
2022	17409,655
2023	13626,415

5.17. Ireland

Table 49. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	-17,8582	1988	-7,0398	2004	1,0386
1973	5,6304	1989	1,7677	2005	2,8327
1974	-1,7171	1990	2,6814	2006	-2,0782
1975	-7,3069	1991	-1,6260	2007	-3,8542
1976	6,4633	1992	-1,3913	2008	0,2275
1977	4,6098	1993	0,1576	2009	-10,0746
1978	-5,6916	1994	3,3401	2010	10,5487
1979	16,1792	1995	-1,8981	2011	-9,5587
1980	-20,3319	1996	2,5021	2012	12,5447
1981	3,3131	1997	-1,0108	2013	-5,7549
1982	-1,0631	1998	3,6262	2014	3,2438
1983	2,5186	1999	-2,8076	2015	4,5265
1984	-1,3304	2000	1,6459	2016	0,5993
1985	5,3815	2001	-0,4362	2017	-7,6982
1986	2,0545	2002	-7,3103	2018	1,9292
1987	-0,8752	2003	2,3459		

Source: https://unctadstat.unctad.org and own calculations

By analysing the data set (k,ρk), corresponding to the period [1972,2018], we found that the minimum average absolute error 4,0184 is obtained applying Fourier Analysis for T=14 for the range of years: [1974,1987].

The optimal number of Fourier series terms is 20 being specified in the table 50.

Table 50.

a_0	1,2475						
a_1	-0,1596	b_1	0,1426	a_2	-0,3521	b_2	0,2637
a_3	0,2117	b_3	0,1320	a_4	0,0947	b_4	0,4512
a_5	0,5490	b_5	-0,0328	a_6	0,0882	b_6	-0,4971
a_7	-0,0648	b_7	-0,3427	a_8	-0,2145	b_8	-0,0301
a_9	-0,0187	b_9	0,1028	a_{10}	-0,0191	b_{10}	0,0008
a_{11}	0,0116	b_{11}	0,0179	a_{12}	0,0011	b_{12}	-0,0067
a_{13}	-	b_{13}	0,0065	a_{14}	0,0008	b_{14}	-0,0064
a_{15}	0,0063	b_{15}	0,0002	a_{16}	-0,0074	b_{16}	-0,0090
a_{17}	-0,0052	b_{17}	-0,0212	a_{18}	-0,0424	b_{18}	-0,0009
a_{19}	-0,0088	b_{19}	0,0526	a_{20}	0,0079	b_{20}	0,0392

The recalculated values of CO_2 emissions are:

Table 51. The Evolution of the Accelerations (Percents) of CO_2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	0,9403	1988	1,3048	2004	2,5946
1973	0,5437	1989	1,1444	2005	-2,0940
1974	-0,3405	1990	-0,1679	2006	0,9419
1975	1,3048	1991	2,5946	2007	0,4405
1976	1,1444	1992	-2,0940	2008	0,9619
1977	-0,1679	1993	0,9419	2009	0,4566
1978	2,5946	1994	0,4405	2010	1,3825
1979	-2,0940	1995	0,9619	2011	0,9403
1980	0,9419	1996	0,4566	2012	0,5437
1981	0,4405	1997	1,3825	2013	-0,3405
1982	0,9619	1998	0,9403	2014	1,3048
1983	0,4566	1999	0,5437	2015	1,1444
1984	1,3825	2000	-0,3405	2016	-0,1679
1985	0,9403	2001	1,3048	2017	2,5946
1986	0,5437	2002	1,1444	2018	-2,0940
1987	-0,3405	2003	-0,1679		

The comparative graphs of the evolution of CO_2 emissions accelerations and their recomputing after the Fourier regression is:

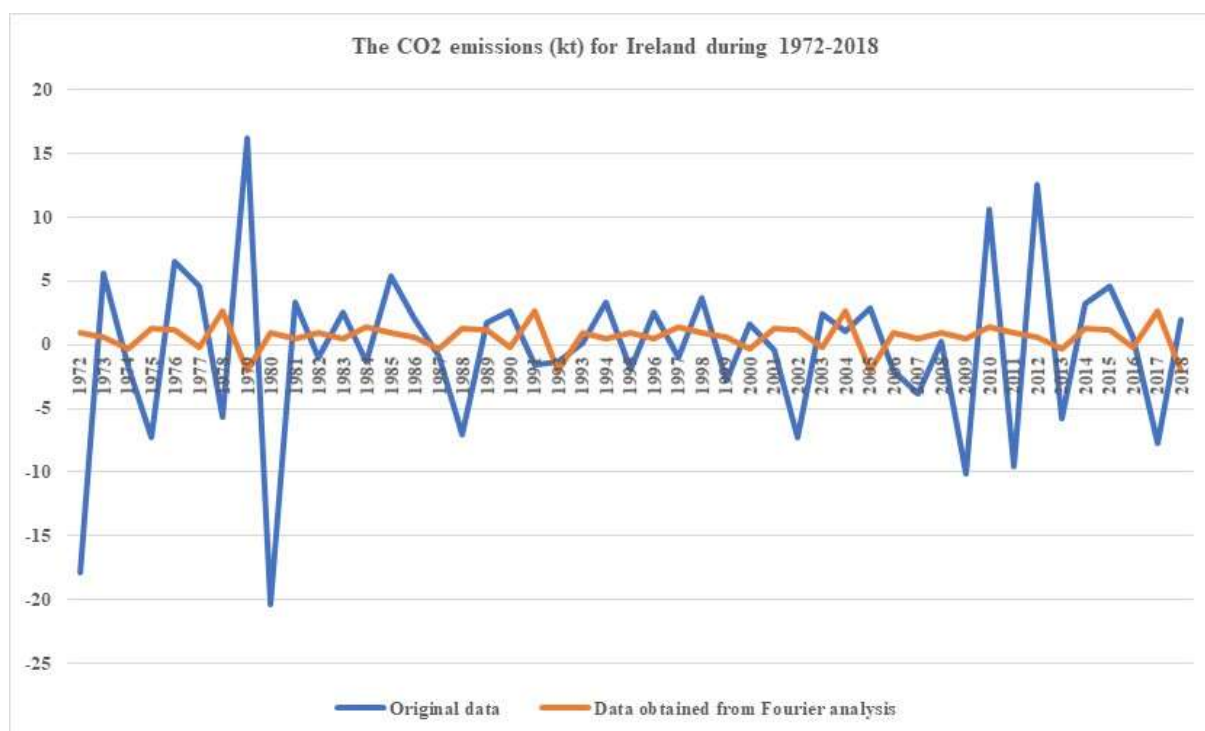The Fourier analysis for the period 1972-2018

Figure 17.

Based on this analysis, and using the growth rate (in percents) corresponding to 44,1377, the forecast of CO_2 emissions for the next 5 years is:

Year	CO2 emissions (kt)
2019	53489,500
2020	77098,536
2021	111128,056
2022	160177,424
2023	230876,055

5.18. Italy

Table 52. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	0,5748	**1988**	-3,1058	**2004**	-2,0145
1973	2,1275	**1989**	3,3148	**2005**	-1,9084
1974	-6,2704	**1990**	-5,7990	**2006**	-1,8159
1975	-6,1921	**1991**	0,5983	**2007**	-0,0448
1976	12,0604	**1992**	-0,1519	**2008**	-1,5725
1977	-10,3357	**1993**	-0,8820	**2009**	-7,6364
1978	7,8214	**1994**	0,1585	**2010**	12,8367
1979	-0,9764	**1995**	7,3201	**2011**	-4,1848
1980	-3,4251	**1996**	-7,1765	**2012**	-2,9095
1981	-3,2030	**1997**	1,8431	**2013**	-3,0159
1982	0,6091	**1998**	1,7935	**2014**	2,5698
1983	-0,0438	**1999**	-1,0539	**2015**	8,6392
1984	3,9890	**2000**	-0,7975	**2016**	-4,5043
1985	-0,5195	**2001**	-0,6979	**2017**	0,0928
1986	-2,7462	**2002**	1,5186	**2018**	-0,0734
1987	6,2245	**2003**	2,6430		

Source: https://unctadstat.unctad.org and own calculations

By analysing the data set (k,ρk), corresponding to the period [1972,2018], we found that the minimum average absolute error 3,1008 is obtained applying Fourier Analysis for T=32 for the range of years: [1981,2012].

The optimal number of Fourier series terms is 20 being specified in the table 53.

Table 53.

a0	-0,5192						
a1	0,0061	b1	-1,1041	a2	0,0281	b2	0,5632
a3	-0,0015	b3	-0,3730	a4	-0,0599	b4	0,2369
a5	0,0201	b5	-0,2224	a6	-0,0125	b6	0,2304
a7	0,0591	b7	-0,1820	a8	-0,0348	b8	0,2513
a9	0,0050	b9	-0,1327	a10	0,0728	b10	0,1425
a11	0,0076	b11	-0,0682	a12	0,0831	b12	0,0126
a13	-0,0111	b13	-0,0438	a14	0,0068	b14	0,0613
a15	0,0595	b15	-0,1113	a16	-0,0523	b16	0,0419
a17	-0,0046	b17	-0,0822	a18	0,0058	b18	0,0875
a19	-0,0332	b19	-0,0941	a20	-0,0023	b20	0,0688

The recalculated values of CO_2 emissions are:

Table 54. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	-1,0482	1988	0,8766	2004	-1,1808
1973	-1,1808	1989	0,2836	2005	-1,3268
1974	-1,3268	1990	0,4280	2006	-1,2820
1975	-1,2820	1991	0,3622	2007	-1,5061
1976	-1,5061	1992	0,2202	2008	-1,9393
1977	-1,9393	1993	0,1172	2009	-0,8785
1978	-0,8785	1994	0,4195	2010	-1,9923
1979	-1,9923	1995	-0,4378	2011	-2,1766
1980	-2,1766	1996	-0,1278	2012	-0,3318
1981	-0,3318	1997	-0,2018	2013	1,5179
1982	1,5179	1998	-0,4660	2014	1,5036
1983	1,5036	1999	-0,5885	2015	1,0003
1984	1,0003	2000	-0,6519	2016	0,9225
1985	0,9225	2001	-0,6560	2017	1,2554
1986	1,2554	2002	-0,7393	2018	0,5764
1987	0,5764	2003	-1,0482		

The comparative graphs of the evolution of CO2 emissions accelerations and their recomputing after the Fourier regression is:

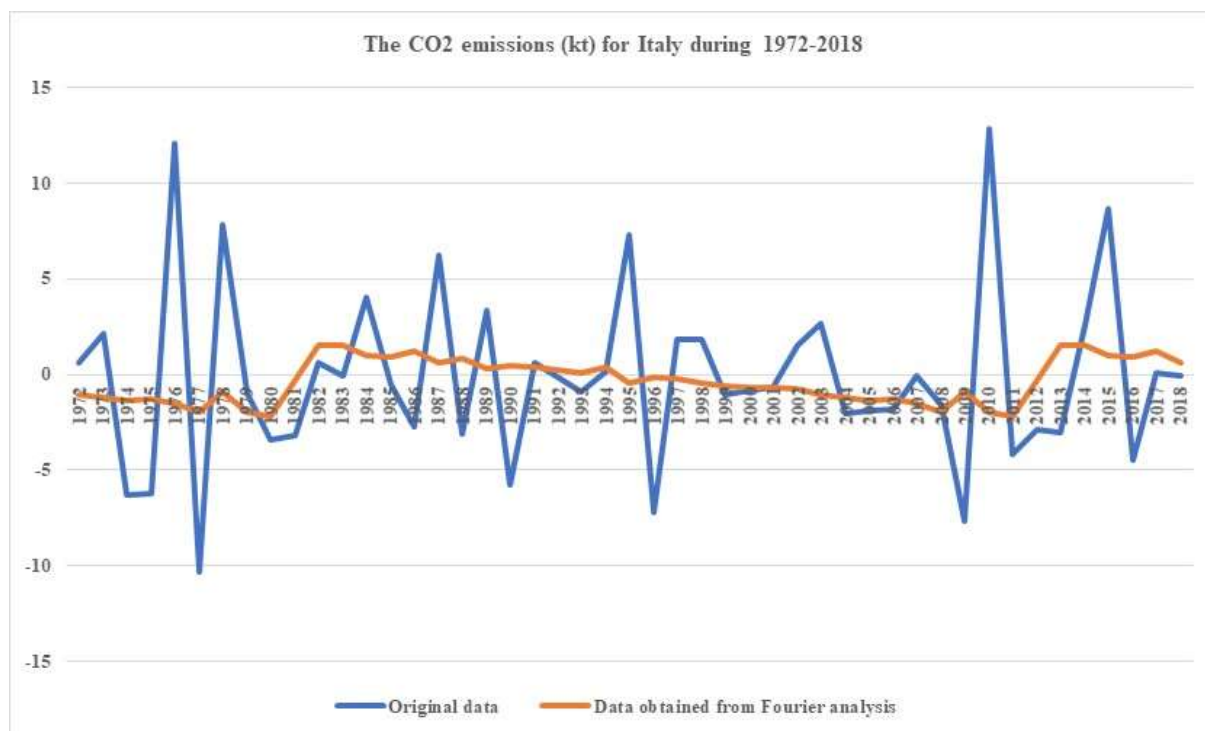The Fourier analysis for the period 1972-2018

Figure 18.

Based on this analysis, and using the growth rate (in percents) corresponding to -9,9308, the forecast of CO_2 emissions for the next 5 years is:

Year	CO2 emissions (kt)
2019	292589,796
2020	263533,289
2021	237362,325
2022	213790,347
2023	192559,255

5.19. Lithuania

Table 55. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1992-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	-	1988	-	2004	5,9661
1973	-	1989	-	2005	1,6694
1974	-	1990	-	2006	-6,2437
1975	-	1991	-	2007	-0,0216
1976	-	1992	-48,1569	2008	-2,5948
1977	-	1993	20,5111	2009	-9,3545
1978	-	1994	15,3127	2010	18,2744
1979	-	1995	-1,3163	2011	-13,8161
1980	-	1996	10,7910	2012	6,7918
1981	-	1997	-5,7447	2013	-5,7894
1982	-	1998	7,8538	2014	0,8810
1983	-	1999	-22,3986	2015	6,0820
1984	-	2000	2,5192	2016	-0,7594
1985	-	2001	20,2935	2017	-0,9957
1986	-	2002	-5,4616	2018	3,1191
1987	-	2003	-0,5387		

Source: https://unctadstat.unctad.org and own calculations

By analysing the data set (k,ρk), corresponding to the period [1992,2018], we found that the minimum average absolute error 6,2887 is obtained applying Fourier Analysis for T=8 for the range of years: [1995,2002].

The optimal number of Fourier series terms is 8 being specified in the table 56.

Table 56.

a0	1,2501						
a1	-0,6533	b1	-1,2749	a2	-1,6331	b2	2,8916
a3	-1,3930	b3	-0,6035	a4	0,7836	b4	1,2383
a5	0,2613	b5	-0,5471	a6	0,0181	b6	0,6658
a7	-	b7	-0,5152	a8	0,0102	b8	0,4144
a9	-	b9	-	a10	-	b10	-
a11	-	b11	-	a12	-	b12	-
a13	-	b13	-	a14	-	b14	-
a15	-	b15	-	a16	-	b16	-
a17	-	b17	-	a18	-	b18	-
a19	-	b19	-	a20	-	b20	-

The recalculated values of CO_2 emissions are:

Table 57. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1992-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	-	1988	-	2004	4,0140
1973	-	1989	-	2005	-3,6624
1974	-	1990	-	2006	0,3533
1975	-	1991	-	2007	3,0605
1976	-	1992	0,3533	2008	-3,2999
1977	-	1993	3,0605	2009	1,5891
1978	-	1994	-3,2999	2010	2,3210
1979	-	1995	1,5891	2011	4,0140
1980	-	1996	2,3210	2012	-3,6624
1981	-	1997	4,0140	2013	0,3533
1982	-	1998	-3,6624	2014	3,0605
1983	-	1999	0,3533	2015	-3,2999
1984	-	2000	3,0605	2016	1,5891
1985	-	2001	-3,2999	2017	2,3210
1986	-	2002	1,5891	2018	4,0140
1987	-	2003	2,3210		

The comparative graphs of the evolution of CO2 emissions accelerations and their recomputing after the Fourier regression is:

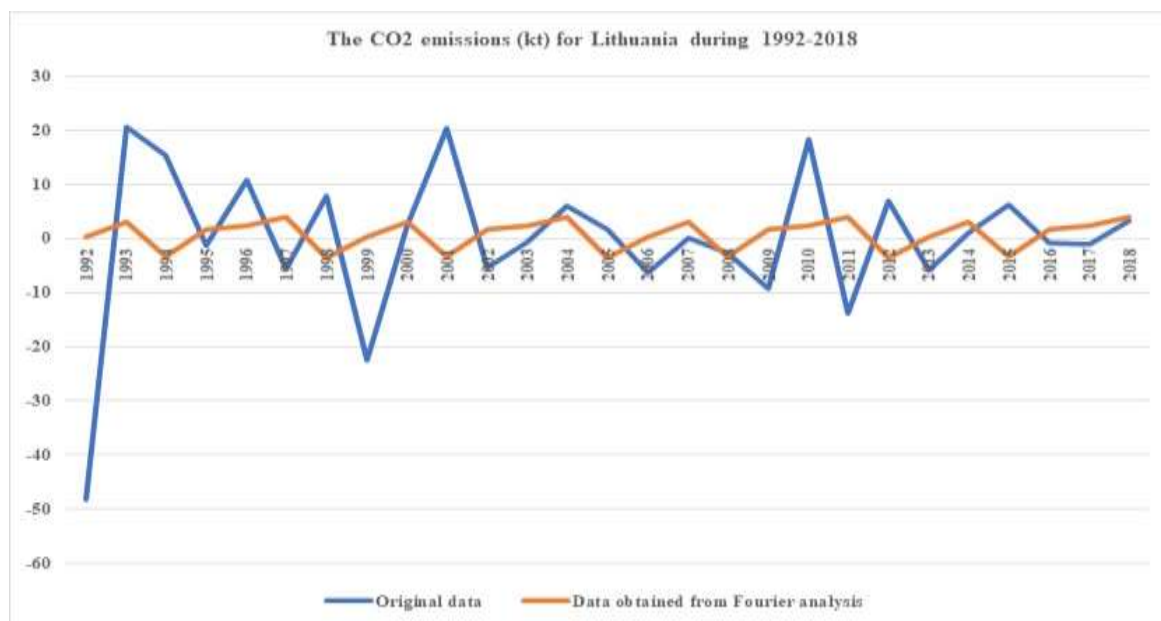The Fourier analysis for the period 1992-2018

Figure 19.

Based on this analysis, and using the growth rate (in percents) corresponding to 21,1648, the forecast of CO_2 emissions for the next 5 years is:

Year	CO2 emissions (kt)
2019	14043,000
2020	17015,173
2021	20616,401
2022	24979,821
2023	30266,750

5.20. Luxembourg

Table 58. The evolution of the accelerations (percents) of CO2 emissions during the period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	6,1966	1988	6,7885	2004	9,5719
1973	2,7778	1989	5,1691	2005	-11,6142
1974	-3,2919	1990	9,0254	2006	-3,9010
1975	-19,5198	1991	-13,1343	2007	-3,4357
1976	17,7807	1992	-6,7801	2008	4,2130
1977	-7,6804	1993	4,5490	2009	-4,3559
1978	16,1342	1994	-8,9448	2010	10,9897
1979	-6,1015	1995	-12,8139	2011	-6,9115
1980	-11,3655	1996	20,8479	2012	-1,0204
1981	-5,4553	1997	-6,5153	2013	-2,8556
1982	8,4707	1998	-2,6289	2014	0,1253
1983	-0,3868	1999	12,9656	2015	-0,4625
1984	14,1113	2000	3,1814	2016	2,4313
1985	-5,0263	2001	-1,3977	2017	4,5374
1986	-4,3894	2002	1,1318	2018	1,9755
1987	-2,0651	2003	-3,3903		

Source: https://unctadstat.unctad.org and own calculations

By analysing the data set (k,ρk), corresponding to the period [1972,2018], we found that the minimum average absolute error 5,8688 is obtained applying Fourier Analysis for T=7 for the range of years: [1976,1982].

The optimal number of Fourier series terms is 11 being specified in the table 59.

Table 59.

a0	-1,5673						
a1	-2,2070	b1	1,2453	a2	-1,4280	b2	-0,5549
a3	1,1128	b3	0,7739	a4	-0,3570	b4	-0,7319
a5	-0,0883	b5	0,5074	a6	-	b6	-0,3869
a7	-0,0450	b7	0,3097	a8	-0,0892	b8	-0,2523
a9	0,1236	b9	0,2580	a10	-0,0571	b10	-0,2564
a11	-0,0182	b11	0,2200	a12	-	b12	-
a13	-	b13	-	a14	-	b14	-
a15	-	b15	-	a16	-	b16	-
a17	-	b17	-	a18	-	b18	-
a19	-	b19	-	a20	-	b20	-

The recalculated values of CO_2 emissions are:

Table 60. The Evolution of the Accelerations (Percents) of CO_2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	-3,1072	1988	-1,5928	2004	-1,3602
1973	-3,8371	1989	2,0377	2005	3,1577
1974	-1,3602	1990	-3,1072	2006	-1,5928
1975	3,1577	1991	-3,8371	2007	2,0377
1976	-1,5928	1992	-1,3602	2008	-3,1072
1977	2,0377	1993	3,1577	2009	-3,8371
1978	-3,1072	1994	-1,5928	2010	-1,3602
1979	-3,8371	1995	2,0377	2011	3,1577
1980	-1,3602	1996	-3,1072	2012	-1,5928
1981	3,1577	1997	-3,8371	2013	2,0377
1982	-1,5928	1998	-1,3602	2014	-3,1072
1983	2,0377	1999	3,1577	2015	-3,8371
1984	-3,1072	2000	-1,5928	2016	-1,3602
1985	-3,8371	2001	2,0377	2017	3,1577
1986	-1,3602	2002	-3,1072	2018	-1,5928
1987	3,1577	2003	-3,8371		

The comparative graphs of the evolution of CO_2 emissions accelerations and their recomputing after the Fourier regression is:

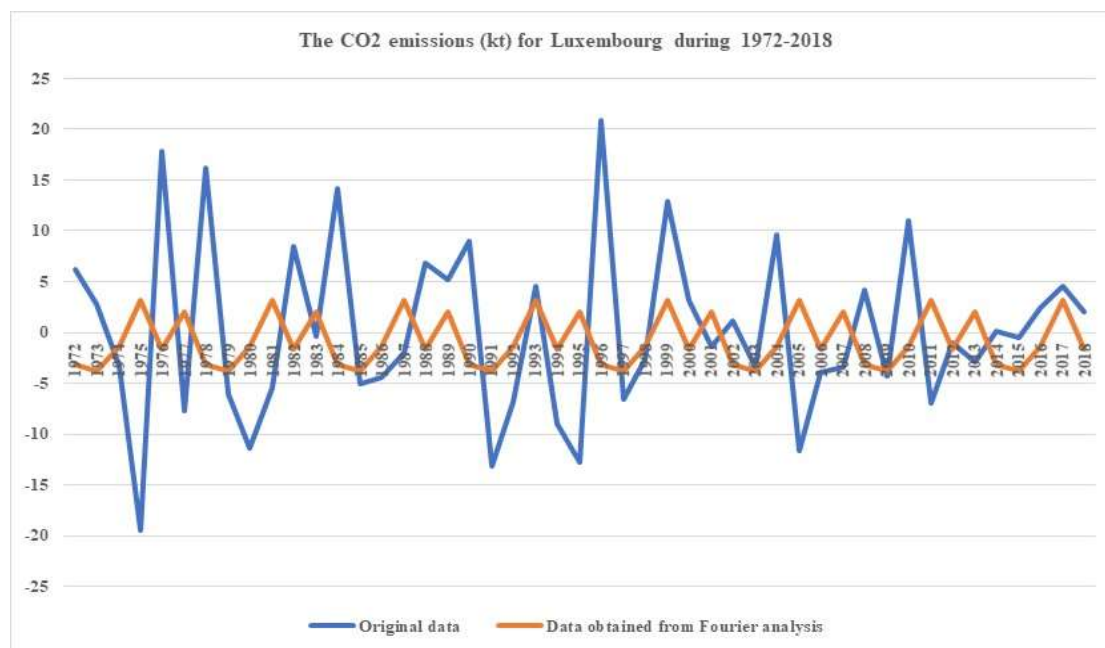The Fourier analysis for the period 1972-2018

Figure 20.

Based on this analysis, and using the growth rate (in percents) corresponding to -43,6273, the forecast of CO_2 emissions for the next 5 years is:

Year	CO2 emissions (kt)
2019	5253,936
2020	2961,785
2021	1669,638
2022	941,220
2023	530,591

5.21. Latvia

Table 61. The evolution of the accelerations (percents) of CO2 emissions during the period 1992-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	-	1988	-	2004	-2,8700
1973	-	1989	-	2005	0,9170
1974	-	1990	-	2006	4,9053
1975	-	1991	-	2007	-2,1932
1976	-	1992	-10,3659	2008	-8,9482
1977	-	1993	2,9595	2009	-4,3240
1978	-	1994	2,7244	2010	25,0087
1979	-	1995	1,1578	2011	-23,0379
1980	-	1996	12,0485	2012	3,0998
1981	-	1997	-5,4385	2013	2,5920
1982	-	1998	0,6381	2014	-0,6967
1983	-	1999	-2,4448	2015	2,8314
1984	-	2000	-1,0778	2016	-2,8719
1985	-	2001	14,4168	2017	1,9028
1986	-	2002	-6,3408	2018	7,5825
1987	-	2003	3,4012		

Source: https://unctadstat.unctad.org and own calculations

By analysing the data set (k,ρk), corresponding to the period [1992,2018], we found that the minimum average absolute error 4,7457 is obtained applying Fourier Analysis for T=15 for the range of years: [1999,2013].

The optimal number of Fourier series terms is 9 being specified in the table 62.

Table 62.

a_0	1,6398						
a_1	-0,2075	b_1	-0,0152	a_2	0,0753	b_2	0,0829
a_3	-0,5210	b_3	-0,3611	a_4	0,0229	b_4	-0,5784
a_5	0,6079	b_5	-0,2661	a_6	-0,1944	b_6	0,6149
a_7	-0,1713	b_7	0,0173	a_8	-0,1093	b_8	-0,3724
a_9	0,1876	b_9	0,1031	a_{10}		b_{10}	
a_{11}		b_{11}		a_{12}	-	b_{12}	-
a_{13}	-	b_{13}	-	a_{14}	-	b_{14}	-
a_{15}	-	b_{15}	-	a_{16}	-	b_{16}	-
a_{17}	-	b_{17}	-	a_{18}	-	b_{18}	-
a_{19}	-	b_{19}	-	a_{20}	-	b_{20}	-

The recalculated values of CO_2 emissions are:

Table 63. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1992-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	-	1988	-	2004	0,8337
1973	-	1989	-	2005	1,2258
1974	-	1990	-	2006	0,5100
1975	-	1991	-	2007	-0,2101
1976	-	1992	0,5100	2008	0,3359
1977	-	1993	-0,2101	2009	3,5588
1978	-	1994	0,3359	2010	-1,6762
1979	-	1995	3,5588	2011	1,2330
1980	-	1996	-1,6762	2012	1,1864
1981	-	1997	1,2330	2013	0,7187
1982	-	1998	1,1864	2014	2,3396
1983	-	1999	0,7187	2015	-0,0300
1984	-	2000	2,3396	2016	1,0107
1985	-	2001	-0,0300	2017	0,4426
1986	-	2002	1,0107	2018	0,8337
1987	-	2003	0,4426		

The comparative graphs of the evolution of CO2 emissions accelerations and their recomputing after the Fourier regression is:

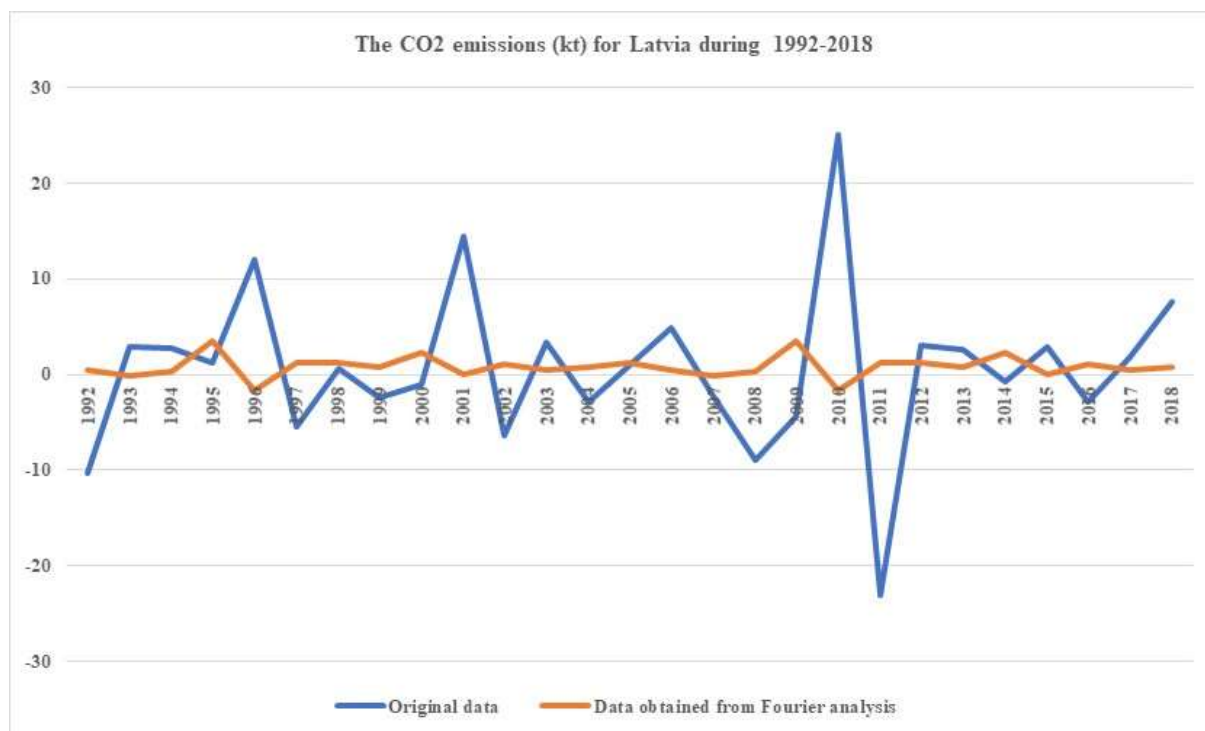The Fourier analysis for the period 1992-2018

Figure 21.

Based on this analysis, and using the growth rate (in percents) corresponding to 21,7320, the forecast of CO_2 emissions for the next 5 years is:

Year	CO2 emissions (kt)
2019	9288,152
2020	11306,653
2021	13763,814
2022	16754,967
2023	20396,156

5.22. Malta

Table 64. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	27,7747	1988	-16,4403	2004	-12,8831
1973	-31,1523	1989	-0,6656	2005	1,1523
1974	-3,7972	1990	-0,9625	2006	0,3758
1975	-2,6175	1991	-11,6113	2007	1,1192
1976	24,6305	1992	2,9314	2008	-1,8952
1977	-8,9972	1993	31,3031	2009	-8,0896
1978	11,1499	1994	-40,1693	2010	10,5094
1979	-19,5757	1995	5,4969	2011	-3,1764
1980	16,0928	1996	2,6583	2012	5,8351
1981	-1,1275	1997	8,9865	2013	-17,9936
1982	2,9156	1998	-10,5141	2014	11,7022
1983	-38,7659	1999	5,7364	2015	-28,9433
1984	60,7870	2000	-13,3061	2016	11,6054
1985	-48,8615	2001	28,5197	2017	30,7744
1986	35,9500	2002	-23,7287	2018	-10,6189
1987	1,0851	2003	19,3273		

Source: https://unctadstat.unctad.org and own calculations

By analysing the data set $(k, \rho k)$, corresponding to the period [1972,2018], we found that the minimum average absolute error 13,0217 is obtained applying Fourier Analysis for T=16 for the range of years: [1981,1996].

The optimal number of Fourier series terms is 8 being specified in the table 65.

Table 65.

a_0	-3,0169						
a_1	-0,0830	b_1	1,4315	a_2	-0,4881	b_2	-0,4788
a_3	-0,4470	b_3	0,7382	a_4	-0,0208	b_4	-0,9917
a_5	1,8356	b_5	1,2542	a_6	-0,0006	b_6	-1,1819
a_7	-1,5979	b_7	0,5526	a_8	1,2234	b_8	-0,0298
a_9		b_9		a_{10}		b_{10}	
a_{11}		b_{11}		a_{12}	-	b_{12}	-
a_{13}	-	b_{13}	-	a_{14}	-	b_{14}	-
a_{15}	-	b_{15}	-	a_{16}	-	b_{16}	-
a_{17}	-	b_{17}	-	a_{18}	-	b_{18}	-
a_{19}	-	b_{19}	-	a_{20}	-	b_{20}	-

The recalculated values of CO_2 emissions are:

Table 66. The Evolution of the Accelerations (Percents) of CO_2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	-3,2375	1988	-2,0701	2004	-1,5066
1973	-2,0701	1989	-1,5066	2005	-1,8321
1974	-1,5066	1990	-1,8321	2006	-0,2916
1975	-1,8321	1991	-0,2916	2007	2,9139
1976	-0,2916	1992	2,9139	2008	-3,8772
1977	2,9139	1993	-3,8772	2009	1,0967
1978	-3,8772	1994	1,0967	2010	1,0558
1979	1,0967	1995	1,0558	2011	-0,5024
1980	1,0558	1996	-0,5024	2012	-7,9762
1981	-0,5024	1997	-7,9762	2013	2,4070
1982	-7,9762	1998	2,4070	2014	-7,2713
1983	2,4070	1999	-7,2713	2015	0,8571
1984	-7,2713	2000	0,8571	2016	-2,3925
1985	0,8571	2001	-2,3925	2017	-3,2375
1986	-2,3925	2002	-3,2375	2018	-2,0701
1987	-3,2375	2003	-2,0701		

The comparative graphs of the evolution of CO_2 emissions accelerations and their recomputing after the Fourier regression is:

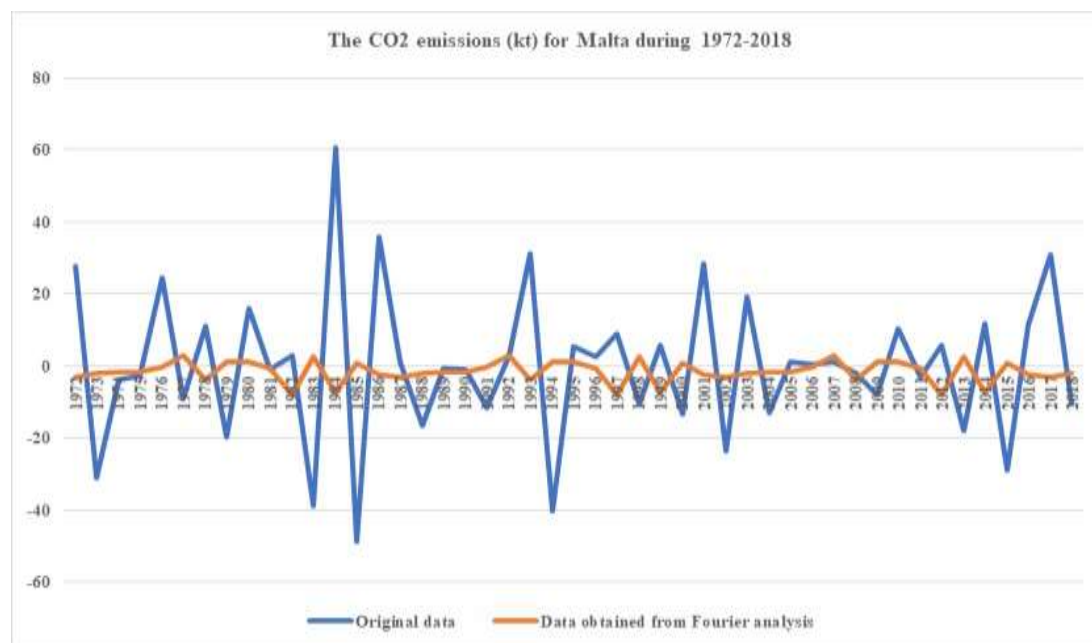The Fourier analysis for the period 1972-2018

Figure 22.

Based on this analysis, and using the growth rate (in percents) corresponding to -73,7411, the forecast of CO_2 emissions for the next 5 years is:

Year	CO2 emissions (kt)
2019	407,013
2020	106,877
2021	28,065
2022	7,369
2023	1,935

5.23. Netherlands

Table 67. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	12,7570	1988	-8,8568	2004	-0,7699
1973	-7,0348	1989	14,7236	2005	-3,4311
1974	-8,1146	1990	-20,0614	2006	-0,1024
1975	-1,4890	1991	13,1694	2007	3,0982
1976	15,5174	1992	-4,9087	2008	-0,1004
1977	-14,0747	1993	4,0523	2009	-3,3941
1978	7,0024	1994	-3,8061	2010	9,5477
1979	6,3058	1995	4,9330	2011	-13,7956
1980	-15,6093	1996	1,4335	2012	6,3306
1981	-1,5848	1997	-10,1072	2013	0,5959
1982	-11,4997	1998	4,5421	2014	-4,3477
1983	21,5003	1999	-3,4275	2015	10,0856
1984	1,9881	2000	3,5715	2016	-5,3828
1985	-2,9228	2001	2,7340	2017	-1,5923
1986	-3,9229	2002	-3,0826	2018	-1,5491
1987	7,0789	2003	1,7075		

Source: https://unctadstat.unctad.org and own calculations

By analysing the data set (k,ρk), corresponding to the period [1972,2018], we found that the minimum average absolute error 5,7668 is obtained applying Fourier Analysis for T=18 for the range of years: [1974,1991].

The optimal number of Fourier series terms is 9 being specified in the table 68.

Table 68.

a_0	1,3070						
a_1	-0,0336	b_1	-0,8693	a_2	0,3559	b_2	0,6701
a_3	0,2739	b_3	-0,4667	a_4	0,5604	b_4	0,0347
a_5	-0,1284	b_5	-0,4377	a_6	0,2647	b_6	0,2290
a_7	0,4256	b_7	-0,1004	a_8	-0,4435	b_8	-0,2437
a_9	0,3504	b_9	-0,4210	a_{10}	-	b_{10}	-
a_{11}	-	b_{11}	-	a_{12}	-	b_{12}	-
a_{13}	-	b_{13}	-	a_{14}	-	b_{14}	-
a_{15}	-	b_{15}	-	a_{16}	-	b_{16}	-
a_{17}	-	b_{17}	-	a_{18}	-	b_{18}	-
a_{19}	-	b_{19}	-	a_{20}	-	b_{20}	-

The recalculated values of CO_2 emissions are:

Table 69. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	-2,1174	1988	0,8156	2004	-1,0011
1973	0,0727	1989	-2,1174	2005	0,8156
1974	0,5031	1990	0,0727	2006	-2,1174
1975	3,5772	1991	0,5031	2007	0,0727
1976	0,5451	1992	3,5772	2008	0,5031
1977	2,2790	1993	0,5451	2009	3,5772
1978	1,8135	1994	2,2790	2010	0,5451
1979	-0,0729	1995	1,8135	2011	2,2790
1980	0,6439	1996	-0,0729	2012	1,8135
1981	-0,0292	1997	0,6439	2013	-0,0729
1982	2,7260	1998	-0,0292	2014	0,6439
1983	0,6403	1999	2,7260	2015	-0,0292
1984	0,3948	2000	0,6403	2016	2,7260
1985	-0,4920	2001	0,3948	2017	0,6403
1986	0,8107	2002	-0,4920	2018	0,3948
1987	-1,0011	2003	0,8107		

The comparative graphs of the evolution of CO2 emissions accelerations and their recomputing after the Fourier regression is:

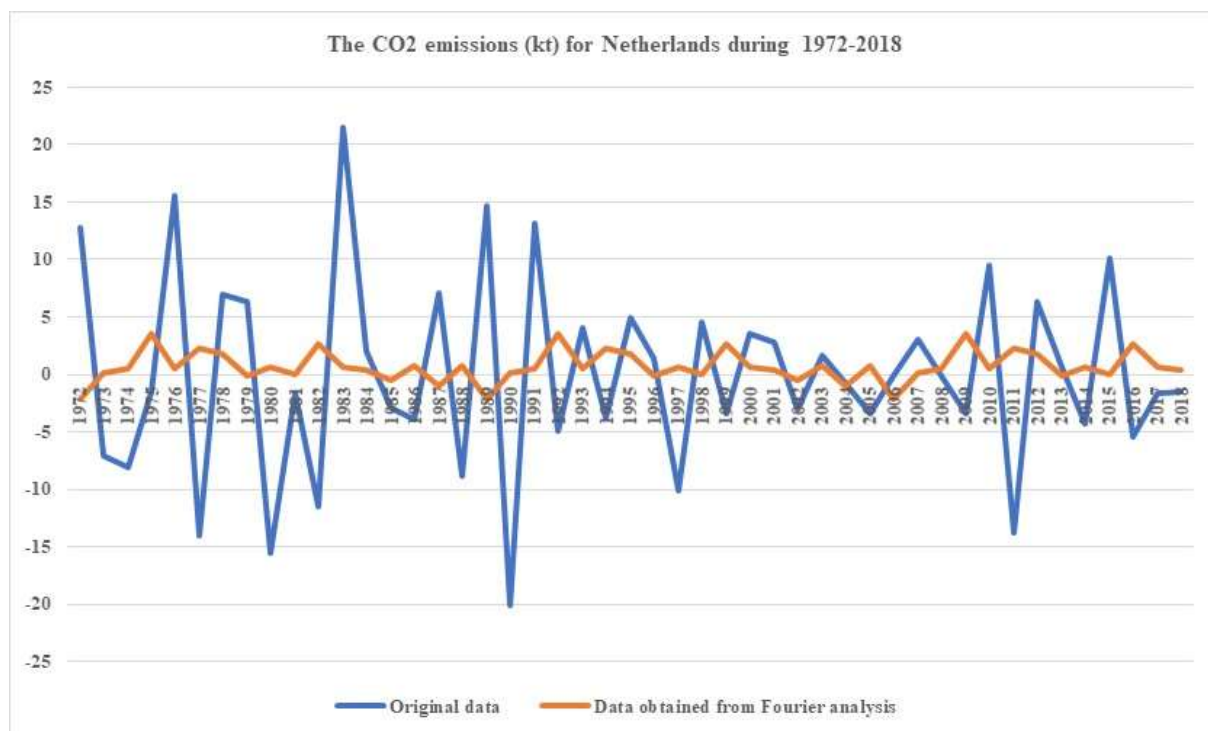The Fourier analysis for the period 1972-2018

Figure 23.

Based on this analysis, and using the growth rate (in percents) corresponding to 32,4480, the forecast of CO2 emissions for the next 5 years is:

Year	CO2 emissions (kt)
2019	200221,642
2020	265189,560
2021	351238,268
2022	465208,062
2023	616158,773

5.24. Poland

Table 70. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	2,4415	1988	-6,8071	2004	-2,2432
1973	-3,4620	1989	-0,8116	2005	-1,5396
1974	1,3261	1990	-12,3842	2006	4,3833
1975	5,0714	1991	17,7622	2007	-4,4568
1976	-2,0180	1992	-2,7517	2008	-1,3823
1977	-1,2417	1993	2,5384	2009	-1,9757
1978	-1,8991	1994	-1,4305	2010	9,1312
1979	-0,6956	1995	1,3148	2011	-6,5480
1980	2,5768	1996	4,4323	2012	-1,3270
1981	-16,7255	1997	-7,5145	2013	0,6761
1982	14,6968	1998	-4,5996	2014	-2,5653
1983	-2,9323	1999	4,6466	2015	5,3786
1984	2,7055	2000	-1,3332	2016	2,5399
1985	0,0311	2001	3,5813	2017	0,6655
1986	-1,0918	2002	-1,4391	2018	-4,3894
1987	0,9681	2003	5,7797		

Source: https://unctadstat.unctad.org and own calculations

By analysing the data set $(k, \rho k)$, corresponding to the period [1972,2018], we found that the minimum average absolute error 3,4650 is obtained applying Fourier Analysis for T=8 for the range of years: [2004,2011].

The optimal number of Fourier series terms is 8 being specified in the table 71.

Table 71.

a_0	-1,3038						
a_1	0,0533	b_1	0,3496	a_2	-0,3933	b_2	0,8426
a_3	-0,1565	b_3	-0,5755	a_4	0,0880	b_4	-0,3533
a_5	0,0629	b_5	0,1538	a_6	-0,0015	b_6	-0,0034
a_7		b_7	0,0097	a_8	-0,0008	b_8	-0,0129
a_9		b_9		a_{10}	-	b_{10}	-
a_{11}	-	b_{11}	-	a_{12}	-	b_{12}	-
a_{13}	-	b_{13}	-	a_{14}	-	b_{14}	-
a_{15}	-	b_{15}	-	a_{16}	-	b_{16}	-
a_{17}	-	b_{17}	-	a_{18}	-	b_{18}	-
a_{19}	-	b_{19}	-	a_{20}	-	b_{20}	-

The recalculated values of CO2 emissions are:

Table 72. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	-0,9699	1988	1,4325	2004	-0,9191
1973	-0,9114	1989	-1,8991	2005	0,2884
1974	1,4325	1990	-0,9191	2006	-1,5846
1975	-1,8991	1991	0,2884	2007	-0,9699
1976	-0,9191	1992	-1,5846	2008	-0,9114
1977	0,2884	1993	-0,9699	2009	1,4325
1978	-1,5846	1994	-0,9114	2010	-1,8991
1979	-0,9699	1995	1,4325	2011	-0,9191
1980	-0,9114	1996	-1,8991	2012	0,2884
1981	1,4325	1997	-0,9191	2013	-1,5846
1982	-1,8991	1998	0,2884	2014	-0,9699
1983	-0,9191	1999	-1,5846	2015	-0,9114
1984	0,2884	2000	-0,9699	2016	1,4325
1985	-1,5846	2001	-0,9114	2017	-1,8991
1986	-0,9699	2002	1,4325	2018	-0,9191
1987	-0,9114	2003	-1,8991		

The comparative graphs of the evolution of CO2 emissions accelerations and their recomputing after the Fourier regression is:

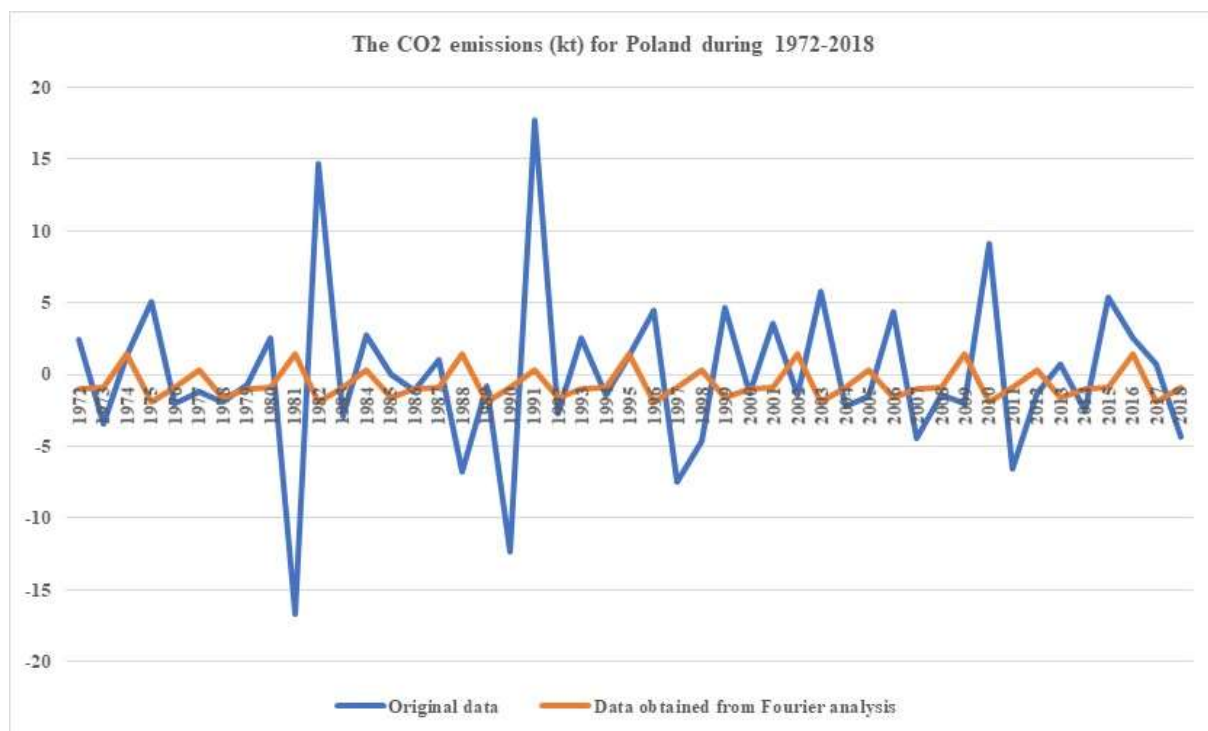The Fourier analysis for the period 1972-2018

Figure 24.

Based on this analysis, and using the growth rate (in percents) corresponding to -27,7542, the forecast of CO_2 emissions for the next 5 years is:

Year	CO2 emissions (kt)
2019	225941,515
2020	163233,255
2021	117929,171
2022	85198,873
2023	61552,607

5.25. Portugal

Table 73. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	4,3240	1988	1,0789	2004	10,4183
1973	-2,8334	1989	20,7517	2005	2,7155
1974	-5,4564	1990	-25,4978	2006	-13,0434
1975	-0,4585	1991	4,4784	2007	4,9381
1976	1,8987	1992	5,2130	2008	-0,6038
1977	-3,6393	1993	-11,4477	2009	2,3833
1978	-1,2928	1994	5,3931	2010	-8,5704
1979	9,9968	1995	3,8693	2011	7,4199
1980	-2,2529	1996	-11,0139	2012	-1,2081
1981	-6,9115	1997	8,3401	2013	-0,1340
1982	6,5509	1998	4,6762	2014	2,0895
1983	-4,2891	1999	2,7191	2015	9,8878
1984	-6,8525	2000	-12,7726	2016	-10,7213
1985	-2,0090	2001	0,4300	2017	11,5590
1986	17,0622	2002	7,3456	2018	-16,0291
1987	-8,0313	2003	-14,6495		

Source: https://unctadstat.unctad.org and own calculations

By analysing the data set (k,ρk), corresponding to the period [1972,2018], we found that the minimum average absolute error 6,1261 is obtained applying Fourier Analysis for T=14 for the range of years: [1987,2000].

The optimal number of Fourier series terms is 17 being specified in the table 74.

Table 74.

a_0	-1,3959						
a_1	0,0216	b_1	0,0521	a_2	-0,0035	b_2	0,1508
a_3	-0,2371	b_3	-0,5920	a_4	0,8250	b_4	0,7792
a_5	0,5145	b_5	-0,7300	a_6	-0,1775	b_6	0,2572
a_7	0,1304	b_7	0,1341	a_8	-0,2010	b_8	-0,2432
a_9	-0,1630	b_9	0,1208	a_{10}	0,0213	b_{10}	-0,0264
a_{11}	0,0001	b_{11}	-0,0172	a_{12}	-0,0002	b_{12}	0,0190
a_{13}	-	b_{13}	-0,0159	a_{14}	-0,0001	b_{14}	0,0134
a_{15}	0,0001	b_{15}	-0,0146	a_{16}	0,0083	b_{16}	0,0313
a_{17}	-0,0457	b_{17}	-0,0524	a_{18}	-	b_{18}	-
a_{19}	-	b_{19}	-	a_{20}	-	b_{20}	-

The recalculated values of CO2 emissions are:

Table 75. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	-0,5677	1988	2,1504	2004	0,1295
1973	-2,5889	1989	-3,6337	2005	-2,0234
1974	-0,4467	1990	-0,0638	2006	0,0100
1975	2,1504	1991	0,1295	2007	-0,1618
1976	-3,6337	1992	-2,0234	2008	-2,0934
1977	-0,0638	1993	0,0100	2009	0,2568
1978	0,1295	1994	-0,1618	2010	-0,0407
1979	-2,0234	1995	-2,0934	2011	-0,5677
1980	0,0100	1996	0,2568	2012	-2,5889
1981	-0,1618	1997	-0,0407	2013	-0,4467
1982	-2,0934	1998	-0,5677	2014	2,1504
1983	0,2568	1999	-2,5889	2015	-3,6337
1984	-0,0407	2000	-0,4467	2016	-0,0638
1985	-0,5677	2001	2,1504	2017	0,1295
1986	-2,5889	2002	-3,6337	2018	-2,0234
1987	-0,4467	2003	-0,0638		

The comparative graphs of the evolution of CO2 emissions accelerations and their recomputing after the Fourier regression is:

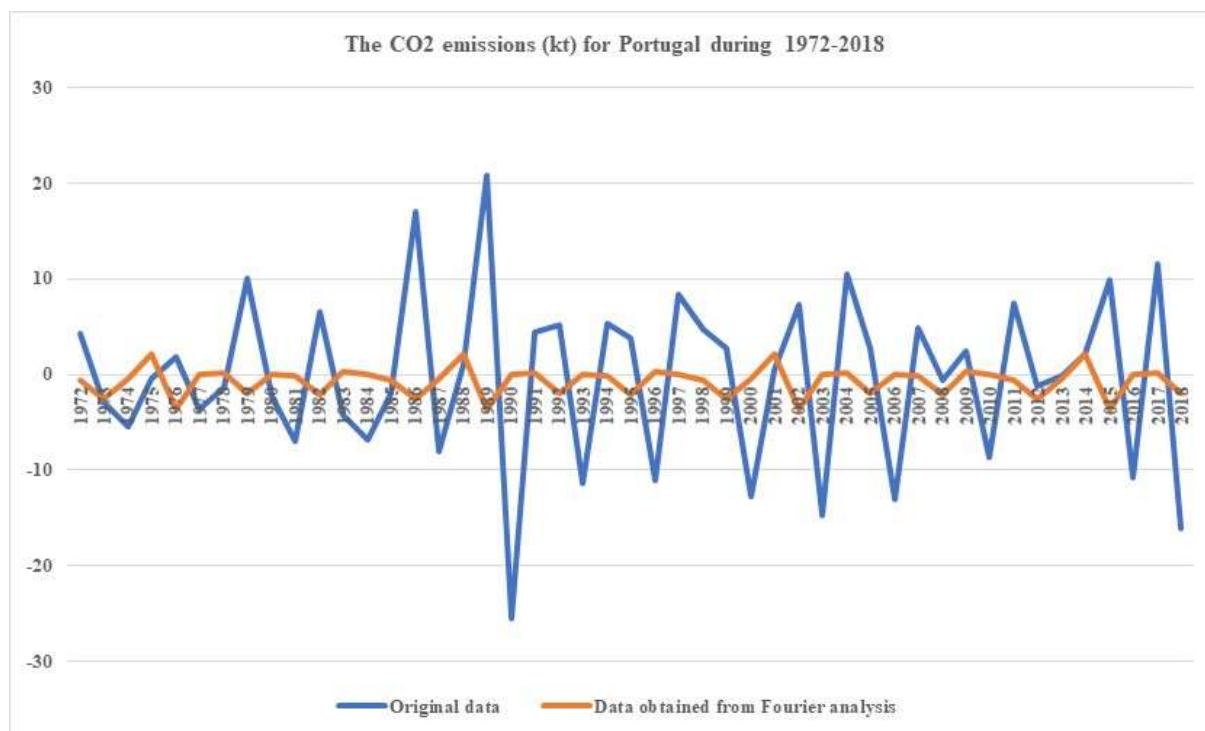The Fourier analysis for the period 1972-2018

Figure 25.

Based on this analysis, and using the growth rate (in percents) corresponding to -26,7423, the forecast of CO2 emissions for the next 5 years is:

Year	CO2 emissions (kt)
2019	36467,683
2020	26715,386
2021	19571,077
2022	14337,321
2023	10503,192

5.26. Romania

Table 76. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	0,4802	1988	-4,6673	2004	-9,3440
1973	4,2280	1989	0,3525	2005	1,9499
1974	-5,3394	1990	-20,0263	2006	4,2180
1975	3,3662	1991	1,8622	2007	-5,7937
1976	0,2142	1992	6,0116	2008	1,2514
1977	-5,6294	1993	4,8839	2009	-14,1537
1978	6,6112	1994	4,4599	2010	11,6785
1979	-7,5710	1995	7,0681	2011	12,0732
1980	-0,8428	1996	-2,2334	2012	-10,9670
1981	0,5047	1997	-11,1625	2013	-9,2484
1982	-1,9825	1998	-3,8746	2014	11,0596
1983	3,6472	1999	-1,6052	2015	2,9197
1984	-8,0757	2000	17,9284	2016	-4,5008
1985	8,3090	2001	1,9311	2017	6,5751
1986	1,3357	2002	-6,4368	2018	-3,1082
1987	0,9407	2003	6,9955		

Source: https://unctadstat.unctad.org and own calculations

By analysing the data set (k,ρk), corresponding to the period [1972,2018], we found that the minimum average absolute error 5,1767 is obtained applying Fourier Analysis for T=20 for the range of years: [1995,2014].

The optimal number of Fourier series terms is 12 being specified in the table 77.

Table 77.

a_0	-0,6647						
a_1	0,0087	b_1	1,3842	a_2	-0,2730	b_2	-0,7761
a_3	0,1566	b_3	0,6033	a_4	0,4918	b_4	-0,5676
a_5	-0,3302	b_5	0,7373	a_6	-0,0973	b_6	-0,3624
a_7	0,3932	b_7	0,2467	a_8	0,1858	b_8	-0,3181
a_9	0,0248	b_9	0,2366	a_{10}	-0,0201	b_{10}	-0,1200
a_{11}	-0,0983	b_{11}	0,0893	a_{12}	-0,1338	b_{12}	-0,1325
a_{13}		b_{13}		a_{14}		b_{14}	
a_{15}		b_{15}		a_{16}		b_{16}	
a_{17}		b_{17}		a_{18}	-	b_{18}	-
a_{19}		b_{19}		a_{20}	-	b_{20}	-

The recalculated values of CO_2 emissions are:

Table 78. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	2,1019	1988	0,4155	2004	-0,2005
1973	0,2556	1989	-0,6658	2005	0,1046
1974	0,8149	1990	1,7680	2006	-0,5021
1975	2,9025	1991	2,1019	2007	0,4155
1976	-0,3338	1992	0,2556	2008	-0,6658
1977	-3,6177	1993	0,8149	2009	1,7680
1978	-2,5732	1994	2,9025	2010	2,1019
1979	-1,8894	1995	-0,3338	2011	0,2556
1980	-0,1590	1996	-3,6177	2012	0,8149
1981	-1,2010	1997	-2,5732	2013	2,9025
1982	-1,6022	1998	-1,8894	2014	-0,3338
1983	-0,4268	1999	-0,1590	2015	-3,6177
1984	-1,5057	2000	-1,2010	2016	-2,5732
1985	-0,2005	2001	-1,6022	2017	-1,8894
1986	0,1046	2002	-0,4268	2018	-0,1590
1987	-0,5021	2003	-1,5057		

The comparative graphs of the evolution of CO2 emissions accelerations and their recomputing after the Fourier regression is:

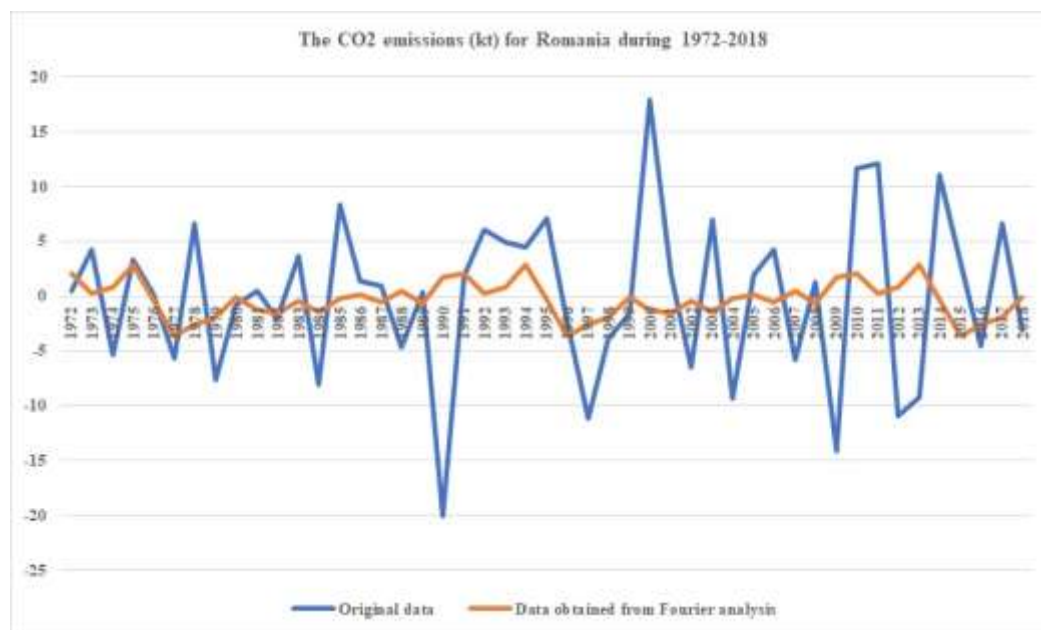The Fourier analysis for the period 1972-2018

Figure 26.

Based on this analysis, and using the growth rate (in percents) corresponding to -10,3670, the forecast of CO2 emissions for the next 5 years is:

Year	CO2 emissions (kt)
2019	**67117,190**
2020	**60159,151**
2021	**53922,452**
2022	**48332,311**
2023	**43321,701**

5.27. Slovak Republic

Table 79. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1992-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	-	**1988**	-	**2004**	**-3,0302**
1973	-	**1989**	-	**2005**	**5,2320**
1974	-	**1990**	-	**2006**	**-4,5461**
1975	-	**1991**	-	**2007**	**-0,0808**
1976	-	**1992**	**8,6961**	**2008**	**1,2856**
1977	-	**1993**	**-0,0231**	**2009**	**-8,2073**
1978	-	**1994**	**-2,0504**	**2010**	**13,4217**
1979	-	**1995**	**7,5183**	**2011**	**-8,4813**
1980	-	**1996**	**-2,0787**	**2012**	**-1,4332**
1981	-	**1997**	**0,7091**	**2013**	**6,9177**
1982	-	**1998**	**-2,2953**	**2014**	**-9,3201**
1983	-	**1999**	**0,2708**	**2015**	**8,5444**
1984	-	**2000**	**-4,5825**	**2016**	**1,4538**
1985	-	**2001**	**7,7095**	**2017**	**4,1642**
1986	-	**2002**	**-2,6356**	**2018**	**-8,3304**
1987	-	**2003**	**1,9788**		

Source: https://unctadstat.unctad.org and own calculations

By analysing the data set (k,ρk), corresponding to the period [1992,2018], we found that the minimum average absolute error 3,6563 is obtained applying Fourier Analysis for T=6 for the range of years: [2008,2013].

The optimal number of Fourier series terms is 8 being specified in the table 80.

Table 80.

a_0	1,3290						
a_1	-0,6467	b_1	-0,5032	a_2	-2,1600	b_2	0,9672
a_3	0,9600	b_3	0,2331	a_4	0,0404	b_4	0,0792
a_5	-	b_5	-0,0708	a_6	0,0180	b_6	0,0632
a_7	0,1763	b_7	-0,1151	a_8	-0,1350	b_8	-0,0051
a_9		b_9		a_{10}		b_{10}	
a_{11}		b_{11}		a_{12}		b_{12}	
a_{13}		b_{13}		a_{14}		b_{14}	
a_{15}		b_{15}		a_{16}		b_{16}	
a_{17}		b_{17}		a_{18}	-	b_{18}	-
a_{19}		b_{19}		a_{20}	-	b_{20}	-

The recalculated values of CO_2 emissions are:

Table 81. The Evolution of the Accelerations (Percents) of CO_2 Emissions during the Period 1992-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	-	1988	-	2004	4,8978
1973	-	1989	-	2005	-1,9358
1974	-	1990	-	2006	0,0032
1975	-	1991	-	2007	2,4189
1976	-	1992	2,4189	2008	-2,0617
1977	-	1993	-2,0617	2009	4,8978
1978	-	1994	4,8978	2010	-1,9358
1979	-	1995	-1,9358	2011	0,0032
1980	-	1996	0,0032	2012	2,4189
1981	-	1997	2,4189	2013	-2,0617
1982	-	1998	-2,0617	2014	4,8978
1983	-	1999	4,8978	2015	-1,9358
1984	-	2000	-1,9358	2016	0,0032
1985	-	2001	0,0032	2017	2,4189
1986	-	2002	2,4189	2018	-2,0617
1987	-	2003	-2,0617		

The comparative graphs of the evolution of CO_2 emissions accelerations and their recomputing after the Fourier regression is:
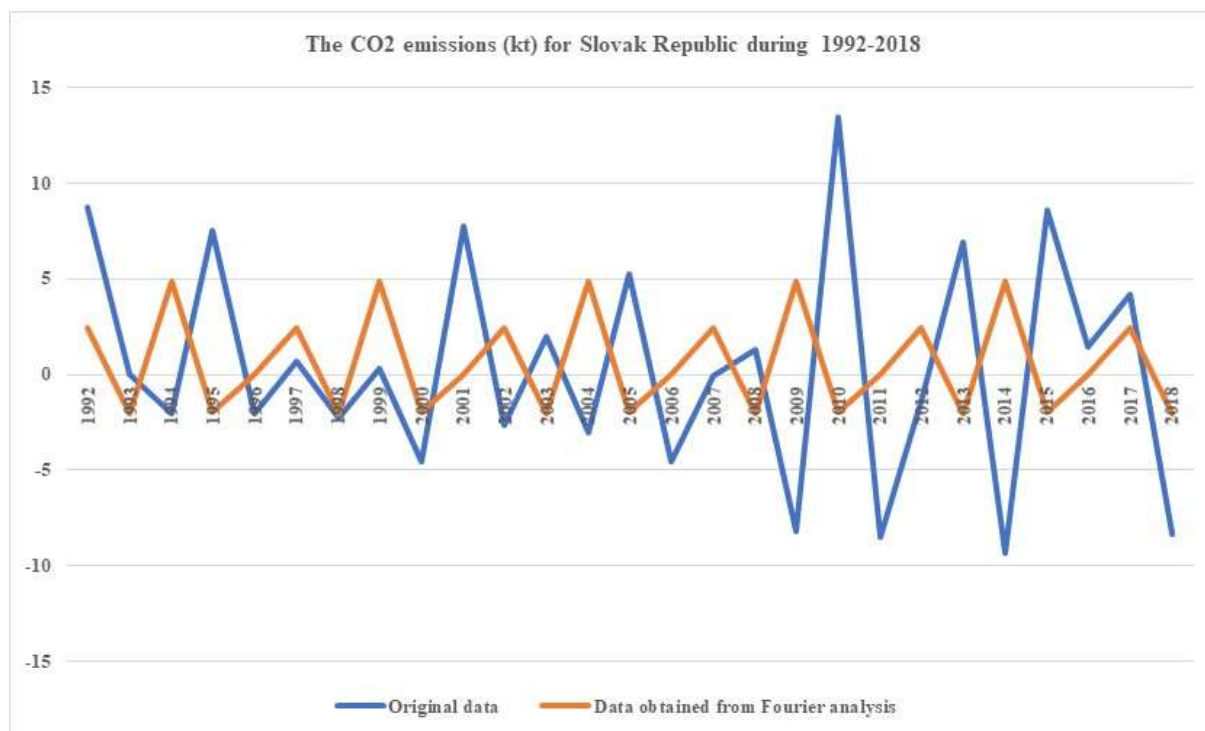
The Fourier analysis for the period 1992-2018

Figure 27.

Based on this analysis, and using the growth rate (in percents) corresponding to 16,9692, the forecast of CO_2 emissions for the next 5 years is:

Year	CO2 emissions (kt)
2019	38599,836
2020	45149,919
2021	52811,499
2022	61773,188
2023	72255,604

5.28. Slovenia

Table 82. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1992-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	-	1988	-	2004	2,5250
1973	-	1989	-	2005	-0,4803
1974	-	1990	-	2006	0,9850
1975	-	1991	-	2007	-2,4467
1976	-	1992	6,5453	2008	6,7484
1977	-	1993	4,9834	2009	-17,3829
1978	-	1994	-5,3211	2010	12,4988
1979	-	1995	5,9502	2011	-2,3090
1980	-	1996	-0,6520	2012	-3,0541
1981	-	1997	-2,7892	2013	-0,1973
1982	-	1998	-4,3399	2014	-6,0371
1983	-	1999	-2,3443	2015	9,7945
1984	-	2000	1,3249	2016	-
1985	-	2001	8,2588	2017	-4,2632
1986	-	2002	-4,8669	2018	-2,1440
1987	-	2003	-1,5546		

Source: https://unctadstat.unctad.org and own calculations

By analysing the data set (k,ρk), corresponding to the period [1992,2018], we found that the minimum average absolute error 3,4341 is obtained applying Fourier Analysis for T=6 for the range of years: [2012,2017].

The optimal number of Fourier series terms is 8 being specified in the table 83.

Table 83.

a_0	-1,3412						
a_1	1,4326	b_1	-0,9382	a_2	0,7782	b_2	-0,5054
a_3	-0,3458	b_3	-0,5689	a_4	-0,0895	b_4	0,1350
a_5	-	b_5	-0,1239	a_6	-0,0398	b_6	0,1121
a_7	-0,0635	b_7	-0,0220	a_8	0,0486	b_8	0,1284
a_9		b_9		a_{10}		b_{10}	
a_{11}		b_{11}		a_{12}		b_{12}	
a_{13}		b_{13}		a_{14}		b_{14}	
a_{15}		b_{15}		a_{16}		b_{16}	
a_{17}		b_{17}		a_{18}	-	b_{18}	-
a_{19}		b_{19}		a_{20}	-	b_{20}	-

The recalculated values of CO2 emissions are:

Table 84. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1992-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	-	1988	-	2004	2,6360
1973	-	1989	-	2005	-0,6859
1974	-	1990	-	2006	-2,3299
1975	-	1991	-	2007	-0,9964
1976	-	1992	-0,9964	2008	-1,9767
1977	-	1993	-1,9767	2009	2,6360
1978	-	1994	2,6360	2010	-0,6859
1979	-	1995	-0,6859	2011	-2,3299
1980	-	1996	-2,3299	2012	-0,9964
1981	-	1997	-0,9964	2013	-1,9767
1982	-	1998	-1,9767	2014	2,6360
1983	-	1999	2,6360	2015	-0,6859
1984	-	2000	-0,6859	2016	-2,3299
1985	-	2001	-2,3299	2017	-0,9964
1986	-	2002	-0,9964	2018	-1,9767
1987	-	2003	-1,9767		

The comparative graphs of the evolution of CO2 emissions accelerations and their recomputing after the Fourier regression is:
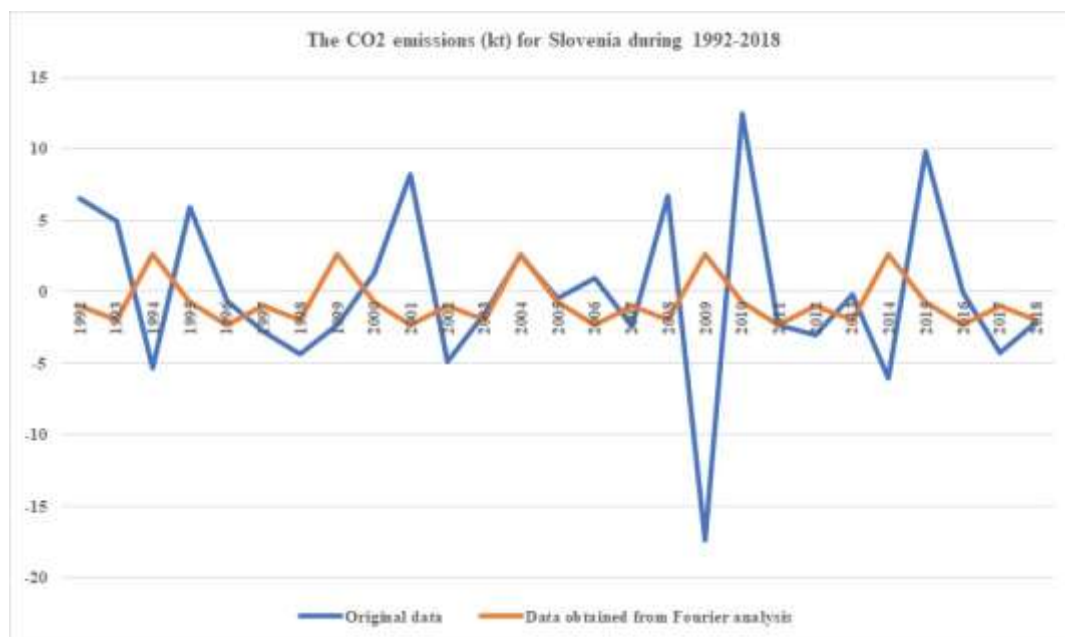
The Fourier analysis for the period 1992-2018

Figure 28.

Based on this analysis, and using the growth rate (in percents) corresponding to -19,7376, the forecast of CO_2 emissions for the next 5 years is:

Year	CO2 emissions (kt)
2019	11276,867
2020	9051,084
2021	7264,617
2022	5830,756
2023	4679,905

5.29. Sweden

Table 85. The Evolution of the Accelerations (Percents) of CO2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	8,6566	1988	-0,0656	2004	-5,1011
1973	2,8239	1989	0,4813	2005	-3,3904
1974	-11,6075	1990	-0,6052	2006	3,6981
1975	9,7287	1991	5,5993	2007	-0,9902
1976	8,0895	1992	2,9594	2008	1,4991
1977	-12,0961	1993	-5,0505	2009	-4,9855
1978	-4,4719	1994	3,9267	2010	19,3291
1979	14,0902	1995	-3,9483	2011	-19,5986
1980	-22,2874	1996	9,7524	2012	1,8830
1981	12,2603	1997	-19,1586	2013	1,6761
1982	-7,0382	1998	11,5586	2014	0,2202
1983	3,8723	1999	-3,5756	2015	3,8316
1984	4,7565	2000	-5,0993	2016	-1,3017
1985	10,4807	2001	5,5030	2017	-0,1400
1986	-9,3965	2002	4,3592	2018	-4,8929
1987	-3,1715	2003	-0,7108		

Source: https://unctadstat.unctad.org and own calculations

By analysing the data set $(k, \rho k)$, corresponding to the period [1972,2018], we found that the minimum average absolute error 5,8142 is obtained applying Fourier Analysis for T=18 for the range of years: [1981,1998].

The optimal number of Fourier series terms is 9 being specified in the table 86.

Table 86.

a_0	1,5727						
a_1	-0,0164	b_1	0,9402	a_2	0,1579	b_2	-0,2253
a_3	0,1665	b_3	0,1204	a_4	-0,0152	b_4	-0,2502
a_5	-0,1044	b_5	0,5730	a_6	0,1251	b_6	-0,3145
a_7	0,0580	b_7	0,3442	a_8	-0,3806	b_8	-0,2099
a_9	0,3007	b_9	0,0654	a_{10}		b_{10}	
a_{11}		b_{11}		a_{12}		b_{12}	
a_{13}		b_{13}		a_{14}		b_{14}	
a_{15}		b_{15}		a_{16}		b_{16}	
a_{17}		b_{17}		a_{18}	-	b_{18}	-
a_{19}		b_{19}		a_{20}	-	b_{20}	-

The recalculated values of CO_2 emissions are:

Table 87. The Evolution of the Accelerations (Percents) of CO_2 Emissions during the Period 1972-2018

Year	Acceleration	Year	Acceleration	Year	Acceleration
1972	0,6446	1988	0,5692	2004	0,1623
1973	1,3427	1989	0,6446	2005	0,5692
1974	1,3399	1990	1,3427	2006	0,6446
1975	0,7304	1991	1,3399	2007	1,3427
1976	1,7436	1992	0,7304	2008	1,3399
1977	1,2137	1993	1,7436	2009	0,7304
1978	2,5392	1994	1,2137	2010	1,7436
1979	0,1797	1995	2,5392	2011	1,2137
1980	3,3160	1996	0,1797	2012	2,5392
1981	0,2689	1997	3,3160	2013	0,1797
1982	-0,4004	1998	0,2689	2014	3,3160
1983	0,1087	1999	-0,4004	2015	0,2689
1984	0,7290	2000	0,1087	2016	-0,4004
1985	-0,9423	2001	0,7290	2017	0,1087
1986	-0,1770	2002	-0,9423	2018	0,7290
1987	0,1623	2003	-0,1770		

The comparative graphs of the evolution of CO_2 emissions accelerations and their recomputing after the Fourier regression is:

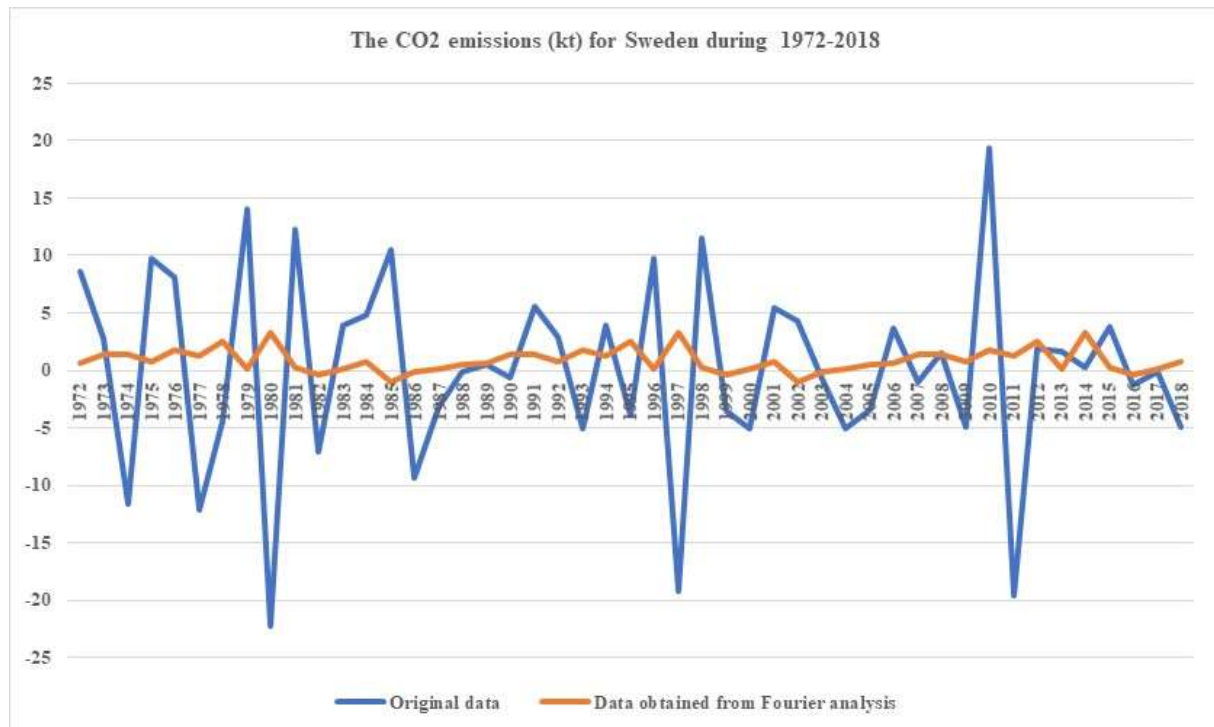The Fourier analysis for the period 1972-2018

Figure 29.

Based on this analysis, and using the growth rate (in percents) corresponding to 32,0612, the forecast of CO2 emissions for the next 5 years is:

Year	CO2 emissions (kt)
2019	47542,032
2020	62784,578
2021	82914,067
2022	109497,312
2023	144603,464

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