RESEARCH ARTICLE
Journal of Biometry Studies (2022) 2(1): 24-31 www.biometrystudies.com
DOI: 10.29329/JofBS.2022.444.04

Journal of Biometry Studies

Research on the future of forestry: A sample of EU

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Received: 10/05/2022, Accepted: 23/06/2022

Abstract

After the industrial revolution, technological developments, unbalanced population growth and excessive consumption have become threatening to the earth. Parallel to the world population, the increasing energy consumption is also increasing rapidly. Increasing energy consumption increases CO_2 emissions more and more every day. Considering the temperature increase caused by greenhouse gases, global climate change has become an important problem that concerns the whole world today. Climate change will affect forest resources and the continuity of ecosystem services more in the future. It is necessary to protect forests, which are beneficial in preventing global climate change, and to prevent deforestation. In this study, using the data between 2001 and 2020, data on carbon emissions, per capita national income, annual population growth rate, forest area, exports and imports of European Union countries were used. The data used in the study were obtained from the world bank data, food and agriculture data, and cover the 2001-2020 periods. In the study, the stationarity of the data sets of the variables was tested with the Dickey-Fuller unit root test (ADF). With the help of the model created, predictions for the forests' future were made by using the variables used in the model for the years 2021-2040. The values obtained were compared with the values of the previous years. When the current data and the estimated values are compared, the population growth rate in EU countries is quite low and sometimes it takes negative values. It has been determined that the CO_2 emission and forest area variables of EU countries are close to each other. It is seen that the forest existence of EU countries has increased and CO_2 emission has decreased.

Keywords: CO_2 emission, Climate change, European Union, Time series, Forecast

Please cite this article as follows:

Bayramoğlu, M. M., & Küçükbekir, E. (2022). Research on the Future of Forestry: A Sample of EU. *Journal of Biometry Studies*, *2*(1), 24-31. https://doi.org/10.29329/JofBS.2022.444.04

1. Introduction

Climate refers to the weather that dominates a region for more than centuries and becomes the characteristic feature of that region (Günsan & Yergin, 2022). Global climate change, on the other hand, refers to the increase in the average surface temperature of the earth and the changes in the climate as a result of the intensification of the natural greenhouse effect of greenhouse gases released into the atmosphere by human activities (Alper & Anbar, 2007). This change is also called the incremental greenhouse effect. This change is also called the incremental greenhouse effect. This naturally causes the earth's surface to warm up much more than it should (Korkmaz & Adıgüzel, 2021). The main types of greenhouses in the atmosphere are gases such as water vapor (H_2O), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sulfur hexafluoride (SF_6) (Sarıkaya, 2005). If this greenhouse environment were not present, it has been calculated that the surface temperature of the world would be at the level of -20 °C (Houghton, 2001). Among these greenhouse gases, carbon dioxide is the most common type of greenhouse gas that has the greatest impact on global warming (Lords, 2005). Because carbon dioxide passes the short-wave rays coming directly from the sun to a great extent while it traps the long-wave rays emitted from the earth (Alper & Anbar, 2007). This situation causes the average temperature of the earth's surface to change, in other words, global warming.

With the industrial revolution, the intense use of energy in the industry has led to a rapid increase in energy demand on a global scale. In addition to the studies that show that

the energy consumption of countries supports economic growth, many studies contain analyse how economic growth affects energy consumption (Mucuk & Uysal, 2009). Especially after the Second World War, economic growth has become humanity's top priority. While growth rates increased as a result of these efforts, global warming, which is one of the environmental problems, increased along with it. Since the 1960s, negative externalities such as environmental pollution caused by growth (decrease in environmental quality), crowding of cities and the increase in fossil fuel use have come to the fore (Bruvoll & Medin, 2003). One of the most striking results revealed in the meetings held by environmental organizations today is the conclusion that soil, water and air will reach the pollution capacity, and therefore growth and consumption must decrease (Arı & Zeren, 2011). But one of the most important goals of the economy is to maximize growth (Uysal & Yapraklı, 2016). However, with the understanding that there is an environmental change in the growth process, the relationship between environment and growth began to be questioned. Especially since the beginning of the 1990s, climate changes, global warming and environmental degradation have come to the fore. The increase in carbon dioxide gas in the air has been shown as the cause of these negative environmental developments (Arı & Zeren, 2011).

Global climate change is considered to be the biggest environmental problem today (Karal & Gençay, 2020). As a result of the concerns arising from climate change, the United Nations Framework Convention on Climate Change (UNFCCC) was signed in 1992. It is emphasized that human-induced greenhouse gas emissions, which have become dangerous in the atmosphere on the global climate system, are increasing every year. It is aimed to keep it at a level that will prevent the rapid increase in other greenhouse gases, especially carbon dioxide, and to keep greenhouse gas emissions at the 1990 level (Öztürk & Öztürk, 2019).

With this purpose, the vital importance of forests is once again revealed. The forest ecosystem has a highly dynamic structure that is affected by many components. Forests are not only structures that can be affected by the consequences of global warming but also one of the components that affect the reality of global warming (Canlı, 2010). Forests covering an area of 3 billion 999 million hectares of the world produce the oxygen necessary for living things to survive (FAO, 2015). Considering this situation, climate change will affect the forest resources and the continuity of ecosystem services more in the future. In this respect, it is an important requirement to ensure the adaptation of forest resources management to climate change (Korkmaz & Adıgüzel, 2021). One of the most important factors in reducing the effects of global climate change is to prevent deforestation (Gençay et al., 2018). The need to prevent climate change has gained importance day by day. In the face of this global problem in the world and Turkey, it has taken an important step by signing the Kyoto Protocol and the Paris Agreement with the responsibility of doing its share as a country. In time, the parties have begun to make changes in their national legislation in order to fulfill their responsibilities (Karal & Gençay, 2020). Changes between land classes at the local level of each country that increases forest areas, especially in our country, should be determined and monitored based on geographical information systems and satellite data (Başsüllü et al., 2014). Because forests remove CO_2 from the atmosphere in the branches, leaves, roots and stems of woody plants and trees, as well as in the living cover and forest soil in the forest. Thus, forests form a sink area by storing CO_2 in the form of carbon (C) (Başsüllü et al., 2014). In this respect, forest ecosystems undertake the task of a treasure. In addition, it is clear that in order to reduce CO_2, which causes an increase in the greenhouse effect, by removing it from the atmosphere by photosynthesis, it is necessary to increase the forests identified as important sink areas and to prevent deforestation (Coşkun & Gençay, 2011). The most important external support in adapting forest resources management to climate change is to increase the awareness of the society about climate change and its effects on forest resources (Korkmaz & Adıgüzel, 2021).

2. Material and Methods

In the study, data on carbon emissions, per capita national income, annual population growth rate, forest area, forest products exports and imports of European Union countries for the period 2001-2020 were used (Table 1). We analyzed the variables as a total of 4 periods in a 5-year period of 20 years.

In the study, a univariate time series was used. Time Series: time units show the change in the values of variables such as hour, day, month, and year. In this context, the annual data of each variable was calculated as a total of 4 periods in a 5-year period.

Time series, with its feature and structure, are not only a source of information used in the prediction of the future but also a method. To obtain meaningful relationships from the data in the time series, the series must be stationary. Therefore, whether the analysis (regression) represents a true or illusory relationship is related to whether the time series data are stationary (Tarı, 2014).

Various methods are used to determine stationarity, which is defined as the approach of variables towards a certain value over time. In the study, the stationarity of the data sets of the variables was tested with the Dickey-Fuller unit root test (ADF). Suggested regression models for ADF testing are;

$$Y_t = \delta Y_{t-1} + \Sigma m \beta_i \Delta Y_{y-1} + 1 + \varepsilon_t \quad (1)$$

$$Y_t = \alpha_0 + \delta Y_{t-1} + \Sigma m \beta_i \Delta Y_{y-1} + 1 + \varepsilon_t \quad (2)$$

$$Y_t = \alpha_0 + \delta Y_{t-1} + \beta_t + \Sigma m \beta_i \Delta Y_{y-1} + 1 + \varepsilon_t \quad (3)$$

Table 1. EU countries data

Period	Years	GDP per capita (current US$)	CO_2 emissions (Mt)	Population growth (annual %)	Forest area (km^2)	Export Value (x1000$)	Import Value (x1000$)
	2001	17185.96	3418140	0.1320	1522799	55797531	51134197
	2002	18682.65	3411220	0.2294	1527614	59950384	52633590
1	2003	22923.65	3503750	0.3560	1532429	71572484	62784804
	2004	26266.17	3508990	0.3756	1537243	82055949	69565620
	2005	27335.77	3489300	0.3551	1542058	85119442	72375804
	2006	29072.61	3497050	0.3251	1546873	94362964	80648950
	2007	33554.45	3456800	0.3364	1551688	113465308	97281875
2	2008	36920.85	3379180	0.3211	1556503	114239808	98544497
	2009	33369.39	3129340	0.2366	1561318	89519153	73402195
	2010	32943.06	3215040	0.1393	1566133	101743608	84474442
	2011	35716.16	3117130	-0.1778	1569420	112335708	92196994
	2012	33160.52	3057640	0.1472	1572707	105477818	82095442
3	2013	34569.65	2983560	0.2432	1575994	105547808	84098522
	2014	35245.86	2838990	0.2502	1579282	107324708	85563527
	2015	30474.50	2896820	0.2180	1582569	92632111	74445829
	2016	31168.44	2904100	0.2123	1584695	91690415	73768430
	2017	33023.79	2926600	0.1568	1586843	98329694	78852141
4	2018	35737.30	2871000	0.1633	1588671	115478908	90009708
	2019	35083.81	3025760	0.0629	1590498	101325608	80690138
	2020	34148.92	3123480	0.1352	1592314	94611590	74257469

In the models used for the ADF test, Y indicates the variable to be determined, t time, Δ difference parameter, α, δ and β constant coefficients, m delay number, ε_t random error terms that fit the least squares assumptions. In the models, equation (1) shows the model without constant and trend, equation (2) shows the model with constant, and equation (3) shows the model with constant and trend.

For the stationarity test of the series, a constant-termless, constant and trending (trending) process is followed in the ADF test. Accordingly, if it has become stationary in a serial trending process, this value is taken as a basis without following other processes. If the series have become stationary, the test is done with a constant term, and if this cannot be achieved, a constant-termless test is performed. As a result of this process, the value that makes the series stationary is taken as a basis (Enders, 2008).

The results obtained with ADF can be compared with MacKinnon critical values at 1%, 5%, and 10% significance levels. If the t statistic of the ADF test is not greater than the absolute value of the MacKinnon critical value, the series is not stationary and must be differentiated until stationarity is achieved (Beşkaya & Manan, 2009).

Since the effect of seasonality was found to be significant in the series in question, they were adjusted seasonally. The following model has been created for the estimation of carbon emissions, per capita income, annual population growth, forest area, and export and import values covering the years 2021-2040.

$$Y_t = \alpha + \beta X_t + \varepsilon_t \quad (4)$$

In the model, Y_t is the estimated carbon emission value, X_t is the current carbon emission amount, t is the time and ε_t is the error terms. This formula is used similarly for other variables (per capita income, annual population growth, forest area, exports and imports).

With the help of the figures created, the values obtained for the years 2021-2040 were compared with the values of the previous years.

3. Results

In the study, EU countries were analyzed with time series. Forecasts for EU countries (2021 - 2040) are presented in Tables 2 and Figures 1-6 (Figure 1 for per capita national income, Figure 2 for carbon emissions, Figure 3 for annual population growth rate, Figure 4 for forest area, Figure 5 for forest products exports, and Figure 6 for imports).

In Table 2, 2001-2040 forecast values estimated by time series are given in 4 periods of 5 years. When Figure 1 is analyzed, it is seen that the national incomes of EU countries increase. Also, periodic decreases are expected. In figure 2, the current carbon emission values and the estimations are similar, and a decrease in emission values is predicted in the future. In figure 3, the differences between present and future population growth draw attention. It is predicted that population growth will have negative values in the future. In figure 4, it is predicted that forest assets will increase in the future. It is seen that the current status of the forest assets and the estimated values overlap. According to Figures 5 and 6, an increase in import and export values is estimated.

Table 2. 2001-2040 forecast values estimated by time series

Period	Years	GDP per capita (current US$)	CO_2 emissions (Mt)	Population growth (annual %)	Forest area (km^2)	Export Value (x1000$)	Import Value (x1000$)
1	2001	24800.21	3568112	0.1091	1529007	80164844	70024577
	2002	25870.06	3544308	0.6065	1532426	84180972	73130907
	2003	28001.89	3459684	0.7571	1535936	89248249	77832850
	2004	28086.17	3364558	0.6679	1540139	84125400	71065491
	2005	26598.07	3410198	0.5143	1544047	82994349	70606091
2	2006	27774.69	3384168	0.0898	1547261	87522347	74271855
	2007	28900.17	3359687	0.4952	1550678	91767810	77513433
	2008	31206.63	3277575	0.6129	1554186	97149359	82441908
	2009	29559.38	3273802	0.0782	1558214	91936849	76820221
	2010	30718.24	3248915	0.4284	1561629	96319914	80142948
3	2011	33129.47	3168309	0.5263	1565136	102838708	85207343
	2012	33114.10	3078179	0.4563	1569349	95834224	77719980
	2013	31255.38	3116813	0.3446	1573262	94348217	77141071
	2014	32533.87	3089857	0.0589	1576468	99294353	81067499
	2015	33748.36	3064294	0.3171	1579880	104547808	84525474
4	2016	36334.21	2986199	0.3821	1583386	112295408	89816402
	2017	36256.56	2899192	0.3240	1587605	103243508	81879035
	2018	34166.20	2933447	0.2385	1591522	101646508	81225433
	2019	37513.54	2827598	0.2710	1594908	106463208	83542657
	2020	35330.53	2860101	0.1961	1598825	104114908	82859178
5	2021	36698.14	2832335	0.0318	1602024	116575408	87013689
	2022	37990.52	2805826	0.1613	1605432	115252308	90661011
	2023	40820.84	2731245	0.1801	1608936	121238808	96269083
	2024	40655.99	2648611	0.1387	1613164	113233608	87701713
	2025	38241.35	2676735	0.0900	1617085	111113908	86943541
6	2026	39672.63	2648391	0.0125	1620278	117122308	91260966
	2027	41020.63	2621205	0.0499	1623684	122098608	95043537
	2028	44025.58	2549135	0.0359	1627185	129045608	101244308
	2029	43798.45	2469624	0.0064	1631420	121159008	91860768
	2030	41152.17	2493370	-0.0160	1635344	118215608	91027903
7	2031	42647.11	2464447	-0.0067	1638532	124768908	95508244
	2032	44050.74	2436584	-0.0613	1641935	133258408	99426063
	2033	47230.32	2367026	-0.1083	1645435	137233508	154565408
	2034	46940.91	2290637	-0.1258	1649677	125477808	96019823
	2035	44063.00	2310004	-0.1220	1653603	126454408	95112266
8	2036	45621.60	2280503	-0.0261	1656787	132503708	99755522
	2037	47080.86	2251964	-0.1726	1660186	137989708	104328308
	2038	50435.06	2184916	-0.2525	1663685	145212908	113425608
	2039	50083.36	2111650	-0.2581	1667933	135345608	146799508
	2040	46973.82	2126638	-0.2281	1671863	133672408	99196628

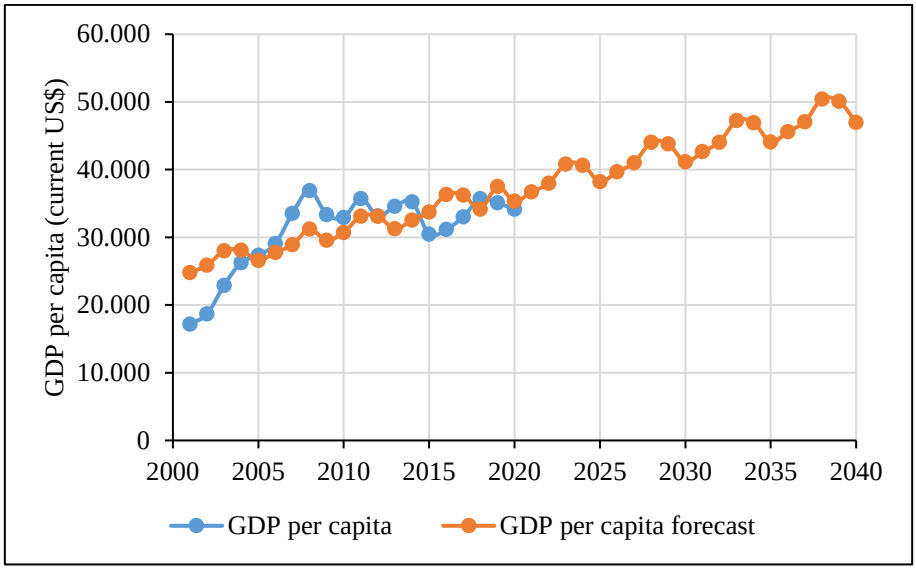

Figure 1. 2021-2040 national income forecast of EU countries

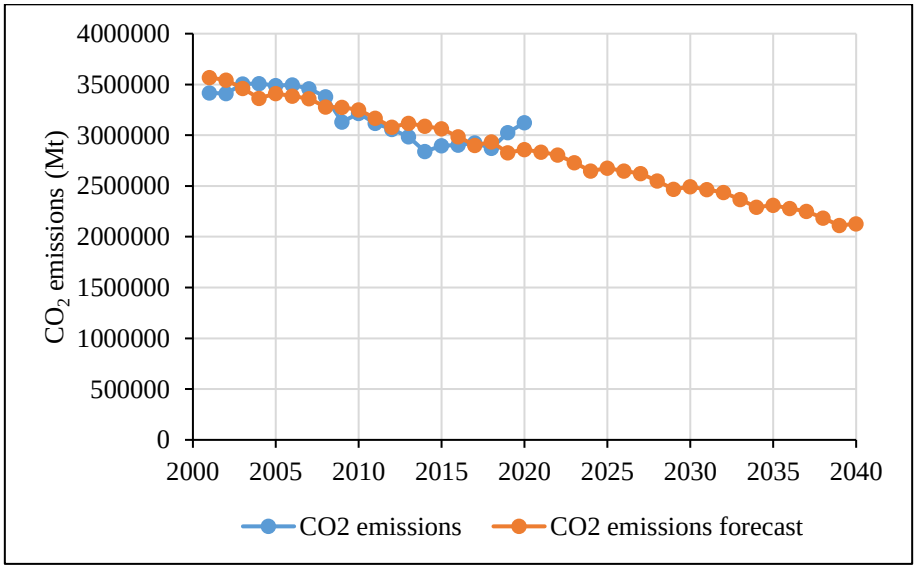

Figure 2. 2021-2040 CO_2 emissions forecast of EU countries

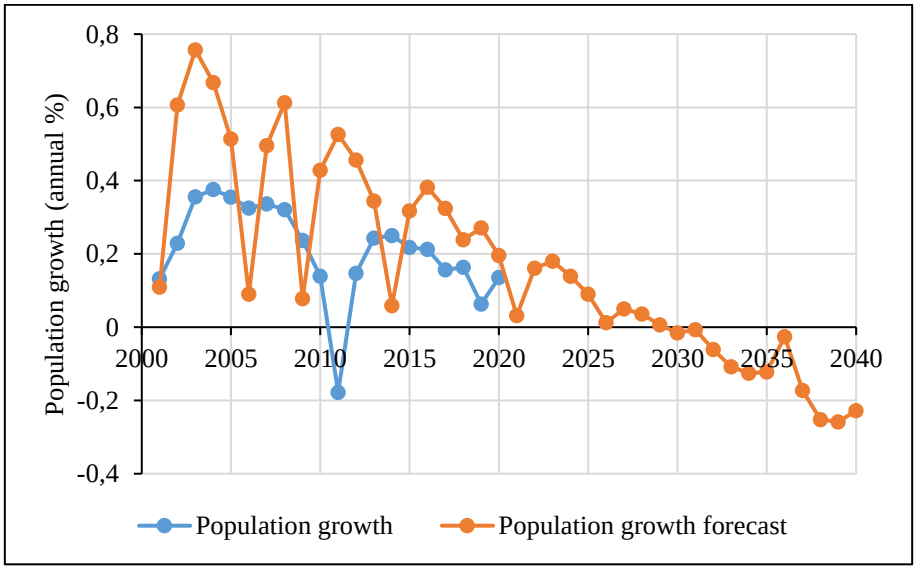

Figure 3. 2021-2040 population growth forecast of EU countries

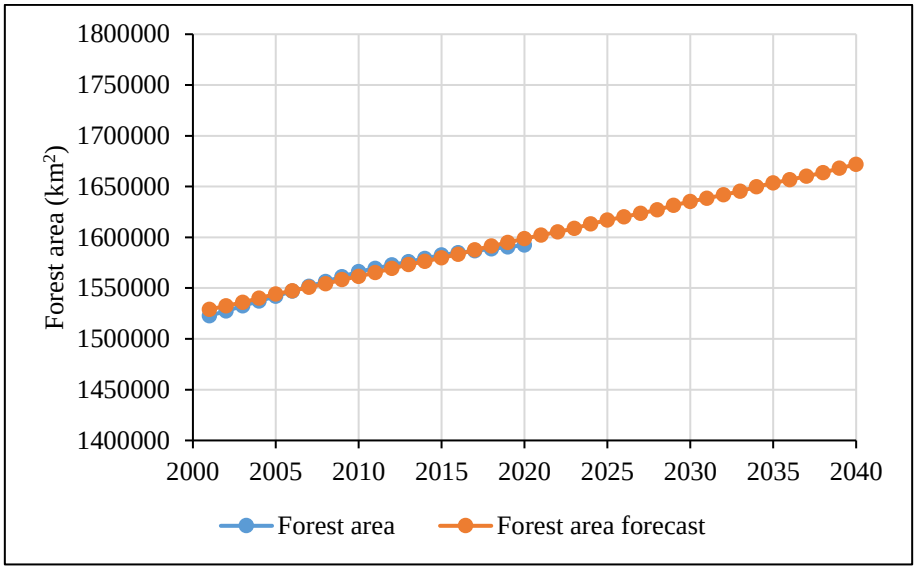

Figure 4. 2021-2040 forest area forecast of EU countries

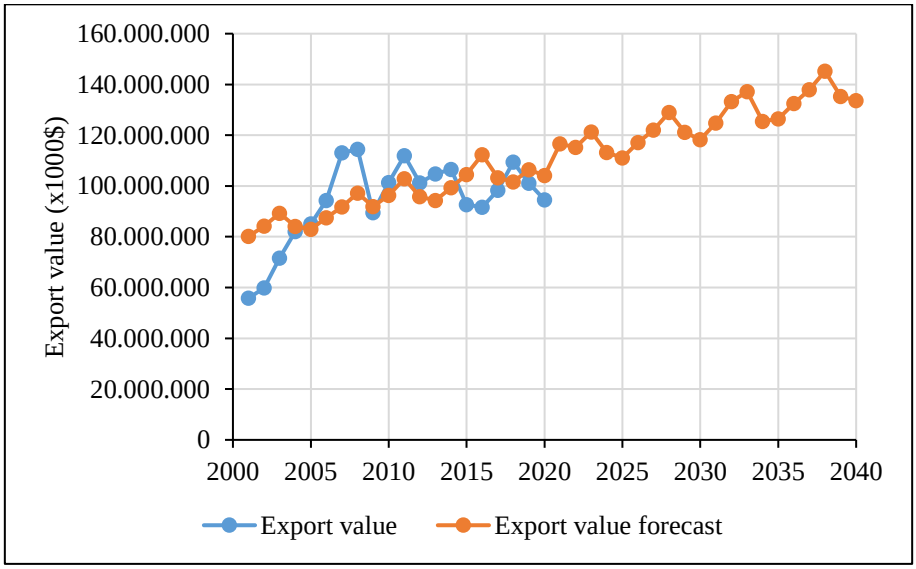

Figure 5. 2021-2040 forest products export forecast of EU countries

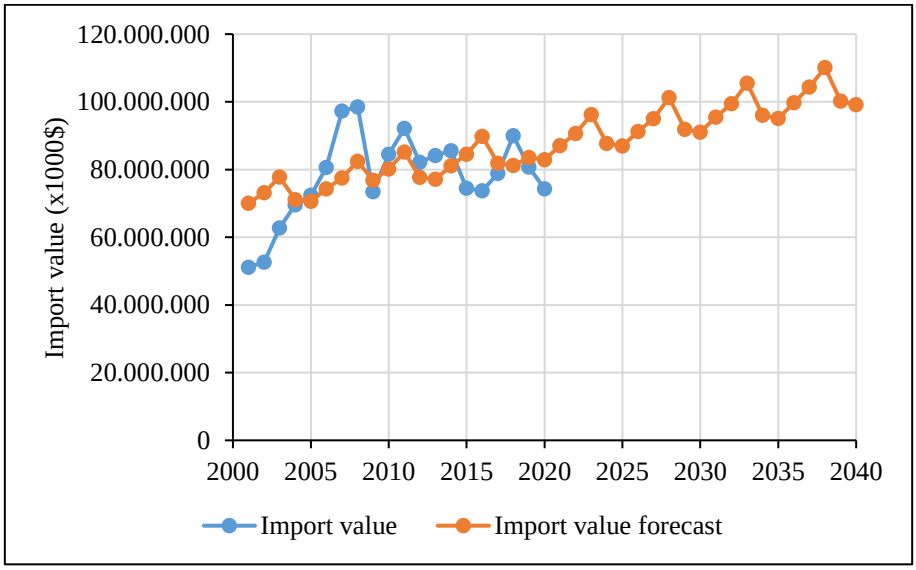

Figure 6. 2021-2040 forest products import forecast of EU countries

4. Discussion and Conclusion

In the study, future predictions were made using the carbon emission, population growth rates, national income, forest area, and forest product import and export figures of EU countries. In studies using time series (Caravaggio, 2022; Olmos, 2022; Woldemedhin, 2022), forest area change is generally examined. The number of studies in which many variables are examined is not at the desired level, especially due to the problems experienced in obtaining data. There is a similar situation in Turkey. There is a few (Kayacan et al., 2012a; 2012b; 2013, Bayramoğlu, 2018) time series studies on forestry.

When the current data and the estimation values are compared, it has been determined that the CO_2 emission and forest area variables of EU countries are close to each other. Similar to the environmental Kuznets curve, changes are observed in EU countries. With the industrial revolution in the second half of the 19th century, there were qualitative and quantitative differences in the demands of societies for natural resources and especially forests. Forests, which were previously seen only as wood raw materials, now come to the fore with their hydrological, soil protection, recreational, carbon sequestration, etc. features. In this process, CO_2 emission is very important, especially against global climate change. With this awareness, it is seen that the forest existence of EU countries increased and CO_2 emission decreased in 2001-2020 data and Figures 2 and 4. Increasing forest assets and decreasing CO_2 emission values show that the process that started with the Kyoto Protocol and continued with the Paris Agreement was successful.

In rural areas, which started with the return to nature movement and reached the highest level with the COVID-19 process, the demand for wood and wood products is increasing with a sustainable life. Again, it is a normal situation that this demand will increase in the coming years, and an increase in export values is expected, especially in countries where forestry is developed.

The population growth rate in EU countries is quite low and sometimes it takes negative values. Again, health, economic and political changes in the world affect people's thoughts about having a child negatively. It is estimated that this situation will not change in the coming years and that the population growth rate will even remain negative.

In line with the results obtained as a result of the study, the following recommendations were developed;

- It will be useful to use panel data and econometric tests in future studies,
- Individual evaluation of all member countries in future studies for a better evaluation of EU countries,
- Continuation of international processes without compromise for the continuation of increasing forest existence and decreasing CO_2 emission values,
- Economic and political developments in EU countries have a significant impact on wood product prices. It is the development of existing trade systems for both export and import of wooden products.

Conflict of interest

The authors declare that there is no conflict of interest.

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