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The Impact of Renewable Energy, Green Economy, and Blue Economy on Economic Growth

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Abstract: *Over the last 20 years, the general trend of economic growth in the European Union shows a slow growth rate, especially in continental economies. Various factors affect the sluggish economic growth in the European Union. This study aims to partially and simultaneously determine the effect of Euribor interest rates, exchange rates, renewable energy consumption, green bond issuance, and production on economic growth in 14 European Union countries for 2014-2022. Estimation is done using the generalized method of moments (GMM) analysis. The estimation results show that the Euribor interest rate and aquaculture production significantly affect economic growth. In contrast, the lag-dependent variable of economic growth and renewable energy consumption significantly negatively impacts economic growth. Meanwhile, exchange rates and green bond issuance are insignificant to economic growth in 14 EU countries. Therefore, policies that support the stability of interest and exchange rates, increase the effectiveness of green investment, and optimize fiscal incentives and funding for strategic sectors, including renewable energy and aquaculture, are needed to accelerate economic growth in the European Union.*

Keywords: *Aquaculture production; Economic growth; Green bond issuance; Renewable energy*

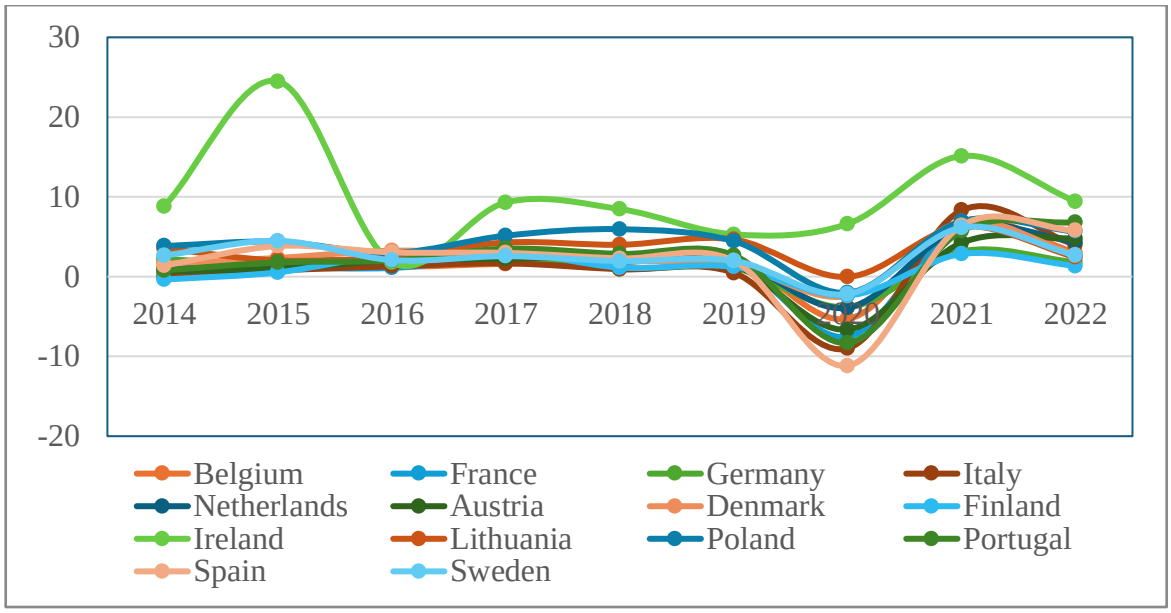
1. Introduction

Economic growth is currently the primary focus for countries worldwide due to the uncertainty of economic and financial conditions. Economic growth is significant in a dynamic world because it reflects a country's economic health. Economic growth means the development of a country's ability in economic activity, which causes the goods and services produced in society to increase (Azwar, 2016). Figure 1 shows a comparison of economic growth in 14 EU countries. It can be seen that 14 EU countries experience fluctuations. The countries with the lowest economic growth rates are Spain and Portugal. Economic growth in the Eurozone has slowed; the region has been behind the United States since the 1980s (Erixon et al., 2023).

Economic growth determines the future of a country, even when faced with inequality, negative externalities, environmental issues, and inflation (Idan & Badan, 2022). Interest rates have become a benchmark for financial markets and reflect competitiveness, including Eurobor. The Euro interbank offered rate (Euribor) is an important benchmark interest rate in European financial markets that major European banks use to lend funds to each other, denominated in Euros (European Central Bank, 2024). The trend of the Euribor interest rate shows a decline from 2014 to 2022 (Bank of Finland, 2025). Empirically, changes in interest rates have been shown to affect economic growth through investment transmission (Rangkuty et al., 2023). Exchange rates are also an important variable in international trade relations. The Euro exchange rate, for example, has depreciated by 1.9% against trading

partners' currencies (European Central Bank, 2024). This can affect European exports' competitiveness and foreign trade structure. An increase in the exchange rate leads to a contraction in economic activity (Karahan, 2020).

In addition to monetary factors, European green deal policies aim to achieve sustainable European economic growth. First, the energy transition from fossil to renewable is important in supporting sustainability and economic growth, especially after Russia invades Ukraine (International Energy Agency, 2023). Previous research shows that using renewable energy positively and significantly impacts long-term economic growth (Chen et al., 2020). Second, the green economy has opened new challenges and opportunities for companies in the 21st century to support green growth. In the green economy, all products and business processes that are wasteful and cause environmental damage are replaced with more efficient and environmentally friendly technologies. Green bonds are an effective tool in supporting sustainable economic development (Joyonegoro et al., 2023). Third, the blue economy contributes through aquaculture development as part of sustainable food production. Aquaculture is one of the fastest-growing food production sectors in the world and an important contributor to global food supply and economic growth (European Commission, 2021). These three variables are essential to achieve Europe's green deal goals and ensure a green recovery.



Source: World Bank (2025)

Figure 1. Development of Economic Growth in 14 EU Countries 2014-2022

Several previous empirical studies have shown mixed results regarding the factors influencing economic growth. Some studies found that lending rate (Budhathoki et al., 2024; Lee & Werner, 2018), exchange rate (Amalia & Suriani, 2024; Shah et al., 2022), renewable energy (Nga, 2021; Taşkın et al., 2020), green bond (Carolina et al., 2022; Joyonegoro et al., 2023), and aquaculture production (Ahammed et al., 2024; Alharthi, 2020; Marwa et al., 2024) have a positive impact on economic growth. However, other studies report contradictory findings, suggesting that interest rate (Bajra & Wagner, 2024; Szemán, 2023),

exchange rate (Karahan, 2020; Salman & Hosny, 2021), renewable energy (Akram et al., 2020), and aquaculture production (Rehman & Deyuan, 2019) have a significant negative impact on economic growth. Based on some of the studies mentioned, varied findings regarding the factors influencing economic growth exist. Therefore, to fill the gaps and problems in the above research, researchers examined the influence of Euribor interest rates, exchange rates, renewable energy consumption, green economy, and blue economy. In contrast to several previous studies, for example (Bajra & Wagner, 2024), the novelty of this research lies in analyzing the combination of monetary variables, energy transition, and green deal goals, namely green economy and blue economy, on economic growth.

2. Literature Review & Hypothesis Development

2.1. New Growth Theory

The new growth theory is an endogenous growth theory. Endogenous growth theory was pioneered by Romer in 1986, Lucas in 1988, and Grossman & Helpman in 1991. Romer explains three basic elements in endogenous growth, including endogenous technological change through the accumulation of knowledge, the creation of new ideas by companies, and the production of consumer goods produced by the production factor of science will grow indefinitely (Arsyad, 2016). Thus, this theory complements neoclassical theory by emphasizing the importance of innovation and knowledge as a source of long-term growth. This concept is relevant as renewable energy, the green and blue economies are often linked to technological innovation and the development of new sectors.

2.2. Euribor Interest Rate

An interest rate is a cost to be paid to the lender and a cost charged to the borrower for the loan received (Kasmir, 2014). The Euribor interest rate is a benchmark interest rate that reflects the average rate at which banks in the Eurozone lend unsecured funds (European Central Bank, 2024). Interest rates determine an individual's decision to invest. Low interest rates will lead to cheaper borrowing costs and thus encourage investment in new projects that can increase productivity and economic growth. Conversely, high interest rates will cause investment demand to decrease due to high borrowing costs. The liquidity preference theory was invented by John Maynard Keynes, which considers the potential for persistent disequilibrium and the risk of instability and speculation. Speculation is highly emphasized in this theory to form expectations. In this case, money is an alternative to investment, especially when interest rate expectations change (Rangkuty et al., 2020). A decrease in interest rates will lower the cost of credit, stimulating consumption and current supply, thus encouraging an increase in the real economy (Bajra & Wagner, 2024; Szemán, 2023).

H_1: The Euribor interest rate has a negative effect on economic growth

2.3. Exchange Rate

The purchasing power parity theory by Gustav Cassel states that the exchange rate reflects a direct comparison of the relative purchasing power between two countries (Krugman & Obstfeld, 2003). This theory states that exchange rates will adjust over time to reflect differences in inflation rates between two countries. This happens because the purchasing

power of consumers to buy domestic products will be equal to the purchasing power to buy foreign products. The exchange rate negatively impacts economic growth (Karahan, 2020; Salman & Hosny, 2021). An increase in the exchange rate causes a contraction in economic activity. This means that a country with a high inflation rate tends to experience a depreciation in the value of its currency, which in turn will increase export competitiveness and boost economic growth. Conversely, countries with low inflation rates tend to experience currency depreciation, which will hamper exports and economic growth. An increase in the exchange rate leads to a contraction in economic activity (Karahan, 2020; Salman & Hosny, 2021).

H_2: The exchange rate has a negative effect on economic growth

2.4. Renewable Energy Consumption

Renewable energy consumption refers to using energy derived from natural renewable sources. A renewable energy transition can create a sustainable and resilient economy, reduce dependence on fossil fuels, minimize the negative impacts of climate change, and influence long-term economic growth (Sovacool, 2016). The transition to renewable energy has significant economic impacts. The development of the renewable energy sector can also spur technological innovation and open up new export opportunities, further strengthening the economy. Renewable energy sources are important to complement non-renewable energy. Renewable energy can reduce dependence on fossil energy, which is often expensive. This will open up opportunities for industries and households to allocate resources to other productive investments. As renewable energy consumption increases, other economic and industrial sectors develop and operate more actively. This indicates that those sectors are growing and contributing to economic growth (Nga, 2021; Taşkın et al., 2020).

H_3: Renewable energy consumption has a positive effect on economic growth

2.5. Green Bond Issuance

Green bonds are instruments exclusively intended to finance part or all of environmentally friendly projects (International Capital Market Association, 2021). The signalling theory states that companies must provide signals in the form of clear information about the company's condition that benefits the recipient (Spence, 1973). The issuance of green bonds can serve as a positive signal that the company is committed to sustainable projects. Investors can invest in projects that are financially profitable while having a positive impact on environmental sustainability and economic growth. Green bonds are important for financing climate change mitigation and promoting green economic growth (Carolina et al., 2022). The issuance of green bonds has a positive and significant impact on economic growth. Green bonds can effectively support climate change mitigation efforts and environmentally friendly, sustainable economic development (Joyonegoro et al., 2023).

H_4: The green bond issuance has a positive effect on economic growth

2.6. Aquaculture Production

Aquaculture is the organized production of plants in aquatic media (Jhingran, 1987). The blue economy is an approach that prioritizes environmental sustainability in utilizing marine and coastal resources. Blue economy in sustainable marine development includes three aspects, among others: the implementation of good ocean governance, the development of blue economy areas, and the development of investments that focus on the blue economy (Sutardjo, 2014). The blue economy approach emphasizes the importance of the aquaculture, renewable energy, and biotechnology sectors to drive sustainable economic growth while promoting environmental sustainability and social inclusion. Theoretically, the potential of the ocean should be developed to improve the lives of coastal communities that depend on these resources to fulfill their needs. Maximizing the potential of the fisheries and aquaculture sector will create jobs, increase income, and strengthen food security (Alharthi, 2020). In the long and short term, aquaculture production positively impacts economic growth (Ahammed et al., 2024; Marwa et al., 2024).

H_5: The aquaculture production has a positive effect on economic growth

3. Methodology

The research objects used are 14 countries that are members of the European Union, including Belgium, France, Germany, Italy, Netherlands, Austria, Denmark, Finland, Ireland, Lithuania, Poland, Portugal, Spain, and Sweden. The sampling technique used in this study was purposive sampling, namely by selecting 14 European Union member countries that have issued green bonds since 2014. The variables used in this study consist of economic growth as the dependent variable and Euribor interest rate, exchange rate, renewable energy consumption, green bond issuance, and aquaculture production as independent variables. The period uses annual data from 2014 to 2022. The data source used in this research is secondary data. In this study, secondary data were obtained from data provided by intermediary media, namely the World Bank, the Bank of Finland, the Climate Bonds Initiative, and the European Commission.

3.1. *Generalized Method of Moments* (GMM) Dynamic Panel Method

Generalized Method of Moments (GMM) is the best statistical estimation method in panel data involving dependent lags, i.e., there is autocorrelation due to the presence of lags in the dependent variable, causing the relationship between them to be dynamic. The dynamic relationship will cause endogeneity problems, which will produce biased estimates in its estimation. Lag on the variable does not mean that the model depends only on the current year, but also on the previous year (Yuniasih et al., 2013). GMM estimation must begin with a theoretical relationship that must be satisfied by the parameters. The estimation is chosen to minimize the distance between theoretical and actual values (Arellano & Bond, 1991).

According to Firdaus (2011), in selecting the best GMM model, several criteria must be met, including:

a. Unbiased
   Data estimation is unbiased if the error estimate is between pooled least squares (PLS) and fixed effects (FE). The lag coefficient of the dependent variable generated by PLS will be biased upwards, and the lag coefficient of the dependent variable generated by FE will be biased downwards.
b. Valid
   The Sargan test of over-identifying restriction is used to test the validity of the model instrument. If the instrument is valid, there is no correlation between the instrument and the error component. The instrument is valid if the Sargan test rejects the null hypothesis. If the first difference method GMM (FD GMM) shows invalid results on the instrument used, the appropriate method is system GMM (sys-GMM).
c. Consistency
   The Arellano-Bond test is an autocorrelation test used to see the consistency of estimates in the GMM approach. The estimate is consistent if the Arellano-Bond test statistic m_1 results in rejection of the null hypothesis and m_2 results in not rejecting the null hypothesis.

In general, the dynamic panel analysis model is as follows: $y_{i,t} = \alpha_i + \delta Y_{i,t-1} + x'_{i,t}\beta + u_{it}; 1,2, \dots Ni = 1, 2, \dots, T$
$y_{i,t}$ is a function of u_{it} where the lag of the dependent variable $y_{i,t-1}$ is also a function of u_{it} so that there will be a correlation between the regressor variable $y_{i,t-1}$ with u_{it}. Instrument variables need to be added as a substitute for the lag of the independent variable, this aims to eliminate the problem of lag correction in the independent variable. This is because there is a lag in the dependent variable with the independent variable, which makes the use of ordinary least squares (OLS) biased and inconsistent. This will cause endogeneity problems if estimated using fixed effects or random effects, which cause bias and inconsistency when there is a lag in the dependent variable. A variable that controls the endogeneity of the independent variable in the regression model is needed to avoid the problem of simplicity in the parameters.

3.2. Model Specification Test

The dynamic panel analysis method with GMM has two approaches: the first difference GMM (FD-GMM) model and the system GMM (Sys-GMM) model. The model is selected based on the dynamic panel model specification test results. The model specification test is carried out with two tests, namely the instrument validity test and the instrument consistency test, using the Sargan test and the Arellano-Bond test.

3.2.1. Sargan Test

The validity test of instrument variables that exceed the number of parameters or over-identify can be seen using the Sargan test. This test is conducted to determine whether or not the model used is valid. Hypothesis testing is as follows:

H_0: The condition of over-identifying restriction in model estimation is valid
H_1: The condition of over-identifying restriction in model estimation is invalid

In this test, decision criteria are determined from the probability value of the chi-square. If the probability value is smaller than the significance level, or P-value < α (1%, 5%, and 10%), then H_0 is rejected.

3.2.2. Arellano-Bond Test

The Arellano-Bond autocorrelation test is used to see the consistency of the estimate and whether or not there is a correlation between errors. Hypothesis testing is as follows:

H_0: There is no autocorrelation in the first-order difference error
H_1: There is autocorrelation in the first difference errors of order i

The decision-making criteria for the Arellano-Bond test are, in the Arellano-Bond test table for zero autocorrelation in first-differenced errors if the Prob value on AR (1) < α (0,05) and AR (2) > α (0,05) then H_0 is not rejected, meaning there is no autocorrelation, or if prob on AR (1) > α (0.05) and on AR (2) < α (0.05) then H_0 is rejected, meaning there is autocorrelation.

4. Results

This study uses the Sys-GMM method to analyze the effect of exchange rate, Euribor interest rate, renewable energy consumption, green bond issuance, and aquaculture production on economic growth. The unbiasedness test is used to test the extent to which the estimated model produced reflects precisely the characteristics of the data used. The main objective of this test is to test whether the parameter estimates used do not lead to biased estimates.

Table 1. Generalized Method of Moments (GMM) Regression Test Results

Variable	FEM	SYSGMM	PLS
EG L1.	-0.649***	-0.620***	-0.243*
IR	7.557***	5.295***	3.054**
LnEXCR	-29.020*	-1.123	1.058
REC	-0.0361**	-0.586*	-0.0731*
LnGB	-0.280	-0.120	-0.615*
LnAP	1.407***	1.613***	0.396
_cons	13.054	4.625	13.520*
N	95	95	95
r2	0.552		0.155
r2_a	0.438		0.098

*p<0.05; ** p<0.01; *** p<0.001

Table 2. Sargan Test Results

Statistical value	P_{value}
47.923	0.057

Table 1 shows that the lag value of the Sys-GMM dependent variable is larger than the lag of the fixed effect model (FEM) variable and smaller than the estimated value in the pooled least square (PLS) model. These results indicate that the parameter estimates in this

model are unbiased. Second, the Sargan test determines whether the instrument used qualifies well and can provide consistent results.

Table 2 shows that the Sys-GMM model and the Sargan test results are valid. This can be seen with the results of the Sargan test, which has a P_{value} at 0,0571 > alpha of 0,05. Therefore, the decision is not to reject H0; the model estimation is valid, or the instrument variable is not correlated with the error. Third, the Arellano-Bond test ensures that the error terms are not serially correlated in AR (1) and AR (2) so that the estimates obtained are consistent with the null hypothesis of no autocorrelation.

Table 3. Arellano Bond Test Results

Order	z	P_{value}
AR (1)	-2.814	0.004*
AR (2)	0.991	0.321

*Sig < 5%

Table 3 shows that the P-value AR (1) value of AR (1) is smaller than alpha (0.05), and the P-value of AR (2) is greater than alpha (0.05). Then the decision is not to reject H_0; the Sys-GMM approach model shows consistent estimation and no autocorrelation.

Table 4. System Generalized Method of Moment (Sys-GMM) Model Test Results

Variable	z	P>z	SYSGMM
EG L1.	-4.450	0.000	-0.620**
IR	3.860	0.000	5.295**
LnEXCR	-0.150	0.877	-1.123
REC	-2.040	0.042	-0.586*
LnGB	-0.360	0.722	-0.120
LnAP	4.310	0.000	1.613**
_cons	0.540	0.590	4.625

* Sig < 5%; ** Sig < 1%

Based on the estimation results using Sys-GMM, it is known that the Euribor interest rate variable has a significant positive effect on economic growth. This result contradicts the initial hypothesis that increasing the Euribor interest rate will reduce economic growth. Interest rates as a component of monetary policy have a positive relationship with economic growth. Appropriate monetary policy for inflation control encourages producers to function better and increase total production, which determines a higher level of economic growth (Idan & Badan, 2022). In 2022, the ECB took monetary policy to increase interest rates in response to the staggering scale of inflation in 2021-2022 and post-pandemic recovery efforts. Controlled inflation helps to create market confidence, maintain people's purchasing power, and support productive investment in the economy. Lending rates have a positive effect on economic growth. Higher interest rates incentivize individuals to increase savings, which banks allocate to productive sectors through loans. Conversely, suppose the real rate of return is sufficiently low. In that case, disintermediation may occur, which causes

individuals to invest in unproductive assets such as gold and transfer their capital outward, hindering economic growth (Budhathoki et al., 2024; Lee & Werner, 2018).

The insignificant negative coefficient of the exchange rate variable on economic growth means that any increase or decrease in the exchange rate will not significantly affect economic growth. This result contradicts the initial hypothesis that increasing the exchange rate will reduce economic growth. This can be caused by several factors, including the relatively high macroeconomic stability in the region, so that exchange rate fluctuations do not significantly impact domestic economic activity. In addition, the impact of exchange rates on economic growth can be indirect, for example, through international trade or foreign investment flows, which are not included in this model. In the context of developed countries, exchange rate depreciation may not always boost exports significantly. Factors such as complex economic structure, the impact of inflation, dependence on global demand, and stable monetary policy may make the effect insignificant in developed countries (Nga, 2021; Njie & Badjie, 2021).

A significant negative coefficient of the renewable energy consumption variable on economic growth. This result contradicts the initial hypothesis that increasing renewable energy consumption will increase economic growth. The implementation of renewable energy is still in its early stages. The energy transition to renewable energy cannot be done instantly, although fossil energy is proven to cause environmental degradation. Many countries have implemented renewable energy policies, but the high cost is the main obstacle (Akram et al., 2020). Using the threshold model, non-OECD countries and developing countries will get significant effects after exceeding a certain threshold. That is, developing countries that use renewable energy at a relatively low level will enjoy the economic benefits of renewable energy after exceeding a certain threshold. In other words, the negative impact of renewable energy use at the initial level can be compensated in the long run when these countries start using renewable energy at a higher level (Chen et al., 2020). Similar results were also found by (Dogan et al., 2020; Mighri & Al Saggaf, 2022).

The negative coefficient is not significant for green bond issuance on economic growth. This result contradicts the initial hypothesis, which states that economic growth will increase when green bond issuance increases. Green bonds are very new instruments that have not been widely recognized, and their efficiency in helping to address climate change is still a matter of debate among financial actors (Lebelle et al., 2020). Bond volumes alone do not guarantee sustainable long-term growth. The green bond market may not have the maturity or efficiency of traditional bond markets, leading to inconsistencies in translating bond performance into economic growth (Bajra & Wagner, 2024). Furthermore, not all green funding is used for "green" or environmentally friendly purposes. Funds allocated from green government bonds are used to finance general deficits, instead of spending them on targeted green purposes. This phenomenon is called greenwashing (Szemán, 2023). Green financing is a relatively new practice, so its impact on economic growth has not been seen significantly in the short term (Gull et al., 2023).

Significant positive coefficient of aquaculture production on economic growth. These results align with the aquaculture sector's blue economy approach, essential for promoting sustainable economic growth. Theoretically, the potential of the sea must be developed to improve the lives of coastal communities that depend on these resources to meet their needs. Maximising the potential of the fisheries and aquaculture sector can create jobs, increase income, strengthen food security, and increase economic growth (Ahammed et al., 2024; Alharthi, 2020). The development of the blue economy model provides hope for fisheries and marine, leading to increased efficiency in production activities, improved marketing channels, increased product diversification, and promotion of environmentally sustainable practices (Marwa et al., 2024).

5. Conclusions and Suggestions

The results show that the Euribor interest rate and aquaculture production significantly affect economic growth. Exchange rates and renewable energy consumption significantly negatively affect economic growth. Meanwhile, green bond issuance has an insignificant negative effect on economic growth. This study has several limitations that can be improved for future research. Future researchers are expected to use other relevant variables to represent the green economy, such as green investment, credit, and finance (Rangkuty et al., 2023). For this purpose, adding all European countries can expand the sample size. In addition, for comparison, other methods can also be used to see each variable's long-term and short-term effects on economic growth (Chen et al., 2020; Gull et al., 2023).

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