Factors that affect Green GDP in 5 world's greenest countries

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Abstract

This study aims to identify the factors affecting green GDP in the world's greenest countries including Sweden, Denmark, United Kingdom, Finland and Switzerland over period 2000-2020. Estimate by panel data regression fixed effects model. The results show significant variables that are exchange rate, foreign direct investment, population and the labor force have positive effects on green GDP, while unemployment has negative effects. However, the exchange rate has a most positive effect. On the other hand, foreign direct investment has a less positive effect on green GDP than expected. So, in developed countries governments should have investment policies that focus on green investment for environmentally friendly and sustainable in the long term.

Keywords: Green GDP; World's greenest countries; Economic factors

1. Introduction

The world has started to change because of economic development, focusing on environmental resources and ecosystems along with the economic growth (Sonthi et al., 2019). This causes "sustainable development" being used for the first time in 1987 by the Brundtland and the discussion about Green GDP gained in the late 20th century, response to growing concerns about environmental sustainability (Mebratu, 1998). The difference between GDP and Green GDP is, Gross Domestic Product is total value of all goods and services produced within the borders of a nation, which solely focuses on economic activity without considering its environmental impact. But Green Gross Domestic Product is economic indicator that evaluates the economic output of a country while considering the environmental costs and

benefits associated with that output. It provides a more perspective on economic growth by reflecting on the sustainability of development among businesses, consumers, policymakers and mitigate environmental degradation (Stjepanović et al., 2017; Wang, 2011).

Internationally, organizations such as the United Nations and World Bank have stimulated the integration of environmental factors into economic indicators and policy frameworks. The System of Integrated Environmental-Economic Accounting it's one of the most accepted methods for calculating Green GDP (Kamesh, 2023). These contribute to understanding the relationship between economic development and environmental sustainability, but global Green GDP has not been measured. Some countries try to have integrate environmental considerations into their national accounting systems, including development of Green GDP. However, the adoption and implementation of these measures vary widely across countries and regions.

Table 1 shows the average differences in growth between the Green GDP and GDP for various groupings of countries. An average difference between the Green GDP and GDP for the world all 160 countries of 7.23% indicates that over the course of 50 years, GDP growth was, on average, over 7% higher than the Green GDP growth. Suggesting that the global economy was indeed implacable over the environmental issues and that ecological aspect of growth was largely ignored within a framework of international preoccupation with economic growth issues (Stjepanović, Tomić, & Škare, 2019)

Average difference in growth rates	Difference in %
Average (all countries)	7.23
EU countries	
- EU 27	2.52
- Euro Area	1.69
- EU 6 Founding countries	1.16
Countries by development	
- WB High-income countries	4.78
- WB Middle-income countries	7.66
- WB Low-income countr	10.54
COUNTRIES BY REGIONS	
- Europe	4.10
- Northern Europe	2.08
- Western Europe	1.07
- Southern Europe	5.49
- Eastern Europe	5.78

Source: Stjepanović, 2022

Table 1 Average of the Green GDP 1970-2019

For the 5 most environmentally friendly countries in the world: Sweden, Denmark, Finland, Switzerland and the United Kingdom, it is a good example for this study. From previous statistics, it can be found that if countries are classified according to their level of development, the growth gap between GDP and Green GDP will be higher with lower income levels. with high-income countries at 4.78%, middle-income countries at 7.66% and low income countries at 10%. All 5 countries are euro area countries with a proportion of 1.69%, with Sweden, Denmark and Finland in Northern Europe 2.08%, also Switzerland and United Kingdom in Western Europe 1.07%. We will see that developed countries invest more and promote sustainable economic behavior and lifestyles, even though those countries use resources from the environment by more than any other country and economic development can be achieved even though the environmental impact is greatly reduced (Stjepanovic, 2022).

At present, there is a lot of research on Green GDP. Which most of them only have research that calculates Green GDP and proves the formula for calculating Green GDP (Luo, Chen, & Wang, 2023; Sonthi et al., 2019; Stjepanovic, Tomic, & Skare, 2022; Stjepanović et al., 2017, 2019), as well as research to find factors affecting Green GDP. But most of them are variables related to the environment such as fossil fuels, renewable energy, CO2 emissions and various pollutants (Kalantaripor & Najafi Alamdarlo, 2021; Tomić & Stjepanović, 2022), And there are only a few research that have economic variables, such as the trade openness and FDI (Kamesh, 2023; Wang, 2011). But there is no research that uses economic variables such as economic variables such as inflation rate, exchange rates and interest rates are researched to see if they can have an impact on Green GDP. Also, there is research that suggests that Green GDP and economic variables are related, such as international trade affects Green GDP growth and carbon leakage. Low carbon trade is critical to stimulating Green GDP growth. Interest rates are positively linked to carbon prices. Meanwhile, exchange rates are negatively linked to carbon prices. (Yang, Wan, & Shen, 2023; Zhang et al., 2023). Bidirectional relationship between exchange rates and renewable energy. In the short term, a significant increase in the use of renewable energy causes the exchange rate to increase. Long-term results show that the use of renewable energy has a negative effect on the exchange rate, while inflation and currency exchange rates significantly affect the use of renewable energy. (Deka, Cavusoglu, & Dube, 2022). The use of renewable energy and financial innovations contribute to improving environmental quality, while economic growth and inflation worsen environmental quality deterioration in both the short and long term (Hao & Chen, 2023). Therefore, we decided to study this matter.

This research aims to study about the economic factors that affect Green GDP by selecting 5 of the most environmentally friendly countries in the world, to find that while the increase in green GDP has negative impact on GDP, what factors enable these countries to develop their economies while conserving the environment. It also serves as a guideline for other countries that are initiating the development of green economies. Moreover, with the

Sustainable Development Goals, which serves as a "blueprint for peace and prosperity" and helps guide to future studies for sustainable development that benefits to people wish to study this matter further.

2. Research Objectives

To investigate the economic, demographic, and investment factors affecting Green GDP in the five world's greenest countries.

3. Research Methodology

3.1 Data

This study focuses on the economic factors affecting Green GDP in world's greenest country using panel data of 5 country including Sweden, Denmark, United Kingdom, Finland and Switzerland from 2000 to 2020. For the data we have Green GDP US dollars calculate by actor, Exchange rate (2010 = 100), Inflation rate (annual %), FDI net (BoP, current US$), population (total), unemployment (% of total labor force), labor force (total). The sourced from World Development Indicators (WDI). Furthermore, Interest rate (percentage) sourced from OECD Statistics database.

3.2 Theoretical model

To study economic factors affecting Green GDP in world's greenest country this study uses production function. The approach follows the method from Zeng et al. (2023) that study Carbon-Reduction, Green Finance and High-Quality Economic Development and Tan and Sun (2024) they study about factor market distortion affect green innovation. where the Cobb Douglas production function following form:

$$Y_{it} = A_{it} K_{it}^{\alpha} L_{it}^{\beta}$$

(1) Where Y_{it} is the output (total production), A_{it} is a total factor productivity (TFP), a constant that captures the effects of technology and other factors not explicitly included as inputs, K_{it} denotes the capital input, L_{it} is the labor input, α and β denote the capital output and labor output of elasticity.

In economics, the production function explains an empirical relationship between specified output and inputs. A production function can be used to show the output of production for a firm, industry and nation (Apostolov, 2016). In this study the output is green gross domestic product of each country (Sweden, Demark, United Kingdom, Finland, Switzerland) and input is independent variable is exchange rate, interest rate, inflation rate, foreign direct investment, labor force, population and unemployment rate. Since this study does not include total factor productivity (TFP), following by Jiang et al. (2023); Oryani et al. (2021) we transform equation 1 into a linear form and rewritten as follows:

$$Y_{it} = f(K_{it}L_{it})$$

(2) Following by Chi et al. (2021); Kinyar and Bothongo (2024); Saidi and Hammami (2015) we added independent and dependent variables to the model. Replace Y and K with the output and the capital input variables following form:

$$GGDP_{it} = f(FDI_{it}L_{it})$$

(3) Replace L with the labor input variables following form:

$$GGDP_{it} = f(FDI_{it}LE_{it}POP_{it}UMP_{it})$$

(4) Add economic variables in the model following form:

$$GGDP_{it} = f(ER_{it}IR_{it}IF_{it}FDI_{it}LF_{it}POP_{it}UMP_{it})$$

(5) Where GGDP is green gross domestic product, ER_{it} is exchange rate, IR_{it} is interest rate, IF_{it} is inflation rate, FDI_{it} is foreign direct investment, LE_{it} is labor force, POP_{it} is population, UMP_{it} is unemployment rate

3.3 Econometric model

This study estimates the economic factors affecting Green GDP in world's greenest country using panel data of 5 country including Sweden, Denmark, United Kingdom, Finland and Switzerland from 2000 to 2020. Following by Chen et al. (2024) we use a panel data model to study the economic factors affecting Green GDP in world's greenest country. The equation of the panel data model is as follows:

$$Y_{it} = \alpha + \beta_0 + \beta_1 x_{1,it} + \beta_2 x_{2,it} + \beta_3 x_{3.it} + \ldots\ldots\ldots + \beta_n x_{n.it} + \varepsilon_{it}$$

(6) Where Y is dependent variable represents green gross domestic product, α is the entity-specific effect which accounts for unobserved heterogeneity across country, β_n is the coefficient vector that represents the effect of the independent variables on the dependent variable, X_n is the vector of independent variables, ε is the error term.

Taking the variables on both sides of Equation (6), we have:

$$GGDP_{it} = \alpha_i + \beta_0 + \beta_1 ER_{it} + \beta_2 IR_{it} + \beta_3 IF_{it} + \beta_4 FDI_{it} + \beta_5 LF_{it} + \beta_6 POP_{it} + \beta_7 UMP_{it} + \varepsilon_{it}$$

(7) Where i is countries (Sweden, Demark, United Kingdom, Finland, Switzerland), t is time period from 2000 to 2020, α is constant, GGDP as a dependent variable represents green gross domestic product, ER_{it} is exchange rate, IR_{it} is interest rate, IF_{it} is inflation rate, FDI_{it} is foreign direct investment, LF_{it} is labor force, POP_{it} is population, UMP_{it} is unemployment rate and ε is error term.

Unit root tests can be used to examine whether the trend data should be first differentiated or regressed on the timing function to keep the data stationary (McLeod et al., 2012). Moreover, economic and finance theory often suggests the existence of long-run equilibrium relationships between nonstationary time series variables. Therefore, we performed a Hausman test to decide whether to specify random or fixed effects (Baltagi, 2014). When using this alternative calculation of the Hausman test based on artificial regression, the null hypothesis is rejected, the random effects estimator is inconsistent and should not be used in regressors.

$$GGDP_{it} = \alpha_i + \beta_1 ER_{it} + \beta_2 IR_{it} + \beta_3 IF_{it} + \beta_4 FDI_{it} + \beta_5 LF_{it} + \beta_6 POP_{it} + \beta_7 UMP_{it} + \varepsilon_{it}$$

(8) Where i is countries (Sweden, Demark, United Kingdom, Finland, Switzerland), t is time period from 2000 to 2020, α is constant, GGDP as a dependent variable represents green gross domestic product, $ER_{it}$is exchange rate, IR_{it} is interest rate, IF_{it} is inflation rate, FDI_{it} is foreign direct investment, LF_{it} is labor force, POP_{it} is population, UMP_{it} is unemployment rate and ε is error term.

This study uses the panel data regression fixed-effect model to test the impact of variables that change over time. With fixed-effect model, it's assumed that something may impact or bias the variables, therefore needed to control such possibilities. This model removes the effects of time-invariant characteristics. So, the net effect of predictors on the outcome variable can be assessed (Wang, 2023).

4. Research Findings Summary

This paper study the factor affects green GDP in the most environmentally friendly country in the world (Sweden, Denmark, United Kingdom, Finland and Switzerland). The result estimated by using Cobb-Douglas production function and use panel data over the period 2000 to 2020 and estimated by panel data regression fixed effect model. The result show as table 2

Variable	Coefficient	Std. Error	T stat	Prob.
C	-2.48E+12	9.08E+10	-27.27069	0.0000
ER	9.51E+08	4.04E+08	2.353298	0.0221**
IF	-3.49E+09	3.04E+09	-1.145195	0.2569
IR	7.71E+08	9.88E+08	0.780656	0.4382
FDI	0.1393	0.048696	2.860580	0.0059**
LF	73174.76	36211.51	2.020760	0.0480**
UMP	-156130.7	12609.68	-12.38181	0.000***
POP	176590	3122.948	56.54605	0.000***
R^2	0.999733			
Adj.R^2	0.999606			
DW	2.045937			

Note: The symbols ***, ** and * are significant at 1%, 5% and 10 % level respectively.

Table 2 Regression analysis result

Table 2 shows the $EE2$ = 0.999 that mean the exchange rate, inflation rate, interest rates, inflation rate, FDI, population, unemployment and labor force can explain the change of green GDP up to 99 %. The result shown that have 5 variables are significant effect to green GDP, that are exchange rate, FDI, population, unemployment and labor force.

5. Discussion of Research Findings

First, exchange rate (ER) has positive effect to green GDP at 9.51E+08 and significant at 5% level, that mean if exchange rate increases 1%, it will make green GDP increase by 951,000,000 dollar. The results shown that an increase in the exchange rate has a positive effect on green GDP. For example, Sweden's exchange rate increase by 6% and make green GDP increase by 5.12% (Data, 2024).On the other hand, the weak exchange rates may boost exports, especially in smaller countries which are more dependent on trade but can grow through price advantages in green countries (Choi et al., 2019; Smaili & Gam, 2023). This is more particularly so because countries that have stable exchange rates can attract more green investments since investors like markets that have a low risk of volatility in the exchange rate that is associated with long-term, capital-intensive projects in green energy (Li et al., 2023).

Next is foreign direct investment (FDI) has positive effect to green GDP at 0.1393 and significant at 5% level, that mean if FDI increases 1%, it will make green GDP increase by 0.1393 dollar. Foreign direct investment (FDI) often acts as a driver for green growth through facilitation of clean technology transfer and energy efficiency. For example, identified that in developed such as Finland the FDI increased by 40% resulting green GDP increase by 3% (Data, 2024). FDI has tended to be important for green growth, mainly through transitions in energy that reduce energy consumption and subsequent emissions with higher effectiveness in countries with robust environmental policies. Further research on E-7 countries shows that FDI, besides the investments in renewable energy, reduces carbon emissions and, therefore, can contribute to greener economic growth. In Central and Eastern Europe, the environmental impact of FDI has been proved to have both a negative and positive effect depending on the quality of the regulatory environment and the mechanisms of technology transfer (Caetano et al., 2022; Christoforidis & Katrakilidis, 2021; Xu et al., 2023).

Labor force (LF) also has positive effect to green GDP at 73174.76 and significant at 5% level, that mean if labor force increases 1%, it will make green GDP increase by 73174.76 dollar. In case of Denmark, labor force increased by 1.4% that make green GDP increase by 4.73% (Data, 2024). Some studies confirm that labor force can increase Green GDP in the positive direction with greater intensity when they are carried out by skilled or educated workers. The productivity of green technologies for example has shown to increase with higher educations in the labor force, thus reduced environmental degradation, enhancing Green GDP and reducing regular one. It also determined that in some countries, namely China and the

BRICS nations, increase of stronger human capital specifically an educated populace could substantially help environmental performance and economic efficiency. Its success is largely because the labor force has adapted more quickly and effectively to new green technologies (Ahmed et al., 2022; Naseer et al., 2022; Qian & Wang, 2022).

Unemployment (UMP) has negative effect to green GDP at 156,130.7 and significant at 1% level, that mean if unemployment increases 1%, it will make green GDP decrease by 156,130.7 dollar. This result is like study of the OECD countries found that lower rates of unemployment are good for transitioning renewable energy, which presupposes higher unemployment rates would do the opposite, it can slow down the transition towards renewable energy and green economic growth (Guler et al., 2024). Such as, unemployment in United Kingdom increased by 33.47% it's reduced green GDP by 6.64% (Data, 2024). The study of G7 countries showed that countries with stable employment can attract more investment since green business initiatives need more labor (Ayad & Djedaiet, 2024).

The last one is population (POP) has positive effect to green GDP at 176,590 and significant at 1% level, that mean if population increases 1%, it will make green GDP increase by 176,590 dollars. The results like previous study show that the countries where population and energy policies are in the right place, it was found that the growth of population positively contributes directly to green economic growth, the rise in population increases demand for green products and services. Population growth can stimulate demand for renewable energy and sustainable infrastructure that increases green GDP (Abbas et al., 2024; Vo & Vo, 2021). For example, Switzerland's population increased by 0.74% can increased green GDP by 4.42% (Data, 2024).

6. Knowledge from Research

This study examines the factors influencing Green GDP in five of the world’s most sustainable countries—Sweden, Denmark, the United Kingdom, Finland, and Switzerland—using the Cobb-Douglas production function with panel data from 2000 to 2020. The analysis employs a fixed-effect panel regression model.The findings indicate that key determinants of Green GDP include the exchange rate, foreign direct investment (FDI), population, labor force, and unemployment rate. Among these, the exchange rate has the most significant impact, as a stronger currency reduces import costs, facilitating the advancement of green technologies. In highly developed economies such as Denmark, the productivity of green industries increases alongside a well-educated workforce.

Additionally, the expansion of the population and labor force has a positive effect on Green GDP by driving demand for environmentally friendly goods and services. However, while FDI contributes to green economic growth, its positive impact may be offset by

investments that are not environmentally sustainable, thereby slowing the overall progress of Green GDP.

Conversely, unemployment negatively affects Green GDP, as the transition to a green economy requires a substantial workforce. High unemployment rates may hinder the expansion of renewable energy sectors and eco-friendly businesses, limiting economic growth in sustainable industries.

Policy Implications

Based on these findings, governments should promote investment in green industries by reducing taxes for environmentally responsible investors and implementing employment policies that support the green economy, such as income certification and employee welfare programs. These measures can enhance domestic production and consumption of green goods and services while also fostering job creation in labor-intensive green industries. This study underscores that the growth of Green GDP is not solely driven by technological advancements but is also influenced by economic, human capital, and policy factors. A comprehensive approach that integrates investment incentives, labor market policies, and sustainable economic strategies is essential for fostering a more resilient and equitable green economy.

7. Recommendation

1. Practical Recommendations Based on the findings, the following practical recommendations can be made:

1 . 1 Investment Incentives for Green Industries – Governments should implement tax reductions or subsidies for businesses investing in sustainable industries to encourage green economic growth.

1.2 Employment Promotion Policies – Policies such as income certification and employee welfare programs should be strengthened to support the green economy, as green businesses are labor-intensive and require a stable workforce.

1.3 Exchange Rate Stability Measures – Policymakers should consider strategies to stabilize exchange rates, as currency fluctuations significantly impact the cost of importing green technologies and materials.

1 . 4 Encouraging Sustainable Foreign Investment – Regulations and incentives should be introduced to attract FDI that aligns with environmental sustainability goals while discouraging investments that harm the green economy.

1 . 5 Workforce Development and Green Education – Investments in education and workforce training should be prioritized to equip workers with the skills needed in green industries, particularly in countries aiming to enhance green technology innovation.

2. Policy Recommendations To enhance the effectiveness of green economic development, governments should:

2.1 Develop integrated green economic policies that align monetary, fiscal, and labor policies to support sustainable economic growth.

2.2 Establish environmental standards for foreign investments to ensure that FDI contributes positively to Green GDP.

2.3 Promote public-private partnerships (PPPs) to enhance collaboration between governments, businesses, and research institutions in developing green technologies.

2.4 Implement unemployment reduction strategies such as job creation programs in the renewable energy sector to support a smooth transition to a green economy.

3. Recommendations for Future Research While this study provides valuable insights into factors affecting Green GDP, further research is needed in the following areas:

3.1 Inclusion of Additional Variables – Future studies could explore the impact of factors such as government environmental policies, renewable energy consumption, and technological innovation on Green GDP.

3.2 Comparative Studies – A comparison between developed and developing countries could offer deeper insights into the effectiveness of different green economic policies.

3.3 Long-Term Effects of FDI on Green Growth – Further research should analyze how different types of foreign investment impact Green GDP in the long run, differentiating between sustainable and non-sustainable investments.

3.4 Sector-Specific Analysis – Examining the role of specific industries, such as renewable energy, transportation, and manufacturing, in contributing to Green GDP would provide more detailed policy recommendations.

3.5 Impact of Global Economic Shocks – Investigating how global crises (e.g., financial downturns, pandemics) affect Green GDP and green investment trends could offer insights into resilience strategies.

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