Impact of CO$_2$ emissions on GDP per capita, FDI, forest area and government spending on education in Indonesia 1991-2020: The GMM methods

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Abstract. The economy is considered an efficient way to materialize, but the relationship between CO$_2$ emissions and economic growth has not been systematically explained. In this study, we will build a model that formalizes the interaction between CO$_2$ emissions and GDP per Capita, FDI, Forest Area and Government Spending on Education used to revisit the trade-off between economic growth and the environment or a green economy. The model captures an essential feature of the continuous innovation process, which is path dependencies. First, this research will create a data analysis using the System GMM Estimation. Second, we will evaluate GDP per Capita, FDI, Forest Area and Government Spending on Education spending on green growth. The results of this study are expected to be a government policy to increase green economic growth. Keywords: Public spending, green economics, System GMM

1. Introduction

Carbon dioxide emissions are a major driver of global climate change. A global study by taking a sample of twelve countries showed that estimates of CO$_2$ emissions that have occurred since 1800, which decompose carbon emissions into carbon emissions, impact the population and natural habitats, income, technology, and energy changes that occur in nature [1]. The world needs to take immediate action or action to reduce carbon dioxide emissions to avoid the worst impacts of climate change.

The main reason for studying CO$_2$ emissions is because CO$_2$ emissions play an important role in environmental protection and sustainable development. A study conducted by Bacon and Bhattacharya [2] found that CO$_2$ is 58.8% of the total greenhouse gas emissions where part of the CO$_2$ emissions is generated by economic growth, so it can be said that the reduction of CO$_2$ emissions can be done by reducing growth. Economy, especially developing countries, and this result is not necessarily the desired output of society. Another reason is that CO$_2$ emissions are directly related to energy consumption, which is an important factor in the world economy, both for production and consumption. Therefore, the relationship between CO$_2$ emissions and economic growth has importance for sustainable economic and environmental policies.

Foreign direct investment (FDI) into least developed countries (LDC) as a share of total world FDI has increased from 25% in the 1990s to 31% in the 2000s. LDC countries welcomed this FDI inflow because FDI has a very important role in the domestic economy as a source of economic growth and job creation [3]. However, researchers show that LDC countries can compete competitively by thinking about the environment between one country and another to attract FDI into the country [4]. This is a fast way in LDC countries for FDI that will cause LDC countries to become "pollution havens," where
multinational companies (MNCs) find strategies to save costs related to the environment [5]. In this scenario, the MNCs that benefit more from relocation is the MNCs in the most polluting industries. Therefore, LDC countries need to assess whether FDI entering LDC countries will be associated with higher pollution levels [6].

The world's forest area, especially the forest area in Indonesia, has been greatly reduced to its lowest level, according to the 2015 United Nations Food and Agriculture Organization report [7]. The U.N. Framework Conventions have created financial incentives to reduce deforestation, but the barrier is a lack of capital at both the national and international levels. Forests can be a productive tool in maintaining climate conditions; however, the challenge of forest destruction needs to be faced, and preventive measures are taken to restore forests that have been damaged by forests, where forests are a source of life for living things. To control or stop deforestation activities is to reduce CO₂ emissions.

Government spending has increased significantly in many countries to mitigate the adverse effects of the 2008-2009 economic crisis. Most of the GDP is used by the government to finance government spending and impact various economic variables and prosperity. Recent research has shown that government spending is an important determinant of environmental quality [8].

The effect of government spending on the environment can be divided into direct and indirect effects. On the one hand, higher government spending will increase redistributive transfers, resulting in increased income equality of the people and thus higher public demand for better environmental quality. Moreover, if the environment is a luxury public good, likely, it will only be demanded when the demand for other public goods has been satisfied, i.e., at the level of large government size [9]. On the other hand, government spending can reduce the level of prosperity. Research conducted by [9–12] found that government spending can, in turn, lead to lower levels of pollution at some levels and can also be higher levels of pollution to others, depending on the shape of the Environmental Kuznets Curve (EKC), as done by [13]. Therefore, the effect of total government spending on the environment cannot be determined a priori.

This study was conducted to examine the impact of CO₂ emissions on GDP per capita, FDI, forest area owned by Indonesia, and government spending on the education sector in improving the quality of human resources with the GMM approach from 1991-2020.

2. Literature review

2.1. Economic growth

Simon Kuznets states that economic growth is an increase in the capacity of a country to produce output or produce goods and services in the long run. The rate of economic growth is an indicator of a country's economic success and development and describes changes in economic activity. Economic growth can be positive when economic activity increases and can be negative when economic activity decreases. According to Todaro, economic growth can be influenced by various factors, including:

- Population growth and labor force are considered positive factors to encourage economic growth.
- Capital accumulation comes from savings and investments that can increase production and income in the future.
- The development of technology is used as innovation in the production process to increase productivity.

The indicators used to assess economic growth are Gross Domestic Product (GDP) for the national level and Gross Regional Domestic Product (GRDP) for the regional level. In determining the value of GDP and GRDP, two approaches are used: the business field approach and the expenditure approach, which are calculated based on current prices and constant prices.

2.2. Environment Kuznets Curve Hypothesis

The list of authors Economic growth and CO₂ emissions are explained in a hypothesis called the Environmental Kuznets Curve (EKC). The EKC hypothesis shows the contribution of economic growth
to higher emissions, but further economic growth can reduce environmental degradation. This is due to technological advances and the shift to a service-based economy.

The EKC hypothesis explains that economic growth will initially increase environmental degradation. This is because the state will focus on increasing production without paying attention to environmental aspects. The production process that is carried out continuously will result in environmental degradation in the form of pollution of both soil, water, and air. Economic growth at a certain point will then make people aware that the need for good environmental quality is very important. The turning point is the point at which economic growth will reduce environmental degradation. The shape of the inverted U curve can be seen in the image below:

![Figure 1. Figure Inverted U Curve (Kuznets Hypothesis).](image)

Based on Figure 1, which explains the stages that occur in the relationship between economic growth and environmental quality, the EKC stages are divided into three. The first explanation of Kuznets inverted U-curve relationship is economic growth through the transition from agriculture to industry, then post-industrial with a service-based economic system. Environmental damage tends to increase due to changes in economic structure from rural to urban areas and from agriculture to industry as mass production and consumption growth. Environmental damaged then declined with the second change in the economic structure from energy-based heavy industry to technology-based industries and services. In the first stage of industrialization, pollution increased fast as people were more interested in jobs and income than clean air and water. In this regard, the community is too poor to pay for environmental control, and regulation is irresponsible. The country will switch from agriculture to industry at low-income levels, and pollution intensity rises as waste from growing production and mass consumption. The manufactured industry is due to greater use of natural resources, polluting emissions, and demands for increased output. Meanwhile, at high-income levels, economic development is dominated by the post-industrial or service economy.

At this stage, environmental awareness increases, spending on the environment is higher, technological efficiency increases, and the demand for environmentally friendly goods/services increases. The movement of the curve that is starting to balance brings the industrial sector cleaner, people value the environment more highly, and regulation becomes more effective before the initial condition.
2.3. Literature reviews

Literature reviews include title, author, variable, methods and results shown in Table 1.

| Title and Author | Variable | Methods and results |
|------------------|----------|---------------------|
| Do institutional quality and financial development affect sustainable economic growth? Evidence from South Asian countries | institutional quality, green growth, financial development | This study examines the long-term cointegration between variables modelled using the Pedroni, Kao, and Westerlund cointegration technique. The results of our panel cointegration approach reveal long-term cointegration between financial development, institutional quality, and green growth |
| Farhan Ahmed, Shazia Kousar, Amber Pervaiz, Aiza Shabbir | Gross Domestic Product (GDP), renewable energy, consumption (REC), CO₂ emission (CO₂), gross fixed capital formation (GFC), Labor force (LABFORCE), access to electricity (ACCEL). | This study uses GMM analysis which more efficiently solves the endogeneity problem and eliminates variable bias than the least-squares method and causal estimation; this study finds that the adoption and development of renewable energy will lead to increased economic growth in Africa, both in the long and short term due to increased one per cent in renewable energy consumption will lead to an increase in the economic growth of 0.07% and 1.9% in both the short and long term, respectively. The study also finds that environmental sustainability through emission reductions may not be Africa's priority for achieving overall development because the CO₂ emission coefficient in this study is not statistically significant. Therefore, governments of African countries should intensify efforts to develop the renewable energy sector, especially using policy instruments, while also taking advantage of mature non-renewable industries for faster growth on the continent and Agenda 2063. The role of agronomic inputs in increasing cereal yields and their consequences for the country's structural change processes. The results show a clear role of fertilizers, modern seeds, and water in increasing yields. We then examine the respective empirical relationships between agricultural output and economic growth, the workforce shares in agriculture and non-agricultural value added per worker. The identification strategy includes new instrumental variables that take advantage of the unique economic geography of fertilizer production and transportation costs to the country's agricultural heartland. |
| Hassan Qudrat-Ullah, Chinedu Miracle Nevo | Cereal Yield, Fertilizer, Precipitation, Modern seeds, Labor-land ratio, Years of Schooling, Tractors per ha, GDP per capita, Government Consumption, Labor Share in Agriculture | |
| Fertilizing growth: Agricultural inputs and their effects on economic Development | |
| John W. McArthur Gordon C. McCord | | |
The economic impact of multifunctional agriculture in Dutch regions: An input-output model

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This paper is an empirical attempt to fill this gap. To that end, an input-output model for multifunctional agriculture was developed in several areas in the Netherlands. The definition used includes four multifunctional agricultural activities: (i) green care, (ii) tourism, recreation, and education, (iii) agricultural sales, and (iv) green services. The value of the multiplier – which shows the multifunctional impact of this multifunctional activity across the economy – is calculated for four regions of the Netherlands. The results show that multifunctional agriculture is not the main driver of economic growth in terms of output and employment. In addition, from the input-output model, it appears that multifunctional agriculture causes more spending in the agricultural sector itself than in other economic sectors. The indirect feedback effect of multifunctional agriculture on the non-agricultural sector in the Dutch economy appears rather small. The input-output model also shows that the multiplier values differ between regions, mainly due to differences in the composition of multifunctional activities. Although the absolute size of employment in multifunctional agriculture is very small, employment per unit of output is high, especially compared to employment/production levels in primary agriculture.

What are the dynamic links between agriculture and manufacturing growth? and environmental degradation? Evidence from different panel income countries

Mirza Md Moyen Uddin

This study investigates the causal relationship between agricultural sectoral growth and manufacturing in the Environmental Kuznets Curve (EKC) framework for 115 countries during the period 1990–2016 using GMM estimates. The results show a long-term equilibrium relationship between CO₂, CH4 and PM2.5 emissions and the macroeconomic determinants of agriculture and manufacturing, GDP growth, energy consumption, urbanization, trade openness, and transportation. Furthermore, agricultural GDP growth (YES 2) has no significant effect on CO₂ emissions for the lower
middle, upper-middle and high-income groups, while it has a significant positive effect on low-income groups. In CH4 emissions, the agricultural sector shows an inverted U-shaped EKC for low, middle, and high-income groups and PM2.5 emissions for all income groups. However, manufacturing GDP growth shows a U-shaped EKC of CO2 emissions and an inverted U-shaped EKC of CH4 emissions for all income groups. Furthermore, the paired Granger causality test shows that the variables have bidirectional and unidirectional causality for all income panels. Our results show that promoting sectoral energy efficiency policies, greener technologies, and strict regulations by the government can protect the environment from degradation in the country.

This study investigates this relationship using cointegration regression methods (FMOLS - fully modified ordinary least squares and DOLS - dynamic ordinary least squares); we use electricity production (hydro, natural gas and renewable energy), trade opening, GDP, and CO2 emissions to establish causality. We find that power generation, GDP, and trade liberalization have both positive and negative effects on the Brazilian economy. We also find a two-way causality between trade openness and all energy generated in Brazil. Separately, we observe that GDP, hydropower, and renewable energy negatively affect the CO2 emission model, while only pollution emissions and trade openness have positive effects on the economic growth model. These results have important policy implications for the Brazilian economy that do not support an appropriate long-term sustainable development strategy.

Consequently, policymakers should consider implementing appropriate management capacities to encourage renewable energy use and benefit from the positive effects of economic growth and environmental policies to control pollution levels through the potential of available natural resources. Our findings were not motivated by differences or sample selection and persisted across multiple specifications, allowing us to observe relationships with great accuracy. Several diagnostic tests have been applied to show that it is not misleading.
3. Study methods

3.1. Study approach
This study uses a quantitative approach that focuses more on proving hypotheses, understanding through various tests. This quantitative approach seeks to measure a concept (variable) so that it is easier to understand statistically and then analyze the model used in the quantitative approach.

3.2. Study model
The study model used is a carbon dioxide emission model by entering the variables of GDP per capita, FDI, forest area, government spending on education with annual data starting from 1991 to 2020.

\[ \text{LCO}_2^{KT} = \alpha_0 + \alpha_1 \text{LGDPCap1} + \alpha_2 \text{FDI} + \alpha_3 \text{Forestarea} + \alpha_4 \text{Gov}_\text{exp}_\text{educ} + \epsilon_t \]

where:
- \( \text{LCO}_2^{KT} \): Carbon dioxide emissions from solid fuel consumption refer mainly to emissions from the use of coal as an energy source
- \( \text{LGDPCap1} \): GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products.
- \( \text{FDI} \): Foreign direct investments are the net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor. This series shows net inflows (new investment inflows less disinvestment) in the reporting economy from foreign investors and is divided by GDP.
- \( \text{Forestarea} \): Forest area is land under natural or planted stands of trees of at least 5 meters in situ, whether productive or not, and excludes tree stands in agricultural production systems (for example, in fruit plantations and agroforestry systems) trees in urban parks and gardens.
- \( \text{Gov}_\text{exp}_\text{educ} \): General government expenditure on education (current, capital, and transfers) is expressed as a percentage of total general government expenditure on all sectors (including health, education, social services). It includes expenditure funded by transfers from international sources to the government. General government usually refers to local, regional, and central governments.

3.3. Generalized Method Moments (GMM)
The research model in the last two decades, studies on econometrics have developed very rapidly, namely estimation of generalized method moments (GMM), vector autoregression (VAR), and non-stationary analysis of time series (unit root test and cointegration test) [14]. The research contributes to the literature on GMM was made by [15]. The research carried out has an important contribution to the development of econometric theory.

The formulation of the two-stage least square (TSLS) estimation as an estimator of the optimal important instrument variable (IV) with conditional homoscedasticity conditions and testing of over-identified restrictions was first introduced by Sargan [16]. This formulation method was also used for nonlinear models called the GMM method to cross-sectional data regression.

Meanwhile, Econometrics is a field of economics that studies applying mathematical statistics and statistical inferential analysis to empirical measurements based on economic theories [17]. Methodologies that combine mathematical statistics and economic theory produce what are called econometric models. In the econometric model, there are three types of data based on their collection techniques: cross-section data, time series data, and data that combines cross section and time-series data, better known as panel data.
Several journals or studies present the results of empirical research using the GMM method and maximum likelihood with the aim that the GMM method has been used in empirical research and has the use and role of GMM in this empirical research. A research survey on using the GMM method was conducted by Hansen [14] to determine the role and advantages of using the GMM method. Hansen [14] surveyed articles on empirical research using time series data in 1990 and 2000 and published in: American Economic Review; Econometrica; Journal of Political Economy; Journal of Monetary Economics; Journal of Money, Credit, and Banking; Quarterly Journal of Economics, and Review of Economics and Statistics.

The category of using the GMM method includes true linear regression for non-parametric variables for serial correlation of the disorder variable where [15] uses over-identification testing and usually it is not included in the OLS and two (two) or even three (three) stages at least square of the linear model.

Several advantages of using the GMM method. First, GMM does not require a distribution requirement such as a normality assumption. Second, any form of heteroscedasticity in the model can still be applied; third, GMM can estimate parameters even if the model cannot be completed. Analytically on the first derivative and the set of instrument variables can be adjusted [18]. Fourth, if there is heteroscedasticity or serial correlation in error terms from the equation model, using the GMM approach will be more efficient than 2SLS [16]. Fifth, if a model has endogeneity problems caused by dependent variables, independent variables, or even error terms, then the GMM method is applied 10/20/2021 8:28:00 PM.

4. Results and discussion

By using GMM method, in this study we analyze the variables that affect environmental pollution. In this case, we assume environmental pollution with variable carbon dioxide emissions.

| Variable      | Definition of variables                  | Coefficient | Probability |
|---------------|------------------------------------------|-------------|-------------|
| C             |                                          | 55.6145     | 0.0000      |
| LGDPCAP1      | GDP per capita                            | 0.3092      | 0.0000      |
| FDI           | Foreign Direct Investment                 | 0.0151      | 0.0022      |
| LFORESTAREA   | Forest area                               | -3.4957     | 0.0000      |
| GOV_EXP_EDUC  | General government expenditure on education | 0.0720      | 0.0001      |
| R²            |                                          | 0.987924    |             |
| Adjusted R²   |                                          | 0.985912    |             |
| Durbin-Watson stat |                                      | 1.160586    |             |
| J-statistic   |                                          | 4.733492    |             |
| Prob(J-statistic) |                                      | 0.192385    |             |

Source: Processed Data, 2021

Table 2 presents GMM data regression result of the variables that have the potential to affect the carbon dioxide emissions from solid fuel consumption. In Table 2, dependent variable is carbon dioxide emissions as log (LCO2_KT). While independent variable consists of GDP Per capita in log (LGDP_CAPI), Foreign Direct Investment % net inflows (FDI) from GDP, Forest area in log (LFORESTAREA), dan General government expenditure on education (GOV_EXP_EDUC). Regression results show that variable GDP per capita, Foreign Direct Investment, and General government expenditure on education have a significant positive effect of 5% on the carbon dioxide emissions from solid fuel consumption. However, forest area variable has a significant negative effect of 5% on the carbon dioxide emissions from solid fuel consumption. It means that all of the dependent variables contribute to produce carbon dioxide emissions that leads to environmental pollution.
5. Conclusion
The contribution of GDP per capita, Foreign Direct Investment, general government expenditure on education and forest area has a significant effect to the carbon dioxide emissions from solid fuel consumption. It means that to be able to create a green economy or economic growth by paying attention to the environment, more innovative government policies and community efforts are needed to achieve these goals. This research is expected to support the community and the government so that it is easier to identify factors that will increase environmental pollution.

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