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Examining the driving factors of CO2 emissions using STIRPAT model based on IPAT identity in Indonesia

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Abstract
The purpose of this study is to illustrate the spatial econometric techniques that estimate carbon dioxide emissions drivers. Following IPAT identity, an extended STIRPAT model was utilized to determine the primary driving factors for carbon dioxide emissions in Indonesia amid 1971-2013. On the premise of the three most important factors in the IPAT model, in particular, population size, economy development, and technological progress, the following influencing factors were introduced: urbanization, industrialization, fixed capital formation, trade openness, and energy consumption structure. The time-series analysis and quantitative investigation were performed on the affecting variable for two different time frames, to be specific, the period of New Order Era (1971-1998) and the period of the Reformation Era (1999-2013). The primary objective of this research is to identify and analyze the driving factors and the correspondences between the variables by utilizing STIRPAT model. This shows that higher population and urbanization further increases the economic development and the energy consumption per capita. Result in the increases CO2 emissions because of energy efficiency, energy saving technology and awareness of environmental protection are still low.

Keywords: CO2 emissions, STIRPAT model, IPAT model, energy consumption, ridge regression

1. Introduction

The accumulation of greenhouse gasses (GHGs) in the air has been a debate topic among scientists since a long time ago as it contributes to the risen of global surface temperature [1]. The emissions of greenhouse gasses, such as CO_2, N_2O, CH_4 or other F-gasses are the most important gases that naturally present in the atmosphere [2]. These gases mainly emitted through fossil fuel uses especially since the Industrial Revolution human activities that produce more of these. The world's CO_2 emissions were increasing over the year since 1960 until 2013 (Fig. 1.1). Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring. The use of energy portrays by far the largest source of emissions followed by agriculture and industrial process not related to energy [3]. CO_2 resulting from oxidation of carbon in fuels is responsible for the largest share of global GHG emissions and a small portion of CH_4 and N_2O. The world is relying so much on fossil source.

At the beginning of the new order, economic and political stability was a top priority. Government programs are tied to the control of inflation, the rescue of state finances and the security of people's basic needs. After seeing the experience, a mixed economic system is chosen within the framework of the Pancasila democratic economic system. All this is done by the implementation of a five-year periodic long-term (25-30 years) general development pattern called Pelita. Development only prioritizes economic growth without balanced equitable political, economic and social life. So although it has succeeded in increasing economic growth, fundamentally national development is very fragile. As a result, when a crisis is the impact of the global economy, Indonesia feels the worst impact. Prices are rising drastically, the rupiah exchange rate weakening rapidly, causing chaos in all fields, especially the economy. The Reformation era began when the leadership of BJ.Habibie's president, but there has not been a significant increase in the economy because of the fundamental problems left in the New Order era. The policy of concern is how to control political stability.

1.1 STIRPAT Model

Many papers from Table 1.1 are examined from more than one country or province, but they mainly focused on EKC and different independent variables. This time, I will conduct this study in Indonesia (as a whole) because there's no available data for each province. The approach of extended STIRPAT model that has been used by Wang *et al*. (2017) for Xinjiang, China will be adopted [4]. Based on their paper, the industrialization was divided into two parts: secondary and tertiary industry proportion, but this paper will adjust the variable just to industrialization [5]. Wang *et al*. also used total fixed assets investment for its independent variable, I will use gross fixed capital formation (GFCF) which is a component element of the expenditure on GDP, and shows about how much of the country's economy is invested in this paper. The dependent variable that I will look for is CO_2 emission, and the independent variables are population, urbanization, economic growth, technological progress, economic growth, technological advances, fixed capital formation, trade openness, energy consumption, and industrialization. This analysis will include 43 years by using annual data from 1971 until 2013. However, empirical studies on the main factors of Indonesian CO_2 emissions using the STIRPAT mode have not been widely discussing though it is data exist for Indonesia.

Table 1: Previous Studies of IPAT/STIRPAT and CO2 Emissions

Study	Period and Region	Methodology	Impact on CO2 emissions
Hwang and Yoo (2012)[14]	1965-2006 (Indonesia)	Granger-causality, co-integration, unit test roots	Energy consumption, economic growth
Bargaoui *et al*. (2014) [15]	*1980-2010 (241 countries)*	STIRPAT model, panel data	Economic and population growth, urbanization, energy intensity, Kyoto protocol
Saboori and Soleymani (2014) [16]	*1971-2007 (Indonesia)*	EKC, ARDL, VAR, unit root test	Economic growth, energy consumption, foreign trade
Liu *et al*. (2015)[17]	1990–2012 (China)	STIRPAT model, panel co-integration, causality analysis	energy consumption, urbanization
Wang *et al*. (2016)[4]	1995-2012 (China)	Panel data model, Granger causality test	Energy consumption, economic growth
Wang *et al*. (2017)[5]	1952-2012 (Xinjiang, China)	Extended STIRPAT model, *OLS, ridge regression*	Population, urbanization, trade openness, industrialization, energy consumption, economic growth, fixed assets investment

1.2 Driving Forces of Greenhouse Gas Emissions

a. Population Growth and Economic Development

The papers listed in Table 1.1 analyzed various dependent variables with different subjects (countries, term, and method). As far as anyone is concerned population growth and economic development's effect on the level of national carbon emissions has not been unequivocally investigated (a conclusion likewise came to in another a survey by Rosa and Dietz 2012)[18]. However, since many studies conducted in Table 1.1 utilize an elasticity model, i.e., all variables in natural logs, the assessed coefficient for population speaks to the rate change effect on the dependent variable that a one percent change in population would bring about. The evaluated population coefficient in those studies mirrors the rate change in the emissions development rate that a one percent change in the population growth rate would cause.

Dietz and Rosa (1997) found that the population and affluence are the driving forces of environmental impact [19]. Those countries with different income group impact on population growth on emissions are slightly different for upper, middle, and low-income countries and that urbanization had a very different impact on emissions for low and lower-middle-income countries and upper-middle income countries [12]. The higher population and higher percentage of working-age population lead to higher CO_2 emissions [20]. Obviously, we might be keen on population growth accurately in light of its roundabout consequences for emissions/energy consumption through its effect on population forms like urbanization, populace density, age structure, and household. It is most likely better to display those four procedures straightforwardly, evaluating the literature's discoveries their impact on emissions or energy consumption. STIRPAT model was suggested for studying the emission from developing countries or low-income level, the impact of GDP is imperative [10]. York (2008b) finds export intensity in Southeast Asia to be positively correlated with energy production.

b. Urbanization and Energy Consumption

Urbanization has a positive relationship with carbon emissions and energy consumption since urbanization is part of the development process. Urbanization impact positively in the energy use for 14 EU countries [21], but there a significantly negative relationship between urbanization and carbon emissions for high-income countries with ordinary least squares (OLS) regressions [10]. Energy consumption in developing countries increases as the urbanization raise that result in the addition in CO_2 emissions.

Higher emissions or energy intake may be prompted through urbanization's relationship with industrialization (i.e., the move from agriculture to manufacturing and service. The advance development of individuals from rural to urban regions and from agricultural to industrial makes energy consumption increment in three ways: agriculture operation must motorize as they turn out to be less labor intensive, urbanization spatially isolates food consumer from its producers, along these lines requiring a transport necessity that did not exist under traditional farming, current industry/producing uses more energy per unit of yield and worker than the conventional way [22]. Later, comparable studies have considered developed and developing countries, CO_2 emissions and disaggregated energy consumption, and additional explanatory variables. These studies have affirmed the positive connection amongst urbanization and emissions or energy consumption. However, it is not clear whether national levels of urbanization are true measures of the density of the sorts of movement that may lead (through efficiencies) to less energy consumption or emission [1].

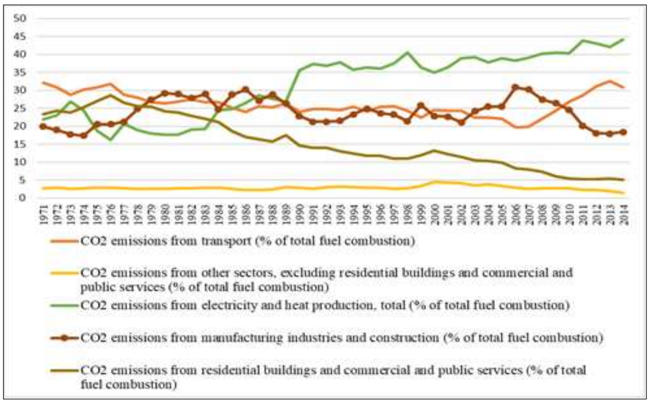
2. Indonesia's Role in CO2 Emissions

2.1 Region of CO2 Emissions

By the total of GHG emissions, Riau is on top. This is due to the massive deforestation for almost 20 years in this province (WRI, 2015). Papua Island slightly on the second rank of GHG emitters and followed by Kalimantan Island. The highest economic activity is in Java Island but, the Island has the lowest GHG gasses, this is in contradiction with the theory. Nevertheless, Indonesia put the industry and has lots of forest outside Java Island. The growth of industrialization outside Java, the availability of land is one factor that boosts the emissions. The problem is the constructor burn the forest to build the industrial area, this had caused a problem since the 2000s, which is the primary resource of CO_2 emission outside Java [23]. Indonesia has dealt and made new regulations, but it seems that the illegal logging still there even though decreasing.

Fig 1: Indonesian CO_2 Emissions by Province in 2001, 2012

2.2 Industry's CO2 Emissions



Source: World Bank, 2017; OECD/IEA, 2014

Fig 2: CO2 Emissions by Sectors (% of total fuel combustion)

During the economic crisis in South Asian countries, Indonesia also has setbacks in its emission from industry sector. Since 1991 until 2005, carbon dioxide emissions from industrial are integrated with production activities; foreign demand was a major driving factor with the addition of energy consumption [24]. By the advancing of technology, industrial processes shift to cleaner and fewer emissions' energy, CO2 emissions since 2005 was clearly decreasing by time to time. As the description in industrial sector of energy use, industry can be deduct as a group of energy consumers which use energy for industrial process such as steam boiler, direct heating, lighting, and mechanical equipment, but does not include energy used for electricity generation for such industries: iron and steel, chemical, non-iron metal, non-metal production, food, paper, wood, construction, textile etc. The industry sector in the 1980s and the early 1990s have shown its rapid development. Recently, Indonesian economic growth has resulted in a steady movement towards industrialization. Unfortunately, the industrial sector was hit hard by the South Asian financial crisis in 1998.

3. Methodology

3.1 STIRPAT Model

IPAT is a model that was established in the field of ecology to assess the intricacies of social, economic, and environmental variables [25]. The IPAT model was originally formulated in the early 70s by Ehrlich and Holdren to establish the dominant forces of anthropogenic environmental impacts [7, 8]. IPAT is a math accounting equation:

$$I=P*A*T \qquad (1)$$

I represent environmental impact, P is population, A is affluence, and T is technology. Change affluence broadly by all human activity on the environment, but it can be examined for a single environmental impact, in this case, is the emission of CO_2. The population is determined by the total amount of Indonesian citizen. Here, the affluence is the per capita gross domestic product (GDP) of that region [25]. Usually, the T term is the most significant driver of environmental impact but can also be used to have a positive effect on the environment. Technology within the IPAT realm has since been delineated further in the field of industrial ecology [26]. After that, York *et al*. established the STIRPAT model from the IPAT framework, which was described as follows:

$$I = a* bP* cA* dT* e \qquad (2)$$

Where a acts as the model coefficient, b, c, d are the dependent variable's exponential, and e is the error of the model. This model could analyze the case of various environmental issues [7. 8]. Adapting the above approaches for empirical analysis presents some challenges. STIRPAT attempt this task by using econometric methods to estimate parameters of human-environment relationships. STIRPAT originated as a stochastic adaptation of Ehrlich, Holdren, and Commoner's IPAT identity model [25, 27]. Standing for Stochastic Impacts by Regression on Population, Affluence, and Technology (STIRPAT), York, Rosa, and Dietz' framework attempts to estimate the degree of environmental impact [7, 8, 19, 28]. The newly established model is shown below:

$$LnI = a + b_1*LnPs + b_2*LnPc + c*LnA + d*LnT + e*LnS + f*LnV + g*LnW + h*LnE + Lne \qquad (3)$$

In STIRPAT analysis of GHG emissions, total population (Ps) is estimated as a scale factor and. often exhibits a positive coefficient near unity. Urbanization (Pc) is an important factor in the industrialization and development process. The economic growth (A) is Indonesian yearly GDP divided by total population. The influence of technological progress (T) calculated by carbon emissions per unit GDP (CO_2 intensity). The industrialization (S) characterized with the proportion of total industry output over the total GDP. Other aspects of technology not captured by energy intensity will be the error term, e. The V is total fixed assets investment. Trade openness (W) is the percentage of gross import and export value of GDP; trading is Indonesia's number one income. Energy consumption (E) estimated by the percentage of coal consumption to total energy consumption since coal is the main energy source of Indonesia. The specific variables were all listed in Table 3.1.

Table 2: Variables Description Used

Variables	Symbol	Description of variable	Unit measurement
CO2 emissions	I	Total CO2 emissions from World Bank database	kt
Population size	Ps	Total population	Million people
Urbanization	Pc	Percentage of urbanization in total population	%
Affluence	A	Economic growth (GDP divided by population)	US$ per capita
Technology	T	Technological progress (CO2 per unit of GDP/ CO2 intensity)	(kg per kg of oil equivalent energy use)
Industrialization	S	Percentage of industry output value over the total GDP	%
Gross fixed capital formation (GFCF)	V	Total fixed capital (fixed asset investment)	Billion US$
Trade openness	W	Percentage of total import and export value of GDP	%

Energy consumption	E	Percentage of fossil fuel consumption in total energy consumption	%

3.2 Hypothesis

From the model, it's hypothesize that the descending trend naturally caused by the fell from most the factors because the increase or decrease of the variable represents the appreciation or depreciation of the impact during the economic crisis, and the ascending trend influenced by the recognition from the variables after the crisis (H1). The result from the assessment will be explained in section 5, including the actions and implementations. Population (Ps) measures the total number of people in Indonesia. Urbanization (Pc) is part of the population that sort of travel and lived around the country. STIRPAT model was suggested for studying the emission in developing countries or low-income level, the impact of GDP is vital. Many studies from Table 1.1 proved that these factors have positive influence directed toward global emissions and Fig. 3.3 also displays escalating values of both. The greater the population is, the greater the urbanization that confidently leads to an absolute coefficient (H2). Affluence (A) represents the total Gross Domestic Product (GDP) per capita in constant value (US$ per capita). Indonesian investment (V) express by GFCF in billion US$. GDP in an indicator of the size of the economy. A rise in GDP and GFCF will occur an expansion of the country's richness and capital input. It put meaning in the increase of export and import. Hence, the graph is escalating over the year (Fig. 3.4). In short, the bigger the economy, the more significant the trade becomes, the more emission it will be. Therefore, a real dependency is expected from both variables (H3). The industrialization (S) expressed by the percentage of industry value added of GDP. Trade openness (W) mean the rate export and import of GDP. From Fig. 3.5, Indonesian industrialization is expanding hence undeniable positive coefficient expected, this hypothesis confirmed by the observations in Table 1.1. At the other hand, the relationship of trading towards the CO_2 emission could be positive or negative depends on whether the effect is strong or not. But, as the economic state and the trade opportunities (supply and demand as in import and export) has a steady growth, both of the variables would generate a positive impact (H4). Energy consumption and technological apparently assures the growth of carbon dioxide emissions hence positive coefficient is expected (H5).

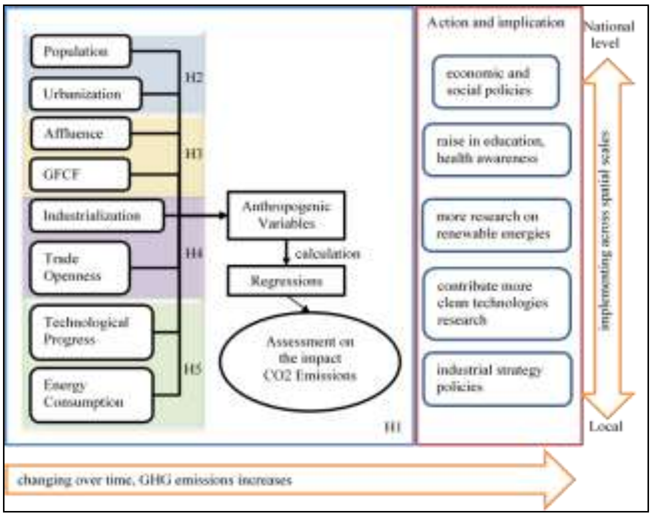


Fig 3: Conceptual Framework

4. Results & Discussion

4.1 OLS Result

A time-series based estimation methods are necessary to serial correlation [29, 30, 31]. In Table 1.1, different papers utilized other regression techniques such as Granger causality, panel data, and unit root test. OLS used to evaluate the unknown parameters in a linear regression, with the objective of limiting the total of the squares of the contrasts between the dependent variable (estimations of the variable being anticipated) in the given dataset and those predicted by explanatory variables.

The output from Table 4.1 shows that the coefficient is unreliable because of severe multicollinearity issues and the coefficient is relatively high due to a different unit of measurement. New Order Era has greater problem compare to Reformation Era. It defines false estimation of the regression, inflates the standard errors of coefficients, gives inaccurate, and lower the reliability of the model. From the year 1971-1998, the collinearity (VIF more than 10) deducted from the highest to the lowest: population, urbanization, capital formation, economic growth, energy consumption, industrial, and trade openness.

Table 3: The Final Result by using OLS Regression*

	C	LnPs	LnPc	LnA	LnT	LnS	LnV	LnW	LnE
1. New Order (1971-1998)									
Coefficient	16867.57	-3203.954	16477.96	66.9605	893.5517	1907.105	4.78485	-791.2721	2361.619
Std. Error	87251.92	1394.059	4750.058	66.794	713.0345	1483.083	995.882	698.8754	1539.74
VIF		425.0900	312.0317	102.4679	8.769410	21.16446	113.2404	17.39675	84.83514
2. Reformation Era (1999-2013)									
Coefficient	-202608.6	-22683.89	90860.99	190.223	23064.74	11939.93	-529.421	-2554.731	9519.285
Std. Error	2064365	25481.67	91447.47	163.284	14162.26	9349.815	1563.86	2513.031	15254
VIF		1366.460	1225.570	387.2689	45.31326	3.323643	326.8952	4.601773	7.626640

4.2 Ridge Result

The ridge trace figure is straightforward to determine the value of *k* (Ridge parameter). The points on the left vertical axis are the OLS regression values ($k = 0$). Along with the increase in the value of *k*, the estimation of standardized betas also changes. At some point, the coefficients seem to settle down and then gradually drift towards zero. Fig. 4.1 showed the value of *k* value would be between 0.0001 and 0.1. The VIFs from 1971-2013 appears below ten once the *k* is greater than 0.02. The value obtained from the standardized ridge regression coefficient output by analytical search it was chosen using the Hoerl's (1976) algorithm and because it does not end in zeros (optimum k value). The value of *k* is 0.436386 for the New Order Era and 0.782372 for the Reformation Era.

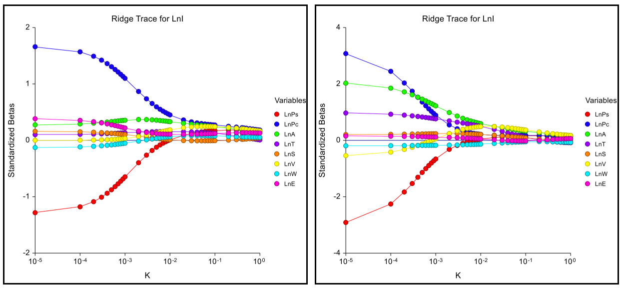


Fig 4: Ridge Regression Trace

*New Order Era (left), Reformation Era (right)

4.3 Discussion

New Order Era (1971-1998)

For the first period (1971-1998), coefficient from Ridge regression will be used (Table 4.2). Based on the equation (3) of the model that has been explained in section 3, the optimal model will be (for k = 0.436386):

LnI = -118330.9 + 443.5651*LnPs + 2187.619*LnPc + 45.73569*LnA + 479.1898*LnT + 237.0667*LnS + 699.0679*LnV + 364.3705*LnW + 839.1619*LnE (4)

Based on equation 4, all of the independent variables are the significant factors contributing the emission development.

Table 4: Ridge Regression Coefficient for k = 0.436386

	LnPs	LnPc	LnA	LnT	LnS	LnV	LnW	LnE
Coefficient	443.5651	2187.619	45.73569	479.1898	237.0667	699.0679	364.3705	839.1619
Std. Error	75.11279	308.8427	8.677245	451.1087	510.6212	126.0494	312.9786	208.0531
VIF	0.1436	0.1534	0.2012	0.4083	0.2918	0.211	0.4059	0.1802

a) Population and urbanization

At this time, Indonesia has shifted its financial system from liberal economic system to Pancasila economic system. Indonesia also carried out long-term economic policies. These systems are run towards development in all areas, reflected in the eight channels of equity: basic needs, education, and health, income sharing, employment opportunities, women's and youth participation, development and judiciary. Thus, for developing country such as Indonesia, urbanization apparently become the major driving factor. The government had promoted preventive checks to reduce the number of births through KB (keluarga berencana).

b) Economic growth and capital formation

Since the early 70s, the former president of Indonesia started trading with the foreign investor, expanded the Indonesian economic scope. The government also had increased the revenue from tax by implementing the tax reform in 1983. As a result, since 1984 the citizen moved to bigger cities to make a better living because, Indonesia succeeded in rice self-sufficiency, poverty reduction, and improvement in welfare indicators such as education participation rate and declining infant mortality rate. Hence, this shows that financial development is escalating the industrial activities, trading, and technology toward CO_2 emissions.

c) Industrialization and trade openness

The economic growth appealed more capital investment and demand (import and export) which boosts the industrial progress and result in higher emissions. The spike of GFCF, industrialization, and trade openness in early 1980 justify this theory. All this happened before the decline of Indonesia during the economic crisis in 1998 where all sectors dropped very drastically, including carbon dioxide emission

d) Technological progress and energy consumption

Because of the advance in industrialization and trading, Indonesia also put a lot of research about renewable energy which is an extension of technological advancement in Indonesia which is represented by CO_2 intensity. These activities required a lot of electricity, in this extent making the increase of energy consumption (especially from fossil fuel as Indonesia's main primary energy supply that has been mentioned in section 2). The fossil fuel indulgenced namely coal, encourage the country's energy consumption, it turns into the second contributing variable of climate impact (the drastically upsurge from CO_2 emissions from electricity and heat sector since the 1990s). The empirical analysis indicates that energy consumption is the second major contributor.

Reformation Era (1999-2013)

For the second period (1999-2013), coefficient from Ridge regression will be used (Table 4.3). Based on the equation (3) of the model that has been explained in section 3, the optimal model will be (for k = 0.782372):

LnI = -302998.5 + 1112.991*LnPs + 4221.478*LnPc + 16.72094*LnA -1842.095*LnT + 280.1178*LnS + 183.7881*LnV - 865.684*LnW+ 3662.476*LnE (5)

Based on equation 5, not all of the independent variables are the significant factors contributing the emission development.

Table 5: Ridge Regression Coefficient for k = 0.782372

	LnPs	LnPc	LnA	LnT	LnS	LnV	LnW	LnE
Coefficient	1112.991	4221.478	16.72094	-1842.1	280.1178	183.7881	-865.684	3662.476
Std. Error	305.4885	1208.232	4.653458	1282.712	6107.724	54.59663	1212.222	5079.409
VIF	0.0405	0.0441	0.0648	0.0766	0.2922	0.0821	0.2206	0.1742

a) Population and urbanization

During the end of the New Order Era, the development only prioritizes economic growth without balanced equitable political, economic and social life. Because of the economic downturn that occurred, Indonesia was struggling hard to rise again. Almost all factors occur a very significant increase. Urbanization remains a major factor followed by the total population for emissions in Indonesia.

b) Economic growth and capital formation

Those problems inherited from the New Order period still cannot be solved completely. It can be seen with the existence of corruption, inflation, economic recovery, the performance of SOEs, and the weakening of the rupiah exchange rate. Early 2000 was the liberation of the Indonesian economy, it intensely flourish until now. It's no doubt that the GFCF and affluence were next in the order. It exposes that economic development contributes in pressing more CO_2 emissions.

c) Industrialization and trade openness

The sign is positive for industrialization, and it has yet to regain the growth rate prior to the crisis and grow into the dominant sector of the Indonesian economy, especially in 2008 which it contributed a big portion of GDP. Reformation era was the time that trade openness played adverse effects on emissions growth. This might be the result of raising the price of fuel during the leadership period of SBY. Indonesia relies so much on fossil fuel, especially for land transportation purpose used to deliver goods (trading activities).

d) Technological progress and energy consumption

Technology development was not the priority of Indonesia at the time. The primary concern was how to control political and economic stability. As described in section 2, the coal consumption has doubled since 2010 and in 2015 coal became Indonesia's dominant energy fuel. When the energy use increases by one percent, the total emissions will drop by 3662.47 percent, ceteris paribus. Keeping other things the same, a raise of energy consumption by one percent will impact as much as 3662.47 percent

5. Conclusions

5.1 General Theoretical Implications

Indonesia should control its fertility rate by implementing KB more since this policy has left behind and Indonesia should open more job with a stable income in rural areas. Increase the availability of qualified human resources. In this context, education and health are entirely borne by the government. The guarantee of the provision of nutrition for the community is not seen as a program of compassion for some poor people (such as the current state's BLT or raskin program). These very basic needs should be enforced so that they can be accessed by all citizens. Exceptions apply only to citizens who have more ability to choose access to education and health outside facilities provided by the state. So that, the citizen does not need to migrate to bigger cities and contributes more CO_2 emissions later on.

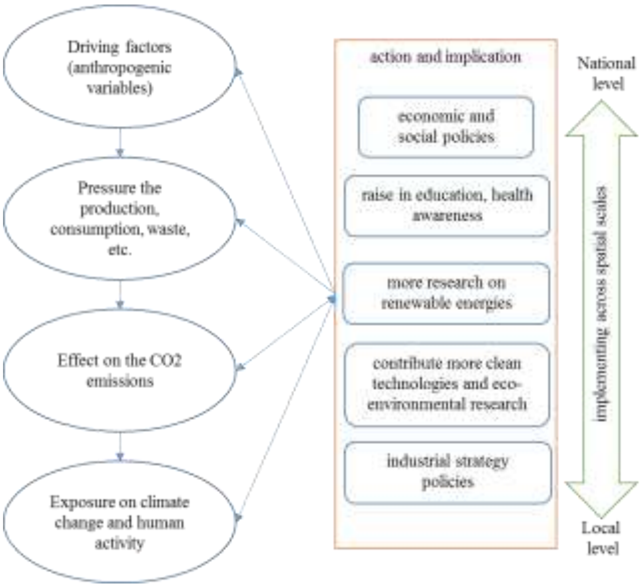


Fig 5: Implication and policy suggestions

The impact of the growth of GDP per capita on CO_2 emissions presents an approximately descending trend with the increase of economic development level from New Order Era to Reformation Era, this statement aligned with the findings from Fan *et al*. (2006). GDP and GFCF are the real result of the development in Indonesia, and a good development shouldn't be stopped. In order to decrease the GHG emissions, policies from other aspects should be implemented. It is imperative to consider the procurement of raw material sources that are still imported, such as cotton for the textile industry, as well as some agricultural products since Indonesia has a lot of natural resources. The export ban should be imposed on the type of raw materials that can be produced or mined in Indonesia. Also, giving more attention to small and medium industries with facilities and ease of access to microcredit, cheap raw material production, and guarantee of market availability. Due to small and medium industries using natural or conventional forces that are more environmentally friendly, this will reduce CO_2 emissions.

The industrial strategy policy with the private or public sector should lead to the development of renewable energy or environmentally friendly machinery and proper waste handling. Includes the built of the parent making the industry of machinery, chemical industry, steel processing industry, aluminum, and so forth. The technological transfer is done through investment cooperation with a country with more advanced technology, or 'adopt' technology learned from abroad (Germany, Japan, Russia, China, etc.). As long-term anticipation, strategic studies on alternative energy sources with minimal adverse impact on the environment are required. Advances in technological fields such as these are expected to decrease the CO_2 emissions.

5.2 Conclusion

From comparing the empirical analysis output with the previous literature, I noted that all of the variables are in accordance with the papers listed in Table 1.1. STIRPAT model gave a clear picture of analyzing anthropogenic factors on CO_2 emissions. Primarily due to critical multicollinearity problem, regression models for this study did not corporate well with all of the variables, even though a solution was produced for analysis.

Table 6: Hypothesis Result

Hypothesis			Result	
			1971-1998	1999-2013
H1	CO_2 emissions	+	+	+
H2	population	+	+	+
	urbanization	+	+	+
H3	affluence	+	+	+
	GFCF	+	+	+
H4	industrialization	+	+	+
	trade openness	+	+	-
H5	technological progress	+	+	-
	energy consumption	+	+	+

In this research, the estimation results of the driving factors of carbon dioxide emissions in Indonesia influenced by some anthropogenic variables such as total population, urbanization, fixed capital formation, industrialization, technological progress, and energy consumption (H1). These results also closely align with my hypothesis (H2) that population and urbanization will have a proportional relationship with CO_2 emissions. However, it was unexpectedly that the urbanization will be the major factors in influencing emissions was found. These results are consistent with my hypothesis (H3) in that affluence and GFCF have a positive relationship with CO_2 emissions. Therefore, a further increase in income would have a greater effect on carbon dioxide emissions in developing country or small sample hence, an increase in revenue does not have as significant effect as developed countries with higher GDP per capita. The positive effect of industrialization affirmed the hypothesis (H4); however, the trade openness has negative influence in Reformation Era, the impact was not as high as others. This means that, it rejected H4 for trade openness. Technological progress shows positive sign in

New Order Era and negative sign in Reformation Era, it denied H5 for technological progress. Energy consumption showed the positive influence to emissions and confirmed the hypothesis (H5).

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