Electricity Production, Energy Consumption and Capital Formation: Analyzing the Footprints in Indonesia

Melyana R. Pugu[1], Yanyan M. Yani[1], Wawan B. Dharmawan[1], Velix V. Wanggai[2], Zuhaina Zakaria[3]*

[1]Universitas Padjadjaran, Bandung, Indonesia, [2]Bappenas RI, Indonesia, [3]School of Electrical Engineering, College of Engineering, Universiti Teknologi MARA, Selangor, Malaysia. *Email: zuhainaz@uitm.edu.my

ABSTRACT

We aim to investigate the effect of gross and fixed form of capital formation on electricity production and energy consumption in Indonesia during the period 1993-2018. Our found results are suggesting that most of the gross/fixed capital formation measures are not affecting either the electricity production or the energy production in Indonesia. However, more specifically key measures of gross/fixed capital formation like Gross fixed capital formation, private sector (% of GDP) and gross fixed capital formation, private sector (current LCU) are showing their mixed impact on electricity production from renewable sources, excluding hydroelectric (% of total), and electricity production from renewable sources, excluding hydroelectric (kWh). On the other hand, Gross fixed capital formation (annual % growth) has its Fossil fuel energy consumption (% of total), and Renewable energy consumption (% of total final energy consumption). The stated findings have some limited implications for the financial analysts and policy makers dealing with the electricity production and overall consumption of fossil fuel and renewable energy sources. Yet, this research is confined to Indonesian economy; however, adding the other regional economies in future studies may provide some different results.

Keywords: Cross/Fixed Capital Formation, Energy Consumption, Electricity Production
JEL Classifications: K32, H54, D24

1. INTRODUCTION

In different field of studies, the idea of capital formation (CF) is principally used, while exploring its conceptual relationship with set of indicators. Rarely, it is also applied in corporate accounts and has got several definitions. In national accounts, statistics, macroeconomics, and econometrics, CF is also applied which is called net investment. In that matter, it is used in an accounting period as measure of the amount to the capital stock of country. Total "stock of capital" is stated as a modern term for capital accumulation in economic theory, or for the development of capital stock (Pinkovskiy and Sala-i-Martin, 2016; Vogel et al., 2017; Ormaechea and Fernández, 2020; Ortiz and Castillo Rentería, 2020). In more current period, the concept "capital formation" has been used to discuss for setting up an organization, with some fiscal measures, saving's drivers, public borrowing, growth of

capital markets as well as secondary markets and privatization of financial institutions . For investments objectives, it mentions any process for control of capital amount, or raising the amount of capital retained, or any scheme in developing the capital resources (Welch, 2016; Hernández, 2020; Hernández and Prieto, 2020; King and Samaniego, 2020).

During 1990s and 2000s, CF started in credit-based economic development, which was related to the fast development of the financial sector. Firstly, capital formation is related with measure of total investment. However, the idea of gross capital formation denotes the accounting value of the "additions of non-financial produced assets to the capital stock less the disposals of these assets. The concept of Investment contains all types of capital assets, financial assets or physical property. Financial assets are not included in the capital formation like stocks and securities.

Secondly, due to the meaning of reinvestment of profits into capital assets, the capital formation is assembled with the idea of capital accumulation. But in modern accounts, capital accumulation is not used in accounting concept. However, it is sometimes used by the International monetary funds (IMF) and United Nations Conference (UNC) on Trade and Development). Contrary to the above idea another notion is that capital accumulation shows that some people become richer, while entire society becomes poorer, and the total capital formation diminishes (Ucak, 2015). Thirdly, gross capital formation is frequently used as the same meaning with the gross fixed capital formation but this is a mistake because capital formation means to more net assets gains than just fixed capital.

Capital formation measures helps to understand the real picture for the economic growth where the goods and services are produced with the help of tangible capital assets (Ali et al., 2017). Across the time, these measures are planned to show the changes in expansion of physical wealth. Meanwhile, many physical changes are occurred in the way that overall structure of the business is organized in a better way in financial sector. The value of capital formation is measured in gross terms, i.e. before the depreciation of consumption of fixed capital, or after deduction of "depreciation" of write-off in economic statistics and accounts (Koowattanatianchai et al., 2019).

Till current years, various economies in the world has experienced a fast economic progress with the start of market-oriented plans. Due to the best chances prevailing across many sectors, there had been an invasion of capital in both developed and developing economies. To retain a higher rate of progress, capital formation is very important for a country (Budiharto et al., 2017). In worldwide, every economy is differently gifted with natural resources, availability of capital and similar factors of production. The origin of capital formulation from endogenous growth model reflects various concepts which needs a complex knowledge to understand. Inside an economy, the growth residual is being endogenously determined, which covers the public and private sector capital formation sections, directly or indirectly.

For the climate change in recent years with some rapid rate, one of the key factors which are playing their role is known as energy consumption (Dirks et al., 2015; Meng et al., 2018; Santamouris, 2016; van Ruijven et al., 2017). For rapid growth of any economy, energy consumption is accepted as an indication. Researchers widely believe that electrical energy is a vital indicator in the modern economies with its massive influence on the long term economic growth (Churchill and Ivanovski, 2019; Sarwar et al., 2017). At the same time, it also promotes the quality of life. For different economies, specifically those which are known under the title of developing states have faced series of issued during the time of higher energy prices because of oil prices. Due to this reason, since 70s to date, energy consumption is under significant attention of the researchers. The crucial role of energy with its variety of impacts on all sectors of the economy is not neglectable and researchers have observed its relationship with variety of factors. Our study investigates the relationship between energy consumption, electricity generation and capital formation in the region of Indonesia.

2. LITERATURE

Literature work is widely supporting the titles of energy consumption, electricity production and capital formation in different economies (Georgantopoulos, 2012; Inglesi-Lotz, 2016; Kum et al., 2012; Ntanos et al., 2018; Ouédraogo, 2010; Rafindadi and Mika'Ilu, 2019; Shahbaz et al., 2012; Solarin, 2011, 2014; Solarin and Shahbaz, 2015). In the economy of UK, research efforts of Rafindadi and Mika'Ilu (2019) believe that the financial transaction in the United Kingdom (UK) is the largest in its nature comparatively to the rest of the world. However, contrary to this, country's economic growth and capital formation is not widely recognized in a way that how sustainable energy consumption effect the sustainability of the UK's developed financial market. From 1970 to 2013, their study worked out while using the time series to accomplish parsimonious results. To explore the relationship between the variables, cointegration the Johansen co-integration test, and the ARDL bounds testing approach were applied. Among the variables, there exists a cointegration between the energy consumption and developed financial market. In the UK, the model arrangement of energy consumption, there is a U-shape pattern of relationship. This proposes that with financial market development the energy demand rises. After a threshold level of market's operational peak, it starts to decline. On sustainable energy consumption, the study found that the economic growth have a significant effect. Whereas energy demand and capital formation are positively connected. On the oterh hand, some auhtors review the prgoress of gross capital formation along with other financial and economic dynamics (Akobeng, 2017; Albiman and Suleiman, 2016; Qayyum and Zaman, 2018; Salazar-Núñez and Venegas-Martínez, 2018; Shuaib and Ndidi, 2015; Södersten et al., 2018).

Ntanos et al. (2018) try to explore the European market for the energy consumption from some renewable sources for the GDP growth and other macroeconomic indicators like gross fixed capital formation. Overall study has collected the data from 25 European countries during the period 2007-2016. Cluster analyses, descriptive analyses and ARDL method were applied which founds a correlation between the GDP and renewable energy sources, energy consumption and non-renewable energy sources and gross fixed capital formation in the selected countries. It is believed set of the empirical results are consistent with earlier research studies with literature support as well. in his research efforts, (Inglesi-Lotz, 2016; Yun, 2020) has explored the panel data using the GDP as depdendent variable with the renewable energy consumption, research and development cost, and capital formation etc. It is believed that there is a direct relationship among the dependent and independent variables where econoimc growth, energy consumption and capital formation are correlated to each other.

Solarin (2011) investigates the association among consumption of electricity and real domestic product with the presence of gross capital formation during the period of 1980 to 2008 in Botswana. It is believed that there exists a causality between the electricity consumption and gross domestic product in the long-run where both are positively associated to each other. However, in the targeted economy of Botswana, significant need is required for

the formation of capital which is determined by adequate level of electricity as well. Ouédraogo (2010) test the association among the energy consumption and economic growth while taking the capital formation as macroeconomic indicator. However, through causality findings, it is found that there is no significant causal association between the investment and consumption of electricity in Burkina Faso. At the same time, evidence shows that there is a positive but feedback causal association between the GDP and capital formation where the consumption of electricity is growing with the increase income level. Authors believe that for the economic and social welfare, electricity consumption is a key factor and for this reason, energy policy needs to be implemented for ensuring the future development in the region.

Georgantopoulos (2012) test the direction of association between the electricity consumption and real gross domestic product in the region of Greece. Author examines the time period of 1998 to 2010 with robust regression results reflecting the fact that there is a causal link between the economics of the green, capital formation and energy consumption. Södersten et al. (2018) predicts the environmental impact of capital formation taking the gross fixed capital formation which represents the financial terms of total demand for the goods and services. It is found that gross fixed capital formation as a share of total carbon footprints significantly verifies in different countries. Through structural decomposition approach authors further state that there is a relative decoupling of carbon footprint of gross capital formation.

In the recent time, Rafindadi and Mika'Ilu (2019) have anzlyed the relationship between sustainble energy consumption and capital formation for the developed financial marekt of United Kingdom. To address the study objective, data was collected during 1970 to 2013 with the application of Zivot-Andrew structural breatk test along with the ARDL bounds testing and Johansen cointegration methods. The findings of the study reveals the fact that there is a conintegration among the study variables. Meanwhile, it is observed that significant relationship exists between the financial market development, energy consumption based on the U-shaped dynamic in the economy of UK. Their study stuggest that energy demand in the economy is playing a good role in the financial market development. Some other studies have also been observed through which energy consumption, capital formation, and econoimc dynamics are significantly observed (Cao et al., 2020; Kamran et al., 2020; Olopade et al., 2020; Rahman and Ahmad, 2019).

3. RESEARCH METHODOLOGY

To investigate the effect of gross and fixed form of capital formation on electricity production and energy consumption, the variables are measure through different proxies as shown in Table 1.

For analyzing the impact of gross and fixed capital formation on the energy consumption and energy production, present study has applied the regression methods which is assumed as among the most cited measures for investigating the casual relationship between the study variables. For this purpose, following equations are developed mathematically and tested through Stata-14.

Table 1: Description of all variables

Gross capital formation	Measured with % of GDP (GCF)
Gross capital formation	Measured with constant LCU (GCFC)
Gross capital formation	Measured with annual % growth (GCFG)
Gross capital formation	Measured with current LCU (GCFLCU)
Gross capital formation	Measured with current US$ (GCFUSD)
Gross fixed capital formation	Measured with % of GDP (GCFFGDP)
Gross fixed capital formation	Measured with constant LCU (GCCFCLCU)
Gross fixed capital formation	Measured with annual % growth (GFC1)
Gross fixed capital formation	Measured with (current LCU) (GFC3)
Gross fixed capital formation	Measured with current US$ (GFC4)
Gross fixed capital formation, private sector	Measured with % of GDP (GFC5)
Gross fixed capital formation, private sector	Measured with current LCU (GFC6)
Electricity production from renewable sources, excluding hydroelectric	Measured with % of total (EPREN)
Electricity production from renewable sources, excluding hydroelectric	Measured with kWh (EPREXH)
Electricity production from hydroelectric sources	Measured with % of total (EPHYDRO)
Fossil fuel energy consumption	Measured with % of total (FFENG)
Renewable energy consumption	Measured with % of total final energy consumption (RENGCOM)

$$y = C + ɓ1 + ώ2 + ӽ3 + Υ4 + \delta5 + \rho6 + □7 + ₣8 + \delta9 + n\ldots + \epsilon \quad (1)$$

Where in the above equation, coefficients for each of the explanatory variables are represented through different symbols till n number of explanatory variables as observed under present study. More specifically, the above equation can be re-written as follows:

$y1\ (EPREN) = C + ɓ1(GCF) + ώ2(GCFC) + ӽ3(GCFG) + Υ4(GCFLU) + \delta5(GCFUSD) + \rho6(GFCFGDP) + □7(GCCFCLCU) + ₣8(GFCI) + \delta9(GFC3) + \beta10(GFC4)\beta11(GFC5) + \beta12(GFC6) + n\ldots + \epsilon \quad (2)$

$y2\ (EPREXH) = C + ɓ1(GCF) + ώ2(GCFC) + ӽ3(GCFG) + Υ4(GCFLU) + \delta5(GCFUSD) + \rho6(GFCFGDP) + □7(GCCFCLCU) + ₣8(GFCI) + \delta9(GFC3) + \beta10(GFC4)\beta11(GFC5) + \beta12(GFC6) + n\ldots + \epsilon \quad (3)$

$y3\ (EPHYDRO) = C + ɓ1(GCF) + ώ2(GCFC) + ӽ3(GCFG) + Υ4(GCFLU) + \delta5(GCFUSD) + \rho6(GFCFGDP) + □7(GCCFCLCU) + ₣8(GFCI) + \delta9(GFC3) + \beta10(GFC4)\beta11(GFC5) + \beta12(GFC6) + n\ldots + \epsilon \quad (4)$

$y4\ (FFENG) = C + ɓ1(GCF) + ώ2(GCFC) + ӽ3(GCFG) + Υ4(GCFLU) + \delta5(GCFUSD) + \rho6(GFCFGDP) + □7(GCCFCLCU) + ₣8(GFCI) + \delta9(GFC3) + \beta10(GFC4)\beta11(GFC5) + \beta12(GFC6) + n\ldots + \epsilon \quad (5)$

$y5\ (RENGCOM) = C + ɓ1(GCF) + ώ2(GCFC) + ӽ3(GCFG) + Υ4(GCFLU) + \delta5(GCFUSD) + \rho6(GFCFGDP) + □7(GCCFCLCU) + ₣8(GFCI) + \delta9(GFC3) + \beta10(GFC4)\beta11(GFC5) + \beta12(GFC6) + n\ldots + \epsilon \quad (6)$

Y1 covers the Electricity production from renewable sources, excluding hydroelectric (% of total), Y2 indicates Electricity production from renewable sources, excluding hydroelectric (kWh), Y3 shows Electricity production from hydroelectric sources (% of total), Y4 demonstrates Fossil fuel energy consumption (% of total), and Y5 explains Renewable energy consumption (% of total final energy consumption) in the above models. Addition to this, Con means the constant values of all of these dependent variables, Bn reflects the marginal or differential values of the dependent variables, determined by gross/fixed capital formation measures. Tables 2 and 3 have shown these results accordingly.

4. RESULTS

Table 4 is dealing the set of descriptive measures for gross capital formation, electricity production, and energy consumption. All of the stated patterns of these descriptive scores are also presented in a graphical layout; Figure 1, while Figure 2 shows the correlation matrix among the variables. The time duration of the study consists of 1993 to 2018 with annual scores. For the data acceptability all of these variables are measured under a valid method as defined by world development indicator. For capital formation, two titles are observed gross and fixed capital, whereas energy consumption is observed with fossil fuel and non-traditional or some new sources.

For these mean score, readers can reasonably understand the average patterns of each of the variable during the last 26 years. On the other hand, standard deviation reflects the measure for the deviation from this mean point in 26 years of the data set. Finally, both highest and lowest score of each of the variable provides the lowest cut point and upper cut point for the variables over the study period.

Reviewing the effect of capital formation in terms of gross and fixed dimensions for Indonesian economy, results are provided in two separate tables where Table 2 is covering EPREN, EPREXH, and EPHYDRO are main dependent variables. At the same time Table 3 provides a range of results for exploring the effect of gross and fixed capital formation on FFENG, RENGCOM, and EPHYDRO over the same study time duration. The findings as provided under Table 2 show that most of capital formation measures are non-significant for explaining the Electricity production from renewable sources, excluding hydroelectric (% of total), Electricity production from renewable sources, excluding hydroelectric (kWh), and Electricity production from hydroelectric sources (% of total). However, contrary to most of the variables,
The influence of Gross fixed capital formation, private sector (% of GDP) is positive but significant for the EPREN, and EPREXH. It means that both of these variables are directly determined by the Gross fixed capital formation, private sector (% of GDP)

Table 2: Regression results for electricity production from renewable sources, excluding hydroelectric (% of total) electricity production from renewable sources, excluding hydroelectric (kWh) electricity production from hydroelectric sources (% of total)

Var List	DV1	DV2	DV3
	EPREN	EPREXH	EPHYDRO
1. GCF	−0.0593	−550868163.1	−0.128
Standard Error	(−0.10)	(−0.73)	(−0.06)
2. GCFC	−4.59E−17	−0.000000146	3.19E−16
Standard Error	(−0.70)	(−1.68)	−1.31
3. GCFG	0.00116	2732209.4	0.00471
Standard Error	−0.53	−0.95	−0.58
4. GCFLCU	2.39E−14	0.00000182	−3.00E−14
Standard Error	−0.91	−0.05	(−0.31)
5. GCFUSD	−2.92E−10	−0.0519	3.80E−10
Standard Error	(−0.80)	(−0.11)	−0.28
6. GFCFGDP	−0.115	310045296	0.0582
Standard Error	(−0.20)	−0.4	−0.03
7. GCCFCLCU	2.81E−15	0.00000328	−6.58E−15
Standard Error	−1.92	−1.7	(−1.22)
8. GFC1	−0.0416	−52852277.7	0.0439
Standard Error	(−1.94)	(−1.86)	−0.55
9. GFC3	−2.71E−14	−0.00000307	3.37E−14
Standard Error	(-0.98)	(−0.08)	−0.33
10. GFCF4	3.20E−10	0.0809	−3.92E−10
Standard Error	−0.83	−0.16	(−0.27)
11. GFCF5	0.211*	2.05****	−0.356
Standard Error	−2.63	−0.36	(−1.20)
12. GFCF6	−2.23e−16**	−0.000000279*	−1.60E−16
Standard Error	(−3.09)	(−2.92)	(−0.60)
_cons	0.659	1.54	30.84*
Standard Error	−0.23	−1.13	−2.87
N	26	26	26
R-sq	0.843	0.774	0.821
adj. R-sq	0.698	0.65	0.655
F-test Sig.	0.000	0.000	0.000

Table 3: Regression results for fossil fuel energy consumption (% of total) renewable energy consumption (% of total final energy consumption)

Var List	−1	−2
	FFENG	RENGCOM
1. GCF	−2.101	1.803
Standard Error	−1.034	−1.395
2. GCFC	−1.54E−16	3.54e−16*
Standard Error	−1.20E−16	−1.61E−16
3. GCFG	0.00513	−0.00753
Standard Error	−0.00397	−0.00536
4. GCFLCU	−3.33E−14	−9.60E−15
Standard Error	−4.76E−14	−6.42E−14
5. GCFUSD	6.79E−10	3.47E−11
Standard Error	−6.64E−10	−8.96E−10
6. GFCFGDP	2.046	−1.379
Standard Error	−1.062	−1.433
7. GCCFCLCU	3.58E−15	−7.15E−15
Standard Error	−2.66E−15	−3.59E−15
8. GFC1	−0.8105***	0.535***
Standard Error	−0.039	−0.0127
9. GFC3	3.48E−14	1.38E−14
Standard Error	−5.03E−14	−6.79E−14
10. GFCF4	−7.20E−10	−7.83E−11
Standard Error	−7.04E−10	−9.49E−10
11. GFCF5	0.204	−0.386
Standard Error	−0.146	−0.198
12. GFCF6	2.85E−17	−2.71E−17
Standard Error	−1.32E−16	−1.78E−16
_cons	57.00***	53.04***
Standard Error	−5.29	−7.138
N	26	26
R-sq	0.928	0.863
adj. R-sq	0.861	0.821
F-test Sig.	0.000	0.000

when the predicted values are observed in STATA-14. Contrary to this effect, Gross fixed capital formation, private sector (current LCU) shows a negative influence on Electricity production from renewable sources, excluding hydroelectric (% of total), and Electricity production from renewable sources, excluding hydroelectric (kWh). It is accepted that fixed capital formation for the private sector is causing a decline in electricity production in Indonesia. the rest of the variables are observed with their no impact on EPREN, EPREXH, and EPHYDRO. All three models are statistically fit as F-test shows a significance level of 1 percent with the explanatory power of 69.8 percent, 65.0 percent and 65.5 percent for all three regressed variables.

For examining the regression results of all dimensions of capital formation either fixed or gross with their impact on fossil and renewable energy consumption, Table 3 is providing some evidences. For renewable energy consumption measured as

percentage of final energy consumption, Gross capital formation (constant LCU) is provided the coefficient of 3.54 and standard error of -1.61. It expresses that whenever there is an increase in gross capital formation constant LCU, there is a decline in the consumption pattern of renewable energy as observed through percentage share of total energy in Indonesia. However, Table 4 shows that there is no significant impact of rest of the variables entitled either gross or fixed capital formation except GFC1 named as Gross fixed capital formation (annual % growth). for Fossil fuel energy consumption (% of total), there is a significant and negative impact like -0.8105, explains that whenever there is more Gross fixed capital formation (annual % growth), there is a less Fossil fuel energy consumption (% of total) on average basis. Contrary to this result, the influence of Gross fixed capital formation (annual % growth) on Renewable energy consumption

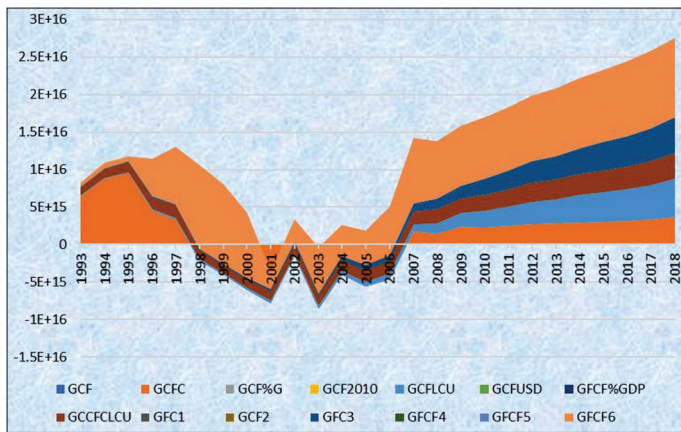**Figure 1:** Overall trend for capital formation, energy consumption and electricity production

Table 4: Descriptive analyses

Variable	Obs	Mean	Std.Dev.	Min	Max
GCF	26	29.053	4.549	21.404	35.072
GCFC	26	7.69e+14	4.82e+15	-8.63e+15	9.50e+15
GCFG	26	10.995	103.141	-164.509	435.616
GCF2010	26	8.46e+10	5.30e+11	-9.50e+11	1.05e+12
GCFLCU	26	1.60e+15	1.64e+15	9.33e+13	5.13e+15
GCFUSD	26	1.52e+11	1.23e+11	2.62e+10	3.60e+11
GFCFGDP	26	27.214	4.824	19.429	32.812
GCCFCLCU	26	1.86e+15	7.67e+14	9.09e+14	3.44e+15
GFC1	26	5.567	10.29	-33.008	16.737
GFC3	26	1.52e+15	1.55e+15	8.67e+13	4.79e+15
GFCF4	26	1.44e+11	1.17e+11	2.43e+10	3.36e+11
GFCF5	26	31.098	5.336	20.872	39.388
GFCF6	26	6.95e+15	3.29e+15	5.76e+14	1.11e+16
EPREN	26	4.706	1.091	2.41	5.972
EPREXH	26	6.51e+09	3.55e+09	1.08e+09	1.22e+10
EPHYDRO	26	9.403	3.776	4.372	21.227
FFENG	26	63.928	2.931	57.469	69.385
RENGCOM	26	42.339	5.497	35.155	55.433

Figure 2: Overall correlation matrix among the variables
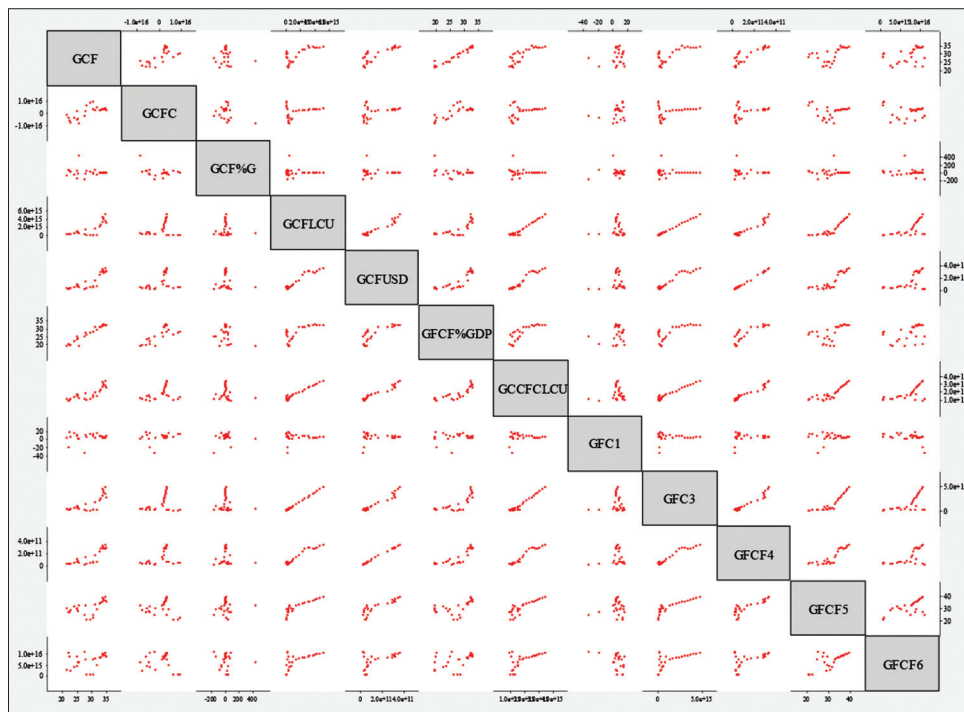
(% of total final energy consumption) is positive as presented through 0.535. The deviation of this coefficient score is -0.0127, which provides a CR of 42.125, hence significant at 1 percent or with the 99 percent confidence level. This confidence level believe that researchers are 99 percent sure to say that higher Gross fixed capital formation (annual % growth) means higher the Renewable energy consumption (% of total final energy consumption) and vice versa. For the model fitness, R2 is 92.8 percent with the adjusted value of 86.1 percent for Fossil fuel energy consumption (% of total), and 86.3 percent (R2) and 82.1 percent (adjusted R2) according to the achieved results of the variables. From both of these adjusted value of R2 is more reliable for accepting the overall marginal change in the dependent variable due to independent variables which are also entitled as explanatory variables by the researchers. Like Table 3, similarly Table 4 is providing the f-test significance at 1 percent, hence believed that both of the dependent variables in Table 4 are significantly depending on the independent variables entitles with gross and fixed formation of the capital.

5. CONCLUSION

Like other regional economies, capital formation in the country of Indonesia is examined with some diversified patterns over the last few decades. However, literature is widely missing the relationship among the gross/fixed capital formation with electricity production and energy consumption specifically in Indonesia. Considering this missing part of the earlier work, this research is carried out during the period of 26 years starting from 1993 with an ending time of 2018 through yearly observations of both dependent and independent variables. For making the contribution stronger, our research has added maximum proxies of gross/fixed capital formation as defined by the world development indicator; one of the significant sources in the world to get the data for such indicators. For this purpose, we have added 12 proxies of capital formation with different measurements as observed from the annual data of World Bank indicators. For examining the electricity production, three variables under the title of Electricity production from renewable sources, excluding hydroelectric (% of total), Electricity production from renewable sources, excluding hydroelectric (kWh), and Electricity production from hydroelectric sources (% of total) are added as first stock of dependent variables. Additionally, energy consumption is reflected with Fossil fuel energy consumption (% of total) and Renewable energy consumption (% of total final energy consumption). However, our study has found that most of the capital formation proxies are non-significant when their effect on both energy consumption and electricity production is analyzed. However, Gross fixed capital formation, private sector (% of GDP) has a positive impact on Electricity production from renewable sources, excluding hydroelectric (% of total) and Electricity production from renewable sources, excluding hydroelectric (kWh), accepting the argument that higher such electricity production is due to determinant effect from gross fixed capital formation from private sector of Indonesia. Opposing this, Gross fixed capital formation, private sector (current LCU) is adversely affecting both of the above electricity production proxies. It reflects that electricity production is low when the Gross fixed capital formation, private

sector (current LCU) is high and vice versa. For two measures of energy consumption, renewable energy consumption is directly determined by Gross capital formation (constant LCU). The findings for both of these energy consumption saying that again most of the capital formation proxies are not showing their determinantal effect. However, Gross fixed capital formation (annual % growth) is causing a decline in consumption of fossil fuel while at the same time, causing an increase in renewable fuel consumption in Indonesia. Overall following key points are added as research implications

a. The implication of the above findings towards the policy developers is that efforts for the specific capital formation as explained earlier for controlling the fossil and similar other energy sources may provide some good benefit to the environment and economy of Indonesia

b. This implies that not only the environmental results could be achieved but at the same, some positive results about the community life may also be experienced in Indonesia

c. For controlling the electricity production, impact of capital formation may also be reviewed by financial analysts for enhancing their knowledge about cross sector and cross industry interdependency.

REFERENCES

Akobeng, E. (2017). Gross Capital Formation, Institutions and Poverty in Sub-Saharan Africa. Journal of Economic Policy Reform, 20(2), 136-164.

Albiman, M., & Suleiman, N. (2016). The relationship among export, import, capital formation and economic growth in Malaysia. Journal of Global Economics, 4(2), 2375-4389.

Ali, M. B., Rehman, O. U., & Amin, A. (2017). The effect of investment in human resources on economic grwoth of developing countries. Kashmir Economic Review, 26(2), 72-84.

Budiharto, A., Suyanto, M., & Aluisius, H. P. (2017). The Relationship Between Economic Growth, FDI, Trade, Labor, and Capital Formation in Indonesia. Paper presented at the Mulawarman International Conference on Economics and Business (MICEB 2017). https://dx.doi.org/10.2991/miceb-17.2018.9

Cao, M., Kang, W., Cao, Q., & Sajid, M. J. (2020). Estimating Chinese rural and urban residents' carbon consumption and its drivers: considering capital formation as a productive input. Environment, Development and Sustainability, 22(6), 5443-5464.

Churchill, S. A., & Ivanovski, K. (2019). Electricity consumption and economic growth across Australian states and territories. Applied Economics 52(8), 1-13.

Dirks, J. A., Gorrissen, W. J., Hathaway, J. H., Skorski, D. C., Scott, M. J., Pulsipher, T. C.,… Rice, J. S. (2015). Impacts of climate change on energy consumption and peak demand in buildings: a detailed regional approach. Energy, 79, 20-32.

Georgantopoulos, A. (2012). Electricity consumption and economic growth: analysis and forecasts using VAR/VEC approach for Greece with capital formation. International Journal of Energy Economics and Policy, 2(4), 263-278.

Hernández Salazar, G. A. (2020). Heterogeneity of associates, capital structure and profitability of non-financial cooperatives in Colombia. Cuadernos de Economía, 39(79), 1-30.

Hernández, G., & Prieto, M. A. (2020). Terms of trade shocks and taxation in developing countries. Cuadernos de Economía, 39(81), 613-634.

Inglesi-Lotz, R. (2016). The impact of renewable energy consumption to economic growth: A panel data application. Energy Economics,

53, 58-63.

Kamran, H. W., Haseeb, M., Nguyen, T. T., & Nguyen, V. (2020). Climate change and bank stability: The moderating role of green financing and renewable energy consumption in ASEAN. Talent Development and Exellence, 12(2), 3738-3751.

Koowattanatianchai, N., Charles, M. B., & Eddie, I. (2019). Incentivising investment through accelerated depreciation: Wartime use, economic stimulus and encouraging green technologies. Accounting History, 24(1), 115-137.

King, K., & Samaniego, P. (2020). Ecuador: Into the abyss thanks to the structural adjustment policies of the Extended Fund Agreement with the IMF. Cuadernos de Economía, 39(spe80), 541-566.

Kum, H., Ocal, O., & Aslan, A. (2012). The relationship among natural gas energy consumption, capital and economic growth: Bootstrap-corrected causality tests from G-7 countries. Renewable and Sustainable Energy Reviews, 16(5), 2361-2365.

Meng, F., Li, M., Cao, J., Li, J., Xiong, M., Feng, X., & Ren, G. (2018). The effects of climate change on heating energy consumption of office buildings in different climate zones in China. Theoretical and applied climatology, 133(1-2), 521-530.

Ntanos, S., Skordoulis, M., Kyriakopoulos, G., Arabatzis, G., Chalikias, M., Galatsidas, S.,… Katsarou, A. (2018). Renewable energy and economic growth: Evidence from European countries. Sustainability, 10(8), 2626.

Olopade, B. C., Okodua, H., Oladosun, M., Matthew, O., Urhie, E., Osabohien, R.,… Johnson, O. H. (2020). Economic growth, energy consumption and human capital formation: implication for knowledge-based economy. International Journal of Energy Economics and Policy, 10(1), 37-43.

Ouédraogo, I. M. (2010). Electricity consumption and economic growth in Burkina Faso: A cointegration analysis. Energy Economics, 32(3), 524-531.

Ormaechea, E., & Fernández, V. R. (2020). Discontinuous continuity: Structural change and its (divergent) meanings in Latin American structuralism and neo-structuralism. Cuadernos de Economía, 39(spe80), 445-469.

Ortiz, C. H., & Castillo Rentería, R. (2020). Breaking Say's Law In A Simple Market Economy Model. Cuadernos de Economía, 39(81), 897-918.

Pinkovskiy, M., & Sala-i-Martin, X. (2016). Lights, camera… income! Illuminating the national accounts-household surveys debate. The Quarterly Journal of Economics, 131(2), 579-631.

Qayyum, A., & Zaman, K. (2018). Dynamic Linkages between International Trade, Gross Fixed Capital Formation, Total Labor Force and Economic Growth: Empirical Evidence from Pakistan. Acta Universitatis Danubius. Œconomica, 15(1), 191-202.

Rafindadi, A. A., & Mika'Ilu, A. S. (2019). Sustainable energy consumption and capital formation: empirical evidence from the developed financial market of the United Kingdom. Sustainable Energy Technologies and Assessments, 35, 265-277.

Rahman, Z. U., & Ahmad, M. (2019). Modeling the relationship between gross capital formation and CO 2 (a) symmetrically in the case of Pakistan: an empirical analysis through NARDL approach. Environmental Science and Pollution Research, 26(8), 8111-8124.

Salazar-Núñez, H. F., & Venegas-Martínez, F. (2018). Impact of energy use and gross capital formation on economic growth. a panel data analysis in 73 countries grouped by income level and oil production. Trimestre Economico, 2018, 341-364.

Santamouris, M. (2016). Innovating to zero the building sector in Europe: Minimising the energy consumption, eradication of the energy poverty and mitigating the local climate change. Solar Energy, 128, 61-94.

Sarwar, S., Chen, W., & Waheed, R. (2017). Electricity consumption, oil price and economic growth: Global perspective. Renewable and Sustainable Energy Reviews, 76, 9-18.

Shahbaz, M., Mutascu, M., & Tiwari, A. K. (2012). Revisiting the relationship between electricity consumption, capital and economic growth: cointegration and causality analysis in Romania. Romanian Journal of Economic Forecasting, 3, 97-120.

Shuaib, I., & Ndidi, N. (2015). Capital formation: impact on the economic development of Nigeria 1960-2013. European Journal of Business, Economics and Accountancy, 3(3), 23-40.

Södersten, C. J., Wood, R., & Hertwich, E. G. (2018). Environmental impacts of capital formation. Journal of Industrial Ecology, 22(1), 55-67.

Solarin, S. A. (2011). Electricity consumption and economic growth: Trivariate investigation in Botswana with capital formation. International Journal of Energy Economics and Policy, 1(2), 32-46.

Solarin, S. A. (2014). Multivariate causality test of electricity consumption, capital formation, export, urbanisation and economic growth for Togo. Energy Studies Review, 21(1), 109-132.

Solarin, S. A., & Shahbaz, M. (2015). Natural gas consumption and economic growth: the role of foreign direct investment, capital formation and trade openness in Malaysia. Renewable and Sustainable Energy Reviews, 42, 835-845.

Ucak, A. (2015). Adam Smith: The inspirer of modern growth theories. Procedia-Social and Behavioral Sciences, 195, 663-672.

van Ruijven, B. J., De Cian, E., & Sue Wing, I. (2017). (Un) certainty in climate change impacts on global energy consumption. Paper presented at the AGU Fall Meeting Abstracts. https://ui.adsabs.harvard.edu/abs/2017AGUFMGC21E0972V/abstract

Vogel, E., Ludwig, A., & Börsch-Supan, A. (2017). Aging and pension reform: extending the retirement age and human capital formation. Journal of Pension Economics & Finance, 16(1), 81-107.

Welch, J. H. (2016). Capital markets in the development process: the case of Brazil: Springer.

Yun, C. (2020). a Subadult Frontal of Daspletosaurus Torosus (Theropoda : Tyrannosauridae) From the Late Cretaceous of Alberta , Canada With Implications for Tyrannosaurid Ontogeny and Taxonomy. PalArch's Journal of Vertebrate Palaeontology, 17(2), 1–13.