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Energy Consumption, Economic Growth and CO2 emissions in Selected ASEAN Countries

Izyan Nazirah Wahid
Jabatan Ekonomi
Fakulti Pengurusan dan Ekonomi
Universiti Malaysia Terengganu
E-mail: Izyan_nazirah@yahoo.com

Azlina Abd Aziz
Jabatan Ekonomi
Fakulti Pengurusan dan Ekonomi
Universiti Malaysia Terengganu
E-mail: aqlina@umt.edu.my

Nik Hashim Nik Mustapha
Jabatan Ekonomi
Fakulti Pengurusan dan Ekonomi
Universiti Malaysia Terengganu
E-mail: nhm06@umt.edu.my

ABSTRACT

Development and urbanization are very important for developing countries, but rapid economic growth alone is not an indicator of development for a dynamic and sustainable economy. Recently, studies on the environmental Kuznet Curve (EKC) revealed that environmental degradation occurs in tandem with economic growth. This profound result has led many economists interested to study about economic growth and environmental degradation. In this paper, we analyze the linkages between energy consumption, economic growth and CO_2 emissions using time series data from 1975-2011 in three ASEAN countries namely Malaysia, Indonesia and Singapore. The objective of this study is to investigate the causal relationship between energy consumption, economic growth and CO_2 emissions for each country. Johansen cointegration test discloses that there were cointegrated variables among these ASEAN countries. The causality result shows evidence of unidirectional causality from CO_2 emissions to energy consumption and from energy consumption to economic growth in Malaysia. While, there were unidirectional granger causality runs from economic growth to CO_2 emissions and energy consumption to economic growth in Indonesia. In Singapore economic growth and energy consumption showed no granger cause to CO_2 emissions but openness and industrialization had granger caused CO_2 emissions. This has proven that Singapore can maintain the economic growth without compromising environmental damage. For Malaysia and Indonesia, the policy implications are very important to ensure economic growth and development that does not adversely affect the environment.

Keywords: Energy Consumption, Economic Growth, CO_2 Emissions

INTRODUCTION

Nowadays, the development of the world economy had an enormous impact, particularly on the environment. Global warming has always been a topic of discussion among world leaders. Up to now carbon dioxide (CO_2) emissions has been identified as one of the main contributors to global warming. Based on statistics of CO_2 production in 2007, Malaysia with an estimate of 29 million tones ranked 26th (0.66%) from 215 countries in the world. In pursuit of national development and improving the living standards of population, economic activities and projects for economic development cannot be avoided. People used to ignore environmental problems arising from the implementation of economic activities and development projects. Negative effect of a highly contagious substance through economic development now is the CO_2 released. CO_2 released through industrial activities and the use of energy such as fossil fuels. Instead of Malaysia, Indonesia is also one of the countries that contribute to the release of CO_2 in economic activity. The CO_2 emission (Kt) in Indonesia was reported at

406,028.58 in 2008 according to the World Development Indicators. CO_2 emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include CO_2 produced during consumption of solid, liquid and gas fuels and flaring. Moreover, Indonesia was the third top producer of green houses to ratify the protocol, thus commit herself to reduce GHG emissions. The country announced her target of CHG emissions reduction about 26-41% below the Business as usual (BAU) scenario with a targeted economic growth rate of 7% by 2020 (Copenhagen Accord, 2009). For Indonesia and Malaysia, the problem in CO_2 emission has become a major problem affecting the environmental degradation to the country. Now, a lot of factors relating to CO_2 emissions in the country can be identified. The use of energy is a main factor in a country. On the other hand, other factors include economic development, openness. But it depends on a country's development in overcoming the problems resulting from the release of CO_2. It can be seen that, Malaysia is a developing country while Indonesia is an emerging market. In fact, for developed countries like Singapore, the main activities contribute to CO_2 emissions is through primary energy consumption (combust fuel) and secondary energy consumption (use electricity) which is the main activities that contribute to CO_2 emissions as much as 21,793 kilo tons (54%) was by industry activities. Followed by electricity was 19,315 kilo tons (48%), buildings was 6,235 kilo tons (16%). Then, consumers households was 3,637 kilo tons (9%) and others was 732 (2%). The total of CO_2 emissions from primary energy consumption (combust fuel) and secondary energy consumption (use electricity) was 40,377 kilo tons in 2005 according to National Climate Change Strategy. Thus, the energy consumption is a major contributor to CO_2 emissions in Singapore. The use of energy in national consumption in a country's economic activity will inevitably result in an increase of CO_2 emissions drastically.

Figure 1 shows the CO_2 emissions and energy use in Malaysia, Indonesia and Singapore from 1975 to 2011 (Refer to appendix). As we can seen, there is an increasing trend of CO_2 emissions in Indonesia which was the highest, followed by Malaysia, but CO_2 emissions trend in Singapore had been steady with small fluctuations after 1995-2011. So does the trend of energy use in the three countries. Indonesia showed increasing energy use and the highest among other countries. Then energy use in Malaysia also has increased but energy use in Singapore was increase for the period 1975-1995 and after which a decline was apparent. Roughly, the increase of CO_2 emissions was affected by energy use. If energy-use has increased rapidly then CO_2 emissions would increase dramatically. Therefore the objective of this study is to identify the causal relationship between CO_2 emissions, economic growth and energy consumption in Malaysia, Indonesia and Singapore. In addition, this paper will also emphasize and recommend the policy implications of the linkages between CO_2 emissions, economic growth and energy consumption for Malaysia, Indonesia and Singapore.

LITERATURE REVIEW

At present fossil fuel consumption is growing in tandem with energy consumption and economic growth. When there is an increase in the standard of living, then energy consumption will grow rapidly in line with economic growth. On the other hand, it is also the fact that economic growth necessitates higher amount of energy consumption thus CO_2 emissions and pollution. Most previous study stressed that energy consumption was related to economic growth and causes an increase in CO_2 emissions. Hooi and Smyth (2009) in their study entitled CO_2 emissions, Electricity Consumption and Output in ASEAN found that there is unidirectional Granger causality running from electricity consumption and emissions to economic growth in the long run among ASEAN countries over the period 1980-2006.The results also point to unidirectional Granger Causality running from emissions to electricity in the short run.

Yoo (2006) investigates the causal relationship between electricity consumption and economic growth among the ASEAN countries namely Indonesia, Malaysia, Singapore, and Thailand for the period 1971-2002. The results suggest that there is a bi-directional causality between electricity consumption and economic growth in Malaysia and Singapore but there are uni-directional causality runs from economic growth to electricity consumption in Indonesia and Thailand. The same results was supported by Chen et al. (2007) who state that bi-directional long-run causality exists between electricity consumption and economic growth and that a uni-directional short run causality runs from economic growth to electricity consumption. As well as the research that has been done by Adjaye (2000), he founds that, in the short run, uni-directional Granger Causality runs from energy to income for India and Indonesia, while bi-directional Granger causality runs from energy to income for Thailand and Philippines.

In addition, a case study in ASEAN by Jalil and Mahmud (2009) on a cointegration analysis for China proved that there is one way causality runs through economic growth to CO_2 emissions. Infact, the results showed that the carbon emissions are mainly determined by income and energy consumption in the long run. Otherwise, Jafari et al. (2012) proposed that energy conservation strategies in Indonesia may not produce desirable effect on emissions reductions, and Indonesia does not have to relinquish economic growth. This is because there was no relationship between energy consumption, economic growth and CO_2 emissions except the causality effect that runs from urban population to energy consumption. Ang (2007) examined the relationship between output, pollutant emissions and energy consumption in Malaysia during the period 1971-1999 concluded that pollution and energy consumption are positively related to output in the long run. Meanwhile, there are strong causality running from economic growth to energy consumption both in the short run and long run.

Recently, Azlina and Nik Hashim (2012) examined the relationship between energy consumption, economic growth and CO_2 emissions in Malaysia. Using a time series data from 1970 to 2010, they found there was unidirectional causality running from economic growth to energy consumption, from pollutant emissions to energy consumption and from pollutant emissions to economic growth. Khalid et al. (2012) investigate the relationship between CO_2 emissions, energy consumption and economic growth in Saudi Arabia and they found that a unidirectional causality runs from energy consumption to GDP per capita and CO_2 emissions to GDP per capita in the short and long run. Meanwhile, there are unidirectional causality runs from employment ratio to GDP in the short run. The results concluded that energy conservation policies and controlling CO_2 emissions in Saudi Arabia was no adverse effect on economic growth in the short run. Md and Khorshed (2012) showed some evidence of bi-directional causality between GDP and energy use from the study of cointegration and causal relationship between energy consumption and output: Assessing the evidence from Australia. Infact, they found strong evidence of Granger causality from energy use to GDP in Australia over the period 1961-2009.

METHODOLOGY

In this analysis, the time series data collected from 1975 to 2011 was used which corresponds to 37 years. There are three variables used in this study, which is CO_2 emissions (Kt), gross domestic product (GDP) and energy consumption (EC). There are additional variables which is Openness, Value added (Industry) and Combustible Renewable energy (metric tons of oil equivalent). To estimate the causality between variables multiple regression equations for each country are specified as follows:

$$\ln CO_{2t} = \alpha_0 + \alpha_1 \ln GDP_1 + \alpha_2 \ln EC_T + \alpha_3 \ln OPE_t + \alpha_4 \ln VA_t + \alpha_5 \ln CRE_t + \varepsilon_t \qquad (1)$$

Where:
$\ln CO_2$ denotes the natural logarithms of CO_2 emissions
lnGDP denotes the natural logarithms of real gross domestic product (economic growth)
lnEC denotes the natural logarithms of energy consumption
lnOPE denotes the natural logarithms of openness
lnVA denotes the natural logarithms of value added (Industry)
lnCRE denotes the natural logarithms of combustible renewable energy

There are three steps involved in estimating the relationship between the variables. The first step is to test the stationarity of the series or their order of integration in all variables. A time series is not stationary if the mean and the variance of time series is increasing over time depending on the time. Otherwise, a time series is said to be stationary if the mean and its variants are fixed to the (independent). Nelson and Plosser (1982) view that most economic variables can be categorize as not stationary. Curtains (1995) also argues that most economic time series are not stationary and only reached stationarity at first difference or higher. Stationarity of a variable is usually determined by Augmented Dickey-Fuller test (Dickey and Fuller, 1979). In this paper, Augmented Dickey Fuller (ADF) test and Phillips-Perron (PP) test were used to determine the stationary state of the series. The choice of the PP test to complement the ADF test is motivated by the argument the ADF test has low power to reject a unit root whereas the PP tests correct for serial correlation in unit root testing. Therefore, by combining these two tests, the order of integration for all series are robust.

The second step is to examine the presence of a long run relationship among all variables in the equation. In this case, the cointegration tests will be conducted to investigate the existence of long-run relationships between the variables. Cointegration test is a combination of the linear relationship of the variables that are not stationary. All variables should be cointegrated at the same level. Cointegrated variable would indicate that the variables have the same stochastic trend and thus have the same direction of movement within in the long run. Cointegration test is an extension of the stationary test. For cointegration test, we need to ensure that the data used is stationary or not. If there are one or more variables that have different levels of integration, the variables cannot be cointegrated (Engle and Granger, 1987). Cointegration relationship can be estimated through two test by Johansen (1988) test, the trace (Trace Test) and maximize the value-Eigen Test (Maximum Eigenvalue Test).

Once the cointegration is confirmed in the model, the residuals from the equilibrium regression can be used to estimate the Vector Error Correction Model (VECM) in the third step. The VECM is the method we can apply if there exists a long-run relationship. Engle and Granger (1987) stated that once the variables are determined to be cointegrated, there always exists a corresponding error correction representation, implying that changes in the dependent variable are a function of the level of disequilibrium in the cointegrating relationship captured by the error correction term (ECT). The ECT is the method to correct the disequilibrium, then to examine the short run and long run relationship between variables.

FINDINGS

The results of unit root test included ADF and PP are shown in Table 4. The result indicates that each of the series for each country is non-stationary at the 1% level. After the first difference of each variable, the null hypothesis of non-stationary is rejected at 1% significance level. As a result, all the variables for each country are stationary at first difference at 1% significance level. Thus, Johansen cointegration analysis can be applied to proceed our main objective. Table 4.1 shows the results of the cointegration test. The empirical results of Johansen trace statistics and Johansen maximum eigenvalue statistics suggest evidence of two cointegrating relationship between the variables, at the 5% level of significance in Malaysia. In the case of Indonesia and Singapore, there is one cointegrating relationship between the variables, at the 5% level of significance. Therefore, there appears to be clear evidence in favor of a long-run relationship between the variables for each country.

Table 4.2 shows the result of causality test based on VECM. The results of the short run causality (F-statistics) found that there are unidirectional causality running from CO_2 emissions to economic growth and energy consumption to economic growth in Malaysia. Unidirectional causality also was found to be running from openness to economic growth and combustible renewable energy to economic growth. On the other hand, the results of the short run (F-statistics) and long run (ECT) show that there are unidirectional causality running from CO_2 emissions, energy consumption, openness, economic growth, and combustible renewable energy to value added in Malaysia. Therefore, we can conclude that pollutant emissions, energy consumption and openness are important factors that affect the economic growth and value added industry in Malaysia. Thus, the results proved that, urbanization and industrialization was effected by economic growth in Malaysia. Moreover, Malaysia was the developing country that relies on energy consumption on economic activity.

Meanwhile, the results of granger causality in Indonesia indicate that unidirectional causality running from economic growth to CO_2 emissions in the short run and long run. Furthermore, there are causality running from value added (Industry) to CO_2 emissions. Energy consumption and openness are granger cause to economic growth in the short run and long run. On the other hand, there are uni-directional causality run from value added (Industry) to energy consumption and openness to value added (Industry). Thus, granger causality results in Indonesia proved that industrialization and economic activity give an impact to economic growth in the short run and long run. The results also found that economic growth and value added (industry) have a strong relationship with CO_2 emissions. This evidence proved that Indonesia need to sustain economic growth without causes an environmental degradation. Otherwise, in Singapore the results show the unidirectional causality runs from openness and value added (industry) to CO_2 emissions in the long run and short run. Then, value added granger cause to energy consumption in the short run and long run. While, there are granger cause from combustible renewable energy and energy consumption to openness. There also causality running from economic growth to combustible renewable energy in Singapore. This result indicates that industrialization and openness in Singapore give an impact for pollutant emissions in short run and long run.

CONCLUSIONS

This paper examined the link between energy consumption, economic growth, and CO_2 emissions in Malaysia, Indonesia and Singapore. The unit root test show all the variables each country was stationary at first differentiated. The cointegration test found that the variable was cointegrated at 5% significance level for each country. Meanwhile, the causality test result indicates that unidirectional causality running from CO_2 emissions and energy consumption to economic growth in Malaysia for the short run. Otherwise, in Indonesia there are unidirectional causality running from economic growth to CO2 emissions in the short run and long run. Similarly, there are unidirectional causality running from energy consumption to economic growth in short run and long run in Indonesia.

Granger causality test in Singapore found that no granger cause between energy consumption to economic growth and economic growth to CO_2 emissions. There are uni-directional causality from openness to CO_2 emissions and value added (Industry) to CO_2 emissions in the short run and long run. Instead of CO_2 emissions, value added (Industry) also granger cause to energy consumption. The finding of this study proved that energy policy implementation in Malaysia and Indonesia was important to make sure that energy consumption and economic growth give no adverse effect on CO_2 emissions. Therefore policy makers should implement environment friendly energy production as well as appropriate technology.

Otherwise, in Singapore economic growth and energy consumption is no granger cause to CO_2 emissions but openness and industrialization was causes to CO_2 emissions. Moreover, there are granger causality runs from energy consumption and renewable energy to openness. Furthermore, industrialization also granger cause to energy consumption. This result suggests policy makers to strengthen the restrictions of international trade such as tax, tariff and quota to reduce CO_2 emissions rather to increase the economic growth only in Singapore.

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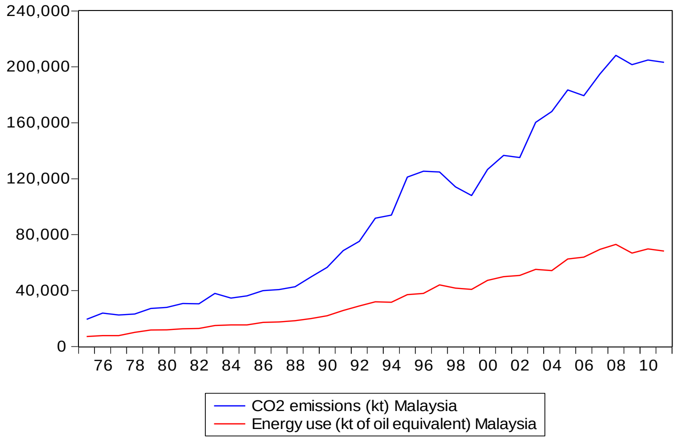
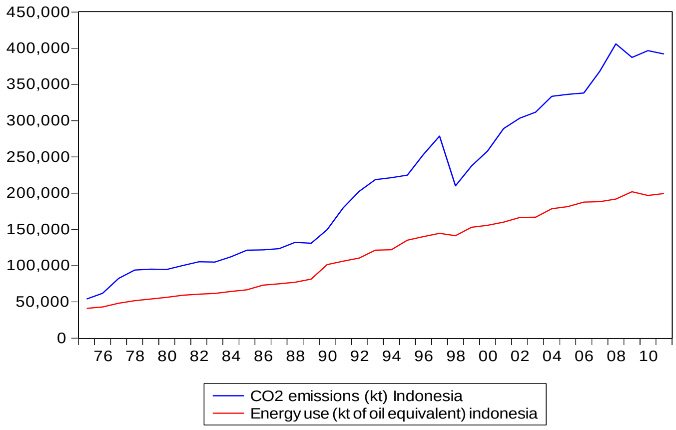
APPENDIX

Malaysia



Indonesia



Singapore

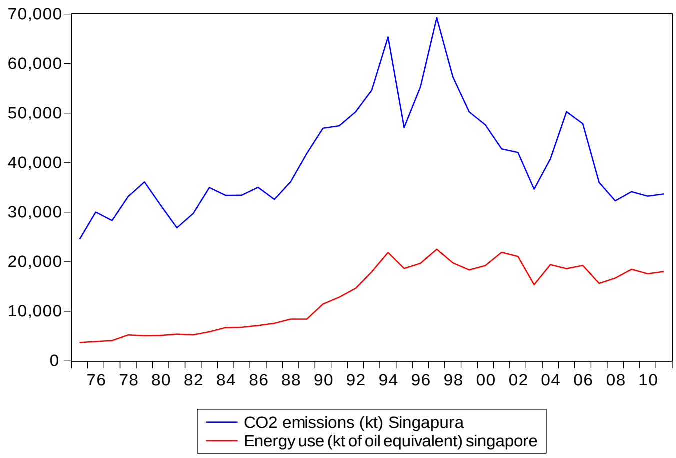


FIGURE 1: CO2 Emissions And Energy Use In In Malaysia, Indonesia And Singapore From 1975-2011

TABLE 4: Results Unit Root Test (ADF) And (PP) In Malaysia, Indonesia, And Singapore.

Country / Variable	Augmented Dickey Fuller (ADF)		Phillips Perron (PP)	
	Level	First Difference	Level	First Difference
Malaysia				
CO_2	-1.412	-6.843	-1.462	-6.770
	(0.840)	(0.000)***	(0.824)	(0.000)***
GDP	-0.719	-4.901	-1.045	-4.896
	(0.964)	(0.002)***	(0.925)	(0.002)***
EC	-1.402	-7.299	-1.192	-7.616
	(0.843)	(0.000)***	(0.897)	(0.000)***
OPE	-3.835	-4.250	-2.452	-4.250
	(0.027)	(0.001)***	(0.348)	(0.001)***
VA	-0.221	-5.663	-0.221	-5.657
	(0.990)	(0.000)***	(0.990)	(0.000)***
CRE	0.267	-6.874	0.060	-4.950
	(0.998)	(0.000)***	(0.996)	(0.002)***
Indonesia				
CO_2	-3.214	-5.538	-3.263	-5.778
	(0.098)	(0.000)***	(0.089)	(0.000)***
GDP	-2.101	-4.326	-1.776	-4.326
	(0.527	(0.008)***	(0.696)	(0.008)***
EC	-0.583	-6.625	-0.446	-6.620
	(0.974)	(0.000)***	(0.982)	(0.000)***
OPE	-2.300	-5.015	-2.280	-4.932
	(0.423)	(0.001)***	(0.434)	(0.001)***
VA	-1.327	-5.653	-1.332	-5.652
	(0.865)	(0.000)***	(0.864)	(0.000)***
CRE	-0.833	-5.660	-0.879	-5.660
	(0.953)	(0.000)***	(0.950)	(0.000)***
Singapore				
CO_2	-1.803	-6.092	-1.700	-9.391
	(0.682)	(0.000)***	(0.733)	(0.000)***
GDP	-1.616	-5.415	-1.616	-5.393
	(0.767)	(0.000)***	(0.767)	(0.000)***
EC	-0.941	-6.788	-0.825	-6.809
	(0.940)	(0.000)***	(0.954)	(0.000)***
OPE	-3.937	-7.650	-3.870	-17.304
	(0.021)	(0.000)***	(0.024)	(0.000)***
VA	-2.742	-5.621	-2.750	-6.422
	(0.227)	(0.000)***	(0.224)	(0.000)***
CRE	-1.491	-5.754	-1.510	-5.754
	(0.814)	(0.000)***	(0.807)	(0.000)***

Note: Figure in the parentheses are p-value.
(***),(**), and (*) indicate 1%, 5%, and 10% level of significance, respectively.

TABLE 4.1: Results for Johansen Cointegration test in Malaysia, Indonesia and Singapore

Country/ Null Hypothesis	Trace Statistics	Critical Value 5%	Max-Eigen	Critical Value 5%
Malaysia				
r = 0*	138.334	95.754	51.703	40.078
r ≤ 1*	86.631	69.819	36.315	33.877
r ≤ 2	50.315	47.856	26.600	27.584
r ≤ 3	23.725	29.797	12.239	21.132
r ≤ 4	11.486	15.495	7.608	14.265
r ≤ 5	3.878	3.841	3.878	3.841
Indonesia				
r = 0*	117.233	95.754	52.162	40.078
r ≤ 1	65.070	69.819	26.367	33.877
r ≤ 2	38.703	47.856	20.528	27.584
r ≤ 3	18.175	29.797	12.883	21.132
r ≤ 4	5.293	15.495	5.206	14.265
r ≤ 5	0.087	3.841	0.087	3.841
Singapore				
r = 0*	96.624	95.754	37.108	40.078
r ≤ 1	59.516	69.819	26.389	33.877
r ≤ 2	33.128	47.856	13.717	27.584
r ≤ 3	19.411	29.797	9.147	21.132
r ≤ 4	10.264	15.495	7.171	14.265
r ≤ 5	3.092	3.841	3.092	3.841

Note: (***),(**), and (*) indicate 1%, 5%, and 10% level of significance respectively.

TABLE 4.2: Granger Causality within VECM

Country/ Dependent Variable	CO_2	GDP	EC	OPE	VA	CRE	ECT
Malaysia							
CO_2	-	0.304	0.260	0.155	0.763	0.751	-0.151
GDP	3.500***	-	3.596**	0.520	1.198	6.760***	0.211
EC	0.223	1.663	-	2.697***	1.240	2.284	0.591
OPE	0.742	0.102	3.055*	-	0.123	1.856	0.005
VA	7.443***	3.211*	7.194***	3.295*	-	9.537***	0.744**
CRE	0.603	0.015	1.467	0.164	0.219	-	0.275
Indonesia							
CO_2	-	4.185***	1.948	0.098	2.862*	0.958	0.091**
GDP	2.282	-	2.973*	2.685*	1.635	1.219	0.051**
EC	0.108	1.046	-	1.023	2.870*	0.132	-0.008
OPE	0.851	0.121	0.648	-	0.352	0.404	-0.089
VA	1.369	1.915	1.201	3.647***	-	0.151	0.027
CRE	1.122	0.136	0.194	0.539	1.778	-	0.027
Singapore							
CO_2	-	0.648	1.232	2.800*	3.681**	0.234	-1.463***
GDP	0.122	-	0.130	0.364	0.116	1.194	0.877
EC	1.360	1.923	-	1.153	3.737**	0.307	-0.9530*
OPE	3.416*	0.872	4.255**	-	1.617	5.014**	-0.119**
VA	0.574	0.141	0.191	0.209	-	1.409	-0.246
CRE	0.687	3.685**	0.475	1.435	2.078	-	9.311

Note: (***),(**),(*),indicates 1%,5%, and 10% level of significance respectively.