Energy Consumption, Carbon Dioxide Emissions and Economic Growth in Ethiopia

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Received: 14 December 2015 Accepted: 3 January 2016 Published: 15 January 2016

Abstract

This study has attempted to investigate the relationship between, energy consumption, CO2 emissions and economic growth in Ethiopia, using time series data from 1970/71 to 2010/11. The finding indicates variables of interests are integrated of the same order I (1). Cointegration test approves existence of one co-integrating equation among the variables. The causality test result shows energy consumption causes Economic Growth in Ethiopia. Based on the outcome shocks to energy consumption have a negative impact on economic growth. The contributions of energy consumption to CO2 emissions were insignificant and economic growth is positively related to CO2 emissions. To secure the sustenance of CO2 emissions free economic growth in Ethiopia, cost effective, carbon free, and efficient utilization of renewable energy consumption based on the country comparative advantage that consider alternative use of resources are advisable like Hydro and Geothermal.

Index terms— energy consumption, CO2 emission, economic growth, VAR.

1 Introduction

he long term trend of economic growth over the last 200 years shows continuous increment over time. To produce such output combinations of physical, natural, social and human capital were used as input. If we compare the growth of CO 2 emissions and the growth of energy use, both on per capita basis CO 2 emission grew more slowly than energy consumption from 1970 to 1990. Since 2000, the variables are going parallel, indicating no further CO 2 emissions savings given the greater use of coal again. Wind and solar contributions are not large enough to make an appreciable difference in CO 2 levels (Alex et al., 2010).

According to the global carbon budget CO 2 emissions is the main cause of environmental degradation. Over the period of 1959 to 2011, 87 percent of all human-produced carbon dioxide emissions come from the burning of fossil fuels used in different sector in the economy. The burning of fossil fuels includes coal, natural gas and oil. While from the clearing of forests and other land use changes in agricultural sector accounts 9%. And as well as from some industrial process such as cement manufacturing is 4% (IEA, 2013).

The interactions among economic growth, energy consumptions and CO 2 emissions have great policy implications for the environment. Economic growth needs different amount and types of resources including energy consumptions. Even if CO 2 emissions intensity vary for different resource processing and sources of energy as explained above, the consumptions of energy and other resource processing for the sake of economic growth inevitably contribute for CO 2 emissions to the environment. Carbon sequestration services provided by soil and forest is one of natural capital including raw materials extract from the earth. Natural capitals unique elements are some have finite limits, irreversible change, its impact extends across many generations, due to critical threshold sudden and dramatic change may occurs. Environment is one of natural capital which need to be used sustainably and efficiently in order to secure growth in the long run with the fate of the coming generations (Alex et al., 2010).

Thus, empirically the African continent while sheltering 15% of the world population, accounts for only 3% of world energy consumption, and the average energy consumption of an African is six times less than that recorded in the world. Contrary to this, USA constitutes 5 percent of the world's population but consume 24 percent of the world's energy. On average, one American consumes as much energy as 2 Japanese, 6 Mexicans, 13 Chinese, 31 Indians, 128 Bangladeshis, 307 Tanzanians and 370 Ethiopians. Sub Saharan Africa account for 9 percent of world population generate 2.5 percent of world economic activity. The region consumes 2.7% of world commercial primary energy. The region has 2% of world proven oil reserves, 3% of world proven gas reserves and 6% of world proven coal reserves. There is a large hydropower potential, even able to export for other region in excess of local need ??UNEP, 2006).

As compared to other African country Ethiopia share 2.4 percent of total gross domestic product, and, 6.9 percent of total agricultural gross domestic product on average over 2003 to 2011. Over the same period within Eastern Africa the country shares 18.8 percent of total gross domestic product and 29.2 percent of agricultural gross domestic product. In Ethiopia, the agricultural sector absorbs 85 percent of the total employment and contributes 46.3 percent of gross domestic product. It is followed by the service sector which account for 10 percent of total employment and contributes 43 percent of gross domestic product, and the industry account 5 percent of employment and 10.7 of gross domestic product and in terms of population the country was the second populous country in Africa (World Bank, 2013).

According to Ministry of Mines and Energy of Ethiopia on average per capita electricity consumption is 28KWH. Beside this, it show the existence of great exploitable potential in natural Gas, coal, wind, solar, geothermal (MW) 5000-7000, hydro (MW) 45000. Considering this the clean renewable green energy (CRGE) strategy projects that the contribution of agriculture will diminish from 42% to 29%, indicating migration of jobs from the agriculture sector to industry and services, this expect to reduce rural environmental burden. In the same analysis the growth and transformation plan of Ethiopia (GTP) explicitly recognizes that environment is a vital and important pillar of sustainable development, and implementation of environmental laws is part of building the green economy (MoFED. 2010).

The empirical findings on the variables relationship also show mixed result and differ from country to county: Abesha (2009) studied Domestic Energy Consumption and Deforestation in Hareri region Assessment of Students' Awareness and Views in Ethiopia. And finds the views about environmental problems resulted from unsustainable dependence of biomass energy and Air pollution, is a serious environmental problem in developed nation, was considered by more than half of students. Finally he recommends the need of awareness creation in the subject area. Mehari (2011) had assessed Granger causality relationship between economic growth and energy consumption in Ethiopia and finds unidirectional causality from economic growth to energy consumption. Finally, in its variance decomposition analysis comparisons of labor and capital with energy indicates that energy was no more than a minor contributing factor to output growth.

This study extend the previous research to investigate not only whether energy consumption and economic growth have a significant impact but also its implication on the CO 2 emissions. According to the Intergovernmental Panel on Climate Change (2001) Ethiopia is one of the country most likely to suffer extremely from the adverse effect of climate change (Environmental protection authority, 2012). Necessity of understanding the relationship and reacting accordingly to overcome such types of warning, Existence of controversy among variables relationship both in theory and empirical finding and its importance for policy implication, is the main rationale motivated this study.

2 II.

3 Literature Review a) Global Economic Growth, Energy Consumption and Green Gas Emissions in the World

The long term trend of economic output shows continuous increment over time. This leads rising level of employment, income, and promote both private and public investment in vast sectors. Natural capital includes raw materials extract from the earth, carbon sequestration services provided by soil and forest. Its unique elements are some have finite limits, irreversible change, its impact extends across many generations, due to critical threshold sudden and dramatic change may occurs. So, it needs to be used sustainably and efficiently in order to secure growth in the long run. In the some way energy consumption and carbon dioxide emission were increased in the world so roughly the last 200 years. This rise in energy consumption is primarily from increased fossil fuel consumption demand (Green Energy act, 2009).

4 b) Economic Growth, Energy Consumption and Greenhouse Gas Emissions in Ethiopia

According to accomplish transition from a subsistence economy to an agro-industrial economy during Ethiopia needed an infrastructure to exploit resources, a material base to improve living conditions, and better health, education, communications and other services. Though, fail to achieve as planed target due to the administrative and technical capabilities to implement a national development plan, staffing problems because they neglected to identify the resources and to establish the organizational structures necessary to facilitate large scale economic development (Alemayehu, 2005).

According to Ethiopian economic update II Over the past decade, Ethiopia has achieved high economic growth, averaging 10.7 percent per year. The economy continued to expand at a rapid pace of 8.5 percent in 2011/12 and rank the country 12th fastest growing While, in Africa including Ethiopia the economy still dominated by agriculture and energy consumption pattern dominated by primary energy source (EIA, 2012). According to Netherlands environmental assessment agency: -since, 2000, an estimated total of 420 billion tonnes CO 2 was cumulatively emitted due to human activities including deforestation. Scientific literature suggests that limiting average global temperature rise to 2 °C above pre-industrial levels -the target internationally adopted in UN climate negotiations -is possible if cumulative emissions in the 2000-2050 period do not exceed 1,000 to 1,500 billion tonnes CO 2 . If the current global increase in CO2 emissions continues, cumulative emissions will surpass this total within the next two decades (Jos et al., 2012) economy in the World. Agriculture, industry, and services grew by 4.9 percent, 13.6 percent, and 11.1 percent, respectively. The expansion of the services and agricultural sectors explain most of this growth 57 and 26 percent respectively, while the contribution of industry was relatively modest to 16.7 percent (World Bank, 2013).

The major source of the electricity supplied in the Ethiopia is from hydropower, which contributes about 84% (668 MW) of the total supply. This amount is, however, less than 2% of the economically affordable power capacity of the total potential of water resource. On the contrary, most towns, villages and rural areas generally lack any access to electricity. Presently only 33% of the population is said to have access to electricity. In 2009 the electric energy consumption per capita is estimated to be 44 kWh, which is one of the lowest consumption among the least developing countries (Ministry of Mines and Energy, 2009).

On the other hand Fossil fuel energy consumption which comprises coal, oil, petroleum, and natural gas products measured at 5.72 % of total energy consumption in Ethiopia for 2011. The value for Energy use (kg of oil equivalent) per $1,000 of GDP (constant 2005 PPP) in Ethiopia was 429.36 as of 2010 and over the past 29 years, the value for this indicator has fluctuated between 697.30 in 1992 and 418.79 in 2006.The value for Energy use (kt of oil equivalent) in Ethiopia was 33,202 as of 2010 over the past 39 years this indicator reached a maximum value of 33,202 in 2010 and a minimum value of 8,607 in 1971 (IEA, 2012). The greenhouse gas emission from energy sector is also important contributor to the total national emission. According to the 2004 inventory, it was accounted for more than 50% of the total GHGs emission and was twice of the 1994 values. Among these sub sectors, the transport and the domestic take the largest contribution which accounts about 68% and 16.1% respectively in 2004. The combustion of fossil fuels mainly in the transportation sector was responsible for 88 % of the total CO 2

5 c) Empirical findings on: Energy Consumption, Carbon Dioxide emission and Economic Growth relationship

The empirical findings results on the variables are vary from country to country: even though scholars way of analysis techniques, data issues and model of their estimations are different. The studies by Mohammed, et al.,(2012) for 12 Middle East and North African Countries over the period 1981-2005 using co integration techniques show that in the long-run energy consumption has a positive significant impact on CO 2 emissions. And real GDP exhibits a quadratic relationship with CO 2 emissions for the region as a whole. However, although the estimated long-run coefficients of income and its square satisfy the EKC hypothesis in most studied countries, the turning points are very low in some cases and very high in other cases, hence providing poor evidence in support of the EKC hypothesis.

Nicholas, M. (2011) in south Africa using ARDL finds distinct unidirectional causal flow from economic growth to carbon emissions and energy consumption Granger-causes both carbon emissions and economic growth. More importantly the finding indicates carbon emission constitutes an impediment to sustainable economic growth in the country. In India by Tiwari, A. (2011) and in china Harry, B.(2012) using Co integration and vector error correction their result indicates the variables are related in the long run and shows inefficient use of energy leads environmental pressure tend to rise faster than economic growth. In Chine the results also reveal bi-directional causality between coal consumption and pollutant emission both in the short and long run it indicates the difficulty to pursue a greenhouse gas abatement policy through reducing coal consumption in the country. Sakib, et al., (2012) for Bangladesh, and, Mahammed, S., and Shahjahan, K., (2013) in Australia employed Johansen co integration using a multivariate framework and their empirical findings indicate bidirectional causal link between energy consumption and economic growth for Australia and the energy use can lead to CO 2 for Bangladesh. The study points out that there is no causal relationship between Economic Growth and CO 2 , for the two countries.

In supports of the neutrality hypothesis, for Denmark using annual data from 1972-2012 by Viktoras, K.(2013) to examine causal relationship between variables employing Granger causality test in VAR framework Results strongly support a unidirectional causality coming from renewable energy consumption to CO 2 emissions. Its result also indicates that there is no statistically causality between the economic growth and renewable energy consumption, between economic growth and CO 2 emissions, and implies that energy conservation policies should not have a significant impact on economic growth.

6 III.

7 Method and Procedure a) Types and sources of the data

For the empirical analysis Real GDP per Capita represented by ry, and urbanization by (urb) from 1970/71 up to 2010/11 were collected from MoFED (2012). Kilogram of oil equivalent per capita for energy consumption represented by ec and carbon dioxide emissions is measured in metric tons per capita represented by CO 2 for the same period was collected from World Development Indicators of the official website of World Bank 2014. The choice of the starting period was constrained by the availability of data on Kilogram of oil equivalent per capita for energy consumption. While over the same period urbanization measured by urban population growth considered as controlled variable. All the data were transferred in to logarithmic form to reduce the problem of heteroskedasticity. As log transformation compresses the scale in which the variables are measured.

8 b) Model Specifications

The Vector Auto regression (VAR) models were first proposed by Sims (1980) who argued that "it should be feasible to estimate large macro models as unrestricted reduced forms, while treating all variables as endogenous". This help to analyze multiple relationship between variables in an accurate and simple way without specifying which variables are endogenous or exogenous (Verbeek, 2004).Based on this a VAR system for this study were establish in one of the following form;Vt= ? ???????? ? ?? + ???? ?? ??=?? ??........**(1)**

Where V t = (Y, C, E) and ? t = (? Y , ? C , ? E), ? i? k are three by three matrices of coefficients and ? is a vector of error terms.

9 c) Estimation Techniques

The estimation technique is based on secondary data analysis of Johnson co-integration analysis framework. Which includes lag length selection, unit root test, and co-integration test, identification of long run model, causality test and diagnostic test of validity. All the analysis in the study were conducted using STATA 11 version software

10 d) Unit Root Test

Stationary is required so as avoid spuriousness of the regression results. A variable is said to be stationary if it's mean, variance and auto-covariance remains the same no matter at what point we measure them. The null hypothesis of non-stationary is tested against alternative hypothesis of stationary. To test the unit root property of the variables, the paper employed Augmented Dickey Fuller test. The Augmented Dickey-Fuller regression model has a form: Î?"y t = ? + ?t +?????? ? ?? + ? ?????????? ? ?? + ????)**4**

Where t is the time index, ? is an intercept constant, ? is the coefficient on a time trend, ? is the coefficient presenting process root, ? is an independently, identically distributed residual term, yt is the variable of interest (Y, E, C). The aim of test is to see whether the coefficient ? equals zero, which would imply that process is non-stationary (Pantula, 1989).

11 e) Co-integration test

One of the most widely used approaches to test for co integration is VAR based Johansen co-integration test. Unlike Engle-Granger test which permits only one co integrating relationship, Johansen co-integration test, allows for more than one co-integrating relationship to be tested in one or more equations. Of coerce the concept of co-integration can be described as a systematic co-movement among the selected time series over the long-run. If each non-stationary variables, but a linear combination of them could be stationary then it can be said that the series are co integrated. So, it is necessary to test for co-integration if we want to provide meaningful results. If the cointegrating relationship is found then in order to account for non-stationary variables VECM model has to be estimated in the following way, following (Cheung, and Lai, 1993).Î?"y t = ? + ? ?? ???????? ? ?? ?? ??=?? +? ??????t ? j ?? ??=?? + Ø? t-1 +? t ????...??????. (**5**)

Where Î?" is the deference operator, p is the number of lags, ? and ? are parameters to be estimated, ? is serially uncorrected error term, and e t-1 is the error correction term (ECM).

12 f) Causality test

According to Granger (1969) causality examine to what extent a change from past values of a variable affect the subsequent changes of the other variable. We can say that there is Granger causality between two variables X t and Y t if a forecast Y t taken from a set of information that includes the past variability of X t is better than a forecast that ignores the past variability X t , keeping other thing remain constant.

13 +? ???

?? ??=?? ?? t-j +u 2t ?????.??..?????????. (7) Unidirectional causality from X t to Y t is indicated if the estimated coefficients on the lagged X t in (**??**) are statistically different from zero as a group and the set of estimated coefficients on the lagged Y t in (7) is not statistically different from zero. Unidirectional causality from Y t to X t is indicated if the estimated coefficients on the lagged Y t in (7) are statistically different from zero as a group and the set of estimated coefficients on the lagged X t in (**??**) is not statistically different from zero. Feedback is indicated when the set of X t and Y t coefficients are statistically different from zero in both regression equations (**??**) and (7).Independence occurs when the set of X t and Y t coefficients are not statistically significant in both regression equations (**??**) and (7).

IV.

14 Results and Discussion

In this part we can discuss the outcomes of the data analysis. The discussion was start from lag length selections. Then, unit root test, cointegrations test, estimations of VAR, diagnostic test and causality test. As indicated in the table 4.1., below the lag length selection criteria strongly advise us to include two lag in the estimations of the variables for the study. Where as in the test of unit root test result, all the variables are non-stationary at level with constant and without constant both at 1% and 5%.On the other hand, all the variables are stationary after taking their first difference as indicated below on the table 4.2.A. and 4.2.B. respectively. The VAR model with two lags, as suggested by AIC, HQIC and SBIC on the table 4.1., is considered to test long run co movement. We compare the trace statistics and max statistics with the critical values and stop only when the null hypothesis is not rejected for the first time. In the Johansen co integration test result both trace statistics and max-Eigen statistics indicates that there is one co integrating vector. The statistics was not reject the null hypothesis at one rank. The finding is confirming existence of long run association among energy consumption, CO 2 emission, and economic growth in the country. Vector normality test: chi^2(10) = 0.592(0.74362) Hetro testchi^2 = 307.8802(0.3646) The insignificant relation between energy consumption and CO 2 emissions indicated in the long run relationship shows that, the contributions of Ethiopia to CO 2 emissions from the consumptions of modern energy like coal consumption indifferent sectors were eminent. According to the global carbon budget, from 1959-2011, 87 percent of all human-produced carbon dioxide emissions come from the burning of fossil fuels like coal, natural gas and oil, while from the clearing of forests and other land use changes 9% and as well as from some industrial process such as cement manufacturing 4% (IEA, 2013). In case of Ethiopia, Energy consumption in the country is dominated by sort of hydro and biomass. Biomass sourcing over 80% of the country's energy and Fossil fuel energy consumption which is a major source of CO 2 emission comprises coal, oil, petroleum, and natural gas products measured at 5.72 % of total energy consumption in Ethiopia for 2011.

Whereas, the positive and significant relation between economic growth and CO 2 indicates economic growth was inevitably increases carbon dioxide emissions in the country. The possible reason for this argument is the early stage economic growth hypothesis of Environmental Kuznets Curve. The hypothesis states that, at the early stage economic growth is at the cost of environment that come from land use, land process and expansions of agricultural activities. This activities can increases emissions emits to the environment (Panayotou, 2003).

The significant and positive sign of Urbanization with CO 2 emissions shows an increment in urban population increasesCO 2 emission to the environment. This might be due to increases in consumptions of: coal, oil, petroleum, and natural gas with increased urban populations. For the validity of the model, vector diagnostics tests confirmed no problem of serial autocorrelation in the error terms in the model, error term was normality distributed and have constant variance.

The vector error correction model captures both the long run and short run relationship. The short run dynamics shows speed of adjustment, variables plays important role in the adjustment process. The error correction term, measures the deviations of the series from the long run relationship. In the process of adjustments, first period of economic growth, carbon dioxide emissions and urbanizations, and all period lagged values of energy consumptions are significant. On the estimated VECM model, the error correction term in the equation is statistical significant at 1% significance level. The negative sign indicates convergence to the equilibrium. This coefficient indicates speed of adjustment is 32%. All variables under Equations are dependent, and the excluded variables are independent or source of causality. Decision rule, null hypothesis is rejected when probability value is less than 5%. As shown on the above table 4.5, as a regular economic phenomenon there is causality from energy consumption to economic growth and urbanization. The argument could be in line with an increases in energy consumptions in different sector can inevitably stimulate the economy. And, an increases in energy consumption also stimulate different activities and expand investments in urban area, this can attract many workers and expand urban population. The other causality is, from economic growth and urbanizations to carbon dioxide emissions. Economic growth and urbanizations, can increases CO 2 emissions to the environment due to an increases in economic activities and an increases in energy consumptions by urban residents for different activities respectively.

15 V. Conclusion and Recommendations

This study was aimed to examine, the relationships between energy consumption, carbon dioxide emission and economic growth in Ethiopia. The unit root test result indicates all the variables are nonstationary at level whereas, they become stationary after taking their first difference. It shows that, the variables under consideration are integrated of the same order one I (1). Co-integration analysis was conducted using Johansen co-integration testing approach with lag two as suggested by lag length selection criteria. The obtained results suggest that there is one co-integrating relationships among variables. From the short-run result, it found a correctly signed and statistically significant coefficient of ECM (-1). The negative sign indicates convergence to equilibrium whereas the coefficient shows speed of adjustment in case of a shock.

The study points out that, there is insignificant relation between energy consumption and CO 2 emissions as indicated in the long run relationship. It shows that, the contributions of Ethiopia to CO 2 emissions from the consumptions of modern energy like coal consumption in different sectors were eminent. Whereas, the positive and significant relation between economic growth and CO 2 indicates, economic growth was inevitably increases carbon dioxide emissions in the country. The significant and positive sign of Urbanization with CO 2 emissions shows an increment in urban population increases CO 2 emission to the environment. And, there is causality from energy consumption to economic growth and urbanization. As well as, from economic growth and urbanizations to carbon dioxide emissions. To minimize CO 2 emissions that comes from, economic growth and urbanizations in Ethiopia, cost effective, carbon free, and efficient utilization of renewable energy consumption based on the country comparative advantage that consider alternative use of resources are advisable like: -Hydro and Geothermal. [1] [2] [3]

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Figure 1: 2) 3)

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1 : Lag length selections

lag	AIC	HQIC	SBIC
0	-5.72448	-5.66327	-5.55386
1	-12.0727	-11.7666	-11.2196
2	-12.8475*	-12.2965*	-11.3119*

[Note: Source:STATA 11 result]

Figure 2: Table 4 .

[2] BEnergy Consumption, Carbon Dioxide Emissions and Economic Growth in Ethiopia

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Variables	Test statistics	Without constant 1% critical value	5% critical value	Test statistics	With constant 1% critical value	5% critical value
LEC	-1.007	-2.638	-1.950	-2.331	-4.251	-3.544
LCO2	-0.294	-2.638	-1.950	-2.784	-4.251	-3.544
LRY	1.022	-2.638	-1.950	0.244	-4.251	-3.544
LURB	-0.439	-2.639	-1.950	-2.945	-4.260	-3.548

Source: STATA 11 result

* And ** indicates the rejection of the null hypothesis at 1% and 5% level of significance, respectively Sourc

Figure 3: Table 4 .

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LEC LCO2 LRY LURB	Test statistics -1.007 -0.294 1.022 -0.439	Without constant 1% critical value -2.638 -2.638 -2.638 -2.639	5% critical value -1.950 -1.950 -1.950 -1.950	Test statistics -2.331 -2.784 0.244 -2.945	With constant 1% critical value -4.251 -4.251 -4.251 -4.260	5% critical value -3.544 -3.544 -3.544 -3.548	Year Volume XVI Issue II Version I ( ) Global Journal of Management and Business Research

Figure 4: Table 4 .

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3.A : Johnson Co-integrations Test Trace Statistics

Rank _Ho	Ha	Eigen value	Trace statistic	5% critical	decision
0		-	61.6255	47.21	
1		0.59352	26.5165*	29.68	accept
2		0.38226	7.7304	15.41	
3		0.17861	0.0566	3.76	
4		0.00145	-	-	
Source: STATA 11 Result					

Table 4.3.B : Johnson Co-integrations Test Max Statistics

Rank_Ho	Ha	Eigen value	Max statistic	5% critical	decision
0		-	35.1091	27.07	
1		0.59352	18.7861	20.97	accept
2		0.38226	7.6738	14.07	
3		0.17861	0.0566	3.76	
4		0.00145	-	-	-
Source: STATA 11 result					

Figure 5: Table 4 .

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Variables	coefficient	Std. error	p-value
Constant	.0137954	.1204968	0.909
DLEC_1	-4.036318	1.191125	0.001
DLEC_2	3.605454	1.344326	0.007
DLURB_1	.7609294	1.511107	0.000
DLURB_2	.4935843	.2891729	0.125
DCO2_1	-.4287555	.3567761	0.009
DCO2_2	-.4060967	.090207	0.167
DLRY_1	.8984152	.2431941	0.000
DLRY_2	.1458625	.2641395	0.581
EMC_1	-.3295002	.0514678	0.000

R^2 = 0.8292

VEC diagnostic test

AR test Chi^2(25) = 19.58049(0.76848)

Normality test chi(^) 2 = .507(0.77599)

Hetro test chi^(22) = 28.36542(.639)

Source: STATA 11

Figure 6: Table 4 . 4 :

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Equations	Excluded	Chi^2	Df	prob> Chi^2
lco2	Lry	9.3831	2	0.009
lco2	Lurb	11.71	2	0.003
lry	Lec	8.8158	2	0.012
lurb	Lec	11.579	2	0.003

[Note: Source:STATA 11]

Figure 7: Table 4 . 5 :

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