

THE IMPACT OF REAL GROSS DOMESTIC PRODUCT AND POPULATION ON ENVIRONMENTAL POLLUTION IN THE PHILIPPINES

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ABSTRACT

This paper focuses on environmental pollution in terms of carbon dioxide emissions, as influenced by real gross domestic product, population, and their respective squared terms. The effect of each determinant and their collective effect on environmental pollution were measured. The directions of causality were determined.

The study utilized descriptive-causal research design. A quadratic multiple regression model and diagnostic tests were applied. These were tests for stationarity, autocorrelation, and significance of the parameter estimates, goodness of fit, overall significance of the model, heteroskedasticity, specification error, normality of residuals, cointegration, and causality.

The results of the study using time series data show that real gross domestic product exerts a statistically significant effect on environmental pollution.. An increase in real gross domestic product leads to an increase in carbon dioxide emissions; and an increase in population worsens environmental pollution. The collective effect of the regressors on environmental pollution is significant.

The Granger causality test shows that there is a unidirectional causality between real gross domestic product and environmental pollution, and between population and environmental pollution. Both real gross domestic product and population cause environmental pollution. The study also reveals that the behaviour of environmental pollution in the Philippines follows the Environmental Kuznets's Inverted U-Curve.

Keywords: Carbon Dioxide Emissions, Environmental Kuznets's Inverted-U Hypothesis, Environmental Pollution, Population, Real Gross Domestic Product

Introduction

The Philippines, just like any other economy, aims to achieve economic growth and development which means more production, income, and consumption, among others, especially as population grows. Attaining economic growth has a trade off which is environmental degradation.

The existence of environmental problems has become one of the most pressing concerns of the world economies; and the Philippines is not an exception. The degree of importance of this concern is shown by the government's effort to reduce catastrophes. The recent attendance of around 115 world leaders, (including the presidents of the United States and that of the Philippines) in the 21st United Nations Climate Change Conference held on November 30, 2015 in Paris, to come up with an agreement that binds them to limit global warming, is an indication also of the serious concern on environmental issues.

This study is undertaken to come up with a scientific view of the effect of real gross domestic product and population on environmental pollution in the Philippines by applying the Environmental Kuznets Curve Hypothesis.

Objectives of the Study

The study has the following objectives:

1. To show the behaviour of environmental pollution measured in terms of carbon dioxide emissions
2. To measure the effect of real gross domestic product, real gross domestic product squared, population, and population squared on environmental pollution when taken individually and collectively
3. To find out whether there is structural stability in the parameter estimates
4. To determine whether there is a long run equilibrium relationship between environmental pollution and the explanatory variables
5. To find out whether the Environmental Kuznets Hypothesis holds true in the Philippines
6. To identify the direction of causality between environmental pollution and each of the explanatory variables such as real gross domestic product, real gross domestic product squared, population, and population squared

Theoretical Framework

The study is anchored on the Environmental Kuznets Curve (EKC) which follows an inverted U-shape. This theory assumes that environmental quality or pollutant emissions per head are correlated with economic growth specifically per capita real gross domestic product and that there is a U-shaped relationship between these variables. This theory implies that as a country continues to grow, carbon dioxide emissions worsen; but after reaching a certain level of higher income, emissions slow down as income rises (Field and Field,2006).

Figure 1 shows the Environmental Kuznets Curve (EKC).

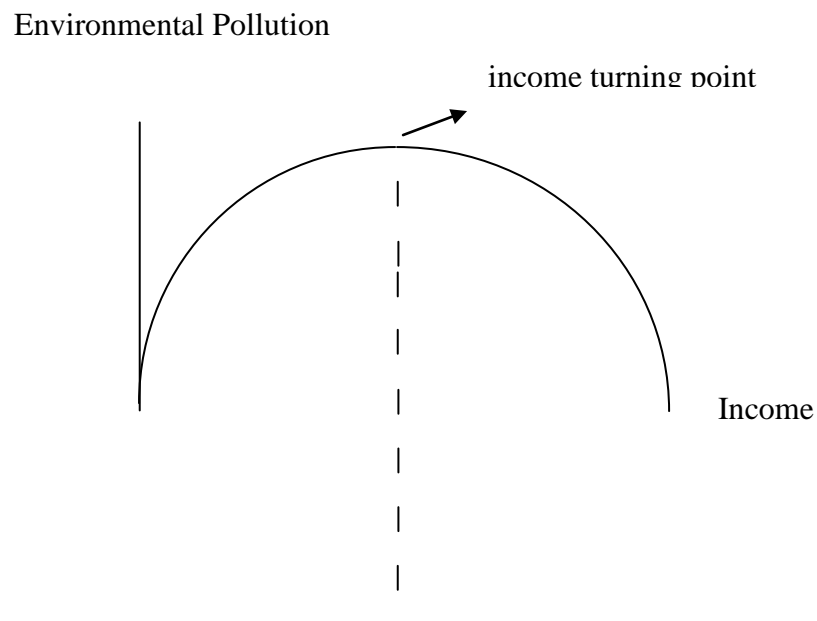


Figure 1
The Environmental Kuznets Curve (EKC)

Conceptual Framework

The schematic diagram of the conceptual framework is illustrated in Figure 2.

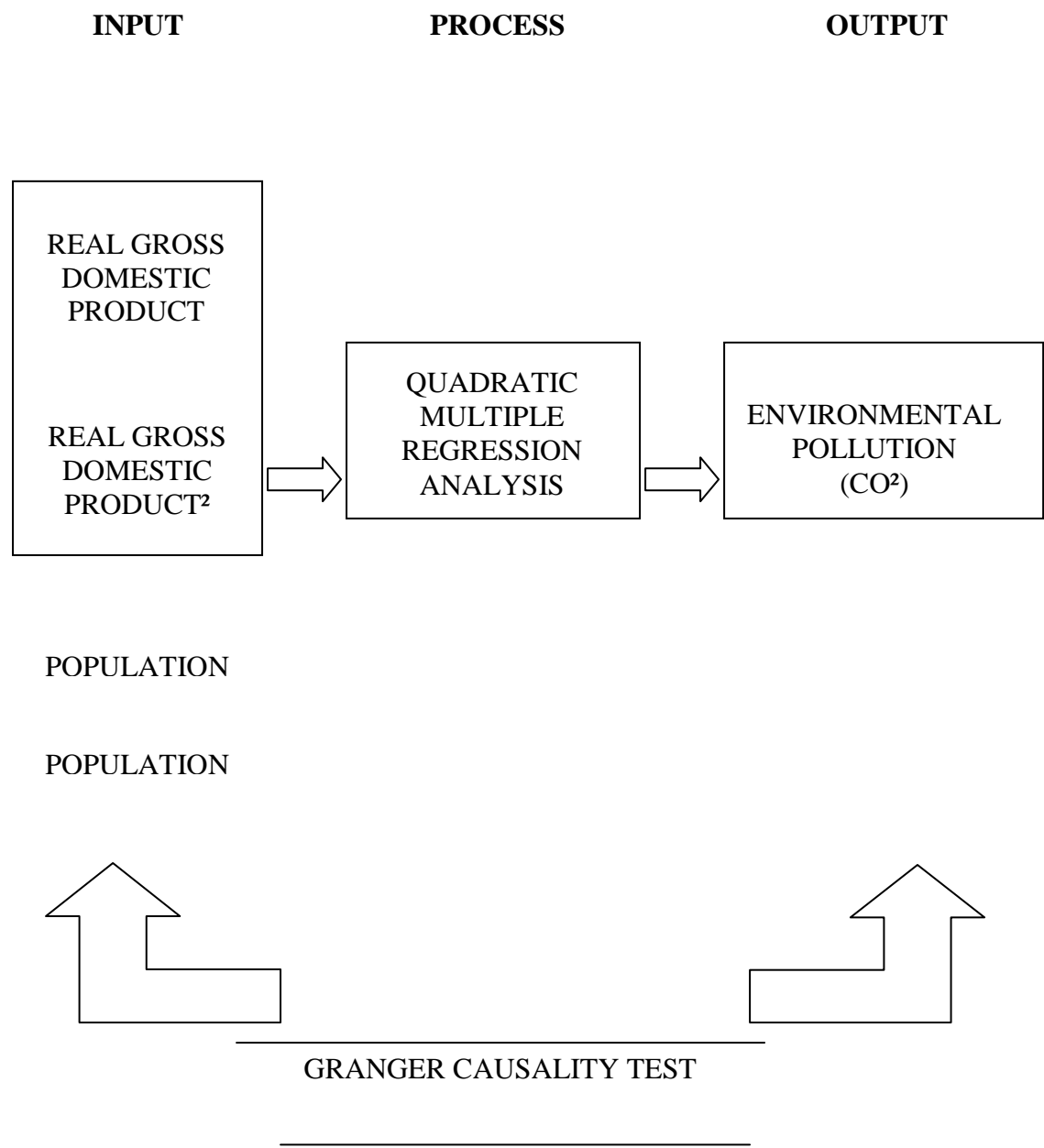


Figure 2

The Conceptual Paradigm

The paradigm assumes that environmental pollution, measured in terms of carbon dioxide (CO₂) emissions, is a function of real gross domestic product,

population and their respective squared terms; and that it could also be the reverse. Hence, the test for Granger causality.

Mathematically, this is expressed in functional form as follows:

$$\begin{matrix} (+) & (-) & (+) & (-) \\ EP = f(RGDP, RGDP^2, Pop, Pop^2) \end{matrix}$$

Where: EP = environmental pollution as measured in terms of carbon dioxide emissions

RGDP = real gross domestic product

RGDP² = real gross domestic product squared

Pop = population

Pop² = population squared

The expected signs are on top of each variable. Both real gross domestic product and population have positive signs; while real gross domestic product squared and population squared bear negative signs.

Data and Procedures

The study utilized the descriptive-causal research design. The data on environmental pollution expressed in terms of carbon dioxide emissions, real gross domestic product, and population are shown in tabular and graphical forms. This is the descriptive aspect since the what, when, and how of the study are described (Pride and Ferrell, 2007). The causal dimension is shown through the estimation of the magnitude of impacts of the regressors on the regressand, determination of causality, and the application of other diagnostic tests Gujarati, 2003).

The time series data covering a 40-year period (1971-2010) on environmental pollution in terms of carbon dioxide emissions were sourced from the World Bank website; and the data on real gross domestic product (at 2000 constant price) and population were culled from the Philippine Statistics Authority-National Statistical Coordination Board

The environmental pollution is the regressand or dependent variable; while real gross domestic product and population as well as their respective squared terms are the regressors or explanatory variables.

The study used a quadratic multiple regression model since it is anchored on the Environmental Kuznets Hypothesis. The model is given as:

$$EP = B_0 + B_1RGDP + B_2RGDP^2 + B_3Pop + B_4Pop^2 + \varepsilon$$

Where: EP = Environmental Pollution measured in terms of carbon dioxide emissions

RGDP = Real Gross Domestic Product

RGDP² = Real Gross Domestic Product squared

Pop = Population

Pop² = Population squared

B's = Parameter estimates

ε = Error term

To facilitate computations of the needed statistics, Econometric Views (E-Views) version 7 was used.

This empirical study applied the following diagnostic tests: Augmented Dickey-Fuller (ADF) Unit Root Test to ensure that the regression is not spurious, Durbin Watson Statistic to detect autocorrelation to be certain of validating the assumption that the error terms are not correlated, t-ratio for the test of the statistical significance of each of the regression coefficients, Coefficient of Multiple Determination (R²) for the test of goodness of fit, i.e., to determine how well the regression line fits the data, Adjusted R-Squared (R²) to verify the adjustment in degrees of freedom associated with an additional explanatory variable, F-ratio for the overall significance of the regression model, Autoregressive Conditional Heteroskedasticity (ARCH) Test to determine if there is heteroskedasticity, i.e., if the forecast errors in the regression function is not constant but varies from period to period, Chow Breakpoint Test to test for structural stability of the regression parameters, Ramsey's Regression Specification Error test (RESET) to test for regression specification error, Jarque - Bera Normality Test to determine if the residuals are normally distributed, Johansen-Juselius Cointegration Test to test for long term relationship between the dependent variable and the independent variables, and Granger Causality test to test for the direction of causality, i.e., cause and effect relationship between the variables.

Results and Discussions

Table 1 shows the carbon dioxide emissions in the Philippines from 1971 to 2010 and its behaviour is exhibited in Figure 3.

Table 1
Carbon Dioxide Emissions (Kilotons) in the Philippines, 1971-2010

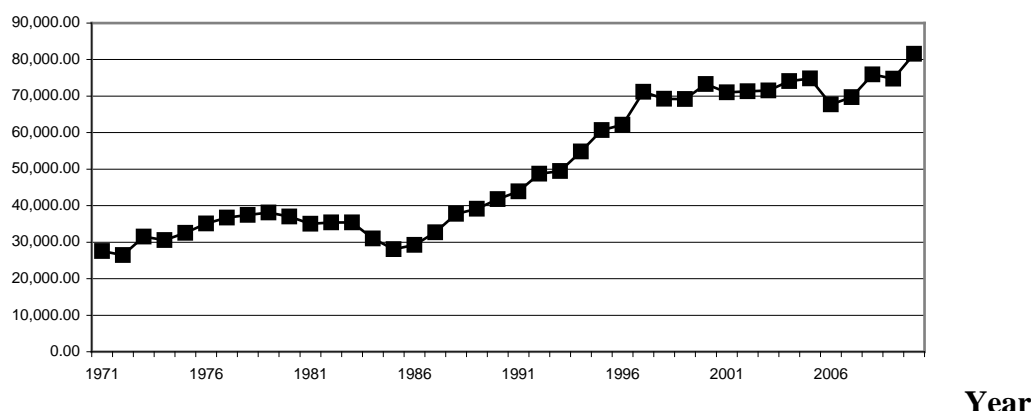
Year	CO ₂	Year	CO ₂	Year	CO ₂
1971	27,586.84	1985	28,048.88	1999	69,159.62
1972	26,442.74	1986	29,207.66	2000	73,307.00
1973	31,543.53	1987	32,683.97	2001	71,051.79
1974	30,531.44	1988	37,729.76	2002	71,337.82
1975	32,526.29	1989	39,141.56	2003	71,532.17
1976	35,129.86	1990	41,763.46	2004	74,066.07
1977	36,754.34	1991	43,930.66	2005	74,832.47
1978	37,476.74	1992	48,752.77	2006	67,692.82
1979	38,136.80	1993	49,482.50	2007	69,669.33
1980	37,000.03	1994	54,799.65	2008	75,943.57
1981	34,997.85	1995	60,710.85	2009	74,784.80
1982	35,415.89	1996	62,162.98	2010	81,590.75
1983	35,415.89	1997	71,158.14		
1984	30,993.48	1998	69,240.29		
<i>Average CO₂ = 33,514</i>					

The Grolier International Dictionary (1984) defines carbon dioxide as a colorless, odorless, incombustible gas, CO₂, formed during respiration, combustion, and organic decomposition and used in refrigeration, carbonated beverages, inert atmospheres, fire extinguishers, and aerosols.

Figure 3 shows that the carbon dioxide emissions in the Philippines for the period under review has an upward behavior in general albeit there were fluctuations. It could be seen from Table 1 and reflected in Figure 3 that the carbon dioxide emissions see-sawed over the years. The highest rate of increase in carbon dioxide emissions transpired in 1973 with 19.29%, i.e., from 26,442.74 kilotons in 1972 to 31,531.44 kilotons in 1973; while the lowest reduction was experienced in 1984 with 12.49% , i.e., from 35,415.89 kilotons in 1983 to 30,993.48 kilotons in 1984. The lowest amount of emissions was in 1972 with 26,442.74 kilotons and the highest was

in 2010 with 81,590.75 kilotons. This high level of emissions into the atmosphere was attributed to the combined effects of human-induced or anthropogenic greenhouse gases emissions from the sectors of energy, industry, agriculture, and wastes. Carbon dioxide emissions are the by-products from processes which require the burning of

Carbon Dioxide Emissions



fossil fuels and deforestation. In addition, carbon dioxide is also emitted by respiratory processes inherent to living organisms like the breathing mechanism of humans (<http://data.worldbank.org/country/philippines>). For the period examined, the average carbon dioxide emissions amounted to 33,514 kilotons per annum and has an annual average increase of 3.05%.

Figure 3

Carbon Dioxide Emissions (Kilotons) in the Philippines, 1971-2010

The real gross domestic product for the 40-year period is given in Table 2 and its behavior is depicted in Figure 4.

The Philippines underwent different conditions and economic policies under different administrations during the 40-year period.

It could be observed from Table 2 and Figure 4 that real gross domestic product has an increasing trend from 1971 to 2010 despite the declines experienced in 1984, 1985, and 1998. These declines could be attributed to the Martial Law years of 1984 and 1985 as well as the 1998 Asian Financial Crisis.

During the administration of President Ferdinand Marcos, the highest real gross domestic product reached 2,448,221 (million pesos) in 1983 and the highest growth rate was at 8.81% in 1976. His administration adopted an import-substitution policy that resulted to massive deficits. In 1984 and 1985, the real gross domestic product registered negative growth rates of 7.32% and 7.31%, respectively. The real gross domestic product dropped from 2,494,116 (million pesos) in 1983 to 2,311,455 (million pesos) in 1984 which further went down to 2,142,566 (million pesos) in 1985. This downward movement was attributed to low productivity and corruption.

President Marcos was then replaced by President Corazon Aquino who was catapulted to power through People Power Revolution. However, her administration later was faced by a lot of coup attempts and natural calamities. Despite these, the economy managed to have a positive growth of 3.42% that made the real gross domestic product go up from 2,142,566 (million pesos) in 1985 to 2,215,773 (million pesos) in 1986. However, her term ended with a negative 0.58% growth rate. During the incumbency of President Aquino, the highest real gross domestic product was 2,700,073 (million pesos) in 1990 but the highest growth rate was 6.75% in 1988.

Table 2

Real Gross Domestic Product (in Million Pesos) 1971-2010

Year	RGDP	Year	RGDP	Year	RGDP
1971	1,355,454	1985	2,142,566	1999	3,429,434
1972	1,429,283	1986	2,215,773	2000	3,580,714
1973	1,556,784	1987	2,311,309	2001	3,684,340
1974	1,612,176	1988	2,467,381	2002	3,818,667
1975	1,701,890	1989	2,620,490	2003	4,008,469
1976	1,851,769	1990	2,700,073	2004	4,276,941
1977	1,955,507	1991	2,684,458	2005	4,481,279
1978	2,056,647	1992	2,693,521	2006	4,716,231
1979	2,172,636	1993	2,750,524	2007	5,028,288
1980	2,284,503	1994	2,871,206	2008	5,237,101
1981	2,362,707	1995	3,005,541	2009	5,297,240
1982	2,448,221	1996	3,181,241	2010	5,701,539
1983	2,494,116	1997	3,346,200		
1984	2,311,455	1998	3,326,902		
Average RGDP = 2,979,264					

Real Gross Domestic Product

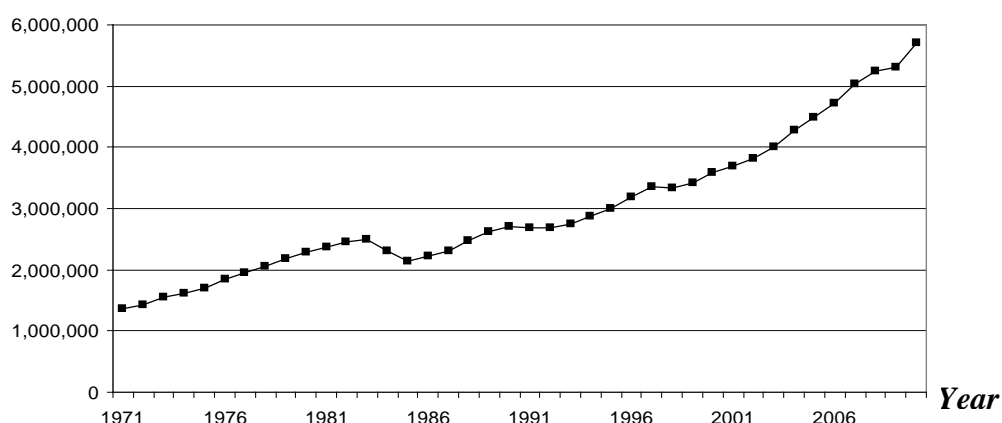


Figure 4

Real Gross Domestic Product (in Million Pesos) 1971-2010

During the incumbency of President Fidel Ramos, the Philippine economy registered positive growth rates all throughout his term. The negative growth rate at the end of the Aquino administration in 1991 was turned around into a positive growth albeit it was only 0.34%. The highest real gross domestic product in his incumbency occurred in 1996 with 3,181,241 (million pesos) but the highest growth rate was 5.85% in 1996. The aim of his administration was to make the Philippines a tiger economy.

In 1998, The Philippine economy was affected by the Asian financial crisis. This happened during the administration of President Joseph Ejercito Estrada. There were also a number of natural disasters that brought down the economy. Consequently, the real gross domestic product dramatically decreased from 3,346,200 (million pesos) in 1997 to 3,326,902 (million pesos) with a negative growth rate of 0.58%. The following year, the economy was able to rebound with a real gross domestic product of 3,429,434 (million pesos) and a growth rate of 3.08%.

In 2004, the economy grew at a rate of 6.7%. President Gloria Arroyo adopted economic measures that were geared towards bringing the country towards greater growth. Throughout her term, the economy has positive growth rates. Her term ended in 2009 with 1.15% growth rate only but posted the highest real gross domestic product of 5,297,240 (million pesos) during that year.

During the first year of the administration of President Benigno Simeon Aquino III in 2010, the real gross domestic product registered 5,701,539 (million pesos) and grew by 7.63%. The last year covered in the study is 2010.

The average real gross domestic product from 1971 to 2010 was 2,979,264 (million pesos) and has an average growth rate of 3.81% per annum.

Table 3 and Figure 5 show the population data and its pattern, respectively. The total population in the Philippines was recorded at 92.6 million persons in 2010 from 37.60 million in 1971, or an increase of 55 million persons in 40 years. The average growth rate for the last 40 years, from 1971 to 2010 was 2.34%. Figure 5 pictures out an increasing behavior of the total population in the country.

Table 3
Population (in Million Persons) 1971-2010

Year	Pop	Year	Pop	Year	Pop
1971	37.60	1985	54.67	1999	76.78
1972	38.70	1986	56.00	2000	76.79
1973	39.76	1987	57.40	2001	78.59
1974	40.87	1988	58.70	2002	80.16
1975	42.02	1989	60.10	2003	81.88
1976	43.20	1990	61.50	2004	83.56
1977	44.40	1991	63.00	2005	85.26
1978	45.63	1992	64.40	2006	86.97
1979	46.86	1993	65.90	2007	88.71
1980	48.32	1994	67.51	2008	90.50
1981	49.54	1995	68.41	2009	91.00
1982	50.78	1996	70.01	2010	92.60
1983	52.06	1997	71.65		
1984	53.35	1998	75.16		
Average Pop = 45.22					

Population

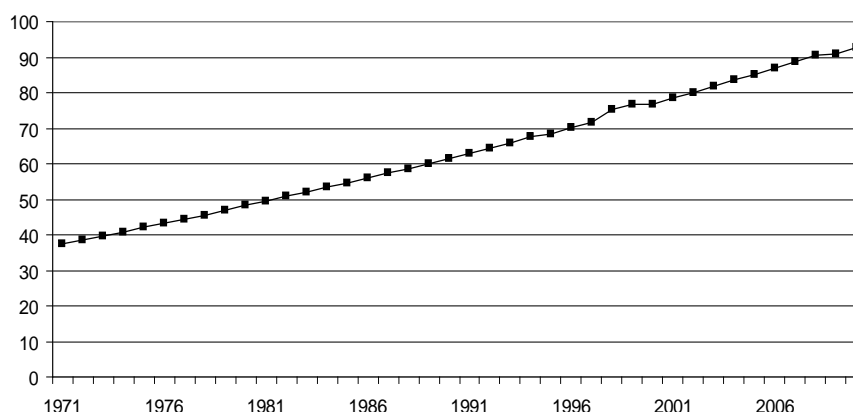


Figure 5

Population (in Million Persons) 1971-2010

The interpretation of the diagnostic tests and findings are discussed in the succeeding paragraphs.

Environmental pollution measured in terms of carbon dioxide emissions, population, and population squared were stationary at first difference because their respective computed ADF statistics of 15.77461, 15.84901, and 16.03181 exceeded their Mac Kinnon critical values at 1%, 5%, and 10% levels of significance. On the other hand, real gross domestic product and real gross domestic product squared were stationary at second difference based on their respective computed ADF statistics of 16.36831 and 14.91461 which were greater than the Mac Kinnon critical values. Since all the variables were stationary at second difference and were integrated of the same order, i.e., 2 I(2), regression at level was feasible. Consequently, regression estimation and testing were performed.

The initial regression result indicated the presence of positive autocorrelation as shown by its Durbin – Watson statistic of 0.616723. But after correcting it for first-order serial correlation and second-order serial correlation, it resulted to absence of positive or negative autocorrelation, with the du of 1.792 being less than d of 1.817976 which is less than $4 - du$ with a value of 2.208. This made the regression equation corrected for autocorrelation as,

$$EP = -1.635886 + 0.058605RGDP - 0.000309RGDP^2$$

$$t\text{-ratio} = \quad (2.262557) \quad (-0.938056)$$

$$+ 0.451335Pop - 0.04644Pop^2$$

$$t\text{-ratio} = \quad (0.501899) \quad (-0.778201)$$

$$R^2 = 0.880927$$

$$\text{Computed F-statistic} = 38.2241$$

$$R^2 = 0.857881$$

$$\text{Critical F-statistic} = 2.69$$

D.W. statistic=1.817976 Critical t-ratio = 2.04

The coefficient for real gross domestic product of 0.058605 shows that for every increase in real gross domestic product by one trillion pesos, carbon dioxide emissions (representing environmental pollution) will increase by 0.058605 kilotons, *ceteris paribus*. Since its computed t-value of 2.262557 is greater than the critical t-value of 2.04 at 31 degrees of freedom and at a significance level of five percent, the null hypothesis that gross domestic product has no significant effect on environmental pollution is rejected. Thus, the alternative hypothesis that real gross domestic product has a significant effect on environmental pollution is accepted. It is consistent with the theoretical expectation that as real gross domestic product rises, environmental pollution rises. However, in the case of the real gross domestic product squared, the coefficient implies that with the passage of time, an increase of one trillion pesos in real gross domestic product will make a reduction of 0.000309 kilotons in carbon dioxide emissions. Hence, an improvement in the environment.

Population is preceded by a positive sign while population squared has a negative sign. Their signs are both consistent with theoretical expectations; but they have insignificant effects on environmental pollution as indicated by their respective t-values of 0.501899 and 0.778201 which are both lower than the critical t-value of 2.04 with 31 degrees of freedom at five percent level of significance. There is therefore no reason to reject the null hypothesis that population and population squared have no significant effects on environmental pollution. The coefficient for population shows that for every one million increase in population, environmental pollution measured in terms of carbon dioxide emissions increases by 0.451335 kilotons. On the other hand, the coefficient for population squared shows that for every million increase in population, environmental pollution diminishes in the amount of 0.04644 kilotons of carbon dioxide emissions. This could be explained by the consciousness of people for the need to minimize pollution to protect the environment as time passes by.

The collective effect on environmental pollution of real gross domestic product, real gross domestic product squared, population, and population squared is significant since the F-statistic of 38.22408 is greater than the critical F-ratio of 2.69 at five percent level of significance and degrees of freedom of 6 and 31. Thus the model is significant.

The R^2 of 0.880927 implies that 88.09% of the variations in environmental pollution are explained by the variations of its explanatory variables such as real gross domestic product, real gross domestic product squared, population, and population squared. The model then has a relatively high predictive power.

The result of the Jarque-Bera Normality test exhibited a JB statistics of 2.060767 with a p-value of 0.356870 which exceeded the five percent level of significance. These show that the regression residuals are normally distributed.

The Autoregressive Conditional Heteroskedasticity (ARCH) test resulted to a Chi squared value of 0.430786 with a p-value of 0.7054 which exceeded five percent significance level. This reveals that the variance of the regression disturbances or forecast errors is relatively constant or homoskedastic. Hence, there is no heteroskedasticity.

The Chow Breakpoint test yielded an F-ratio of 1.380943 and a p-value of 0.2584 which exceeded the five percent level of significance. This means that there is structural stability in the parameter estimates.

Based on the results of the Ramsey's Regression Specification Error Test (RESET), the model is correctly specified since the F-ratio of 2.4370 with a p-value of 0.1290 is higher than the five percent level of significance.

The Johansen-Juselius Cointegration Test showed that based on trace statistics, there are three cointegrating equations at five percent level of significance. This suggests that there is a long-run equilibrium relationship between the variables.

The Granger Causality Test revealed that there is unidirectional causality between each of the explanatory variables and the dependent variable. This means that the direction of causation is coming from real gross domestic product, real gross domestic product squared, population, and population squared to environmental pollution. It appears that each of the explanatory variables is the cause and environmental pollution is the effect based on the F-statistic and p-value for each of the explanatory variables being paired with environmental pollution. The respective F-statistics and p-values for real gross domestic product, real gross domestic product squared, population, and population squared as a cause of environmental pollution are: 3.77596, 0.0207; 4.50123, 0.0101; 3.11232, 0.0409; and 2.96021, 0.0480. These are all statistically significant.

Conclusion

Given the findings, the conclusions drawn are as follows:

1. A direct relationship exists between real gross domestic product and environmental pollution measured in terms of carbon dioxide emissions, i.e., as real gross domestic product rises, environmental pollution intensifies.
2. Real gross domestic product exerts a significant effect on environmental pollution.
3. With real gross domestic product bearing a positive sign and real gross domestic product squared having a negative sign, is indicative that environmental pollution will increase at first as real gross domestic product increases; but the former will eventually decline after passage of time even if the latter continues to rise.
4. Population and population squared have insignificant effects on environmental pollution.
5. Population and its squared term have positive and negative relationships, respectively. These relationships show that as population grows, environmental pollution surges; but as time passes by, an upward movement in population lessens environmental pollution.
6. The behaviour of environmental pollution as influenced by real gross domestic product and population and their respective squared terms appears to be an inverted U-shaped curve which is consistent with the Environmental Kuznets's Inverted-U Hypothesis. This is based on the findings that real gross domestic product and

population have positive signs and their respective squared terms bear negative signs, which are consistent with the theoretical expected signs. While the behaviour of environmental pollution follows the Environmental Kuznets's Inverted U-Curve, but it is not validated because real gross domestic product squared, population, and its squared term are not significant. This could be explained by the fact that the Philippines is still a developing country and not widely a fully developed country. This could further be explained that although the people have become more conscious of minimizing pollution to protect the environment, but it could be gleaned that there are still many individuals who have not reached their "income turning point" thereby make them still unwilling to trade consumption for investment in environmental protection.

7. Real gross domestic product, real gross domestic product squared, population, and population squared, when taken collectively, have a significant effect on environmental pollution.

8. There is structural stability in the regression parameters.

9. Environmental pollution has a long run equilibrium relationship with real gross domestic product, real gross domestic product squared, population, and population squared.

10. The direction of causality is from real gross domestic product and population to environmental pollution, i.e., real gross domestic product and population cause environmental pollution.

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Appendix 1

Augmented Dickey-Fuller Result on Environmental Pollution (at level)

Null Hypothesis: EP has a unit root
 Exogenous: Constant, Linear Trend
 Lag Length: 0 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-1.536896	0.7992
Test critical values: 1% level	-4.211868	
5% level	-3.529758	
10% level	-3.196411	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
 Dependent Variable: D(EP)
 Method: Least Squares
 Date: 02/25/14 Time: 22:38
 Sample (adjusted): 1972 2010
 Included observations: 39 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EP(-1)	-0.120021	0.078093	-1.536896	0.1331
C	0.081481	0.056728	1.436349	0.1595
@TREND(1971)	0.000745	0.000779	0.955362	0.3458
R-squared	0.064810	Mean dependent var		0.003194
Adjusted R-squared	0.012855	S.D. dependent var		0.050420
S.E. of regression	0.050095	Akaike info criterion		3.075974
Sum squared resid	0.090344	Schwarz criterion		2.948007
Log likelihood	62.98149	Hannan-Quinn criter.		3.030061
F-statistic	1.247422	Durbin-Watson stat		1.792665
Prob(F-statistic)	0.299364			

Appendix 2

Augmented Dickey-Fuller Result on Environmental Pollution (at 1st difference)

Null Hypothesis: D(EP) has a unit root
 Exogenous: Constant, Linear Trend
 Lag Length: 0 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-5.765124	0.0002
Test critical values: 1% level	-4.219126	
5% level	-3.533083	
10% level	-3.198312	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
 Dependent Variable: D(EP,2)
 Method: Least Squares
 Date: 02/25/14 Time: 22:38
 Sample (adjusted): 1973 2010
 Included observations: 38 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(EP(-1))	-0.975057	0.169130	-5.765124	0.0000
C	0.003626	0.017775	0.203986	0.8395
@TREND(1971)	4.69E-05	0.000765	0.061322	0.9515
R-squared	0.487080	Mean dependent var		0.002912
Adjusted R-squared	0.457770	S.D. dependent var		0.070183
S.E. of regression	0.051680	Akaike info criterion		-3.011825
Sum squared resid	0.093480	Schwarz criterion		-2.882542
Log likelihood	60.22468	Hannan-Quinn criter.		-2.965827
F-statistic	16.61836	Durbin-Watson stat		1.720213
Prob(F-statistic)	0.000008			

Appendix 3

Augmented Dickey-Fuller Result on Environmental Pollution (at 2nd difference)

Null Hypothesis: D(EP,2) has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 1 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-7.800602	0.0000
Test critical values: 1% level	-4.234972	
5% level	-3.540328	
10% level	-3.202445	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(EP,3)

Method: Least Squares

Date: 02/25/14 Time: 22:39

Sample (adjusted): 1975 2010

Included observations: 36 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(EP(-1),2)	-2.057690	0.263786	-7.800602	0.0000
D(EP(-1),3)	0.400872	0.146216	2.741648	0.0099
C	-0.004412	0.019624	-0.224801	0.8236
@TREND(1971)	0.000283	0.000821	0.344377	0.7328
R-squared	0.795039	Mean dependent var		0.006794
Adjusted R-squared	0.775823	S.D. dependent var		0.107804
S.E. of regression	0.051042	Akaike info criterion		3.007880
Sum squared resid	0.083371	Schwarz criterion		2.831933
Log likelihood	58.14184	Hannan-Quinn criter.		2.946470
F-statistic	41.37565	Durbin-Watson stat		1.923038
Prob(F-statistic)	0.000000			

Appendix 4

Augmented Dickey-Fuller Test Result on Real Gross Domestic Product (at level)

(Null Hypothesis: RGDP has a unit root)

Exogenous: Constant, Linear Trend

Lag Length: 0 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	1.478406	1.0000
Test critical values: 1% level	-4.211868	
5% level	-3.529758	
10% level	-3.196411	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(RGDP)

Method: Least Squares

Date: 02/26/14 Time: 22:34

Sample (adjusted): 1972 2010

Included observations: 39 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RGDP(-1)	0.072173	0.048818	1.478406	0.1480
C	-0.584078	0.627152	-0.931318	0.3579
@TREND(1971)	-0.020070	0.045652	-0.439625	0.6628
R-squared	0.269518	Mean dependent var	1.114382	
Adjusted R-squared	0.228936	S.D. dependent var	1.068577	
S.E. of regression	0.938321	Akaike info criterion	2.784353	
Sum squared resid	31.69603	Schwarz criterion	2.912319	
Log likelihood	-51.29489	Hannan-Quinn criter.	2.830266	
F-statistic	6.641270	Durbin-Watson stat	1.271402	
Prob(F-statistic)	0.003507			

Appendix 5

Augmented Dickey-Fuller Test Result on Real Gross Domestic Product (at 1st difference)

Null Hypothesis: D(RGDP) has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 1 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-3.518441	0.0520
Test critical values: 1% level	-4.226815	
5% level	-3.536601	
10% level	-3.200320	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(RGDP,2)

Method: Least Squares

Date: 02/26/14 Time: 22:35

Sample (adjusted): 1974 2010

Included observations: 37 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(RGDP(-1))	-0.679616	0.193158	-3.518441	0.0013
D(RGDP(-1),2)	0.202781	0.201409	1.006813	0.3214
C	-0.049315	0.327819	-0.150434	0.8813
@TREND(1971)	0.039778	0.015707	2.532487	0.0163
R-squared	0.300112	Mean dependent var	0.074811	
Adjusted R-squared	0.236486	S.D. dependent var	1.024099	
S.E. of regression	0.894850	Akaike info criterion	2.717485	
Sum squared resid	26.42498	Schwarz criterion	2.891638	
Log likelihood	-46.27347	Hannan-Quinn criter.	2.778882	
F-statistic	4.716811	Durbin-Watson stat	1.657937	
Prob(F-statistic)	0.007569			

Appendix 6

Augmented Dickey-Fuller Test Result on Real Gross Domestic Product (at 2nd difference)

Null Hypothesis: D(RGDP,2) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-6.368284	0.0000
Test critical values: 1% level	-4.234972	
5% level	-3.540328	
10% level	-3.202445	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RGDP,3)
Method: Least Squares
Date: 02/27/14 Time: 03:43
Sample (adjusted): 1975 2010
Included observations: 36 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(RGDP(-1),2)	-1.674561	0.262953	-6.368284	0.0000
D(RGDP(-1),3)	0.551746	0.193248	2.855116	0.0075
C	-0.164403	0.363247	-0.452593	0.6539
@TREND(1971)	0.013010	0.015226	0.854455	0.3992
R-squared	0.593483	Mean dependent var	0.115628	
Adjusted R-squared	0.555372	S.D. dependent var	1.421718	
S.E. of regression	0.948007	Akaike info criterion	2.835530	
Sum squared resid	28.75897	Schwarz criterion	3.011477	
Log likelihood	-47.03954	Hannan-Quinn criter.	2.896940	
F-statistic	15.57251	Durbin-Watson stat	1.726117	
Prob(F-statistic)	0.000002			

Appendix 7

Augmented Dickey-Fuller Test Result on Real Gross Domestic Product Squared (at Level)

Null Hypothesis: RGDP2 has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	3.670737	1.0000
Test critical values: 1% level	-4.211868	
5% level	-3.529758	
10% level	-3.196411	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RGDP2)
Method: Least Squares
Date: 02/27/14 Time: 03:46
Sample (adjusted): 1972 2010
Included observations: 39 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RGDP2(-1)	0.125159	0.034096	3.670737	0.0008
C	-13.81690	21.75144	-0.635218	0.5293
@TREND(1971)	-1.367573	2.128424	-0.642528	0.5246
R-squared	0.592184	Mean dependent var	78.64177	
Adjusted R-squared	0.569527	S.D. dependent var	97.84412	
S.E. of regression	64.19593	Akaike info criterion	11.23556	
Sum squared resid	148360.2	Schwarz criterion	11.36353	
Log likelihood	-216.0934	Hannan-Quinn criter.	11.28147	
F-statistic	26.13753	Durbin-Watson stat	1.801387	
Prob(F-statistic)	0.000000			

Appendix 8

Augmented Dickey-Fuller Test Result on Real Gross Domestic Product Squared (at 1st difference)

Null Hypothesis: D(RGDP2) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-3.234814	0.0930
Test critical values: 1% level	-4.219126	
5% level	-3.533083	
10% level	-3.198312	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RGDP2,2)
Method: Least Squares
Date: 02/27/14 Time: 03:47
Sample (adjusted): 1973 2010
Included observations: 38 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(RGDP2(-1))	-0.652877	0.201828	-3.234814	0.0027
C	-32.13918	25.53988	-1.258392	0.2166
@TREND(1971)	4.309990	1.420277	3.034611	0.0045
R-squared	0.254582	Mean dependent var		11.16106
Adjusted R-squared	0.211987	S.D. dependent var		81.99785
S.E. of regression	72.78959	Akaike info criterion		11.48868
Sum squared resid	185441.4	Schwarz criterion		11.61796
Log likelihood	-215.2849	Hannan-Quinn criter.		11.53468
F-statistic	5.976757	Durbin-Watson stat		1.614013
Prob(F-statistic)	0.005848			

Appendix 9

Augmented Dickey-Fuller Test Result on Real Gross Domestic Product Squared (at 2nd difference)

Null Hypothesis: D(RGDP,2) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-6.368284	0.0000
Test critical values: 1% level	-4.234972	
5% level	-3.540328	
10% level	-3.202445	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RGDP,3)
Method: Least Squares
Date: 02/27/14 Time: 03:43
Sample (adjusted): 1975 2010
Included observations: 36 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(RGDP(-1),2)	-1.674561	0.262953	-6.368284	0.0000
D(RGDP(-1),3)	0.551746	0.193248	2.855116	0.0075
C	-0.164403	0.363247	-0.452593	0.6539
@TREND(1971)	0.013010	0.015226	0.854455	0.3992
R-squared	0.593483	Mean dependent var		0.115628
Adjusted R-squared	0.555372	S.D. dependent var		1.421718
S.E. of regression	0.948007	Akaike info criterion		2.835530
Sum squared resid	28.75897	Schwarz criterion		3.011477
Log likelihood	-47.03954	Hannan-Quinn criter.		2.896940
F-statistic	15.57251	Durbin-Watson stat		1.726117
Prob(F-statistic)	0.000002			

Appendix 10

Augmented Dickey-Fuller Test Result on Population (at level)

Null Hypothesis: POP has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 0 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-1.705256	0.7299
Test critical values: 1% level	-4.211868	
5% level	-3.529758	
10% level	-3.196411	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(POP)

Method: Least Squares

Date: 02/25/14 Time: 22:40

Sample (adjusted): 1972 2010

Included observations: 39 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
POP(-1)	-0.091616	0.053726	-1.705256	0.0968
C	0.420132	0.181960	2.308927	0.0268
@TREND(1971)	0.014846	0.007789	1.905951	0.0647
R-squared	0.223058	Mean dependent var		0.142718
Adjusted R-squared	0.179895	S.D. dependent var		0.045594
S.E. of regression	0.041290	Akaike info criterion		3.462582
Sum squared resid	0.061376	Schwarz criterion		3.334615
Log likelihood	70.52034	Hannan-Quinn criter.		3.416669
F-statistic	5.167758	Durbin-Watson stat		1.950939
Prob(F-statistic)	0.010641			

Appendix 11

Augmented Dickey-Fuller Test Result on Population (at 1st difference)

Null Hypothesis: D(POP) has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 0 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-5.848353	0.0001
Test critical values: 1% level	-4.219126	
5% level	-3.533083	
10% level	-3.198312	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(POP,2)

Method: Least Squares

Date: 02/25/14 Time: 22:41

Sample (adjusted): 1973 2010

Included observations: 38 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(POP(-1))	-0.990992	0.169448	-5.848353	0.0000
C	0.109985	0.023648	4.650947	0.0000
@TREND(1971)	0.001576	0.000704	2.239604	0.0316
R-squared	0.494368	Mean dependent var		0.001203
Adjusted R-squared	0.465475	S.D. dependent var		0.059540
S.E. of regression	0.043531	Akaike info criterion		3.355048
Sum squared resid	0.066322	Schwarz criterion		3.225765
Log likelihood	66.74592	Hannan-Quinn criter.		3.309050
F-statistic	17.11017	Durbin-Watson stat		1.996006
Prob(F-statistic)	0.000007			

Appendix 12

Augmented Dickey-Fuller Test Result on Population (at 2nd difference)

Null Hypothesis: D(POP,2) has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 0 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-10.37774	0.0000
Test critical values: 1% level	-4.226815	
5% level	-3.536601	
10% level	-3.200320	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(POP,3)

Method: Least Squares

Date: 02/25/14 Time: 22:42

Sample (adjusted): 1974 2010

Included observations: 37 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
.D(POP(-1),2)	-1.519950	0.146463	-10.37774	0.0000
C	0.005426	0.019244	0.281939	0.7797
@TREND(1971)	-0.000166	0.000817	-0.202786	0.8405
R-squared	0.760053	Mean dependent var	0.000181	
Adjusted R-squared	0.745938	S.D. dependent var	0.105220	
S.E. of regression	0.053036	Akaike info criterion	2.958103	
Sum squared resid	0.095634	Schwarz criterion	2.827488	
Log likelihood	57.72491	Hannan-Quinn criter.	2.912056	
F-statistic	53.84898	Durbin-Watson stat	2.321252	
Prob(F-statistic)	0.000000			

Appendix 13

Augmented Dickey-Fuller Test Result on Population Squared (at level)

Null Hypothesis: POP2 has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 0 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-0.545983	0.9768
Test critical values: 1% level	-4.211868	
5% level	-3.529758	
10% level	-3.196411	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(POP2)

Method: Least Squares

Date: 03/05/14 Time: 11:08

Sample (adjusted): 1971 2009

Included observations: 39 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
POP2(-1)	-0.014404	0.026382	-0.545983	0.5884
C	73.20710	24.32000	3.010160	0.0047
@TREND(1970)	8.699719	4.934845	1.762916	0.0864
R-squared	0.569589	Mean dependent var	186.7607	
Adjusted R-squared	0.545677	S.D. dependent var	91.66412	
S.E. of regression	61.78479	Akaike info criterion	11.15899	
Sum squared resid	137425.0	Schwarz criterion	11.28696	
Log likelihood	-214.6004	Hannan-Quinn criter.	11.20491	
F-statistic	23.82050	Durbin-Watson stat	2.023914	
Prob(F-statistic)	0.000000			

Appendix 14

Augmented Dickey-Fuller Test Result on Population Squared (at 1st difference)

Null Hypothesis: D(POP2) has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 0 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-6.030972	0.0001
Test critical values: 1% level	-4.219126	
5% level	-3.533083	
10% level	-3.198312	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(POP2,2)

Method: Least Squares

Date: 03/05/14 Time: 11:09

Sample (adjusted): 1972 2009

Included observations: 38 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(POP2(-1))	-1.019398	0.169027	-6.030972	0.0000
C	65.55809	23.80525	2.753934	0.0093
@TREND(1970)	6.218524	1.389442	4.475555	0.0001
R-squared	0.509616	Mean dependent var	5.369932	
Adjusted R-squared	0.481594	S.D. dependent var	87.32098	
S.E. of regression	62.87145	Akaike info criterion	11.19572	
Sum squared resid	138348.7	Schwarz criterion	11.32500	
Log likelihood	-209.7186	Hannan-Quinn criter.	11.24172	
F-statistic	18.18634	Durbin-Watson stat	1.998355	
Prob(F-statistic)	0.000004			

Appendix 15

Augmented Dickey-Fuller Test Result on Population Squared (at 2nd difference)

Null Hypothesis: D(POP2,2) has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 0 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-10.43267	0.0000
Test critical values: 1% level	-4.226815	
5% level	-3.536601	
10% level	-3.200320	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(POP2,3)

Method: Least Squares

Date: 03/05/14 Time: 11:09

Sample (adjusted): 1973 2009

Included observations: 37 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(POP2(-1),2)	-1.523907	0.146071	-10.43267	0.0000
C	9.320296	28.15506	0.331035	0.7427
@TREND(1970)	-0.049183	1.194577	-0.041172	0.9674
R-squared	0.761973	Mean dependent var		0.283230
Adjusted R-squared	0.747971	S.D. dependent var		154.5396
S.E. of regression	77.58275	Akaike info criterion		11.61817
Sum squared resid	204648.8	Schwarz criterion		11.74879
Log likelihood	-211.9362	Hannan-Quinn criter.		11.66422
F-statistic	54.42033	Durbin-Watson stat		2.321709

Appendix 16

Initial Regression Results

Dependent Variable: EP
 Method: Least Squares
 Date: 03/05/14 Time: 11:13
 Sample: 1971 2010
 Included observations: 40

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.327302	0.341518	6.814579	0.0000
RGDP	0.068731	0.018850	3.646194	0.0009
RGDP^2	-0.001118	0.000240	-4.650490	0.0000
POP	-0.881438	0.170437	-5.171648	0.0000
POP^2	0.072669	0.013390	5.426965	0.0000
Mean dependent				
R-squared	0.571995	var		0.778794
Adjusted R-squared	0.523080	S.D. dependent var		0.113372
S.E. of regression	0.078294	Akaike info criterion		-2.140214
Sum squared resid	0.214550	Schwarz criterion		-1.929104
		Hannan-Quinn		
Log likelihood	47.80428	criter.		-2.063883
F-statistic	11.69367	Durbin-Watson stat		0.616733
Prob(F-statistic)	0.000004			

Appendix 17

Regression Results Corrected Autocorrelation

Dependent Variable: EP
 Method: Least Squares
 Date: 03/04/14 Time: 05:00
 Sample (adjusted): 1973 2010
 Included observations: 38 after adjustments
 Convergence achieved after 135 iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.635886	3.252792	-0.502917	0.6186
RGDP	0.058605	0.025902	2.262557	0.0308
RGDP^2	-0.000309	0.000330	-0.938056	0.3555
POP	0.451335	0.899256	0.501899	0.6193
POP^2	-0.046440	0.059675	-0.778201	0.4424
AR(1)	1.198375	0.183403	6.534118	0.0000
AR(2)	-0.277771	0.186362	-1.490490	0.1462
R-squared	0.880927	Mean dependent var	0.781735	
Adjusted R-squared	0.857881	S.D. dependent var	0.115476	
S.E. of regression	0.043533	Akaike info criterion	-3.265775	
Sum squared resid	0.058749	Schwarz criterion	-2.964114	
Log likelihood	69.04972	Hannan-Quinn criter.	-3.158446	
F-statistic	38.22408	Durbin-Watson stat	1.817976	
Prob(F-statistic)	0.000000			
Inverted AR Roots	.88	.31		

Appendix 18

Ramsey Regression Equation Specification Error Test

Ramsey RESET Test

Equation: EQ02

Specification: EP C RGDP RGDP^2 POP POP^2 AR(1) AR(2)

Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	1.561092	30	0.1290
F-statistic	2.437009	(1, 30)	0.1290
Likelihood ratio	2.967901	1	0.0849

F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	0.004414	1	0.004414
Restricted SSR	0.058749	31	0.001895
Unrestricted SSR	0.054335	30	0.001811
Unrestricted SSR	0.054335	30	0.001811

LR test summary:

	Value	df
Restricted LogL	69.04972	31
Unrestricted LogL	70.53367	30

Unrestricted Test Equation:

Dependent Variable: CO2

Date: 03/04/14 Time: 05:00

Sample: 1973 2010

Included observations: 38

Convergence achieved after 8 iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.270515	0.278748	0.970463	0.3396
RGDP	-0.029460	0.013223	-2.227961	0.0335
RGDP^2	0.000329	0.000185	1.777285	0.0857
POP	0.152007	0.133637	1.137467	0.2643
POP^2	-0.008067	0.010620	-0.759584	0.4534
FITTED^2	0.705988	0.068385	10.32369	0.0000
AR(1)	-0.199133	0.193880	-1.027093	0.3126
AR(2)	-0.096856	0.192816	-0.502323	0.6191
R-squared	0.889873	Mean dependent var		0.781735
Adjusted R-squared	0.864177	S.D. dependent var		0.115476
S.E. of regression	0.042558	Akaike info criterion		-3.291246
Sum squared resid	0.054335	Schwarz criterion		-2.946491
Log likelihood	70.53367	Hannan-Quinn criter.		-3.168585
F-statistic	34.63040	Durbin-Watson stat		1.750938
Prob(F-statistic)	0.000000			
Inverted AR Roots	-.10-.29i	-.10+.29i		

Appendix 19

Autoregressive Conditional Heteroskedasticity Test

Heteroskedasticity Test: ARCH

F-statistic	0.430786	Prob. F(3,31)	0.7324
Obs*R-squared	1.400719	Prob. Chi-Square(3)	0.7054

Test Equation:

Dependent Variable: RESID^2

Method: Least Squares

Date: 03/14/14 Time: 16:18

Sample (adjusted): 1976 2010

Included observations: 35 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.001647	0.000580	2.838068	0.0079
RESID^2(-1)	-0.140315	0.178312	-0.786904	0.4373
RESID^2(-2)	-0.030294	0.178574	-0.169645	0.8664
RESID^2(-3)	-0.116539	0.141890	-0.821335	0.4177
R-squared	0.040021	Mean dependent var	0.001243	-
Adjusted R-squared	-0.052881	S.D. dependent var	0.002274	-
S.E. of regression	0.002333	Akaike info criterion	9.175823	-
Sum squared resid	0.000169	Schwarz criterion	8.998069	-
Log likelihood	164.5769	Hannan-Quinn criter.	9.114462	-
F-statistic	0.430786	Durbin-Watson stat	2.070671	-
Prob(F-statistic)	0.732406			

Appendix 20

Chow Breakpoint Test

Chow Breakpoint Test: 2000

Null Hypothesis: No breaks at specified breakpoints

Equation Sample: 1973 2010

F-statistic	1.380943	Prob. F(7,24)	0.2584
Log likelihood ratio	12.86119	Prob. Chi-Square(7)	0.0756
Wald Statistic	19.80290	Prob. Chi-Square(7)	0.0060

Appendix 21

Johansen-Juselius Cointegration Test Result

Sample (adjusted): 1973 2010				
Included observations: 38 after adjustments				
Trend assumption: Linear deterministic trend				
Series: EP RGDP RGDP^2 POP POP^2				
Lags interval (in first differences): 1 to 1				
Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.722476	122.4431	69.81889	0
At most 1 *	0.624918	73.73291	47.85613	0
At most 2 *	0.536867	36.46974	29.79707	0.0073
At most 3	0.162568	7.219556	15.49471	0.5523
At most 4	0.012494	0.477768	3.841466	0.4894
Trace test indicates 3 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Appendix 22

Granger Causality Tests (with 3 Lags)

Pairwise Granger Causality Tests

Date: 03/04/14 Time: 05:11

Sample: 1971 2010

Lags: 3

Null Hypothesis:	Obs	F-Statistic	Prob.
RGDP does not Granger Cause EP	37	3.77596	0.0207
EP does not Granger Cause RGDP		2.23653	0.1044
RGDP^2 does not Granger Cause EP	37	4.50123	0.0101
EP does not Granger Cause RGDP^2		1.57475	0.2160
POP does not Granger Cause EP	37	3.11232	0.0409
EP does not Granger Cause POP		1.63626	0.2018
POP^2 does not Granger Cause EP	37	2.96021	0.0480
EP does not Granger Cause POP^2		1.51815	0.2300
RGDP^2 does not Granger Cause RGDP	37	4.83979	0.0073
RGDP does not Granger Cause RGDP^2		6.87454	0.0012
POP does not Granger Cause RGDP	37	1.03649	0.3906
RGDP does not Granger Cause POP		1.08788	0.3693
POP^2 does not Granger Cause RGDP	37	1.42252	0.2556
RGDP does not Granger Cause POP^2		0.70875	0.5544
POP does not Granger Cause RGDP^2	37	1.21440	0.3215
RGDP^2 does not Granger Cause POP		1.57219	0.2166
POP^2 does not Granger Cause RGDP^2	37	1.02381	0.3960
RGDP^2 does not Granger Cause POP^2		1.51936	0.2297
POP^2 does not Granger Cause POP	37	0.53373	0.6627
POP does not Granger Cause POP^2		0.65271	0.5875