Modelling the effect of climate change and globalisation on the manufacturing sector of Ghana

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20 February 2016

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Abstract

The double impact effect of climate change and economic globalisation on the manufacturing sector is examined in the research for the period 1961-2013 for Ghana using annual time series data. The augmented Dickey Fuller (ADF) and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test were used to examine the nature of the effect of shock to climate change and economic globalisation on the manufacturing sector. The ordinary Least Square (OLS) method was used to examine the effect of climate change and economic globalisation on the manufacturing sector. The Johansen framework was use to establish significant long run equilibrium relationship among the variables. The vector error correction model was to trace the reconciliation of the transitory deviation from the short run disequilibrium to long run equilibrium. The granger-predictability test results revealed evidence of bidirectional causality between climate change and manufacturing sector productivity and between economic globalisation and manufacturing sector productivity. The findings of the study indicate that reducing the effect of climate change and economic globalisation will not have negative effect on the productivity of the manufacturing sector. Future studies should examine the effect of structural change on climate change and economic globalisation on the manufacturing sector. In addition, other proxies of economic globalisation and climate change should be modelled.

Keywords: Carbon Emissions, Manufacturing Sector Productivity, Trade Openness
Jet Classification: Q54, Q56, Q57
Subject Area: Development Economics/ Environmental economics

1.1 Introduction

There has been an increase concern of the role of the climate change (increasing levels of carbon dioxide) and economic globalisation (operations of a business activities on a global scale) globalisation on manufacturing Sector in recent times by researchers in various fields such as development economics, environmental economics, geography, agricultural economics, and engineering (Dell et al., 2012; Tol, 2009; Stern, 2008; O'Brien & Leichenko, 2000). The two phenomena are ongoing and there is the need to continue to pay attention to them in order to develop appropriate mitigation measures.

The increased concern on the effect of climate change and globalisation on manufacturing Sector results from the fact that climate change is considered to have positive and deleterious effects on the economy (Kerry et al., 1999; Parry & Carter, 1998; Smith et al., 1998; Stix, 1996, Liverman, 1994) whereas economic globalisation (trade openness) is considered to have positive (winners), negative (losers), and mixed effect (neutral) on developed and developing economies (Tardanico & Rosenberg, 2000; Cook & Kirkpatrick, 1997; Dicken, 1997; Greider, 1997; Wood, 1994; Conroy & Glasmeier, 1993; Fischer, 1990).

Various factors (the nature of competition among firms, the nature of the production process, and technology and innovation) results in economic globalisation (Dicken, 1997; Greider, 1997; Boyer & Drache, 1996; Castells, 1996; Harrison, 1994; Stalk & Hout, 1990). In the case of climate change, various factors (anthropogenic greenhouse gas emissions) account for the change, whose effects are varied physically, socially, and economically.

Theoretically, and empirically, the effect of climate change and globalisation on the various sectors of the economy (agriculture, manufacture, and service) have been modelled using different modelling frameworks with various criticism in all economies (Acemoglu & Robinson, 2012; Dell et al., 2012; Kaminski, Kan & Fleischer, 2013; Deschênes & Greenstone, 2007; Mendelsohn & Dinar, 2003; Weber & Hauer, 2003; O'Brien & Leichenko, 2000).

The findings in the literature have been inconsistent. According to the Organisation for Economic Co-operation and Development (OECD) (2007) report, different manufacturing industries face different impact of globalisation and that traditional industries (eg. Textiles) are featured by a high degree of international openness than medium and high technology-based manufacturing industries. Firms that benefit from globalisation do so through various channels. For instance, Akpan and Atan (2015) examined the impact of globalisation on the Nigerian economy and report that globalization has some positive impact on the selected sectors (agriculture, Manufacture, and International trade) of the economy studied, although the magnitude and significance of these impacts varied from one sector to another.

Gatawa, Aliyu, and Musa (2013) report that globalization have significant negative effect on the output of the textile subsector of the manufacturing industry in Nigeria. Umaru, Hamidu, and Musa (2013) report that globalization has had positive impact on some sectors of the Nigerian economy such as agriculture sector, transportation sector, and communication sector, with significant negative impact on the petroleum sector, manufacturing sector, and solid minerals sector.

Firms in the manufacturing industries are able to outsource inputs and outputs of production as a result of globalisation (Corswant, 2002; Reyes, Raisinghani & Singh, 2002). Globalisation results in increased resource accessibility, enhance investment potential, enhance trade potential, increases market potential for the firms in the manufacturing sector (Jones, 2002; Shocker, Srivastava & Ruekert, 1994; Fawcett & Closs, 1993).

Globalisation, empirically has been identified to pose threats to firms in the manufacturing sector (Hafsi, 2002; Jones, 2002; Eng, 2001; Burgers, Hill & Kim, 1993; Fawcett & Closs, 1993) as a result of increased competition among the firms in the industry. Globalization in addition, affects human capital in the manufacturing sector and sector output, since various diseases are able to spread (Anthony, 2003; Meredith, 2003) among countries. The recent financial crisis (2000 and 1997) has affected the output of the manufacturing sector (Woo, 2000; McLean, 2001).

In summary the empirical findings on the effect of climate change and globalisation on the manufacturing sector are mixed. There is also limited current research works on the topic. Most works examine the effect of globalisation on the manufacturing sector and the effect of climate change on the manufacturing sector singly and not the effect of both phenomenon on the manufacturing sector (O'Brien & Leichenko, 2000).

The effect of climate change and economic globalisation is ongoing in all sectors of the economy, globally and locally and that the effects of climate change keeps on worsening, as well as poverty. According to World Bank (WB, February 6, 2015) report, the effect of climate change on poorer economies are severe than richer economies, since poorer people unlike richer people, do not have adequate resources to appropriately adapt to shocks from climate change. "As the impacts of climate change worsen, it will become harder to eliminate poverty", the report indicated.

The effect of climate change and economic globalisation on the manufacturing are both considered as important research area by researchers and policy makers with the quest for reducing poverty. However, there is no known empirical work in literature that examines the effect of the two phenomenon on the manufacturing sector simultaneously in the study area and very few works in the literature simultaneously focused the joint effect of the two event on other economies (O'Brien & Leichenko, 2000). O'Brien and Leichenko (2000) examined the effect of the two events on the agriculture sector of Mexico, and not on the manufacturing sector. The very few works identified did not focus on quantitative studies but on qualitative research (O'Brien & Leichenko 2000, OECD, 1997). The current paper examines the simultaneous effect of climate change (carbon emissions) and economic globalisation (trade openness) on the manufacturing sector (manufacturing value added).

The paper contributes to the theories of climate change and economic globalisation by providing answers to the research questions underlying the paper by modelling the effect of climate change and economic globalisation on manufacturing sector. The empirical findings provide information to policy makers on how to mitigate the effect of climate change and economic growth on manufacturing sector. The findings in addition serve as reference material.

The general objective of the paper is to contribute to the body of knowledge in the area of climate change and economic globalisation by empirical modelling the joint effect of climate change and economic globalisation on the manufacturing sector. The paper specifically assesses:

- The nature of shock to climate change, economic globalisation and the manufacturing sector.
- The nature of long run and short run relationship among climate change, economic globalisation and manufacturing sector.
- The nature of causality among climate change, economic globalisation and manufacturing sector, and why.

The paper provides answers to these questions. Answers are provided to these questions through the use of econometric analysis using the models of Ordinary Least Squares (OLS), Johansen Model, Vector Error Correction Model (VECM), and the Granger Predictability Test.

- What is the nature of shock to climate change, economic globalisation, and the manufacturing sector?
- How does climate change and economic globalisation both influence manufacturing sector in the long run and short run?
- What is the nature of causality among climate change, economic globalisation and the manufacturing sector?

The hypotheses tested are:

H1: Shock to climate change, economic globalisation and the manufacturing sector are permanent.

H1: There is significant long run relationship among climate change, economic globalisation and the manufacturing sector.

H2: There is significant short run relationship climate change, economic globalisation and manufacturing sector.

H3: There is significant Granger-Predictability link among climate change, economic globalisation and manufacturing sector

In modelling the simultaneous effect of climate change, and economic globalisation on the economy, the paper did not focus on all the sectors of the economy but on the manufacturing sector. Secondary data from official sources are used. Challenges of using secondary data (data massage, errors in variable) might affect the interpretation of the findings. In examining the unit root properties of the data, structural breaks were not considered. The rest of the paper considers the research methodology, empirical results; conclusions and recommendations.

2. Methodology

2.1 Research Design/Research format

The research paper is based on quantitative research design and time series modelling whereas the research format is causal study.

2.2 Population/Sampling method

The paper is based on annual time series data for Ghana for the period 1961-2012. This is the most up-to-date comprehensive time series data set for the modelling. The sample size for the paper is 52 which is an indication that the sample size is large (greater than 30).

2.3 Conceptual Framework

The current paper is in modelling the simultaneous effect of climate change and economic globalisation on the manufacturing sector is based on the concept of 'double exposure' as explained by O'Brien and Leichenko (2000). According to O'Brien and Leichenko (2000), the concept means, the sectors of the economy experience shocks from both climate change and economic globalisation at the same time, differently, creating loser and winners in the economy.

2.4 Econometric Model

The research is based on a trivariate model as specified in equation (1). The dependent variable is manufacturing sector productivity (MSP) (proxied by manufacturing value added, MVA) whereas the explanatory variables are climate change (proxied by carbon emissions, CE) and economic globalisation (EG) (proxied by trade openness, TO).

$$\ln MSP_t = a + b\ln CC_t + c\ln EG_t + e_t \quad (1)$$

2.5 Estimation Methods

The estimation methods for the current paper are: (1) Augmented Dickey-Fuller (1981) (ADF) and Kwiatkowski et al. (1992, KPSS) tests to examine whether shocks to climate change, economic globalisation, and manufacturing sector are permanent or transitory (specified as in equations); 2) The Ordinary Least Square method (OLS) which is used to examine the linear link among the variables in a log-linear form; (3) The Johansen Method, which is used to investigate the long run relationship among the variables; (4) The VECM, which is used to examine the short run link among the variables; (5) The Granger-Predictability test, used to examine the nature of causality among the variables.

The ADF test is based on the null assumption (H_0) that there is a unit root or the series are non-stationary in levels (shock is permanent). The alternative assumption (H_1) is that the series are stationary or there is no unit root in the series (shock is transitory).

The KPSS is a reversed test for unit root when the ADF is used and it is used as a confirmation of the stationarity properties of the series. The KPSS test is based on the null assumption (Ho) that the series variables under investigation are stationary (series are not unit root) against the alternative assumption (H1) that the series are not stationary (series are unit root).

There are two forms of Johansen method, the trace test and the eigenvalue test, with identical conclusions. The null assumption for the trace test is that the number of cointegration vectors is $r=r^*<k$, against the alternative assumption that $r=k$. Testing proceeds sequentially for $r^*=1, 2, 3, \ldots, T$. The first non-rejection of the null assumption is taken as an estimate of r. The null assumption for the "maximum eigenvalue" test is the same as that for the "trace" test but the alternative assumption is $r=r^*+1$ and, again, testing proceeds sequentially for $r^*=1, 2, 3, \ldots T$, with the first non-rejection used as an estimator for r.

The Granger-Predictability test aims at testing whether there is neutral causality, unidirectional causality or bidirectional causality among the variables (MVA, CE, and TO). For the purposes of the study Engel Granger (EG) causality test is used. According to the Granger (1986) if variables are integrated of order one and are cointegrated there is at least one form of causality such as unidirectional causality. The assumption underlying Granger-Predictability test is that, the variables under investigation should have significant long run relationship.

2.6 Diagnostic Methods

The estimated model in equation (1) is assessed for it goodness of fit using various diagnostic tests such as the R-Square (R^2), Joint significance test, J-B Normality test, Breusch-Godfred LM test, ARCH LM test, White Heteroskedasticity test, Ramsey RESET. The stability of the model is tested using the Cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals (CUSUMSQ). In the use of the two plots, CUSUM and CUSUMSQ, if the statistics stay within the critical bonds of 5% level of significance, the null hypothesis of all coefficients in the given regression are stable and cannot be rejected. The tests are shown in Table 1. The reset test for specification is based on the assumption of adequate specification; heteroskedasticity test is based on the null assumption of heteroskedasticity not present; test for normality of residual is based on null assumption that the errors are normally distributed; LM test for autocorrelation up to order 1 is based on the null assumption that there is no autocorrelation; test for ARCH of order 1 is based on the null assumption that no ARCH effect is present, and CUSUM test for parameter stability is based on the null assumption that there is no change in parameters estimated.

Table 1 Diagnostic Tests

Test Statistics	LM Version	F Version
A:Serial Correlation		
B:Functional Form		
C:Normality		
D:Heteroscedasticity		
A:Lagrange multiplier test of residual serial correlation B:Ramsey's RESET test using the square of the fitted values C:Based on a test of skewness and kurtosis of residuals D:Based on the regression of squared residuals on squared fitted values		

2.7 Data and Sources

Data for the estimation of the model are taken from World Development Indicators (WDI-2012). The study period is from 1970-2011. The data used are reported in Table 2.

Table 2 Data Description, Proxies and Sources

Data Description	Proxy	Source
Climate Change (CC)	Carbon Emissions	World Bank World Development Indicator (WDI)
Economic Globalisation (EG)	Trade Openness	World Bank World Development Indicator (WDI)
Manufacturing Sector Productivity (MSP)	Manufacturing Value Added	WorldBank WDI

3 Empirical Results

3.1Time Series Plot

The time series plot results are reported in figure 1 to figure 6. The figures indicate that the variables (CC, EG, and MSP) are non-stationary in levels (figure 1 to figure 3), however, the variables attained stationarity after first differenced (figure 4 to figure 6). The unit root properties are further examined scientifically using the ADF and the KPSS tests. The results are reported in Tables 1 to Table 4.

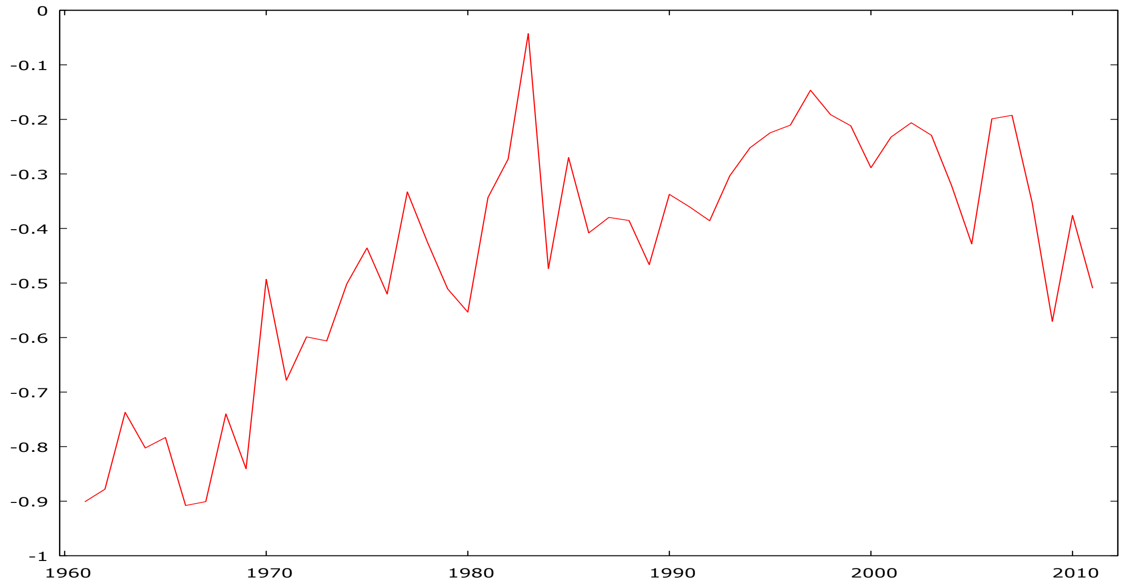

Figure 1. Time series Plot of lnCC in levels

Figure 2. Time series Plot of lnEG levels

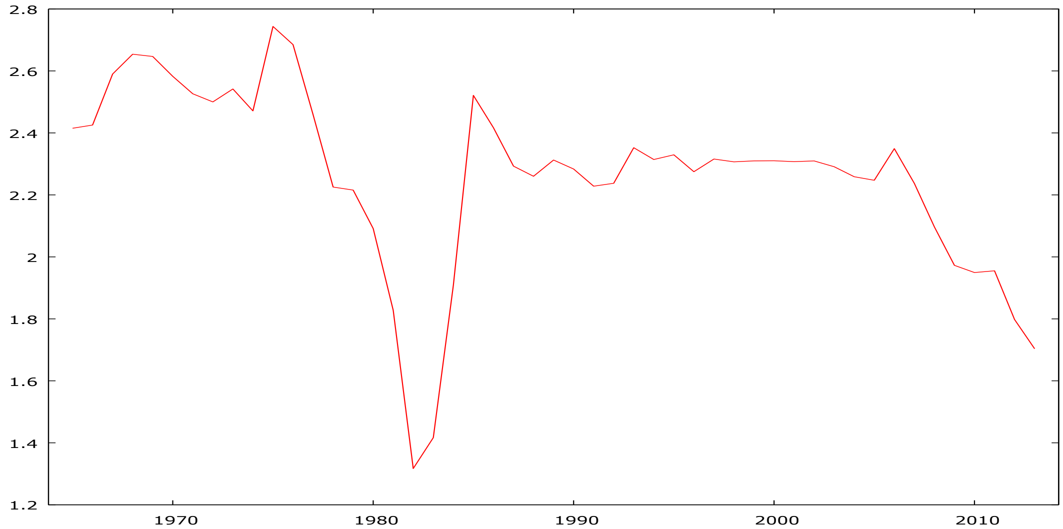

Figure 3. Time series Plot of MSP in levels

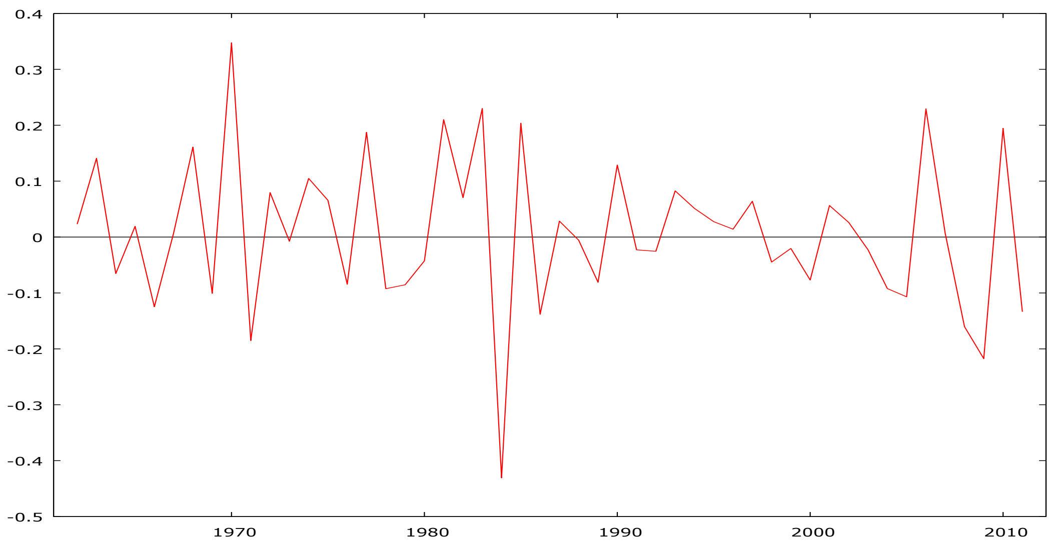

Figure 4. Time series Plot of lnCC in first difference

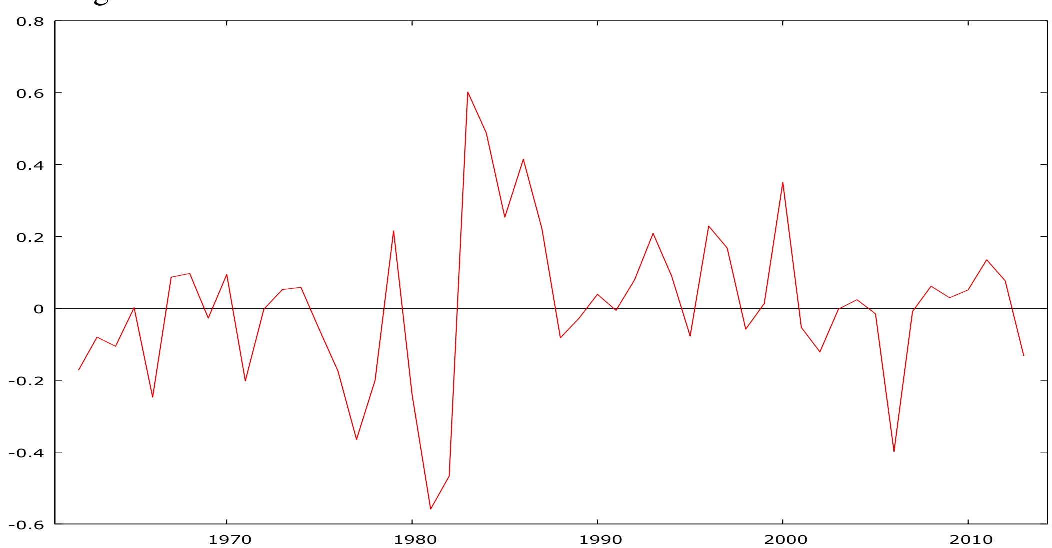

Figure 5. Time series Plot of lnEG in first difference

Figure 6. Time series Plot of lnMSP in first difference

3.2 The ADF/KPSS Test Results

Table 3 and Table 4 report of the ADF test results. The results indicate that the series are unit root in levels (Table 1), however, they attained stationarity after first differenced (Table 4). Table 5 and Table 6 report the results of the KPSS test results. The results indicate that the series are unit root in levels (Table 5), however, they attained stationarity after first differenced (Table 6). The findings show that shocks to climate change, economic globalisation, and manufacture sector productivity are permanent and not temporary.

Table 3 ADF Stationarity Test Results with a Constant and Trend

Variables	Coefficients	T-statistics	ADF/P-Value	Results	Max Lag length
lnCC	-0.2414	-1.7560	0.7260	Not Stationary	9
lnEG	-0.1310	-2.3792	0.3905	Not Stationary	9
lnMSP	-0.3247	-3.0904	0.1085	Not Stationary	9

Source: Author's computation, 2015

Table 4 ADF Stationarity Test Results with a Constant and a Time Trend

Variables(1st dif.)	Coefficients	t-statistics	ADF/P-Value	Results	Max Lag length
ΔlnCC	-1.4897	-11.4787	6.656e-015	Stationary	9
ΔlnEG	-0.8652	-5.2027	7.127e-005	Stationary	9
ΔlnMSP	-1.0195	-3.5778	0.0317	Stationary	9

Source: Author's computation, 2015: Note: *** denotes significance at 1% level

Table 5 KPSS Stationarity Test Results with a Constant and a Time Trend

Variables (levels)	T-statistics/P-value	Results	Max Lag length
lnCC	0.2676	Not Stationary	3
lnEG	0.2128(0.010)	Not Stationary	3
lnMSP	0.0981	Stationary	3

(Source: Author's computation, 2015): Critical values at 10% (0.122), 5% (0.149) and 1% (0.212) significant levels

Table 6 KPSS Stationarity Test Results with a Constant and a Time Trend

Variable (first diff.)	T-statistics	Results	Lag Length
ΔlnCC	0.0504	Stationary	3
ΔlnEG	0.0877	Stationary	3
ΔlnMSP	0.0595	Stationary	3

(Source: Author's computation, 2015): Critical values at 10% (0.122), 5% (0.149) and 1% (0.212) significant levels

3.3 OLS Regression Results

3.3.1 Parameter Estimates

The specified model in equation (1) was estimated using OLS. Table 7 shows the results. There is significant negative link between climate change and the manufacturing sector of Ghana. The results indicate that 1% increase in climate change leads to about 69.1% decrease in the productivity of the manufacturing sector.

The results indicate significant positive link between economic globalisation and manufacturing sector productivity. The results indicate that 1% increase in economic globalisation leads to about 19.4% increase in the productivity of the manufacturing sector.

The R^2 value of 0.3638 does not show that the estimated model performs well. The value indicates that economic globalisation and climate change jointly explains only about 36.4% changes in the manufacturing sector productivity.

Table 7. OLS Regression Results

Model 4: OLS, using observations 1965-2011 (T = 47): Dependent variable: lnMSP

Variables	Coefficient	Std. Error	t-ratio	p-value
const	1.263	0.2269	5.5637	<0.0000***
lnCC	-0.6905	0.1711	-4.0359	0.0002***
lnEG	0.1942	0.0530	3.6625	0.0007***

Mean dependent var	2.2825	S.D. dependent var	0.2810
Sum squared resid	2.3109	S.E. of regression	0.2291
R-squared	0.3638	Adjusted R-squared	0.3349
F(2, 44)	12.5813	P-value(F)	0.0000
Log-likelihood	4.1034	Akaike criterion	-2.2067
Schwarz criterion	3.3437	Hannan-Quinn	-0.1180
rho	0.7091	Durbin-Watson	0.6252

(Source: Author's Computation, February, 2016)

Note *** denotes significance at 1% and 5% levels

3.3.2 Diagnostic Test for OLS Test Results

The estimated model using the OLS test did not pass all the diagnostic test such as Reset test for specification (0.0003); heteroskedasticity (0.0021); LM test for autocorrelation up to order (1.56249e-007); ARCH of order 1 (0.0006); CUSUM test for parameter stability (1.51293e-006) except the normality test (0.261618). Since the estimated model did not pass all the diagnostic tests and the variables are unit root, the OLS results are not robust and as such the Johansen and the vector error correction models were used to examine the long run and short links (section 3.4).

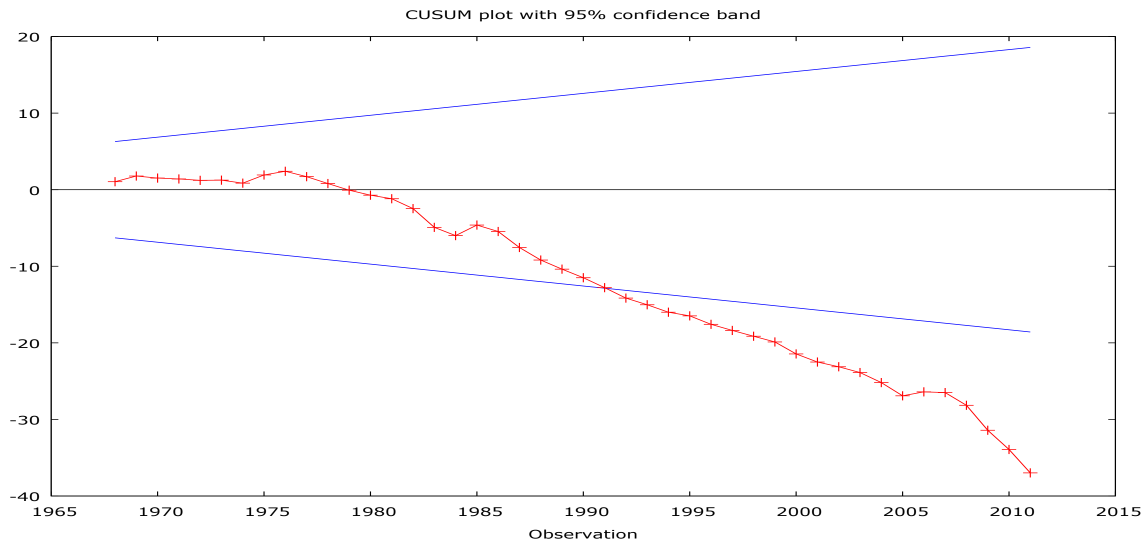

Figure 7. Plots of CUSUM

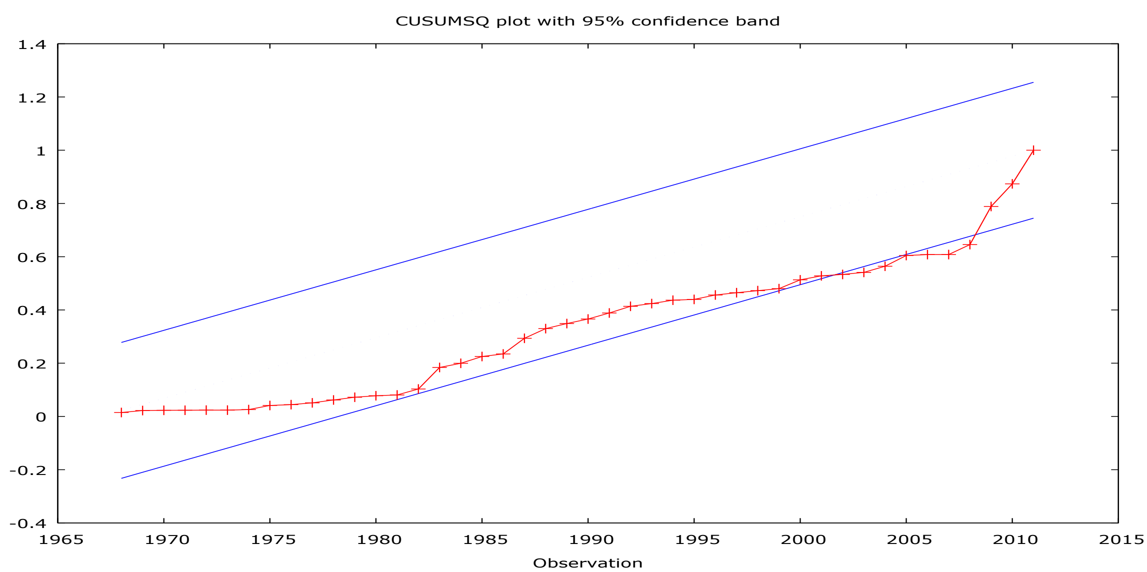

Figure 8. Plots of CUSUMSQ

3.4. Johansen Cointegration Test Results

3.4.1. Cointegration results with Manufacturing Sector Productivity as the Dependent Variable

The results of the long run cointegration link among climate change, economic globalisation, and manufacturing sector productivity with manufacturing sector productivity as the dependent variable are shown in Table 8. The results using both the Trace test statistics and Maximum Eigenvalue Test values indicate the rejection of the null hypothesis of no cointegration. The results show that there is at least one cointegration rank. The conclusion is that there is significant cointegration link among climate change, economic globalisation, and manufacturing sector productivity.

Table 8 Johansen Hypothesised Cointegration Results [Dependent variable= MSP]

Rank	Eigenvalue	Trace test P-value	Lmax test p-value
0	0.3964	31.9320[0.0273**]	21.2010 [0.0472**]
1	0.2111	10.7310[0.2325]	9.9571 [0.2191]
2	0.0183	0.7744[0.3789]	0.7744 [0.3789]

1. Null hypothesis r=0
2. Alternative hypothesis r=1

3. Null hypothesis r≤1
4. Alternative hypothesis r=2

λ_{Trace}=Tracy statistic; λ_{Max}= Maximum Eigen-value

The VAR estimation covered the period 1961-2013, It comprised two lags of each explanatory variable. A constant term entered into the unrestricted form. The null hypothesis is expressed in terms of cointegrating rank r.

Johansen test:
Number of equations = 3
Lag order = 5
Estimation period: 1970 - 2011 (T = 42)

Author's computation, 2016: Note **denotes significance at 5% level

3.5 The Vector Error Correction Model for Short Run Parameter Estimates (VECM)

Table 9 reports the results of the estimated error correction model (Short run dynamics). The error correction term (ECM) is significant at 5% level and has expected a priori theoretical sign of negative. The value of -0.2743 indicates a slower adjustment rate of about 27.43% from short run disequilibrium to long run equilibrium.

Table 9 Error Correction Results [Dependent var.=lnMSP]

Variable	Coefficient	Std Error	T-Ratio	P-Value
Cons	0.3994	0.1908	2.0929	0.0423**
ECM_{-1}	-0.2743	0.1113	-2.4638	0.0178**
ECM_{-1}	-0.2029	0.1486	-1.3654	0.1792

Mean dependent var	-0.0099	S.D. dependent var	0.1707
Sum squared resid	1.1493	S.E. of regression	0.1635
R-squared	0.1238	Adjusted R-squared	0.0830
rho	0.4608	Durbin-Watson	1.0775

Author's computation, 2016: Note ** denote significance at 5% level

3.6 Results of Granger-Predictability Test

Table 10 shows the results of the Granger-Predictability test. The test is based on the null assumption (Ho) that climate change and economic globalisation does not granger-predict manufacturing sector productivity and manufacturing sector productivity do not granger-predict climate change and economic globalisation. The alternative assumptions (H1) are that climate change and economic globalisation granger-predict manufacturing sector productivity and manufacturing sector productivity granger-predict climate change and economic globalisation. The results show that climate change and economic globalisation granger-predict manufacturing sector productivity with feedback. However, there is no significant granger-predictability link between climate change and economic globalisation. The results imply that reducing climate change and globalisation effects will not hamper manufacturing sector productivity.

Table 10 Granger-Predictability Test Results

Variables	Chi-square values	P-values	Decision
lnCE does not cause lnMPS	12.403	0.000***	Reject Ho
lnMPS does not cause lnCE	3.5039	0.061*	Reject Ho
lnEG does not cause lnMPS	3.1964	0.074*	Reject Ho
lnMPS does not cause lnEG	20.509	0.000***	Reject Ho
lnEG does not cause lnCE	1.0622	0.303	Accept Ho
lnCE does not cause lnEG	0.02158	0.883	Accept Ho

Authors computation, 2016: Note *** and * denote significance at 1% and 10% levels

3.7 Discussions of the Results

The findings of the study shows that shocks to Climate Change, Economic Globalisation, and Manufacturing Sector Productivity are permanent and not transitory. The findings on climate change (proxied by carbon emissions) are in support of the studies of previous studies (Christidou, 2013; Xu, 2012; Lee, 2009; Müller-Fürstenberger, 2004) that reported of significant permanent shock to carbon emissions and that carbon emissions do not have the tendency to revert to their past means. The finding of this study is inconsistent with previous works (Panopoulou & Pantelidis, 2009; Westerlund & Basher, 2007; Nguyen-Van, 2005) that found evidence of transitory effect of shock to carbon emissions. In relation to theoretical implications, the theories on unit root in time series are supported. Policy implications are that there are no gains in efficiency for the period under investigation since there has been a significant increase in industrial production during this period, and in addition, the policies to mitigate greenhouse effect are not effective.

The findings on economic globalisation (proxied by trade openness) is consistent with that of earlier research works (Habibi, 2015; Altaee, Saied & Adam, 2014; Kar, Nazlioğlu, & Ağir, 2014; Adhikary, 2012; Arif & Ahmad, 2012) that reported of permanent effect of shock to globalisation. Policies to ensure economic globalisation are not achieving the intended target.

The findings of permanent shock to the manufacturing sector productivity are in line with that of earlier works (Uddin, 2015; Bhattacharya & Narayan, 2013; Ilyas, Ahmad, Afzal & Mahmood, 2010; Ajaga & Nunnenkamp, 2008) that found evidence of non-transitory effect of shocks to the manufacturing sector. The findings are inconsistent with that of Guillaumont and Hua (2015) and Oyewale and Musiliu(2015) who reported that shock to manufacturing value added is transitory and not permanent. Policies to enhance productivity in the manufacturing sector are not yielding the intended purposes.

The studies show that in the OLS method, climate change have negative effect on manufacturing sector productivity which is in support of the studies of pervious researchers (Kumar & Yalew, 2012). The findings of the research indicates that, economic globalisation has positive effect on the productivity of the manufacturing sector which is in line with that of previous studies (Akpan & Atan, 2015; Corswant, 2002; Reyes, Raisinghani & Singh, 2002). However, the findings are not in agreement with that of Gatawa et al. (2013) and Umaru et al. (2013) who report that globalization have significant negative effect on the output of the manufacturing industry in Nigeria.

The findings of the Johansen cointegration test show that there is significant long run effect of climate change and economic globalisation on manufacturing sector productivity. In addition, the results of the research based on the error correction model indicate that there is significant short run effect of climate change and globalisation on manufacturing sector productivity. This supports the long run link among climate change, globalisation and manufacturing sector productivity.

The findings of the research indicate that both climate change, and economic globalisation predict manufacturing sector productivity with feedback. These means that current values of climate change and economic globalisation are useful in predicting the future values of manufacturing sector productivity and vice versa. The feedback hypothesis is supported in the current paper. The policy implication is that policies to reduce climate change and economic globalisation effects will not have deleterious effect on the manufacturing sector productivity.

4 Conclusions and Policy Implications

The double impact effect of climate change and economic globalisation on the manufacturing sector is examined in the current study. The ADF and KPSS test were used to examine the nature of the effect of shock to climate change and economic globalisation on the manufacturing sector. The Johansen framework was use to establish significant long run equilibrium relationship among the variables. The vector error correction model was to trace the reconciliation of the transitory deviation from the short run disequilibrium to long run equilibrium.

The significant long run link was supported by the short run stable link. The granger-predictability test results revealed evidence of bidirectional causality between climate change and manufacturing sector productivity and between economic globalisation and manufacturing sector productivity. However, there is no significant causality link between climate change and economic globalisation. The findings of the study indicate that reducing the effect of climate change and economic globalisation will not have negative effect of the productivity of the manufacturing sector.

Future studies should examine the effect of structural change on climate change and economic globalisation on the manufacturing sector. Other sectors of the economy such as the agricultural sector, the industry sector, and the service sector should be examined. In addition, other proxies of economic globalisation such as exchange rate regime, foreign direct investment (FDI) should be modelled. Other proxies of climate change such as temperature should be used as explanatory variable in further research.

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