Chapter 6

Export, Import, Economic Growth, and Carbon Emissions in Bangladesh: A Granger Causality Test under VAR (Restricted) Environment

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Additional information is available at the end of the chapter

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Abstract

Purpose: This paper examines the causal and cointegrating relationship between economic growth and CO_2 emissions in a multivariate framework by including imports and exports as others control variables for an emerging economy like Bangladesh.
Design/methodology: The paper applied vector error correction model (VECM) Granger casualty test for assessing the direction of causality and variance decomposition to explain the magnitude of the forecast error variance determined by the shocks to each of the explanatory variables over time. LB (Q-stat) test is to determine data properties and WILD test is to assess short run causality from independent variables to dependent variable.
Findings: The study results revealed that variables are integrated in the same order. The results of Johansen Juselius cointegration tests indicate that there is a unique long-term or equilibrium relationship among variables. Again, Granger causality test revealed that short run unidirectional causality are running from carbon dioxide emission to exports, GDP to import, and from import to carbon dioxide emissions. Variance decomposition function shows that the positive shocks in error term will produce positive effects on all variables in the long run. Therefore, a concerted effort from all national and international stakeholders, i.e., enterprises, consumers, and governments are expected to take measures to offset carbon emission and pursue environment-friendly trade plan for better managing the cities and regions in order to fight against global warming and climate change risk.

Keywords: GDP, exports, CO_2 emission, imports, VECM, climate change, carbon management

1. Introduction

Rise of global average temperatures and its impacts on climate change is now a burning issue. The Intergovernmental Panel on Climate Change (IPCC) often claimed that any given level of warming is associated with a range of cumulative CO_2 emissions. Scientists emphasize on climate targets, carbon budgets, and emission reductions pathways to meet the 2°C target. Evidence shows that industrial revolutions and trade liberalization afterwards have made excessive use of energy, (i.e., gas, coal, electricity, fossil fuels, etc.), infrastructures (i.e., road, buildings), which resulted in deforestation, aviation services, and other forms of transportation for making goods available in other countries through export & import and business trips worldwide, which has emitted thousand tons of carbon. In depth analysis perhaps will lead to the conclusion that all the dimensions of globalization somehow affect the natural environment. Globalization accelerates structural change, thereby altering the industrial structure of countries, and hence resource use and pollution levels increase [1]. It has been widely accepted that trade is the part of development of the modern economy and in the globalization era, trade is considered as the power of economic development. Moreover, globalization intensifies trade liberalization, and trade-related activities and trade activities effect on the environment when all goods and services produced in the economy directly and indirectly associated with uses of power and energy (various petroleum, oil, gas), which are obvious for all countries [1]. Therefore, intensive research is required in identifying causal relationship among international trade, economic development, and environmental pollution, so that countries can well articulate appropriate environmental policies without affecting economic growth. Countries having weak and inappropriate environmental regulations can attract more harmful trade negotiations. Copeland and Taylor [2] argued that under certain circumstances, the pollution-intensive industries migrated to countries having economic growth with weaker environmental regulation. The purpose of this study is to investigate the causal relationships between the export and import, CO_2 emissions and economic growth in Bangladesh for the period between 1972 and 2013; and examine the stability properties of the variables as a prerequisite for cointegration and error correction analyses. The questions this study seeks to answer are formulated as follows:

- Is there a (Granger) causal link between export-import and GDP?
- Is there a (Granger) causal link between GDP and CO_2 emissions? What is the direction of this causality?

The next sections of this study are organized as follows: section two focuses literature on climate change, carbon emissions, and their causal link with trade and economic growth; section three explains material and methods used in the study; section four shows findings of unit root test, cointegration test, vector error correction model (VECM) with impulse function; and finally based on findings, section five draws conclusion and recommendation for carbon cap and sustainable trade implication.

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2. Carbon emission: global warming & climate change

CO_2 emissions attract worldwide attention now-a-days as it is claimed that they are the main contributors to global warming, which are created mainly by burning fuels like petrol, organic-petrol, oil, natural gas, diesel, organic-diesel, and ethanol. While some say that global warming is resulting from a natural process like respiration and that there have always been greenhouse gases; however, it is frequently observed that the Industrial Revolution had a big part to play in the amount of atmospheric CO_2 being released. Live science produced detail reports about the causes of carbon emissions along with their remedy [3]. According to the 2010 Global Forest Resources Assessment, nearly a billion tons of carbon are being released to the atmosphere every year due to deforestation. More importantly, global warming, however, is resulting from atmospheric circulation, which influences rainfall patterns, plant and animal extinctions, ocean acidification, as well as, leads to big environmental and social changes, and challenges like extreme weather, rising sea levels, and unprecedented social upheaval for people all across the globe.

3. Drivers of carbon emissions and rational to study their causal dimension

Population and the size of the economy are two major drivers of absolute emissions. From the chart, we can see that the largest absolute emitters comprised 61% of global population and 75% of global GDP in 2012 [4]. The top 10 emitters produce around 70% of global emissions, based on historical emissions data from CAIT Climate Data Explorer (**Figure 1**).

Economic growth of countries impels an intensive use of energy, which results in growing CO_2 emissions, so pollution is directly linked with economic growth and development; such strong association induces researches over the decade to explore directional relations between them. Çakir and Başarir [5] find evidences of unidirectional causal relationship between the tourist arrivals and financial development. Their study also found a bidirectional causality relationship between CO_2 emission, financial development, and energy and tourist arrival. Attention toward exploring causal relationship between energy consumption, CO_2, and economic growth is dramatically increasing now-a-days, as global warming and climate change poses threats to all living beings in the planet. State governments' planning toward economic growth must consider the determinants of economic growth and potential contribution of such determinants toward the environments. Economic growth very often are achieved through rapid industrialization, increased trade in the forms of import & exports, growing urbanization, which contributed toward deforestation and resulted in global warming, climate change, and environmental degradation. Thereby, numerous studies conducted in many regions in the world attempted to investigate the causal link among CO_2 emissions, energy consumption, industrial development, and economic growth [6–20]. Most of the studies found either unidirectional or bidirectional relations and reaches to conclusions that the higher economic growth rates are very often associated with the

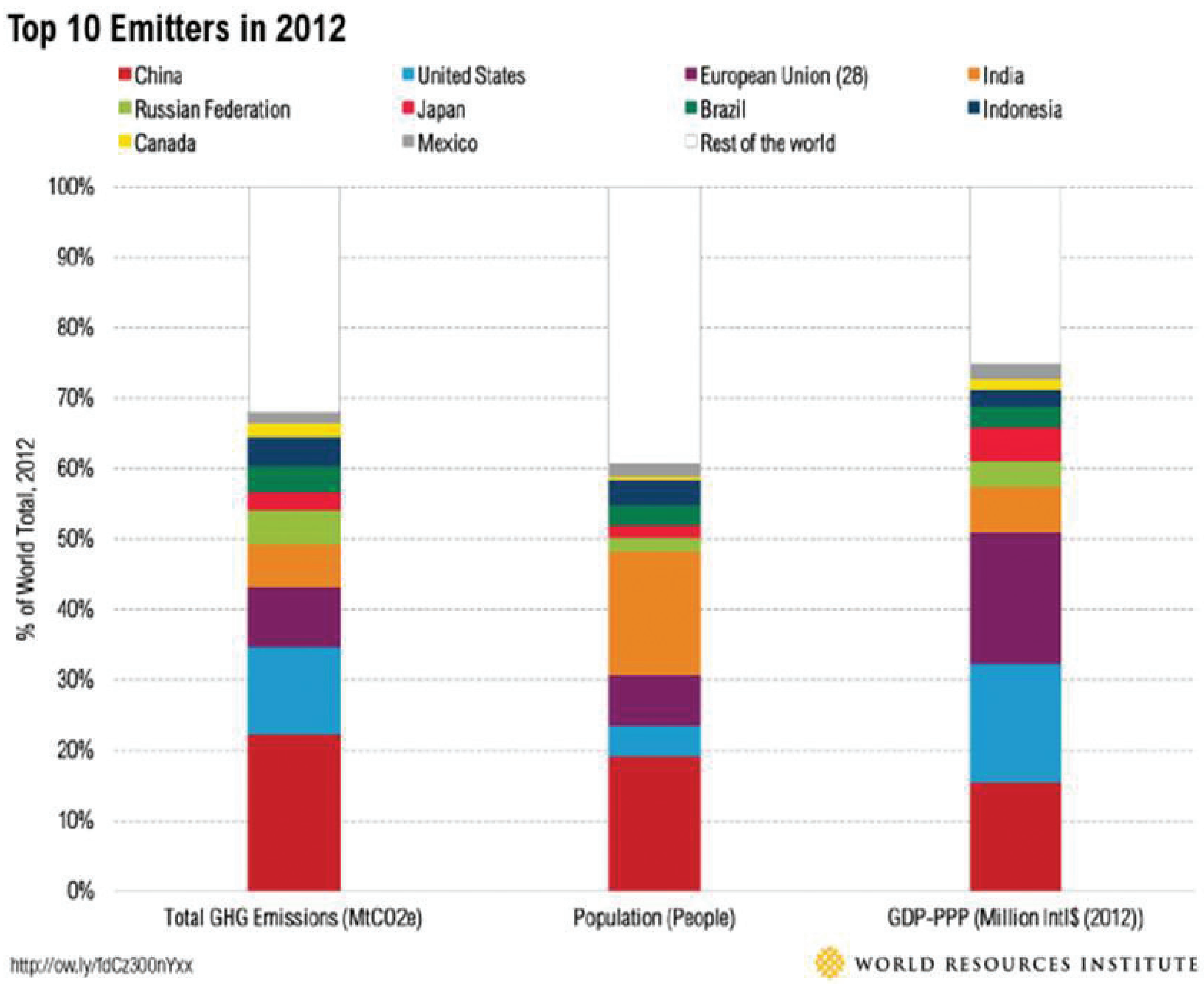

Figure 1. Top 10 emitters in 2012.

consumption of larger quantity of energy, which in turn has the impact on carbon dioxide emissions. There however, remains a confusion regarding whether energy consumption is a stimulating factor for or a result of economic growth. Therefore, a renewed interest in examining the relationship between these variables are still required for improved policy initiative and adaptation of appropriate and efficient technology to fight against global warming in order to mitigate climate change effects.

Although small developing and underdeveloped economies are not the major CO_2 emitter; however, consequences of global warming will affect everyone. Moreover, the global emissions profile has been changing due to international pressure of carbon budget (**Figure 2**) and carbon tax. In response to building decarbonized economy, developed countries are more capable in adopting innovative and efficient technologies to reduce the effect of global warming. Kelly Levin reported that in 1990, 66% of global emissions came from developed countries; while in 2013, that figure had dropped to 38% (i.e., EU set example by reducing 5.9% emission during

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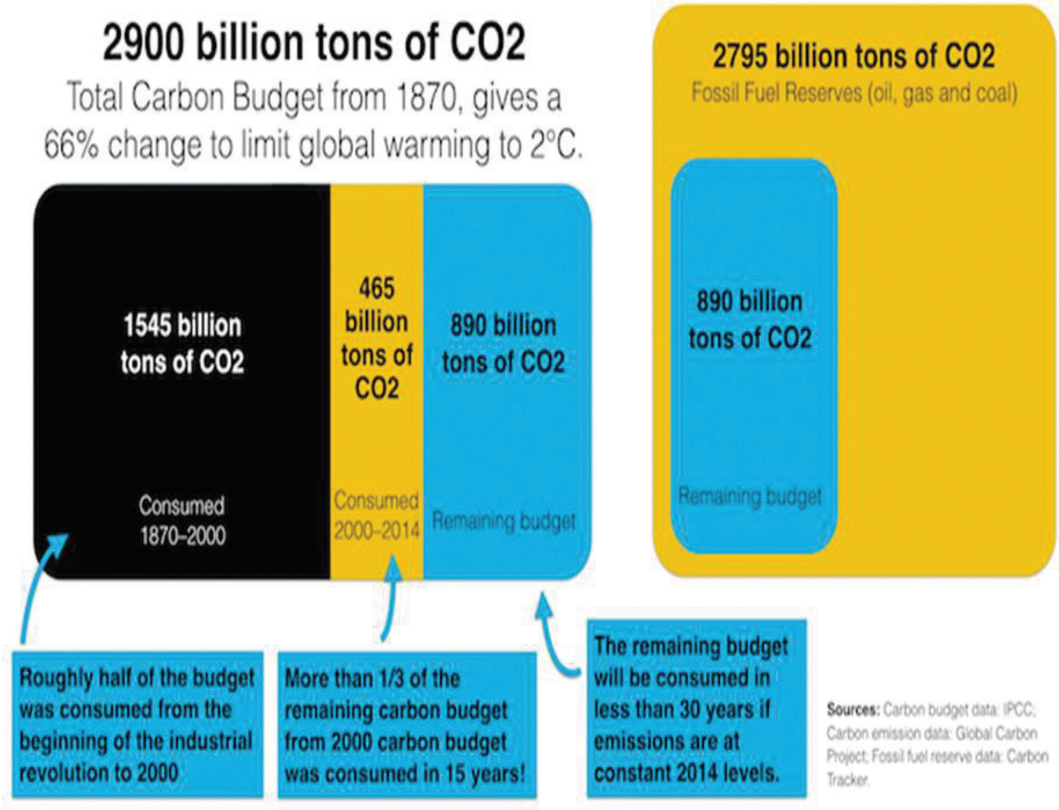

Figure 2. Carbon budget.

2013–2014) [21]. Therefore, identifying the casual relations among CO_2 and economic growth dynamics may help to develop appropriate carbon management plan for sustainable economic growth (**Figure 2**).

4. Material and methods

Vector autoregression (VAR)-based Granger causality test is employed in order to determine the causal link between the chosen variables. The data for the study are of the time series form and were collected from several reliable sources. Data related to the exports and imports of Bangladesh, have been collected from the Bangladesh Bureau of Statistics (BBS) (www.bbs.gov.bd). Economic growth has been used as a proxy of real GDP, which has been collected from the database of world Bank (http://data.worldbank.org/country/bangladesh) and data related to the environmental pollution, especially carbon (CO_2) emissions, have been collected from the Carbon Dioxide Information Analysis Center (CDIAC) (www.cdiac.ornl.gov). Data have been measured for 41 years, which were covered from 1972 to 2013 time periods. Data from 2013 onward were intentionally avoided as the climate change action plans were mostly designed before 2013 but not being pursued rigorously within that time period. Summary of descriptive statistics are given in **Table 1**.

	CO_2	Export	GDP	Import
Mean	25772.48	90.30788	4.96E + 10	103.2684
Median	23422.96	60.65112	4.38E + 10	77.25993
Maximum	57069.52	382.5200	9.93E + 10	407.6765
Minimum	7638.361	11.32173	2.32E + 10	25.89463
Std. Dev.	15577.69	94.08567	2.21E + 10	94.09631
Skewness	0.649886	1.478441	0.743401	1.657838
Kurtosis	2.185320	4.589869	2.432816	5.169804
Jarque-Bera	3.137481	15.02778	3.376373	20.93568
Probability	0.208307	0.000545	0.184854	0.000028
Sum	824719.3	2889.852	1.59E + 12	3304.589
Sum Sq. Dev.	7.52E + 09	274415.5	1.51E + 22	274477.6

Table 1. Descriptive statistics of dependent and independent variables.

The model intends to establish the relationship among export, import, GDP, and CO_2 emissions of Bangladesh where it can be expressed in the following basic multivariate model.

$$Y_t = \alpha + \beta\, Exp_t + \beta\, \mathrm{Im}\, p_t + +\beta GDP_t + \varepsilon_t \tag{1}$$

where Y_t is total carbon emissions, Exp_t is export, Imp_t is import, and GDP_t is real gross domestic product t, and ε_t is white noise. Logarithmic transformation of the above equation and inclusion of a trend variable would leave the basic equation as follows

$$LY_t = \alpha_0 + \alpha_1 t + \beta\, Exp_t + \beta\, \mathrm{Im}\, p_t + \beta GDP_t + \varepsilon_t \tag{2}$$

where, t is the trend variable.

In this study, Granger causality test will be used in order to test the hypothesis regarding the presence and direction of causality among carbon emissions, export, import, and economic growth.

A stationary time series refers to the series with a constant mean, constant variance, and constant auto covariance for each given lag [22]. The use of nonstationary data usually leads to spurious regressions. Thus, there is a need to conduct a unit root test to determine the order of integration of the variables using the Augmented Dickey Fuller test Dickey and Fuller [23]. The Augmented Dickey Fuller regression

$$\Delta Y_t = \alpha_0 + \gamma Y_{t-1} + \Sigma\, \beta_i \Delta Y_{t-I} + U_t \tag{3}$$

where $\Delta Y_t = Y_t - Y_{t-1}$ is the difference of series Y_t.

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α_0, γ, β_i, are parameters to be estimated and Ut is a stochastic error term. The null hypothesis of nonstationarity (presence of unit root) is accepted if $\gamma = 0$, while the null hypothesis of nonstationarity is rejected if $\gamma < 0$. This implies that if H_0 cannot be rejected, then the series has a unit root but if otherwise, then the series does not have a unit root.

The Granger method in this study involves the estimation of the following equations:

$$LY_t = \beta_0 + \sum_{i=1}^{q} \beta_{1i} LY_{t-i} + \sum_{i=1}^{q} \beta_{2i} LExp_{t-i} + \sum_{i=1}^{q} \beta_{2i} L\,\mathrm{Im}\,p_{t-i} + \sum_{i=1}^{q} \beta_{2i} LGDP_{t-i} + \varepsilon_{1t} \quad (4)$$

$$LGDP_t = \beta_0 + \sum_{i=1}^{q} \beta_{1i} LY_{t-i} + \sum_{i=1}^{q} \beta_{2i} LExp_{t-i} + \sum_{i=1}^{q} \beta_{2i} L\,\mathrm{Im}\,p_{t-i} + \sum_{i=1}^{q} \beta_{2i} LGDP_{t-i} + \varepsilon_{1t} \quad (5)$$

$$LExp_t = \beta_0 + \sum_{i=1}^{q} \beta_{1i} LY_{t-i} + \sum_{i=1}^{q} \beta_{2i} LExp_{t-i} + \sum_{i=1}^{q} \beta_{2i} L\,\mathrm{Im}\,p_{t-i} + \sum_{i=1}^{q} \beta_{2i} LGDP_{t-i} + \varepsilon_{1t} \quad (6)$$

$$L\,\mathrm{Im}\,p_t = \beta_0 + \sum_{i=1}^{q} \beta_{1i} LY_{t-i} + \sum_{i=1}^{q} \beta_{2i} LExp_{t-i} + \sum_{i=1}^{q} \beta_{2i} L\,\mathrm{Im}\,p_{t-i} + \sum_{i=1}^{q} \beta_{2i} LGDP_{t-i} + \varepsilon_{1t} \quad (7)$$

5. Result of the analysis

5.1. Correlogram test

Analysis of inherent properties of variables is imperative in time series analysis under different models. In order to determine the nature of data, we use Correlogram test. From **Table 2**, it is obvious that variables are nonstationary at level but after first differentiation, variables become stationary, which is considered as a predominant condition for a number of time series analysis model.

Selection of optimal Lag is inevitable for time series analysis when data are nonstationary at level and stationary after first difference. We chose Akaike information criterion (AIC) Model for Lag selection and the results have been shown in **Table 3**.

Variables	**At level (Ljung-Box)**			**First difference (Ljung-Box)**		
	Q-stat	**P-value**	**Decision**	**Q-stat**	**P-value**	**Decision**
GDP	111.87	0.000	Nonstationary	92.895	0.1525	Stationary
CO_2	108.54	0.000	Nonstationary	17.053	0.382	Stationary
Import	65.321	0.000	Nonstationary	10.551	0.394	Stationary
Export	72.926	0.000	Nonstationary	12.672	0.243	Stationary

Table 2. Results of LB (Q-statistics).

Lag	LogL	LR	FPE	AIC	SC	HQ
0	−1123.406	NA	2.18e + 31	83.51152	83.70350	83.56861
1	−994.0011	210.8814	4.99e + 27	75.11119	76.07107*	75.39661
2	−982.4785	15.36339	7.59e + 27	75.44285	77.17064	75.95661
3	−956.7385	26.69334*	4.70e + 27	74.72137	77.21706	75.46347
4	−929.5737	20.12210	3.53e + 27	73.89435	77.15794	74.86478
5	−893.2059	16.16348	2.61e + 27*	**72.38562***	76.41711	73.58439*

*indicates lag order selected by the criterion.
LR, sequential modified LR test statistic (each test at 5% level); FPE, final prediction error; AIC, Akaike information criterion; SC, Schwarz information criterion; HQ, Hannan-Quinn information criterion.

Table 3. Lag selection models outcome.

5.2. Unit root test

Summary results of different unit root tests (**Table 4**) reveal that at level, all methods of P-value is significantly higher than 5%, so we cannot reject the null hypothesis rather we accept that there is a unit root that means that data are nonstationary at level. After first difference of unit root test, results show that P-value of each method is lower than 5% of critical value, which means that we can reject null hypothesis, rather we can accept alternative hypothesis which means that data are stationary at first difference.

Unit root test conforms that after first difference, data become stationary such that nature of time series data motivates to go for testing cointegration among variables.

5.3. Cointegration analysis

There is a need for cointegration test in order to examine whether there is a long-term equilibrium among LnCO_2, LnGDP, LnExport, and LnImport. Johansen Juselius's cointegration test is

Null: unit root (assumes common unit root process)				
	At level		**First difference**	
	Statistic	**P value**	**Statistic**	**P value**
Levin, Lin, & Chu t*	1.50156	0.9334	−7.77291	0.0000*
Null: unit root (assumes individual unit root process)				
Im, Pesaran, and Shin W-stat	3.57258	0.9998	−10.2802	0.0000*
ADF–Fisher Chi-square	0.42572	0.9999	91.0505	0.0000*
PP–Fisher Chi-square	1.64834	0.9900	154.096	0.0000*

*Null hypothesis is rejected at 5%.

Table 4. Summary of units root test results.

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Hypothesized no. of CE(s)	Eigenvalue	Trace statistic	0.05 critical value	Prob.**
None*	0.604939	51.51861	47.85613	0.0218
At most 1	0.250739	17.15617	29.79707	0.6285
At most 2	0.160272	6.475462	15.49471	0.6393
At most 3	0.000335	0.012396	3.841466	0.9111

Trace test indicates one cointegratingeqn(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)

Hypothesized no. of CE(s)	Eigenvalue	Max-eigen statistic	0.05 critical value	Prob.**
None*	0.604939	34.36244	27.58434	0.0058
At most 1	0.250739	10.68070	21.13162	0.6791
At most 2	0.160272	6.463066	14.26460	0.5545
At most 3	0.000335	0.012396	3.841466	0.9111

Max-eigenvalue test indicates 1 cointegratingeqn(s) at the 0.05 level.*denotes rejection of the hypothesis at the 0.05 level.
**MacKinnon-Haug-Michelis (1999) p-values.

Table 5. Johansen-Juselius cointegration tests results.

used because data satisfy two important criteria such as data are stationary at level and integrated at same level, which means that after first difference data become stationary (**Table 5**).

The results from JJ cointegration tests indicate that there is a unique long-term or equilibrium relationship between variables. Both trace statistics and λ-max statistics show that there exists one cointegrating vectors at 5% significance level (**Table 6**).

So, long run cointegration can be developed under VAR (restricted) environment.

$$LY_t = 1.695 - \sum_{i=1}^{q} 16.595LExp_{t-i} + \sum_{i=1}^{q} 41.364L\,\mathrm{Im}\,p_{t-i} - \sum_{i=1}^{q} 23.389LGDP_{t-i} + \varepsilon_{1t} \quad (8)$$

	Coefficient	Standard error	t-statistics
Imports(−1)	41.36380	(2.14208)	[−19.3101]
Exports(−1)	−16.59512	(1.39595)	[11.8881]
GDP(−1)	−23.38893	(1.09083)	[21.4415]
Intercept	1.649468		

Table 6. Long run cointegration equation coefficient under VECM.

Null hypothesis	Obs	F-Stat	Prob.	Outcome
DGDP does not Granger cause DCO_2	35	2.25	0.0844	Does not Granger cause
DCO_2 does not Granger cause DGDP		1.99	0.1192	Does not Granger cause
DEXPORTS does not Granger cause DCO_2		0.88	0.5062	Does not Granger cause
DCO_2 does not Granger cause DEXPORTS		2.89	0.0373*	CO_2 emission Granger cause exports
DIMPORTS does not Granger cause DCO_2		2.75	0.0445*	Imports Granger cause CO_2
DCO_2 does not Granger cause DIMPORTS		0.93	0.4800	Does not Granger cause
DEXPORTS does not Granger cause DGDP		2.21	0.0894	Does not Granger cause
DGDP does not Granger cause DEXPORTS		1.40	0.2623	Does not Granger cause
DIMPORTS does not Granger cause DGDP		1.73	0.1674	Does not Granger cause
DGDP does not Granger cause DIMPORTS		5.35	0.0023*	GDP ganger cause imports
DIMPORTS does not Granger cause DEXPORTS		0.67	0.6464	Does not Granger cause
DEXPORTS does not Granger cause DIMPORTS		1.12	0.3770	Does not Granger cause

Table 7. Pairwise Granger causality tests.

5.4. Granger causality test

Test of cointegration conformed that there is a long run association among variables, which means that in long run variables move together. But still there is a scope to establish directional relationship among variables. The result of Granger causality test on $LnCO_2$, LnIm, LnEx, and Ln GDP is illustrated in **Table 7**.

The findings indicate that short run unidirectional causality running from carbon dioxide emission to exports, import to CO_2, and GDP to import in Bangladesh. Although previous studies in Malaysia [24, 25] found that an increase in economic growth causes an increase in CO_2 emission. In this study, GDP has been used as a proxy of economic growth. Bangladesh is mainly characterized as a rural-based poor economy, which is moving toward rapid urbanization through industrialization and deforestation, which increases CO_2. Industrialization ultimately will lead to export and import along with CO_2 emission. Thus, the Granger causality results are very relevant with this situation. However, as economic growth Granger causes imports, there is enough scope to purchase more carbon offset, i.e., innovative source of renewable energy and sustainable technology which, in the long run, can intensify more sustainable economic growth of the country.

5.5. Vector error correction model

Since, it is obvious from cointegration test that variables are cointegrated, a valid error correction model should also exist among variables. We, therefore, priced to test VECM to establish long run relations between dependent and independent variables. **Table 8** shows model results under restricted vector autoregressive (VAR), it is revealed from VEC Model that there is a long run causality from imports, exports, and GDP to CO_2.

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$$
\begin{aligned}
D(CO_2) = {} & C(1)^*(CO_2(-1) - 41.3637963874^*IMPORTS(-1) + 16.5951217241^*EXPORTS(-1) \\
& + 23.3889289266^*GDP(-1) - 1.64946834684) + C(2)^*D(CO_2(-1)) \\
& + C(3)^*D(CO_2(-2)) + C(4)^*D(CO_2(-3)) + C(5)^*D(CO_2(-4)) + C(6)^*D(CO_2(-5)) \\
& + C(7)^*D(IMPORTS(-1)) + C(8)^*D(IMPORTS(-2)) + C(9)^*D(IMPORTS(-3)) \\
& + C(10)^*D(IMPORTS(-4)) + C(11)^*D(IMPORTS(-5)) + C(12)^*D(EXPORTS(-1)) \\
& + C(13)^*D(EXPORTS(-2)) + C(14)^*D(EXPORTS(-3)) + C(15)^*D(EXPORTS(-4)) \\
& + C(16)^*D(EXPORTS(-5)) + C(17)^*D(GDP(-1)) + C(18)^*D(GDP(-2)) \\
& + C(19)^*D(GDP(-3)) + C(20)^*D(GDP(-4)) + C(21)^*D(GDP(-5)) + C(22) \qquad (9)
\end{aligned}
$$

CointegratingEq:	**CointEq1**			
$CO_2(-1)$	1.000000			
IMPORTS(−1)	−41.36380			
	(2.14208)			
	[−19.3101]			
EXPORTS(−1)	16.59512			
	(1.39595)			
	[11.8881]			
GDP(−1)	23.38893			
	(1.09083)			
	[21.4415]			
C	−1.649468			
Error correction	$D(CO_2)$	D(IMPORTS)	D(EXPORTS)	D(GDP)
CointEq1	−0.005225	−0.002942	0.052260	−0.010698
	(0.00500)	(0.01568)	(0.01117)	(0.00797)
	[−1.04416]	[−0.18767]	[4.67733]	[−1.34169]
$D(CO_2(-1))$	−0.333024	−0.192240	0.654389	−0.403684
	(0.27644)	(0.86621)	(0.61728)	(0.44053)
	[−1.20468]	[−0.22193]	[1.06011]	[−0.91636]
$D(CO_2(-2))$	−0.631720	−0.546011	−0.256822	0.235995
	(0.24304)	(0.76156)	(0.54270)	(0.38730)
	[−2.59924]	[−0.71697]	[−0.47323]	[0.60933]
$D(CO_2(-3))$	0.063992	0.634957	−9.58E-05	0.033521
	(0.22272)	(0.69789)	(0.49733)	(0.35492)
	[0.28732]	[0.90983]	[−0.00019]	[0.09445]
$D(CO_2(-4))$	−0.441036	−0.367313	−0.139453	0.023142
	(0.20042)	(0.62802)	(0.44754)	(0.31939)
	[−2.20051]	[−0.58488]	[−0.31160]	[0.07246]

CointegratingEq:	CointEq1			
D(CO_2(−5))	−0.561520	−0.748745	0.086342	−2.54E-05
	(0.21334)	(0.66848)	(0.47637)	(0.33997)
	[−2.63209]	[−1.12007]	[0.18125]	[−7.5e-05]
D(IMPORTS(−1))	−0.390623	−0.590689	1.291104	−0.307429
	(0.21073)	(0.66032)	(0.47056)	(0.33582)
	[−1.85365]	[−0.89455]	[2.74378]	[−0.91546]
D(IMPORTS(−2))	0.008323	−0.087034	1.322422	−0.304978
	(0.18439)	(0.57778)	(0.41174)	(0.29384)
	[0.04514]	[−0.15064]	[3.21180]	[−1.03789]
D(IMPORTS(−3))	−0.375320	−0.405511	0.899360	−0.169091
	(0.16273)	(0.50991)	(0.36337)	(0.25932)
	[−2.30640]	[−0.79526]	[2.47505]	[−0.65205]
D(IMPORTS(−4))	−0.285832	−0.224405	0.358266	−0.398754
	(0.12840)	(0.40234)	(0.28671)	(0.20462)
	[−2.22609]	[−0.55775]	[1.24956]	[−1.94878]
D(IMPORTS(−5))	−0.077385	−0.013157	0.454985	−0.096369
	(0.12027)	(0.37687)	(0.26856)	(0.19166)
	[−0.64342]	[−0.03491]	[1.69414]	[−0.50280]
D(EXPORTS(−1))	0.287169	0.454061	−1.545865	0.345068
	(0.16100)	(0.50449)	(0.35951)	(0.25657)
	[1.78366]	[0.90005]	[−4.29996]	[1.34494]
D(EXPORTS(−2))	0.327490	0.647337	−1.238350	0.423040
	(0.16489)	(0.51669)	(0.36820)	(0.26277)
	[1.98607]	[1.25286]	[−3.36324]	[1.60992]
D(EXPORTS(−3))	0.175561	0.225170	−1.137877	0.208423
	(0.13838)	(0.43361)	(0.30900)	(0.22052)
	[1.26868]	[0.51929]	[−3.68245]	[0.94513]
D(EXPORTS(−4))	0.215072	0.343157	−0.751545	0.156784
	(0.12514)	(0.39212)	(0.27943)	(0.19942)
	[1.71864]	[0.87513]	[−2.68952]	[0.78619]
D(EXPORTS(−5))	0.203798	0.280932	−0.300601	0.056137
	(0.07676)	(0.24052)	(0.17140)	(0.12232)
	[2.65503]	[1.16802]	[−1.75380]	[0.45893]
D(GDP(−1))	0.288925	1.072414	1.583191	0.486659
	(0.21698)	(0.67988)	(0.48450)	(0.34577)
	[1.33160]	[1.57735]	[3.26768]	[1.40747]

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CointegratingEq:	CointEq1			
D(GDP(−2))	−0.138598	−0.856794	0.180661	−0.419163
	(0.10763)	(0.33725)	(0.24033)	(0.17151)
	[−1.28775]	[−2.54056]	[0.75173]	[−2.44391]
D(GDP(−3))	−0.142222	0.081684	0.460852	0.190960
	(0.13090)	(0.41016)	(0.29229)	(0.20860)
	[−1.08651]	[0.19915]	[1.57669]	[0.91545]
D(GDP(−4))	0.124918	−0.213654	0.189876	−0.130303
	(0.10923)	(0.34228)	(0.24391)	(0.17407)
	[1.14359]	[−0.62421]	[0.77846]	[−0.74856]
D(GDP(−5))	−0.016156	0.163734	0.313926	0.277035
	(0.13590)	(0.42584)	(0.30347)	(0.21657)
	[−0.11888]	[0.38449]	[1.03447]	[1.27918]
C	0.069315	0.022427	0.025685	0.012545
	(0.01856)	(0.05815)	(0.04144)	(0.02957)
	[3.73519]	[0.38569]	[0.61985]	[0.42422]
Model summary under vector error correction model				
R-squared	0.868595	0.778007	0.913920	0.811754
Adj. R-squared	0.617731	0.354202	0.749586	0.452375
Sum sq. resids	0.002522	0.024761	0.012575	0.006404
S.E. equation	0.015141	0.047445	0.033810	0.024129
F-statistic	3.462414	1.835766	5.561356	2.258767
Log likelihood	109.5826	71.89211	83.07273	94.20507
Akaike AIC	−5.308035	−3.023764	−3.701378	−4.376065
Schwarz SC	−4.310363	−2.026092	−2.703706	−3.378393
Mean dependent	0.030335	0.040099	0.043490	0.032667
S.D. dependent	0.024490	0.059040	0.067565	0.032606

Table 8. Results of VECM.

It is obvious from **Table 9** that coefficient of error correction term {C (1)} is negative in sign, which means that there is long run causality from imports, exports, and GDP to CO_2. **Table 10** shows coefficient diagnostic test result and it is revealed that there is a short-term causality from imports and GDP to CO_2 and no causality from exports to CO_2 in short run.

So, we can conclude from VECM outcome that there is long run casualty from imports, exports, and GDP to CO_2 but in case of short run, only imports and GDP have causality toward CO_2.

	Coefficient	Std. error	t-Statistic	Prob.
C(1)	−0.005225	0.005004	−1.044161	0.3188
C(2)	−0.333024	0.276441	−1.204684	0.2536
C(3)	−0.631720	0.243040	−2.599238	0.0247
C(4)	0.063992	0.222721	0.287318	0.7792
C(5)	−0.441036	0.200424	−2.200513	0.0500
C(6)	−0.561520	0.213336	−2.632092	0.0233
C(7)	−0.390623	0.210732	−1.853647	0.0908
C(8)	0.008323	0.184391	0.045139	0.9648
C(9)	−0.375320	0.162730	−2.306396	0.0416
C(10)	−0.285832	0.128401	−2.226085	0.0479
C(11)	−0.077385	0.120272	−0.643418	0.5331
C(12)	0.287169	0.161000	1.783656	0.1021
C(13)	0.327490	0.164894	1.986070	0.0725
C(14)	0.175561	0.138381	1.268676	0.2307
C(15)	0.215072	0.125141	1.718642	0.1137
C(16)	0.203798	0.076759	2.655030	0.0224
C(17)	0.288925	0.216976	1.331596	0.2099
C(18)	−0.138598	0.107628	−1.287753	0.2243
C(19)	−0.142222	0.130898	−1.086511	0.3005
C(20)	0.124918	0.109233	1.143586	0.2771
C(21)	−0.016156	0.135903	−0.118883	0.9075
C(22)	0.069315	0.018557	3.735187	0.0033
R-squared	0.868595	Mean dependent var		0.030335
Adjusted R^2	0.617731	S.D. dependent var		0.024490
S.E. of regression	0.015141	Akaike info criterion		−5.308035
Sum squared resid	0.002522	Schwarz criterion		−4.310363
Log likelihood	109.5826	Hannan-Quinn criter.		−4.972349
F-statistic	3.462414	Durbin-Watson stat		2.082039
Prob(F-statistic)	0.018882			

Table 9. Short run coefficients of cointegration under VECM.

Variables	Null hypothesis	Chi-square	P-value	Decision
Imports	C(7) = C(8)…. = C(11) = 0	12.85853	0.0120	Short run causality
Exports	*C (12) = C(13)… = C(16) = 0*	7.615243	0.1788	No short run causality
GDP	*C(17) = C(18)…C(21) = 0*	14.94731	0.0106	Short run causality

Table 10. Coefficient diagnostic (WALD test).

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5.6. Variance decompositions (VDCs) and impulse response functions

The results of variance decomposition presented in **Table 11** explain the magnitude of the forecast error variance determined by the shocks to each of the explanatory variables over time. The cells in the variance decomposition represent percentages of the forecast variance (error) in one variable at different time periods induced by innovations of the other variables. These percentages help to determine the relative contribution the innovations make toward explaining movements in the other variables.

Variance decomposition indicates to what extent a shock or impulse (innovation) may cause on dependent variable in long run and short run. Here, we consider period three as short run and period 10 for long run. Model 1: In short run, a shock or impulse to CO_2 cause 83.59% of variance fluctuation in CO_2, whereas exports, imports, and GDP may cause 2.34, 10.58, and 3.48% fluctuation to CO_2, respectively. In long run, an innovation or impulse to CO_2 causes 62.94% fluctuation to CO_2 whereas an impulse on exports, imports, and GDP may cause 4.11, 14.29, and 18.63% variance fluctuation to CO_2, respectively, so we can say that in long run, a shock to CO_2 from both imports and GDP can cause variance fluctuation significantly. **Table 11** also manifests that for Model 2: In short run, an innovation to imports cause 69.93% of variance fluctuation in imports whereas, an impulse to CO_2 causes 22.78% of variance fluctuation in imports. On the other hand, in long run, an innovation to GDP and imports causes 36.20 and 45.55% of variance fluctuation to imports, respectively.

Period	S.E	Ln_CO_2	Ln_Imports	Ln_Exports	Ln_Gdp
Model 1: Variance decomposition of CO_2					
1	0.015141	100.0000	0.000000	0.000000	0.000000
3	0.025100	83.58684	10.58374	2.342176	3.487247
10	0.036526	62.94419	14.29237	4.114592	18.64885
Model 2: Variance decomposition of imports					
1	0.047445	22.98996	77.01004	0.000000	0.000000
3	0.088757	22.78454	69.93553	2.168897	5.111029
10	0.156676	11.13882	45.55258	7.102613	36.20599
Model 3: Variance decomposition of exports					
1	0.033810	93.25995	0.911852	5.828195	0.000000
3	0.072762	21.06030	16.60876	11.44612	50.88482
10	0.148897	7.612917	8.412356	13.24554	70.72918
Model 4: Variance decomposition of GDP					
1	0.024129	0.544248	59.02425	4.180525	36.25098
3	0.057256	7.744674	62.79744	4.522423	24.93546
10	0.140051	7.842519	60.31108	4.898937	26.94747

Table 11. Variance decomposing results under VAR environment.

Model 3: Both in short run and long run, an innovation to GDP causes significant variance fluctuation to exports 50.88 and 72.72%, respectively. Whereas, from Model 4, it is evident that both in short run and long run, a shock to import and GDP causes similar level of variance fluctuation in GDP. Impulse responses identify the responsiveness of dependent variables in the VAR system when a positive shock is put to the error term. Any shock in error term will change dependent variable and simultaneously change independent as well as dependent variables in next period.

It is obvious from **Figure 3**: that one standard deviation of innovation in CO_2 has positive effect on both GDP, imports and CO_2 as well, but significant effect occurs in GDP having positive trend and export shows negative affect because shock on CO_2 decreases effect on exports and eventually goes negative after period 5. It also manifests that a positive shock in error term of GDP will produce positive effect to all variables itself as well, which means that any innovation in GDP may have significant effects on variable in long run, meaning that all the variables are associated with GDP in long run. Impulse response of exports revealed positive effect on variable in long run. So, we can say that both GDP and exports have long run association and any positive shock in GDP and exports causes positive effect in long run.

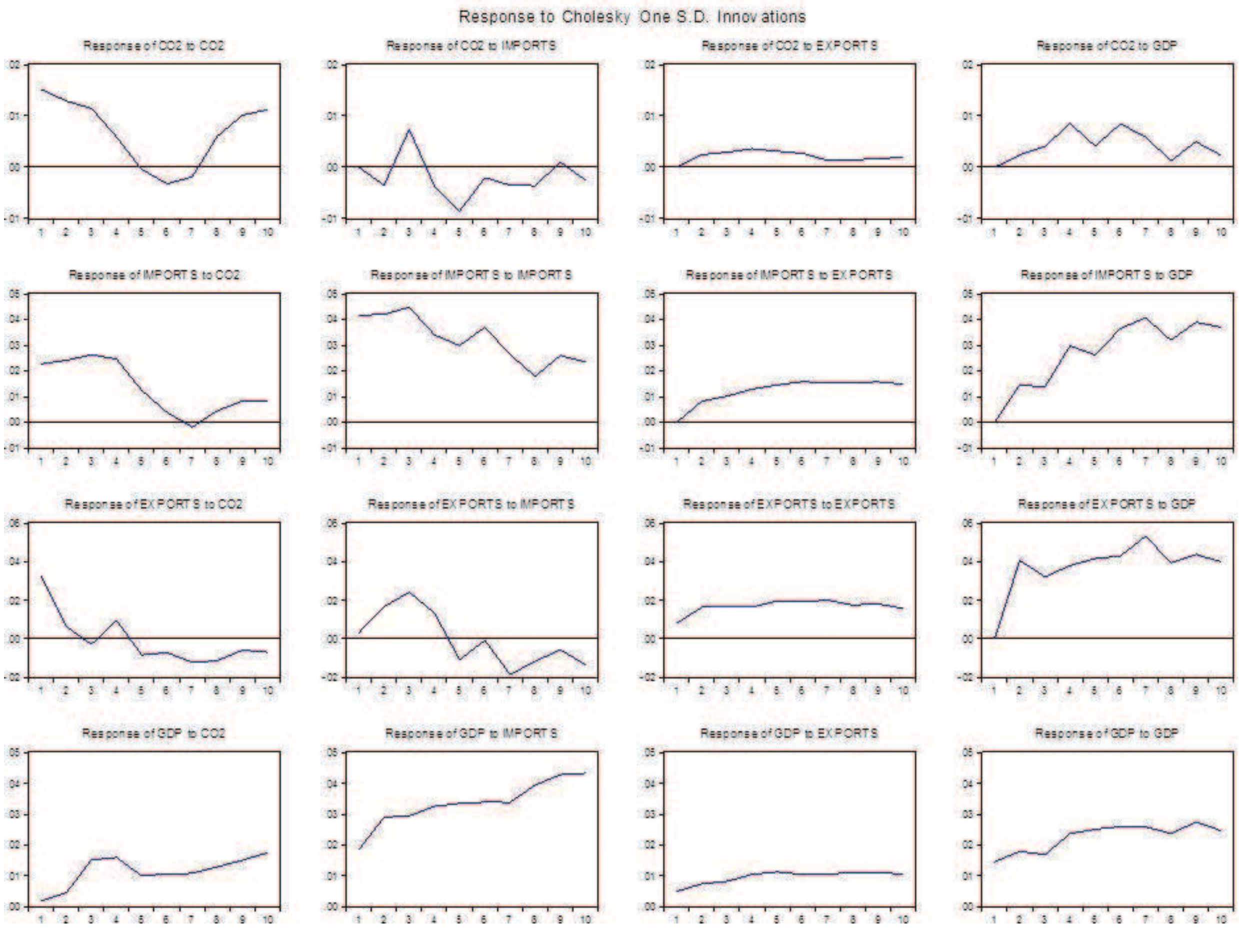

Figure 3. Impulse response of endogenous variables under VECM.

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6. Conclusion

This study employed a vector autoregressive analysis to investigate the link between Bangladesh's exports, imports, GDP, and carbon dioxide emissions. Study variables show that all the variables are nonstationary at level but data become stationary after first difference such that nature of data motivates to apply different time series models for analysis. In order to get optimal outcome from time series models, it is inevitable to choose appropriate Lag. This study selects optimal Lag if 5 on the basis of Akaike Information Criteria (AIC) in selecting optimal Lag based on the empirical analysis. Granger Causality shows short run unidirectional causality running from carbon dioxide emission to exports, GDP to import, and from carbon dioxide emissions to exports in Bangladesh. Test of JJ cointegration results revealed that there is one cointegration vector exist among explained variables. Considering both unit root test and JJ cointegration, we process to apply VAR restrict well-known VECM, in order to assess VECM Granger casualty of variables. Test result revealed that there is long run association from imports, exports, and GDP to CO_2 during the study period. Granger causality test shows that there is unidirectional causality running from carbon dioxide emission to exports, GDP to import, and from carbon dioxide emissions to exports in Bangladesh.

7. Recommendation

Being a low-lying coastal country, Bangladesh is the most climate vulnerable country in the world although industrialization still remains limited to some urban and semi-urban peripheries; villages occupied the major land of Bangladesh, which are also deprived from adequate electrification; and being a poor country, majority of the population cannot afford luxurious consumption. Therefore, Bangladesh might seem to be reluctant to embrace the new paradigm of low carbon resilient development, which seeks to reduce emissions, often referred to as climate change mitigation, and climate change adaptation together in one agenda. However, the government of Bangladesh formulated the Bangladesh Climate Change Strategy and Action Plan (BCCSAP) in 2008, incorporating comprehensive strategy for adapting to the effects of climate change, despite the problems being created mostly by rich countries thousands of miles away. However, it is perhaps surprising that the government of Bangladesh has plans to introduce measures to reduce greenhouse gases, such as introducing solar powered irrigation systems and adopting new energy efficient technologies.

Findings of this study revealed long run casual relations between exports, imports, GDP, and carbon emissions. Therefore, for sustainable business and environmental development, organizations are recommended to set up a mechanism whereby individuals or companies can purchase "carbon offsets", i.e., finance various projects that increase renewable energy resources (e.g., wind power, solar power, biofuels, geothermal, and hydrothermal) or increase energy efficiency (e.g., improved cooking system, installation of insulation) or destroy various pollutants (e.g., plant trees to absorb CO_2). Government needs to be sincere in implementing carbon management policies and consumers need to be encouraged to take wise decision in redesigning their eco-consumption decision. A concerted effort from all national and international stakeholders to offset carbon emission and pursuing environment-friendly trade plan is highly expected from all the poor and rich country to remain in win-win situation. Carbon tax from rich countries should be utilized for supporting poor countries' carbon management initiatives. Some of the most carbon-intensive emissions scenarios could be avoided if low- or no-emissions growth continues and countries implement their climate action plans.

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References

[1] Al-Amin, Siwar C, Hamid A, Nurul. Globalization & environmental degradation: Bangladeshi thinking as a developing nation by 2015. IRBRP Journal. 2008;**3**(1):381-395

[2] Copeland BR, M Scott Taylor. Trade and the environment: A partial synthesis. American Journal of Agricultural Economics. 1995;**77**(3):765-771. DOI: http://www.jstor.org/stable/1243249

[3] Marc Lallanilla. Greenhouse Gas Emissions: Causes & Sources [Internet]. 10-02-2015. Available from: https://www.livescience.com/37821-greenhouse-gases.html[Accessed: 23-02-2017]

[4] World Resources Institute. Top 10 Emitters in 2012 [Internet]. 2012. Available from: http://www.wri.org/resources/charts-graphs/top-10-emitters-2012 [Accessed: 03-06-2017]

[5] Basarir C, Çakir YN. Causal interactions between CO_2 emissions, financial development, energy and tourism. Asian Economic and Financial Review. 2015;**5**(11):1227-1238

[6] Mohiuddin, Obaidullah, Samuel Asumadu-Sarkodie, Madina Obaidullah. The relationship between carbon dioxide emissions, energy consumption, and GDP: A recent evidence from Pakistan. Cogent Engineering. 2016;**3**(1):1210491. DOI: doi/full/10.1080/23311916.2016.1210491

[7] Kasperowicz R. Economic growth and CO_2 emissions: The ECM analysis. Journal of International Studies. 2015;**8**(3):91-98. DOI: 10.14254/2071-8330.2015/8-3/7

[8] Xingjun Ru, Shaofeng Chen, Hongxiang Dong. A study on relationship between CO_2 emissions and economic development in china based on dematerialization theory. Energy and Environment Research. 2012;**2**(2):37. DOI: http://dx.doi.org/10.5539/eer.v2n2p37

[9] Dinh HL, Lin S-M. CO_2 emissions, energy consumption, economic growth and FDI in Vietnam. Managing Global Transitions. 2014;**12**(3):219-232

[10] Jalle M, Gujjunuri S. The dynamic relationship between energy consumption, economic growth and CO_2 emissions: Evidence from India. Asian Journal of Research in Business Economics and Management. 2016;**6**(6):13-26. DOI: 10.5958/2249-7307.2016.00036.0

[11] Bozkurt C, Akan Y. Economic growth, CO_2 emissions and energy consumption: The Turkish case. International Journal of Energy Economics and Policy. 2014;**4**(3):484-494

[12] Rahman AFMA, Porna AK. Growth environment relationship: Evidence from data on South Asia. Journal of Account Finance Econ. 2014;**4**(1):86-96

[13] Dritsaki C, Dritsaki M. Causal relationship between energy consumption, economic growth and CO_2 emissions: A dynamic panel data approach. International Journal of Energy Economics and Policy. 2014;**4**(2):125-136

[14] Safdari M, Barghandan A, Shaikhi AM. Has CO_2 emission increased the Iranian economic growth? International Journal of Academic Research in Business and Social Sciences. 2013;**3**(1):341

[15] Tiwari AK. Energy consumption, CO_2 emissions and economic growth: Evidence from India. Journal of International Business and Economy. 2011;**12**(1):85-122

[16] Naranpanawa A. Does trade openness promote carbon emissions? Empirical evidence from Sri Lanka. The Empirical Economics Letters. 2011;**10**(10):973-986

[17] Odhiambo NM. Economic growth and carbon emissions in South Africa: An empirical investigation. Journal of Applied Business Research. 2012;**28**(1):37

[18] Govindaraju, VGR Chandran, Chor Foon Tang. The dynamic links between CO_2 emissions, economic growth and coal consumption in China and India. Applied Energy. 2013;**104**:310-318. DOI: https://doi.org/10.1016/j.apenergy.2012.10.042

[19] Bakirtas I, Bayrak S, Cetin A. Economic growth and carbon emission: A dynamic panel data analysis. European Journal of Sustainable Development. 2014;**3**(4):91. DOI: https://doaj.org/toc/2239-6101

[20] Alam, Mohammad Jahangir, et al. Energy consumption, carbon emissions and economic growth nexus in Bangladesh: Cointegration and dynamic causality analysis. Energy Policy. 2012;**45**:217-225. DOI: https://doi.org/10.1016/j.enpol.2012.02.022

[21] World Resources Institute. 4 Things you Need to Know about Current Trends in Carbon Dioxide Emissions [Internet]. 09-12-2015. Available from: http://www.wri.org/blog/2015/12/4-things-you-need-know-about-current-trends-carbon-dioxide-emissions[Accessed: 05-06-2017]

[22] Brooks C. Introductory Financial Econometrics. Cambridge University Press; UK. 2008

[23] Dickey DA, Fuller WA. Distribution of the estimators for autoregressive time series with a unit root. Journal of the American Statistical Association. 1979;**76**(366 a):427-431. DOI: http://dx.doi.org/10.1080/01621459.1979.10482531

[24] Borhan H, Ahmed EM, Hitam M. The impact of CO_2 on economic growth in ASEAN 8. Procedia–Social and Behavioral Sciences. 2012;**35**:389-397. DOI: https://doi.org/10.1016/j.sbspro.2012.02.103

[25] Mugableh MI. Analysing the CO_2 emissions function in Malaysia: Autoregressive distributed lag approach. Procedia Economics and Finance. 2013;**5**:571-581. DOI: https://doi.org/10.1016/S2212-5671(13)00067-1