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Determining the Relationship between International Trade, Economic Growth, and CO_2 Emissions in the Philippines: An Econometric Analysis

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***Abstract*: This paper studies the relationship between the Philippines' imports and exports, GDP growth, and CO_2 emissions. The data was collected from the World Bank, and the method used for this study was multiple regression analysis using a number of 60 observations from 1962 to 2021. Results showed that from 1962 to 2002, economic growth had a significant relationship with CO_2 emissions. This means that as the economic growth increased, the CO_2 emissions also increased. However, the annual growth of exports and imports did not significantly impact the CO_2 emissions in the Philippines during this period. From 2003 to 2021, the annual growth of exports and imports showed a significant relationship between CO_2 emissions, while the economic growth showed an insignificant relationship between CO_2 emissions during this period. From this, the researchers concluded that the imports and exports of goods and services and economic growth significantly affect CO_2 emissions in the Philippines. It is also observed that the relationships between the variables can change throughout the years.**

***Keywords*: CO_2 emissions, economic growth, exports, GDP growth, goods, imports, international trade, Philippines, services, trade openness.**

1. Introduction

International trade, or global trade, is how companies in different countries buy or trade goods and services from other countries (Cambridge Dictionary; Heakal, R., 2023). When international trade happens, countries that participate in it can gain benefits, such as an increase in living standards when a cheaper alternative of a good or service can be made in another country (McDonald, 2019) or when a product is not locally available (Diaz, 2022). These are only some factors that make up the vital role of international trade in many countries worldwide. A study by Salcedo et al. (2023) explained that engaging in international trade significantly increases the country's economic growth.

Carbon dioxide plays an essential role on our planet. Lindsey (2023) defines carbon dioxide, or CO_2, as a clear gas that raises the earth's temperature and is the most dominant greenhouse gas. Without CO_2, the earth's natural greenhouse effect would be too weak, leading the surface temperature into extreme coldness. The United States Environmental Protection Agency (2023) stated that almost all of the increase in greenhouse gasses in the atmosphere has been managed by human activities for over the last 150 years. The primary sources of CO_2 emissions are natural sources like ocean release, respiration, and decomposition, and human sources such as deforestation, burning of fossil fuel, and cement production (CO_2 Human Emissions, 2017). According to Sabado et al. (2022), the Philippines is one of the most significant CO_2 contributors. Transportation, households, and especially building infrastructures, including factories, will significantly affect carbon dioxide emissions since they produce greenhouse gasses, increasing CO_2 emissions. The agricultural sector also contributes 8% of greenhouse gasses to the Philippine economy.

Furthermore, international trade is involved in environmental footprints, specifically in the form of carbon dioxide. CO_2 Emissions produce goods and services that will later be traded across borders (Kang & Gapay, 2023). The International Transport Forum (2015) states that international trade contributes to global carbon dioxide emissions, commonly through freight transport.

In this study, the researchers selected the Philippines as the country to focus on and determined if there is a positive or negative relationship between international trade, CO_2 emissions, and economic growth from 1962 to 2021. A literature review was also made to explain further how international trade affects CO_2 emissions and how CO_2 emissions affect economic growth, and policy implications and recommendations were also discussed.

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2. Literature Review

A. Imports and Exports of Goods and Services and CO_2 Emissions

Aghasafari et al. (2021) reveal that exports significantly affect CO_2 emissions; a 1 percent rise in exports increases the CO_2 emissions by 0.32 percent. Bosupeng (2016) also examined that exports and carbon dioxide emissions have a direct relationship. A study by Fang et al. (2019) observed a positive impact of export product quality on CO_2 emissions. Ullah et al. (2019) illustrate the critical relationship between CO_2 emissions and exports from 1960 to 2017, where the researchers explained that the two variables are very closely related, emphasizing that exports are the significant determinant of CO_2 emissions in China. Moreover, Apergis et al. (2018) used the panel quantile regression to indicate that the effect of the product concentration export upon the CO_2 emissions per capita was relatively high at the higher quantiles.

According to Mania E. (2019), export diversification positively affects CO_2 emissions using the environmental Kuznets curve, where export diversification increases CO_2 emissions per capita for less developed countries. Wang et al. (2020) also discussed the empirical findings of their study using cross-sectionally augmented autoregressive distributed lags (CS-ARDL), which shows that CO_2 emissions are significantly related to export diversification. The results of the study conducted by Ren et al. (2014) suggest that exports are connected with higher CO_2 emissions, while the import variables have a negative coefficient. Furthermore, as Gozgor and Can (2016) observed, the higher product diversification of exports yields higher carbon dioxide emissions.

In a study conducted by Su & Ang (2013) about the assumptions of imports (competitive and non-competitive imports) in embodied emissions studies, they found no similarity between the implications of results derived from the mentioned assumptions of imports. Rodrigues et al. (2020) stated that if the electricity imported is less carbon-intensive than when produced locally, there would be lower carbon emissions brought about by international trade.

Hasanov et al. (2018) explained that in only-oil exporting countries, there is a statistically significant effect of opposite signs on consumption-based CO_2 emissions made by exports and imports, evident in both the long run and the short run, while there is a statistically insignificant effect for territory-based CO_2 emissions. Li et al. (2013) also observed that the embodied carbon dioxide emissions in export trade are much more significant than in import trade. With that being the case, production-based CO_2 emissions are also much more significant than consumption-based CO_2 emissions. Jebli and Youssef (2015) stated in their study focusing on Tunisia that trade and non-renewable energy positively affect CO_2 emissions in the long run. It was also shown that the impact of renewable energy is weak and negative towards CO_2 emissions when exports are used in the model utilized for the study. In contrast, when imports are used, results show that renewable energy is statistically insignificant to CO_2 emissions.

According to the study of Al-mulali et al. (2014), exports positively affect CO_2 emission, and there is a bidirectional long-run relationship found between the trade variables such as exports, imports, and total trade of goods and services and CO_2 emissions. Bento & Moutinho (2016) also explained in their study focusing on Italy that international trade can only positively affect CO_2 emissions per capita in the long run, and there is a Granger causality between international trade and emissions per capita. A study by Danish et al. (2018) found that in the long run, technologies that are imported into China are the main reason for the CO_2 emissions in the country and that there is a bidirectional causality between the two variables.

In a study by Ahmed et al. (2017) focusing on selected Asian countries, it was stated that trade openness contributes to increased environmental degradation. A unidirectional causality was found between the variables energy consumption, trade openness and population, and CO_2 emissions. In a related study by Sebri and Ben-Salha (2014) focusing on BRICS countries, they stated that there is a significant effect between trade openness and CO_2 emissions when it comes to the development of renewable energy consumption. Shen et al. (2022) also stated that when developing countries open for trade, it will increase CO_2 emissions.

B. Imports and Exports of Goods and Services and Economic Growth

In a study conducted by Zahonogo (2017), it was stated that in sub-Saharan Africa (SSA), the relationship between trade openness and economic growth is not linear. For the economic growth of the countries in the region to improve, they should consider having their trade openness to be more effective, such as controlling their import levels more effectively. According to Abdullahi et al. (2016), in a study about the relationship between West Africa's international trade and economic growth from 1991-2011, it was found that exports and imports have opposite outcomes on the GDP growth, further explaining that when the exports rise by one percent, it will result in a boost in the GDP by 5.11 percent. Meanwhile, imports have a positive but insignificant effect on GDP growth.

The study of Omri et al. (2015), which focuses on MENA countries, explained an interrelated relationship or bidirectional causality between economic growth and trade openness. Ali et al. (2017) added that there is a unidirectional causality between exports and imports and economic growth and a bidirectional Granger causality between imports and exports. The results further revealed that imports and exports are the source of economic growth in Somalia. Alam and Sumon (2020), in their study examining the causal relationship between trade openness and economic growth in fifteen Asian countries, explained that trade openness positively impacts economic growth. The panel vector error correction Granger causality analysis showed the bidirectional causality between economic growth and trade openness. Similar to the previous study, the results of Yusoff and Nuh's (2015) Granger causality tests revealed that foreign trade and foreign direct investment are significant determinants of economic growth in Thailand. The correlational analysis of Dudzevičiūtė et al. (2017) found a significant relationship between export and economic growth in the twenty-two

countries in the European Union. As illustrated in the empirical study of Hye et al. (2016), trade openness is positively related to economic growth in both the long and short run in China.

Keho (2017) found that there are positive impacts of openness to trade on economic growth both in the short and long run, and trade openness is also a positive and strong complementarity in promoting economic growth. Azeez et al. (2014) conducted a study about the effect of international trade on Nigerian economic growth. The results show a significant and positive impact of international trade on economic growth and further explain that imports, exports, and trade openness significantly affect the economy. Yakubu and Akanegbu (2015) found that international trade and economic growth have a relationship, while some parts of international trade create positive and significant effects on economic growth. Tahir and Azid (2015) indicate that trade openness influenced the economic growth of the fifty developing countries positively and significantly. It was suggested that developing countries should speed up the trade liberalization process to advance economic growth and improve society's living standards. According to Hamdan (2016), exports and imports have had a positive effect on the economic growth of Arab countries from 1995 to 2013. Also, exports and imports were significant at 1 percent, whereas if exports increased by 100 percent, the economic growth of the Arab countries increased by 30 percent. If the imports increased by 100 percent, the economic growth of the Arab countries increased by 29 percent. The pool mean group estimator (PMG) model of Mangir et al. (2017) illustrated that an increase in trade openness causes a positive impact on economic growth in the long run. Furthermore, Ijirshar (2019) showed that trade openness in ECOWAS countries positively affects economic growth. Kilic and Beser (2017) also stated that within the scope of the findings, the import and export of the Eurasia Economic Union are essential determinants of economic growth.

Kumari (2014) stated that exports and imports contribute to economic growth in India, and to have continuous economic growth, exports must support imports. Ozturk (2017) explained in a panel study focusing on selected Latin American countries that CO_2 emissions positively contribute to increasing GDP per capita. Ragahutla (2020) explained that the findings in the study suggested that trade openness significantly supports economic growth in five emerging countries, including Brazil, Russia, India, China, and South Africa. Abendin and Duan (2021) concluded the result of the study that Africa's digital economy and international trade play a vital role in the country's economic growth. Furthermore, the results of the study by Jouini (2014) indicate that economic growth responds positively to trade openness in the short and long run.

C. CO_2 Emissions and Economic Growth

According to Mardani et al. (2019), in a comprehensive review of journals about CO_2 emissions and economic growth, they discovered that the relationship between the two variables could be a prompt for policies that tackle reducing these CO_2 emissions to also consider including factors that can limit economic growth. Another result in the same study that considers bidirectional causality showed that as economic growth increases or decreases, CO_2 emissions are further stimulated at higher or lower levels and vice versa. Alshehry and Belloumi (2015) also explained in a study determining the relationship between energy consumption, carbon dioxide emissions, and economic growth in Saudi Arabia that a bidirectional causality exists between CO_2 emissions and economic growth. Long et al. (2015), in a study concerning the case of China, found that the country's GDP has a bidirectional relationship with CO_2 emission, coal, gas, and electricity consumption. In the Gulf Cooperation Council (GCC) countries, Salahuddin et al. (2015) discussed that the relationship between economic growth and CO_2 emissions, in the long run, is positive; the GCC countries' economic growth stimulates CO_2 emissions, and there is a bidirectional causal link between the two variables mentioned. Moreover, Bildirici and Gökmenoğlu (2017) also stated in their study focusing on the G7 countries that in the crisis regime and high growth regime, there is a bidirectional Granger causality between CO_2 emissions and economic growth, while in all governments, CO_2 emissions are the Granger cause of economic growth.

Bouznit and Pablo-Romero (2016) conducted a study where they analyzed the relationship between CO_2 emissions and economic growth in Algeria and found that emissions will persist alongside the country's economic growth. In a related study, Lau et al. (2014) chose Malaysia as the country in which they decided to determine the relationship between CO_2 emissions and economic growth. They found out that as the CO_2 emissions increase, the economic growth in Malaysia also increases, and, using the Granger causality test, it showed that the relationship between CO_2 emissions and economic growth can be vulnerable to the quality of institutions. Furthermore, Agyeman et al. (2022) also found that Africa's economic growth is a positive factor that causes increased CO_2 emissions.

In an econometric study by Kais and Sami (2016) focusing on 58 countries, it was explained that the effect of economic growth on the environment has been concerning. This has been shown by the positive relationship between the per capita GDP and carbon for the global panel and the three regional sub-groups. Nawaz et al. (2020) also stated that from 2000 to 2018, economic growth positively impacted CO_2 emissions in the ASEAN countries.

D. Research Simulacrum

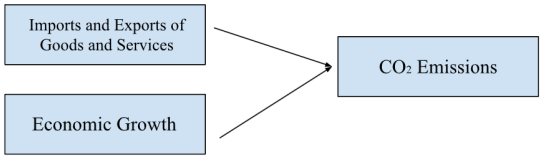

Fig. 1. Research simulacrum

3. Method

A. Research Design

This study applied a quantitative and correlational research design to analyze the numerical data gathered statistically. This allowed the researchers to describe, illustrate, and determine the

direction and strength of the relationship between the different variables (imports and exports of goods and services, economic growth, and CO_2 emissions in the Philippines).

B. Data Collection

The data used for imports and exports of goods and services is the percentage of the annual growth of imports and exports of goods and services from 1961 to 2021; for CO_2 emissions are the annual CO_2 emissions measured in tonnes from 1961 to 2021; and for economic growth is the annual percentage of GDP Growth from 1961 to 2021 in the Philippines. The data of the following variables were obtained from reliable secondary sources such as the World Bank.

C. Data Analysis

After gathering the data from reliable secondary sources, the researchers used the Eviews software to examine the relationships between the variables. Multiple regression analysis was used as the statistical technique to analyze the relationship between the independent variables (imports and exports of goods and services, economic growth) and the dependent variable (CO_2 emissions).

D. Econometric Model

The multiple regression analysis uses two or more independent variables that predict the outcome of the dependent variable. Furthermore, multiple regression analysis extends the OLS regression since it includes more than one independent variable (Hayes, 2023).

The regression model that will be used is as follows:

$$CO_2 = \beta_0 + \beta_1 IMP + \beta_2 EXP + \beta_3 GDP + \varepsilon$$

where the CO_2 is the annual CO_2 emissions, IMP is the annual growth of imports of goods and services, EXP is the annual growth of exports of goods and services, and GDP is economic growth.

4. Results and Discussion

The results of the Unrestricted Cointegration Rank Test show that the first p-value of 0.0017 is less than the significance level of 0.05 therefore, reject the null hypothesis that there is a cointegration relationship. The second p-value of 0.0155 is also less than the significance level of 0.05; therefore, we reject the null hypothesis again. The third p-value of 0.0994 is more significant than the significance level of 0.05; therefore, we accept the null hypothesis that there is a cointegration relationship.

As shown in the regression model results, the researchers divided the period from 1962 to 2002 and 2003 to 2021 to quickly determine whether the relationships between the variables changed during the periods. In 1962-2002, the model shows that GDP growth is positively significant at the 0.05 significance level. Although the annual growth of exports and imports is positive, they are insignificant at the 0.05 significance level. In 2003-2021, the model shows that the annual growth of exports and imports is positively significant at the 0.05 significance level, while the GDP growth is positively insignificant at the 0.05 significance level. According to the Jarque-Bera Normality Test, the t-statistics of 0.512640 and the probability of 0.773894 are greater than the 0.10 significance level. Therefore, accept the null hypothesis, which implies that the data is normally distributed. The Breusch-Godfrey Serial Correlation LM Test reveals that the p-value of 0.3455 is greater than the 0.10 level of significance. Therefore, accept the null hypothesis, which implies no first-order autocorrelation in the Breusch-Godfrey Serial Correlation LM Test. The result of the Heteroskedasticity test ARCH shows that the p-value of 0.4079 is greater than the 0.10 level of significance therefore, accept the null hypothesis. This implies that there is no presence of heteroskedasticity in the model. The results of the Variance Inflation Factors show that in 1962-2002, the coefficient variance for annual growth of exports and imports and GDP growth are between 1 and 5, which means that there is no severe collinearity present. In 2003-2021, the coefficient variance for annual growth of exports and imports are between 1 and 5, which implies that there is no severe collinearity present, while the coefficient variance for GDP growth is greater than 5, which also means that there is no severe collinearity present. According to the Ramsey RESET Test, the p-value of 0.7507 is greater than the significance level of 0.10; therefore, the null hypothesis is accepted, and no specification error is shown in the model. This implies that the

Table 1
Augmented Dickey-Fuller tests

Variable	Level	Prob.*	1st difference	Prob.*
ANNUAL_CO2_EMISSIONS	0.031675	0.9958	-6.415933	0.0000
ANNUAL_GROWTH_OF_EXPORTS	-6.411531	0.0000	-10.11943	0.0000
ANNUAL_GROWTH_OF_IMPORTS	-5.679066	0.0001	-7.155797	0.0000
GDP_GROWTH	-5.482042	0.0001	-7.380257	0.0000

Table 2
Unrestricted cointegration rank test (Trace)

Sample (adjusted): 1965 2021
Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.380851	61.32355	47.85613	0.0017
At most 1 *	0.302697	33.99726	29.79707	0.0155
At most 2	0.127533	13.44677	15.49471	0.0994
At most 3 *	0.094690	5.670246	3.841465	0.0172

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
*denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table 3
Multiple regression model

Dependent Variable: D(ANNUAL_CO2_EMISSIONS)				
Method: Least Squares with Breaks				
Sample (adjusted): 1962 2021				
Break type: Bai-Perron tests of L+1 vs. L sequentially determined breaks				
Break: 2003				
Selection: Trimming 0.15, Max. breaks 5, Sig. level 0.05				
Variable	**Coefficient**		**Std. Error**	**t-Statistic**	**Prob.**
	1962 - 2002 – 41 obs				
ANNUAL_GROWTH_OF EXPORTS	16291.70		34610.82	0.470711	0.6399
ANNUAL_GROWTH_OF IMPORTS	58113.65		44286.36	1.312225	0.1953
GDP_GROWTH	317411.2		147825.3	2.147204	0.0366
Constant	-1464583.		835315.4	-1.753330	0.0856
	2003 - 2021 – 19 obs				
ANNUAL_GROWTH_OF EXPORTS	-363714.0		119274.6	-3.049384	0.0036
ANNUAL_GROWTH_OF IMPORTS	600978.7		127255.1	4.722628	0.0000
GDP_GROWTH	465363.7		273692.8	1.700314	0.0952
Constant	-3131544.		2029439.	-1.543059	0.1290
	Non-Breaking Variables				
ANNUAL_CO2_EMISSIONS	0.032289		0.015257	2.116393	0.0392
R-squared	0.710711		Mean dependent var		2259189.
Adjusted R-squared	0.665332		S.D. dependent var		3953089.
S.E. of regression	2286882.		Akaike info criterion		32.26076
Sum squared resid	2.67E+14		Schwarz criterion		32.57491
Log likelihood	-958.8227		Hannan-Quinn criter.		32.38364
F-statistic	15.66177		Durbin-Watson stat		2.243258
Prob(F-statistic)	0.000000				
Jarque-Bera Normality Test	0.512640				
Probability	0.773894				
Breusch-Godfrey Serial Correlation LM Test					
Null hypothesis: No serial correlation at up to 1 lag					
F-statistic	0.907043	Prob. F (1,50)		0.3455	
Heteroskedasticity Test ARCH					
F-statistic	0.695146	Prob. F (1,57)		0.4079	
Ramsey RESET Test					
	Value		**df**	**Probability**	
t-statistic	0.319715		50	0.7505	
Variance Inflation Factors					
Sample: 1961 2022					
Included observations: 60					
Variable	**Coefficient Variance**		**Uncentered VIF**		
	1962 - 2002 – 41 obs				
ANNUAL_GROWTH...	1.20E+09		1.655684		
ANNUAL_GROWTH...	1.96E+09		2.160468		
GDP_GROWTH	2.19E+10		4.183739		
Constant	6.98E+11		5.470127		
	2003 - 2021 – 19 obs				
ANNUAL_GROWTH...	1.42E+10		5.377017		
ANNUAL_GROWTH...	1.62E+10		7.326742		
GDP_GROWTH	7.49E+10		10.42260		
Constant	4.12E+12		14.96298		
	Non-Breaking Variables				
ANNUAL_CO2_EMIS...	0.000233		12.31146		

model is properly specified.

As discussed by Aghasafari et al. (2021) and Bosupeng (2016) regarding the relationship between international trade and CO_2 emissions, exports have a significant effect and direct relationship with CO_2 emissions. Al-mulali et al. (2014) also attested to this statement by showing that exports have a positive effect on CO_2 emissions and a bidirectional long-run relationship between exports, imports, and CO_2 emissions. In the context of international trade and economic growth, Ali et al. (2017) concluded that there is a unidirectional causality between exports, imports, and economic growth in Somalia. Kumari (2014) also stated that in India, exports and imports play a part in the country's economic growth and that exports should support imports to see a better result in economic growth. On the topic of the relationship between CO_2 emissions and economic growth, Mardani et al. (2019), Alshehry and Belloumi (2015), and Lau et al. (2014) observed that there is a bidirectional causality between the two variables, which results in the increase of the other variable when there is a rise in the other one.

Based on the result of the regression model of this study, it showed that from 1962 to 2002, only the economic growth had a significant relationship with CO_2 emissions. This supports the studies of (Salahuddin et al. 2015; Lau et al. 2014; Agyeman et al. 2022), wherein as economic growth increases, CO_2 emissions also increase and vice versa. However, the imports and exports of goods and services did not significantly impact the CO_2 emissions in the Philippines during this period, which

contradicts the papers of (Aghasafari et al. 2021; Bosupeng 2016; Ullah et al. 2019; Apergis et al. 2018; Mania 2019; Wang et al. 2020; Can 2016; Li et al. 2013) stating that exports have a significant relationship between CO_2 emissions; the studies by (Jebli & Youssef 2015; Bento & Moutinho 2016; Shen et al. 2022) where it was stated that trade positively affects the CO_2 emissions; as well as the analysis by Danish et al. (2018), where it was described that the technology imports are the main reason of the CO_2 emissions in China.

From 2003 to 2021, there was a change in the result, unlike in the previous period, where it was shown that the imports and exports of goods and services were significantly related to CO_2 emissions, supporting the statements of (Aghasafari et al. 2021; Bosupeng 2016; Ullah et al. 2019; Apergis et al. 2018; Mania 2019; Wang et al. 2020; Can 2016; Li et al. 2013; Jebli & Youssef 2015; Bento & Moutinho 2016; Shen et al. 2022; Danish et al. 2018). Meanwhile, economic growth showed an insignificant relationship with CO_2 emissions, contrary to the evidence from (Salahuddin et al. 2015; Lau et al. 2014; Agyeman et al. 2022; Nawaz et al. 2020), explaining that economic growth has a positive impact on CO_2 emissions. Therefore, the null hypothesis is rejected since it is observed that the relationships between the variables can change throughout the years.

5. Conclusion

Based on the findings of this study, the researchers conclude that the imports and exports of goods and services and economic growth significantly affect CO_2 emissions in the Philippines. However, the results may vary depending on the period or year, as shown in this study, where only the economic growth had a significant relationship with CO_2 emissions from 1962 to 2002, while from 2003 to 2021, only the imports and exports of goods and services were significantly related with CO_2 emissions.

International trade builds greenhouse gas emissions that contain carbon dioxide through the production, transportation, consumption, and distribution of traded goods and services. Greenhouse gas emissions through trade can be reduced by boosting energy efficiency and using alternative and renewable energy. Given that CO_2 emissions affect the environment, the researchers recommend using green technologies to mitigate CO_2 emissions, lessening the rise of global temperature that causes climate change, affecting biodiversity, human health, and economic growth. The researchers also recommend implementing public policies promoting clean energy and encouraging firms and consumers to be environmentally conscious. Furthermore, CO_2 emissions should be used wisely and responsibly to avoid future consequences that will negatively damage the world.

In the Philippines, the country mainly contributes to CO_2 emissions from transportation, households, building infrastructures, factories, and agriculture. With that, it is advisable to follow the recommendations stated above especially to these sectors to prevent risks to the environment, economy and society.

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