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Exploring the Impact of Global Oil Price Volatility, Food Prices, Inflation, and Their Nexus with Economic Growth in Indonesia: A Vector Autoregression (VAR) Investigation

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Abstract

Global oil and food prices shape people's living costs and purchasing power. These prices increase can intensify inflationary pressures, diminish individuals' purchasing capacity and potentially affect economic growth. This study intends to explore the responds of the world oil prices and world food prices towards inflation, the impacts of global oil price shocks, world food prices, inflation, towards the economic growth from 2015 to 2022. The study utilizes monthly time series data and applies the vector autoregressive analysis (VAR) and vector error correction (VECM) model. The Granger causality findings of this investigation reveal specific relationships: World oil prices exhibit a one-way causality connection to inflation, world food prices demonstrate a two-way causality relationship with inflation, inflation shows a two-way causality relationship with world food prices, and world food prices have a one-way causality relationship with world oil prices. Consequently, fostering economic stability necessitates coordinated efforts between monetary and fiscal policies to enhance public welfare and elevate the standard of economic growth. Additionally, there is a need to promote energy-saving initiatives. Beyond their efficient and effective impact on the national budget, such initiatives can contribute to reducing inflation.

Keywords: Economic growth, Oil price shock, Inflation, World food price.

Introduction

The year-over-year inflation rate for the worldwide consumer price index of food demonstrated a consistent rise, ascending from 2.1 percent in 2017 to 3.7 percent in 2021, the inflation rate surged, almost tripling to reach 10.6 percent in 2022. During the same year, Eastern Europe, Eastern Africa, South America, and Western Africa experienced an annual inflation rate of over fifteen percent in consumer price indices related to food (1). The impact of food prices varies across countries (2). In 2022, Eastern Asia experienced the lowest the rate of inflation for the overall or broader context. Consumer Price Index (CPI) compared to other Asian regions. This pattern was primarily influenced by China, where efforts to recover from the African swine flu crisis of 2019–2020 and the economic slowdown due to the COVID-19 pandemic contributed to the fluctuations in inflation. The study on oil prices, inflation, and interest rates in G-7 countries indicate that there is a significant influence of oil prices on the inflation rate in most countries, except for Japan and the UK (3). Developing nations without robust social security systems encounter a substantial void that requires attention. The rising costs of food present a risk to the agricultural industry, creating greater difficulties for farmers to meet production expenses, especially in countries heavily reliant on imports. Consequently, this is likely to impact consumer purchasing power and, consequently, economic growth. The impact of oil price shocks on economic growth exhibits strong statistical significance and direct positive correlation. Notably, the positive impact of oil is evident only in states with a notably high economic freedom index, and the cumulative the direct impact of oil prices on economic growth persist over an extended period (4). A study indicates that the growth of India's economy is notably hampered by a surge in global crude oil prices, confirming the researchers' predictions. Interestingly, the researchers were surprised to find that a boost in

domestic crude oil prices actually have a substantial positive effect on India's economic growth, contrary to their initial expectations (5). However, the consequences of changes in oil prices on economic growth was found to be statistically not significant over an extended period. The Granger causality test demonstrated unidirectional causality is observed the correlation between economic growth and oil prices. In summary, fluctuations in oil prices were determined to have no noteworthy influence on the growth of the Ghanaian economy.

Economic growth is defined as increasing production capacity to increase output. This is assessed through the examination of a country's Gross Domestic Product (GDP) and the Gross Regional Domestic Product (GRDP) of individual regions within that country. According to study (6) there are three aspects of economic growth: the process, per capita output, and long-term factors are evaluated in this analysis. Economic growth is a process, not a snapshot of the economy at a point in time; This looks at the dynamic aspects of the economy, namely how the economy develops or changes over time. Economic growth is defined as the sustained expansion of per capita output over an extended period. The focus is on three key elements: the process, output per capita, and the extended time frame. This perspective highlights the dynamic nature of an economy. Consequently, economic growth serves as a metric to gauge the developmental progress of an economy (7). According to study (8) economic growth is increasing the long-term capacity of a country to provide its population with various economic goods through advances or adjustments in technology, institutions, and ideology.

From the various existing growth theories, namely Harold Domar's, Neoclassical, Solow's theory, and Romer's endogenous theory, economic growth consists of three primary factors or components. The three are:

a. The accumulation of capital encompasses various types of new investments directed towards land, physical assets, and both human and financial resources.

b. The expansion of the population, expected to rise in the coming years, will contribute to an increase in the workforce.

c. Technology advances

In market economics, general axioms determine fluctuations in crude oil prices in international markets; An important factor in price fluctuations is the supply and demand mechanism—also known as the supply and demand mechanism—while other factors, especially those related to infrastructure, geopolitics, and speculation, are considered non-fundamental factors (9).

1. The primary factor is the foundational element, encompassing oil demand, oil supply, oil reserves, global production capacity, and worldwide refinery capabilities.

2. The second element comprises non-essential factors, encompassing geopolitics, governmental regulations, meteorological conditions, natural calamities, labor strikes, disruptions to production facilities, depreciation of the dollar, and speculative activities.

3. The third factor is the influence of OPEC supply policy.

The increase in world oil prices has an impact on economic indicators, where oil is a very sensitive fuel. If oil prices are increased, conditions will occur that will encourage inflation. In several countries, including Indonesia, most of the economic growth is financed by oil exports, meanwhile energy consumption has grown rapidly, tripling in a ten year period, and the transportation sector consumes 33.4% of all oil products (10). Meanwhile, according to the ADB (Asia Development Bank) in a report entitled Asian Development Outlook 2004 Update, inflation will be the first economic indicator affected by the increase in world oil prices.

Global oil prices exhibit a positive trend influence on economic growth in Indonesia. Variations in global oil prices exert a substantial impact. on economic growth (11). Fluctuations in world oil prices are one of the factors that influence the economy in Indonesia because they have a very important role in the economy and have various implications or impacts. In certain periods, economic growth responds quickly and positively to the effects of fluctuations in global oil prices (12). Theoretically, food importing countries are most likely to experience inflation as a result of food price shocks. Consumers consume food

products directly, unlike oil which is included in production input, so that rising food prices have a more direct impact on inflation. As most people spend more money on food, the weight of food group inflation on inflation will increase. Therefore, it is very important to investigate further relationship between inflation components and food prices. Rising prices then cause inflation, to which monetary policy then responds by lowering interest rates, even though inflation continues to rise.

Economic growth plays a crucial role in elucidating fluctuations in macroeconomic variables in Indonesia, with world food prices being a significant factor in this context. So, in conclusion, variations in global food prices impact the economic growth of Indonesia by influencing inflation. The analysis of impulse responses reveals that shocks to global food prices elicit the quickest and most potent response from inflation (13). Several literatures reveal food prices contribute to decelerating global economic growth. Research based on empirical evidence states that increasing global increased food prices may lead to a decrease in the demand for food exports, ultimately resulting in a decrease in net exports which are part of national income. In his book, Mankiw asserts that the balance of exports and imports. represent the net value of goods and services exported to other countries, excluding. the worth of goods and services brought in from other nations. This distinction is made because goods and services that are brought in from other countries are not taken into account. part of a country's output.

Methodology

In this study, the researcher employed a quantitative approach methodology. The quantitative method aligns with the positivist philosophy and involves investigating specific variables, gathering data through research instruments, and analyzing quantitative data to test predetermined hypotheses (14). The data utilized in this research is quantitative, comprising numerical values amenable to calculation, including information on petroleum, global food, inflation, and economic growth. The data encompasses monthly secondary data in a time series format from January 2015 to November 2022, encompassing world oil prices (in dollars), global food prices, inflation rates, and GDP calculated at constant prices (in billions of rupiah). Monthly GDP data is derived through interpolation from quarterly GDP data. The data is acquired indirectly through intermediary sources, generated by third parties, or utilized by institutions other than the primary managers but deemed relevant for specific research purposes.

The VAR model is a regression equation framework that employs time series data to address issues of stationarity and cointegration among its constituent variables. The initial step in establishing the VAR model involves testing the stationarity of the data. If the variable data exhibits stationarity at the base level, it results in an ordinary VAR model (unrestricted VAR) (15). Conversely, if the data lacks stationarity at the base level but demonstrates stationarity through the differentiation process, a cointegration test is conducted to ascertain the presence of a long-term relationship. If the data is stationary after differentiation, but the variables are not cointegrated, it is referred to as a VAR model with differentiated data (VAR in difference). However, if cointegration is observed, the VAR model transforms into a Vector Error Correction Model (VECM). The VECM model, characterized by cointegration, represents a constrained VAR model, indicating the existence of a long-term relationship among variables in the VAR estimation.

Generally the model Vector Autoregressive (VAR) can be formulated as follows:

$MD_t = A_0 + PD_1Y_{t-p} + INF_2Y_{t-p} + PDB_3Y_{t-p} + \mathcal{e}_t$
$PD_t = A_0 + MD_1Y_{t-p} + INF_2Y_{t-p} + PDB_3Y_{t-p} + \mathcal{e}_t$
$INF_t = A_0 + MD_1Y_{t-p} + PD_2Y_{t-p} + PDB_3Y_{t-p} + \mathcal{e}_t$
$PDB_t = A_0 + MD_1Y_{t-p} + PD_2Y_{t-p} + INF_3Y_{t-p} + \mathcal{e}_t$

Where:
A0 = Constant
MDt = World oil in the current month (dollars)
PDt = World food in the current month (percent)
INFt = Inflation in the current month (percent)
GDPt = GDP in the current month (percent)

Yt-p = Vector of endogenous changes with 2nd lag
MD1Yt-p = World oil in the previous month (dollars)

PD1Yt-p = World food in the previous month (percent)

PD2Yt-p = World food in the previous month (percent)

INF2Yt-p = Inflation in the previous month (percent)

INF3Yt-p = Inflation in the previous month (percent)

GDP3Yt-p = Economic growth in the previous month (percent)

ɤt = error term

To determine impact of shocks in world oil and global food prices on inflation. and economic growth in GDP (Gross Domestic Product et al.) using the VAR (Vector Autoregression) / VECM (Vector Error Correction Model) method. According to study (16), Vector Autoregression is a model in the form of a time series that can analyze the interdependent relationship between economic variables. VECM (Vector Error Correction Model) is a multivariate time series method for data that is not stationary and has cointegration. Cointegration is a linear combination of non-stationary and integrated variables of the same order. The analysis employs the VAR method if each variable demonstrates stationarity at the base level. However, when all variables lack stationarity at the base level but exhibit it at the first difference level, a cointegration test is necessary to ascertain the presence of a long-term relationship should cointegration be established, the method utilized shifts to VECM. Before conducting a cointegration test, it is crucial to determine the optimal and sTable lag length to ensure the validity of the analysis results. This study utilizes the Johannsen cointegration test, generating multiple cointegration equations that formulate a VECM equation model.

Various analyses, including short-term, long-term, and IRF analyses, can be conducted. The IRF serves to examine the response of global oil and global food to inflation and the economic growth of Indonesia

Result and Data Processing

Stationary Test

The values presented in Table 1 reflect the outcomes of the stationarity test conducted on data at the base level. It is evident that none of the variables exhibit stationarity at the base level.

Subsequently, a stationarity test was performed at the first difference level, as illustrated in Table 2, revealing that all data achieves stationarity at the first difference level. This is evidenced by the probability values for all variables being < 0.05 and the ADF (t-statistics) exceeding the critical value, thereby fulfilling the initial requirement for the VAR model. The subsequent step involves determining the optimal lag.

Optimal lag test

To ascertain the impact on each variable within the Vector Error Correction Model (VECM) system, the initial step involves determining the optimal lag. This determination is facilitated through various criteria, one of which is the Akaike Information Criterion (AIC), where the smallest value is considered indicative of the optimal lag. The optimal lag test is conducted using indicators such as Lag Length (LL), Likelihood Ratio (LR), Final Prediction Error (FPE), Akaike Information Criterion (AIC), Hannan-Quinn Information Criterion (HQIC), and Schwarz Bayesian Information Criterion (SBIC), with the optimal lag marked by an asterisk (*) in STATA.

In Table 3 it can be seen that the smallest AIC value is located at lag 1 so it can be concluded that the optimal lag in this model is 1 which is showing the most asterisks, namely Likelihood Ratio (LR), Final Prediction Error (FPE), Akaike Information Criterion (AIC) and Hannan-Quinn Information Criterion (HQIC).

Stability model test

Stability testing is needed to see whether the Impulse Response Function (IRF) and Forecast Error Variance Decomposition (FEVD) estimates in the Vector Error Correction Model (VECM) model are valid. Stability testing is carried out by testing the roots of the polynomial function or VECM estimation is said to be sTable if all roots have a modulus < 1. The results of the stability test can be seen in Table 4 which displays all moduli < 1, so it can be concluded that the estimates in the Vector Error Correction Model (VECM) are sTable.

Table 1: Stationary test on level

Variable	ADF STATISTIC	Mac Kinnon Critical Value			Prob	Information
		1%	5%	10%		
Inflation	-1.576827	-3.501445	-2.892536	-2.583371	0.4904	Not Stationary
GDP	-1.464244	-3.501445	-2.892536	-2.583371	0.5474	Not Stationary
World Oil Prices	-2.530368	-3.502238	-2.892879	-2.583553	0.1116	Not Stationary
World Food Prices	-0.649854	-3.502238	-2.892879	-2.583553	0.8531	Not Stationary

Table 2: First difference stationary test

Variable	ADF STATISTICS	Mac Kinnon Critical Value			Prob	Information
		1%	5%	10%		
Inflation	-8.116381	-3.502238	-2.892879	-2.583553	0,0000	Stasioner
GDP	-10.07831	-3.502238	-2.892879	-2.583553	0,0000	Stasioner
World Oil Prices	-7.527908	-3.503049	-2.893230	-2.583740	0,0000	Stasioner
World Food Prices	-6.394058	-3.502238	-2.892879	-2.583553	0,0000	Stasioner

Table 3 : Determining optimal lag

Lag	LogL	LR	FPE	AIC	SC	HQ
0	596.9840	NA	2.22e-11	-13.17742	-13.06632*	-13.13262*
1	614.0692	32.27192*	2.17e-11*	-13.20154*	-12.64602	-12.97752
2	623.3820	16.76319	2.53e-11	-13.05293	-12.05301	-12.64971
3	638.3188	25.55848	2.60e-11	-13.02931	-11.58497	-12.44687
4	648.9504	17.24682	2.96e-11	-12.91001	-11.02126	-12.14836

VAR lag order selection criteria
Endogenous variables: D(PDB) D(INFLASI) D(MD) D(PD), Exogenous variables: C
Date: 06/22/23 Time: 15:41 Sample: 2, 015M01 2022M11
Included observations: 90,
*indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level), FPE: Final prediction error

Table 4: Stability test

Roots of characteristic polynomial endogenous variables: D(PDB) D(INFLASI) D(MD) D(PD)
Exogenous variables: C Lag specification: 1 1
Date: 06/22/23   Time: 15:42

Root	Modulus
0.305147	0.305147
0.234646 - 0.015254i	0.235141
0.234646 + 0.015254i	0.235141
-0.208213	0.208213

No root lies outside the unit circle. VAR satisfies the stability condition.

Table 5: Co integration test

Date: 06/22/23   Time: 15:45
Sample (adjusted): 2015M04 2022M11 Included observations: 92 after adjustments Trend assumption: Linear deterministic trend Series: D(PDB) D(INFLASI) D(MD) D(PD)

Lags interval (in first differences): 1 to 1

Unrestricted cointegration rank test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statis tic	0.05 Critical Value	Prob.**
None *	0.453335	159.1720	47.85613	0.0000
At most 1 *	0.417245	103.6114	29.79707	0.0000
At most 2 *	0.274201	53.93243	15.49471	0.0000
At most 3 *	0.233361	24.44807	3.841465	0.0000

Trace test indicates 4 cointegrating eqn(s) at the 0.05 level
* Denotes rejection of the hypothesis at the 0.05 level

Table 6: Granger causality test

Pairwise Granger Causality Tests Date: 08/19/23
Time:18:43
Sam ple: 2015M01 2022M11
Lags: 1

Null Hypothesis	Obs	F-Statis tic	Prob.
MD does not Granger Cause INFLASI	94	20.4351	2.E-05
INFLASI does not Granger Cause MD		3.13999	0.0797
PD does not Granger Cause INFLASI	94	12.6998	0.0006
INFLASI does not Granger Cause PD		25.4686	
			k2.E-06
PDB does not Granger Cause INFLASI	94	2.41428	0.1237
INFLASI does not Granger Cause PDB		0.50385	0.4796
PD does not Granger Cause MD	94	6.82166	0.0105
MD does not Granger Cause PD		3.22748	0.0757
PDB does not Granger Cause MD	94	1.26771	0.2632
MD does not Granger Cause PDB		0.72636	0.3963
PDB does not Granger Cause PD	94	1.82028	0.1806
PD does not Granger Cause PDB		2.43101	0.1224

**MacKinnon-Haug-Michelis (1999) p-values

Co integration test

The Cointegration Test is carried out to determine the existence of a long-term relationship between variables. In the presence of cointegration, the subsequent analysis uses (VECM). However, when cointegration does not occur then proceed with the VAR First Difference estimation. The criteria used when carrying out cointegration tests are use. Johansen Cointegration Test. The model is said to be cointegrated if the trace statistic value > critical value.

Based on Table 5, it shows that at a 5% confidence interval all equations have a trace statistical value > critical value. So it can be concluded that there are three cointegrations so it can be interpreted that there is a long-term relationship between variables.

Granger causality test

This Granger causality test is to determine whether or not there is a causal relationship between the variables in the model to see the relationship between the variables (Table 6).

World oil price toward inflation

In the Table it can be seen that there is an indication of a 1-way relationship between world oil prices and inflation. This is indicated by the probability value of world oil prices < alpha, namely 0.00002 < 0.005. It can be concluded that Changes in world oil prices have an influence on inflation in Indonesia.

Inflation towards food price fluctuation

In the Table it can be seen that there is an indication of a two-way relationship between world food prices and inflation, this is indicated by the probability value <alpha, namely 0.0006 <0.05. So it can be concluded that changes in world food prices have an influence on inflation in Indonesia. This research is in line with research conducted by Ilmia *et al.* which found that shocks to world food received the fastest and strongest response from inflation. Therefore, it can be inferred that inflation is highly susceptible to changes in food prices.

Inflation towards world food prices

In the Table it can be seen that there is an indication of a two-way relationship between inflation and world food prices, this is indicated by the probability value <alpha, namely 0.00002 <0.05. According to CNBC Indonesia, it can be concluded that changes in inflation have an influence on world food prices in Indonesia.

Indonesian food prices this year have been heavily impacted by extreme climate change, export restrictions and the impact of the Russia-Ukraine war. This big impact is reflected in the fast rate of volatile price inflation (volatile items), which is dominated by foodstuffs. This condition is of course a burden on Indonesian society and households, where the majority of living expenses are for consuming food.

World food prices toward oil price in Indonesia

In the Table it can be seen that there is an indication of a unidirectional relationship between world food prices and world oil prices, this is indicated by the probability value <alpha, namely 0.001 <0.05. So it can be concluded that changes in world food prices have an influence on world oil in Indonesia. This research is in line with research conducted (17). The increase in food commodity prices has attracted the attention of policy makers throughout the world in recent years. As a country that imports crude oil, Indonesia is vulnerable to fluctuations in food prices because fluctuations in crude oil prices can affect prices food commodities directly through agricultural production inputs such as fertilizer and transportation, and indirectly through increasing biofuel production. Crude oil prices are considered to be the main factor influencing food price fluctuations.

Impulse response function test (IRF)
Inflation response to world oil shocks

The purpose of the Impulse Response Function (IRF) is to see the effect of shocks from variables on the present value and the value coming from the model (18). In this study, the results of the IRF test are displayed in graphical form which is explained over the next 24 months of the research period. The outcomes from the Impulse Response Function analysis of inflation in response to the world oil price shock indicate that in the initial period, inflation has not exhibited a response. However, in the second period inflation responded positively to world oil price shocks, namely 0.015. This positive influence continues to increase in the third to eighth periods. Furthermore, there is no visible sign of long-term changes in world oil prices so that they have reached equilibrium until the 24th period.

Economic growth towards world oil shocks

The outcomes of the Impulse Response Function of economic growth to the shock of world oil prices in the first period appear to have not been responded to by economic growth. However, in the second period economic growth responded positively due to world oil price shocks, namely 0.0036. This positive influence fluctuated until the 10th period. And reached stability after the 10th period.

Inflation towards world food shock

The outcomes of the Impulse Response Function of inflation regarding the shock of world food prices in the first period have not been responded to by inflation. However, in the second period there was a positive response from inflation of 0.0081. This influence increased in the third to eighth periods and reached stability after the 24th period.

Economic growth towards world food shock

The outcomes of the Impulse Response Function of economic growth to world food shocks in the first period were not responded to by economic growth. However, in the second period the response was positive by economic growth of 0.000098. This influence increased until the 12th period and reached stability after the 12th period.

Based on all tests in the data processing, the findings can be drawn in accordance with the objectives of this study, namely:

1. World oil prices exhibit a one-way causality connection to inflation.
2. World food prices demonstrate a two-way causality relationship with inflation.
3. Inflation shows a two-way causality relationship with world food prices, and world food prices have a one-way causality relationship with world oil prices.

Discussion

From the results of using the VAR/VECM model, it is found that world oil prices have a significant influence on inflation in Indonesia. So the results of this research are in line with research conducted not only in Indonesia but also in other countries, for examples, in USA (19, 20). In Ghana, a study (21) found that the causality findings indicated a one-way link from oil prices to inflation, implying that changes in oil prices are a Granger cause of inflation. Findings by Purnomo (22), which found that world oil prices have a positive influence on inflation in Indonesia.

However, surprisingly the research found a negative response from inflation to world food price shocks. This study aligns with the findings of prior research conducted (23), which concluded that the independent variable holds a significant influence when the probability (Prob.) value is lower than the chosen alpha significance level. The food ingredient variables that have a significant effect are onions, rice, garlic, chicken, beef, granulated sugar and cooking oil. Garlic, chicken, and granulated sugar as food components contribute positively to inflation. The inflation is projected to increase with a 1% elevation in the prices of garlic, chicken meat, and granulated sugar. Research conducted (24) and found that food prices have a direct impact on inflation because food is consumed directly by consumers. By Utilizing time series methods on a dataset comprising 259 monthly observations spanning from September 1990 to March 2012, (25) discovered considerable and statistically significant long-term partial elasticities concerning domestic food price inflation in relation to global food commodity prices in UK. This is in accordance with this research.

Another finding of this study is the oil prices and economic growth do not have a significant effect in the short term on economic growth in Indonesia. Obtained evidence, by means of a time-varying VAR, that the impact of the oil price shock on GDP growth has declined over time in Spain (26). However, this is in line with research conducted (27) which found that price fluctuations of world oil have a positive but not significant influence on economic growth. This study is accordance with the study (28) found that the shocks in oil prices exert a direct influence on economic growth, particularly when the economy heavily relies on revenue from oil exports. The study conducted in Russia from 1990 to 2015. This research has similar results with study findings the fluctuations in the actual price of crude oil positively impact real GDP and various other factors in distinct ways (6).

The results using the VAR/VECM model show that world food price has an insignificant influence in the short term on economic growth in Indonesia.

The results pertaining to this investigation imply that the government should pay more attention to

keep the stability in food prices in Indonesia due to the price oil shocks and world food prices. Not only have to consider about the price oil shocks and world food prices but also the rate of inflation in Indonesia. For further research, the use of data with a longer period of time is highly recommended.

Conclusions

The conclusions of this study
1. World oil prices exhibit a one-way causality connection to inflation.
2. World food prices demonstrate a two-way causality relationship with inflation.
3. Inflation shows a two-way causality relationship with world food prices, and world food prices have a one-way causality relationship with world oil prices.

Abbreviations

VECM: Vector Error Correction Model,
IRF: Impulse Response Function Test,
LL: Lag Length,
LR: Likelihood Ratio,
FPE: Final Prediction Error,
AIC: Akaike Information Criterion,
HQIC: Hannan-Quinn Information Criterion,
SBIC: Schwarz Bayesian Information Criterion.

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Author contribution

This research was carried out by a team of writers with contributions according to their respective duties.

Conflict of interest

There is no conflict of interest in the conduct of this research.

Ethics approval

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