EXAMINING THE EFFECT OF GDP GROWTH ON ENERGY CONSUMPTION DURING HIGH AND LOW GROWTH PERIODS OF ASIAN COUNTRIES

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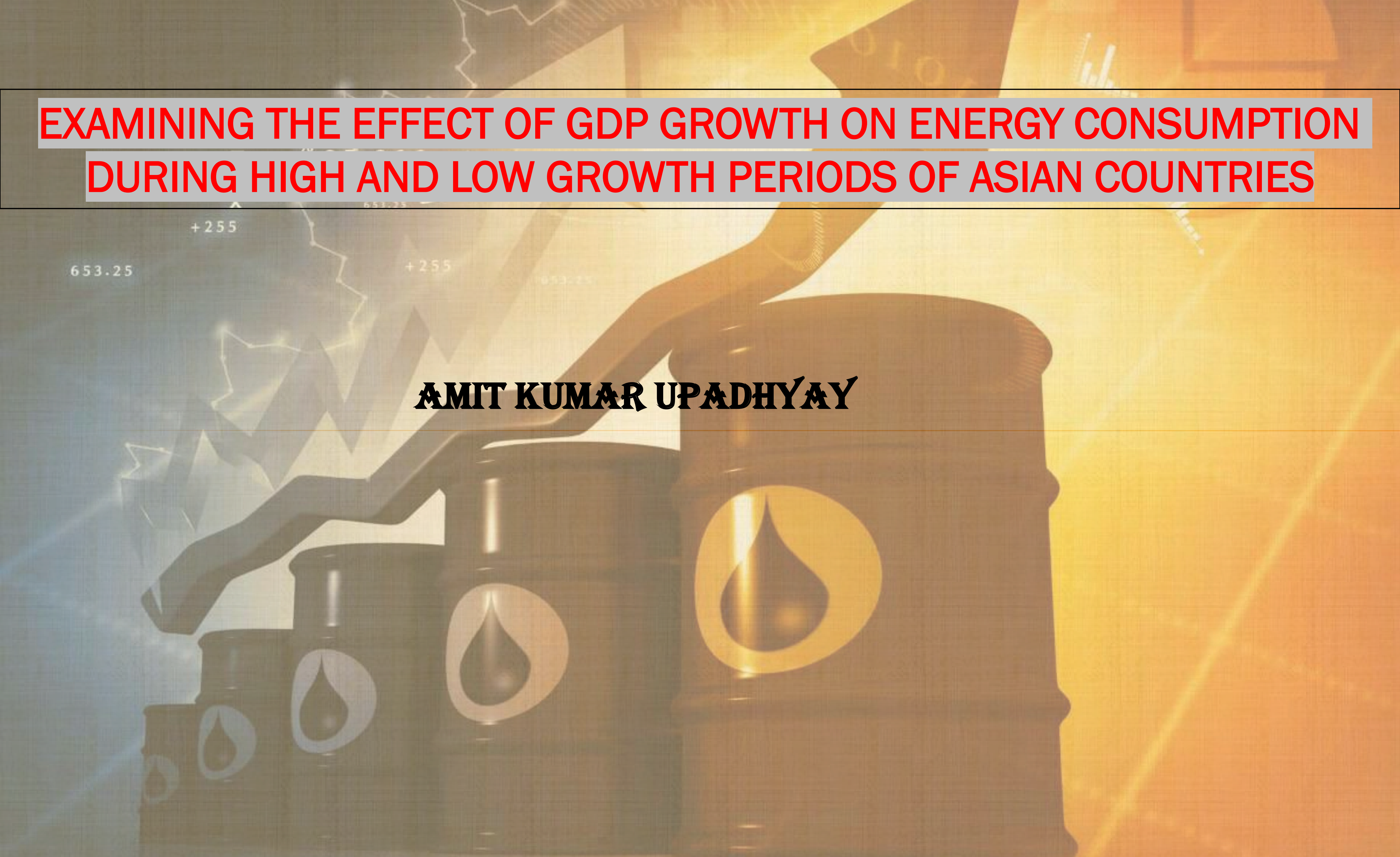


- We live in an era dominated by energy. From powering our houses to enabling transportation, communication, and innovation, energy has become a significant force driving our daily activities.

- On the other hand, GDP growth profoundly impacts our lives. It influences job opportunities, income level, and overall economic well-being.

- Higher growth rates can enhance living standards, while slower rates may lead to challenges such as unemployment and reduced purchasing power.

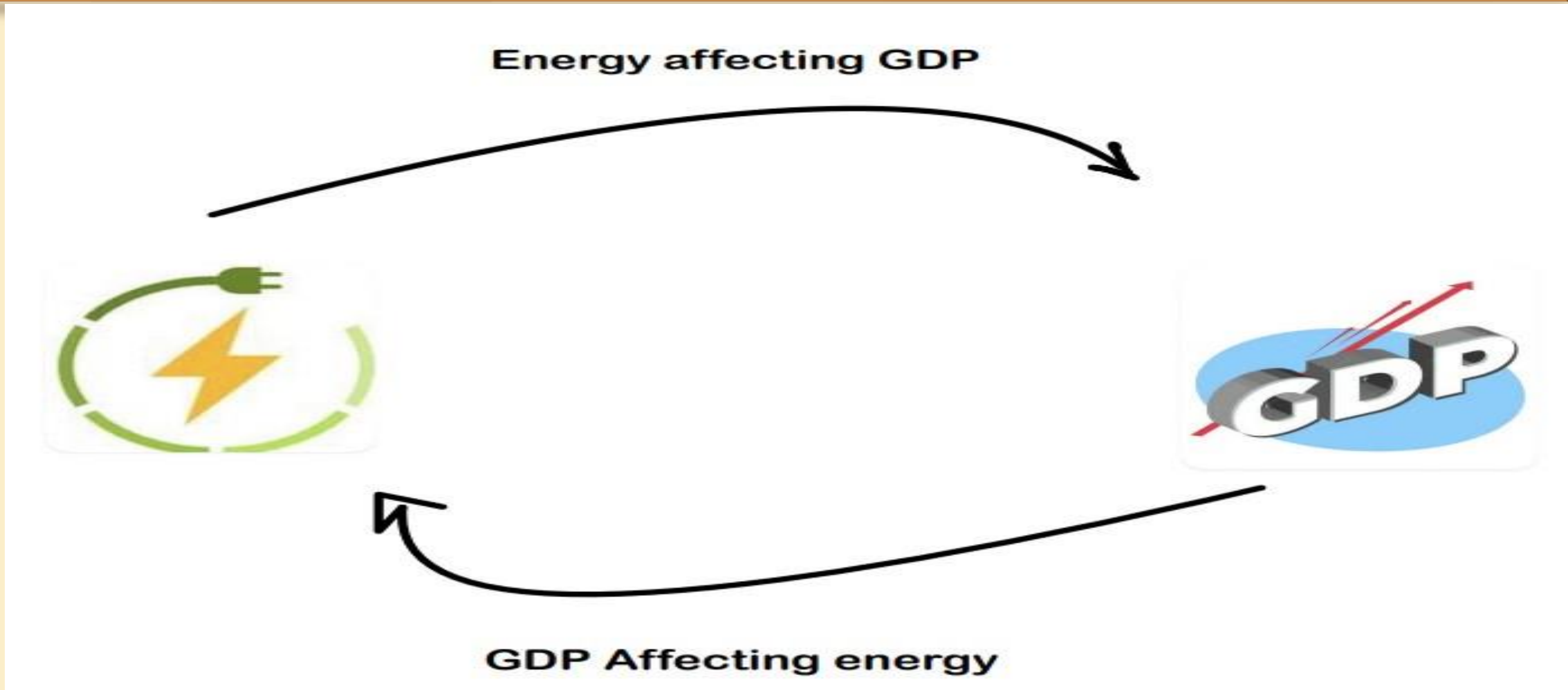
- Since every country wants economic prosperity for high-quality life and energy has become one of the vital components for Economic growth

- The study of the correlation between GDP growth and energy consumption is essential for informed policymaking, enabling a deeper understanding of environmental implications and facilitating the development of effective energy management strategies that promote sustainable economic growth.

INTRODUCTION

- In the past, earlier economists did not assign much importance to energy's role in the economic development process. However, significant efforts have been made to explore the precise relationship between energy and other production factors.
- As industrialization, innovation & globalization increased, they started considering energy as a factor of growth
- Numerous efforts have been undertaken in the past to examine the causal relationship between energy consumption and the economic development of various economies.

Causal relationship :

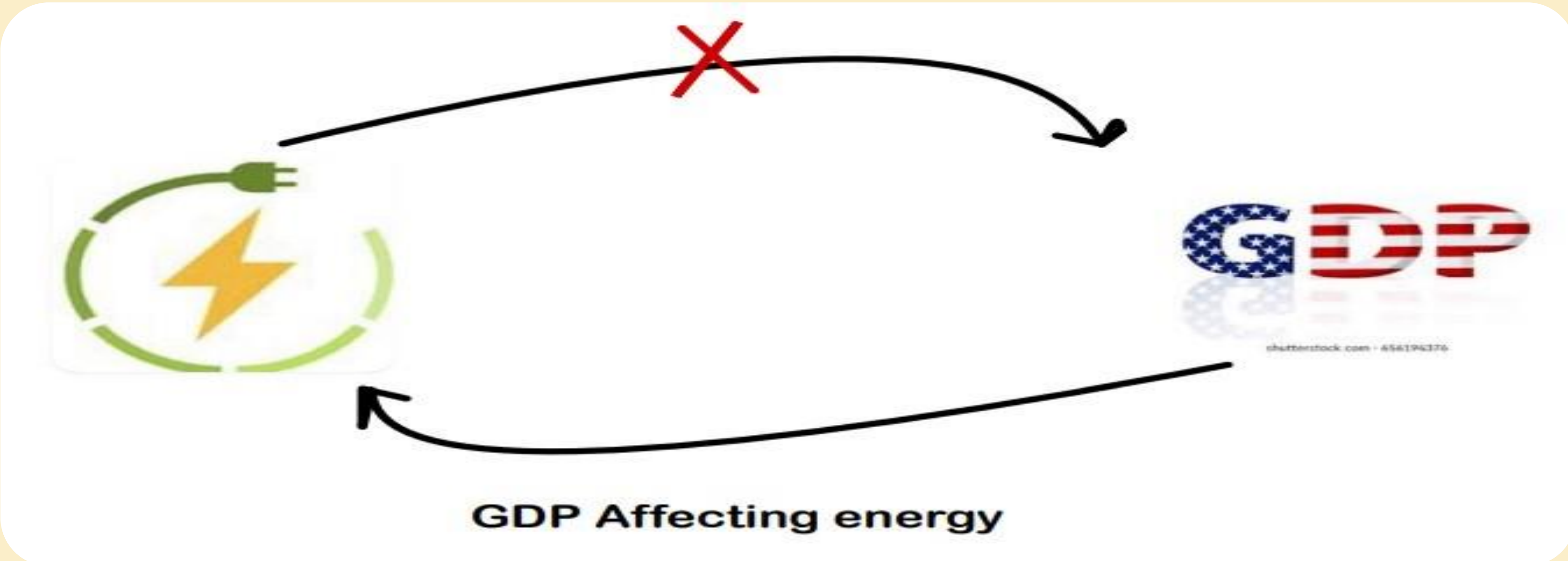


- **In 1978 Kraft published a remarkable paper on this causal relationship between energy & GDP found unidirectional causality running from GNP to energy consumption for the United States**

- After this at different time periods, researchers have analyzed causality for different countries

- Some researchers have found a causality between economic growth to energy consumption

- whereas some have found a causality running from energy consumption to economic growth.



- **Only a limited number of studies have been conducted to investigate the relationship between energy consumption and economic development during both high-growth and low-growth periods.**

OBJECTIVE OF OUR STUDY :

- The objective of our study is to investigate the impact of economic growth on energy consumption during both high and low-growth periods in some developed and developing ASIAN countries.
- In order to examine the impact of GDP growth on energy consumption, we will employ a time series model and analyze the coefficients of the equation.

- Our hunch is , if GDP will grow, then people's income will grow and so energy consumption will grow

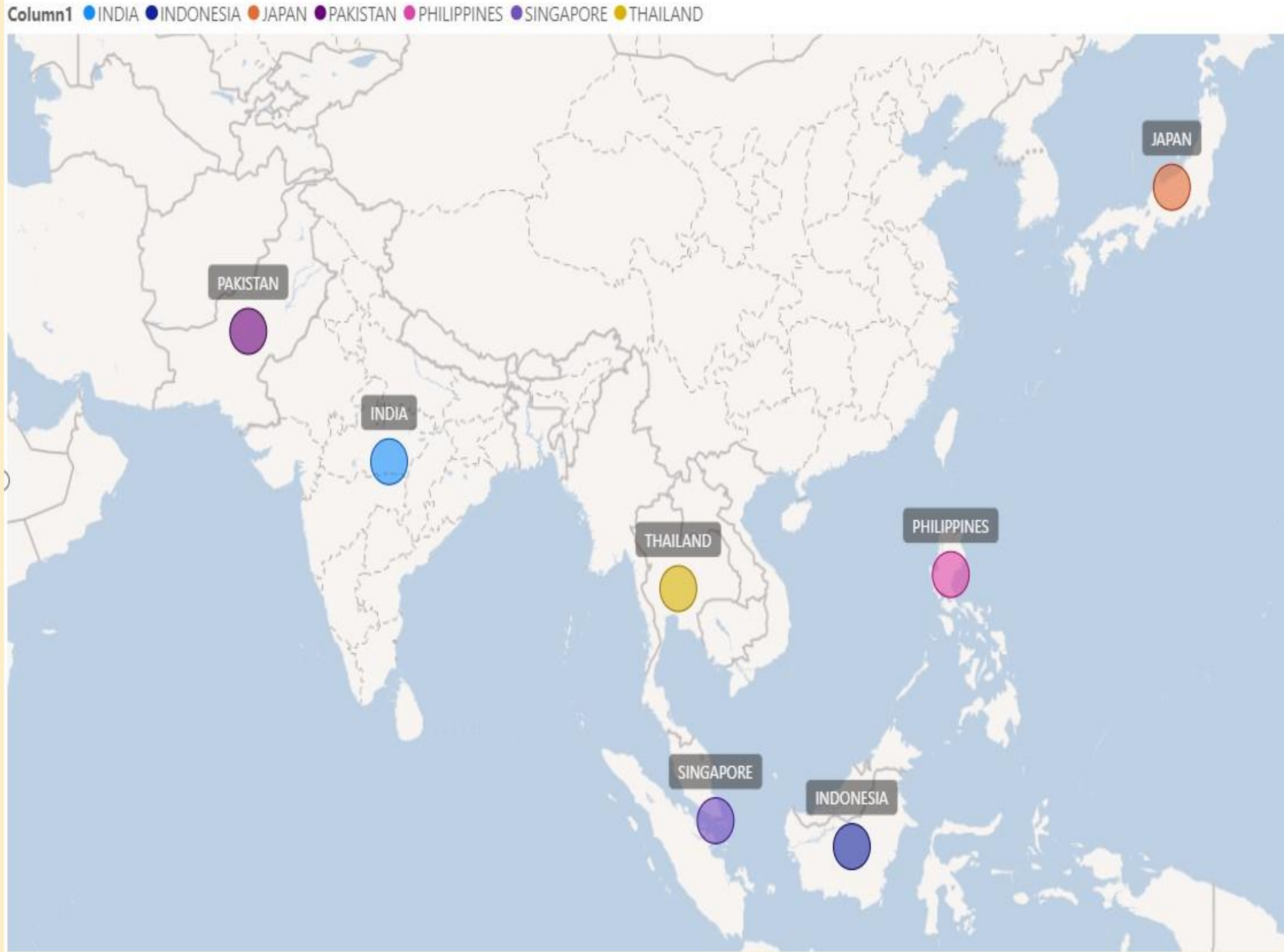
COUNTRIES CHOOSEN

➢ DEVELOPING COUNTRIES

- THAILAND
- INDIA
- INDONESIA
- PHILIPPINES
- PAKISTAN

➢ DEVELOPED COUNTRIES

- JAPAN
- SINGAPORE



➢ The selection of these developed & developing offer a diverse representation of economic, social, and geographical factors in the Asian region. This allows for a comprehensive analysis of how GDP growth affects energy consumption patterns across different stages of economic development.

Our model :

EXPLANATORY VARIABLE → G.D.P GROWTH

RESPONSE VARIABLE → ECONOMIC GROWTH

Persistence component of Energy(if any)

ENERGY GROWTH = ___ + ECONOMIC GROWTH

High growth

Low growth

GDP

- GDP serves as an indicator of income by reflecting the overall economic output within a country. As GDP represents the total value of goods and services produced, it provides insight into the level of economic activity and the potential income generated for individuals and businesses within the economy.
- GDP growth refers to the increase in the value of goods and services produced within an economy over a specific period, indicating the rate of economic expansion.
- GDP growth in real terms accounts for inflation and provides a more accurate measure of economic expansion. Calculating it at a constant rate allows for meaningful comparisons over time, by eliminating the impact of price changes, it has been calculated at a constant price of 2010 (USD)

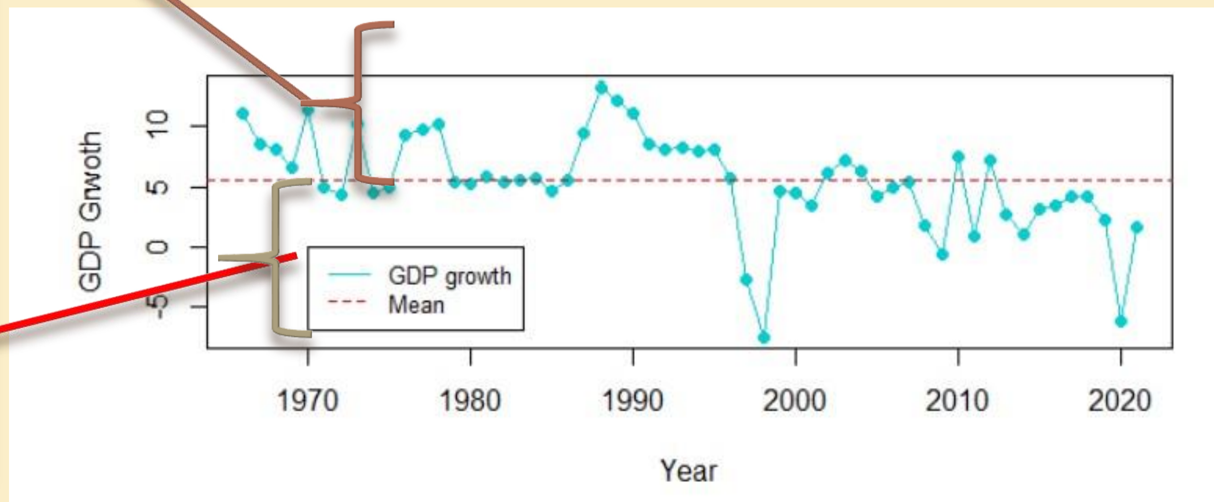
$$\text{Real GDP Formula} = \frac{\text{Nominal GDP}}{\text{Deflator}}$$

➢ <u>HIGH GROWTH GDP</u> :

High growth refers to growth rates that exceed the mean growth rate.

➢ <u>LOW GROWTH GDP :</u>

Low growth refers to growth rates that are below the mean growth rate.



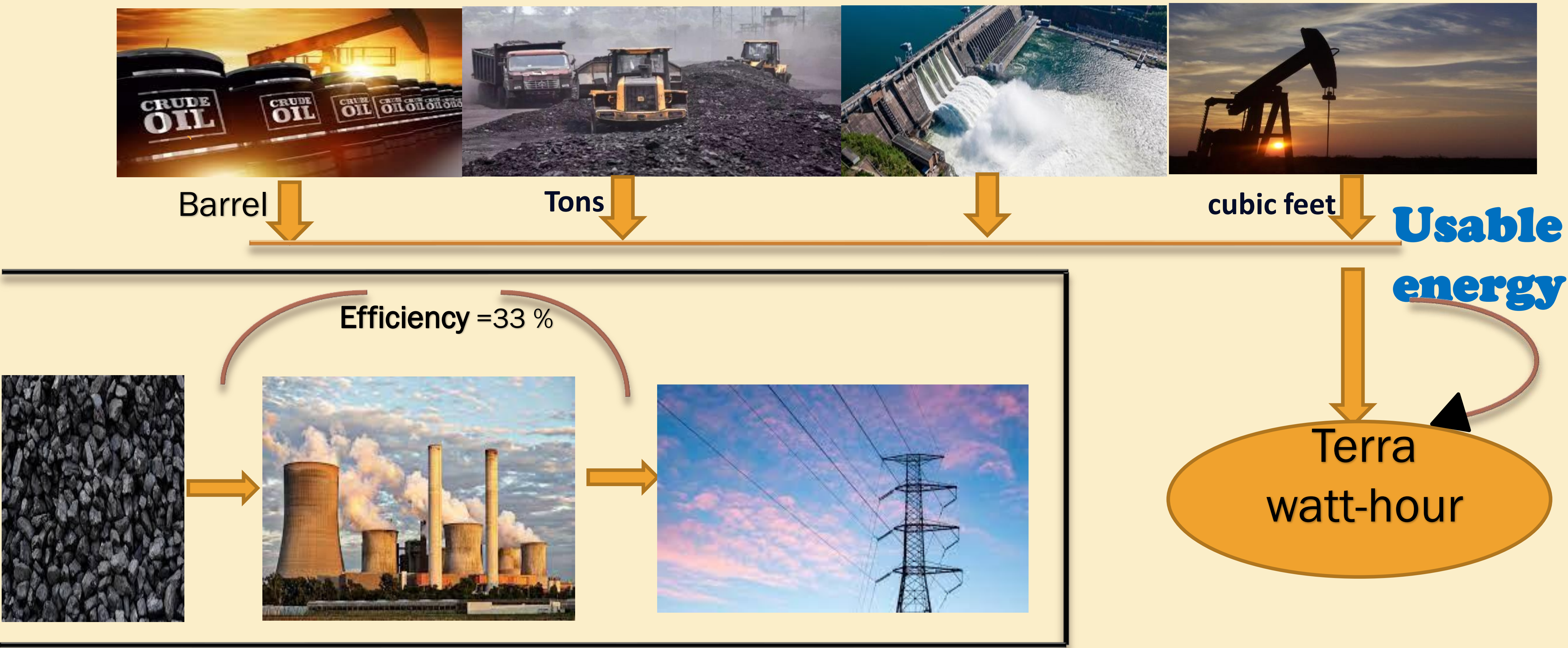
ENERGY CONSUMPTION

- Energy consumption data included electricity, transport, and heating, calculated using the ”substitution method” accounting for energy waste as heat during combustion. To ensure consistency, energy data was converted to terawatt-hours

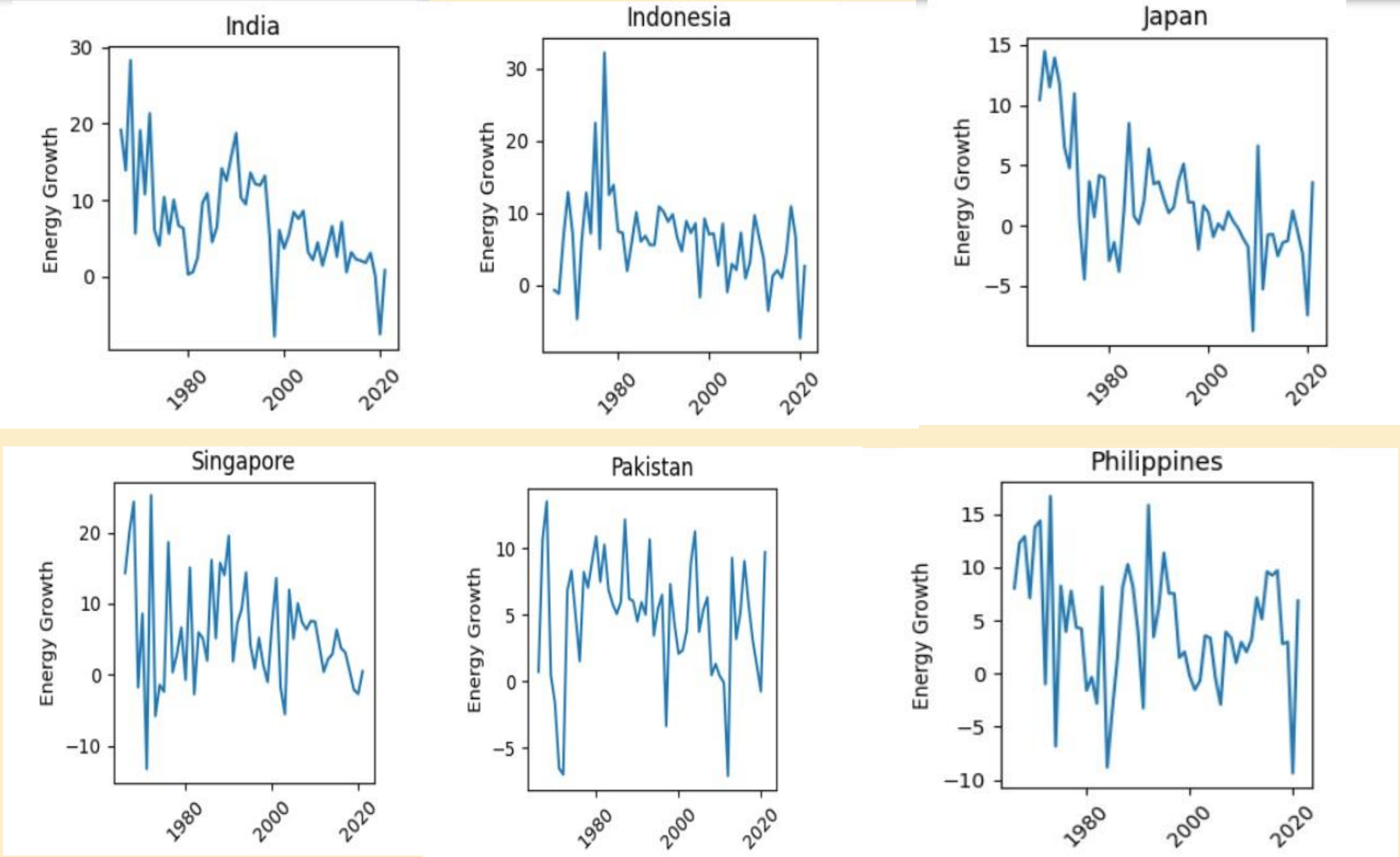
- **Energy growth can be calculated by subtracting the current year's energy consumption from the previous year's consumption and dividing it by the previous year's consumption.**

Energy data :

Since energy source like coal, oil, etc., is measured in different units .to ensure consistency, energy data was converted to terawatt-hours.



- When we burn fuel in a thermal power plant most of the energy we put into the process is lost – primarily in the form of heat. Most fossil fuel plants run with an efficiency of around 33% to 40%. The remaining 60% to 67% of energy is wasted as heat



India
Energy Growth
30
20
10
0
1980
2000
2020
Indonesia
Energy Growth
30
20
10
0
1980
2000
2020
Japan
Energy Growth
15
10
5
0
−5
1980
2000
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Singapore
Energy Growth
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−10
1980
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Pakistan
Energy Growth
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Philippines
Energy Growth
15
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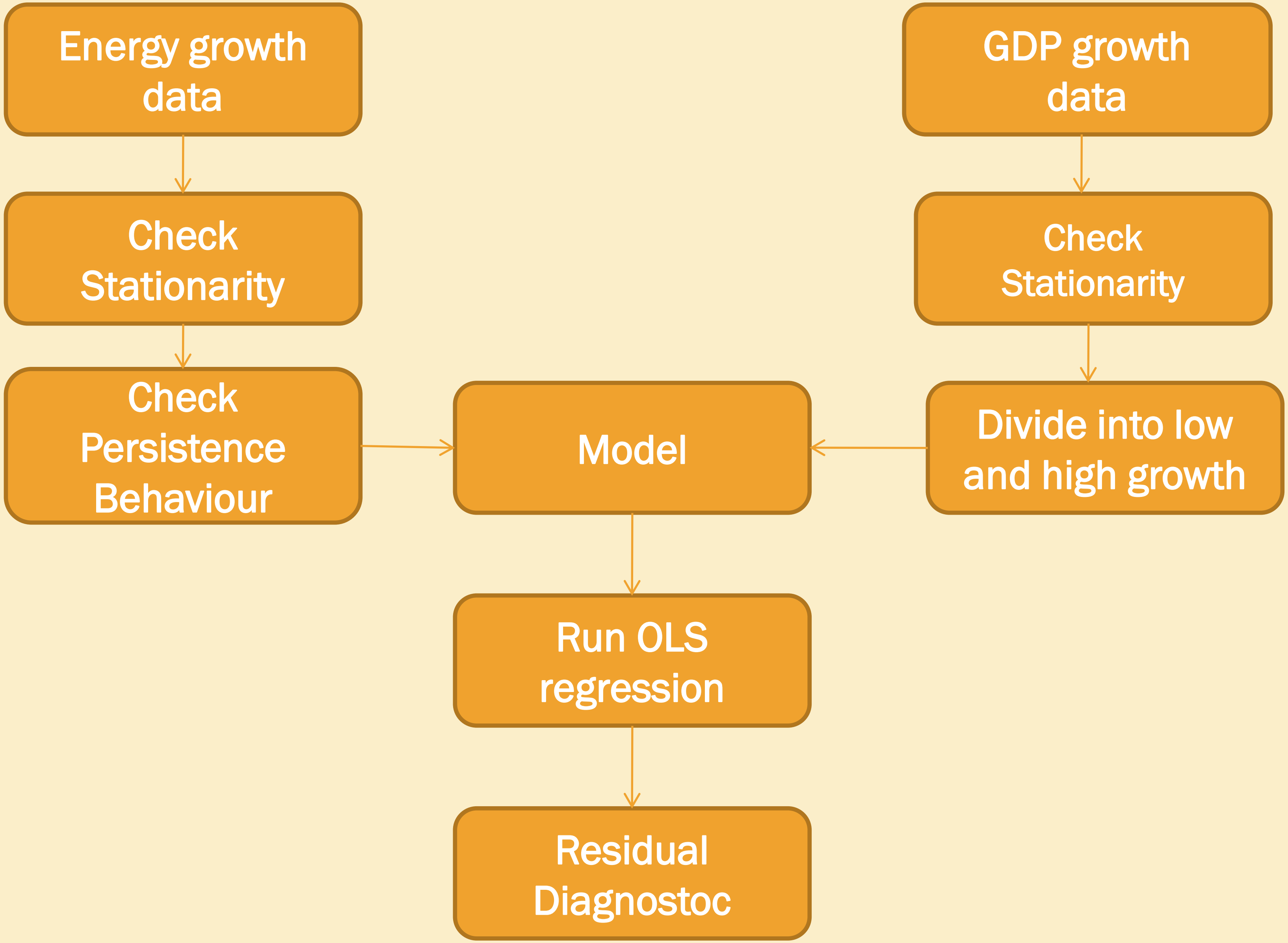
1980
2000
2020

PROCEDURE


Energy growth data
Check Stationarity
Check Persistence Behaviour
GDP growth data
Check Stationarity
Divide into low and high growth
Model
Run OLS regression
Residual Diagnostoc

STATIONARITY

- Before applying the statistical model to time series data, it is crucial to determine whether the data is stationary.

- A stationary time series is one whose properties do not depend upon the time at which the series is observed.
- To check the stationarity of a given time series data, we use Augmented Dickey-Fuller (ADF) test.
- The hypothesis for ADF test is

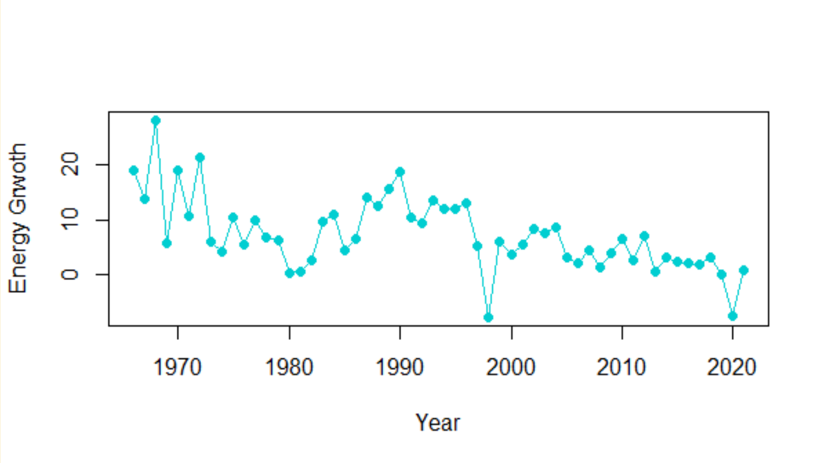
$$H_0 : \gamma = 0 \text{ (The data is not Stationary)}$$

$$H_1 : \gamma \neq 0 \text{ (The data is Stationary)}$$

THAILAND

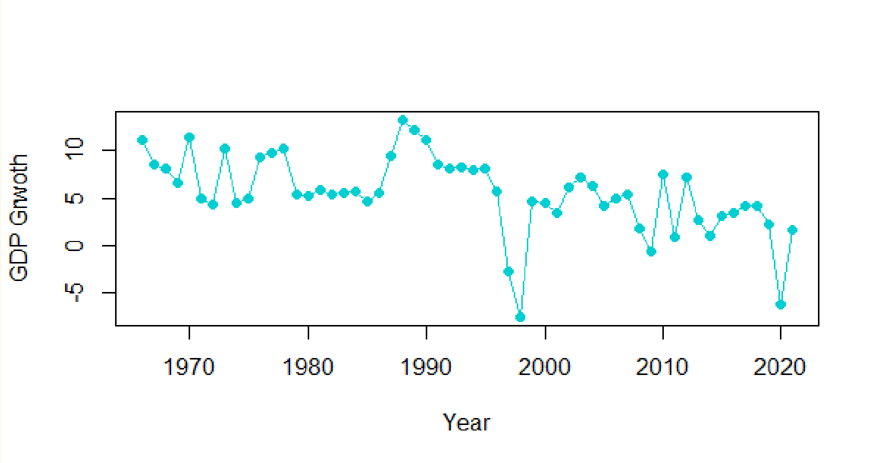
ENERGY CONSUMPTION

From the ADF test, the test statistic obtained for the growth data of energy consumption is -3.8462 and the critical value at 5% level of significance is -3.45, this implies that the data



GDP GROWTH

The ADF test statistic for GDP growth data is -3.4356 and the critical value at 10% level of significance is -3.15, this implies that the data is stationary with 10% level of significance.



- For all other countries we got stationarity

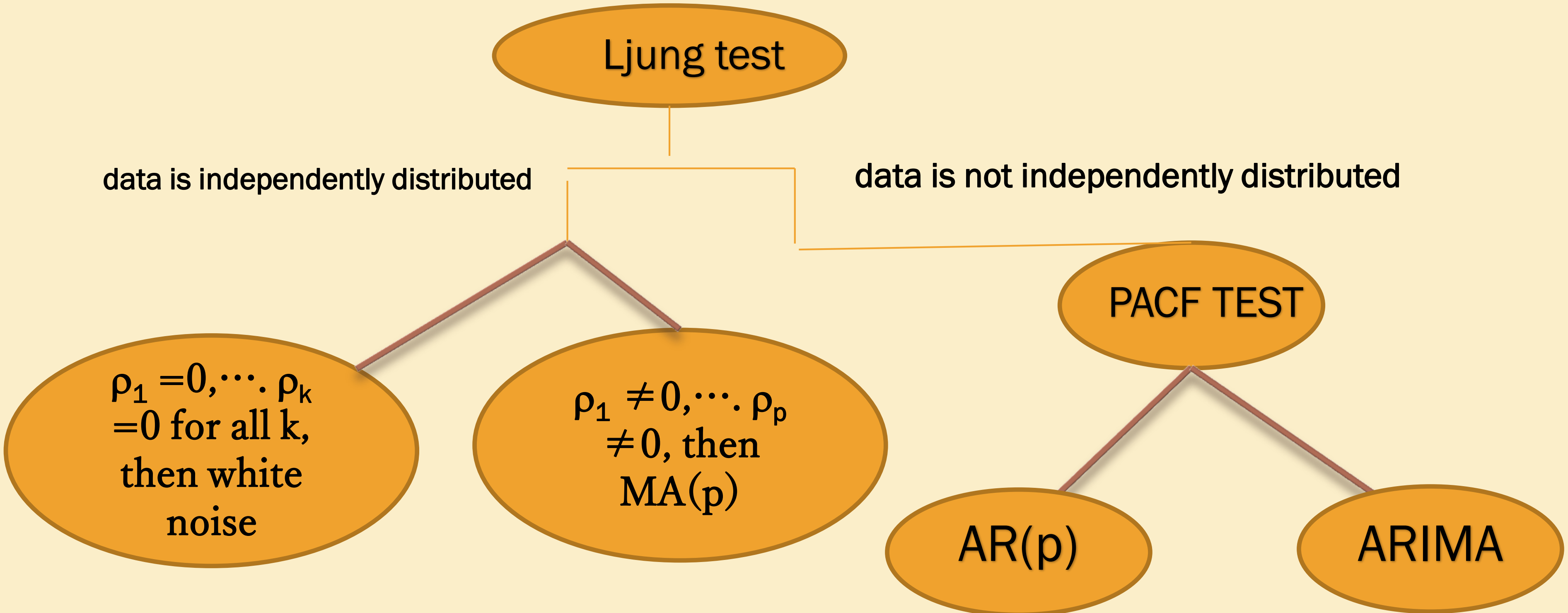
STATIONARITY

PERSISTENCE

PERSISTENCE COMPONENT

- After getting the Stationary Series, we will check for the persistent behavior of our the dependent variable, i.e. we will find till what lag the variable depends.

➢ We will do the Ljung-Box test and PACF test to find the persistence component



PERSISTENCE COMPONENT

- After getting Stationary Series, we will check for the persistence behaviour of our dependent variable, i.e. we will find till what lag the variable depends.

- We will do Ljung-Box test and PACF test to find the persistence component..

- Ljung Box test evaluates whether any auto-correlation values of the time series differs from zero.

- The hypothesis of the Ljung-Box test is

$H_0 : \rho_1 = \rho_2 = . . . = \rho_k = 0$ (The data is independently distributed)

H_1 : at least one $\rho \neq 0$ (The data is not independently distributed)

- The PACF provides the partial correlation of a stationary time series with its own lagged value, aiming to identify the extent of lag in an autoregressive model.

- The hypothesis of the sample partial correlation test is given by:

$H0 : \tau_1 = \tau_2 = . . . = \tau_k = 0$

$H1$: at least one $\tau \neq 0$

Thailand

- From Ljung Box test, the p-value obtained for different lags is less than 0.05, so we reject null hypothesis, i.e. the data is not independently distributed.

K	ACF	Q-statistic	P-value
5	0.296	36.97	6.06e-07
10	-0.033	41.08	1.09e-05
15	-0.123	42.63	1.79e-04

- From PACF test, the test statistic till lag 2 is greater than 1.96, so we can conclude that energy consumption growth depends on past 2 lags, thus it follows an AR(2) process.

K	PACF	Test Statistic	Normal at 0.05
1	0.448	3.357	1.96
2	0.344	2.56	1.96
3	-0.073	-0.55	1.96
5	0.030	0.225	1.96

Table of the model of presentence behavior of energy consumption :

Country	Persistence Component
Thailand	AR(2)
India	No persistence component
Indonesia	No persistence component
Philippines	No persistence component
Pakistan	No persistence component
Japan	AR(1)
Singapore	No persistence component

STATIONARITY

↓

PERSISTENCE

↓

High , Low growth

↓

Model

ENERGY GROWTH = $\sqcup$ + ECONOMIC GROWTH

High growth

Low growth

Persistence component of Energy(if any)

Will use the Indicator function to incorporate high-growth & low growth

ENERGY GROWTH = $\sqcup$ + I * (Low growth) + (1 - I) * (High growth)

(GDP)

I is Indicator function

$$I = \begin{cases} 1: \text{Low growth} \\ 0: \text{other wise} \end{cases}$$

At low growth, this part will get activated

At high growth, this part will get activated

Previously we get to knew that Thailand's persistence behavior follows AR(2) Model

Model

ENERGY GROWTH $= \Phi_0 + \phi_1 * Energy_{t-1} + \phi_2 * Energy_{t-2}$ + GDP

ENERGY GROWTH = $\quad + I * (\Phi^l_0 + \Phi^l_1 *$ GDP GROWTH$)$

$(1 - I) * (\Phi^h_0 + \Phi^h_1 *$ GDP GROWTH $)$

Thus the model for Thailand is

The model obtained is

$$y_t = (\alpha_0^l + \alpha_1^l y_{t-1}^l + \alpha_2^l y_{t-2}^l + \beta_{gdp}^l x_t^l) I(.) + (\alpha_0^h + \alpha_1^h y_{t-1}^h + \alpha_2^h y_{t-2}^h + \beta_{gdp}^h x_t^h)(1 - I(.))$$

0	0	0	0	1	13.89	19.17	8.12
0	0	0	0	1	28.29	13.89	6.55
0	0	0	0	1	5.61	28.29	11.41
1	19.12	5.61	4.89	0	0	0	0
1	10.76	19.12	4.27	0	0	0	0
0	0	0	0	1	21.35	10.76	10.23

X matrix for Thailand for 6 observations

Where

$$I(.) = \begin{cases} 1, & when\ x_t\ belongs\ to\ low\ growth \\ 0, & when\ x_t\ belongs\ to\ high\ growth \end{cases}$$

y_t^l : $energy\ growth\ data\ during\ low\ growth$

y_t^h : $energy\ growth\ data\ during\ high\ growth$

x_t^l : $gdp\ growth\ data\ during\ low\ growth$

x_t^h : $gdp\ growth\ data\ during\ low\ growth$

After running the OLS regression, we get the following statistics and p-value

α^l_0	α^h_0	β^l_{gdp}	β^h_{gdp}
2.704 (1.622)	-5.294 (4.095)	-0.022 (0.403)	1.066* (0.531)

* indicates the significance at a 10% level of significance

RESIDUAL DIAGNOSTIC

- Residuals are useful in checking whether a model has adequately captured the information in the data.
- A good forecasting method will yield residuals with the following properties:

  1. The residuals are uncorrelated. If there are correlations between residuals, then there is information left in the residuals which should be used in computing forecasts.
  2. The residuals have zero mean. If the residuals have a mean other than zero, then the forecasts are biased.

- For residual diagnostic, we do the ADF test with the residual data and check whether there exist significant correlation or not.

From the residual diagnostic of the error, we found that the p-value of the test for different lags is greater than 0.05, thus we cannot reject the null hypothesis, i.e. the data is independently distributed.

K	Q-Statistic	p-value
5	2.635	0.75
10	10.057	0.43
15	11.944	0.68

Since the error follows white noise, this means our model is adequate.

OLS results for all countries is given in the table below

Country	α^l_0	α^h_0	β^l_{gdp}	β^h_{gdp}
Thailand	2.704 (1.622)	-5.294 (4.095)	-0.022 (0.403)	1.066* (0.531)
India	3.034*** (0.722)	6.201 (2.895)	0.260* (0.193)	-0.0185 (0.3987)
Indonesia	2.099 (1.494)	-0.193 (5.849)	0.491 (0.303)	1.181 (0.821)
Philippines	0.202 (1.175)	2.009 (4.412)	0.763* (0.286)	0.710 (0.745)
Pakistan	-2.344 (1.669)	6.585* (3.356)	1.749* (0.488)	-0.002 (0.492)
Japan	1.133* (0.528)	0.399 (1.379)	-0.117 (0.333)	0.912** (0.323)
Singapore	3.719* (2.137)	0.025 (6.356)	-0.397 (0.482)	0.826 (0.608)

*,**,*** indicates significance at 10%, 5%, 1% level of significance and the numbers inside parenthesis indicate standard error.

CONCLUSION :

- We had a hunch that, as income increases people will consume more energy
- From coefficients, we can see that there is no such pattern of energy consumption
- To understand more about this, a future investigation requires country wise
- Generally researchers have taken a linear relationship between these two but here we can see beta coefficient of GDP growth is different of high & low growth periods, so we can conclude that there is an effect of regime change in this relation.