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King Abdullah Petroleum Studies and Research Center

The Role of Renewable Energy and Economic Structure in Import Demand for Petrochemicals

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The Third ERF GCC Conference - GCC Economies in an Era of Energy Transition

KAPSARC

October 30-31, 2023

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Background and Motivation

Energy transition from hydrocarbon to renewables plays a crucial role in achieving SDGs:

Goal 7 – Affordable and Clean Energy and
Goal 13 – Climate Action. Sustainable Development Goals

This transition may raise some essential opportunities for hydrocarbon-based economies

Projected growth in renewable manufacturing, solar panels and wind turbines, will induce growth in petrochemicals (IEA, 2018; Korniejenko et al, 2021; WEO, 2022)**.**

The IEA projects by 2040 (WEO, 2019):

Non-combustion demand for oil (e.g., as a feedstock for Petrochemicals) to lead energy consumption.
Petrochemicals demand for feedstocks to rise by 41% and 29%, in STEP and SD scenarios.

Industrialization creates higher demand for petrochemicals (e.g., plastics and rubber)

Automobiles, Electrical and Electronics, Healthcare, Textiles, Food processing, Packaging (Guo et al., 2023; Giannikopoulos et al., 2022; Raj et al., 2021; Halawani and Al Dabbagh, 2020; Mangaraj et al., 2019; The Future of Petrochemicals, IEA, 2018).

Aim and Merits

This study aims at investigating
the impacts of the renewables and economic structure on petrochemicals imports
in the developing economies
to suggest policy insights that could be useful for both importing and exporting countries

Merits of the Study:

Considers not only economic factors, but also renewable transition for petrochemical imports.

Addresses the main issues of the panel data, namely non-stationarity, cross-sectional dependence, and heterogeneity.

Conducts not only a pooled analysis of all countries, but also individual analysis for each country.

Theoretical Framework and Empirical Model

The theoretical underpinning of our study is the international trade theories

E.g., Leamer and Stern (1970), Goldstein and Khan (1985), Rose and Yellen (1989) and Rose (1990).

$$\boldsymbol{M = f(Y, PR\ )}$$

Extending theoretical model with the interested variables - the combination of theory-driven with data-driven approaches

Widely used and even suggested for empirical studies by seminal scholars (see e.g., Hendry, 2018; Castle and Hendry, 2017, 2019; Hendry and Johansen, 2008; Juselius, 2006, 2011; Campos et al., 2005)

$$\boldsymbol{ln(MP_{it}) = \alpha_{0_i} + \alpha_{1_i} ln(Y_{it}) + \alpha_{2_i} ln(PR_{it}) + \alpha_{3_i} ln(RE_{it}) + \alpha_{4_i} ln(ES_{it}) + v_{it}}$$

$\boldsymbol{MP}$ = import demand for petrochemicals; $\boldsymbol{Y}$ = importing countries' income; $\boldsymbol{PR}$ = the price ratio,

$PR = \frac{P^D}{P^F}$. P^D = petrochemicals' domestic price; P^F petrochemicals' international markets prices

$\boldsymbol{RE}$ = renewable energy; $\boldsymbol{ES}$ = economic structure;

$\boldsymbol{ln}$ = the natural logarithm; $\boldsymbol{v}$ = the error term; i =countries; t = time;

$$\boldsymbol{\alpha_{1i} > 0;\ \alpha_{2i} < 0;\ \alpha_{3i} > 0;\ \alpha_{4i} > 0.}$$

Data

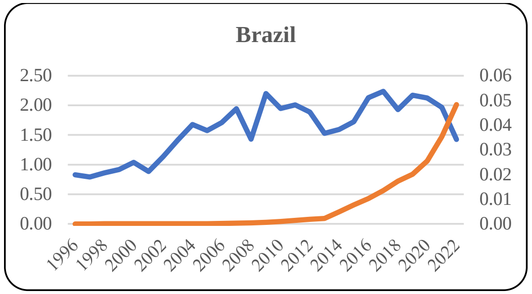
Variable	Definition	Measurement	Source
Imports of Petrochemicals (*MP*)	The import volumes of the petrochemical products of rubber and plastic.	Thousand tons	UNCOMTRADE
Income (*Y*)	Gross Domestic Product.	Million US$ at 2015 constant prices	WDI database, 2023 release.
Price Ratio (*PR*)	The ratio of the international prices of rubber and plastic to domestic prices. The international price of rubber and plastic is calculated as the ratio of value of these products in thousand US$ to their volume in thousand tons. The resulting series is divided by the figure in 2015 to get index as 2015=100. The domestic price is represented by the GDP deflator, 2015=100. This is dictated by the data availability.	Index, 2015=100	The value and volume of rubber and plastic are from UNCOMTRADE. GDP deflator data are from WDI database, 2023 release.
Economic Structure (*ES*)	The industry value added share in GDP. Industrialization is one of the key indicators to represent structural changes in economies, particularly in developing countries (UNIDO, 2016a, b).	Percentage	WDI database, 2023 release.

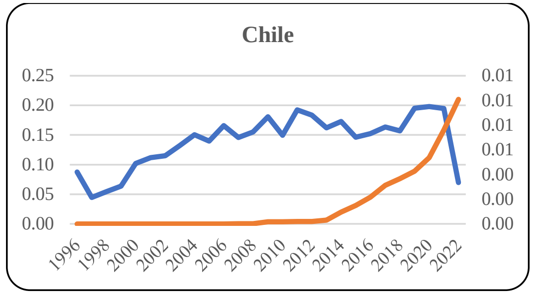
Time dimension: **1996-2022**

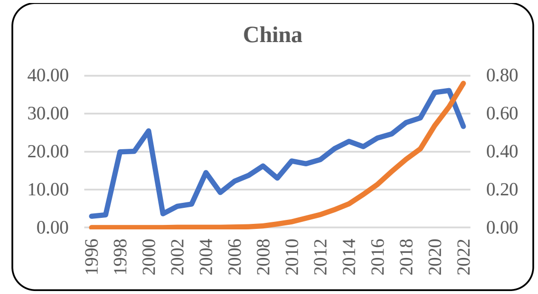
Countries: **China**, **India**, **Brazil**, **Turkey**, **Mexico**, **Poland**, **Romania**, **Chile**, **Thailand**, and **Czechia**.

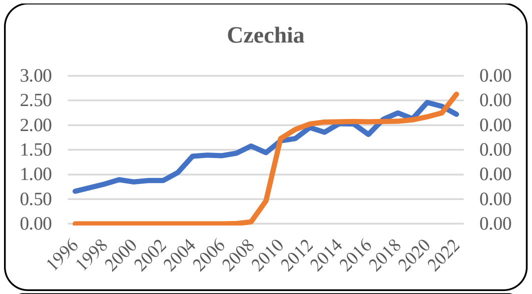
Top 10 developing countries regarding the share of installed solar and wind capacity in total of the developing countries for the last 10 years.

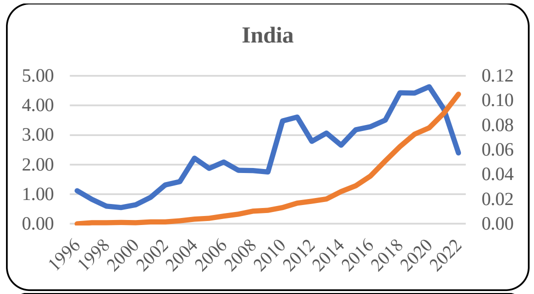
Data

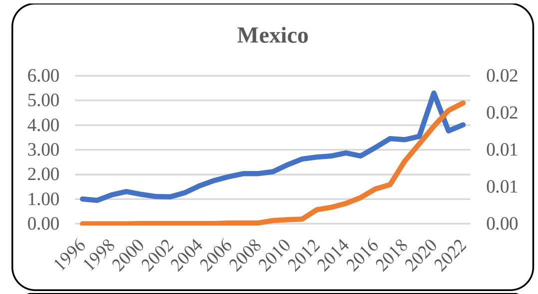


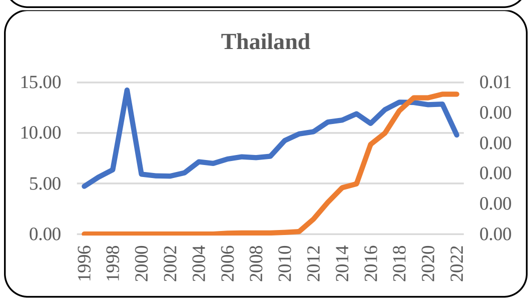


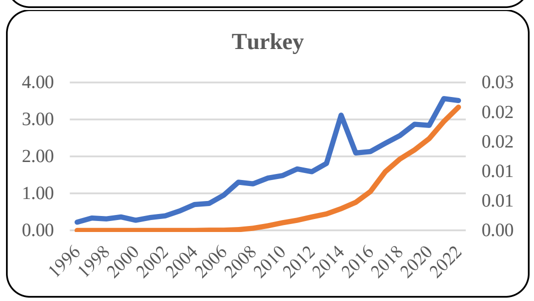


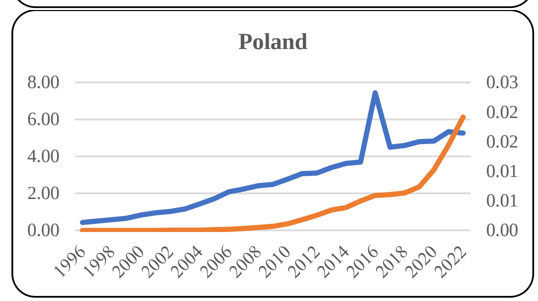


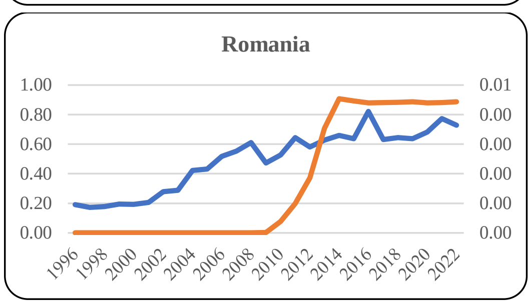






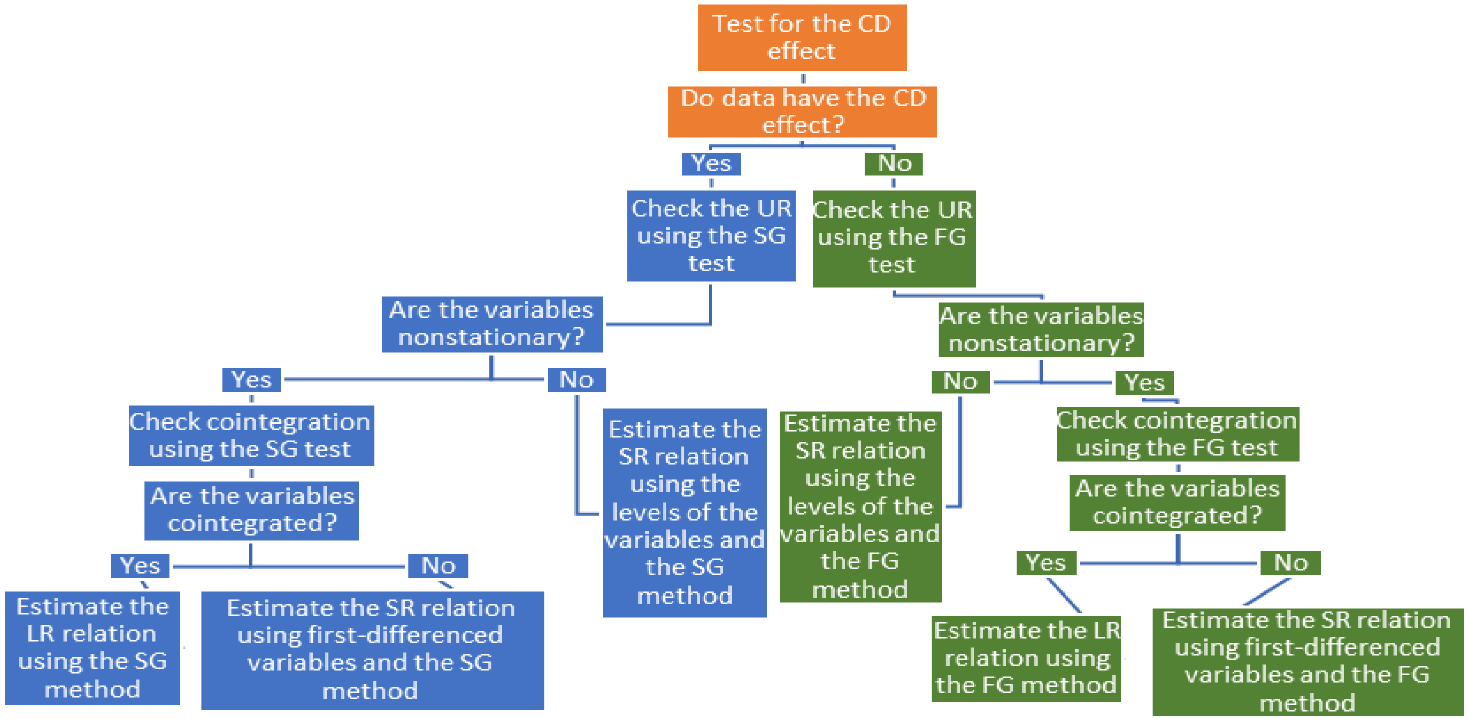






Note:
Blue line is Petrochemicals imports in million tons.
Orange line is renewable energy installed capacity in million Megawatts.

Empirical Analysis Strategy and Econometric Methodology



Source: Re-produced from Hasanov et al. (2023).

Method	PURT	PCT	Long-run Estimation	Short-run Estimation
I Generation	Maddala and Wu (1999), Hadri (2000)	Pedroni (1999, 2004), Kao (1999)	PDOLS, PFMOLS, MG or PMG	PECM or PDR with GTSMS
II Generation	Pesaran (2007)	Westerlund (2007)	CCEMG or CCEP, AMG	

Note. PURT=Panel Unit Root Test; PCT=Panel Cointegration Test; PDOLS=Panel Dynamic Ordinary Least Squares, PFMOLS=Panel Fully Modified Ordinary Least Squares, MG=Mean Group; PMG=Polled Mean Group, CCEMG=Common Correlation Effect Mean Group; CCEP= Common Correlation Effect Pooled; PECM=Panel Error Correction Model; PDR=Panel Dynamic Regression; GTSMS=General to Specific Modeling Strategy.

Source: Re-produced from Hasanov et al. (2018).

Results of the Empirical Analysis

The CD test results.

Variables	Pesaran (2015)	Fan et al. (2015)	Pesaran and Xie (2021)
mp	27.93***	185.84***	-1.73*
reic	32.18***	213.83***	-3.60***
es	13.11***	117.97***	-0.20
y	34.05***	226.30***	-0.93
pr	20.24***	144.66***	0.54

Notes: *, **, and *** indicate rejection of the null hypothesis of weak CD in favour of the alternative hypothesis of strong CD at the 1%, 5%, and 10% significance levels, respectively.

Conclusion: CD effect in all variables.

Pesaran (2007) panel unit root test results.

Variables	Level	First difference	Second difference
	CIPS	CIPS	
mp	0.239 (0.594)	-6.033 (0.000) ***	
reic	-0.378 (0.353)	-3.573 (0.000) ***	
es	0.495 (0.690)	-3.443 (0.000) ***	
y	0.745 (0.772)	-2.004 (0.023) **	
pr	-0.967 (0.167)	-0.551 (0.291)	-7.597 (0.000) ***

Notes: *, **, and *** indicate rejection of the null hypothesis of unit root in favour of the alternative hypothesis of (trend) stationarity at the 1%, 5%, and 10% significance levels, respectively. The values in the table are the Z statistics from the cross-sectionally augmented Im-Pesaran-Shin (CIPS) test by Pesaran (2007) and values in the parentheses are the associated probabilities.

Conclusion: All variables are I(1), *pr* is I(2).

Westerlund (2007) panel cointegration test results.

Statistics	Gt	Ga	Pt	Pa
Sample value	-2.101*	-8.031**	-5.864	-6.294

Notes: *, **, and *** indicate rejection of the null hypothesis of unit root in favour of the alternative hypothesis of stationarity at the 1%, 5%, and 10% significance levels, respectively. The test is run with bootstrap (80 values).

Conclusion: The variables are cointegrated.

Results of the Empirical Analysis

Long-run estimations results for the panel of 10 countries.

Regressor	*Model 1*	*Model 2*	*Model 3*	*Model 4*	*Model 5*
$reic_{it}$	0.175* (0.124)	0.1856* (0.143)	---	0.125*** (0.005)	**0.097**** **(0.056)**
es_{it}	0.425 (0.246)	0.322 (0.411)	---	0.630 (0.438)	**1.425**** **(0.098)**
y_{it}	-0.395 (0.427)	-0.215 (0.672)	-0.504 (0.046)	---	**---**
d_pr_{it}	-0.1165 (0.900)	---	0.922 (0.437)	-0.553 (0.601)	**---**
Constant	10.229 (0.214)	9.238 (0.255)	0.425 (0.917)	0.600 (0.719)	**1.377*** **(0.158)**
Slope Heterogeneity Test:					
Adjusted test value:	2.802**** (0.005)	3.635**** (0.000)	0.756 (0.450)	3.029**** (0.002)	**3.520****** **(0.000)**

Notes: Dependent variables is mp_{it}.

*, **, *** and **** indicate rejection of the null hypothesis of no statistical significance at the 16%, 10%, 5% and 1% significance levels, respectively.

Model 1: General specification: $mp_{it} = \alpha_{0_i} + \alpha_{1_i} reic_{it} + \alpha_{2_i} y_{it} + \alpha_{3_i} d\_pr_{it} + \alpha_{4_i} es_{it} + v_{it}$
Model 2: General specification without d_pr_{it};
Model 3: General specification without $reic_{it}$ and es_{it};
Model 4: General specification without y_{it};
Model 5: General specification without y_{it} and d_pr_{it};

Number of observations = 27 (Time series observations) x 10 (Number of countries) = 270.

Results of the Empirical Analysis

<u>Country-specific</u> long-run estimation results from Model 5.

Country	*reic*	*es*
Brazil	0.063 (0.405)	0.923 (0.372)
Chile	-0.038 (0.688)	-1.573 (0.033)
China [A]	0.235 (0.000)	1.193 (0.198)
Czechia	-0.013 (0.644)	-0.632 (0.488)
India	0.400 (0.002)	5.038 (0.006)
Mexico	0.093 (0.122)	1.057 (0.211)
Thailand	0.044 (0.253)	1.369 (0.278)
Turkey	0.216 (0.150)	-0.495 (0.544)
Poland	0.301 (0.000)	2.001 (0.032)
Romania	0.004 (0.891)	-0.549 (0.289)

Notes: Dependent variable is ***pm***.
P-values are in parentheses. N=10, T=27.
[A] indicates that the coefficients for China are from the ARDL time series estimation accounting for structural break.

Discussion of the Results

For the panel of the countries:
a **1%** increase in renewable energy installed capacity increases petrochemicals imports by **0.1%**.

For the countries in the panel:
- The elasticity of petrochemical imports w.r.t. renewable energy installed capacity is positive for 8 out of 10 countries. This shows that expansion in the renewable energy installed capacity can lead to an increase in imports of petrochemicals in 80% of the entire country sample.
- The size of the elasticity is quite diverse varying from the minimum of **0.004** in Romania to the maximum of **0.4** in India.

For the panel of the countries:
a **1.4%** rise in petrochemicals imports is caused by **1%** increase in the industrialization.

For the countries in the panel:
- The elasticity of petrochemicals imports w.r.t. industrialization is positive for 6 out of 10 countries. The finding indicates that enlargement in industrialization can lead to expansion in petrochemical imports in 60% of the entire country sample.
- The magnitude of the elasticity varies from the minimum of **0.92** in Brazil to the maximum of **5.0** in India.
- All the positive elasticities are greater than unity, except for that of Brazil, which is still quite close to unity. This indicates elastic effect of industrialization on imports of petrochemicals.

Concluding Remarks and Policy Implication

The findings of our empirical analysis show that:

- Contrary to common belief, the transition to renewable energy can create substantial growth in demand for petrochemical products.

- Hydrocarbon feedstocks such as ethane, propane, and naphtha are fundamental to the petrochemical industry, and currently, there are no readily available substitutes with better environmental impact, cost-effectiveness, or efficiency for these energy transition technologies.

- The industrial development also requires an expansion of the petrochemical sector. In fact, the sector's products are essential for the establishment of various industries, such as automobiles, electrical and electronics, healthcare, textiles, food processing, packaging.

Policy decision making in exporting countries may wish to take into account that the renewable energy transition and industrialization can open avenues for the expansion of petrochemical exports, manufacturing, and related sectors, including hydrocarbons for feedstock industries.

Thank You