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Sustainable Solution for Achieving Energy Security in the CAREC Region

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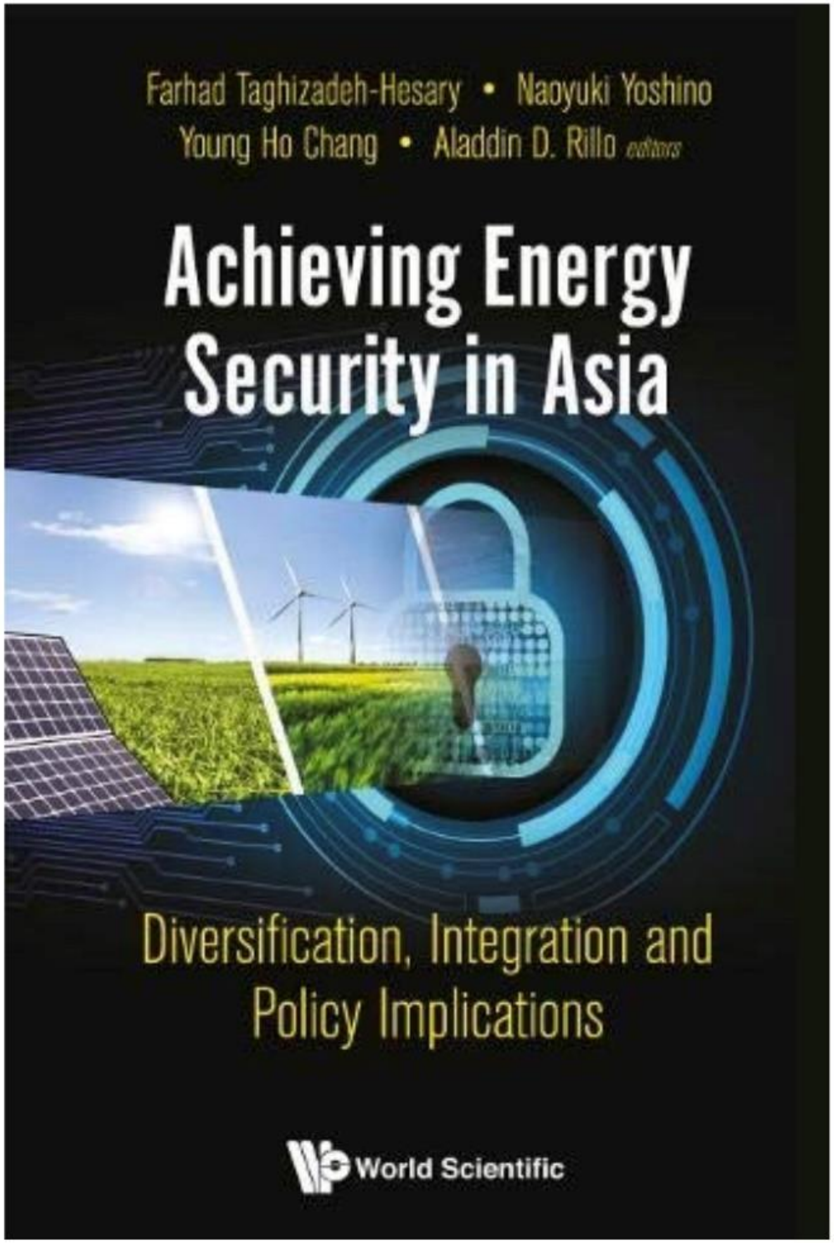
Outline

1. **Background and definition of energy security**
2. **Using 4-As framework to measure the energy security level in Central Asia**
3. **Energy and food security nexus**
4. **Conclusion and Policy Recommendations**



Achieving Energy Security in Asia

Diversification, Integration and Policy Implications

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1- Background and Definition of Energy Security

1-1-Background and definition of energy security

- Energy security is multi-dimensional and is a measure of a unique nexus that encompass economic, political, geopolitical, and institutional, legal and regulatory aspects of a country or region. (Taghizadeh-Hesary et al. 2019).
- Energy security can be defined as an adequate and reliable supply of energy resources at a reasonable price (Toman, 1993; Bohi and Toman, 1996; Bielecki, 2002).
- However, this definition is not complete, an we need to consider different aspects of energy supply and demand for measuring the energy security level.

Four Perspectives on Energy Security (4As)

- Availability (Scientific/resource aspect)
  - Fossil fuels and nuclear energy: Proven reserves
  - Renewable energy resources: Potential
- Applicability (Engineering or technological aspect)
  - Technologies to harness useful energy from the proven reserves and the potential
- Acceptability (Environmental and social aspect)
  - How a society or an economy is willing to use an energy resource
- Affordability (Economic Aspect)
  - How affordable the cost of using an energy resource (i.e., useful energy) is

2- Using the 4A-s Framework to Measure the Energy Security Level in CAREC Region

The 4-As Framework of Energy Security:
Possible Indicators

- There could be many indicators. Here are some examples

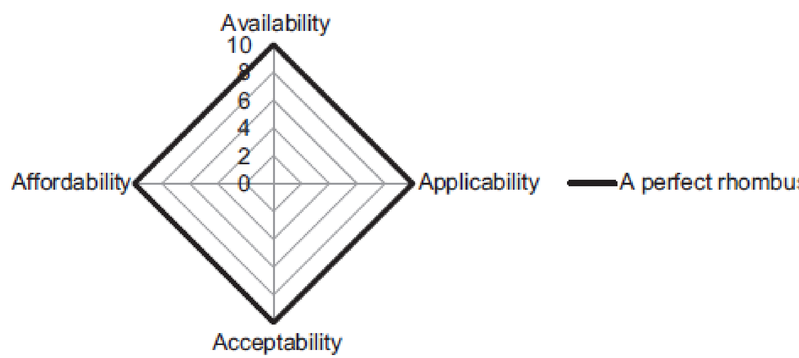
	Availability	Applicability	Affordability	Acceptability
IAEA	• Share of households without electricity • Reserves to production ratio • Diversification of Primary Energy Demand • Dependence on imports (mtoe)	• Share of households without electricity • R&D • Energy use per unit GDP • commercial and transport energy intensity • energy efficiency measures	• Share of household income spent on fuel and electricity • Energy use per capita	• GHG emissions per capita • GHG emissions per unit GDP • Ambient air pollutant concentrations
APERC	• Reserves to production ratio (R/P ratio)	• Energy use per unit GDP • Industrial, household, agricultural, commercial and transport energy intensity	• Energy use per capita	• GHG emissions per capita • GHG emissions per unit GDP
IEEJ and ASEAN Center for Energy		• Energy use per unit GDP • Industrial, household, agricultural, commercial and transport energy intensity	• Energy use per capita	

Source: Chang and Taghizadeh-Hesary (2019)

Energy Security in CAREC Countries

(Taghizadeh-Hesary and Mortha, 2019; Chang and Taghizadeh-Hesary, 2019)

- The 4-As framework is applied to all CAREC countries to examine the status of energy security
- Time span: 2012 to 2016
- Values of individual indicators are normalized
- The inside area of the rhombus indicates the overall status of energy security



- A collective analysis, not an individual country analysis

Energy Security in CAREC Countries:
Selected Indicators

The 4-As Framework is applied to CAREC countries (4x2 matrix)

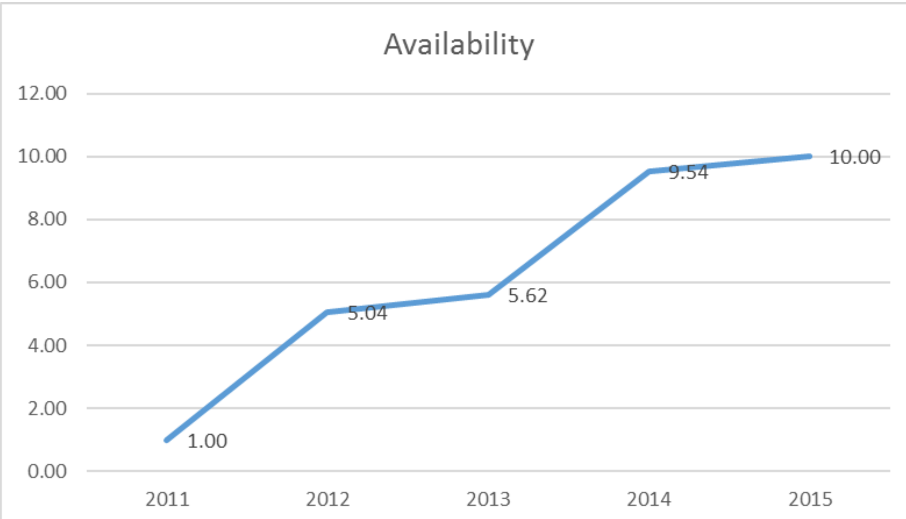
Dimension		Indicators
Availability (Endowment)	AV1	Reserve-Production (R/P) ratio of oil (years)
	AV2	Share of renewable electricity output (%)
Applicability (Efficiency)	AP1	CAREC countries' energy intensity (MJ/$2011 PPP GDP)
	AP2	CAREC countries' carbon intensity (t CO_2/toe)
Acceptability (Preference)	AC1	CO_2 emissions per capita (t CO_2/person)
	AC2	Share of renewable energy consumption (%)
Affordability (Capability)	AF1	Energy consumption per capita (toe/person)
	AF2	Access to electricity (%)

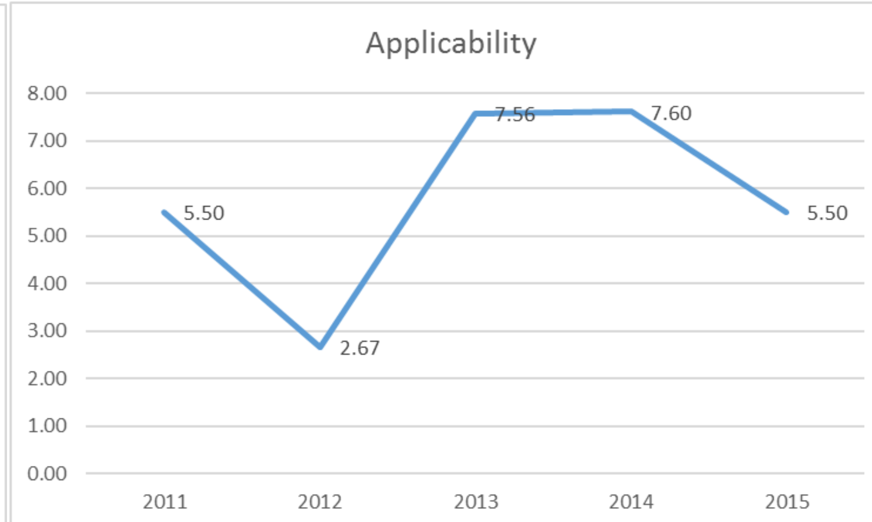
Source: (Taghizadeh-Hesary and Mortha, 2019; Chang and Taghizadeh-Hesary, 2019)

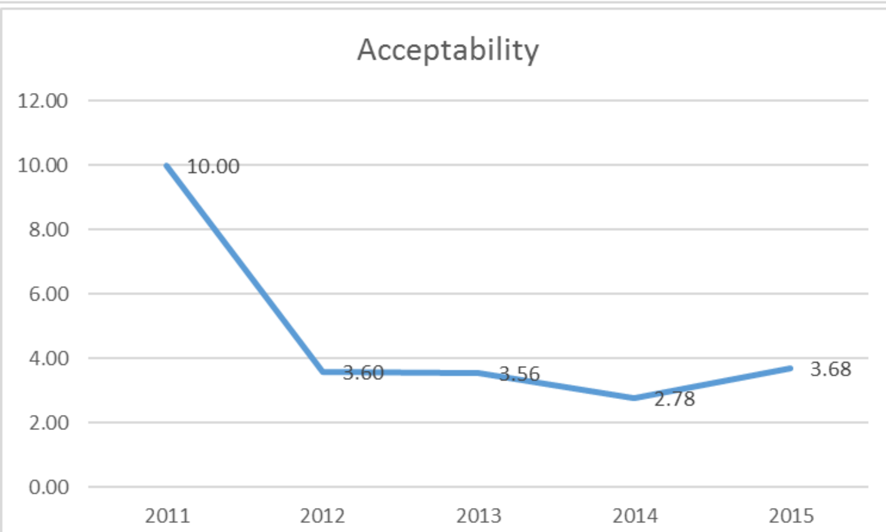
Energy Security in CAREC Countries:
Data Normalization

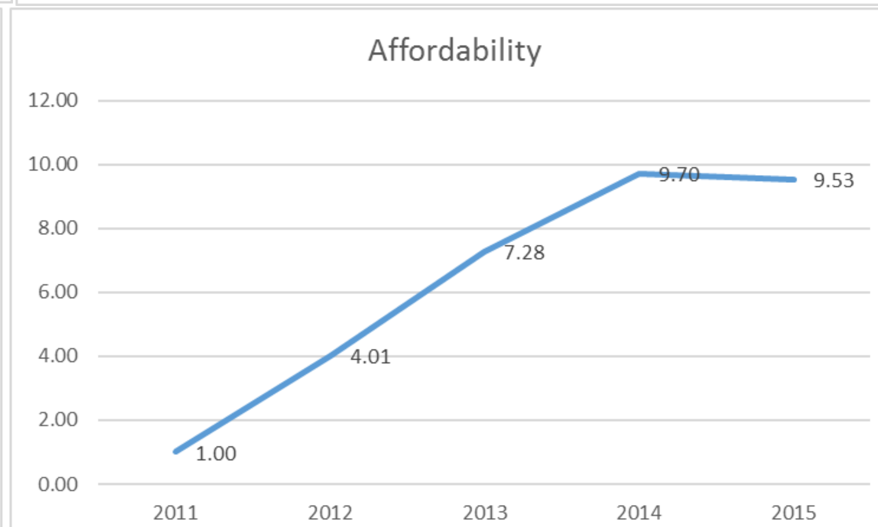
- For each A, the maximum and the minimum values are identified
- The cardinal value of each indicator is normalized by the following formula
  - For the indicator, "the higher, the better"
  - $1 + \frac{Actual\ value - Minimum_A}{Maximum_A - Minimum_A} * (10 - 1)$
  - For the indicator, "the lower, the better"
  - $1 + \frac{Actual\ value - Maximum_A}{Minimum_A - Maximum_A} * (10 - 1)$

Energy Security in CAREC Countries:
Trend of Each Dimension



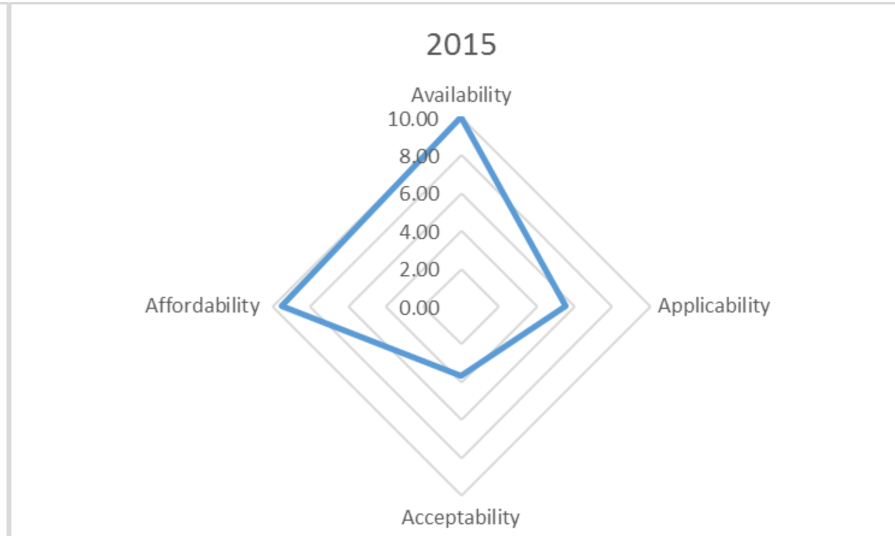






Source: (Taghizadeh-Hesary and Mortha, 2019; Chang and Taghizadeh-Hesary, 2019)

Energy Security Status in CAREC Countries 2011 vs 2015



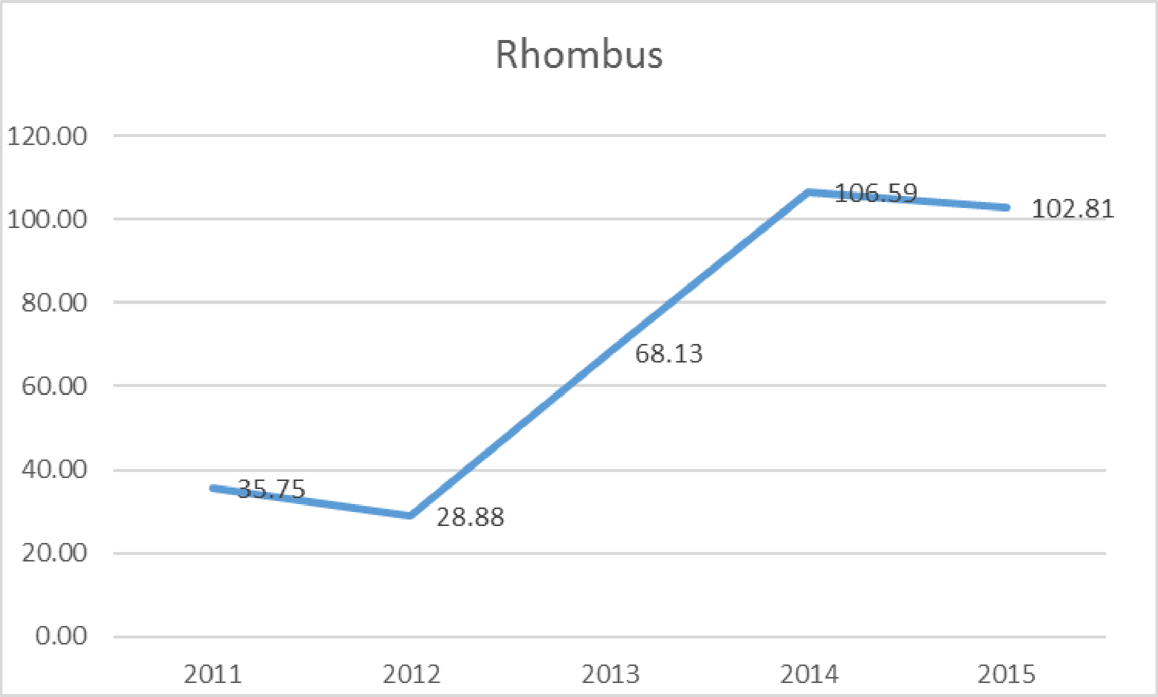
For the 4-A perspectives, between 2011 and 2015, Availability and Affordability appear to have improved while Acceptability appears to shrink considerably and Applicability seems to be more likely the same.

	2011	2012	2013	2014	2015
Rhombus	35.75	28.88	68.13	106.59	102.81

Source: (Taghizadeh-Hesary and Mortha, 2019; Chang and Taghizadeh-Hesary, 2019)

Energy Security Status in CAREC Countries

	2011	2012	2013	2014	2015
Rhombus	35.75	28.88	68.13	106.59	102.81



Source: (Taghizadeh-Hesary and Mortha, 2019; Chang and Taghizadeh-Hesary, 2019)

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Energy security in Pakistan: Perspectives and policy implications from a quantitative analysis

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ABSTRACT

Pakistan imports nearly a third of its energy resources in the form of oil, coal and Liquefied Natural Gas (LNG). An import-driven energy policy is not sustainable for Pakistan, making it energy insecure in the long-term. Besides being a drain on its foreign exchange reserves, it exposes the economy to international energy price shocks putting the entire economy at risk through inflation. Inflationary pressures reduce the competitiveness of the country's exports which further constrain the economy's capacity to pay for energy imports. This paper analyzes Pakistan's energy security under the 4-A framework over the six-years period 2011–2017. The 4-As methodology attempts to measure and illustrate graphically the change in the energy security of a region by mapping it on to four dimensions – namely availability, applicability, acceptability, and affordability. The analysis indicates that Pakistan's energy security improved initially over the first three years but then deteriorated over the next three years. Despite significant investments in energy infrastructure over the last five years, Pakistan continues to be energy insecure. This paper recommends immediate and rapid adoption of green energy solutions like distributed solar and smart metering and increased conservation efforts like developing and implementing building insulation standards to turn the tide on energy insecurity.

Table 1
Specification of variables.

INDICATORS	RAW DATA (Unit of Measurement)	FORMULA	DATA SOURCE
Availability			
Share of Imports in Oil Supply	Oil Imports (TOE), Total Oil Supply (TOE)	Oil Imports ÷ Total Oil Supply	Pakistan Energy Yearbook 2017
Share of Imports in Gas Supply	LNG Imports (TOE), LPG Imports (TOE), Total LPG Supplies (TOE), Indigenous Gas Supplies (TOE)	(LNG Imports + LPG Imports) ÷ (Total LPG Supplies + Indigenous Gas Supplies)	Pakistan Energy Yearbook 2017
Share of Imports in Coal Supply	Coal Imports (TOE), Total Coal Supplies (TOE)	Oil Imports ÷ Total Oil Supply	Pakistan Energy Yearbook 2017
Hydro power Generation	Hydro Electricity Supply (TOE)	Hydro Electricity Supply	Pakistan Energy Yearbook 2017
Applicability			
Gas Power Generation Efficiency	Gas Consumed in Power (MMCft), Gas based Power (Gwh)	(Gas based Power x 3412 btu/Kwh) ÷ (Gas Consumed in Power x 980 btu/Cft)	Pakistan Energy Yearbook 2017
No. of Exploratory Wells Drilled for Oil & Gas	No. of Exploratory Wells Drilled for Oil & Gas		Pakistan Energy Yearbook 2017
Energy Intensity - Agriculture and Transport	Energy Consumption in Transport (MTOE), Energy Consumption in Agriculture (MTOE), GNP at Constant Prices - Agriculture (PKR Trillion), GNP at Constant Prices - Transport & Communication (PKR Trillion)	Sum of Energy Consumed in Transport and Agriculture ÷ Sum of GNP at Constant Prices from Agriculture, Transport & Communication	Pakistan Energy Yearbook 2017, Pakistan Economic Survey 2016-17
Energy Intensity – Industry	Energy Consumed in Industry (MTOE), GNP at Constant Prices - Industry (PKR Trillion)	Energy Consumed ÷ GNP from Industry	Pakistan Energy Yearbook 2017, Pakistan Economic Survey 2016-17
Acceptability			
Share of Nuclear & RE in Power Generation	Nuclear Power Generation (Gwh), RE Power Generation (Gwh), Total Power Generation (Gwh)	Nuclear & RE Power Generation ÷ Total Power Generation	Pakistan Energy Yearbook 2017
CO_2 Emission per Capita	CO_2 Emissions of Pakistan (M tonnes), Population (Million)	CO_2 Emissions of Pakistan ÷ Population	BP Statistical Review of World Energy (2017), Pakistan Economic Survey 2016-17
Share of Global CO_2 Emissions	CO_2 Emissions of Pakistan (M tonnes), CO_2 Emissions of World (M tonnes)	CO_2 Emissions of Pakistan ÷ CO_2 Emissions of World	BP Statistical Review of World Energy (2017)
No. of Energy Sources/ Adoption of New Sources	# of Energy Sources	Simple count	Author's own list
Affordability			
Energy Supply per Capita	Total Primary Energy Supply (MTOE), Population (Million)	Total Primary Energy Supply ÷ Population	Pakistan Energy Yearbook 2017, Pakistan Economic Survey 2016-17
Gas Price	Average Retail Prices of Gas Charges (100cf) - Average of 17 Centers		Pakistan Economic Survey 2016-17
Electricity Price	Average Retail Prices of Electricity Charges (upto 50 units) - Average of 17 Centers		Pakistan Economic Survey 2016-17
Gasoline Price	Average Retail Prices of Petrol Super (per ltr.) - Average of 17 Centers		Pakistan Economic Survey 2016-17

Source: Authors compilation.

3- Energy and Food Security Nexus

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Energy and Food Security: Linkages through Price Volatility

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ABSTRACT

This study examines the linkages between energy price and food prices over the period 2000–2016 by using a Panel-VAR model in the case of eight Asian economies. Our results confirm that energy price (oil price) has a significant impact on food prices. According to the results of impulse response functions, agricultural food prices respond positively to any shock from oil prices. Our results show that there is a linkage between energy and food security through price volatility. Since inflation in oil price is harmful for food security, it would be necessary to diversify the energy consumption in this sector, from too much reliance on fossil fuels to an optimal combination of renewable and nonrenewable energy resources that will be in favor of not only the energy security by also the food security. In addition, the paper found that the impact of biofuel prices on food prices is statistically significant but explains less than 2% of the food price variance. However, by increasing the demand for biofuel, there should be more concern about the global increase in agricultural commodities prices and endangering food security, especially in vulnerable economies.

3-1- Introduction

- Energy has always been essential for the production of food.
- As a result of the industrialization and consolidation of agriculture, **food production has become increasingly dependent on energy derived from fossil fuels.**
- This study examines the linkages between energy prices and food prices in eight Asian economies.
- The empirical part of this survey opens up new policy insight and provides recommendations to increase the ***food security*** and at the same time developing ***Energy-Sustainable Agriculture.***

3-2- Agricultural Energy Inputs

3-2-1- Primary Production

Energy carriers, especially fossil fuels (oil, gasoline, diesel, natural gas, etc.), are widely used in the primary production of agricultural products

a) Farm Equipment: As a fuel for tractors and machinery

b) Water Consumption: pumping, treating and moving water for agricultural consumption require a great deal of energy.

c) Fertilizer Production: Industrial farms use huge quantities of synthetic fertilizers, which require significant energy inputs (primarily natural gas) to be produced

d) Greenhouse production: In protected cropping in greenhouses

e) And in fishing and aquaculture, livestock, and forestry

3-2-2- Primary Production and commercialization

Energy is widely consumed not only in primary production, but also in secondary production such as in processing, drying, cooling, storage, transport and distribution and in selling and commercialization.

3-3- Challenges of fossil fuels in Agri-development

Limited access to cheap fossil fuels and GHG emissions that cause climate change are the two main challenges that the agricultural sector of Asia has in using fossil fuels.

1. Ambitions to increase global food supplies in Asia through increased productivity of crops, animals, and fish resources may be partly constrained by **the limited future availability of cheap and accessible fossil fuel**.
2. Small-scale agricultural and fishery production systems in low-income countries in Asia may not be able to emulate the past efforts of high-income countries in achieving desirable productivity increases if to do so will depend on increased reliance on fossil fuels .
3. **The modernization of food supply chains has been associated with higher GHG emissions** from both pre-chain inputs (fertilizers, machinery, pesticides, veterinary products, transport) and post-farm gate activities (transportation, processing, and retailing) (FAO 2016).

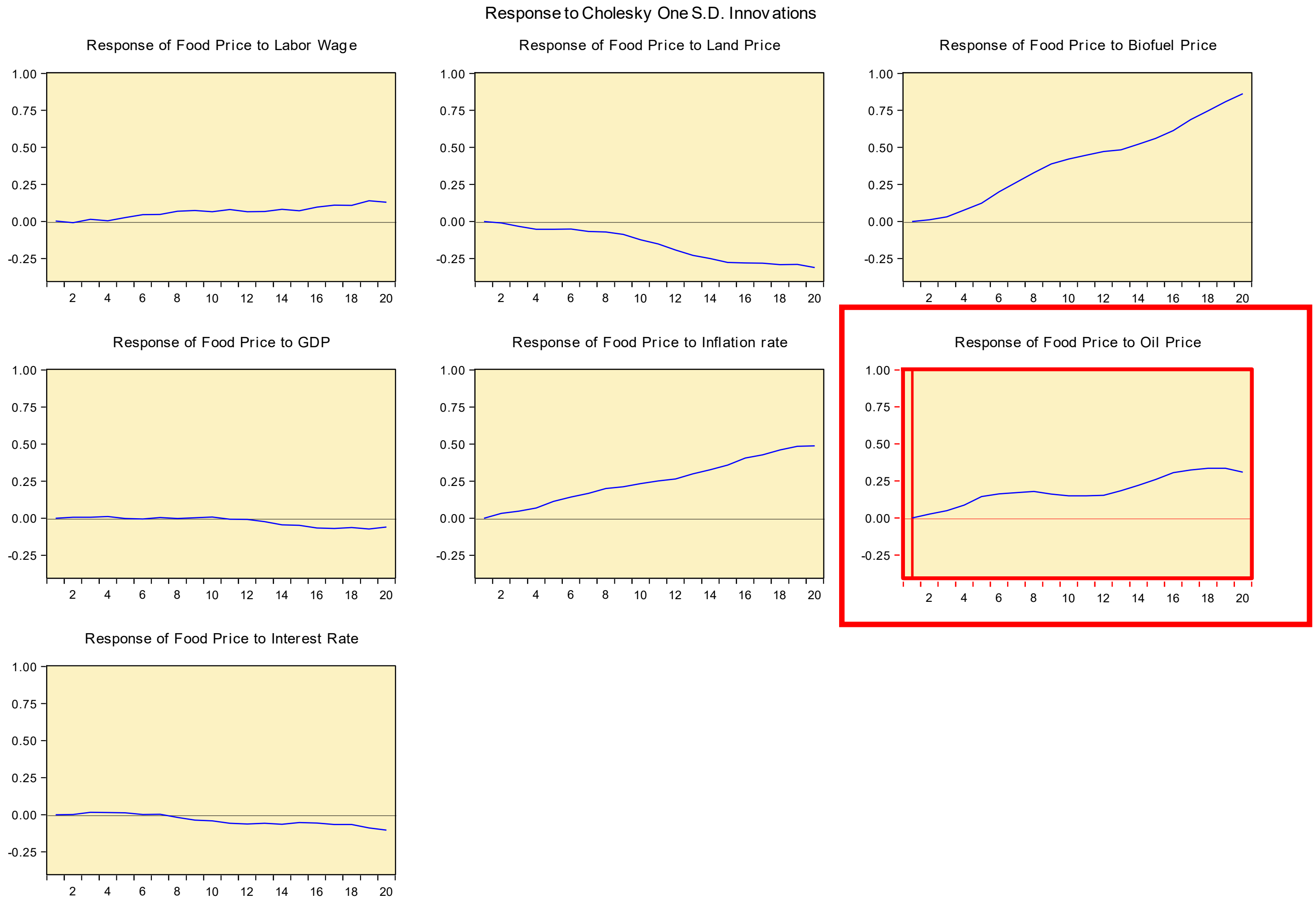
3-4- Energy price volatility versus agricultural commodity prices

Energy prices are expected to be one of the major reasons behind Food price fluctuations

1. Recently, in developing Asia, the inflation rate has increased.
2. A part of this higher inflation rate is due to an increase in higher food prices.
3. Supply-side factors, in particular, higher energy prices (oil prices) are expected to be one of the main factors behind the higher food prices.

Empirical Results

Figure Accumulated response of food price to impulse of variables



Source: Authors compilation

3-5- Conclusion

1. For CAREC member governments its important to use a comprehensive framework for measuring the level of energy security by including the environmental indicators and setting the targets for achieving a higher level of energy security.
2. Based on the empirical study results, following any shock from oil price, the agricultural food prices show a positive response. An increase in oil price may directly increase the cost of production of agricultural commodities and food products.
3. The research findings revealed that a higher inflation rate has a significant positive impact on food prices. Inflation means an increase in the price of various inputs to produce agricultural products, including wage rates, price of machinery, seeds, fertilizers, price of energy inputs, and other inputs, which raises the production cost, and pushes up the price of agricultural product costs and food prices.
4. The study revealed that real interest rate movements also significantly explain the volatilities in food prices. An increase in real interest rate increases food prices. An increase in interest rate increases the cost of capital in agricultural production, and therefore increases the production cost in different sectors, including agricultural products, thereby raising the prices of agricultural products and foods. Recently the agricultural sector became more automated, which means it became more capital-intensive than in the past and hence more elastic in relation to interest rate movements.

3-6- Policy Implication

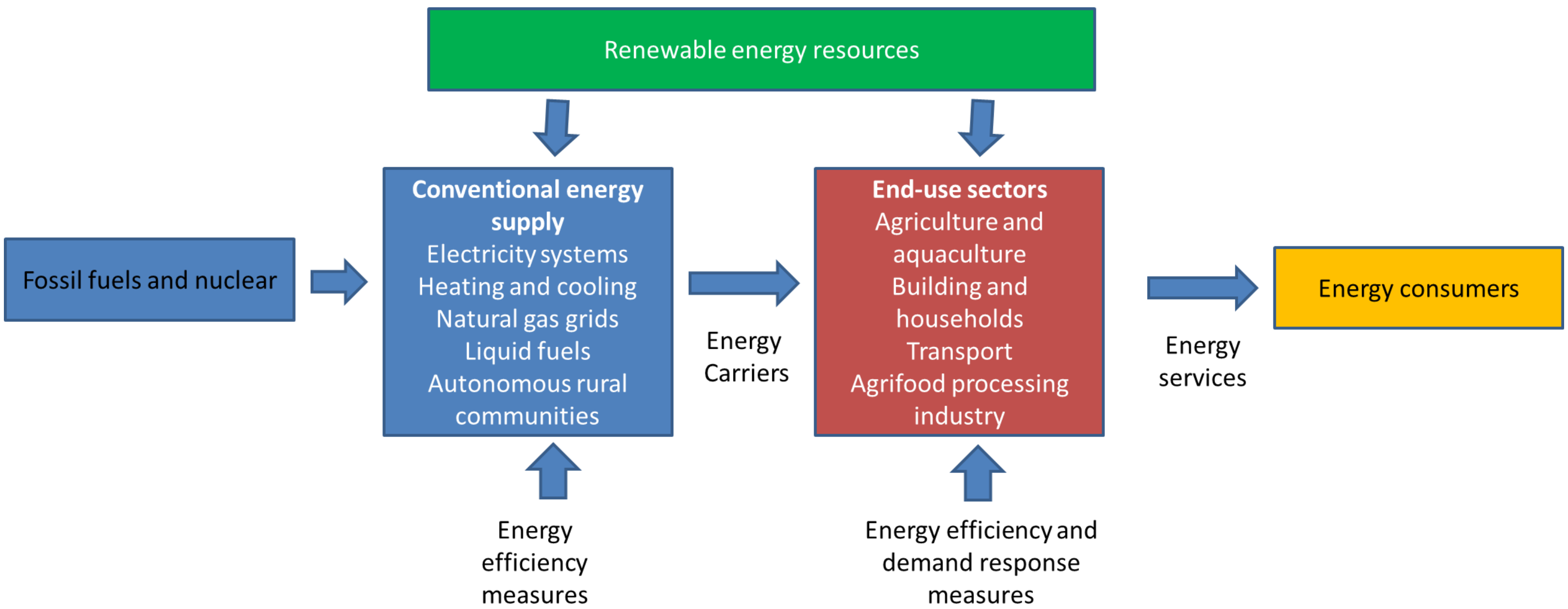
Diversification of the energy basket in the CAREC region is crucial: from too much reliance on fossil fuels to an optimal combination of renewable and nonrenewable energy resources'.

Because of the large impact of energy price fluctuations on agricultural product prices, and due to an increasing share of industrialized agricultural production and more GHG emissions, which is the result of more use of fossil fuels in this sector, it is necessary to diversify the energy consumption in this sector, from too much reliance on fossil fuels to an optimal combination of renewable and nonrenewable energy resources'.

Toward Energy-Sustainable Agriculture

Renewable energy resources can be used directly by the end-use sectors of the agrifood chain or indirectly through integration with conventional energy supply systems that are mainly based on fossil fuels (Figure bellow).

Figure. Use of renewable energy resources in agrifood chain



Source: IPCC (2011)

Thank you for your attention!

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