Energy Use and Gross Domestic Product under Income Uncertainty: Evidence from Net Importing and Net Exporting Countries

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  - Conservation hypothesis (Growth→Energy)
  - Growth hypothesis (Energy→Growth)
  - Feedback hypothesis (Energy↔Growth)
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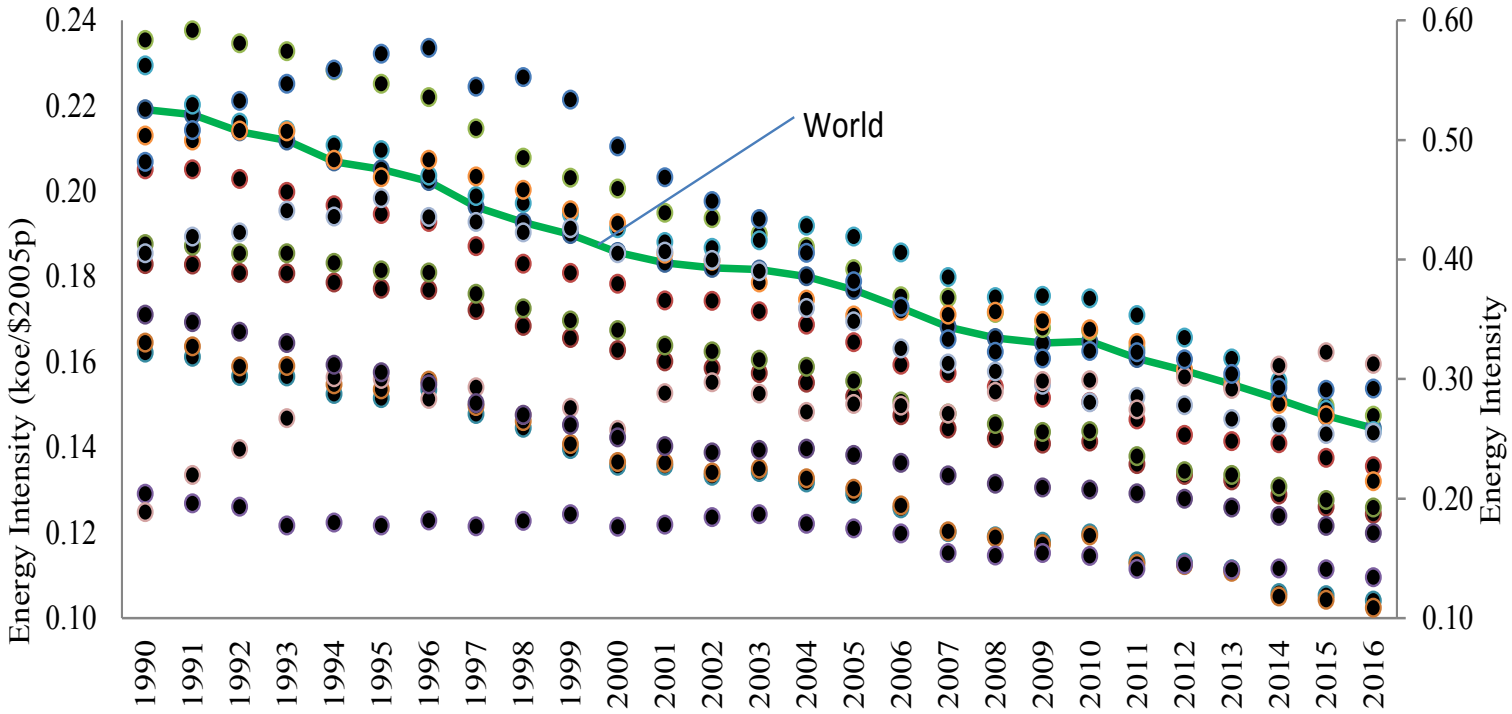
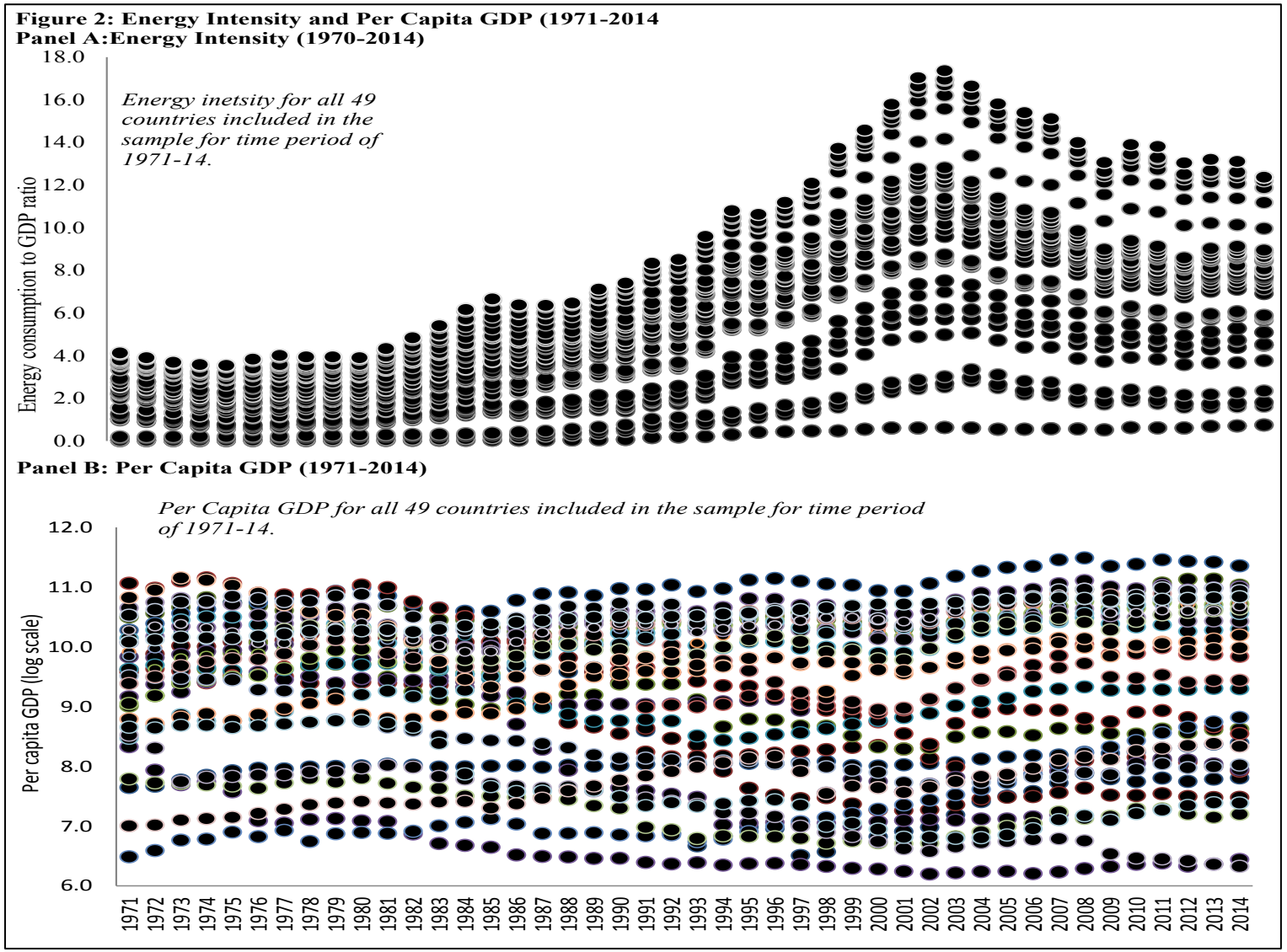
Introduction: Energy Intensity; Global perspective

Figure 1: Energy intensity across the globe (1990-2016)



Notes: Energy intensity of GDP at constant purchasing power parities (koe/$2005p). This figure includes trends from all regions including OECD, G7, Europe, European Union, America, North America, Latin America, Asia, PAcific, Africa, Middle East, BRICS and CIS countries.

Introduction: current trends of energy intensity and per capita GDP from sample countries



Introduction: Research Scope and Unique Features

- Does falling trends of energy intensity reconcile with findings of literature in energy-growth nexus?
  - Income elasticity of energy consumption $0<\eta< 1$ and < 0.
- Energy consumption and income volatility—new dimension of analysis in energy-growth nexus.
- Large sample of countries (developing, developed, OECD, NON-OECD countries, Net energy importing and Net energy exporting countries).

Energy Growth Conundrum

- Literature: (Ilhan, 2010); (Anis, 2014); (Angeliki and Can, 2016); (Karel and Marouan, 2016); (Robert and Masami, 2016); (Tiba and Anis, 2017).
  - Conservation hypothesis (Growth→Energy)
  - Growth hypothesis (Energy→Growth)
  - Feedback hypothesis (Energy↔Growth)
  - Neutrality hypothesis (Growth $\not\leftrightarrow$ Energy)

Sample Countries & Data

Appendix Table 1: List of countries with status					
Country	Net importing	Net Exporting	Developed	Developing	OECD
ALBANIA	✓			✓	Non-OECD
ALGERIA		✓		✓	Non-OECD
AUSTRALIA		✓	✓		OECD
AUSTRIA	✓		✓		OECD
BANGLADESH	✓			✓	Non-OECD
BELGIUM	✓		✓		OECD
BOLIVIA		✓		✓	Non-OECD
BRAZIL	✓			✓	Non-OECD
CANADA		✓	✓		OECD
CHILE	✓			✓	OECD
CHINA	✓			✓	Non-OECD
COLOMBIA		✓		✓	Non-OECD
CZECH	✓		✓		OECD
DENMARK	✓		✓		OECD
ECUADOR		✓		✓	Non-OECD
EGYPT		✓		✓	Non-OECD
FINLAND	✓		✓		OECD
FRANCE	✓		✓		OECD
GABON		✓		✓	Non-OECD
GERMANY	✓		✓		OECD
HUNGARY	✓			✓	OECD
INDIA	✓			✓	Non-OECD
INDONESIA		✓		✓	Non-OECD
IRAN		✓		✓	Non-OECD
ITALY	✓		✓		OECD
JAPAN	✓		✓		OECD
KOREA	✓		✓		OECD
NETHERLANDS	✓		✓		OECD
NEW ZEALAND	✓		✓		OECD
NIGERIA		✓		✓	Non-OECD
NORWAY		✓	✓		OECD
PAKISTAN	✓			✓	Non-OECD
PHILIPPINES	✓			✓	Non-OECD
PORTUGAL	✓		✓		OECD
SOUTH_AFRICA		✓		✓	Non-OECD
SPAIN	✓		✓		OECD
SRILANKA	✓			✓	Non-OECD
SUDAN		✓		✓	Non-OECD
SWEDEN	✓		✓		OECD
SYRIA		✓		✓	Non-OECD
THAILAND	✓			✓	Non-OECD
TRINIDAD_TOBAGO		✓		✓	Non-OECD
TURKEY	✓			✓	OECD
UAE		✓		✓	Non-OECD
UK	✓		✓		OECD
USA	✓		✓		OECD
VENEZUELA		✓		✓	Non-OECD
VIETNAM		✓		✓	Non-OECD

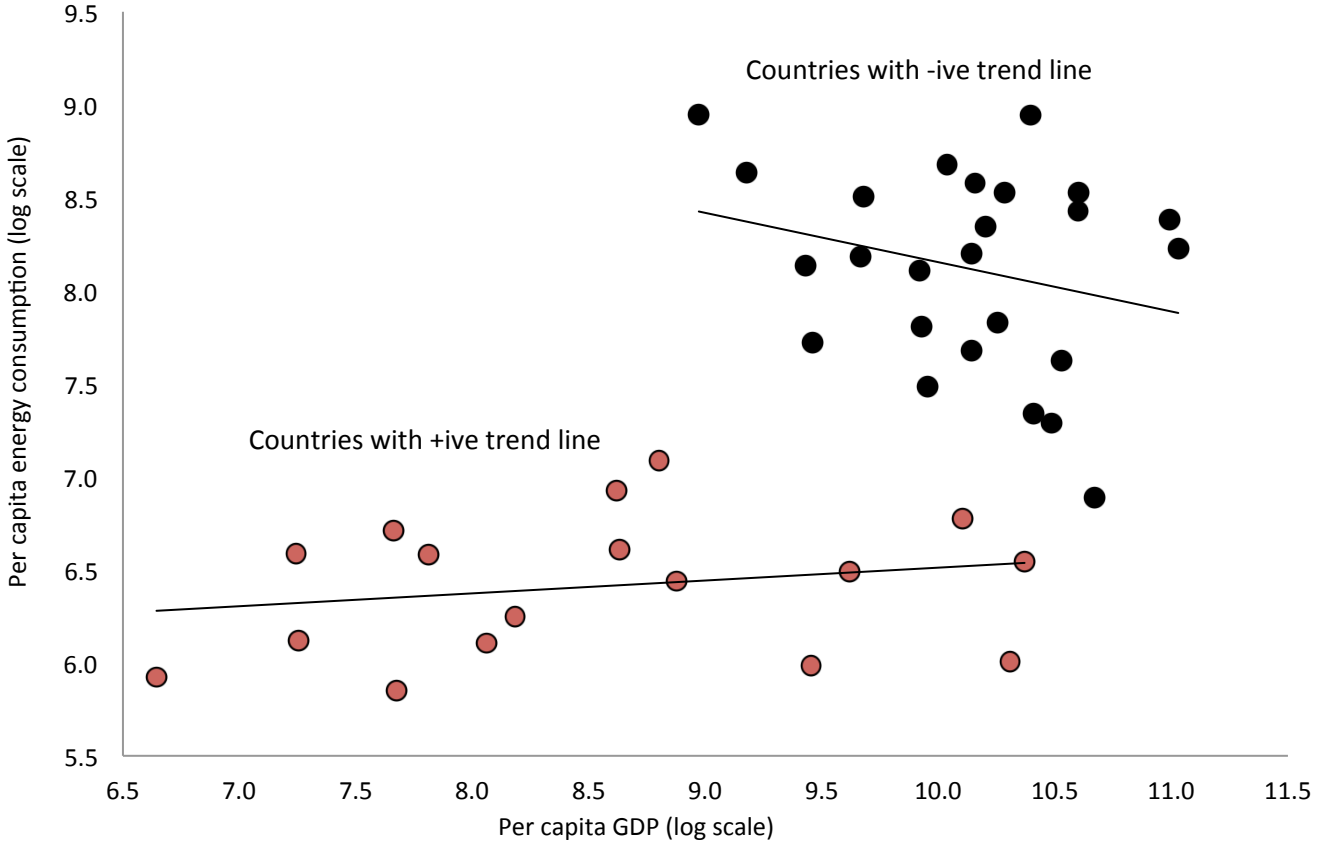
1) Net energy imports are estimated as energy use less production, both measured in oil equivalents. A negative value indicates that the country is a net exporter. For this purpose, average of EG.IMP.CONS.ZS from 1960 to 2017 is used. This classification is reconciled from Jalil (2014) and there is only difference in case of Albania. In Jalil (2014), Albania is taken as net exporter country.

2) 1in column D (developed) indicates advanced economies as given in Table B, page 178 of World Economic Outlook, April 2017, World Economic and Financial Surveys, Gaining Momentum. International Monetary Fund.

3) Dates given in OECD column are the dates on which these countries deposited their instruments of ratification. These dates are extracted from the offical website of OCED on 16th April 2018.

Methodology: Descriptive

Figure 3: Per capita GDP and energy consumption



Methodology: Descriptive

Figure 4: Income and energy intensity (period averages-1970-2014)

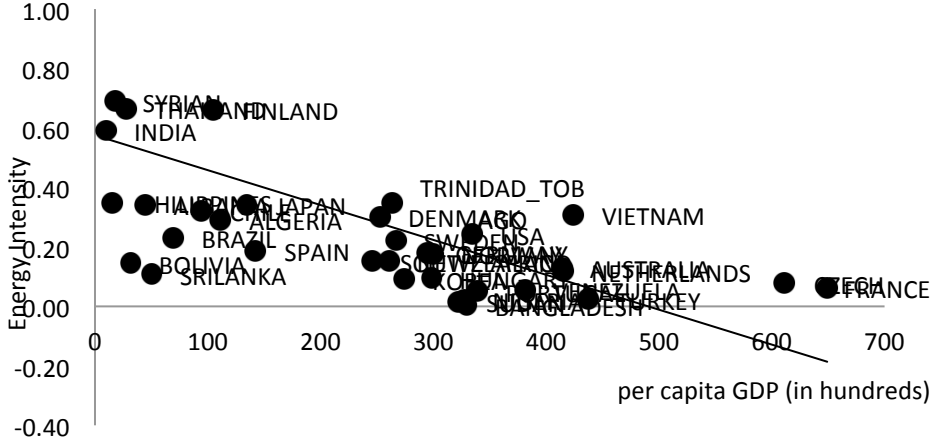


Figure 5: Income and energy consumption volatility (period averages-1970-2014)

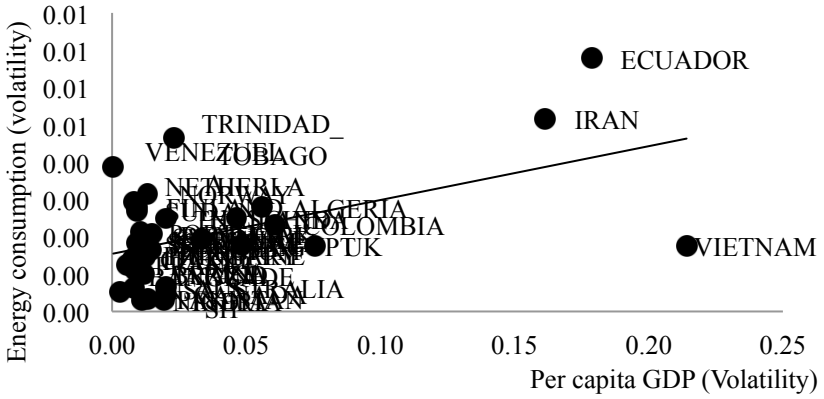
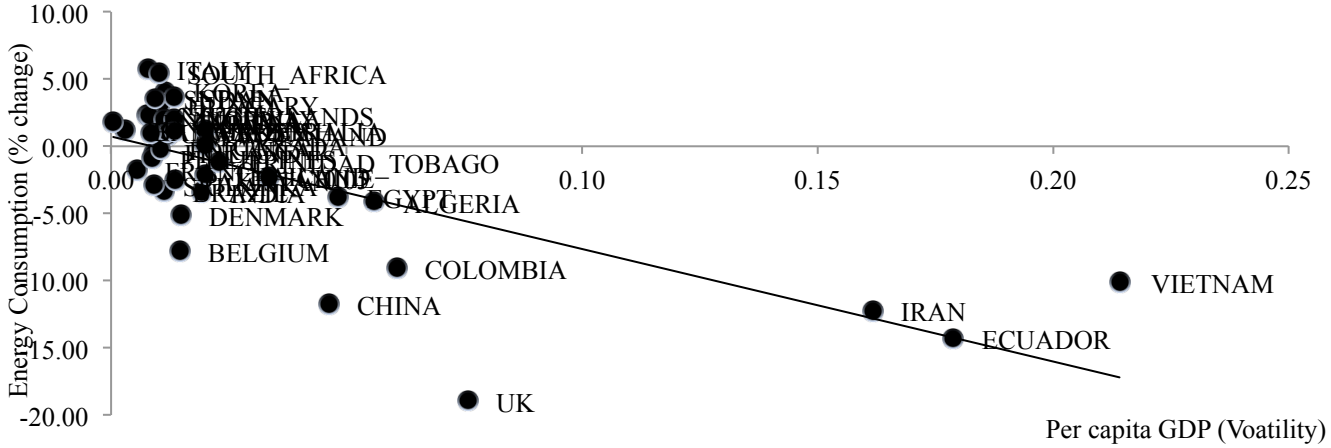


Figure 6: Income volatility and energy consumption (period averages-1970-2014)



Methodology: Granger Causality

- **EGARCH models** – Income and Energy Consumption Volatility
- **Unit Root Tests – ADF, PP and KPSS**
  - GDP per capita and Energy Consumption per capita ~ I(1)
  - Income and Energy Volatility ~ I(0)
- **Cointegration Test : λ-Trace and λ-Max**
  - 3 Cointegrating Vectors : two representing trivial cointegrating vector of stationary volatility variables and one representing the long-run equilibrium relationship between GDP and Energy consumption

Methodology: Granger Causality

- **Yamamoto and Kurozumi (2006) Technique**
  - Long-run Granger Causality Test
  - Short-run Granger Causality Test

- **Rajaguru and Abeysinghe (2008) sign rule**
  - Causal inferences are distorted due to aggregation
  - Sign rule to determine "Genuine" long-run causal realtionship

Results: long-run Granger Causality

Causality	Positive ($0 < \eta < 1$)	Negative ($\eta < 0$)
Income → Energy Consumption	Albania, Algeria, Bangladesh, Brazil, China, Columbia, France, Sweden, Turkey	Australia, Belgium, Bolivia, Canada, Chile, Denmark, Finland, Germany, Iran, Italy, Japan, Netherland, New Zealand, Thailand, UAE, UK, USA
Energy Consumption → Income	Algeria, Austria, France, India, Korea, Turkey	Australia, Bolivia, Canada, Egypt, Iran, Italy, New Zealand, Sri Lanka, UAE, UK, Vietnam
Income ↔Energy Consumption	Algeria, China, France, Turkey	Australia, Canada, Iran, New Zealand, UAE and UK
Income ↮ Energy Consumption	Czech, Ecuador, Gabon, Hungary, Indonesia, Nigeria, Norway, Pakistan, Philippines, Portugal, South Africa, Spain, Sudan, Syrian, Trinidad and Tobago, Venezuela	

Results: Short-run Granger Causality

Causality	Positive ($0 < \eta < 1$)	Negative ($\eta < 0$)
Income à Energy Consumption	Bolivia, Canada, Ecuador, Gabon, Germany, Hungary, India, Indonesia, Iran, Japan, Netherland, Pakistan, Portugal, Spain, Sweden, Syria, Thailand, Venezuela	Albania, Belgium, Sudan
Energy Consumption à Income	Albania, Canada, China, France, Gabon, Hungary, Iran, Italy, Korea, Pakistan, Philippines, Portugul, Safrica, Spain, UK, USA, Venenzula, Vietnam	
Income Volatility to Energy Consumption		Algeria, Belgium, Bolivia, Brazil, Canada, Chile, Colombia, Denmark, Eucador, France, Gabon, Germany, Hungary, Indonesia, Iran, Japan, Korea, Netherland, Nigeria, Philippines, Portugul, Safrica, Spain, Syrian, UAE
Energy Consumption to Income Volatility	Canada, Indonesia, Italy, Spain, Turkey, UK	China, Hungary, Japan, Thailand, UAE
Energy Volatility to Income	Albania, Algeria, Austria, France, Portugul, Syrian	Chile, China, Hungary, Iran, Italy, Korea, Norway, Venenzula
Energy Volatility to Energy Consumption	Algeria	Brazil, Eucador, Finland, Germany, Netherland, Nigeria, Portugul, Syrian, Trinidad and Tobaco, Turkey, UAE, USA
Income Volatility to Energy Volatility	Bolivi, Czech, Denmark, Eucador, Germany, India, New Zealand, Nigeria, Norway, Pakistan, Portugul, Sudan, Syrian, Thailand, UK USA	
Energy Volatility to Income Volatility	Albania, Austria, China, Hungary, Indonesia, Japan, Pakistan, Safrica, Sudan, Syrian, UK	

Conclusions

Findings reconcile with literature:

- Conservation hypothesis (Growth→Energy)
- Growth hypothesis (Energy→Growth)
- Feedback hypothesis (Energy↔Growth)
- Neutrality hypothesis (Growth ↔ Energy)

* **Positive ($0 < \eta < 1$)**
* **Negative ($\eta < 0$)**