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# Causality between trade openness and energy consumption: What causes what in high, middle and low income countries

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## H I G H L I G H T S

- Trade openness and energy consumption are cointegrated for long run.
- The feedback effect exists between trade openness and energy consumption.
- The inverted U-shaped relationship is found between both variables in high income countries.

## A R T I C L E I N F O

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## A B S T R A C T

This paper explores the relationship between trade openness and energy consumption using data of 91 high, middle and low income countries. The study covers the period of 1980–2010. We have applied panel cointegration to examine long run relationship between the variables. The direction of causal relationship between trade openness is investigated by applying Homogenous non-causality, Homogenous causality and Heterogeneous causality tests.

Our variables are integrated at I(1) confirmed by time series and panel unit root tests and cointegration is found between trade openness and energy consumption. The relationship between trade openness and energy consumption is inverted U-shaped in high income countries but U-shaped in middle and low income countries. The homogenous and non-homogenous causality analysis reveals the bidirectional causality between trade openness and energy consumption. This paper opens up new insights for policy makers to design a comprehensive economic, trade and policies for sustainable economic growth in long run following heterogeneous causality findings.

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## 1. Introduction

Trade liberalization has affected the flow of trade (goods and services) between developed and developing countries. The Heckscher–Ohlin trade theory reveals that under free trade, developing countries would specialize in production of those goods that are produced by relatively abundant factors of production such as labor and natural resources. Developed countries would specialize in production of those goods that are produced by human capital and manufactured capital-intensive activities. Trade openness entails

movement of goods produced in one country for either consumption or further processing to other country. Production of those goods is not possible without effective use of energy. Trade openness affects energy demand via scale effect, technique effect and composite effect. Other things being same, trade openness increases economic activity, thus stimulate domestic production and hence economic growth. A surge in domestic production reshapes energy demand because of expansion in domestic production commonly refers as scale effect. Such scale effect is caused by trade openness. Economic condition of the country and extent of relationship between economic growth and trade openness determine the impact of trade openness on energy consumption (Shahbaz et al., 2013a,b; Cole, 2006). Trade openness enables developing economies to import advance technologies from developed economies. The adoption of advanced technology lowers energy intensity. The economic consequences of advance technologies implementations consume less energy and produce more output that

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is usually referred as technique effect (Arrow, 1962). Composite effect reveals that with the use energy intensive production as economic development i.e. shift from agriculture to industry. In initial stages of economic development, since economy is based largely on agriculture sector, thus the use to energy consumption is relatively less. As economy starts shifting from agriculture to industry, the use of energy consumption increases. Arrow (1962) calls it positive composite effect. Finally, following maturity stage of economic development, shifts in industry to service consume less energy consumption which implies that energy intensity is lowered because of composite effect.

Energy affects trade openness via various channels. First, energy is an important input of production because machinery and equipments in the process of production require energy. Second, exporting or importing manufactured goods or raw material requires energy to fuel transportation. Without adequate energy supply, trade openness will be adversely affected. Consequently, energy is an important input in trade expansion and adequate consumption of energy is essential to expanding trade via expanding exports and imports. The relationship between trade openness and energy consumption is important. If energy plays its key role to flow exports or imports then any policies aiming at reduction energy consumption such as energy conservation policies will negatively impact the flow of exports or imports and hence, reduce the benefit of trade openness. The bidirectional causal relationship between trade openness and energy consumption suggests in adopting energy expansion policies because energy consumption stimulates trade openness and as result, trade openness affects energy consumption (Sadorsky, 2011). The energy conservation policies will not have an adverse effect on trade openness if causality is running from trade openness to energy consumption or neutral effect exists between trade openness and energy consumption (Sadorsky, 2011).

Energy consumption in the world increases parallel to technological development, increase in trade and population growth. The world average energy consumption was 1454 kg of oil equivalent per capita in 1980 while the amount increased to 1852 kg of oil equivalent per capita in 2010 (see Fig. 1). According to American Energy Information Administration (EIA) and to the International Energy Agency (IEA), the worldwide energy consumption will on average continue to increase by 2% per year.

Between 1980 and 2006, energy consumption has increased but the change of different fuel consumption structure varies by region. Coal has the largest increase in all fuel consumption of the world, accounting for 30.4% of total increase; Asia and Oceania contributed 97.7% of total coal increase between 1980 and 2006. During the same period, natural gas ranks the second in all fuel

consumption in total energy consumption, accounting for 28.7%, Asian and Oceania still contributed the largest part, 24% of total gas increase, Eurasia, Europe and Middle East contributed about 17% to 20% by each. Oil was the third fuel in total consumption, accounting for 21.5%. Asia and Oceania still were the biggest contributor; about 67.9% of increase in oil consumption came from this region. The nuclear power has increased by 10.7% of the total increase, mainly is contributed by Europe, North America and, Asia and Oceania where more new nuclear reactors have been started. Hydropower has developed in Asia and Oceania and Central and, South America, because of their abundant hydro resources. And these two regions contribute 80% of global hydropower increase. However, global industry sector has reduced its share of total energy use from 33% in 1980 to 27% in 2006 because most developed countries used less energy in industry by improvement in energy efficiency, technology development and major production structure changes.

Growth in world energy consumption reached 5.6% in 2010, the highest growth rate since 1973. Energy consumption in OECD countries grew by 3.5%, while non-OECD countries by 7.5% in 2010. Chinese energy consumption grew by 11.2% and China surpassed the United States as the world's largest energy consumer. Oil remains the world's leading fuel in 2010, accounted for 33.6% of global energy consumption. World natural gas consumption grew by 7.4% in 2010, the most rapid increase since 1984. The United States had the world's largest increase in consumption, rising by about 5.6% in 2010. Asian countries also registered large increase of about 10.7%, led by a 21.5% increase in India. Coal consumption grew by 7.6% in 2010, the fastest global growth since 2003. The share of coal in world energy consumption is 29.6%, larger than 25.6% of ten years ago. China consumed 48.2% of world coal and accounted for nearly two-third of global coal consumption. The use of modern renewable energy sources including wind, solar, geothermal, marine, modern biomass and hydro continued to grow rapidly and accounted for 1.8% of world energy consumption in 2010, up from 0.6% in 2000. Energy use in transport sector increased very rapidly during the recent years due to rapid economic development and population growth. Over the past 30 years, energy use in transport sector has doubled. Transport sector accounts for 25% of world energy consumption in 2010 (World Energy Outlook, 2012).

The volume of merchandise trade between countries has been rapidly increasing for last two decades due to globalization. Global merchandise trade (exports plus imports of goods) was US\$ 3.8 trillion in 1980 but it is amounted to US\$ 37 trillion in 2010 (see Fig. 2).

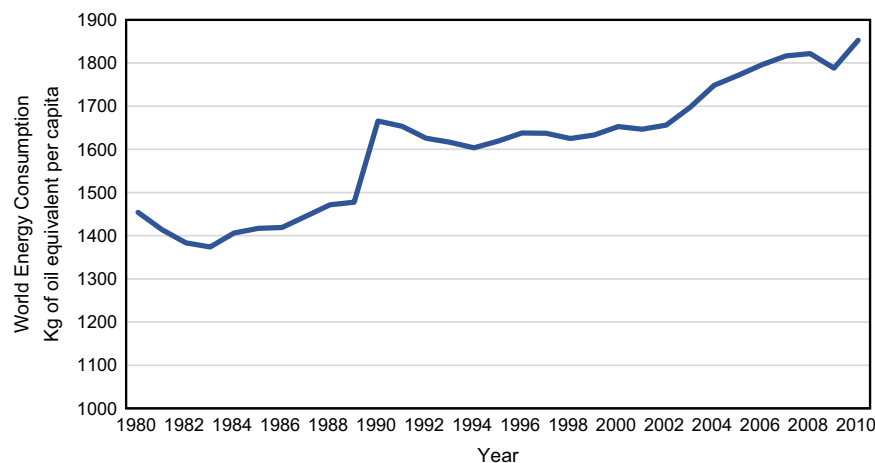


Fig. 1. World Energy Consumption per Capita.

Source: World Development indicators (CD-ROM, 2012).

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