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Clean energy, non-clean energy, and economic growth in the MIST countries

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HIGHLIGHTS

- This novel study can provide more robust bases to strengthen sustainable energy policy settings.
- Fossil fuel/nuclear energy use and economic growth is bidirectional causality.
- Renewable energy consumption long term causes economic growth.
- There is substitutability between renewable and fossil fuel energy.
- Clean and non-clean energy partnerships can achieve a sustainable energy economy.

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ABSTRACT

This paper explores the causal relationship between clean (renewable/nuclear) and non-clean energy consumption and economic growth in emerging economies of the MIST (Mexico, Indonesia, South Korea, and Turkey) countries. The panel co-integration tests reveal that there is a long-term equilibrium relationship among GDP, capital formation, labor force, renewable/nuclear, and fossil fuel energy consumption. The panel causality results indicate that (1) there is a positive unidirectional short-run causality from fossil fuel energy consumption to economic growth with a bidirectional long-run causality; (2) there is a unidirectional long-run causality from renewable energy consumption to economic growth with positive bidirectional short-run causality, and a long-run causality from renewable to fossil fuel energy consumption with negative short-run feedback effects; and (3) there is a bidirectional long-run causality between nuclear energy consumption and economic growth and a long-run causality from fossil fuel energy consumption to nuclear energy consumption with positive short-run feedback effects. These suggest that MIST countries should be energy-dependent economies and that energy conservation policies may depress their economic development. However, developing renewable and nuclear energy is a viable solution for addressing energy security and climate change issues, and creating clean and fossil fuel energy partnerships could enhance a sustainable energy economy.

1. Introduction

In the past decade, using panel data to study the causal relationships between renewable and non-renewable energy consumption (Apergis and Payne, 2011a, 2011b, 2012a, 2012b, 2013) and nuclear energy consumption (Lee and Chiu, 2011; Nazlioglu et al., 2011; Apergis and Payne, 2010), respectively and economic growth have attracted significant research interest. Indeed, it is important to understand the extent to which different types of energy consumption contribute to the economic growth process. The causalities between energy consumption and economic growth have different directions, so as to generate different policy implications. Under the assumption of positive correlation between energy consumption and economic growth, the presence of unidirectional causality from energy consumption to economic growth or bidirectional causality between them would suggest that energy conservation policies that reduce energy consumption may lead to decline in economic growth. In contrast, unidirectional causality from economic growth to energy consumption or no causality in either direction suggests that energy conservation policies will have little or no impact on economic growth (Apergis and Payne, 2013). However, various empirical study outcomes show different and even conflicted results with each other. According to Ozturk (2010), the main reasons of this inconsistence come from the differences in country

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Table 1
Empirical results on the causal relationship between different types of energy consumption and economic growth using panel data.

Author	Methodology	Period	Countries or economies	Results
Panel A: causal relationship between renewable and non-renewable energy consumption and economic growth				
Apergis and Payne (2011a)	Panel VECM	1990–2007	25 developed and 55 developing countries	**R↔Y** **NR↔Y**
Apergis and Payne (2011b)	Panel VECM	1990–2007	16 emerging market economies	**R↔Y** **NR↔Y**
Apergis and Payne (2012a)	Panel VECM	1990–2007	80 countries	**R↔Y** **NR↔Y**
Apergis and Payne (2012b)	Panel VECM	1990–2007	6 Central America countries	**R↔Y** **NR↔Y**
Apergis and Payne (2013)	Panel VECM	1990–2007	9 South America countries	**R↔Y** **NR↔Y**
Panel B: causal relationship between nuclear energy consumption and economic growth				
Apergis and Payne (2010)	Panel VECM	1980–2005	16 countries	**N→Y**
Apergis et al. (2010)	Panel VECM	1984–2007	19 developed and developing countries	**N↔Y**
Nazlioglu et al. (2011)	Panel causality approach (Kónya, 2006)	1980–2007	14 OECD countries	**N⇹Y**
Lee and Chiu (2011)	Panel VECM	1971–2006	6 highly industrialized countries	**Y→N**

Notes: R, NR, N, and Y are renewable, non-renewable, nuclear energy consumption and real GDP, respectively. →, ↔, and ⇹ indicate unidirectional causality, bidirectional causality, and neutral causality, respectively.

characteristic, time period, econometric methodology, and types of energy consumption. In the recent articles of Apergis and Payne (2011a, 2011b, 2012a, 2012b, 2013) and Pao and Fu (2013a), non-renewable energy consumption, which includes clean (nuclear) and non-clean (fossil fuel) energy sources, is considered to be aggregate energy consumption. In this study, the aggregate non-renewable energy consumption is further partitioned into nuclear and fossil fuel energy consumption, so as to explore the relationships between renewable, nuclear, and fossil fuel energy consumption, respectively and economic growth (Pao and Fu, 2013b). The dual goals are to distinguish the relationship between disaggregate consumption of clean and non-clean energy and economic growth, and to verify the substitutability of clean for non-clean energy consumption. Thus, the pitfalls of policy decision based on aggregate energy consumption alone can be avoided.

Another reason of using the proposed disaggregated analysis is to achieve the vision of transition to a global green economy. If the world's enormous demand for clean energy is to be met, nuclear power complemented by new renewable sources of energy is urgently needed (Macusani Yellowcake, 2011). Currently, nuclear power plants supply approximately 5.7% of the global energy and 13–14% of the global electricity needs. Additionally, by 2018, renewable power will make up a quarter of the world's energy mix, up from 20% in 2011. With the increasing importance of sustainable development, clean energy sources (e.g., nuclear and renewable) have become the major components in the energy matrix. Therefore, two types of clean energy, renewable and nuclear, alongside fossil fuel non-clean energy consumption impact on economic growth are investigated. The proposed model is a novel study and provides more robust bases to strengthening the sustainable energy policy settings.

For developing and emerging market economies, clean energy plays a significant role in the growth prospects and reduces negative environmental and health impacts. Such is the case in MIST (Mexico, Indonesia, South Korea, and Turkey), the next tier of large emerging economies with abundance of clean resources and increasing demand for energy. The MIST nations are expected to exhibit high growth over the next 20–30 years, but they are also in the top 20 countries producing carbon emissions. Developing clean energy is critical to offer a viable alternative for sustainable economies. A brief description of clean energy resources and recent developing achievements of these countries are as follows. For wind power, Mexico's annual growth rate in wind power capacity was the highest in the world in 2012. The country intends to increase its wind energy capacity to 15% of the country's electricity mix to diversify its energy portfolio. South Korea has initiated a massive wind energy program to reduce the country's huge fossil fuel imports. Indonesia will cooperate with the United Nations Development Program to develop wind power generation projects. Turkey's wind power capacity will increase 16-fold by 2020 to meet the demand for an annual growth rate of 7% in electricity. For hydropower, the electricity sector in Mexico obtains approximately 19% of its total installed capacity from hydropower. In South Korea, hydroelectric generation represents 40% of the country's energy supply. Indonesia also has great potential to develop mini hydroelectric power plants (1 MW–10 MW of capacity). In Turkey, 32–35% of the electricity demand could be met by hydro power plants by 2020. For geothermal power, the installed capacities in Indonesia, Mexico, and Turkey rank the third, the fifth, and the tenth, respectively in the world. Indonesia added the most geothermal capacity in 2012, and Turkey was second. In fact, Turkey is the world's seventh richest country for geothermal energy potential. South Korea also has substantial geothermal potential; 2% of geothermal energy developed from surface to a depth of 5 km will be equivalent to approximately 200 times the country's annual primary energy consumption in 2006 (Lee et al., 2010). For solar energy, Mexico's solar thermal resources are among the best in the world. The quality of its PV is also among the world's best. Solar thermal and PV power generation will account for 5% of Mexico's energy supply by 2030 and up to 10% by 2050. South Korea is currently ranked among the top 10 installers of solar power in the world. Indonesia is one of the most important emerging solar markets in Southeast Asia. Turkey is located in an advantageous position for solar power because it has average 7.2 hours a day of sunny weather throughout the year. Solar energy is the most important alternative clean energy source in Turkey. For bio-energy, Mexican bio-energy power may account for 16.17% of the total energy consumption by 2030 (Islas et al., 2007). The government of South Korea plans to increase the use of biomass to 30.8% of new renewable energy by 2030 (Bioenergy Crops, 2012). Indonesia has one of the best biomass energy potentials because it has one of the highest levels of energy for photosynthesis per unit area. Biomass may be able to replace fossil fuel in Indonesia (Panjaitan, 2013). In Turkey, biomass energy is generally used as non-commercial fuel in traditional methods and accounts for approximately a fourth of domestic energy production. However, traditional biomass energy production should be gradually reduced to allow the development of

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