Income, trade openness and energy interactions: Evidence from simultaneous equation modeling

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ABSTRACT

This survey aims to examine the three-way causality between income, trade openness, and energy consumption through the use of the simultaneous-equation panel data models (SEPDM) for 24 middle- and high-income countries for a time span 1990–2011. We were motivated by the fact that there is no study has investigated simultaneously these linkages through the use of the simultaneous equations models approach. Our empirical highlights for the high-income countries pointed out the presence of feedback causality between energy consumption and income and between trade openness and income. However, the findings support the occurrence of unidirectional causality running from trade openness to energy consumption without any feedback effects. In the case of middle-income countries, we recorded also the occurrence of feedback relationships between energy consumption and income and between trade openness and income, and a unidirectional causality running from energy consumption to trade. These empirical insights are of particular interest to policymakers as they help build sound economic policies to sustain economic development.

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1. Introduction

The linkage between income, trade openness, and energy consumption has been the topic of large-scale research in the energy-economic theory during the latest decades, thus revitalizing the long debate in both academic and policy spheres about their advantages and costs related to their interactions. The motivation that lies behind focusing on this topic is that energy and trade show considerable promise to understand the role of these variables in economic growth. Indeed, trade openness exerts positive externalities on economic performance through technology transfer, spillover effects and productivity gains that promote managerial skills (e.g. Ref. [40]. The relationship between trade and energy consumption is still an understudied area, understanding the dynamic economic growth-trade-energy consumption three-way nexus seems as a cornerstone to build their ambitions economic blueprints, consistent with their objectives in terms of environmental and energy policy.

The energy-growth nexus is widely stressed in the energy-economic literature (e.g. Refs. [14,22,25,28,35], through the use of the Granger causality tests to investigate the causality direction without reaching a unanimous verdict. The absence of consensus may due to the bias omission of relevant variables that deeply affect the output-energy nexus. Furthermore, recent works test this linkage have included other relevant variables such as capital and labor [36,37,48,62]. Other studies have included trade in an augmented production function to explain this relationship [67].

This body of literature can be structured around three research axes. The first one looks at the relationship between energy and income level. Indeed, this nexus is structured around four hypotheses [8,24]. First, *the growth hypothesis* refers to the fundamental role played by energy consumption in the growth process: the existence of unidirectional causality which runs from energy to income; therefore, energy conservation policies aim to decrease the consumption of energy will have an adverse effect on growth. Second, *the conservation hypothesis* records the existence of unidirectional relationship running from energy consumption to income. This means that the demand for energy contributes heavily in the production process as a complement to production factors (i.g. Labor and capital), and thus in income. Therefore, energy consumption constitutes a limiting factor to growth and, hence, shocks to energy supply will generate an adverse effect on economic performance [66]. Third, *the feedback hypothesis* postulates the existence of a bidirectional relationship between growth and

energy, implying that energy conservation policies aimed to decrease the energy consumption will generate an adverse impact on economic performance and vice versa. Finally, *the neutrality hypothesis* suggests the absence of causality between output and energy. In this case, energy conservation policies devoted to decreasing energy consumption will not have any impact on income.

Nevertheless, the second ax of research looks at the income-trade nexus. The majority of the literature (e.g. Refs. [29,30] looks directly at the nexus among economic growth and exports. The income-exports nexus can be explained by two hypotheses: the first one called the export-led growth hypothesis, meaning that an increase in the export level may generates an increase in the demand for a country's economic output conjointly with an increase in real economic activity. Also, export expansion promotes specialization in the production of exports which can lead to higher skill levels, economies of scale and gains in terms of productivity for the economy as a whole. In addition, an increase in exports can provide foreign exchange making it easier to import goods, services, and foreign financial capital which contribute to the domestic-capital formation. Further, the growth-led exports hypothesis means the fact that an increase in economic growth is justified by an increase in technology to boost productivity. As a consequence, economic growth leads to greater skills and technology which can lead to a comparative advantage which facilitates growth in exports. Moving to the second hypothesis which is called the import-led growth hypothesis, which postulates that import play a key role in revitalizing economic growth through the bias of technology transfer and production factors and facilitating the access to foreign knowledge and foreign R&D, which increase productivity and as a result the economic growth [11].

Moreover, other surveys treated the nexus between trade openness and energy consumption, where we can find a unidirectional relationship running from export to energy consumption. This means that an increase in exports generates an increase in energy consumption. Therefore, a conservation energy policy has a negative impact on the ability to produce and export goods. Moreover, there is evidence of a feedback relationship between trade and energy consumption which is, in this case, energy consumption and trade share interdependence and complementary effects. In addition, we can find a neutral relationship between energy consumption and exports; which means that there is neither a relationship between these variables nor statistically significant relationship at conventional levels. Concerning imports, we can support the evidence of unidirectional relationship running from import to energy consumption. It is also possible that energy consumption can affect the flow of import. Moreover, we can find a feedback causality relationship between imports and energy consumption, and the possibility of neutrality relationship between these variables [36,37].

The third ax of research examines the energy-trade-economic growth nexus. In this context, to the best of our knowledge, the only existing paper which investigated this linkage is related to Ben Aïssa et al. [15] studied this linkage by applying panel cointegration techniques to investigate the relationship between renewable energy consumption, trade and output on a sample of 11 African countries covering the period 1980–2008. On the other hand, Nasreen and Anwar [49] examined the causal linkage between economic growth, trade openness, and energy consumption using data from 15 Asian countries during the period between 1980 and 2011. Furthermore, Sbia et al. [61] investigated this linkage using the VECM Granger causality approach for the UAE covering the time span of 1975–2011. More recently, Tiba et al. [67] investigated this linkage in a comparative analysis over a time span of 1990–2011.

The interactions between these variables are widely recognized by the economic literature. Indeed, thanks to the positive externalities of these mentioned variables on each other such as spillovers, technology transfer, enhancement productivity, among others, with all these facts we are motivated to investigate simultaneously this three-way nexus through the use of simultaneous-equation models. Our study, thus, contributes to the existing literature in the two following ways. First, we use simultaneous-equation models approach in order to investigate the three-way linkages simultaneously. Indeed, this modeling approach relies on GMM estimator, which enables us to simultaneously examine the combined causality effects as follow: from trade and energy consumption to economic growth; from trade and economic growth to energy consumption; and from economic growth and energy consumption to trade openness. Second, compared to the previous studies and to the best of our knowledge there is no existing study which investigates the three-way linkages between these variables in a comparative framework between two sub-panels which categorized into the income level (high- and middle-income countries).

The remainder of this work is organized as follows: Section 2 portrays the theoretical background. Section 3 outlines the econometric methodology. Section 4 contains the empirical results. Section 4 reports the highlights discussion. Section 6 concludes the article and offers some policy implications.

2. Theoretical background

The energy–trade–growth nexus has mainly been examined with respect to the following three competing hypotheses: the feedback hypothesis, the unidirectional hypothesis, and the neutrality hypothesis. Indeed, the unidirectional assumption means the existence of a unidirectional nexus running from particular variable to the remaining variable (i.e., from energy consumption and trade to economic growth; from economic growth and trade to energy consumption; and from economic growth and energy consumption to trade), whereas the acceptation of the feedback and neutrality hypotheses is strongly related to the existence of bidirectional or the absence of causality among these variables, respectively. In the following, we review the most important works in this literature.

2.1. Unidirectional hypothesis

Ewing et al. [24] investigated the relationship energy-income nexus in the case of the United States through the use of the Generalized Variance Decomposition approach. Their highlights pointed out the fact that coal, nature gas and fossil fuels explain the maximum variations in output, whereas renewable energy consumption explains a little variation in output. Also, their findings validated the unidirectional hypothesis which called growth hypothesis. Moreover, Lise and Montford [42] applied the VECM procedure over the study period of 1970–2003 for the case of Turkey, where they pointed out the existence of the unidirectional hypothesis which the income causes energy consumption supporting the conservation hypothesis. Also, Huang et al. [31] used the GMM system for a panel of 82 countries covering the period of 1972–2002. Their findings have been confirmed the conservation assumption. Sari et al. [60] employed the ARDL bounds testing approach. Their empirical investigation confirmed the existence of conservation hypothesis. Later on, Chontanawat et al. [21] employed the Granger causality technique to detect the causality direction among energy and income for a time span to 1971–2000 for a panel of 30 OECD and 78 non-OECD countries. They findings are consistent with the growth hypothesis. In the same spirit, Bowden and Payne [17] have studied this nexus through the Toda-