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Energy consumption synchronization between Europe, United States and Japan: A spectral analysis assessment

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ABSTRACT

This paper aims to advance a model able to explain the synchronization tendency in energy consumption, under the impact of international technology transfers. The key argument is related to the differences in energy consumption efficiency of local and foreign technologies. One direct testable consequence of the model is that there might be a certain correlation between the energy consumption between countries and/or economic areas where a free movement of capital goods and technologies takes place. Hence, it is further tested, in the framework of a multivariate spectrum analysis, the case of energy consumption synchronization between Europe and, respectively, United States and Japan for a time span between 1981 and 2011 based on the data provided by U.S. Energy Information Administration. There are evidences of a leading behavior of energy consumption in United States and Japan in respect to Europe as well as of short-run phase delays of 2 up to 5 months.

1. Introduction

On Saturday, 29th of March, from 8:30 p.m. to 9:30 p.m. in local time coordinates, citizens from more than 7000 cities worldwide turn off their non-essential lights for one hour. Despite several criticisms (varying from arguments concerning a reduced impact to an alleged "anti-technology" position), this movement turns the attention on the current critical issue of energy consumption (and broadly on various aspects related to climate change).

As [1] notices, cultural and social contexts are at least as relevant for energy consumption, as economic and technological aspects. If traditional factors are largely analyzed, the literature pays less attention to the particular features of globalization processes, i.e. international flows of technology transfers as an underlying factor of energy consumption.

The aim of this paper is to advance a two-fold argument in order to justify the potential existence of synchronization in energy consumption between developed countries. First, this argument considers the global business cycles' harmonization for such economies. Second, it accounts for the linkages between individual business cycles and energy consumption. So, the emerging effects of determinants for cross-country common business cycles may lead to a certain synchronization for energy consumption as well. Thus, we consider: (i) a relation between growth and energy consumption, with the causality running from the economic dynamics to the use of energy; and (ii) the existence of a business cycles' harmonisation, especially for countries or jurisdictions which are highly integrated, by means of real and financial international flows. The potential harmonisation of the energy consumption might occur as an effect of this causal pair. Simply put, our argument implies that energy consumption may appear as being harmonised among countries, because the business cycles are largely harmonised. However, these elements of our argument are not separately tested. Rather, our aim is to check for the existence of a synergic association among such economic jurisdictions in regard to their energy consumption. The main envisaged driving factor is the international diffusion rate for technologies with different energy efficiency: the spread of new technologies contributes, on one hand, to an increased synchronicity of macroeconomic evolutions and changes, on the other hand, the pattern and structure of energy consumption for individual economies.

To the best of our knowledge, this argument was not previously explicitly considered in the literature. Nevertheless, our approach is strongly related to various streams of current research.

First, an extensive body of literature suggests that countries engaged in substantial bilateral trades exhibit also a high degree of business cycle co-movement ([2–4]). Juvenal and Santos Monteiro [5]

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identifies three channels for supporting the extensive empirical evidences that strong trade linkages have more synchronized business cycles. According to their framework, an intensive bilateral trade: (i) raises the correlation between each country's technology shocks,(ii) raises the correlation between each country's share of expenditure on domestic goods and, respectively, (iii) raises the response of the domestic import penetration ratio to foreign technology shocks.

[6] concludes their study on annual data, over the period 1960–1999 for a sample of 76 countries (21 industrial and 55 developing), by noticing that: "The results in this paper provide at best limited support for the conventional wisdom that globalization leads to an increase in the degree of synchronization of business cycles. We found some evidence for the proposition that trade and financial-market integration enhances global spillovers of macroeconomic fluctuations". [7] advances a detailed explanatory framework to argue that trends toward financial globalisation have been accompanied by significant trends toward real regionalisation. Based on a sample of 56 countries, [8] documents the fact that strong economic ties between countries foster business cycle synchronisation and it disentangles the role of various channels, including trade and financial linkages as well as similarity in sectorial specialisation. It concurs that economies with more intensive bilateral trade move more closely together. For the particular case of United States and Japan, [9] provides evidences on the short-term links between the United States and Japan, while controlling for global oil prices (even if in its findings the transmission between the two economies is relatively 'modest'). [10] shows that the primary determinant of trade imbalance between United States and Japan seems to be the continual depreciation of the United States real exchange rate. This finding is at odds with standard real business cycle theory, where such relative price movements are endogenous.

Still, bilateral trade is not a unique determinant of economic dynamics' harmonisation. For instance, [11] investigates the key factors underlying business cycle synchronisation in the euro area. It found that several factors are foremost to such synchronisation, such as the industrial and financial structures. Similarly, [12] uses wavelet analysis to study business cycle synchronization across countries, which are part of the Euro 12 Area. In this analytical framework, the authors find that France and Germany form the core of the Euro land, being the countries most synchronized with the rest of Europe. For East Asia, [13] finds that trade openness and intra-industry trade are major channels of business cycle synchronization.

In our approach, it should be emphasised that one key factor leading to fluctuations in business cycles is represented by technological shocks. As Rabanal [14] notes: "proponents of the real business cycle (RBC) paradigm have claimed a central role for exogenous variations in technology as a source of economic fluctuations in industrialized economies". Illustrating this idea, [15] estimates that new investment goods are the source of about 30% of output fluctuations in United States' output.

However, studies, like [16], show that: "While the impacts of technology are present throughout the United States, the impacts of trade tend to be more geographically concentrated, owing in part to the strong spatial agglomeration of labour-intensive manufacturing" [[16]: 224]. Braun et al. [17] compares the Japanese and United States business cycles and documents some important differences in the adjustment of labour input between the two countries.

Also, Heathcote and Perri [18] find that from 1960 to 2002 the United States' business cycle has become less synchronized with the cycle in Japan and 15 countries of the European Union. Still, Yoon [19] shows that once adjustments for the lower variability – experienced in the United States since the early 1980s – are made, the cross-country correlation coefficient for output actually increases.

Overall, the international spread of technological innovations can be seen as a driving force of high similarities in the economic dynamics of integrated economies. Still, as a cautionary note, it is not only the absolute level of technological flows per se which is relevant. Perhaps, even more, it matters: the structure of such flows, with the weight of highly technological goods; the international diffusion of information, skills and knowledge; as well as, broadly, the human capital involved in using the new technologies. The specific technological structures and economic policies of the host countries might also count for the final impact of technology flows.

Second, our approach is related also to the current research on the existence of a potential single or even bi-dimensional, relationship between energy consumption and economic growth, quite extensively studied in the energy economics literature for both developing and developed countries. However, as Ozturk et al. [20] notice: "The empirical outcomes of these studies have been varied and sometimes found to be conflicting due to the different time periods, different variables used, countries studied and different econometric methodologies used". For instance, a literature stream shows a significant connection between energy consumption and growth. Belke et al. [21] examines the long-run relationship between energy consumption and real GDP, including energy prices, for 25 OECD countries from 1981 to 2007. It found that international developments dominate the long-run relationship between energy consumption and the real GDP. Moreover, the article provides empirical support for the presence of a bi-directional causal relationship between energy consumption and economic growth. Rühl et al. [22] draws conclusions supported by evidences from the last two centuries of industrialisation, by analysing the evolution of energy intensity on long- and short-run. It concludes that the increased specialisation of the fuel mix, coupled with the accelerating convergence of both the sectorial and technological composition of economies, will continue to improve the energy intensity of the economic output and to reduce the reliance on any single energy resource. Sheng et al. [23] estimates an energy demand function, with a dataset of 71 countries, for a period between 1965 and 2010. The results show that countries undergoing rapid economic growth may display relatively higher income and price elasticities on the long run. This can induce a certain pressure on energy demand on both domestic and international markets. Nevertheless, energy market integration can reduce such pressure, smoothing energy demand, by lowering its income elasticity and increasing its price elasticity.

At country level, Shahbaz et al. [24] documents in a study covering the period 1971 to 2009 a bi-directional Granger causality between electricity consumption, economic growth and employment for the case of Portugal. Shahbaz et al. [25] explores the relationship between globalization and energy consumption for India, by endogenizing economic growth, financial development and urbanization. The results reveal that on the long run, the acceleration of globalization (as measured according to three dimensions – economic, social and overall globalization) causes a decline in energy demand in India. Furthermore, while financial development is negatively related to energy consumption, economic growth and urbanization are the key factors leading to increased energy demand on the long run. For the case of United States, Kialashaki and Reisel [26] points out toward the fact that: „the industrial sector is the driving engine of economic development, and energy consumption in this sector may be considered as the fuel for this engine" [[26]:749]. Moreover, Apergis and Payne [27] examines the relationship between energy consumption and economic growth for nine South American countries from 1980 to 2005, within a multivariate framework, revealing a long-run equilibrium relationship between real GDP, energy consumption, labour force, and real gross fixed capital formation.

However, not all the evidences in the literature support the connection between energy consumption and economic dynamics. For instance, Nguyen-Van [28] finds, based on a balanced panel of 158 countries and jurisdictions for the period 1980-2004, that energy consumption increases with income, for a majority of countries, and then it stabilizes, for very high income countries. Though, changes in neither energy structure nor macroeconomic cycle/technological change have significant effect on energy consumption. The mentioned