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Oil prices and the macroeconomy reconsideration for Germany: Using continuous wavelet

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ABSTRACT

The cross wavelet analysis is used in the study to decompose the time–frequency effects of oil price changes on the German macroeconomy. We argue that the relationship between oil prices and industrial production is ambiguous. Our results show that there are both phase and anti-phase relationships between oil price returns and inflation and in most of the cases inflation is the leading variable. Additional evidence shows that there is a huge inconsistency between the phase-difference of the return series of oil price and industrial production at the 12–16 month frequency bands but at the 16–24 month frequency bands, we find that oil price changes that have occurred during 1982–2009 were demand-driven. In a nutshell our results suggest that oil price changes that have occurred after 1994 were demand-driven and the volatility of the inflation rate started to decrease after the 1990s but the volatility of the industrial output growth rate started to decrease after the 2000s.

1. Introduction

The oil prices and macroeconomy are one of the extensively studied topics in the literature. Studies have used a vast variety of statistical tools and techniques but focusing on, mainly, the US economy. For the US economy, the empirical evidence shows that until the mid-1980s oil prices were a significant determinant of the economic activity (for details, see Aguiar-Conraria and Soares, 2011; Aguiar-Conraria and Wen, 2007; Gisser and Goodwin, 1986; Hamilton, 1983, 1985) and after 1985 the correlation between oil prices and economic activity is not very clear (Hooker, 1996). However, in the present study we focus on the German economy. Germany is of special interest because of her position enjoyed in the world crude oil market, among others. Germany was ranked 5th in 2006 in the world in the demand for crude oil by consuming 2.638 million barrels of crude oil per day as per the US Energy Information Administration. Nonetheless, her crude oil consumption has continued to decline from a record high of 2.923 million barrels of crude oil per day in 1998 which has reduced to 2.4 million barrels of crude oil per day in 2011. Germany produced 123.20036 thousand barrels of total oil per day in 2006, which was only 4.668% of total petroleum consumption. In 2004, Germany consumed 2.6 million barrels of oil per day, with imports supplying over 90% of these needs. To meet her demand, Germany imported 794.29405 thousand barrels of refined petroleum products per day in 2006. According to the Oil and Gas Journal, Germany had 390 million barrels of proven oil reserves in 2005 which has fallen to, as of January 2006, an estimated 367 million barrels of proven oil reserves. However, because of her economic size and the lack of significant domestic oil production, Germany is one of the world's largest oil importers. "To save energy cost and develop renewable energy technologies, Germany is the world largest producer of biodiesel and generator of electricity from wind and provided tax incentives to encourage consumers to blend biodiesel with conventional diesel fuel" (Hsing, 2007). Substitution policies away from oil to more secure domestic energy sources, although pursued effectively, have only resulted in gradual improvement because close to half of total oil demand is used in the transportation sector where alternatives remain very limited. Domestic German oil production meets only 5.874% of total oil needs as of 2011. In Fig. 1, we present total petroleum consumption, total imports of refined petroleum products and total oil supply/production measured in thousand barrels per day.

According to the conventional wisdom the relationship between the oil prices and both fundamental macroeconomic and financial market variables is much less clear as one would perhaps anticipate. A number of studies have addressed the issues of linearity versus non-linearity, symmetry versus asymmetry or stability versus instability while analyzing this issue. In this work we extend the context of oil prices and macroeconomy addressed in Gronwald (2009) in the framework of Aguiar-Conraria and Soares (2011). Gronwald (2009) has investigated for the German economy whether the extent of causality running

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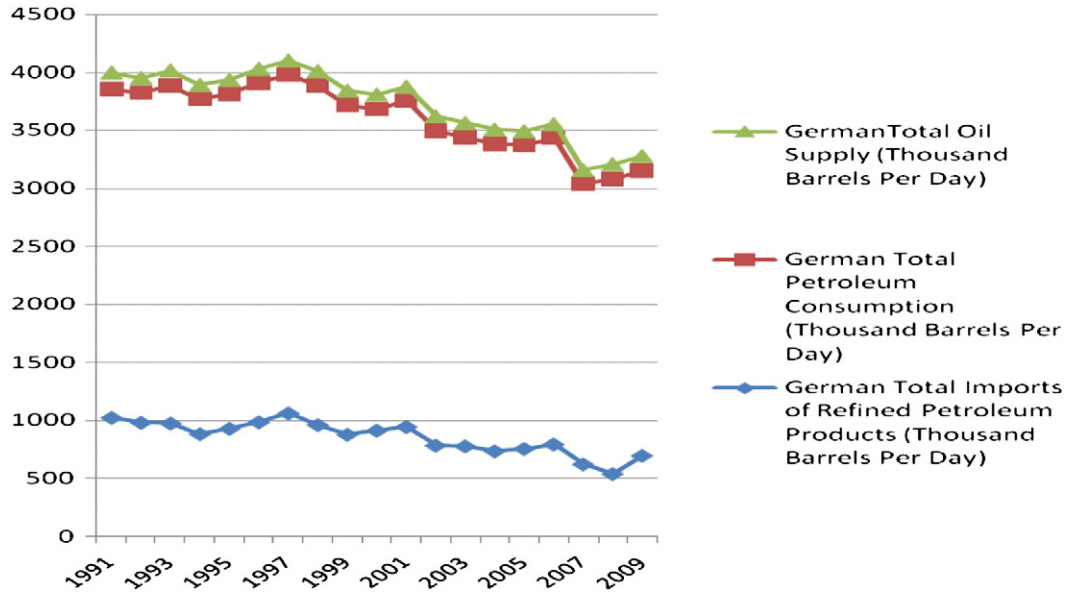

Fig. 1. Total petroleum consumption, total imports of refined petroleum products and total oil supply/production (thousand barrels per day).

from the oil price to both fundamental macroeconomic and financial market variables differs between frequency bands using Breitung and Candelon's (2006) frequency-domain causality test, which is build on Geweke's (1982) and Hosoya's (1991) frequency-wise causality measures. Aguiar-Conraria and Soares (2011) addressed the issue of oil prices and macroeconomy for the US economy by utilizing the tools such as wavelet coherency of continuous wavelets approach. Tools used in Aguiar-Conraria and Soares (2011) to analyze the same issue as addressed in Gronwald (2009) are relatively superior (for superiority of the continuous wavelet tools over the discrete wavelet tool and the frequency-domain approach please see Section 2).

Our present contribution is built upon three pillars. In the first place, the much debated question of whether or not a causal relationship exists between the oil price and fundamental macroeconomic (that is industrial production, a proxy of macroeconomic activity, and inflation, measured by consumers price index) variables, calling upon the notion of causality based on the pioneering work of Granger. Secondly, within this causality debate, the relevance of frequency domain concepts is introduced as Granger and Lin (1995) documented that the extent and direction of causality can differ between frequency bands. Thirdly, we introduced time concept with frequency domain hence we analyzed time–frequency relationship as in the frequency-domain framework time information is lost. Hence, in our contribution we used continuous wavelet tools[1] such as the wavelet power spectrum, wavelet coherency, and wavelet phase-difference to analyze the impact of oil price changes in two macroeconomic variables namely industrial production and CPI based inflation. The wavelet power spectrum illustrates the evolution of the variance of a time-series at the different frequencies; the wavelet coherency demonstrates the correlation coefficient in the time–frequency space; and the information on the delay between the oscillations of two time-series i.e., lead–lag relationships provided by phase-difference.

The remainder of the paper is organized as follows: Section 2 briefly discusses the data and methodology. Section 3 presents and discusses the results, and Section 4 concludes.

[1] These tools were also used in Jevrejeva et al. (2003), Bloomfield et al. (2004), Cazelles et al. (2007) and Aguiar-Conraria and Soares (2011) and we have followed them.

2. Data and methodology

2.1. Data

For the empirical estimation, monthly data from 1958M1 to 2009M2, of industrial production and CPI was accessed from IFS CD-ROM of IMF 2010 and data of crude oil prices is the spot price: West Texas Intermediate (WTI) — Cushing Oklahoma (Source: U.S. Department of Energy: Energy Information Administration).

2.2. Motivation and introduction to methodology

In many studies, the analysis is exclusively done in the time-domain and the frequency domain is ignored. However, some appealing relations may exist at different frequencies: oil price may act like a supply shock at high and medium frequencies (see Section 2; Naccache, 2011), therefore, affecting industrial production, whereas, in the long run (i.e., at the lower frequencies) it is the industrial production, through a demand effect, that affects the oil price.

There has been a general practice to utilize Fourier analysis to expose relations at different frequencies between interest variables. However, the shortcomings of the use of Fourier transform for analysis has been well established. A big argument against the use of Fourier transform is the total loss of time information and thus making it difficult to discriminate ephemeral relations or to identify structural changes which is very much important for time series macroeconomic variables for policy purposes. Another strong argument against the use of Fourier transform is the reliability of the results. It is strongly recommended (i.e., it is based on assumptions such as) that this technique is appropriate only when time series is stationary, which is not so usual as in the case with macro-economic variables. The time series of macro-economic variables are mostly noisy, complex and rarely stationary.

To overcome such situation and have the time dimensions within Fourier transform, Gabor (1946) introduced a specific transformation of Fourier transform. It is known as the short time Fourier transformation. Within the short time Fourier transformation, a time series is broken into smaller sub-samples and then the Fourier transform is applied to each sub-sample. However, the short time Fourier transformation approach was also criticized on the basis of its efficiency as it takes