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ORIGINAL PAPER

Reconsidering the macroeconomics of the oil price in Germany: testing for causality in the frequency domain

Marc Gronwald

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Abstract This paper reconsiders the macroeconomics of the oil price for Germany. It investigates whether causality between the oil price and a selection of both macroeconomic and financial market variables differs between frequency bands. Both a bivariate frequency-wise causality measure and its higher-dimensional extension are applied. The main findings are that short-run causality exists between the oil price and variables such as short-term interest rates and the German share price index, while long-run causality is found between the oil price and long-term interest rates. Moreover, the oil price predicts the consumer price index at a high number of different frequencies, while no significant causality is found to run from the oil price to industrial production and the unemployment rate.

Keywords Oil price · Causality · Frequency domain · Spectral analysis · Vector autoregressions

JEL Classification C22 · E22

1 Introduction

There is no shortage of papers analyzing the macroeconomics of the oil price. Various statistical methods have been applied, mostly focussing on the US economy. Conventional wisdom suggests that the relationship between the oil price and both fundamental macro and financial market variables is not as clear-cut as one would possibly expect. The issues of linearity versus non-linearity, symmetry versus asymmetry or stability

M. Gronwald (✉)
Department of Economics, Hamburg University, Von Melle Park 5, 20146 Hamburg, Germany
e-mail: gronwald@econ.uni-hamburg.de

versus instability have been investigated in a large body of work; among those methods applied, VAR frameworks have enjoyed considerable popularity.

The analysis that follows is built on two pillars: first, the much debated question of whether or not a causal relationship exists between the oil price and different macroeconomic variables, invoking notions of causality based on the pioneering work of Clive Granger; and second, within this causality debate, the relevance of frequency domain concepts, as illustrated by Granger's (1969) proposal of a frequency domain causality measure and Granger and Lin's (1995) finding that extent and direction of causality can differ between frequency bands.[1]

This paper seeks to consider these two issues in unison. Since causality is naturally of great interest within oil price research, this paper addresses the question whether employing frequency-wise causality measures sheds further light on the relationship between the oil price and a choice of both fundamental macro and financial market variables. This issue is tackled here by applying procedures proposed by Hosoya (2001) and Breitung and Candelon (2006), which further develop work owing its origin to Geweke (1982) and Hosoya (1991).[2]

The following stream of literature encompasses this analysis: on the macro front, Hamilton's (1983) application of a VAR framework represents a landmark in this literature, as it sparked research efforts that, however, confronted a number of obstacles to finding models correctly reflecting the macroeconomics of the oil price: Mork (1989) finds the oil price–output relationship to be asymmetric, in that only oil price increases significantly affect output growth; Hamilton (1996) and Lee et al. (1995) argue that not just the magnitude of the oil price increase matters but also the volatility of the oil price in the episode an increase takes place. Ferderer (1996) includes a volatility measure of the oil price in his empirical approach; Huang et al. (2005) find that an oil price increase must exceed a certain threshold value in order to significantly affect macro variables.[3] These issues are based on different theoretical foundations: Lilien (1982), representing sectoral shock literature, argues that economic shocks lead to expensive labor and capital reallocations across sectors, with these sectors being affected to different degrees. Hamilton (1988) constructs a multi-sector model of the economy in order to further investigate this issue. Bernanke (1983), as an exponent of irreversible investment literature, emphasizes the inverse relationship between irreversible investment and uncertainty caused by the option value of waiting for a better time to invest.

Similar stumbling blocks have appeared on the financial market front, in terms of both volatility and linearity. Sadorsky (1999) shows that oil price volatility, as well as the oil price level, is an important factor for real stock returns and, moreover,

1 Further papers which have evolved from this causality research are Granger (1980, 1988).

2 Sources of further motivation include the work of Beaudry and Portier (2006), who argue that forward looking variables such as stock prices will react to new information much earlier than other macroeconomic variables. Building further on this idea, this paper investigates whether the frequency-wise causality measure which is applied here is able to capture this Beaudry and Portier insight by disentangling short- and long-run causality.

3 Hamilton (2003) summarizes this discussion and provides further evidence of the non-linear character of this relationship.

considers the issue of asymmetry; Ciner (2001) provides evidence of a non-linear causal relationship between oil futures and broad-based stock index returns.[4] Moreover, Huang et al.'s (2005) threshold-finding applies to the oil price–stock price relationship as well. Baily (1981) discusses the causal link between oil price shocks and stock prices: a jump in the oil price makes large fractions of the capital stock obsolete; energy inefficient machines are shut down and expected profits of machines in operations decline. The existing capital is no longer technologically suited to the new economic conditions—reflected by a decline of the stock prices following an oil shock.

While most of the papers mentioned so far consider the US economy, this study focusses on the German economy.[5] It investigates whether the extent of causality running from the oil price to both fundamental macro 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. As these measures are based on a bivariate framework, this paper also employs Hosoya's (2001) measure of partial causality.[6]

The remainder is organized as follows: Sect. 2 briefly discusses the data and presents some descriptive statistics as well as basic estimation results. Section 3 describes the frequency-wise causality measure, and Sect. 4 presents empirical results. Finally, Sect. 5 offers some concluding remarks.

2 Data and basic estimation results

This study's empirical investigation is concerned with the relationship between the oil price and an assortment of fundamental macro as well as financial market variables. This is investigated here by employing bivariate VAR models, each consisting of the real oil price (OIL) and one of the following variables: the composite German share price index (CDAX), the consumer price index (CPI), the day-to-day interbank offered rate (IBR), the 3-month money market rate (MMR), the yield for government bonds maturing in more than 3 (GBY3) and more than 10 (GBY10) years, the industrial production index (IPI) and the unemployment rate (UR).[7] Potential third-variable effects are also taken into account, e.g., influences of the central bank's reference rate (RR) on the relationship between the oil price and the financial market variables. A total

[4] Ciner (2001) expands upon Huang et al.'s (1996) application of a linear approach, who find no evidence of a causal relationship between oil futures and various stock indices returns. Moreover, Jones and Kaul (1996) and Kaul and Seyhun (1990) provide general modeling approaches, Sakellaris (1997) and Wei (2003) attend to theoretical considerations.

[5] Other papers emanating from this research field that consider the German economy include Mork et al. (1994) and Jiminez-Rodrgiuez and Sanchez (2005).

[6] Thus, both direct relationships as in Hooker (1999) and Ciner (2001) and transmission channels as in Jiminez-Rodrgiuez and Sanchez (2005) are investigated here.

[7] Similar to papers such as Carruth et al. (1998), Hooker (1999) and Jiminez-Rodrgiuez and Sanchez (2005), the real oil price is used in this study. It is calculated as follows: the price of an international traded variety of crude (UK Brent) in US Dollars is converted to German Marks and EURO, respectively, and deflated using the German producer price index. Using the nominal oil price—as suggested by Hamilton (2003)—does not affect the results.

Table 1 Unit root tests

Variable	ADF (levels)	ADF (first differences)	PP (levels)	PP (first differences)
CDAX	0.9167	0.0001	0.8914	0.0001
CPI	0.9816	0.0002	0.9985	0.0001
MMR	0.0095	–	0.0471	–
IBR	0.0037	–	0.0137	–
GBY3	0.3552	0.0001	0.4174	0.0001
GBY10	0.3891	0.0001	0.4749	0.0001
IP	0.4816	0.0001	0.1553	0.0001
UR	0.6206	0.0001	0.7533	0.0001
OIL	0.2689	0.0001	0.3146	0.0001

The numbers are the P values to the corresponding t and adjusted t statistics. Both tests have the H_0: variables are of $I(1)$. The lag length in case of the ADF test has been chosen according to the Schwarz Information Criterion, the bandwidth for the PP test according to Newey-West using the Bartlett kernel. CPI, OIL and UR have been taken in logs. For CPI, IP and UR, a constant and a linear trend, for the remaining variables a constant have been included in the test equation
ADF augmented Dickey-Fuller, *PP* Phillips-Perron unit root test

of eight VAR models are considered here; monthly data is used, and the period of observation is 1963:1 to 2006:8.[8]

The frequency-wise causality measure employed here requires stationary data. Therefore, unit root tests have been performed, see Table 1. It is clearly evident that all variables are $I(1)$, with exception of the short-term interest rates IBR and MMR, who are are $I(0)$. Hence, the variables are taken as follows throughout this paper: CPI, OIL and UR in growth rates, IPI, CDAX, GBY3, and GBY10 in first differences, and IBR as well as MMR in levels.[9]

The frequency-domain descriptive statistics presented in Figs. 1 and 2 illustrate some data properties. To highlight some findings, Fig. 1 shows that the consumer price index, the short-term and the long-term interest rates have low-frequency spectra, while the power of the share price index is high at both lower and higher frequencies. Moreover, the spectrum of the real oil price is concentrated at frequencies below 1. Figure 2 depicts coherency estimates for the same eight relationships mentioned above.[10] The estimates suggest that there is a significant relationship between the real oil price and the short-term interest rates at higher frequencies. In contrast, the correlation

[8] Data are drawn from the Deutsche Bundesbank, the OECD, the Handelsblatt and the IFS database.

[9] Since the variables are integrated of different order, investigating the issue of cointegration is only required for the bivariate relationships between OIL and CPI, UR as well as the long-term interest rates. The Johansen (1991, 1995) procedure clearly indicates that no cointegration relationship is present. The detailed results are available from the author on request.

[10] The coherency of a bivariate process is based on the cross spectrum, defined as the Fourier transformation of the cross-covariance function. Since this function is not an even function, the cross spectrum is complex-valued. It is conventionally decomposed into its two real-valued parts, the co- and the quadrature spectrum, which are then used to calculate the coherency. The coherency measures the square of the linear correlation between the two components of the bivariate process, see e.g., Priestley (1981).

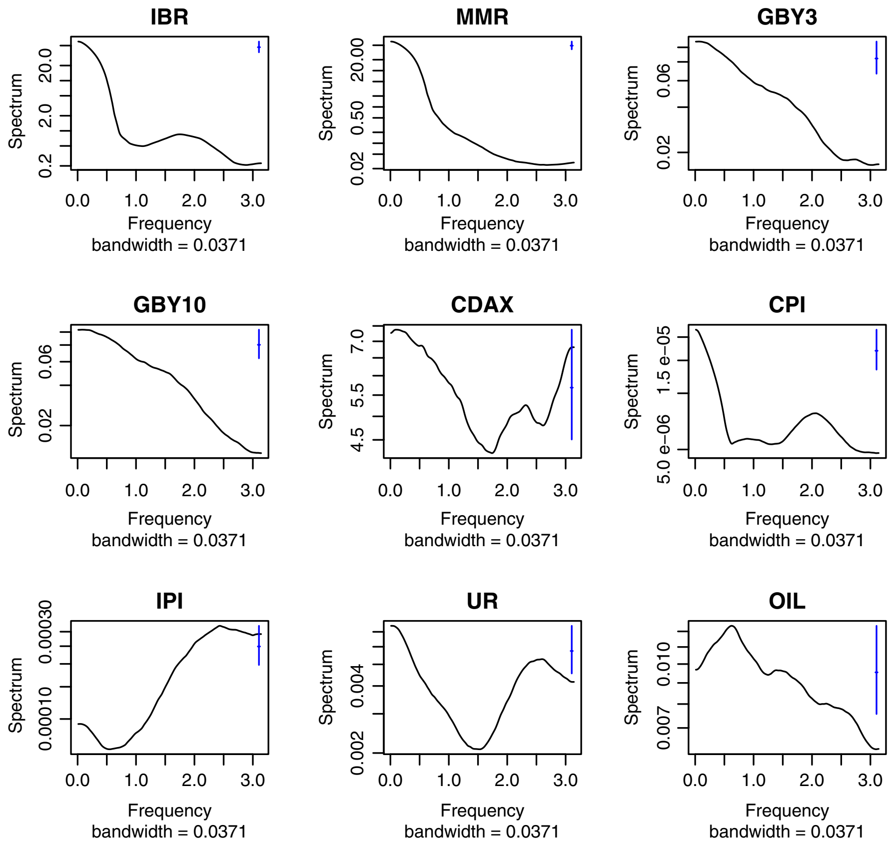

Fig. 1 Estimated spectra. The estimates have been smoothed using the modified Daniell-smoother

between the oil price and the long-term interest rates proves to be significant at lower frequencies. Moreover, the estimated coherency for the oil price and the consumer price index has a noticeable peak just at those frequencies below 1 the spectrum of the real oil price has its maximum. Thus, the oil price periodicity at those frequencies leads to a palpable correlation with corresponding components of the consumer price index. The correlation between the oil price and the remaining variables is negligible.

The overall picture gleaned from Fig. 2 is that the frequency band can play an important role when analysing the relationship between the oil price and different macro as well as financial market variables. This becomes more apparent when the frequency-wise causality measure is applied, the essence of which is outlined in the following section.

3 Estimation method

Causality measures in the frequency domain have been proposed by Geweke (1982) and Hosoya (1991). To illustrate these measures, consider the two-dimensional times

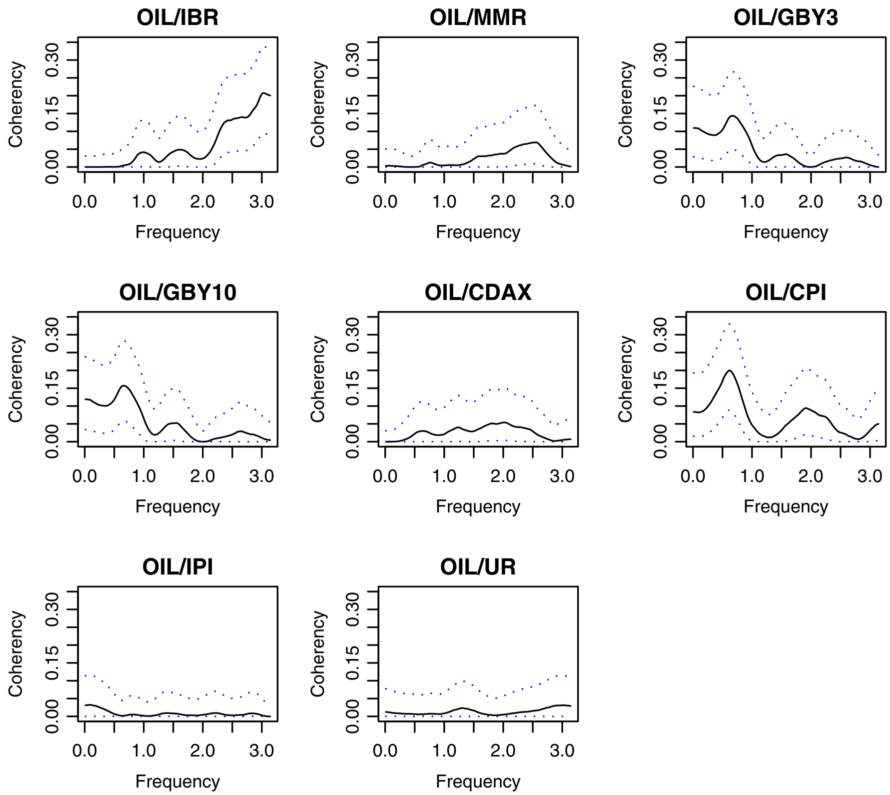

Fig. 2 Coherency estimates. The figure displays coherency estimates between the real oil price and the eight variables discussed in Sect. 2 together with the 95% confidence bands (*dotted lines*). The confidence bands follow Bloomfield (2000)

series vector $z_t = [x_t, y_t]'$, observed at $t = 1, \ldots, T$. It is assumed that z_t has the finite-order VAR representation

$$\Theta(L)z_t = \epsilon_t, \tag{1}$$

with $\Theta(L) = I - \Theta_1 L - \cdots - \Theta_p L^p$ as 2×2 lag polynomial with $L^k z_t = z_{t-k}$.[11] By assumption, the error vector ϵ has the usual properties of being white noise with $E(\epsilon_t) = 0$, $E(\epsilon_t \epsilon_t') = \Sigma$ and Σ positive definite. Furthermore, let G be the lower triangular matrix of the Cholesky decomposition $G'G = \Sigma^{-1}$, such that $E(\eta_t \eta_t') = I$ and $\eta_t = G\epsilon_t$. The system is assumed to be stationary, implying that the following MA representation can be derived:

[11] For ease of exposition, deterministic terms in Eq. (1) are neglected.

$$z_t = \Phi(L)\epsilon_t = \begin{bmatrix} \Phi_{11}(L) & \Phi_{12}(L) \\ \Phi_{21}(L) & \Phi_{22}(L) \end{bmatrix} \begin{bmatrix} \epsilon_{1t} \\ \epsilon_{2t} \end{bmatrix}$$
$$= \Psi(L)\eta_t = \begin{bmatrix} \Psi_{11}(L) & \Psi_{12}(L) \\ \Psi_{21}(L) & \Psi_{22}(L) \end{bmatrix} \begin{bmatrix} \eta_{1t} \\ \eta_{2t} \end{bmatrix}, \quad (2)$$

where $\Phi(L) = \Theta(L)^{-1}$ and $\Psi(L) = \Theta(L)G^{-1}$. Using this, the spectral density of x_t can be expressed as

$$f_x(\omega) = \frac{1}{2\pi}\{|\Psi_{11}(e^{-i\omega})|^2 + |\Psi_{12}(e^{-i\omega})|^2\}. \quad (3)$$

The measure of causality suggested by Geweke (1982) and Hosoya (1991) is defined as

$$M_{y\to x}(\omega) = \log\left[\frac{2\pi f_x(\omega)}{|\Psi_{11}(e^{-i\omega})|^2}\right]$$
$$= \log\left[1 + \frac{|\Psi_{12}(e^{-i\omega})|^2}{|\Psi_{11}(e^{-i\omega})|^2}\right] \quad (4)$$

and, thus, makes use of a Fourier transformation of the MA coefficients. This measure is 0 if $|\Psi_{12}(e^{-i\omega})| = 0$, in which case it is said that "y does not cause x at frequency ω".

Employing Hosoya's (2001) measure of partial causality enables one to examine higher-dimensional systems. The central idea of Hosoya's approach is to eliminate third-variable effects by appropriately transforming the original variables. Breitung and Candelon (2006) illustrate this using the example of investigating the causal effect of y_{1t} on y_{2t} in the three-dimensional system $y_t = [y_{1t}, y_{2t}, y_{3t}]'$ and define w_t as the projection residual from projecting y_{3t} onto the Hilbert space $H(y_{1t}, y_{2t}, y_{t-1}, y_{t-2}, \ldots)$ and, furthermore, u_t and v_t as the projection residuals from projecting y_{1t} and y_{2t}, respectively, on w_t. Using the representation

$$\begin{bmatrix} \Delta y_{1t} \\ \Delta y_{2t} \\ \Delta y_{3t} \end{bmatrix} = \begin{bmatrix} \Psi_{11}(L) & \Psi_{12}(L) & \Psi_{13}(L) \\ \Psi_{21}(L) & \Psi_{22}(L) & \Psi_{23}(L) \\ \Psi_{31}(L) & \Psi_{32}(L) & \Psi_{33}(L) \end{bmatrix} \begin{bmatrix} \eta_{1t} \\ \eta_{2t} \\ \eta_{3t} \end{bmatrix}$$

it can be shown that $u_t = \Psi_{11}(L)\eta_{1t} + \Psi_{12}(L)\eta_{2t}$ and $v_t = \Psi_{21}(L)\eta_{1t} + \Psi_{22}(L)\eta_{2t}$. Thus, there is equivalence between the measures: $M_{y_1\to y_2|y_3}(\omega) \equiv M_{u\to v}(\omega)$.

In order to test the hypothesis $M_{y\to x}(\omega) = 0$ a number of procedures have been proposed. For instance, Yao and Hosoya (2000) suggest replacing theoretical expressions by those obtained from estimating the parameters and applying the delta method. However, this approach suffers from the fact that $|\Psi_{12}(e^{-i\omega})|$ is a complicated non-linear function of the VAR parameters and, thus, complex calculations of derivatives are necessary.[12] Breitung and Candelon (2006) remedy this by showing that the hypothesis $M_{y\to x}(\omega) = 0$ is equivalent to a linear restriction on the VAR coefficients. Their argument is as follows.

As asserted above, $M_{y\to x}(\omega) = 0$, if $|\Psi_{12}(e^{-i\omega})| = 0$. Since $\Psi(L) = \Theta(L)^{-1}G^{-1}$ and $\Psi_{12}(L) = -\frac{g^{22}\Theta_{12}(L)}{|\Theta(L)|}$, with g^{22} as the lower diagonal element of G^{-1} and $|\Theta(L)|$ as the determinant of $\Theta(L)$, it follows, that, y does not cause at frequency ω if

$$|\Theta_{12}(e^{-i\omega})| = \left|\sum_{k=1}^{p}\theta_{12,k}\cos(k\omega) - \sum_{k=1}^{p}\theta_{12,k}\sin(k\omega)i\right| = 0, \tag{5}$$

with $\theta_{12,k}$ denoting the $(1, 2)$-element of Θ_k. Therefore,

$$\sum_{k=1}^{p}\theta_{12,k}\cos(k\omega) = 0 \tag{6}$$

$$\sum_{k=1}^{p}\theta_{12,k}\sin(k\omega) = 0 \tag{7}$$

is a necessary and sufficient set of conditions for $|\Theta_{12}(e^{-i\omega})| = 0$. Breitung and Candelon's (2006) approach is based on these linear restrictions (6) and (7). In order to simplify the notation, let $\alpha_j = \theta_{11,j}$ and $\beta_j = \theta_{12,j}$. Then the VAR equation for x_t can be expressed as

$$x_t = \alpha_1 x_{t-1} + \cdots + \alpha_p x_{t-p} + \beta_1 y_{t-1} + \cdots + \beta_p y_{t-p} + \epsilon_{1t}. \tag{8}$$

Using this simplification, Breitung and Candelon (2006) conclude that the hypothesis $M_{y\to x}(\omega) = 0$ is equivalent to the linear restriction

$$H_0: \; R(\omega)\beta = 0, \tag{9}$$

with $\beta = [\beta_1, \ldots, \beta_p]'$ and

$$R(\omega) = \begin{bmatrix} \cos(\omega) & \cos(2\omega) & \ldots & \cos(p\omega) \\ \sin(\omega) & \sin(2\omega) & \ldots & \sin(p\omega) \end{bmatrix}.$$

To assess the significance of the causal relationship, the causality measure for $\omega \in (0, \pi)$ is compared with the 5% critical value of a χ^2-distribution with 2 degrees of freedom, which is 5.99.

[12] The delta method gives rise to the expansion $\hat{M}_{y\to x}(\omega) = M_{y\to x}(\omega) + D_\gamma(\gamma)'(\hat{\gamma} - \gamma) + o_p(T^{-1/2})$, with $\hat{M}_{y\to x}(\omega)$ as the estimated causality measure, $\gamma = \text{vec}\,(\Theta_1, \ldots, \Theta_p, \Sigma)$ as the vector of parameters and $D_\gamma(\gamma)$ as the vector of derivatives of the causality measure with respect to γ. Moreover, Yao and Hosoya (2000) suggest using a numerical procedure instead of the exact analytical expression.

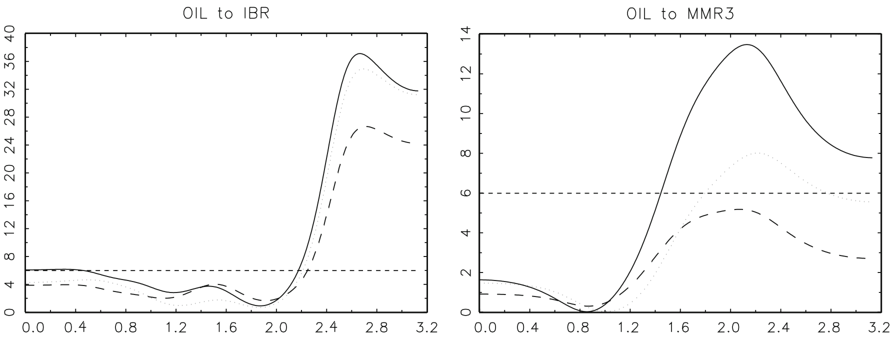

Fig. 3 Causality between the oil price and short-term interest rates. The figure presents the causality running from the oil price to the short-term interest rates, measured using the original bivariate causality measure (*solid*) and the measure of partial causality, with RR (*dashed*) and CPI effects (*dotted*) eliminated

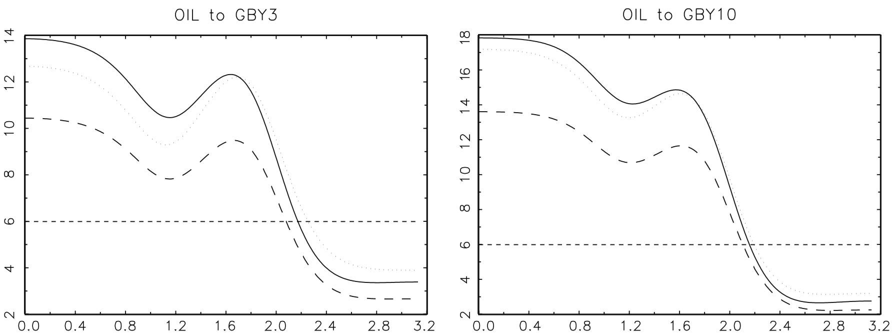

Fig. 4 Causality between the oil price and long-term interest rates. The figure presents the causality running from the oil price to the long-term interest rates, measured using the original bivariate causality measure (*solid*) and the measure of partial causality, with MMR (*dashed*) and CPI effects (*dotted*) eliminated

4 Results

The frequency-wise causality measure outlined in the previous section is now applied to the eight bivariate VAR models discussed in Sect. 2.[13]Figures 3, 4, 5 and 6 report the causality measures between the oil price and the other variables for all frequencies $\omega \in (0, \pi)$ together with the 5% critical value. As asserted above, in some cases potential third-variable effects should be taken into account. Therefore, the figures report both the original bivariate causality measure (solid lines) and the measure of partial causality (dashed and dotted lines).[14]

13 The decision regarding lag lengths in the VAR models has been based on the AIC. Moreover, in order not to cut off possible significant coefficients, larger lag lengths have also been considered; Assenmacher-Wesche and Gerlach (2006a,b) proceed in a similar manner. A VAR(7) has been chosen for the OIL/CPI and OIL/IBR relationship, a VAR (5) for OIL/MMR, a VAR(4) for OIL/GBY3 and OIL/GBY10, and VAR(3) models for the remaining relationships. The detailed results are available from the author on request.

14 The variables have been transformed according to Hosoya's (2001) proposal, accompanied by the loss of a small number of early observations. For further applications of this method, see Assenmacher-Wesche and Gerlach (2006a,b).

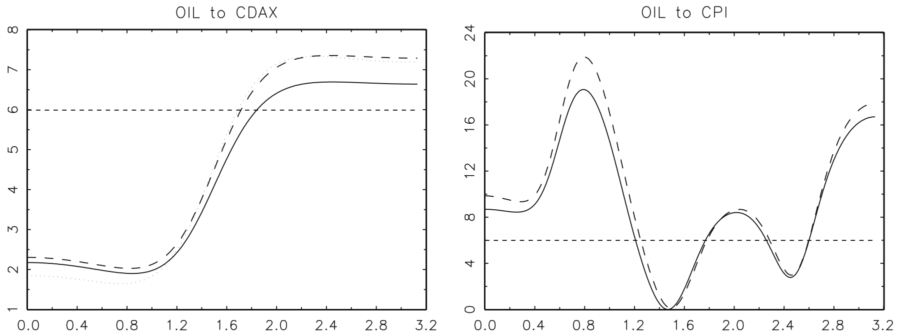

Fig. 5 Causality between the oil price and the share price as well as the consumer price index. The figure presents the causality running from the oil price to the share price and the consumer price index, measured using the original bivariate causality measure (*solid*) and the measure of partial causality, with RR (*dashed*) and CPI effects (*dotted*) eliminated in the OIL/CDAX relationship and with RR effects (*dashed*) eliminated in the OIL/CPI relationship

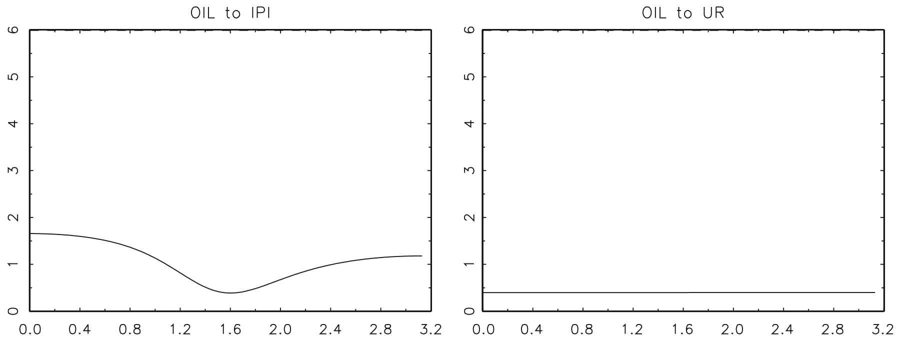

Fig. 6 Causality between the oil price and industrial production as well as the unemployment rate. The figure presents the causality running from the oil price to the fundamental macro variables, measured using the original bivariate causality measure

Investigating the relationship between the oil price and the different interest rates clearly indicates that the maturity of the underlying asset is crucial—a result anticipated by Sect. 2's coherency analysis, see Fig. 3. It is clearly evident that, according to the original measure, the null hypothesis of no predictability is rejected for frequencies larger than 2.2 and 1.4, respectively, but for the latter the degree of causality is considerably smaller. These frequencies correspond to cycle lengths shorter than about 3 and 4.5 months, respectively. Thus, only the short-run component of the short-term interest rates is significantly affected by the oil price. However, eliminating RR-effects yields further insights in the driving forces of this result. The degree of causality considerably declines; in case of the OIL/MMR relationship even no significant causality is found any more. Hence, the short-run causality running from the oil price to the short-term interest rates is attributable to different degrees to effects of the central bank's reference rate.[15] Eliminating inflation effects yields comparable results: the

[15] Eliminating IBR-effects in the OIL/MMR relationship leads to similar results as eliminating RR-effects. Moreover, no direct causality is found to run from the oil price to the central bank's reference rate itself.

impact of inflation on the OIL/IBR-relationship is negligible, while the one between OIL and MMR3 is considerably affected.

A very different pattern emerges for the relationship between the oil price and the long-term interest rates, see Fig. 4. Here, predictability is found only for frequencies below 2.2, corresponding to cycle lengths longer than about 3 months. However, here also considerable third-variable effects occur. Eliminating MMR-effects leads to a decline in the causality measure, but the qualitative results remain essentially unchanged.[16] Inflation, however, does not have a considerable impact on this relationship.

For the causality running from the oil price to the composite DAX index similar results as for the relationship between the oil price and the short-term interest rates are obtained, see the left panel of Fig. 5. Predictability is only found for frequencies above 2, corresponding to cycle lengths shorter than 3 months.[17] Eliminating RR- and CPI-effects does not change the general pattern of these results.

Investigating the relationship between the oil price and the consumer price index (right panel of Fig. 5), once again leads to results which have already been anticipated by the coherency analysis of Sect. 2. Significant causality can be found for frequencies below 1.2, between 1.8 and 2.3 and above 2.6, corresponding to cycle lengths longer than about 5 months, between 3.5 and 2.75 months, and shorter than 2.5 months. Prominent peaks emerge at frequencies below 1—those frequencies were already conspicuous in Sect. 2's coherency analysis—and at very high frequencies. Thus, the consumer price index is predicted by the oil price at a evidently larger number of frequencies than variables such as the short-term interest rates and the share price index. Eliminating RR-effects does not substantially alter the results; only for frequencies below 1 a slightly stronger causal relationship is found.

The results presented so far clearly show that the extent of causality from the oil price to different variables can substantially differ across frequencies and that for different types of variables different patterns of the causality measures can emerge. However, Fig. 6 shows that this need not be the case. It displays the causality measures from the oil price to fundamental macro variables industrial production and the unemployment rate and show that the oil price does not cause the two variables at any frequency. However, investigating the relationship between the oil price and this type of variables has proved to be the most problematic task for researchers. The analysis undertaken here confirms this finding of a weak relationship by showing that even this frequency-wise notion of causality does not bring to the surface any significant relationship.

5 Conclusions

In recent decades, the oil price has persistently proved itself to be a thorn in the side of the global economy. Its development has been characterized by large oil price

16 Eliminating IBR-effects leads to similar results. There is no third-variable effect of GBY3 in the OIL/GBY10-relationship. Moreover, the central bank's reference rate does not have any impact on the oil price-long-term interest rate relationship.

17 This result is confirmed by using the DAX instead of the composite DAX, which consists of a smaller number of shares.

shocks, associated with the two oil crises of the 1970s, and long-standing increases as witnessed after 2000. What is more, while the two oil crises were triggered by marked changes in supply, the recent increases owe their origins to swelling demand, especially from USA and China.

Shedding light on the macroeconomic consequences of these oil price increases is, no doubt, a noble pursuit for both theoretical and empirical economists. A large body of literature has emerged from this research effort, revealing, however, a considerable high degree of difficulties. The issues of whether the relationship between the oil price and both fundamental macro and financial market variables is symmetric or asymmetric, linear or non-linear and structurally stable or instable have been vigorously debated in this literature, highlighting the fact that this relationship is not as clear-cut as one would expect.

In keeping with such views, this paper investigates the macroeconomics of the oil price from a frequency domain perspective. As it is widespread in this research field, both bivariate VAR models and corresponding higher-dimensional extensions are used here, addressing the question of whether the extent of causality between the oil price and variables such as share prices, the consumer price index, short- and the long-term interest rates, industrial production, and the unemployment rate differs between frequencies. Frequency-wise causality measures allowing one to investigate this have been proposed by Geweke (1982) and Hosoya (1991); here a measure of partial causality suggested by Hosoya (2001) and a testing procedure proposed by Breitung and Candelon (2006) are applied.

The German economy is the focus of the investigation undertaken here. Salient findings to emerge from this analysis include: first, the extent of causality between the oil price and other variables clearly changes across frequencies; and, second, for different types of variables different results are obtained. While significant causality running from the oil price to stock market variables and short-term interest rates can only be found for higher frequencies, the relationship between the oil price and long-term interest rates is characterized by long-run causality. Eliminating third-variable effects shows, for instance, that the relationship between the oil price and the short-term interest rates is considerably affected by the central bank's reference rate. Moreover, the oil price predicts the consumer price index at a higher number of different frequencies, in particular at frequencies corresponding to cycle lengths longer than 6 months, while no significant causality can be found to run from the oil price to fundamental macro variables such as industrial production and the unemployment rate.

The key message to emerge from this study is that frequency bands are an important factor in the investigation of causal relationships between the oil price and both fundamental macro and financial market variables.

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