

Nonlinear interest rate effects of global oil price changes: the comparison of net oil-consuming and net oil-producing countries

Author

Sotoudeh, M Ali, Worthington, Andrew C

Published

2015

Journal Title

Applied Economics Letters

Version

Accepted Manuscript (AM)

DOI

[10.1080/13504851.2014.969821](https://doi.org/10.1080/13504851.2014.969821)

Rights statement

© 2015 Taylor & Francis (Routledge). This is an Accepted Manuscript of an article published by Taylor & Francis in Applied Economics Letters on 28 Oct 2014, available online: <http://www.tandfonline.com/doi/abs/10.1080/13504851.2014.969821>

Downloaded from

<http://hdl.handle.net/10072/141694>

Griffith Research Online

<https://research-repository.griffith.edu.au>

Nonlinear interest rate effects of global oil price changes: comparison of net oil consuming and net oil producing countries

M. Ali Sotoudeh^{a,b,*}, Andrew C. Worthington^b

^a *Department of Economics, University of Sistan and Baluchestan, Zahedan, Iran*

^b *Department of Accounting, Finance and Economics, Griffith University, Brisbane, QLD 4111, Australia*

In this paper, we test nonlinear causality between global oil price changes and short-term real interest rate in large net oil consuming and producing countries. Applying nonlinear non-parametric Hiemstra-Jones and parametric Mackey-Glass models, we find no evidence to suggest that potential direct effects of global oil price changes on short-term real interest rate are nonlinear in net oil consuming countries. In contrast, such effects are reported to be nonlinear and asymmetric in net oil producing countries.

Key words: short-term interest rate, global oil price, net oil consuming/producing countries, nonlinearity, asymmetry.

JEL Classification: C14; E44; E63; Q43

*Corresponding author. Email: ma.sotoudeh@griffithuni.edu.au

I. Introduction

Real interest rate is supposed to be a separate channel in transferring oil price shocks to economies (Ferderer, 1996; Hooker, 1999; Balke *et al.*, 2002). However, there is not enough evidence comparing differences in such mechanisms of effects among large net oil producing and net oil consuming countries. Theoretically, increases in oil price shift purchasing power from oil importing nations to oil exporting nations. This movement reduces consumer demand in oil importing countries and raises consumer demand in oil exporting countries. Thus, world demand for productions of oil importing countries is reduced and supply of savings is increased. Finally, real interest rate is reduced due to increasing supply of savings. The literature addresses significant effects of the oil price changes on real interest rate. Studying the US economy, Wu (2010) and Arora and Tanner (2013) show that oil price is consistently responsive to real interest rate. Evidences show that such effects are reported to be asymmetric (Balke *et al.*, 2002; Sadorsky, 1999). For instance, using a financial accelerator model, Balke *et al.* (2002) note that interest rate is the most important channel in transferring asymmetry from the oil price movements to the GDP.

On the other hand, some studies find that interest rate effects of oil price changes might be conditional. For example, Lowinger *et al.* (1985) reveal that only very high increases in oil price induce significant impacts on real interest rate. Dotsey *et al.* (2003) show that only high level of interest rate responds significantly to the oil price changes. Finally, Cologni and Manera (2008) prove that unexpected changes in oil price can affect real interest rates significantly.

A question that motivates us to consider the subject is that whether oil price movements affect real interest rate nonlinearly. Also, are the results identical across countries? To answer these questions, we implement the most powerful nonlinear models, monthly data for a long period and the possible largest panels of net oil consuming and net oil producing countries. The contribution of this paper would be of great interest of investors, policy decision makers and researchers.

II. Data and Methodology

Our sample includes the US, Brazil, Denmark, Italy, Sweden, Germany and Netherlands as the net oil consuming and Canada, Mexico and Norway as the net oil producing. Data which cover 1986m1–2013m8 include short-term real interest rate (IR) collected from Organisation for Economic Co-operation and Development (OECD) website as well as Portal de Financas website in case of Brazil. Also, we use West Texas Intermediate (WTI) crude oil price (OP) which is collected from the World Bank website and is inflation adjusted. Data are indexed to monthly-averaged 2010. Fig. 1 illustrates the growth rate of global oil price versus growth rate of short-term real interest rate within sample countries. By the Figure, it is evident that IR is mostly moving after OP .

(FIGURE 1 IS AROUND HERE)

Nonparametric nonlinear model

We employ Baek and Brock (1992) nonparametric nonlinear causality model, which has been modified by Hiemstra and Jones (1994). Denote m -length lead vector of IR_t by IR_t^m and Lir -length and Lop -length lag vectors of IR_t and OP_t by IR_{t-Lir}^{Lir} and OP_{t-Lop}^{Lop} . For given values of $m, Lir, Lop \geq 0$ and for $e > 0$, OP does not strictly Granger cause IR if:

$$\begin{aligned} \Pr(\|IR_t^m - IR_s^m\| < e \mid \|IR_{t-Lir}^{Lir} - IR_{s-Lir}^{Lir}\| < e, \|OP_{t-Lop}^{Lop} - OP_{s-Lop}^{Lop}\| < e) \\ = \Pr(\|IR_t^m - IR_s^m\| < e \mid \|IR_{t-Lir}^{Lir} - IR_{s-Lir}^{Lir}\| < e) \end{aligned} \quad (1)$$

where $\Pr(\cdot)$ is the probability and $\|\cdot\|$ is the maximum norm. As Hiemstra and Jones (1994) and Kanas and Ma (2000) explain, this model has a very good power in estimating non-linear Granger causal and non-causal relationships.

Parametric nonlinear model

The Mackey and Glass (1977) parametric model — which has been modified by Kyrtsou and Labys (2006) — employs a bivariate noisy procedure in estimating nonlinear causality. To examine the existence of nonlinear causality, we estimate the following models:

$$\begin{aligned} DIR_t = \alpha_{21}(DOP_{t-\tau_1})(1 + DOP_{t-\tau_1}^{c_1})^{-1} - \delta_{21}DOP_{t-1} + \alpha_{22}(DIR_{t-\tau_2})(1 + DIR_{t-\tau_2}^{c_2})^{-1} \\ - \delta_{22}DIR_{t-1} + u_t \end{aligned} \quad (2)$$

$$\begin{aligned} DOP_t = \alpha_{11}(DOP_{t-\tau_1})(1 + DOP_{t-\tau_1}^{c_1})^{-1} - \delta_{11}DOP_{t-1} + \alpha_{12}(DIR_{t-\tau_2})(1 + DIR_{t-\tau_2}^{c_2})^{-1} \\ - \delta_{12}DIR_{t-1} + \varepsilon_t \end{aligned} \quad (3)$$

where DIR_t and DOP_t are the first differences of IR and OP , respectively. Also, $\tau = \max(\tau_1, \tau_2)$ is the calculated integer delays, c is the constant and $t = \tau, \tau + 1, \dots, N$. The parameters α and δ denote linear and non-linear effects of the cause variable on dependent variable, respectively. Finally, the two error terms u_t and ε_t are assumed to be $N(0, I)$. The integer delays τ_i and constants c_i are chosen prior to the model estimation using Schwarz criterion and likelihood ratio.

III. Empirical Results

Data stationary tests

Our nonlinear models are sensitive to the data order of integration. To assure whether data are stationary, we conduct Augmented Dicky-Fuller (ADF), Dicky-Fuller generalized least squares (DF-GLS) and Philips-Perron (PP) tests. The results of unit root tests presented in Table 1 indicate that IR is integrated of order one in all of the countries while its first difference is reported to be stationary. Likewise, the first difference of OP is reported to be stationary.

(TABLE 1 IS AROUND HERE)

Results for nonparametric model

Table 2 demonstrates the results of Hiemstra-Jones model. Concerning mostly negative statistics and their respected t-values, it is worth noting that only positive values of OP helps predict IR , whereas a significant negative value suggests that knowledge of the lagged values of OP confounds the prediction of IR (Hiemstra and Jones, 1994). Thus, the negative

statistics are unacceptable and hence, this model shows no evidence on nonlinear linkages between *OP* and *IR*.

(TABLE 2 IS AROUND HERE)

Results for parametric model

The outcomes displayed in Table 3 differ slightly from those resulted from Hiemstra-Jones model. The responses of *IR* to changes in *OP* are statistically significant. Furthermore, the statistics for Canada, Norway and Mexico are significant at 1 per cent, 10 per cent and 10 per cent levels, respectively. On the other hand, there is still no evidence indicating nonlinear causal relationship between *OP* and *IR* in net oil consuming countries rather than Sweden. In short, the linkages between oil price and short-term real interest rate addressed in the literature do not seem to be nonlinear in net oil consuming countries whereas such relationship is unilaterally nonlinear in net oil consuming countries.

(TABLE 3 IS AROUND HERE)

Results for asymmetric model

The literature supports the assumption of asymmetric responses of *IR* to *OP*. To test such asymmetry, we implement asymmetric test using Kyrtsov-Labys parametric model. Thus, we run the model once using positive and then using negative values of *OP*.

(TABLE 4 IS AROUND HERE)

The asymmetric test results displayed in Table 4 and Table 5 reveal that nonlinear responses of *IR* to *OP* in net oil producing countries are asymmetric. That is, only positive changes in *OP* cause nonlinear changes in *IR*. This finding is consistent with Balke *et al.* (2002) and Sadorsky (1999).

(TABLE 5 IS AROUND HERE)

IV. Conclusions

A number of past studies have investigated oil price-interest rate relationship, mostly in the US economy. But, there is less evidence on the existence of nonlinear linkages explaining possible heterogeneities across large net oil consuming and net oil producing countries. In this paper, we used the most powerful nonlinear tests to address the above issues. Our finding for the net oil consuming countries reveals that the causal effects of global oil price changes on short-term interest rate reported in the literature is not nonlinear. Conversely, such linkages are reported to be statistically significant and also asymmetric in net oil producing countries. The differences between the results of parametric and nonparametric nonlinear tests can be explained by the ways in which they are constructed. Although the nonparametric model is free of any distribution assumption, the parametric model lets us conduct asymmetry test. For further research, it is recommended to consider such nonlinearities by using domestic oil price changes.

References

- Arora, V., and Tanner, M. (2013) Do oil prices respond to real interest rates?, *Energy Economics*, **36**, 546–555.
- Baek, E.G., and Brock, W.A. (1992) A general test for nonlinear Granger causality: Bivariate model, In: Working paper. Ames: Iowa State University and Madison: University of Wisconsin.
- Balke, N.S., Brown, S.P.A., and Yucel, M.K. (1998) Crude oil and gasoline prices: An asymmetric relationship?, *Economic Review - Federal Reserve Bank of Dallas*, 2–11.
- Balke, N.S., Brown, S.P.A., and Yucel, M.K. (2002) Oil price shocks and the U.S. economy: Where does the asymmetry originate?, *The Energy Journal*, **23**, 27–40
- Cologni, A., and Manera, M. (2008) Oil prices, inflation and interest rates in a structural cointegrated VAR model for the G-7 countries, *Energy Economics*, **30**, 856–888.
- Dotsey, M., Lantz, C., and Scholl, B. (2003) The Behavior of the Real Rate of Interest, *Journal of Money, Credit and Banking*, **35**, 91–110.
- Ferderer, P.J. (1996) Oil price volatility and the macroeconomy, *Journal of Macroeconomics*, **18**, 1–26.
- Hiemstra, C., and Jones, J.D. (1994) Testing for linear and nonlinear Granger causality in the stock price-Volume Relation, *The Journal of Finance*, **49**, 1639–1664.
- Hooker, M.A. (1999) The maturity structure of term premia with time-varying expected returns, *The Quarterly Review of Economics and Finance*, **39**, 391–407.
- Kanas, A., and Ma, Y. (2000) Testing for a nonlinear relationship among fundamentals and exchange rates in the ERM. *Journal of International Money and Finance*, **19**, 135–152.
- Kyrtsou, C., and Labys, W.C. (2006) Evidence for chaotic dependence between US inflation and commodity prices, *Journal of Macroeconomics*, **28**, 256–266.
- Lowinger, T.C., Wihlborg, C., and Willman, E.S. (1985) OPEC in world financial markets: Oil prices and interest rates, *Journal of International Money and Finance*, **4**, 253–266.
- Mackey, M.C., and Glass, L. (1977) Oscillation and chaos in physiological control systems, *Science*, **197**, 287–289.
- Sadorsky, P. (1999) Oil price shocks and stock market activity, *Energy Economics*, **21**, 449–469.
- Wu, M. (2010) Investigating the relationships among oil prices, bond index returns and interest rates, *International Research Journal of Finance and Economics*, **38**, 147–164.

Tables

Table 1. Unit root tests

Country	ADF		DF-GLS		PP	
	Level	First difference	Level	First difference	Level	First difference
<i>Unit root test for IR</i>						
Brazil	-2.532	-13.526*	0.380	-7.048*	-1.391	-13.529*
Denmark	-1.589	-20.213*	-0.042	-1.259***	-1.681	-20.051*
Germany	-1.246	-14.009*	-0.824	-3.543*	-1.630	-14.221*
Italy	-0.232	-15.364*	-0.376	-2.293**	-1.140	-15.397*
Netherlands	-0.123	-11.281*	-0.810	-4.211*	-1.203	-11.413*
Sweden	-1.369	-18.646*	0.049	-1.474***	-1.488	-18.621*
US	-1.662	-16.013*	-1.091	-1.965**	-1.504	-15.518*
Canada	-1.200	-16.000*	-1.511	-1.620***	-1.315	-15.952*
Norway	-1.092	-18.827*	-0.886	-2.723*	-1.032	-18.782*
Mexico	-1.817	-10.945*	0.325	-1.984***	-1.676	-10.924*
<i>Unit root tests for OP</i>						
	-0.905	-12.852*	-0.402	-1.694***	-0.276	-12.835*

Notes: *, ** and *** indicate significance at the 1%, 5% and 10% levels, respectively.

Table 2. Hiemstra-Jones' nonlinear causality test

Lags	OP → IR		IR → OP		Lags	OP → IR		IR → OP	
	CS	TVAL	CS	TVAL		CS	TVAL	CS	TVAL
Brazil					Sweden				
1	0.0131	0.1816	0.0074	0.1032	1	-0.0060	-0.1092	-0.0148	-0.2655
2	0.0203	0.2809	0.0050	0.0695	2	-0.0228	-0.4080	-0.0303	-0.5434
3	0.0217	0.2997	0.0020	0.0284	3	-0.0562	-1.0041	-0.0310	-0.5545
4	0.0241	0.3313	0.0022	0.0313	4	-0.0777	-1.3873	-0.0221	-0.3947
5	0.0226	0.3111	0.0007	0.0103	5	-0.0851	-1.5159	-0.0146	-0.2608
6	0.0242	0.3316	-0.0009	-0.0126	6	-0.0829	-1.4741	-0.0194	-0.3456
7	0.0300	0.4103	-0.0029	-0.0408	7	-0.0980	-1.7399	-0.0276	-0.4899
8	0.0296	0.4027	-0.0049	-0.0679	8	-0.1115	-1.9769	-0.0312	-0.5531
Denmark					US				
1	-0.0105	-0.1863	-0.0237	-0.4198	1	0.0114	0.2053	-0.0111	-0.1997
2	-0.0330	-0.5821	-0.0442	-0.7804	2	-0.0073	-0.1310	-0.0345	-0.6197
3	-0.0668	-1.1777	-0.0644	-1.1351	3	-0.0153	-0.2746	-0.0353	-0.6330
4	-0.1016	-1.7866	-0.0750	-1.3192	4	-0.0074	-0.1335	-0.0449	-0.8026
5	-0.1227	-2.1537	-0.0792	-1.3901	5	0.0036	0.0643	-0.0617	-1.1005
6	-0.1444	-2.5309	-0.0832	-1.4586	6	0.0045	0.0810	-0.0804	-1.4322
7	-0.1741	-3.0466	-0.0843	-1.4755	7	-0.0095	-0.1703	-0.0958	-1.7038
8	-0.1900	-3.3185	-0.0871	-1.5214	8	-0.0242	-0.4308	-0.0926	-1.6448
Germany					Canada				
1	-0.0123	-0.2199	-0.0260	-0.4658	1	-0.0180	-0.3243	-0.0215	-0.3874
2	-0.0361	-0.6452	-0.0574	-1.0250	2	-0.0535	-0.9611	-0.0460	-0.8254
3	-0.0857	-1.5260	-0.0773	-1.3779	3	-0.0962	-1.7240	-0.0613	-1.0985
4	-0.1177	-2.0938	-0.0888	-1.5798	4	-0.1386	-2.4799	-0.0800	-1.4312
5	-0.1243	-2.2063	-0.0985	-1.7486	5	-0.1673	-2.9895	-0.0938	-1.6766
6	-0.1361	-2.4128	-0.1131	-2.0041	6	-0.1766	-3.1505	-0.1081	-1.9278
7	-0.1538	-2.7220	-0.1055	-1.8674	7	-0.1995	-3.5530	-0.1190	-2.1204
8	-0.1579	-2.7897	-0.0925	-1.6353	8	-0.2241	-3.9847	-0.1193	-2.1207
Italy					Norway				
1	-0.0131	-0.2360	-0.0145	-0.2612	1	-0.0086	-0.1559	-0.0221	-0.3981
2	-0.0430	-0.7733	-0.0386	-0.6952	2	-0.0309	-0.5553	-0.0443	-0.7963
3	-0.0898	-1.6122	-0.0661	-1.1878	3	-0.0708	-1.2690	-0.0592	-1.0622
4	-0.1203	-2.1556	-0.0940	-1.6844	4	-0.1150	-2.0587	-0.0702	-1.2565
5	-0.1392	-2.4907	-0.1183	-2.1171	5	-0.1486	-2.6545	-0.0788	-1.4090
6	-0.1511	-2.7004	-0.1335	-2.3860	6	-0.1806	-3.2212	-0.0918	-1.6375
7	-0.1710	-3.0497	-0.1462	-2.6074	7	-0.2082	-3.7080	-0.1073	-1.9118
8	-0.1865	-3.3214	-0.1526	-2.7181	8	-0.2240	-3.9835	-0.1112	-1.9775
Netherlands					Mexico				
1	-0.0073	-0.1321	-0.0253	-0.4564	1	-0.0229	-0.3041	-0.0247	-0.3425
2	-0.0228	-0.4110	-0.0524	-0.9424	2	-0.0539	-0.7432	-0.0656	-0.9046
3	-0.0643	-1.1553	-0.0636	-1.1416	3	-0.0973	-1.3380	-0.0966	-1.3285
4	-0.1121	-2.0098	-0.0635	-1.1385	4	-0.1340	-1.8378	-0.1323	-1.8147
5	-0.1388	-2.4830	-0.0552	-0.9886	5	-0.1527	-2.0888	-0.1713	-2.3429
6	-0.1521	-2.7178	-0.0520	-0.9303	6	-0.1473	-2.0089	-0.2061	-2.8117
7	-0.1662	-2.9647	-0.0512	-0.9138	7	-0.1522	-2.0713	-0.2336	-3.1774
8	-0.1681	-2.9936	-0.0533	-0.9493	8	-0.1384	-1.8776	-0.2388	-3.2392

Notes: OP and IR indicate oil price and short-term interest rate, respectively. CS and TVAL are the difference between the two conditional probabilities, and the standardized test statistic, respectively.

Table 3. Symmetric nonlinear Kyrtsou-Labys causality test

Country	H0: OP does not cause IR	H0: IR does not cause OP
	Statistic	Statistic
Brazil	0.9503	0.1704
Denmark	1.4574	0.0601
Germany	2.4045	0.3673
Italy	0.5679	0.0404
Netherlands	2.6504	0.6061
Sweden	3.2196**	2.1159
US	0.4398	0.1800
Canada	26.4716*	2.2214
Norway	3.7750**	0.0213
Mexico	2.7191**	0.1855

Note: the statistic is F-distributed. * and ** denote significance at 1% and 10% levels, respectively.

Table 4. Asymmetric test for negative changes of the causing variable

Country	H0: OP does not cause IR	H0: IR does not cause OP
	F-statistic	F-statistic
Brazil	1.2227	0.3800
Denmark	NA	0.2836
Germany	0.7296	0.6061
Italy	0.3633	0.5121
Netherlands	0.0531	0.7068
Sweden	0.2722	0.0607
US	0.1240	0.3357
Canada	0.2182	0.3542
Norway	0.1743	0.2814
Mexico	1.7004	0.5827

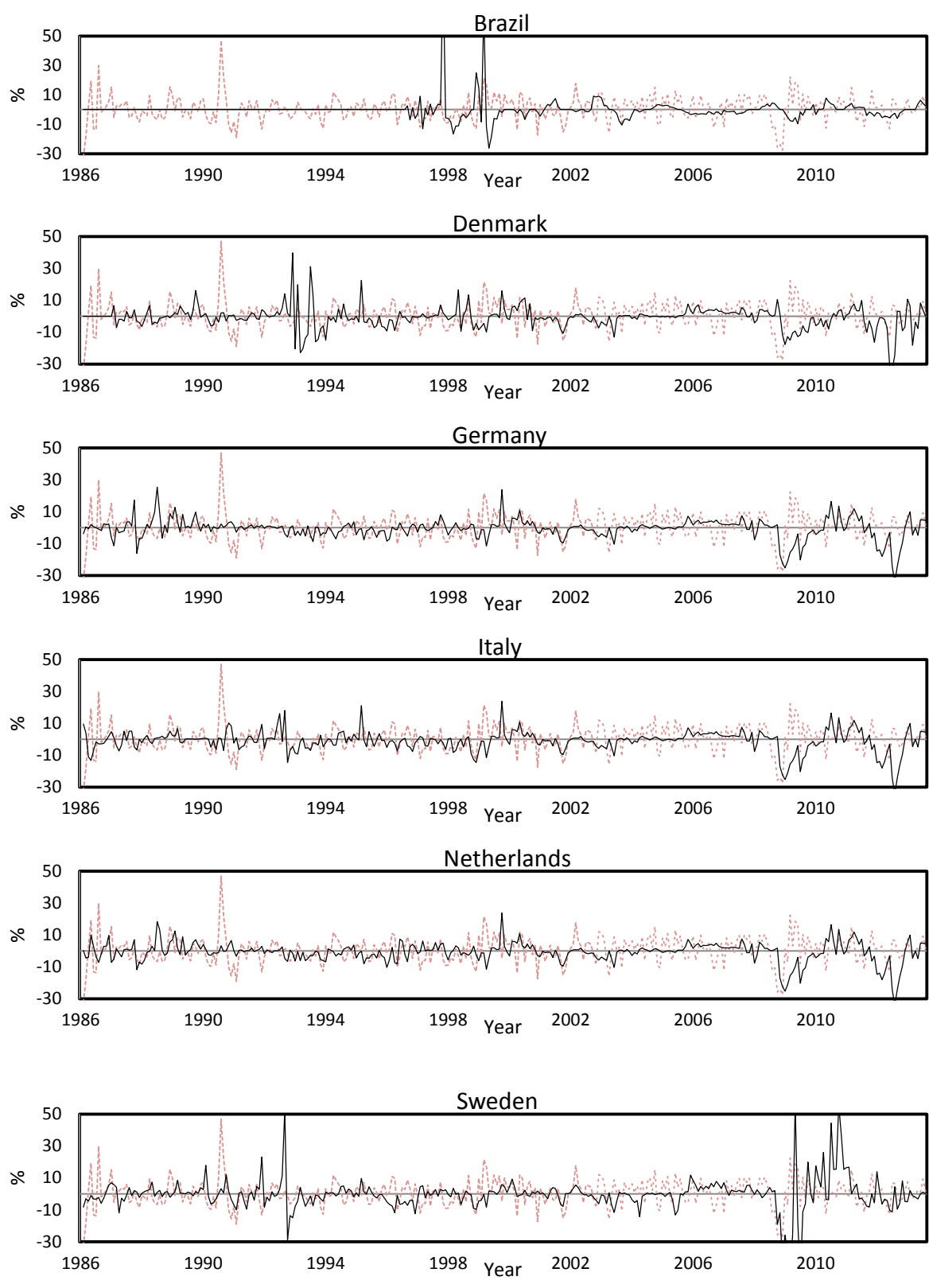
Note: the statistic is F-distributed.

Table 5. Asymmetric test for positive changes of the causing variable

Country	H0: OP does not cause IR	H0: IR does not cause OP
	F-statistic	F-statistic
Brazil	0.0388	0.2570
Denmark	1.4892	0.0248
Germany	2.1783	0.2236
Italy	0.1103	0.2758
Netherlands	2.6225	0.2991
Sweden	1.8811	2.0817
US	1.9538	0.1124
Canada	39.075*	2.1543
Norway	5.4648**	0.0160
Mexico	3.8224***	0.1488

Note: the statistic is F-distributed. *, ** and *** indicate significance at 1%, 5% and 10% levels, respectively.

Figures



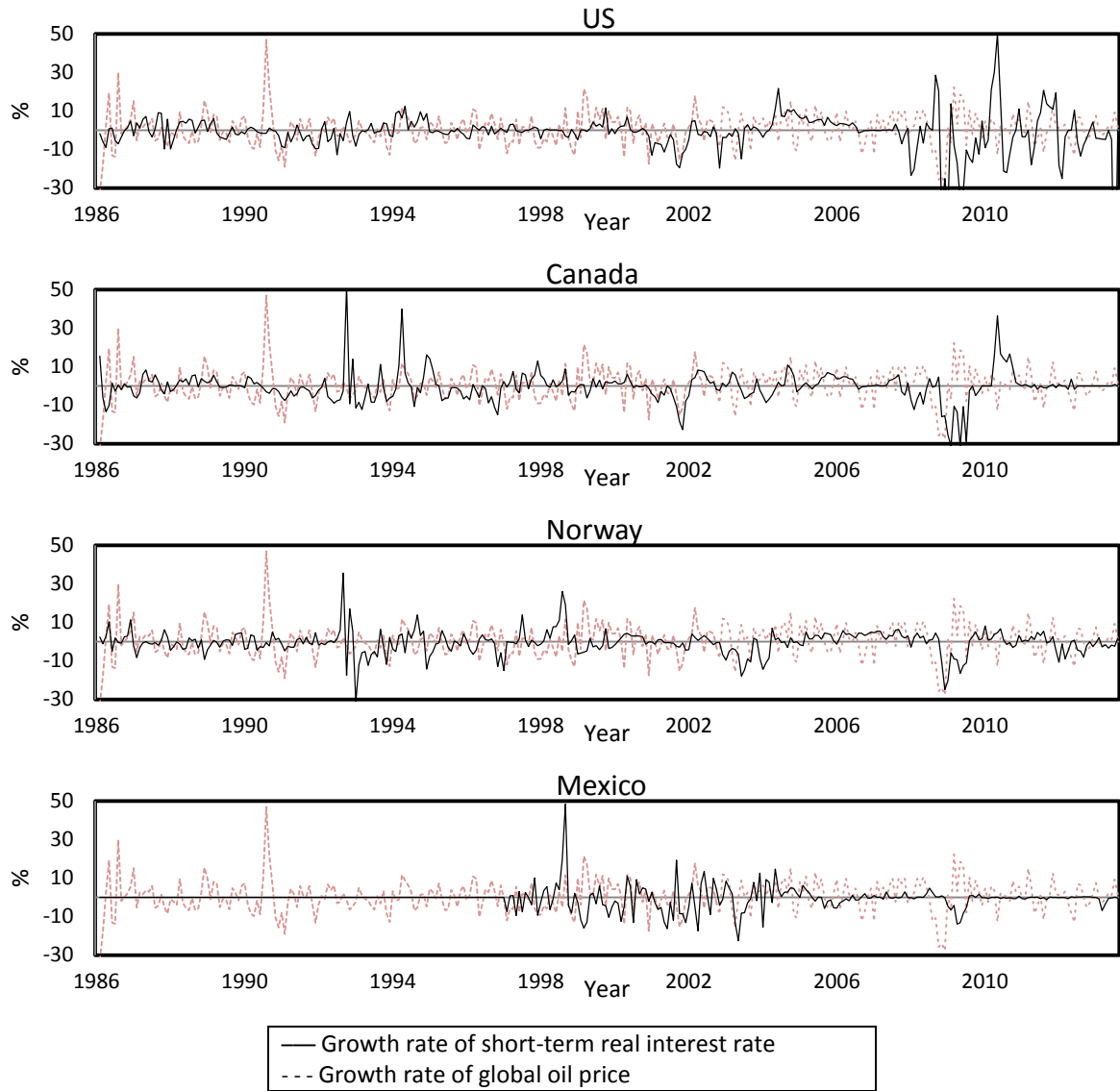


Fig 1. Growth rate of global oil price versus growth rate of short-term real interest rate