An asymmetric analysis of the relationship between oil prices and output: the case of Turkey

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Motivation

- Oil shocks and stagflation in the developed economies during the 1970s have attracted a great deal of attention in understanding the effects of oil price shocks on economic fluctuations.

- However the oil price collapses around the mid-80s have not led to an expansion in economic activity. This launched a new debate on the existence of asymmetric relationship.

- Some studies confirmed the validity of this type of relationship for developed economies: Positive oil shocks has a significant negative impact whereas negative ones does not have any effect on output.

- Our aim in this paper is to determine the nature of the relationship between oil prices and output in Turkey.

- Why it is important for Turkey?
    - Turkey is highly reliant on imported oil.

- Oil shocks have
    - Direct impact by rising current account deficit.
    - Indirect effect in terms of rising production costs.

- 1988-2011, incorporates important financial crisis and turbulent periods in terms of output and oil price movements.

- The impact of oil prices on macroeconomic activity may not be linear.

Plan of the Paper

- **An Overview of the Literature on Oil Price-Economic Activity**
- **Data**
- **Methodology: Linear VAR and TVAR models**
- **Empirical Results**
- **Conclusions**

Literature

- Hamilton (1983): ***negative and significant correlation between oil price increases and output***, oil shocks is a major contributor of US recessions since the Second World War.

- Mork (1989): ***The relationship shows an asymmetric behavior***. The negative correlation between oil prices and output is in fact not statistically significant when the sample is extended to include the oil collapse in 1986.

- Oil price increases and decreases are estimated separately, coefficients for oil price increases become significant and negative. However, oil price decreases are not significant.

- Alternative transformations of oil prices: Hamilton (1996), Lee *et al.* (1995) also use based on the view that only persistent oil price increases are able to create a contractionary effects.

- The use of nonlinear models is relatively new: Sadorsky (1999) used a two-regime threshold VAR model. Oil price increases has a greater impact on economic activities and explain better the evolution of macroeconomic variables than interest rates.

Literature

- Huang *et al.* (2005) improved the model of Sadorsky (1999): Instead of using arbitrary threshold level of oil price change (i.e. greater than zero or less than zero) optimal threshold value of oil price change is estimated by the model.

- The asymmetric behavior of oil prices: oil price changes had a limited impact on the economy if the change fell below the threshold levels.

- The studies on Turkey:

  -Alper and Torul (2008): Linear VAR, declined after 2000s

  - Torul and Alper (2010): The same VAR model, but it is at the industrial level, found negative relationship for only some industries (i.e. the production of petro-chemicals) .

- The existence of asymmetric effects was not statistically validated. The asymmetry is introduced in an ad-hoc manner with the inclusion of various oil price increase variables.

Our contribution

- The nonlinearity in the relationship between oil prices and macroeconomic activity in Turkey is empirically tested.

- The existence of the optimal threshold value of oil price changes is examined through a multivariate threshold vector autoregressive model, as proposed by Tsay (1998).

- Regime-dependent impulse response and forecast error variance decomposition analysis to capture the asymmetric response of economic activity to oil price shocks as in Huang *et al.* (2005).

Data

- Monthly data for the period January 1988- March 2011 from Electronic Data Delivery System of the Central Bank of The Republic of Turkey (CBRT)'s, IFS Database of IMF

- The vector of endogenous variables

$$X_t' = [lroil_t\ lner_t\ \ intrate_t\ lwpi_t\ \ lgdp_t]$$

$lroil_t$: imported real oil prices in terms of Turkish Lira (deflated by wholesale prices).

$lner_t$: nomial exchange rate.

$inrate_t$: interbank rate

$lwpi_t$: Wholesale Price Index (WPI) for the general price level.

$lgdp_t$: Gross Domestic Product interpolated through the monthly industrial production index using the method in Friedman (1962).

- The exogenous variables, the federal funds rate and the log of US industrial production index

$$Z_t' = [ffr_t\ lindus_t]$$

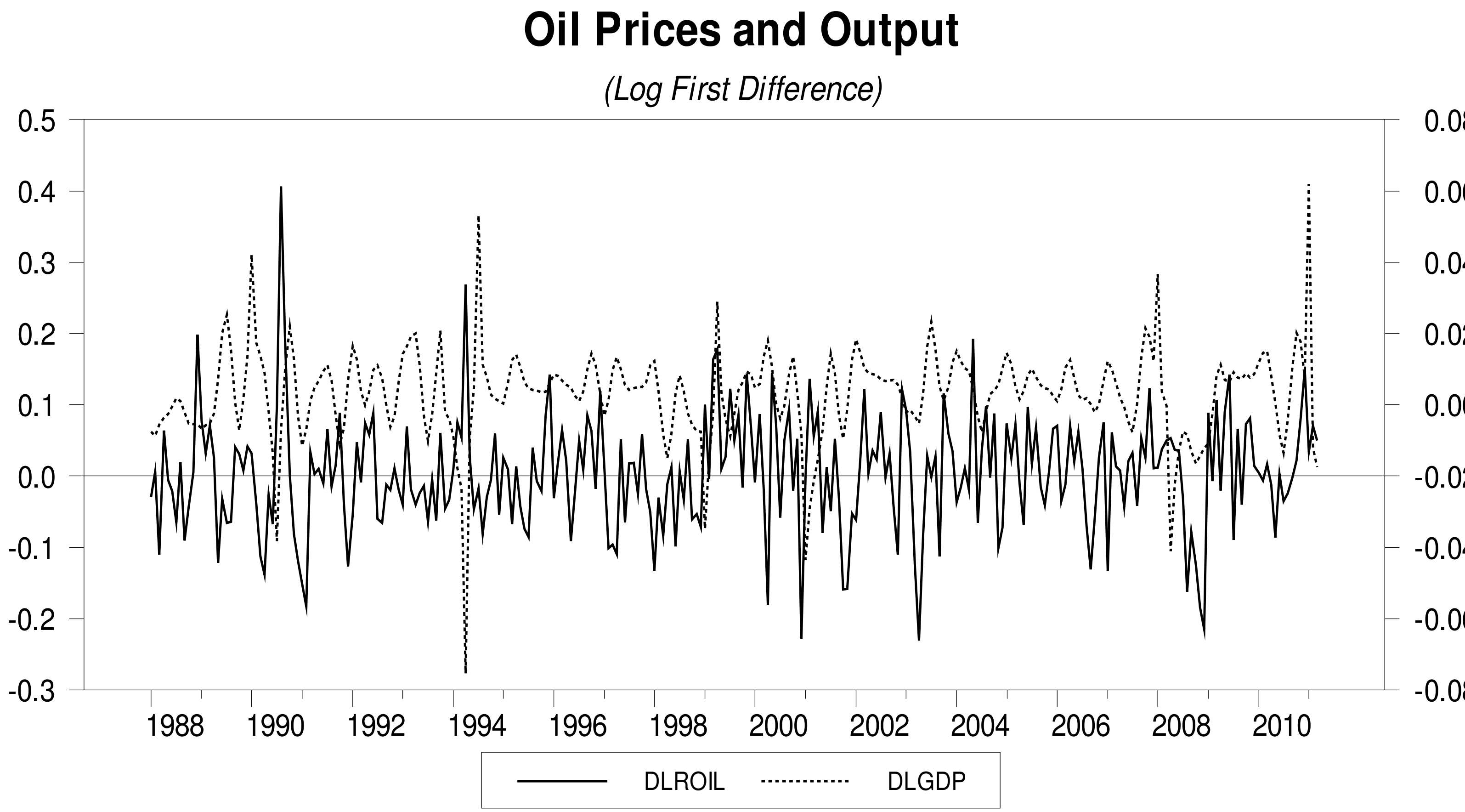

Fig. 1. Oil Prices and Output in Turkey

The Methodology

Our VAR model,

$$X_t = \alpha + \sum_{i=1}^{p} A_i X_{t-i} + \sum_{i=1}^{q} B_i Z_{t-i} + \theta Dcr_t + \varepsilon_t \ , \qquad (1)$$

A dummy variable, Dcr_t, to uncover the possible impacts of structural breaks due to the 1994, 2001 and 2008 crises in Turkey.

If the variables are I(1) and cointegrated, VAR model can be rewritten as VECM :

$$\Delta X_t = \alpha + \Pi X_{t-i} + \sum_{i=1}^{p} \Gamma_i \Delta X_{t-i} + \sum_{i=1}^{q} B_i \Delta Z_{t-i} + \theta Dcr_t + \varepsilon_t \ , \qquad (2)$$

where,

$\Pi = -I + \sum_{i=1}^{p} A_i$ and $\Gamma_i = -\sum_{i=1}^{p} A_j$.

The two-regime TVAR model

-Tsay (1998): a special extension of the VAR model in which the economy has two regimes and switches between them depending on the value of a threshold variable.

- In this case equation (1) may be converted into a two-regime TVAR model as follows:

$$X_t = I[c_{t-d} \geq \gamma]\left(\alpha^1 + \Pi^1 X_{t-i} + \sum_{i=1}^{p-1} \Gamma_i^1 \Delta X_{t-i} + \sum_{i=1}^{q-1} B_i^1 Z_{t-i} + \theta^1 Dcr\right) + (1 - I[c_{t-d} \geq \gamma])\left(\alpha^2 + \Pi^2 X_{t-i} + \sum_{i=1}^{p-1} \Gamma_i^2 \Delta X_{t-i} + \sum_{i=1}^{q-1} B_i^2 Z_{t-i} + \theta^2 Dcr_t\right) + \varepsilon_t \quad (3)$$

- c_{t-d} is the threshold variable lagged by d periods and γ is the optimal threshold

- $I[.]$ is the dummy indicator function that equals 1 when $c_{t-d} \geq \gamma$, and 0 otherwise.

- The threshold variable is selected as the log-first-difference of the imported oil prices $\Delta lroil_{t-d}$.

- The economy is in regime 1 when the threshold variable, lagged by *d* periods, exceeds or is equal to the threshold; otherwise, the economy is in regime 2.

- The existence of multiple regimes is tested using the *C(d)* statistics based on the estimation of an arranged regression as proposed by Tsay (1998).

The Estimation Steps of the TVAR Model

1. The variables in the linear VAR model in are ordered according to the ascending values of the threshold variable *c*.

$$X_t = \alpha + \sum_{i=1}^{p} A_i X_{t-i} + \sum_{i=1}^{q} B_i Z_{t-i} + \theta Dcr_t + \varepsilon_t$$

2. The VAR model is estimated recursively starting from the first m_0 observations and the predictive residuals of the VAR model are obtained. *If the model is linear, the residuals should be uncorrelated with the explanatory variables in the arranged regression.*

3. Finally the *C(d)* test is calculated by regressing each residual on the explanatory variables and testing for the joint significance of the explanatory variables.

4. χ^2 distribution under the null hypothesis that the model is linear

$$H_0 : \alpha^1 = \alpha^2, \Pi_i^1 = \Pi_i^2, \Gamma_i^1 = \Gamma_i^2, B_i^1 = B_i^2 .$$

4. The delay parameter with the highest *C(d)* statistics is selected as the optimum delay *d* for the model.

5. The interval including the max. and the min. values of the threshold variable is partitioned into particular grids, and the TVAR model is estimated for each grid. The grid including the minimum selection criteria value is selected as the optimal threshold value γ of the transition variable.

6. The model is estimated, irfs and VDCs are computed.

Empirical Results

-***Unit root tests:*** ADF and PP test suggest the difference stationarity of the variables.

Table 1. Lee and Strazicich Unit Root Test with two Structural Breaks

	Model A (Crash Model)				*Model C (Trend Shift Model)*					
	LM-Stat	Lag	Breaking Time		LM-Stat	Lag	Breaking Time			
			D_{1t}	D_{2t}			D_{1t}	DT_{1t}	D_{2t}	DT_{2t}
$lner_t$	-2.24381	5	1994:03	2002:04(ns)	-5.64754	8	2001:10(ns)	2001:10	2005:02(ns)	2005:02
$\Delta lner_t$	-11.204*	0	2001:03	2001:06(ns)	-11.697*	0	1994:01	1994:01	1994:08(ns)	1994:08(ns)
$lroil_t$	-4.76599	1	2000:04	2000:04	-5.07934	2	1999:04 (ns)	2001:08	1999:04	2001:08
$\Delta lroil_t$	-12.9092*	0	1990:04 (ns)	1990:10	-13.635*	0	1990:06 (ns)	1990:06	1990:09	1990:09
$lwpi_t$	-1.15868	7	1992:01(ns)	1994:01	-3.40467	5	1994:01	1994:01	2003:01	2003:01
$\Delta lwpi_t$	-8.9469*	5	1994:07	1994:12	-10.445*	3	1994:03	1994:03	1994:11(ns)	1994:11
$intrate_t$	-4.35937	3	1994:10	2000:12	-7.11367	3	1999:10(ns)	1999:10	2000:12	2000:12
$\Delta intrate_t$	-9.38430*	1	1999:12	2001:02	-15.95139*	0	1998:12 (ns)	1998:12	2000:09	2000:09
$lgdp_t$	-4.34856	8	1998:03 (ns)	2003:06(ns)	-5.24607	8	2000:12	2000:12(ns)	2008:02(ns)	2008:02
$\Delta lgdp_t$	13.0578*	8	2001:03	2008:09	-9.44295*	8	2000:12	2000:12(ns)	2008:04	2008:04
ffr_t	-4.23418	8	1994:10	2007:11(ns)	-4.72102	8	1990:09(ns)	1990:09	1996:02	1996:02
Δffr_t	-10.37637*	5	1992:12	2003:07(ns)	-11.09079*	1	1991:02	1991:02	2008:01(ns)	2008:01
$lindus_t$	-1.59608	6	1990:10	2008:12	-3.85736	6	1991:05	1991:05	1999:01	1999:01
$\Delta lindus_t$	-8.58825*	12	1996:01	2008:9	-9.38569*	6	1996:01	1996:01	2008:09	2008:09

[a] * indicates significant at least at 5%. Maximum lag size of augmented part is set to12.

[b] General to specific procedure is followed to find optimum lag size of the augmented part.

[c] Critical values are obtained from Lee and Strazicich (2003).

[d] (ns) denotes insignificant breakpoints, and the other breakpoints are found to be significant at 10% level.

- ***Cointegration analysis:*** Both eigenvalue and trace statistics reject the null hypothesis of no cointegration and support the existence of three cointegrating vectors.[3]

Table 2. Johansen Cointegration Test

	$r=0$	$r \leq 1$	$r \leq 2$	$r \leq 3$	$r \leq 4$
Trace (λ_{trace})	153.75*	74.03728*	36.6759*	15.45691*	3.790663
Eigenvalue ($\lambda_{\max}$)	79.71274*	37.36139*	21.21898*	11.66625*	3.790663

[a] *r* denotes the number of cointegrating vector. Critical values are obtained from McKinnon *et al.* (1999) .
[b] * denotes rejection of the hypothesis at the 0.05 level.

Testing the Existence of Threshold Effect

Table 3. Threshold Nonlinearity Test

D	m_0	*C(d)*	Prob.	*D*	m_0	*C(d)*	Prob.
1	25	120.36	0.0000	7	25	139.49	0.0000
1	50	118.69	0.0001	7	50	140.96	0.0000
2	25	125.94	0.0000	8	25	107.29	0.0008
2	50	125.27	0.0000	8	50	100.76	0.0030
3	25	125.01	0.0000	9	25	79.32	0.1090
3	50	122.53	0.0000	9	50	76.35	0.1585
4	25	153.73	0.0000	10	25	111.08	0.0003
4	50	142.05	0.0000	10	50	101.07	0.0028
5	25	95.01	0.0090	11	25	93.32	0.0122
5	50	97.65	0.0055	11	50	93.42	0.0120
6	25	106.68	0.0009	12	25	105.47	0.0011
6	50	103.18	0.0018	12	50	112.85	0.0002
γ	2.357%	AIC	-3298.8679				

[a] γ is the optimum value of the threshold variable determined by the test. AIC is Akaike Information Criterion.

The *C(d)* threshold nonlinearity test results, based on the recursive estimation of arranged regression using alternative starting points of m_0=25 and m_0=50 and delay parameters *d*, are reported in Table 4. The test results indicate that except for the statistics of the ninth lag, the null hypothesis on the linearity of the model is rejected at least at the 1% significance level for each alternative threshold.

After finding the delay parameter, the interval including the possible breakpoint of the threshold oil price change $\Delta lroil_{t-d}$ is partitioned into 300 grids, and the grid with the minimum Akaike Information Criterion (AIC) is obtained when γ is equal to 2.357%.

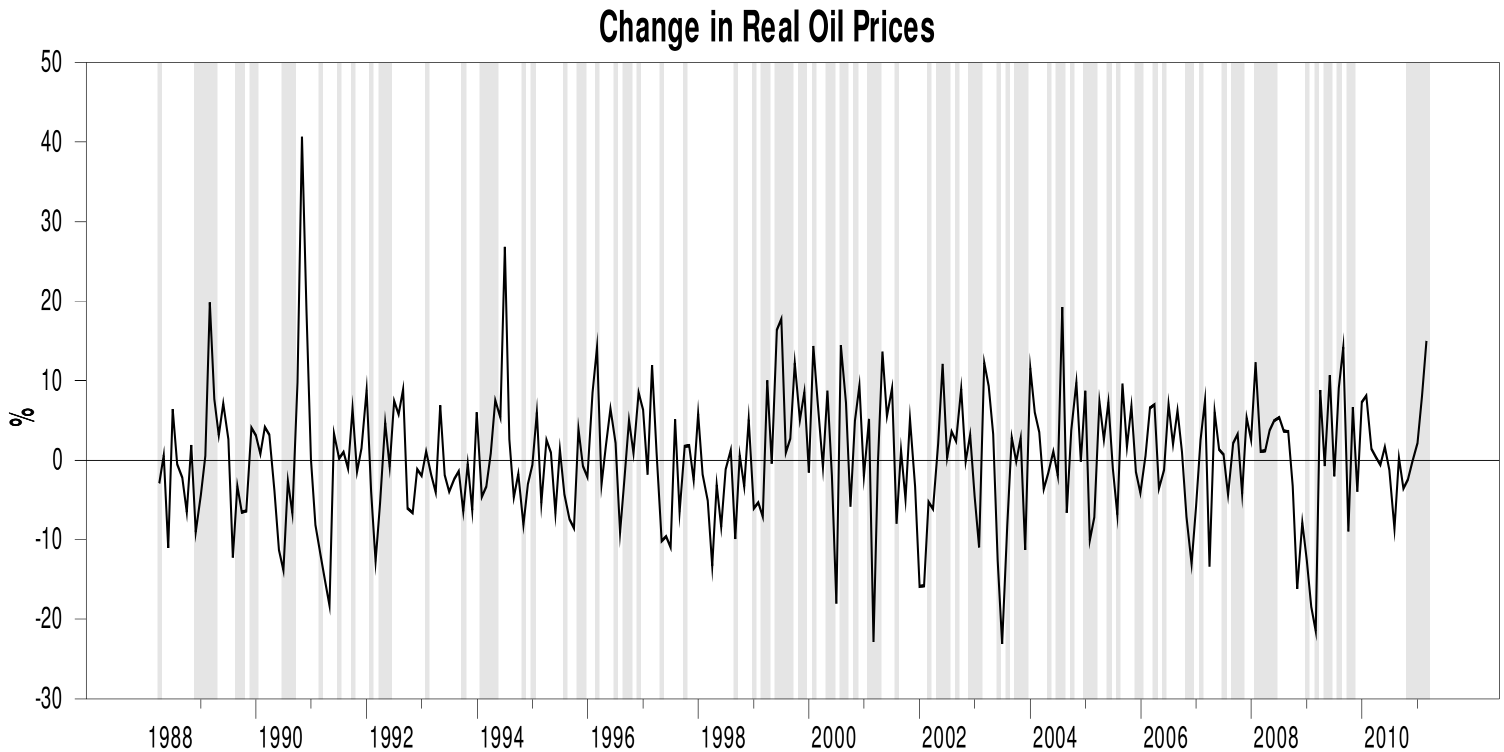

Fig. 2. Regime Classifications (The shaded area show regime 1 periods where the transition variable exceeds the optimal threshold value $\gamma > 0.02357$).

- TVAR model in Eq. 2 is estimated and irfs and VDCs are obtained:

$$X_t = I[c_{t-d} \geq \gamma]\left(\alpha^1 + \Pi^1 X_{t-i} + \sum_{i=1}^{p-1} \Gamma_i^1 \Delta X_{t-i} + \sum_{i=1}^{q-1} B_i^1 Z_{t-i} + \theta^1 Dcr\right) + (1 - I[c_{t-d} \geq \gamma])\left(\alpha^2 + \Pi^2 X_{t-i} + \sum_{i=1}^{p-1} \Gamma_i^2 \Delta X_{t-i} + \sum_{i=1}^{q-1} B_i^2 Z_{t-i} + \theta^2 Dcr_t\right) + \varepsilon_t \quad (3)$$

Variance Decompositions and Impulse Response Functions

Table 4. Forecast Error Variance Decomposition of DLGDP and DLWPI: Linear VAR Model

	$\Delta lwpi_t$						$\Delta lgdp_t$						
Step	Std Error	ε_{oil}	ε_{er}	ε_{int}	ε_{π}	ε_{gdp}	Step	Std Error	ε_{oil}	ε_{er}	ε_{int}	ε_{π}	ε_{gdp}
1	0.018	7.814	33.128	0.891	58.167	0.000	1	0.010	0.536	12.897	0.191	0.562	85.814
3	0.022	12.224	44.376	0.740	41.375	1.285	3	0.012	0.595	21.874	1.928	2.391	73.212
6	0.024	11.429	47.080	0.882	39.413	1.197	6	0.013	1.180	21.349	2.120	2.771	72.580
9	0.025	11.410	47.547	0.831	39.052	1.160	9	0.013	1.312	21.473	2.160	3.343	71.711
12	0.026	11.413	48.020	0.807	38.640	1.119	12	0.013	1.354	21.656	2.151	3.350	71.488
15	0.026	11.393	48.235	0.798	38.472	1.102	15	0.013	1.358	21.642	2.152	3.364	71.485
18	0.026	11.389	48.311	0.794	38.412	1.094	18	0.013	1.362	21.641	2.152	3.372	71.473

[a] Ordering of the variables are as follows: $\Delta lroil_t$, $\Delta lner_t$, $\Delta intrate_t$, $\Delta lwpi_t$, $\Delta lgdp_t$.

Table 5. Forecast Error Variance Decomposition of DLGDP and DLWPI: TVAR Model

	Regime 1												
	$\Delta lwpi_t$						$\Delta lgdp_t$						
Step	Std Error	ε_{oil}	ε_{er}	ε_{int}	ε_{wpi}	ε_{gdp}	Step	Std Error	ε_{oil}	ε_{er}	ε_{int}	ε_{wpi}	ε_{gdp}
1	0.0174	10.3691	42.1449	2.0959	45.3901	0.0000	1	0.0059	1.3203	3.8998	2.4642	0.1151	92.2005
3	0.0200	14.2303	49.1048	2.0023	34.5230	0.1396	3	0.0071	6.6201	9.6647	3.3233	1.2397	79.1522
6	0.0256	13.8859	51.6012	5.1294	25.5070	3.8765	6	0.0077	8.1117	10.3528	3.1872	1.5391	76.8092
9	0.0292	13.2348	53.2405	8.7041	20.8584	3.9622	9	0.0077	8.2084	10.7681	3.1944	1.5617	76.2674
12	0.0315	12.6684	53.5756	11.0317	18.5762	4.1482	12	0.0078	8.2096	10.7495	3.1933	1.6021	76.2456
15	0.0332	12.3148	53.5985	12.6023	17.2060	4.2785	15	0.0078	8.2196	10.7562	3.1921	1.6248	76.2072
18	0.0343	12.0784	53.5832	13.6428	16.3629	4.3327	18	0.0078	8.2183	10.7620	3.1916	1.6326	76.1955
	Regime 2						**Regime 2**						
	$\Delta lwpi_t$						$\Delta lgdp_t$						
Step	Std Error	ε_{oil}	ε_{er}	ε_{int}	ε_{wpi}	ε_{gdp}	Step	Std Error	ε_{oil}	ε_{er}	ε_{int}	ε_{wpi}	ε_{gdp}
1	0.0140	2.8587	14.4661	0.3372	82.3380	0.0000	1	0.0057	6.0418	0.4163	0.225	0.4573	92.8596
6	0.0181	3.6841	20.7219	1.1820	74.0313	0.3807	6	0.0073	5.4869	4.7416	5.6864	0.3926	83.6925
9	0.0203	3.8182	21.2793	1.5266	71.2745	2.1014	9	0.0075	5.0843	7.8289	10.3404	0.6031	76.1433
12	0.0212	4.1739	21.1753	1.6223	70.5146	2.5139	12	0.0076	5.0208	8.0109	10.7266	0.8229	75.4188
15	0.0216	4.2437	21.3996	1.5986	70.2132	2.5449	15	0.0076	5.0787	8.4747	11.096	0.8519	74.4987
18	0.0218	4.2596	21.4640	1.5833	70.1025	2.5907	18	0.0076	5.0842	8.744	11.2596	0.8732	74.0391

[a] Ordering of the variables are as follows: $\Delta lroil_t$, $\Delta lner_t$, $\Delta intrate_t$, $\Delta lwpi_t$, $\Delta lgdp_t$. Regime 1 covers the period where the transition variable exceeds the optimal threshold $\gamma > 0.02357$, whereas regime 2 covers the period where $\gamma \leq 0.02357$.

Summary Table for Forecast Error Variance Decomposition of DLGDP and DLWPI (at 18 months hor.)

	$\Delta lwpi_t$					$\Delta lgdp_t$				
	ε_{oil}	ε_{er}	ε_{int}	ε_{π}	ε_{gdp}	ε_{oil}	ε_{er}	ε_{int}	ε_{π}	ε_{gdp}
Linear	11.389	48.311	0.794	38.412	1.094	1.362	21.641	2.152	3.372	71.473
Reg. 1	12.0784	53.5832	13.6428	16.3629	4.3327	8.2183	10.7620	3.1916	1.6326	76.1955
Reg. 2	4.2596	21.4640	1.5833	70.1025	2.5907	5.0842	8.744	11.2596	0.8732	74.0391

[a] Ordering of the variables are as follows: $\Delta lroil_t$, $\Delta lner_t$, $\Delta intrate_t$, $\Delta lwpi_t$, $\Delta lgdp_t$. Regime 1 covers the period where the transition variable exceeds the optimal threshold $\gamma > 0.02357$, whereas regime 2 covers the period where $\gamma \leq 0.02357$.

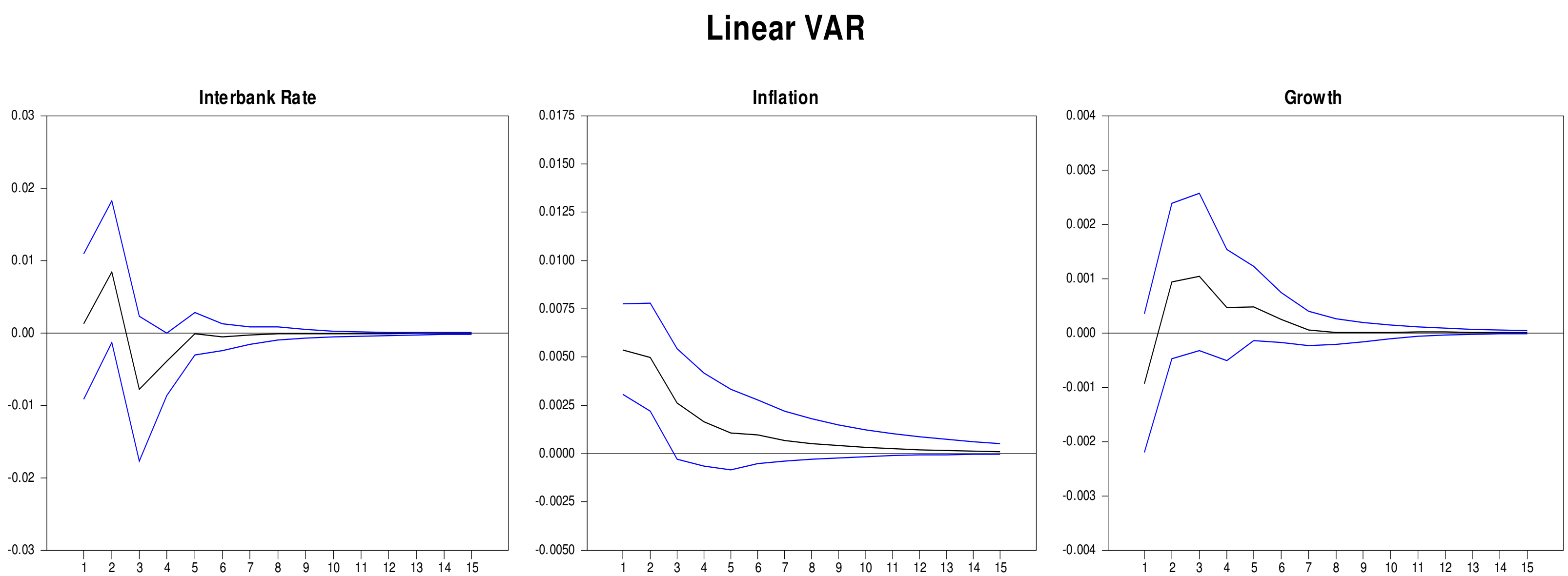

Fig. 3. Responses to one-standard-deviation oil price shocks: Linear VAR

*The responses are plotted with their upper and lower one-standard-error bands in order to assess their significance over the 15th month horizon.

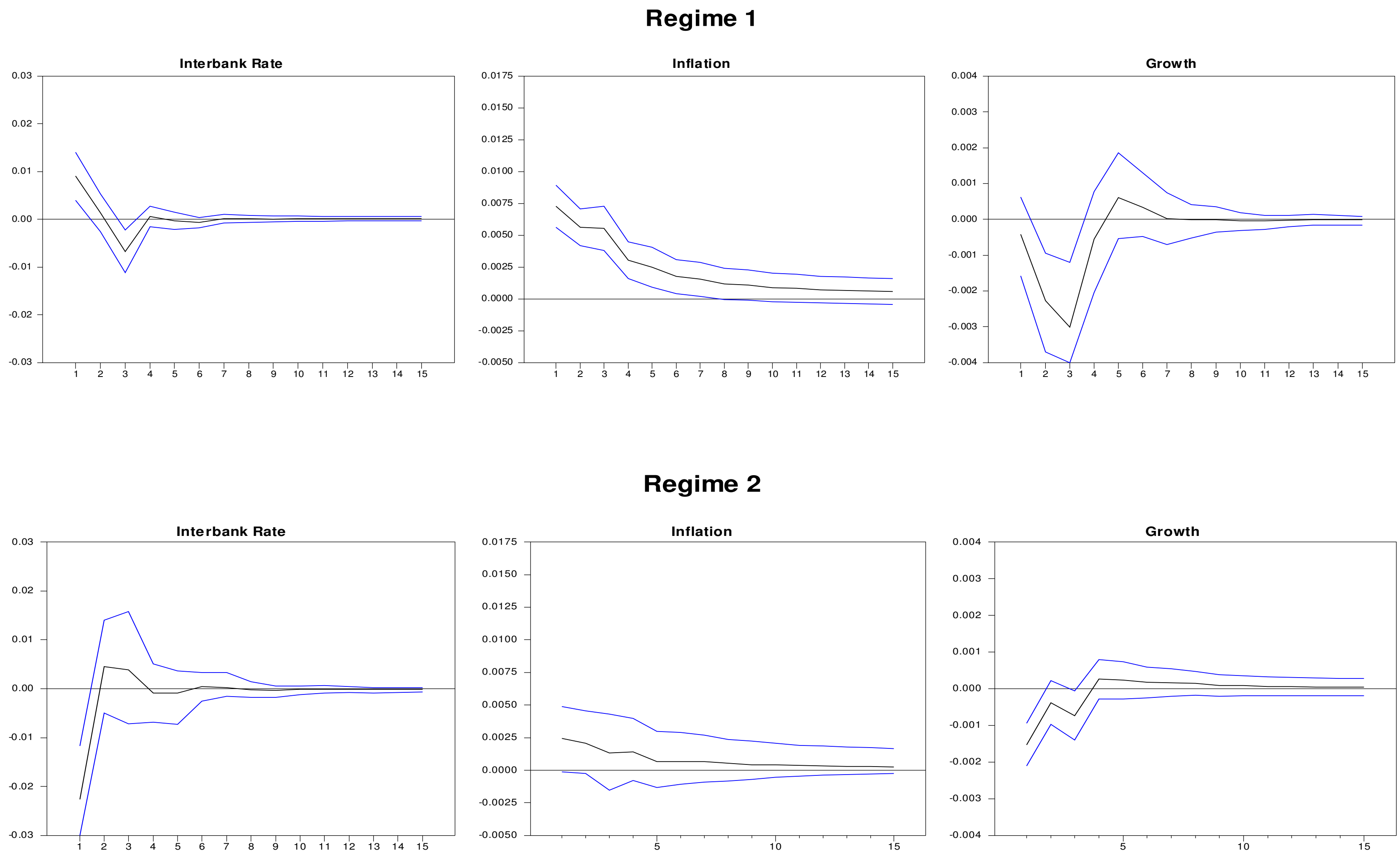

Fig. 4. Responses to one-standard-deviation oil price shocks: Threshold VAR

<u>5. Conclusions</u>

- We analyze the asymmetric impact of oil price changes on economic activity for the period January 1988- March 2011.

- We estimate the linear and Threshold VAR models compromised of output, imported oil prices and the other key macroeconomic variables.

- We account for the endogenous threshold and the nonlinearity in the econometric model as in Huang *et al.* (2005).

- The existence of an asymmetric response of output to oil price shocks is investigated by regime-dependent impulse response functions and forecast error variance decompositions based on a multivariate two-regime Threshold VAR (TVAR) model.

- The relationship between oil prices and macroeconomic activity follows an asymmetric pattern: oil shocks have a larger effect on inflation and output when the change exceeds the optimal threshold level.

5. Conclusions

- Our findings are consistent with the results of Huang *et al.* (2005). Turkey (2.357%) has a lower threshold level of tolerance to positive oil price shocks than Canada (2.70%), Japan (2.58%) and the USA (2.58%).

- The lower response of macroeconomic variables to oil price shocks in regime 2 also indicates that policymakers might not respond to all oil price shocks, since the shocks exceeding the optimal threshold level are able to create a contraction in the economic activity.

- The need for a deeper analysis of the impact of oil price shocks to discover the complete structure of the transmission channels leading to an asymmetric relationship.

<u>Thanks for your Attention</u>