

## The Co-movement between Output and Prices: Evidence from Iran

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### Abstract

This paper employs a multivariate dynamic conditional correlation GARCH model, which is developed by Engle (2001, 2002), to detect the timing and nature of changes in the comovement between Iranian output and prices for the periods after Iran's Iraq war, known as imposed war. The results showed that there is a weak correlation between output and prices after imposed war and varies periodically and changes from positive to negative after imposed war and changes from negative to positive again after 2009 crisis in Iran. We conclude that there is a contagion effect of the price index on output. The predominantly negative output-price co-movement suggests that the overall price level was typically countercyclical rather than procyclical. These findings imply the presence of aggregate supply versus aggregate demand shocks and sticky prices. Supply shocks are the main causes of stagflation. To solve the problem of stagflation, governments must adopt policies to push out the aggregate supply curve.

**Keywords:** Dynamic Conditional Correlation, GARCH, Output, Prices, Iran.

### 1. Introduction

The co-movement between output and prices has received considerable attention in the business cycle literature. For many years, economists widely accepted that output and prices displayed a positive correlation, at least in the short run. This evidence has been explained as the result of a short-run Phillips curve phenomenon. Recently, several studies (Cooley and Ohanian, 1991; Backus and Kehoe, 1992; Smith, 1992; Fiorito and Kollintzas, 1994; Kim, 1996; Den Haan, 2000; Haslag and Hsu, 2012) have challenged this view by showing that the correlation between detrended output and prices is negative for several countries during the post-war period.

In a noteworthy study, Cooley and Ohanian (1991) find that, although the correlation between output and prices is positive from 1870 to 1975, it appears to be negative during the postwar period. They showed that the correlation between prices and real activity filtered with the HP filter of Hodrick and Prescott (1997)

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is negative in the postwar period. Using VAR forecast errors for prices and output, Den Haan (2000) finds that the correlation coefficients become negative when the forecast horizon increases. Lee (2006) find that the overall price level tended to move in the same direction as output in periods before World War II but in the opposite direction after the war. Jesus Vazquez (2002) studied the co-movement between output and prices in the EU15 countries. He finds that ten countries (Austria, Belgium, France, Germany, Greece, Italy, Luxembourg, Spain, Sweden and UK) display a significant negative co-movement between output and prices in the 'long run' whereas this is positive in the 'short run' only for three countries (France, Italy and Portugal). Finally, four countries (Denmark, Finland, Ireland and Netherlands) do not exhibit any significant comovement between prices and output.

This paper carries out the methodology suggested by Den Haan (2000). The comovement between prices and output is described using the correlation coefficients of VAR residuals. This procedure has two important advantages over traditional statistics used in the literature. First, the procedure considers a full set of statistics to characterize the dynamics in an efficient manner. As pointed out by Hansen and Heckman (1996) the observed dynamics of economic variables provide important identifying information to evaluate dynamic macroeconomic models. Second, the statistics are intuitive and easy to interpret. The correlation of detrended series is much harder to interpret since one has to understand the dynamics of the trend.

The aim of this paper is to analyse whether the pattern exhibited by the US output - price relationship also characterizes the co-movement between prices and output for Iran after Iran-Iraq war (1988-2010).

## 2. Methodology

Given the stylized fact of conditional heteroskedasticity in the output and price series, it is only natural to take this feature into account when estimating their conditional correlation. Studies concerning plausible changes in the comovement between output and prices in developing countries are limited, however. We intend to partially fill this gap with Iranian data. To accomplish this objective, we derive measures of the time-varying (conditional) variances of output and the prices and their correlation using Engle's (2002) dynamic conditional correlation (DCC) GARCH model. This model allows us to pinpoint precisely the timing and nature of plausible changes in the time series comovement.

The particular framework suggested by Engle (2002) is:

Let  $y_t = [y_{1t} \ y_{2t}]$  be a 2  $\times$  1 vector containing the output and price series in a conditional mean equation. A common representation for the conditional mean equation is a reduced-form VAR:

$$A(L)y_t = \varepsilon_t \quad \text{Where } \varepsilon_t \mid \psi_{t-1} \sim N(0, H_t) \quad t = 1, 2, \dots, T \quad (1)$$

$A(L)$  is a polynomial matrix in the lag operator  $L$ , and  $\varepsilon_t = (\varepsilon_{1t}, \varepsilon_{2t})'$  is a vector of innovations with a conditional variance-covariance matrix  $H_t \equiv \{h_{ij}\}_t$ ,  $i = 1$  and  $2$ , and  $\Psi_{t-1}$  is the  $\sigma$ -algebra generated by all the available information up through time  $t-1$ .

The GARCH component of the framework can be easily understood by first rewriting the conditional variance-covariance matrix as:

$$H_t \equiv D_t R_t D_t$$

Where  $D_t = \text{Diag}\{\sqrt{h_{it}}\}$  is a  $2 \times 2$  diagonal matrix of time-varying standard deviations from univariate GARCH models, and  $R_t \equiv \{\rho_{ij}\}_t$  for  $i, j = 1, 2$ , which is a correlation matrix containing conditional correlation coefficients.

The elements in  $D_t$  follow the univariate GARCH(p,q) processes in the following manner:

$$h_{it} = \omega_i + \sum_{p=1}^p \alpha_{ip} \varepsilon_{it-p}^2 + \sum_{q=1}^q \beta_{iq} h_{it-q} \quad i=1,2 \quad (2)$$

Engle's (2002) particular DCC(m,n) structure can be written as:

$$R_t = Q_t^{*-1} Q_t Q_t^{*-1} \quad (3)$$

where

$$Q_t = (1 - \sum_{m=1}^M a_m - \sum_{n=1}^N b_n) \bar{Q} + \sum_{m=1}^M a_m (\xi_{t-m} \xi_{t-m}') + \sum_{n=1}^N b_n Q_{t-n}$$

Where  $\xi_t = \varepsilon_{it}/\sqrt{h_{it}}$ , which is a vector containing standardized errors;  $Q_t \equiv \{q_{ij}\}_t$  is the conditional variance-covariance matrix of the standardized errors with its time-invariant (unconditional) variance-covariance matrix  $\bar{Q}$  obtained from the first stage of estimation; and  $Q_t^*$  is a diagonal matrix containing the square root of the diagonal elements of  $Q_t$ :

$$Q_t^* = \begin{bmatrix} \sqrt{q_{11}} & 0 \\ 0 & \sqrt{q_{22}} \end{bmatrix}$$

The key element of our interest in  $R_t$  is  $\rho_{12,t} = q_{12,t}/\sqrt{q_{11,t}q_{22,t}}$ , which represents the conditional correlation between output and prices. This DCC-GARCH framework (2)-(3) can be estimated using the maximum likelihood method in which the log-likelihood can be expressed as:

$$L = -\frac{1}{2} \sum_{t=1}^T \{2 \log(2\pi) + 2 \log|D_t| + \log|R_t| + \xi_t' R_t^{-1} \xi_t\} \quad (4)$$

The estimation process involves two stages. In the first stage,  $R_t$  is replaced by a  $2 \times 2$  identity matrix, which reduces equation (4) to the sum of log-likelihoods of the univariate GARCH equations in (2). In the second stage, the DCC parameters in equation (3) are estimated using the original likelihood in equation (4) conditional on the first stage GARCH parameter estimates. While many GARCH parameterizations enforce positive definiteness in the variance-covariance matrix,

this restriction is not imposed in our DCC model such that the conditional correlation coefficients can vary freely between positive and negative values.

### 3. Data and empirical results:

In this section, we explore plausible variation in the comovement between Iranian output and prices using the DCC-GARCH model described in the preceding section. We measure output by the I.R. real GDP, and the overall price level by the I.R. GDP deflator. The data are observed quarterly and cover the period 1988:1 to 2010:4. The data are made available from the economic time series database of the Central Bank of Iran.

Our empirical work begins with estimating the conditional means represented by Eq. (1). The innovation series for the DCC-GARCH model are the residuals of a bivariate VAR of output and prices. Based on the Bayesian information criterion (BIC), we select an autoregressive order of 3 for both output and price series such that the conditional mean equation (1) is represented by a 3 order bivariate VAR.

Table 1 displays some diagnostic statistics for the residuals of the conditional mean equation. The first set of statistics shows results of the Ljung-Box test for serial correlation using the residuals and squares of the residuals. The Q-statistics for an order of 10 clearly indicates the presence of serial correlation in both output and price residuals.

The second set of statistics represents test results on the variance-covariance matrices: The first is the Lagrange multiplier (LM) test for ARCH with 4 lags and the second is Breusch and Pagan's (1980) test for heteroskedasticity. The evidence of conditional heteroskedasticity lends support to the use of ARCH-type models and GARCH, in particular, to capture the time-varying volatility behavior of the data series.

The bottom three rows of Table 1 show results for testing the null hypothesis of normality. The price residuals are found to have a fat tail and a sharper central peak than the standard normal distribution. This finding calls for the use of Bollerslev and Wooldridge's (1992) quasi-maximum likelihood method to generate consistent standard errors that are robust to non-normality.

**Table 1. Diagnostic test results**

VAR residuals	Output	Price
<b>Autocorrelation tests</b>		
Ljung-Box Q (10)		
Residuals	186.38 (0.000)	17.46 (0.0064)
Residuals squared	476.48 (0.000)	476.37 (0.000)
<b>Heteroskedasticity tests</b>		
ARCH (4) LM test	8.29 (0.000)	2.38 (0.058)
LM Hetero test	4.14 (0.000)	5.11 (0.000)
<b>Normality tests</b>		
Skewness	0.22 (0.37)	2.24 (0.000)
Excess Kurtosis	2.41 (0.25)	18.69 (0.000)
Jarque° Bera	2.068 (0.35)	988.32 (0.000)

Note: P-values are indicated in parentheses.

A comparison of the log-likelihood values among alternative lag specifications of the DCC-GARCH model suggests that the data are best represented by a DCC(1,1) with each of the conditional variances captured by a univariate GARCH(1,1) model, i.e.,  $M=N=P_i=Q_i=1$ .

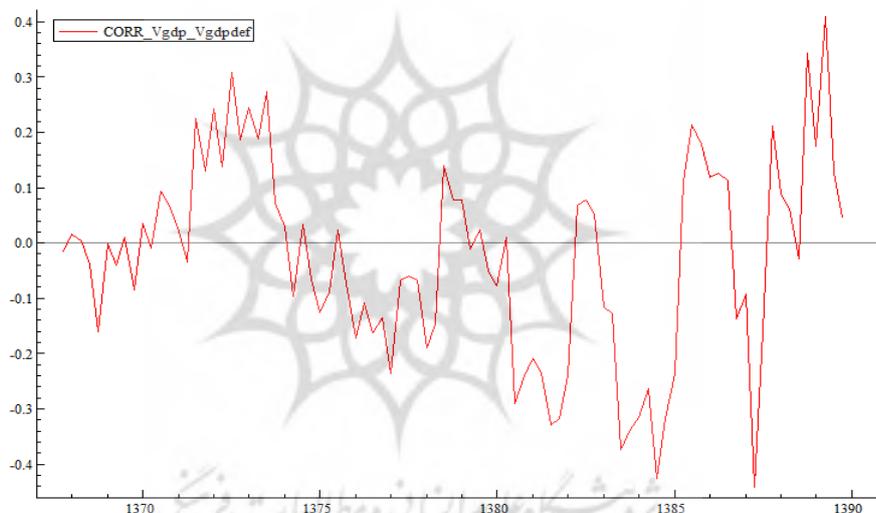
Table 2 displays estimation results for the DCC (1, 1)-GARCH (1, 1) model. In particular, the sums of  $\alpha_i$  and  $\beta_i$  in both GARCH equations are fairly close to 1, indicating rather high persistence in the conditional variances. The mean value of the conditional correlation coefficient ( $\bar{\rho}_{12}$ ), which reflects unconditional correlation, appears to be rather small in absolute size. However, the results of two parameter constancy tests indicate evidence against the assumption of a constant conditional coefficient. The first test involves an LM statistic, which is developed by Tse (2000) for testing the null hypothesis of constancy in the correlation coefficient. Alternatively, the second test involves a  $\chi^2$  statistic, which is developed by Engle and Sheppard (2001) for testing the null that  $R_t=R$ . The test results indicate significant variation in the correlation coefficient over the observation period.

**Table 2. DCC–GARCH model estimation results, 1988–2010**

Parameter	Estimate
$\alpha_{11}$	0.034
$\beta_{11}$	0.96 ***
$\alpha_{22}$	0.21 ***
$\beta_{22}$	0.78 ***
$a$	0.18
$b$	0.51 ***
$\bar{\rho}_{12}$	-0.01
Tests for Dynamic Correlation (H0: CCC model)	
LM test of Tse (2000)	2.91 *
Engle and Sheppard Test (2001)	20.83 **

P-values are indicated in parentheses.

**Figure 1 shows the evolution of the conditional correlation between output and prices,  $\bar{\rho}_{12}$ .**



Examining the graphic evolution of correlations between outputs and prices leads to the following observations:

It seems to point to a weak correlation after imposed war. Indeed, during this period, conditional correlations do not exceed 1%.

The conditional correlation varies periodically and it changes from positive to negative after imposed war and changes from negative to positive again after 2009 crisis<sup>1</sup> in Iran.

<sup>1</sup> - Iran's tenth presidential election in 2009

The  $b$  coefficient that implies the contagion effect of fluctuation is significant then we conclude that there is a contagion effect of the price index on output.

The predominantly negative estimates suggest that the overall price level was typically countercyclical rather than procyclical. A common interpretation for a negative output-price co-movement is that the economy is dominated by aggregate supply versus aggregate demand shocks. However, Ball and Mankiw (1994), Judd and Trehan (1995), and Rotemberg (1996) show that this empirical finding is consistent with the prediction of a sticky price model with only aggregate demand shocks.

#### 4. Conclusion and policy implication

In this paper, we have employed a dynamic conditional correlation GARCH model to explore the conditional correlation between output and prices for agricultural sector of IRAN after Iran-Iraq war.

The estimation results confirm that all conditional correlation varies over time and changes from positive to negative after imposed war and changes from negative to positive again after 2009 crisis in Iran. Nevertheless, during this period, conditional correlations do not exceed 1%. However, we conclude that there is a contagion effect of the price index on agricultural output. The predominantly negative estimates suggest that the overall price level was typically countercyclical rather than procyclical. These finds are very effective in providing information that is important for economists who try to build a structural model. A negative correlation between prices and output implies the presence of aggregate supply versus aggregate demand shocks and sticky prices. Supply shocks are the main causes of stagflation. This is very critical situation for any country to come out from stagflation. This cannot be rectified alone with monetary policy. Supply side constraints should be met first, by increasing production, and second, medicine for inflation should be done by cutting down policy rates. Fiscal stimulus will also play important role in this. Therefore, to solve the problem of stagflation, governments must adopt policies to push out the aggregate supply curve.

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