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Impact of Oil Price Volatility on Macroeconomic Variables (A Case Study of Pakistan)

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Abstract

This study examines the impact of oil price volatility on macroeconomic variables of the economy of Pakistan. We employed the GJosten, Jagannathan and Runkle (GJR) and Vector Autoregressive (VAR) models. The outcomes of the GJR model show the symmetric effect of oil price shock on conditional variance. Whereas Impulse Response Functions (IRFs) show the hostile effect on the employment and the output. Although the oil price uncertainty affects the consumption but declining image is less severe. The trade deficit and consumer price index rise due to negative oil price shock in the long run.

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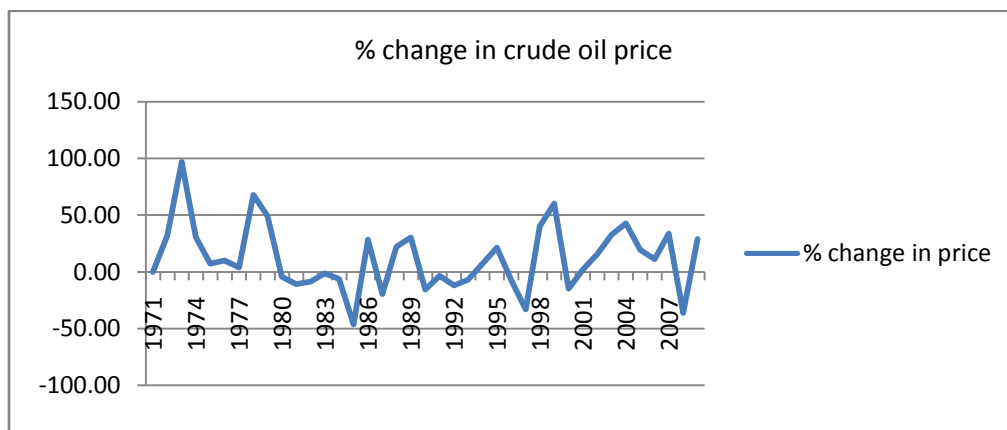
Introduction

Energy is a vital input in the production process. For economic growth, it is essential to maintain equilibrium between energy supply and upcoming demand. The delay in taking the appropriate measures to bring these two into equilibrium impedes development.

The history of crude oil is very eventful, with sudden ups and downs in crude oil price. The first shock of the 20th

century in oil market occurred in 1973-74, when Arab members of OPEC announced an oil embargo against US. The price reached to \$9.35 per barrel which was 96.84 percent higher from the last year price.

The second shock of 1979 occurred due to the Iranian Revolution and Iran-Iraq war. The shortage of oil supply caused the oil price to rise to \$ 25.1 per barrel, around 67.89 percent higher than the previous year.



A major decline was observed in crude oil price in 1986, when Saudi Arabia increased oil production. Crude oil price declined to \$ 14.44 per barrel, 46.36 % less from

previous year price. Similarly, in 1999-2000, OPEC again limited oil production and as a result the oil price reached to \$ 36.54 per barrel which is 60 percent more

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than last year price. Another shock generated in 2003-04, lasted till 2008. In 2009, price of crude oil dropped to \$ 61.74 from \$ 96.94 per barrel in 2008, a decrease of 36.31 percent, which was primarily due to global financial crisis.

These fluctuations in oil price cause uncertainty among consumers, investors and regulators. This uncertainty and concern lead the consumers and producers to delay the decision of purchase of consumer's durable and new investment respectively (Bernanke 1983 and Henry 1974). These delays cause loss of market opportunities and inefficient resource allocation in the long run. It also creates pressure on regulators to intervene and restrict the market participants by generating undue profits.

Pakistan is a country of 180.7 million peoples growing with a real GDP growth rate of 3.67 percent per annum. The energy demand grows rapidly in most of the economic sectors; the annual growth rate of total energy consumption is 2.7 percent¹ In literature, the relationship between energy consumption and economic growth is well established. To meet the future challenges of rising demand it is essential to look into the performance of various sectors of the economy and the pattern of energy consumption by sectors.

Table 1: Demand side of the energy (year 2011)

Sector	% share of TEC ²	Annual growth rate of energy consumption
Agriculture	2	1.1
Industry	38.5	0.4
Transport	30.9	4.8
Services	28.6	3.47

Source: Hydrocarbon Development Institute of Pakistan

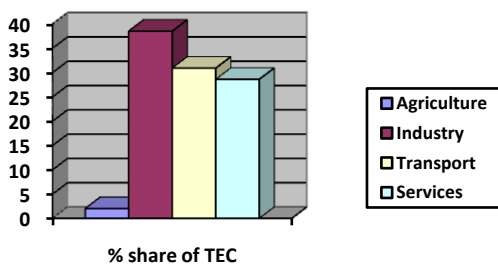


Fig 1: %Change in crude oil price

Source: Hydrocarbon Development Institute of Pakistan

¹ Pakistan Energy Yearbook 2011

² TEC stands for Total energy consumption and Service sector include commercial+ Domestic +other Govt

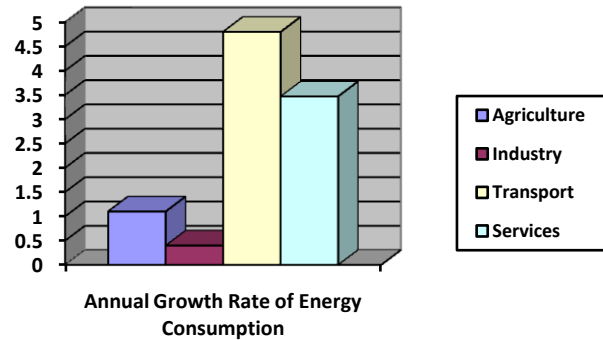


Fig 2: Demand side of the Energy

Source: US Energy Information Administration (EIA)

The agriculture sector generates 21.1 percent of GDP and has a growth rate of 3.1 percent. It consumes only 2.0 percent of total energy and the annual compound growth rate (ACGR) of energy consumption in agriculture sector is 1.1 percent. The industrial sector generates 25.5 percent of GDP having a growth rate of 3.4 percent. It consumes 38.5 percent of total energy consumption and has ACGR of 0.4 percent. Similarly, the transport sector consumes 30.9 percent of total energy, having ACGR of 4.8 percent. The service sector contributes 53.4 percent of GDP and its growth rate is 4.4 percent per annum. It utilizes the 28.6 percent of total energy consumption having ACGR of 3.47 percent.

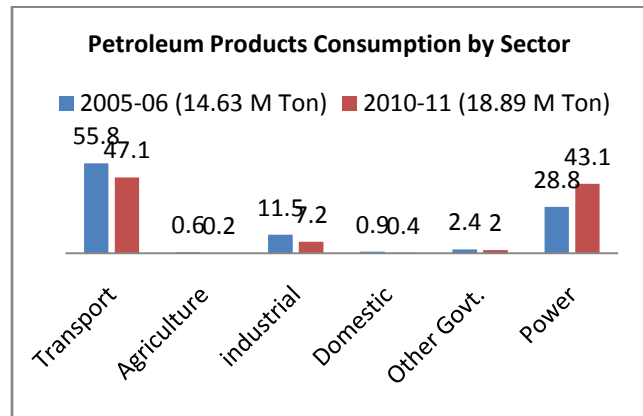


Fig 3: Petroleum products consumption by sector

Source: Pakistan Energy Yearbook, 2011.

The composition of petroleum product consumption shows that transport and power sectors are the main users of oil, consumes 47.1 and 43.1 percent respectively. The comparison between 2005-06 and 2010-11 shows that there is a decrease in consumption of oil in all sectors of the economy except power sector. Transport sector shows a significant decline of 8.7 percent in consumption of oil, while the power sector demonstrates an increase in consumption of oil by 14.3 percent. The above data shows that Pakistan's economy witnessed a phase of

transition wherein expensive imported fuel was replaced by the relatively cheaper domestically available sources³.

The core objective of the study is to examine the impact of oil price volatility on macroeconomic indicators of Pakistan. As Pakistan's economy heavily relies on imported oil to meet its energy demand, therefore, it is more vulnerable to oil shocks. There is no such study which has examined the impact of oil price volatility on Pakistan's economy. The arrangement of the study is as follows. Section 2 consists of literature review, data and methodology is explained in section 3. Section 4 discusses the results. Section 5 summarizes and concludes.

Literature review

Ahmed *et al.* (2011) examined the impact of oil price volatility on US industrial production for the time span of 1980 to 2010. They applied CGARCH and VAR model and found asymmetric effects of oil price shocks on the transitory oil price volatility. Impulse Response Functions (IRFs) also show the significant and long term effects of rising transitory oil price volatility on industrial production.

The study also revealed that transitory oil price volatility induces the rise in the general price level and non-fuel commodity prices in the US. Moreover, the variance decomposition used in the study strengthens the idea that transitory volatility is an important component of variance in industrial production. Ahmed and Wadud (2011) used the structural VAR (SVAR) model to estimate the dynamic IRFs, which shows the elongated deteriorating effect of oil price volatility on Malaysia's industrial output. The study shows that the consumer price index (CPI) has an inverse relationship with oil price uncertainty. The EGARCH model evaluates significant asymmetric of oil price fluctuations on conditional variance.

Rafiq *et al.* (2009) find the unidirectional causality runs from oil price volatility in investment, unemployment rate, interest rate and trade balance in the case of Thailand. The results of the VAR model show that the oil price volatility has significant impact on growth, employment and investment. Huang *et al.* (2005) used monthly data on US, Japan and Canada for the time period from 1970 to 2002 and employed the threshold test; they found that the price change has better descriptive power to explain the economic activities than oil price volatility. On the other hand, oil price volatility

has better explained the stock return than a change in industrial production.

A large panel data set of US companies is used by Henriques and Sadorsky (2011) found the U shaped relationship between oil price volatility and firm's level of investment by analyzing a large number of US firms. Radchenko (2005) estimated the impact of oil price volatility on the degree of asymmetry in the response of gasoline prices to the oil price increase and decreases for US economy. The study found that the degree of asymmetry in gasoline prices declines with an increase in oil price volatility.

Qianqian (2011) investigated the long run connection between oil price and output CPI, net exports and the monetary policy for the Chinese economy. Rising oil prices cause the net exports and the real GDP to decline and CPI to rise. It has a negative impact on the actual money supply.

Du *et al.* (2010) explored that oil prices effect China's economic growth and inflation but no effect on China's output is found on global oil prices, hence oil price exogenous with respect to China. The study considers structural break in the VAR model because of China's reforms. Jbir and Ghorbel (2009) explored that the oil price shocks have no direct effect on economic activity but these shocks indirectly affected the economic activity via government expending in Tunisia. The variance decomposition explains that the oil price fluctuation is the leading source of government spending changes.

Berument and Tasc (2002) estimated the inflationary effect of crude oil prices by using 1990 input-output table for Turkey. The inflationary effect is limited to fixed nominal wages, profits, rent earnings and interest but, when wages, profits, interest and rent earnings are adjusted to the general price level, the inflationary impact of oil prices becomes significant.

Data and methodology

Data

The study used annual data in Pakistan from 1972 to 2010. The variables used in the study are GDP growth rate (Y), unemployment (unmp), consumer price index (CPI), consumer private consumption (COM), the trade deficit (TD) and crude oil price (OP). The data is taken from world development indicators (WDI), different volumes of Pakistan Economic Survey and US Energy Information Administration (EIA). All variables are in logarithmic form except trade deficit.

³ The comparison of energy fuel mix during 2005-06 and 2010-11 shows that the consumption of petroleum products continuously declining and is being replaced by the natural gas because of substitution effect.

The GJR model

The GARCH models developed by [Bollerslev \(1986\)](#) and [Taylor \(1986\)](#) are good enough to explain the volatility clustering and leptokurtosis in a series but the standard GARCH (p, q) model has some limitations. First, the parameters are forced to be positive in order to avoid the non-negativity condition. Second, GARCH model cannot measure the leverage effect; it shows the similar response of volatility to positive and negative shocks. Finally, the GARCH model does not let for any direct feedback between the conditional variance and mean. Many extensions have been suggested since the GARCH model has developed.

A famous model developed by [Glosten et al. \(1993\)](#) is used to explain the leverage effect. The GJR model is the improved form of the GARCH model with an extra term used to assess the asymmetries. In the GJR model conditional variance is expressed as

$$\sigma^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta \sigma_{t-1}^2 + \gamma u_{t-1}^2 I_{t-1}$$

Where $I_{t-1} = 1$ if $u_{t-1} < 0$
 $= 0$ otherwise

For a leverage effect, we would see $\gamma > 0$. The condition for non-negativity will be $\alpha_0 > 0, \alpha_1 > 0, \beta \geq 0$, and $\alpha_1 + \gamma \geq 0$. That is, the model is still permissible, even if $\gamma < 0$, provided that $\alpha_1 + \gamma \geq 0$.

Vector autoregressive models

Vector autoregressive (VAR) models are used to determine the relationship among multiple series. VAR models are generalized form of univariate autoregressive models. Vector autoregressive models have several advantages over univariate autoregressive models and simultaneous equations structural models. Firstly, no need to describe the nature of variables, like endogenous or exogenous. Secondly, VARs allow the variable to depend on its own lags and white noise disturbance terms, therefore, VARs are more flexible. Thirdly, the forecast of VARs models are improved than other structural models ([Sims, 1980](#); [McNees, 1986](#)).

The bivariate VAR is the simplest form of VAR, in which only two variables, whose current values depend on the previous k values of these variables, and error terms.

$$y_{1t} = \alpha_{10} + \alpha_{11}y_{1t-1} + \dots + \alpha_{1k}y_{1t-k} + \gamma_{11}y_{2t-1} + \dots + \gamma_{1k}y_{2t-k} + u_{1t}$$

$$y_{2t} = \alpha_{20} + \alpha_{21}y_{2t-1} + \dots + \alpha_{2k}y_{2t-k} + \gamma_{21}y_{1t-1} + \dots + \gamma_{2k}y_{1t-k} + u_{2t}$$

Where u_t is the error term with $E(u_t) = 0, (I = 1, 2), E(u_{1t} u_{2t}) = 0$

Empirical findings

GJR estimates

Table 2 shows the estimates from GJR model. Parameters are estimated using asymmetric based GJR over the period 1972 to 2010. Findings from the conditional variance show that the asymmetric term γ has a negative sign and significant. As the sum of $\alpha_1 + \gamma < 0$, so the model remains no longer permissible.

Table 2: Estimates from asymmetric GJR

Parameters	Estimated coefficients	P- Values
α_0	185.993	0.323
α_1	0.168	0.637
γ	-.6022	0.066
β	0.198	0.821

***Significant at 10 % level

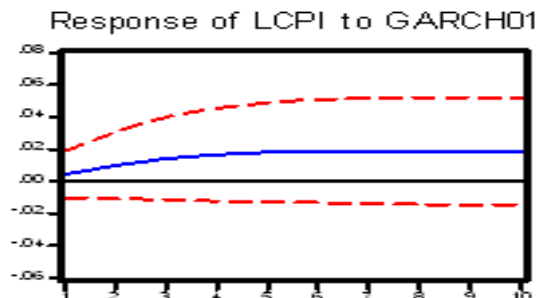
VAR model estimates

As the VAR model is lag sensitive, therefore to determine the appropriate lag length for VAR, we employed the multivariate information criterion. The optimal lag length for VAR model is 1, based on Schwarz Information Criterion (SIC).

Dynamic impulse response functions (IRFs)

The impulse response functions of oil price shocks (measured by condition volatility) on GDP growth rate, CPI, unemployment; trade deficit and consumer private consumption are plotted in the fig. 3 Impulse response for each variable associated with separate unit shock to each variable is noted. As the VAR has six variables, it can generate 36 impulses. The main concern of our study is to look at the impact of oil price volatility on other variables, so we only draw the responsiveness of the dependent variables in the VAR to shock.

VAR impulse response functions



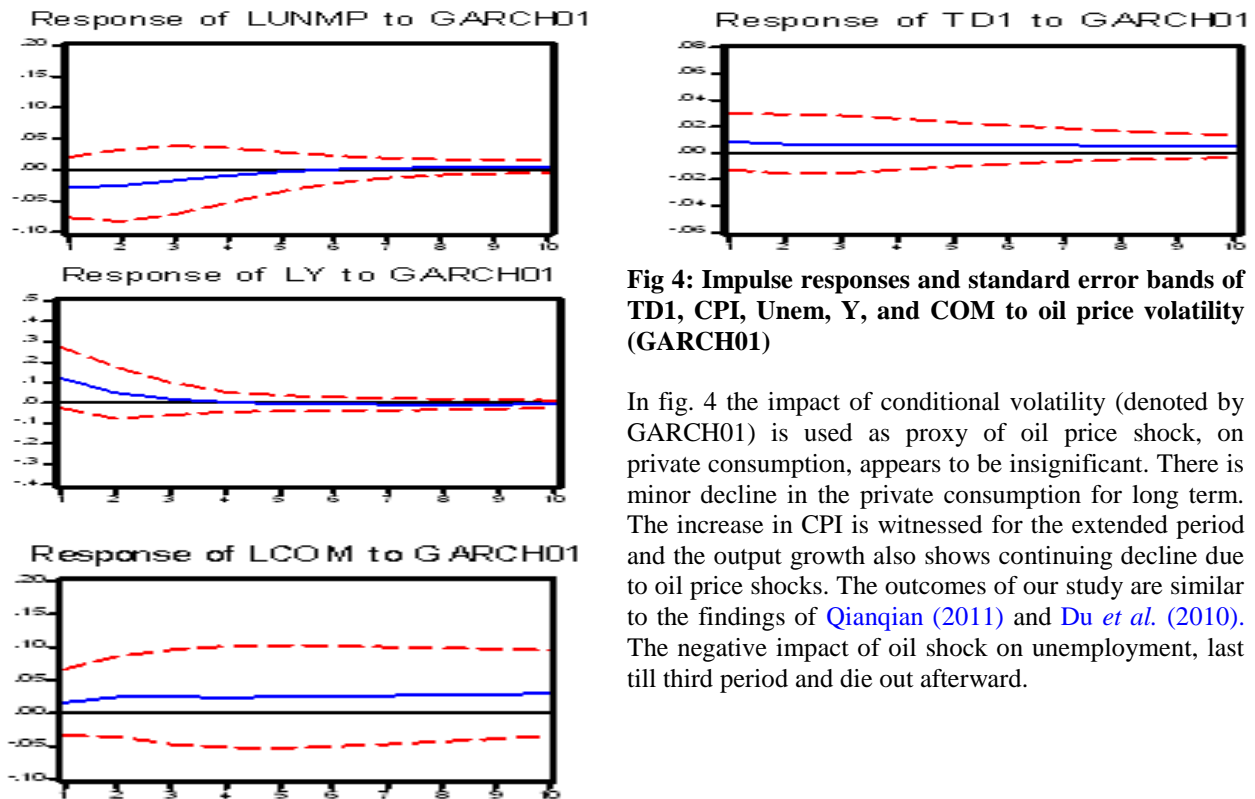


Fig 4: Impulse responses and standard error bands of TD1, CPI, Unem, Y, and COM to oil price volatility (GARCH01)

In fig. 4 the impact of conditional volatility (denoted by GARCH01) is used as proxy of oil price shock, on private consumption, appears to be insignificant. There is minor decline in the private consumption for long term. The increase in CPI is witnessed for the extended period and the output growth also shows continuing decline due to oil price shocks. The outcomes of our study are similar to the findings of Qianqian (2011) and Du *et al.* (2010). The negative impact of oil shock on unemployment, last till third period and die out afterward.

Table 3: Estimation from variance decomposition

	Percentage of variation due to					
	Y	TD	CPI	COM	GARCH01	UNMP
COM	(%)	(%)	(%)	(%)	(%)	(%)
2	7.523	4.111	50.023	38.265	0.066	0.007
5	8.867	5.434	52.487	32.259	0.203	0.747
10	9.242	6.406	48.960	34.377	0.288	0.725
CPI	(%)	(%)	(%)	(%)	(%)	(%)
2	5.266	4.022	83.177	0.002	0.449	7.080
5	1.944	0.948	70.715	5.717	7.302	13.371
10	3.633	3.490	60.437	21.572	4.240	6.6244
TD	(%)	(%)	(%)	(%)	(%)	(%)
2	2.864	95.796	0.0007	1.006	0.313	0.018
5	6.982	88.602	2.059	1.066	0.578	0.710
10	6.013	74.307	8.825	1.150	4.056	5.647
UNMP	(%)	(%)	(%)	(%)	(%)	(%)
2	6.803	10.704	1.985	4.241	19.866	56.396
5	13.452	11.124	1.603	10.516	19.386	43.915
10	13.717	10.619	1.301947	15.312	19.462	39.587
Y	(%)	(%)	(%)	(%)	(%)	(%)
2	92.222	3.5567	0.030	0.655	0.0001	3.534
5	81.915	3.823	1.168	1.164	4.1001	7.827
10	79.292	3.748	1.465	1.260	5.356	8.876

Cholesky Ordering: COM CPI GARCH01 TD UNMP Y

Table 3 represents the variance decomposition of macroeconomic activities of the VAR model that used the oil price volatility as exogenous variables. The results show that the oil price volatility is the second largest component of variation of unemployment. Oil price

volatility contributes significantly in the variation of GDP growth rate in 5th and 10th periods.

It also indicates that the contribution of oil volatility is very small, while explaining the variation of private

consumption. The oil price volatility significantly explains the fluctuation of consumer price index in 5th and 10th periods. The contribution of oil price volatility in initial periods is very small in explaining the variation of trade deficit, but in the 10th period, it is 4 percent.

Conclusion

The present study tried to examine the impact of oil price volatility on the macroeconomic variables. We used the famous asymmetric GJR model. The estimation results of GJR model do not show the asymmetric effect of oil price shock on conditional volatility. We used the conditional variance (GARCH01) of the GJR model as a measure of the price shock in the VAR model. We checked the impact of conditional variance as an oil price shock on GDP growth rate, CPI, unemployment, trade deficit and consumer's private consumption. Our estimation results from VAR and impulse responses showed that the unemployment is badly affected by the oil price shock.

The results also show that Pakistan's output growth has also declined due to oil shock. The trade deficit responded adversely to oil price shocks only in the long run. The consumer price index is found to rise for long period but the insignificant effect of oil shock is found in private consumption in the case of Pakistan. The findings of our study are similar to Qianqian (2011) and contradict that of Ahmed and Wadud (2011).

As most of the macroeconomic variables of Pakistan's economy are affected by the oil price volatility, so, it is an important issue and need proper attention of authorities. Here are a few suggestions to protect the economy from vulnerability of oil price volatility. First, the dependency on imported crude oil should be lowered. Second, special incentives should be given to investors to attract the private investment in the energy sector, especially in coal, wind and solar energy. Third, strong political determination is needed to initiate medium and long term hydro power projects.

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