Cheating Behaviour among OPEC Member-States and Oil Price Fairness and Stability: An Empirical Analysis

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Abstract

Within the context of a target oil price band regime, this paper posits that cheating behaviour in OPEC has ethical and accountability implications for the organisation. It also impacts on its reputation and ability to ensure stable and fair oil prices in the oil markets. Based on datasets covering the period from 2000 to 2012 (i.e. production quota era), analysed using the vector autoregression/vector error correction (VAR-VEC) framework, the study’s results indicate that OPEC cheating, mainly instigated by the amount of spare production capacity available to OPEC members, does not seem to have a significant direct effect on international oil prices. However, the degree of cheating by OPEC member-states might disrupt its ability to maintain surplus capacity enough to reduce price speculation in the oil markets. Should cheating behaviour in OPEC continue unabated, this could jeopardise an effective energy regulatory framework and market transparency. The paper, therefore, recommends a policy action in OPEC to support the redesigning of the existing quota system that is fair and just to its members and capable of controlling any cheating behaviour.

Keywords: OPEC cartel, cooperation, cheating, fairness and oil price stability

Introduction

OPEC (which stands for the Organization of the Petroleum Exporting Countries) is an intergovernmental organisation that is responsible for setting production quotas for its members in order to influence global oil prices (Kaufmann et al., 2004). OPEC production allocation decisions have been of interest to many analysts when modelling oil prices (Ji & Guo, 2015). The overall aim of the decisions is to achieve basic economic objectives - microeconomic (i.e. a stable oil price in the markets) and macroeconomic (i.e. economic development of members by ensuring a fair price) (Noguera & Pecchecnino, 2007). Achieving these twin objectives therefore involves the use of political powers – as evident in production allocation decisions based on quota system and by virtue of the members' reserves (i.e. over 70% of conventional reserves are in OPEC member states according BP, 2013 and OPEC, 2013). However, the market expectations about members' compliance with OPEC's allocation can equally influence the degree of oil price volatility, which may, in turn, produce a strong motivation for members to exceed the allocated production quota.

For example, high oil prices are associated with speculation that OPEC might reduce oil production level during its ordinary or extra-ordinary meetings and vice versa (Schmidbauer & Rösch, 2012). In many cases, members allegedly embark on supply of oil above the allocated quotas (Dibooglu & AlGudhea, 2007), otherwise known as "cheating"[1]. The historical deviation from official quotas in OPEC member states occurs where (a) oil is sneaked out of a member country with the consent of the government and sold in black-market[2] or (b) a member country takes any unilateral action to increase/decrease production contrary to the official quota (e.g. Saudi Arabia) for personal reasons. These practices may make individuals or governments richer in some way but often at the expense of others. In Nigeria alone, billions of US dollars were lost in revenue and taxes on over 500,000 barrel per day (b/d) according to the U.S. EIA (2015)[3] (see also Katsouris & Sayne, 2013). Although there is widely documented evidence that changes in OPEC production would impact on oil prices, there have been a few

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[1] Cheating is defined by Kaufmann et al. (2004) and Diblooglu & AlGudea (2007) as the degree to which actual oil production in OPEC member nations exceeds the official allocated quota.

[2] Example of these countries includes Nigeria, Iran, Iraq and Venezuela.

[3] See full report at http://www.eia.gov/beta/international/country.cfm?iso=NGA

studies on cheating behaviour among OPEC members. Therefore, it will be interesting to understand how cheating may affect oil price and the organisation's prime objectives of fair and stable oil prices in the oil markets.

Many economic analysts had predicted low oil prices at the beginning of the new millennium based on the premise that OPEC countries would cheat while the rising oil prices would induce more production from non-OPEC countries (see Abraham, 2000). However, the evidence proved contrary as oil prices continued to rise (from $12.50 per barrel in January 1999 to $70 per barrel in January 2006 and $125 per barrel in July 2008) despite cheating behaviour by OPEC members that would have presumably lowered oil prices (see Birol, 1998; Gonigam, 2007; Smith & Habiby, 2010).

Consequently, in response to the criticisms over rising oil prices in the late 1990s, OPEC introduced oil price band policy in the early start of the new millennium (03/2000) with a pre-determined mechanism that was set to automatically adjust oil production in response to any adverse changes in prices beyond certain levels of the band (Farrell, 2001). This policy seemed to be complementary to achieving the fundamental OPEC's objectives of fair and stable oil prices in the oil market. To achieve the set objectives that mainly targeted oil prices, OPEC must be able to coordinate its members effectively (see Chalabi, 2010). However, cheating practices by some OPEC members have received wide attention from international observers/analysts (see Smith & Habiby[4], 2010; Katsouris & Sayne, 2013[5]) and the media. For instance, Katsouris & Sayne (2013) noted that oil theft in Nigeria during the first quarter of 2013 alone accounted for an average of 100,000 b/d (barrels/day) and there was no political will to address this issue among many politicians and government officials because some of them are allegedly involved. Furthermore, cheating by members such as Venezuela, United Arab Emirate (UAE) and Saudi Arabia was found to be significant. In addition, Goldstein (1992) noted that the volatility in oil prices and the volume of debt owed to the U.S.A by the Saudi has increased the chances of cheating in OPEC.

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[4] Read more from Smith and Habiby (2010).

[5] See more on Chatham House report by Katsouris & Syane (2013).

Furthermore, Dibooglu & AlGudhea (2007) found evidence of cheating by OPEC members on a varied scale depending on the upward or downward movements in oil prices. While some scholars (for example, Goldstein, 1992) argued that rising oil price induces cheating among OPEC member-countries, others (such as Chalabi, 2010) attributed the practice to OPEC's inability to discipline its members accordingly. This manifests a structural weakness despite OPEC's consistent measures aimed at discouraging members from cheating (see Molchanov, 2003). The oil obtained via cheating by OPEC member-countries is sold in the international oil markets and this trend affects the ability of OPEC to achieve stable and fair prices.

Therefore, some interesting questions at this juncture are: if OPEC countries had been cheating, why should oil prices continue to rise? What economic and political consequences would cheating in OPEC have on its fair and stable price objective? Therefore, finding answers to above questions and dynamics in oil market is important to analysts and policy makers (see Chalabi, 2010 and Kaabia et al. 2018). Understanding motivational dynamics of cheating in OPEC can help in identifying the main factors that drive high oil prices. It will equally help OPEC in devising strategy to minimise cheating behaviour and enhance its reputation as a major single cartel to the global oil market. Additionally, the study of cheating is important in order to address ethical challenges that may put the reputation of international oil markets in jeopardy, given that extractive industries have long been subjected to many accusations of unethical practices.

In this regard, this study investigates the dynamic association between cheating in OPEC and international oil prices, with specific attention to OPEC's oil price band policy that was introduced earlier to achieve stable prices. The remaining sections are organised as follows: section two reviews relevant literature while section three presents the data description and the methods employed for analysis in this study. Section four presents the analyses of data and related discussions while the final section (i.e. five) contains the conclusions drawn thereof.

A Review of Related Studies

OPEC, as a cartel, is generally confronted with a problem related to its inability to ensure effective coordination of the members' actions (in form of a "collective action problem") as stipulated in their policy and objective statements (Rousseau, 1998; Chalabi, 2010). This inability to coordinate effectively leads to what is generally documented as "cheating behaviour" amongst OPEC members in the extant literature (Dibooglu & AlGudhea, 2007). The first evidence of cheating is established following the self–imposed quota system agreed at the members' 63rd extraordinary meeting in 1982. The meeting agreed an additional practical stabilisation measure to strengthen the unification policy enshrined in the OPEC's Statute since inception in 1960. However, the measure lacks full compliance given that OPEC members' incentives for higher production were fuelled by two emerging groups within the organisation that embarked on a "constant sum game" (Gately, 2004). In this type of game, any gain to a player group is made at the expense of the other group and this usually results in mixed strategies. Consequently, any move initiated by one group is responded to by the other group in order to avoid any negative consequences. An individualisation (where individual interest is placed at the expense of the group) in responding to each other's actions/inactions raises a challenge that impedes the coordination power towards attaining the overall objectives of the organisation. One of the strategies members often use in self-defence is deliberate production above the officially allocated quota (i.e. cheating). This could be by way of black-market activities which a government fails to address or a deliberate effort by a government to embark on excessive production beyond its limit for a different motive.

In this regard, the expectation is that cheating benefits oil market particularly when OPEC, as the major producer, is alleged in undersupplying the market its production cut policies (see Adelman & Lynch, 2004; Adelman, 2002). This situation implies a negative association between OPEC production and oil prices (i.e. increased production from cheating activities lowers global oil prices (Abraham, 2000). The reverse is the case for less cheating behaviour in the organisation given that oil market will be less supplied by official OPEC production, which translates into higher oil prices (see Morris & Meiners, 2013). Therefore, cheating behaviour is inversely related to oil prices when a "soft market"[6] exists and vice versa. Consequently, a bi-directional Granger causality will be projected between global oil prices and the cheating behaviour in the organisation. This

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[6] Soft market is characterised with stagnant oil prices, lower production induced by low demand and excess supply.

implies that high or low cheating behaviour in OPEC is likely to impact on oil prices; and rise or decline in oil prices induces cheating in OPEC consistent with the demand and supply theory. Additionally, evidence of non-cartel behaviour with core members of the organisation operating as price leaders or dominant sub-group is also documented in the extant literature. The effect of this behaviour is associated with increased disagreements on the ground of segmentation it creates within the group/organisation (Yousefi & Wirjanto, 2004).

Earlier evidence on cheating behaviour in OPEC indicates the presence of many incentives for individual members to cheat and free ride on collective good (Rousseau, 1998). This incentive or motivation to cheat exists because an organisation traditionally perceived as cartel, is likely to short-live due to lack of formal control (in form of a binding legal contracts or arbitration) to settle any potential differences (Jaspers, 2017). The cheating behaviour among OPEC members will not only have potential segmentation effect on the organisation as a whole, but it will also affect its reputation as an effective cartel in the oil market. This is even more likely in a period when the oil markets witness a divestment into alternative sources of energy (e.g. renewables and shale resources).

Parnes (2019) categorised OPEC members into 3 different clusters namely: top oil; mid oil and relatively low oil producers. This categorisation was carried out with a view to extending a model that incorporates oil production quotas set by OPEC to the real oil production cuts through time and based on incidence matrix. The analysis explores overall cheating behaviour in terms of its frequency, magnitude, and volatility by establishing herding, offsetting, and independent conducts amongst the clusters. Considering OPEC as a system, the model used in Parnes (2019) makes it possible to examine the structure of a complex process in order to carry out system analysis for understanding operational mode of OPEC, the 3 subsets, its structure or any pattern in members' behaviour. Our study will complement this study by extending the model into a system equation within VAR-VEC framework.

Furthermore, using Granger causality with a case study approach, Reynolds & Pippenger (2010) examine Venezuela's production decisions in order to establish whether or not OPEC had operated as a cartel. The results reveal evidence of bidirectional causality between Venezuela and the group production patterns over different periods within the short run. This indicates cheating by Venezuela whenever the group proposes production cuts. Reynolds & Pippenger (2010) describe this game as a 'tit-for-tat oligopoly'[7] as opposed to anti-competitive behaviour. Additionally, in the long-run, they document evidence of uni-directional causality from Venezuela's production to OPEC, indicating OPEC's failure to effectively coordinate its production output as opposed to its reaction to the output. Further evidence based on vector error correction models (VECM) fails to establish whether production by Venezuela converges towards its assigned production quota by the group centrally. Similarly, evidence of cheating is documented by Hamilton (2011) who concludes that the country's deliberate unilateral decisions of altering production with the sole intention to influence oil prices are fundamental in accounting for the events that contribute to the volatility following first oil price shock of 2010. This finding lends support to Dibooglu & AlGudhea (2007).

In a similar attempt to understand OPEC behaviour within the oil market, previous studies such as Kaufmann et al. (2008) examine association between a range of variables in the member countries of OPEC in response to fluctuations in oil prices over time. Hence the, study finds that cheating behaviour and quota system in OPEC are key determinants for elasticity of production in form of response by the members. It therefore concludes that, although by virtue of the amount of reserves held by its members, OPEC possess the ability to influence oil price but unable to control such prices as often portrayed in the literature. It highlights further evidence of production sharing behaviour amongst all members apart from Saudi Arabia, which leads to conclusion on "mismatches" between the set quotas and the production.

OPEC's production quota decisions have been widely studied since the inception of the policy in the early 1980s (see Kaufmann et al., 2004; Al-Saif, 1997; Morse, 1997; Alsalem et al., 1997; Gault et al., 1990; Mabro, 1989). For example, Gault et al. (1999) examine OPEC behaviour vis-à-vis their quota system and find that from February 1998, arbitrary allocations with undisclosed basis generally define OPEC's imposed production cuts. Furthermore, violations of allocated quota by

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[7] Tit-for-tat game involves a situation an action is taken in "equivalent retaliation" but with highly sophisticated and effective strategy by one player within the premise of game theory.

members of OPEC have often been linked to perceived unfair distribution of the quotas to each state (see Ait-Laoussine, 1997). This is consistent with the conclusion by Gault et al. (1999) that the perception of fairness among the members increases with 'explicit allocation formula'. Other media sources such as Business Week (2008) confirm the cheating practices in OPEC by revealing that the cartel is unable to enforce any punitive measures on defaulting members with a view to ending such behaviour.

Similarly, increased black-market activities are found to drive cheating behaviour in OPEC member-countries (Colitt, 1998; Belton, 1998). This evidence holds because most of the OPEC member countries are associated with corruption (Mehrara et al., 2011), which increases the likelihood of officials conniving to divert country's resources for personal purposes or gain. Belton (1998) believes that this action renders OPEC less potent and unable to effectively coordinate its members. Therefore, effectiveness in OPEC's coordination of quota will impact on prices accordingly. Using a range of techniques to ascertain the level of compliance with pre-set production in OPEC, based on monthly data from 1995 to 2002, Mazraati & Jazayeri (2004) apply intervention analysis and econometric models to establish that 94-99% compliance level attracts higher oil prices (given that it achieves effective control of supply to oil markets). However, less compliance results in high volatile but lower oil prices. This finding is crucial in understanding the nature of the relationship between price collusions; cartel power/stability and potential competition policy (see Bos & Harrington, 2015).

Insert Table 1

Table 1 shows the nature of the complexity of OPEC quota system that could explain potential cheating behaviour in some member states. For example, as good as the quota percentage for OPEC members appears to be, countries with high population may feel aggrieved considering the size of demands to cater for locally (e.g. Nigeria). The quota system does not appear to reflect the percentage reserve, and this could mean that Venezuela, for example, might not support its allocated quota relative to the quota given to Saudi Arabia during the same periods. Quota as a percentage of GDP clearly shows how unrepresentative the quota system could be. It also explains some country's tendency to cheat for a simple economic objective of improving the wellbeing of their citizens.

It can be deduced from the foregoing review of previous relevant studies that cheating behaviour in OPEC is linked to the metrics set in the quota system for its member-states. This would suggest that high cheating might negatively affect the production levels of OPEC which subsequently influences oil prices accordingly. Therefore, evidence from this review demonstrates incompleteness of OPEC's quota system and its likelihood to create confusion depending on the degree to which cheating is embedded in the allocation decisions. In the light of recent data, this study contributes to the on-going debate on OPEC cheating by investigating the effect of cheating in OPEC on international oil prices vis-à-vis OPEC commitment to ensure stable oil price within a target range (see Tang & Hammoudeh, 2002 for review of target price zone).

Data and Methodology

Data Description

This study employs monthly data relating to cheating in OPEC (denoted by OPC); OPEC production quota (denoted by OPQ); OPEC spare capacity (denoted by OSC) and oil prices (denoted by OPR) for a 13-year period from 2000 to 2012 that relates to when production quota was operated. OPC is defined in Kaufmann et al. (2004:67) as "the degree to which OPEC exceeds" members' allocated "production quota". Cheating was attributable to the structure of the quota system in OPEC (Griffin & Xiong, 1997; Chalabi 2010) and is derived by deducting OPEC official production allocation from the actual OPEC production based on U.S. EIA data. OPQ refers to the periodic quota set by OPEC to control/restrict the amount of oil flow into the market with a view to influencing oil prices.

Therefore, production quota is regarded as the major tool used by OPEC to influence oil prices (King et al., 2012; Kaufmann et al., 2008; Noguera & Pecchecnino, 2007; Bentzen, 2007and). The variable, which was derived from OPEC allocation decisions, has been employed previously in related studies (see Kaufman et al., 2004 and Barros et al., 2011). OPR variable represents the spot crude oil prices from West Texas Intermediate (WTI) collected from the U.S. EIA data sources. Generally, WTI prices are reference prices which are established to influence any future crude oil contracts (Horn, 2001). The prices have equally served as the yardstick for measuring the OPEC reference basket – basis for pricing in the oil markets. On this basis, using WTI as a reference price which guides the sales of the oil produced by OPEC members from the cheating practices may be realistic. It has been used in studies such as King et al. (2012). OSC refers to the surplus crude oil based on U.S. EIA estimates of crude oil production capacity held by OPEC members. Although this capacity could be used to prop up oil prices, it is primarily meant to be applied as a 'buffer against disruptions' in the oil markets (see EIA, 2012[8]). The data were collected on monthly basis from the U.S. EIA.

Furthermore, three exogenous variables (namely the global economic recession[9]. US led war in Iraq, and the oil price band policy) were considered in order to observe the effect of such exogenous shocks on upward or downward movements on the cheating behaviour of OPEC as well as the oil prices. Therefore, the global economic recession is measured using dummy variables with "1" representing period during the recession and "0" for no recession period. Similarly, dummy variables were introduced to indicate presence and absence of official oil price band policy where "1" is assigned to period when the policy was in place and "0" when it was withdrawn. All endogenous variables were transformed into logarithmic forms for modelling.

Empirical Methodology

To examine the empirical relationship among the variables (namely: cheating behaviour in OPEC, the existing spare capacity within OPEC members, OPEC quota and variations in oil prices), a unit root test for each variable and cointegration tests were carried out with a view to understanding the data properties in our study. Cointegration between variables may only be established through a statistical analysis as against any visual inspection of datasets (Hoover et al., 2008). On this basis, Johansen system is used for cointegration test as it is used in many related studies in social sciences.

VAR, as a system regression model with multivariate framework, can consider two or more dependent variables within a system. Previous studies (such as Dibooglu

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[8] For OPEC spare capacity, we employ the EIA's (2012) definition as "potential oil production that could be brought online within 30 days and sustained for at least 90 days, consistent with sound business practices…").

[9] See Alvarez-Ramirez et al. (2011) and Haughton and Khandker (2013) for evidence of recession and oil prices.

& AlGudhea, 2007; Killian & Park, 2009; Farzanegan & Markwardt, 2009 and Kumar et al., 2012; Zhao et al., 2015; Chang et al., 2015) found this innovative tool useful in exploring complex dynamics between variables of interest. However, the model has to satisfy many assumptions related to stationarity and cointegration.

We consider a VAR of order p, based on four endogenous monthly data from 2000 to 2012, expressed in (1):

$$Y_t = C + A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots + A_p Y_{t-p} + BZ_t + e_t \tag{1}$$

Where Y_t is a n x 1 vector of endogenous variables , A_i and B represent the coefficients matrices, C is the n × 1 intercept vector of the model , whereas Z_t represents the vector of variables considered to be exogenous, and e_t is the (n×1) generalisation of a white noise process. Therefore, "n" in this case is number of the endogenous variables which are four (see section on data description). Therefore, Y_t=[OPR_t, OPC_t, OSC_t, OPQ_t] and the exogenous variables which include OPEC's policy to set oil prices within a band, popularly known as (oil price band policy – OPB), the global economic recession - GER and the US invasion of Iraq (war in Iraq – WAR). Hence, Z_t = [OPB_t GER_t WAR_t].

In view of the pervasiveness of nonstationary data and the economic theory that advocates that the attainment of optimal and systemically coordinated outcomes are usually based on adjustment of one variable to another, Hoover et al. (2008) noted that cointegrated vector autoregression (CVAR) model can address both challenges. CVAR model is simply a VEC model with a reduced-rank error-correction coefficient. It allows analysis of data as short-run variation around moving long-run equilibrium depending on the nature of the long-run forces. The long-run forces could push the equilibria and result to stochastic trends or pull from the equilibria and result to cointegration relations (Hoover et al., 2008).

In order to examine the causality within our set of data, given the non-stationarity of the series, we first examined short and long-run causality in terms weak or strong on the basis of the error correction results (see Asafu-Adjaye, 2000) and we subsequently adopted a modified Wald test (see Toda and Yamamoto, 1995) because it fits a standard level VAR. The latter minimises any potential risks of wrong identification related to order of integration among the variables (Mavrotas

& Kelly, 2001). This is carried out by augmenting VAR order ‘k’ to its maximum order of integration (i.e. dmax). In this regard, level VAR is estimated based on the (k+dmax)th order where the dmax vector associated coefficients are subsequently disregarded (Zapata & Rambaldi, 1997).

Subsequently, we employ VEC model in Equation 2 as a framework that allows imposition of identifying restrictions with a view to deriving meaningful interpretation of the long/short-run dynamic relationships among variables and the rate at which such variables adjust to disequilibrium in cointegrating relation (Juselius, 2006). Therefore, we present our VEC model (equation 2) which is a restricted form of equation 1 above:

$$\Delta Y_t = {}^{\mathrm{AB}'} Y_{t-1} + \sum_{i=1}^{q} Bi\Delta yt - i\,C + +\mathrm{Dx} + e_t \tag{2}$$

For the elaboration of the restricted form of our model, equation 3 below sets rather a more comprehensive view of the variables:

$$\Delta lnY_t = \beta_0 + \sum_{i=1}^{k} \beta_1 \Delta ln\mathrm{OPR}_{\mathrm{t-1}} + \sum_{i=1}^{k} \beta_2 \Delta ln\mathrm{OPQ}_{\mathrm{t-1}} + \sum_{i=1}^{k} \beta_3 \Delta ln\mathrm{OPC}_{\mathrm{t-1}} + \sum_{i=1}^{k} \beta_4 \Delta ln\mathrm{OSC}_{\mathrm{t-1}} + \phi_1 \mathrm{BZ}_t + e_{1t} e_t \tag{3}$$

Results and Discussions

We start by presenting descriptive statistics to enhance understanding of our datasets prior to model estimation.

Insert Table 2

From Table 2, the average oil prices during the period stood at nearly $60 with min (minimum) value at $19.39 and max (maximum) values at $133.88. However, the standard deviation showed 28 (i.e. $28) which is high in comparison to its average price, indicating volatile and high risk during the period of time under study (see Guildi et al., 2007). Although the data did not exhibit much skewness, there is evidence of kurtosis suggesting further risk particularly for oil prices. Averages for production quota assigned by OPEC, spare capacity and cheating in production stood at 25.85million, 2.6million and 7.56million respectively. The standard deviations compared to the respective means were low except OPEC spare capacity which stood at £1.42million.

To perform an acceptable vector error correction analysis, we started with tests for unit root on the basis of both[10] Augmented Dickey Fuller (popularly shortened as ADF) and Phillip-Perron (popularly shortened as PP), thus reflecting parametric and non-parametric tests respectively (see Table 3 for results).

Insert Table 3

Generally, from Table 3, the univariate test statistics indicate that we fail to reject each of the null hypotheses (except for OPC). To explore the cointegrating association between OPEC related variables and oil prices, the variables need to be nonstationary at level but stationary at first difference as indicated in the results based on ADF and PP. The results are important because they provide information on the potential effect of non-stationarity on unique properties of a variable given the level of persistence in the shocks (Juselius, 2006). Therefore, estimating VAR model may produce spurious regressions (Greene, 2006). Subsequently, we carried out cointegration tests based on Johansen system cointegration (JSC) procedure to explore the relationship or co-movement between the variables (see Table 4). This has been widely used in the previous literature to determine if OPEC's actions have any long run effect on oil prices (see Gulen, 1996; Bentzen, 2007; Kaufamnn et al., 2004).

Insert Table 4

Table 4 presents the JSC results for both trace statistics and maximum Eigenvalue based on Johansen & Juselius (1990) and Johansen (1991). The null hypothesis, which postulates absence of cointegrating equation, is rejected at 5% level of significance. This indicates two cointegrating equations, thus affirming appropriateness of use of VEC model to quantify the relations among the variables.

Furthermore, a pre-test was carried out to select appropriate lag to estimate the VAR model. This is because a large lag length affects the degree of freedom relative to the sample size and this often leads to a large standard error. In the

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[10] A similar approach was adopted by Farzanegan & Markwardt (2009).

same way, a small lag length often misses out the dynamic properties of variables in a model. Table 1 of Appendix I presents the analysis based on five criteria to select “2” lags for the estimation of VECM. Akaike information criterion (AIC) has been widely used in related social science studies. Furthermore, Toda and Yamamoto (1995) highlighted that a lag selection procedure employed for estimating VAR model can equally become valid for integrated or cointegrated VAR process. Consequently, we estimated the VEC results with no identifying restrictions in the first instance. Given the presence of intercept as well as trend in the data, model 3 (with intercept and linear trend, but with no trend in VAR), was found most suitable in addressing biases in the given datasets. Tables 5 and 6 present the short/long-run results respectively based on VEC framework.

Insert Table 5

Insert Table 6

From Table 6, long-run association from the other endogenous variables to cheating in OPEC can be established. This is indicated by the error correction value (-22) which found to be statistically significant at 10%. This interprets that all the three variables may have collectively, in different ways, resulted to cheating behaviour in OPEC over the long-run period. However, short-run VECM results do not support causality in the short-run from other variables to cheating in OPEC except dummy for the U.S. invasion of Iraq which is significant at 1%. Furthermore, considering the restricted VAR as a system, short-run causality could be found running from some explanatory variables at some different points. For example, results in Table 6 revealed evidence of causality running from lagged values of some explanatory variables (such as LOPQ(-2) and OPB policy) to oil prices (LOPR).

Similarly, evidence suggests a short-run causality from lagged values of LOPR and dummy for war in Iraq to the OPEC quota allocation. These results are expected given that OPEC quota allocation decisions (in addition to the OPB policy) and the U.S. invasion of Iraq may have some roles in causing high oil prices examined during the period. The bi-directional causality running from lagged values of oil price (LOPR(-2)) to OPEC allocated quota in production (LOPQ) is another evidence in support of how the previous period oil price produces a short-run causality to the OPEC production quota. However, lagged values of prices of oil (LOPR(-1)), LOPR(-2)) and U.S./Iraq war produce a short-run causality to spare capacity in OPEC.

Insert Table 7

In this regard, we performed Toda & Yamamoto (1995) and the results are presented in Table 8.

Insert Table 8

Table 8 presents some interesting results that support our short-run causality results reported in Table 5, although with a few exceptions. For example, Toda & Yamamoto (1995) indicates LOSC to be significant in Granger causing the cheating behaviour in OPEC. Furthermore, the joint chi-square statistics for the cheating (LOPC) indicates that the remaining three variables Granger cause cheating behaviour in OPEC. However, outcome of the impulse response functions (IRF) analysis together with the variance decomposition (VD) analysis provide more support to these results. Although the variables are not established to be significant in Granger causing oil price, we have found most of them to be important (i.e. statistically significant) in causing movements in OPEC quota and OPEC spare capacity.

Impulse response functions (IRF) and endogenous variables.

Figure 2 presents responses of all the variables in the model to a unit shock in the LOPC based on Cholesky one standard deviation innovations. Panel 1 (response of LOPC to LOPC) is positive as would be expected. This is probably because cheating has become some common practices in some member states such that, irrespective of the allocated quota and the ruling oil prices, there is a high tendency for such countries to produce in excess of their quota.

Insert Figure 1

Figure 1 has four different panels (1-4) with each panel having four different types of graphs based on the response of the four variables in our Y_t to Cholesky one s.d. innovations vis-à-vis the relevant dependent variable. Graph 1 of Panel 1 presents response of OPEC cheating (LOPC) to LOPC in the top left corner. The response to the shock is positive throughout the period considered. However, it was initially high in Period 1 but declines with time over to Period 12. This implies how the cheating behaviour potentially informs the future actions of members of OPEC as an organisation. Similarly, Graph 2 of Panel 1 (i.e. response of oil price to cheating behaviour) is positive at a start of Period 1 of the shock and this continues to increase until its peak level in Period 7 where it begins to gradually drop towards the periods remaining. This interprets that a unit rise in the price of oil is often tailed by increase in cheating behaviour in OPEC members. Our findings are consistent with Dibooglu & AlGudhea (2007) who establish similar pattern in OPEC members around rising oil prices than falling oil prices.

In other words, increasing oil prices could potentially serve as incentives for members of OPEC to embark on cheating behaviour at the start of the period but, because it so much depends on some other factors such as availability of spare capacity, assigned production quota and the ruling price, then it becomes challenging to sustain the practice in the future. This is particularly practicable when the prices at which a member sells the crude oil based on the allocated quota become more expensive than the sales of the crude oil in black-markets. This path is important to OPEC as can be observed based on the remaining graphs (3 and 4) of Panel 1. It is evident that response of LOPQ (allocated production quota) to cheating behaviour in OPEC is initially negative from Period 1 until period 7 indicating how changes in quota occur relative to cheating in the organisation. This response becomes positive from Period 8 and keeps a steady and consistent pattern in the periods remaining.

Similarly, Graph 4 of Panel 1 shows response of spare capacity in OPEC (LOSC) to OPEC cheating (LOPC). This was initially negative from period 1 until period 5 where it turns to stay positive over the periods remaining in the model. This is not a surprise given that increase in cheating could potentially reduce the existing capacity and that takes time to be recovered depending on the existing climate in the member nations and the markets. Furthermore, in Panel 2 of Figure 2, responses of all four variables to a unit innovation in prices of oil are all positive although in different forms. Interestingly, the response of LOPC to LOPR (in Graph 1 of Panel 2) indicates how cheating would react to a shock in the price of oil. This positive response continues but in a declining state up to Period 7 and regains a momentum in an upward movement.

Additionally, response of the price of oil to its own shock as indicated in Graph 2 of Panel 2 examines how price of oil responds to a unit change in the lag of the price of oil. This initially remains positive from Period 1 before it increases to peak at Period 3 before it declines towards the end of the period considered. In Graph 4 of Panel 2 (response of LOSC to LOPR), the spare capacity within OPEC reveals a positive but declining response from periods 1 to 5. This pattern of response may be connected to the fact that oil prices may promote cheating as earlier mentioned which could probably put some pressure on the spare capacity until price gets back to an equilibrium level again. Therefore, the negative response in Graph 4 of Panel 1 could be important in explaining the events relating to response of LOSC to LOPR. Similarly, positive response is established in LOPR and LOPQ with a unit shock in LOPQ and LOPR respectively. Although our findings are contrary to Kaufmann et al. (2004) who establish negative association between price and production quota in a cointegrating relation for the price, our results are more consistent with a general notion that rising oil prices serve as strong motivation for cheating behaviour in OPEC as members will produce above set production quota.

The results of response of Y_t to LOPQ are presented in Panel 3. Graph 1 shows an interesting pattern where the response begins with a negative trend from periods 1 to 6. On the other hand, response of price of oil to OPEC cheating indicates that response of the price of oil is positive to the OPEC cheating behaviour. Nevertheless, from Figure 1, Panel 1 shows a near U-shaped IRF line which indicates that the pattern of the response begins with positive at a low level which achieves its peak level in Period 6, and later declines with the remining time in the period considered (although it still remains positive throughout). Graph 4 of Panel 1 also shows a that the response of spare capacity in OPEC to production cheating in OPEC is positive. This pattern remains positive in the entire period included in the test. The second panel on the top hand side of Figure 1 presents results of responses of the four variables to various shocks in the prices of oil. The pattern of the response of LOPQ to LOPC indicates the response of allocated quota to the cheating behaviour in OPEC from periods 1 to 6. Subsequently, the response turns positive from Period 7 up to the end of the entire periods considered in the analysis.

Analysis of variance decomposition of all endogenous variables

We reported the variance decompositions of all the endogenous variables in Table 9 in an attempt to observe how each of the explanatory variables accounts for variation(s) in the dependent variables.

Insert Table 9

Panel 1 of Table 9 shows variation in cheating behaviour in OPEC is 99% accounted for by cheating in 2nd period which suggests that cheating behaviour may have been a common practice among the members and does not depend much on the existing spare capacity, allocated quota or ruling oil prices. However, in period 4, 13% of the variation is accounted for by spare capacity within OPEC while oil price and allocated quota account for 2% and 3% respectively as the contribution of cheating declines to 82%. As at the 6th period, the variation accounted for by spare capacity and allocated quota in OPEC increase to 25% and 8% respectively while OPEC production cheating declines to 62%. These results are consistent with the causality results based on Toda & Yamamoto (1995) approach. Over the subsequent periods (namely: periods 10 and 12), contribution by OPEC production cheating in accounting for variation in itself declines from 41% to 35% respectively. During the same periods, OPEC allocated quota, spare capacity within OPEC and global oil prices account for variations in the following patterns: increase from 14% to 17%, 37% to 40% and 7.89% to 8.14% respectively.

In contrast, from panel 2 of Table 9, variation in oil price is largely accounted for by oil price itself with 98% in period 2 and subsequently a decline to 77% in period 12. Other variables such as cheating and spare capacity do not seem to account for significant movement to the prices (although cheating accounts for increase of 1% to 8% from periods 2 to 12 respectively. In this regard, OPEC production quota accounts for a key change in oil price with increase from 0% to 11%. Furthermore, we examine how variation in allocated quota is accounted for by other variables as indicated in panel 3 of Table 9. In period 2, production cheating accounts for more than 50% variation before declining to 15% and 7% later in periods 6 and 12 respectively. During the same period, oil prices accounts for 4% but increases to 28% and 30% in the periods 6 and 12 respectively. OPEC production capacity accounts for 0% in period 1 but sharply rises to 14% and 17% respectively while contribution from OPEC production quota remains within the range of 43% and 47%. The results suggest that OPEC cheating is an important variable that accounts for variation in cheating behaviour in OPEC. Our findings are consistent with Goldstein (1992); Kaufmann et al. (2004); Dibooglu & AlGudhea (2007); and Parnes (2019) who establish evidence of association between cheating and oil prices, although we differ in methodology.

Similarly, panel 3 of Table 9 shows proportion of the three variables in explaining changes in OPEC production spare capacity. Oil price starts with the lowest of 4% in period 2 before rising to 28% in period 6 and dropping to 26% in period 12%. OPEC production quota accounts for nearly between 25% and 31%. These results are consistent with the target revenue theory which purports that production cuts in OPEC usually take place in response to increasing oil prices to enable members match their revenue with investment needs (see Ramcharran, 2002). However, in doing so, there is no clearly defined penalty and enforcement of such penalty for countries that cheat. In other words, this indicates absence of proper audit mechanism to detect and punish non-compliance and accountability to the large stakeholders of the organisation. This could considerably affect the reputation of the organisation.

Conclusion

Despite OPEC's importance (as a regulator of key oil market producers) and the impact of oil prices on the global economies, there is a few literature sources that investigated the effect of OPEC cheating behaviour on oil prices. Our study contributes to this literature by applying VAR-VEC framework to understand the political economy of cheating behaviour in OPEC and how that could have impaired the attainment of fair and stable oil price objective in the oil markets. Consistent with its policy to stabilise the prices within a target band, it is imperative that OPEC understands the cheating boundaries within its members and the effects of such cheating on its pricing strategy. The aggregate OPEC production quota ceiling is the limit believed by OPEC to set oil prices within the desired level in the best interest of its members who collectively own over 70% global proven conventional oil reserves. In addition to discussing the main impetuses for cheating in OPEC members, this paper examines the impact of cheating in OPEC on international oil prices, using monthly data on a range of variables from 2000 to 2012.

Our study contributes to the literature with empirical evidence, based on IRFs and VDCs, to explain the complex dynamics between oil prices and activities within OPEC that may have implications for the global oil markets. Although our analysis did not find strong evidence that variations in oil prices are the main incentives for cheating behaviour in OPEC, this study produces an interesting finding about OPEC's collective policy response to cheating behaviour by its members. The results have implications for the reputation of OPEC as a major oil producer as it exposes its weaknesses in harmonising members' production policies to achieve its objective of global oil price stability. Consequently, uncertainty about the actual level of OPEC production because of cheating might increase the chances of unwanted speculative activities that might result in high and volatile oil prices.

In view of the fact that OPEC spare production capacity explains major variations in the cheating behaviour of OPEC members, it is instructive to note that OPEC needs to design a framework for efficient and fair allocation of quotas that best minimises cheating among its members in order for its objectives to be achieved. This implies that for OPEC to accomplish its stable and fair oil price objectives in the oil markets, a holistic approach that integrates policies around production quota, spare capacity and monitoring mechanisms for cheating becomes inevitable in the era when many non-OPEC producers are emerging. This must involve the introduction and enforcement of a fair and transparent system that reflects members varying capacities and needs.

Furthermore, such a robust system will enhance the reputation and the credibility of the organisation as a key player in the international markets. Similarly, the war in Iraq has increased the cheating in OPEC members partly because of the rising demand and effort to make up the lost Iraq production. However, other nations seemed to have overproduced to gain from increased prices of oil. The absence of a clear scientific and objective framework for allocating quotas in OPEC could have contributed to this practice. The combined effects of the global pandemic of COVID-19; the remnants of the Arab Spring in the oil-rich MENA region (directly affecting three OPEC giants – Iraq, Iran and Saudi Arabia); the Boko Haram carnage and the Niger-Delta uprisings in Nigeria will further exacerbate the instability in the oil sector and hence, the cheating issue. Therefore, without a robust allocation framework, as proposed in this study, the tide of cheating in OPEC is bound to escalate. This could potentially impact on any regulators' ability to capture relevant oil data should there be the need to regulate climate or international oil markets. As such, the reputation of the organisation to achieve its objective of fair and stable oil prices (i.e. price within a target price zone) may be at stake given the sensitivity of the markets to OPEC collective actions. This will suggest that OPEC may need to come up with an effective means of quota allocation that members consider fair before it can extend such fairness to the market.

OPEC's inability to effectively administer the production quota among its member countries will continue to pose a huge challenge in the oil markets. In view of our findings that cheating behaviour impacts on oil prices and the latter serves as an important motivation for cheating in OPEC, we conclude that the lack of consensus about the causes of volatility in the oil prices may have been related to the intriguing dynamics within OPEC - particularly around oil production quota allocations. More specifically, the debate on OPEC's ability to influence the prices of oil globally in the oil markets will continue to widen so long as cheating in OPEC remains unclear. In the interest of accountability and transparency in the oil market, our study recommends understanding of these boundaries by OPEC. Additionally, OPEC should set up a disclosure framework within its monthly oil market report to account for the cheating, potential implications and specific measures taken to address the issue. This will make a positive impact as opposed to leaving the subject to interpretations of different oil market analysts which could encourage speculative activities surrounding actions and policies of OPEC, thus promoting volatile oil prices.

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Table 1: OPEC quota, % Reserves, and quota as % of GDP and population (2013)

Country	% Quota of OPEC members (2013)	% Reserves of OPEC members (2013)	OPEC quota as a % of GDP (2013)	OPEC quota as a % of population (2013)
Algeria	3.84	1.01	0.51	2.98
Angola	5.79	0.75	1.43	8.97
Ecuador	1.78	0.73	0.57	3.36
Iran	9.25	13.08	0.75	3.57
Iraq	10.16	11.96	1.32	8.60
Kuwait	9.42	8.42	1.52	70.80
Libya	0.84	4.01	0.34	3.97
Nigeria	6.46	3.07	0.37	1.11
Qatar	2.46	2.09	0.36	36.41
Saudi Arabia	32.97	22.04	1.31	32.67
UAE	9.22	8.11	0.69	32.38
Venezuela	7.81	24.74	0.62	7.74

Source: OPEC (2014)

Table 2: Descriptive Statistics of Datasets

	OPR($)	OPQ (mbd)	OSC (mbd)	OPC (mbd)
Mean	59.95	25.85	2.65	7.56
Median	59.18	25.3	2.31	7.04
Maximum	133.88	30.00	6.83	11.37
Minimum	19.39	21.07	0.71	4.19
Std. Dev.	28.18	2.40	1.42	1.64
Skewness	0.38	0.08	0.66	0.59
Kurtosis	2.17	2.32	2.72	2.53
Jarque-Bera	8.36	3.18	11.69	10.51
Probability	0.02	0.20	0.00	0.01
OBS (N)	**156**	**156**	**156**	**156**

Key:
OPR: Oil prices in U.S. dollar ($)
OPQ: OPEC production quota in million barrels per day
OSC: OPEC spare capacity in million barrels per day
OPC: OPEC production cheating in million barrels per day

Table 3: Augmented Dickey-Fuller vs Philips Perron unit root tests (intercept and trend & intercept)

ADF with intercept			**PP with intercept**	
	Level	**1st difference**	**Level**	**1st difference**
Variables	t-statistics	t-statistics	t-statistics	t-statistics
LOPR	-1.4561	-9.5350*	-1.4757	-9.5744*
LOPQ	-1.9018	-11.8737*	-2.0746	-11.8807*
LOPC	-3.5129*	-13.7416*	-3.5129*	-14.9671*
LOSC	-2.4844	-10.2967*	-2.1843	-10.2041*
ADF with trend & intercept			**PP with trend & intercept**	
	Level	**1st difference**	**Level**	**1st difference**
Variables	t-statistics	t-statistics	t-statistics	t-statistics
LOPR	-3.0372	-9.5035*	-2.8582	-9.5434*
LOPQ	-2.3261	-11.8369*	-2.5523	-11.8443*
LOPC	-3.7177*	-13.7089*	-3.6996*	-14.9439*
LOSC	-2.4564	-10.2824*	-2.1442	-10.1858*

** indicates the probability level (which rejects the null hypothesis at 5% level of significance).*

Table 4: Cointegration Rank Test (Trace and Maximum Eigenvalue)

Cointegration Rank Test (Trace)				(Maximum Eigenvalue)	
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Max-Eigen Statistic	0.05 Critical Value
None	0.1899	66.3156*	47.8561**	32.2272*	27.5843**
At most 1	0.1153	34.0885*	29.7971**	18.7379	21.1316
At most 2	0.0797	15.3506	15.4947	12.7062	14.2646
At most 3	0.0171	2.6444	3.8415	2.6444	3.84147

*Trace test indicates 2 cointegrating eqn(s) at the 0.05 level, * denotes rejection of the hypothesis at the 0.05 level, **MacKinnon-Haug-Michelis (1999) p-values. Eigenvalue same for both tests.*

Table 5: Short-run Causality (VECM Framework)

	ECM (DLOPC)			ECM (DLOPR)			ECM (DLOPQ)			ECM (DLOSC)		
ECT 1	C(1)	-0.22 (0.00)*	Y	C(15)	0.20 (0.00)*	N	C(29)	0.02 (0.20)	N	C(43)	0.25 (0.03)**	N
ECT 2	C(2)	0.06 (0.33)	N	C(16)	-0.16 (0.00)*	Y	C(30)	0.01 (0.61)	N	C(44)	-0.10 (0.26)	N
D(LOPC(-1))	C(3)	-0.04 (0.79)	N	C(17)	-0.12 (0.34)	N	C(31)	-0.01 (0.75)	N	C(45)	0.03 (0.90)	N
D(LOPC(-2))	C(4)	0.09 (0.55)	N	C(18)	-0.24 (0.05)**	Y	C(32)	-0.05 (0.24)	N	C(46)	-0.28 (0.25)	N
D(LOPR(-1))	C(5)	-0.14 (0.21)	N	C(19)	0.30 (0.00)*	Y	C(33)	0.05 (0.09)***	Y	C(47)	-0.39 (0.02)**	Y
D(LOPR(-2))	C(6)	-0.11 (0.33)	N	C(20)	0.15 (0.10)***	Y	C(34)	0.09 (0.00)*	Y	C(48)	-0.43 (0.02)**	Y
D(LOPQ(-1))	C(7)	0.02 (0.98)	N	C(21)	-0.14 (0.76)	N	C(35)	-0.07 (0.65)	N	C(49)	-0.07 (0.94)	N
D(LOPQ(-2))	C(8)	0.27 (0.64)	N	C(22)	-0.76 (0.10)***	Y	C(36)	-0.15 (0.30)	N	C(50)	-0.69 (0.45)	N
D(LOSC(-1))	C(9)	-0.08 (0.24)	N	C(23)	-0.04 (0.50)	N	C(37)	0.02 (0.38)	N	C(51)	0.19 (0.08)***	Y
D(LOSC(-2))	C(10)	0.08 (0.29)	N	C(24)	-0.04 (0.42)	N	C(38)	-0.02 (0.30)	N	C(52)	-0.02 (0.88)	N
C	C(11)	-0.02 (0.18)	N	C(25)	0.03 (0.02)**	Y	C(39)	0.00 (0.58)	N	C(53)	0.04 (0.09)*	Y
GER	C(12)	-0.01 (0.85)	N	C(26)	0.01 (0.76)	N	C(40)	0.00 (0.61)	N	C(54)	0.00 (0.94)	N
WAR	C(13)	0.12 (0.00)*	Y	C(27)	0.01 (0.82)	N	C(41)	-0.02 (0.00)*	Y	C(55)	-0.09 (0.07)***	Y
OPB	C(14)	-0.02 (0.48)	N	C(28)	-0.06 (0.01)*	Y	C(42)	0.01 (0.09)***	Y	C(56)	-0.03 (0.52)	N
Test statistics												
R-squared		0.24			0.18			0.27			0.23	
DW		1.94			1.99			1.90			1.90	

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

Table 6: Long-run VECM regression results

Error Correction:	CointEq1	Standard error	t-statistics	CointEq2	Standard error	t-statistics
D(LOPC)	-0.22	(-0.08)	[-2.93]	0.06	(-0.06)	[0.98]
D(LOPR)	0.20	(-0.06)	[3.31]	-0.16	(-0.05)	[-3.52]
D(LOPQ)	0.03	(-0.02)	[1.28]	0.01	(-0.02)	[0.51]
D(LOSC)	0.25	(-0.12)	[2.12]	-0.10	(-0.09)	[-1.12]

Table 7: Test for strong causality based on VECM

Variables		Weak causality presence	Wald F-test	F-statistics	Strong causality presence
ECT (-1)	C(1)				
D(LOPR(-1))	C(5)	N	C(4)=C(5)=0	1.39(0.253)	N
D(LOPQ(-1))	C(7)	N	C(6)=C(7)=0	0.47(0.626)	N
D(LOSC(-1))	C(9)	N	C(8)=C(9)=0	0.83(0.435)	N

Notes: P-values are shown in parenthesis and significant at 10% (*), 5% (**), and 1% (***). 'N' indicates 'No'

Table 8: Toda & Yamamoto causality test

Dependent	LOPC	LOPR	LOPQ	LOSC	Joint
LOPC		1.00	0.42	9.96	14.11
		[0.6061]	[0.8087]	[0.0069]***	[0.0285]**
LOPR	0.61		1.10	0.48	1.89
	[0.7304]		[0.5780]	[0.7865]	[0.9299]
LOPQ	0.38	16.01		8.33	32.69
	[0.8284]	[0.0003]***		[0.0155]**	[0.000]***
LOSC	1.406	19.67	0.34		25.95
	[0.48]	[0.0001]***	[0.8432]		[0.0002]***

*Notes: ***, **and * represent significance at the 1%, 5% and 10% levels respectively. Significance implies that the column variable Granger causes the row variable except for the joint column.*

Table 9: Variance Decomposition of the Endogenous Variables

Variance Decomposition of LOPC: Panel 1

Period	S.E.	LOPC	LOPR	LOPQ	LOSC
2	0.13	99.35	0.28	0.02	0.35
4	0.16	81.90	1.98	2.87	13.25
6	0.18	62.24	4.78	7.74	25.24
8	0.21	48.97	6.94	11.46	32.63
10	0.23	40.49	7.89	14.38	37.23
12	0.25	34.86	8.14	16.77	40.23

Variance Decomposition of LOPR: Panel 2

Period	S.E.	LOPC	LOPR	LOPQ	LOSC
2	0.13	1.26	98.18	0.50	0.06
4	0.19	2.05	96.31	1.24	0.40
6	0.22	4.21	91.65	3.80	0.34
8	0.24	6.07	86.52	6.77	0.64
10	0.25	7.27	81.66	9.37	1.70
12	0.26	7.97	77.35	11.43	3.25

Variance Decomposition of LOPQ: Panel 3

Period	S.E.	LOPC	LOPR	LOPQ	LOSC
2	0.04	50.87	4.06	44.67	0.41
4	0.05	27.69	20.83	43.13	8.35
6	0.07	15.84	27.87	42.70	13.60
8	0.09	10.68	29.94	43.58	15.80
10	0.10	8.11	29.95	45.24	16.69
12	0.11	6.62	29.25	47.10	17.03

Variance Decomposition of LOSC: Panel 4

Period	S.E.	LOPC	LOPR	LOPQ	LOSC
2	0.25	4.76	4.47	27.94	62.83
4	0.38	2.42	21.32	25.93	50.32
6	0.47	1.56	28.05	24.77	45.61
8	0.54	1.20	28.67	26.40	43.72
10	0.59	1.02	27.58	28.86	42.53
12	0.63	0.93	26.22	31.22	41.63

Cholesky Ordering: LOPC LOPR LOPQ LOSC

Figure 1: Impulse response functions for one standard deviation innovation in the endogenous variables