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On quota violations of OPEC members ☆

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ABSTRACT

Over the last decades quota violations have become a norm for OPEC countries. However, the academic literature on OPEC focuses more on its production behavior than on analyzing the quota allocation process or characterizing quota violation patterns. This paper offers a theoretical model with empirical evidence to explain OPEC members' incentives for abiding or violating quotas. We first offer a cartel model with a quota allocation rule and an *endogenous* capacity choice. The model highlights the trade-off between building spare capacity to bargain for a higher legitimate quota versus risking quota violation punishment. Using the quarterly data from 1995 to 2007, we empirically support the main results and intuitions for the model. Our empirical evidence is consistent with a theoretical framing in which capacity constraints work as an enforcement mechanism in good times and OPEC's quota system disciplining its members in bad times.

1. Introduction

OPEC has a fragile cartel structure. It does not have a formal enforcement mechanism in place (except for the occasional price war) to incentivize its members to comply with their quota allocations (Alhajji and Huettner, 2000). As a result, non-compliance to the quota has become a norm among OPEC members over the past decades. In every single quarter from 1993 to 2005, total OPEC production exceeded the sum of its members' quotas. In this period, an OPEC member over-produced its quota by an average of 6.7%. In this paper, we provide a framework to explain such a persistent non-compliance pattern based on strategic interactions among members inside OPEC.

Quota violations vary significantly among different countries. For example, Saudi Arabia's overproduction averaged around 3.2% from 1995 to 2007 but Qatar's overproduction averaged around 18.5% during the same period. In extreme cases, some members overproduce their quotas by a large margin. For example, in the second quarter of 1998, OPEC requested that Qatar cut its production to reach a quota of 384 thousand bpd due to falling oil prices, but Qatar kept its production level at 670 thousand bpd–a 75% quota non-compliance. Another extreme example is Algeria who overproduced its quota by more than 50% in 13 out of 24 quarters between 2002 and 2006. Moreover, as suggested by a large body of theoretical literature[1], the difficulty of supporting collusion varies with the economic state of the market. Based on these preliminary observations, we ask the following: is non-compliance related to oil market conditions? If so, is it a pro-cyclical or a counter-cyclical behavior? How does the degree of non-compliance differ for smaller vs. larger producers? To what extent does OPEC rely on the quota system?

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[1] See Feuerstein (2005) for a survey of collusion literature.

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There are a number of prominent empirical studies on OPEC behavior, but the majority of them focus on whether OPEC behaves as a cartel or not, rather than analyzing the nature of quotas and violations. To name a few, Griffin (1985), tests the market-sharing hypothesis by looking at the co-movement of each country's production with that of the rest of OPEC. He concludes that "OPEC is a looser cartel" given that market sharing considerations only partially affect production decisions. Gülen (1996) uses a similar intuition to test for parallel movements in members' output levels. He finds evidence of coordination among members, especially during the rationing period, 1982–1993. Dahl and Yücel (1991) find no evidence in support of several hypotheses for OPEC behavior including dynamic optimization, target revenue, cartel, competitive, and swing producers. Therefore, they conclude that "loose coordination or duopoly" is the closest description to OPEC behavior. However, as pointed out by Smith (2005), there are serious concerns regarding the low power of the statistical tests employed in these studies and the extent to which they are capable of distinguishing between collusive and competitive behavior within OPEC. He describes OPEC as "much more than a non-cooperative oligopoly, but less than a friction-less cartel." Instead of calling this strand of literature inconclusive, we prefer the conclusion that some of the studies reach—such as Geroski et al. (1987), Almoguera et al. (2011) and Kaufmann et al. (2008)—that OPEC behavior cannot be fitted into a single model, but rather it follows a varying-conduct model that switches between collusive and non-cooperative behavior over time. We use the same notion in our theory model by formulating the proposed framework as a combination of a cooperative game and a non-cooperative behavior.

Although the empirical evidence for OPEC's collusion behavior is mixed, the field of industrial organization provides a sharp predictions for one of the factors affecting collusion: the link between market conditions and the incentive to cheat in a cartel. The standard approach in this literature is to repeat game models in which cartel members interact via their choice of production levels or prices. In this approach, members choose to cooperate or cheat in each period by comparing the net value of cooperation vs. that of deviation. If they cooperate, they receive a moderate period payoff for cooperation with a continuation of this payoff in the future. However, if they decide to cheat, they will enjoy a high period payoff but will face punishment in the future. The prediction of this literature is that it's harder to collude in booms because the incentive to cheat is higher[2]. For example, Rotemberg and Saloner (1986) show that with an i.i.d. demand structure collusion is harder to support in booms, simply because the net gains of deviation are higher. Assuming a cyclical demand, Haltiwanger and Harrington Jr (1991) show that the incentive to cheat is stronger at the end of a boom when the demand is about to fall. This is because with falling demand the value of cooperation is at its lowest. Consistent with Rotemberg and Saloner (1986), Kandori (1991) and Bagwell and Staiger (1995) generalize this result for the cases of serially correlated and Markov demand shocks respectively. Overall, the theory predicts a monotonic relationship between market conditions and the incentives to cheat: the more favorable the market conditions, the more difficult it is to support collusion.[3] Staiger and Wolak (1992) introduce the capacity-constraints features to previous models and show that large excess capacities can result in severe price wars.

We use a less complex economy to characterize the non-compliance behavior of an OPEC-like cartel. Our model consists of a small and a large capacity country. We use a simple multistage model where in the first period countries choose their optimal level of capacity. In the second stage the optimal aggregate production of the cartel and the quota level for each member are determined through maximizing the joint profit of the cartel members. In the third stage countries decide their production level and in the fourth stage possible deviations from the quota might be punished.

The model implies that OPEC members take into account the investment cost of building capacity with the possible benefit of obtaining a larger quota. We show that for the small member, the endogenously chosen capacity work as an implicit quota enforcement mechanism in good times and leaves very little room for non-compliance. Therefore, we predict that OPEC relies on its quota and punishment system more in bad times than in good times. We also allow the punishment reaction of the cartel's police (Saudi Arabia) to vary in a range (between very weak enforcement to a full enforcement) to study the reaction of investment and production decisions of small members to changes in the stringency of the punishment mechanism. We show that while more stringent punishment results in lower quota violations, it increases investment in capacity expansion.

The key feature of our theoretical framework is to model the decision making process by the cartel members inside and outside of OPEC. We do this by highlighting the role of an important variable, under-emphasized in literature, as the key variable explaining the compliance behavior of cartel members. More specifically, we emphasize the role of *capacity* as the fundamental heterogeneity among cartel members in three ways. First, empirical and anecdotal evidence support the idea of a direct link between the production capacity of a country and its share of total quota. Second, we introduce convex capacity building costs, which pin down the optimal *maximum* production capacity for each member. We argue that the marginal cost of oil production is much smaller than the initial cost of building capacity, as pointed out by Gault et al. (1999). Therefore, some of results are driven by the capacity limits. Third, larger capacity provides the option to produce in high-demand states for the larger member in the production game that follows the quota allocations.

Our empirical analysis supports these predictions. Using quarterly data for the period of 1995 to 2007, during when OPEC had a stable structure, we build a panel data model to test the statistical significance of the predictions of our theory model. We use Instrumental Variable approach to control for potential endogeneity of the size measure, *Capacity*. Consistent with the notion that capacity constraint works as an enforcement mechanism in good times, we find that unlike the police that always holds spare capacity to keep the potential punishment credible, other OPEC members become more capacity constrained when oil prices are higher. Next, consistent with OPEC relying on quota system in bad times, we find that OPEC meets more frequently when oil prices are lower. Moreover, consistent with a size-dependent punishment mechanism, we provide empirical evidence that shows non-compliance relative to quota levels is more common among the smaller countries especially in bad times.

Three things distinguish our paper from earlier studies on OPEC non-compliance. First, our paper is one of the few studies that look into strategic interactions and cheating behavior inside OPEC, instead of looking at the behavior of OPEC as a whole. Second, unlike the bulk of the literature on OPEC that are merely empirical (e.g., Molchanov, 2003), we provide a theoretical model that is tuned to resemble the OPEC decision-making process and delivers empirically testable predictions along with our empirical analysis. Third, we offer a more universal framework that integrates the effects of general market conditions (e.g., demand fluctuations) and country-specific characteristics (e.g., cost of capacity building) on quota violations into a single framework. This is in contrast to other studies such as

[2] In contrast, Green and Porter (1984) predict that price wars occur in periods of low demand. However, the key assumption in their model is that firms cannot observe the demand or the production of other firms, which is clearly not plausible for OPEC.

[3] This monotonic relationship between demand/price and difficulty to support collusion is altered with adding the capacity constraint as in Brock and Scheinkman (1985), Staiger and Wolak (1992), and Fabra (2003), or by assuming risk-averse members as suggested by Bernhardt and Rastad (2016).