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The role of market expectations in commodity price dynamics: Evidence from oil data ☆

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ABSTRACT

This paper examines the contribution of market expectations to commodity price dynamics. It proposes a dynamic competitive storage framework with an explicit expectations shock along with concurrent shocks to study the commodity price movements. This allows for a refined analysis of the expectations' effect on price and inventory and the estimation of the expectations. Applied to the world crude oil market, it finds that the contribution of market expectations to the crude oil spot price movements is limited from 1987 to 2014.
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1. Introduction

Inventory behavior is usually linked to the expectations about the future. In the discussion of the causes of the recent crude oil price increases especially during 2007–2008, one key question is whether speculation played an important role. Regardless of their stand on it, researchers turn to inventory data for a better understanding of speculative or precautionary incentive in the oil market, as anticipation of future increases in oil price could lead to speculative inventory increase and result in immediate price increase.[2] Earlier work like Brennan (1958) has already pointed out that inventory is related to the expected change in price.

Hamilton (2009b) applied this insight to make the case that, all else equal, there is a link between increases in speculative (or storage) demand and the accumulation of inventories. Fattouh et al. (2013) observed that this link breaks down in the presence of other oil demand or oil supply shocks. Using data on oil inventory, Kilian and Murphy (2014), Kilian and Lee (2014) and Knittel and Pindyck (2016) show that speculative demand alone cannot explain this surge in the real price of oil. On the other hand, Juvenal and Petrella (2014) find a more important role of speculation also using data on inventories.

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[2] Given the many interpretations and uses of the term "expectations" in academic and non-academic publications, to avoid ambiguity this term will be defined on page 3.

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The current paper is complementary to this literature. The objective is to formalize the link between changes in oil inventories and shifts in market expectations within a dynamic rational expectations model. To avoid ambiguity, this paper uses a neutral term "expectation" and defines it mathematically. Building "expectation" in a rational expectation equilibrium model, this paper specifically focuses on the difference between shocks to market expectations and shocks to contemporaneous market condition.[3] It contributes in two ways to the literature on commodity price dynamics, especially the discussion on the role of speculation. Theoretically, the model solution provides new insights of the features of market expectations' effect on price and inventory. Empirically, it estimates a structural model using oil market data to quantify the contribution of market expectations.

The new insight from the structural model is the dynamic shape of the expectations' effect. Everything else being equal, an expectations shock like expected future supply shortfalls would cause an immediate increase in the spot price and a hump-shaped price path over time, while a contemporaneous shock like a current supply shortage causes an initial price increase and then a monotonically decreasing price path. As a result, an expectations shock would result in response functions shaped differently over time compared to a contemporaneous shock. This different dynamic shape has not yet been discussed in the literature or adopted in the identification of the expectations, and should enable more refined identification of market expectations in the empirical analysis.

The intuition works as follows. Today's expectations of a strong future demand relative to supply will result in a higher spot price today, due to the lower current availability of the commodity from the accumulated inventory in response to such expectations. This immediate effect has been discussed in earlier literature. Furthermore, this model shows that while the inventory accumulation helps alleviate some expected quantity (demand/supply) fluctuations, it would be too costly to accumulate inventory so much that the price does not change or changes little on the future date when the strong demand actually hits. Thus the increase in the spot price at the future date would be larger than that in the spot price immediately. The resulting price response function is hump-shaped.

On the other hand, today's strong relative demand to supply will also result in an immediately higher spot price, as discussed in earlier literature. Furthermore, it will also instantaneously result in a higher future spot price due to lower future availability from the depleted inventory (everything else being equal). However, the impact of today's strong demand dissipates, thus the increase in the future spot price is smaller than that in the spot price. The resulting price response function is monotonically decreasing after the initial jump.

This refined intuition can be captured by an expectations shock that has no contemporaneous but only lagged impact on the supply and demand processes. Here the expectations specifically refer to the innovations and macroeconomic activities that could affect the commodity market supply and demand with a delay, in the style of the "news shock" that has been discussed by Beaudry and Portier (2006) and adopted by a large macroeconomic (DSGE) literature like Davis (2007), Barsky and Sims (2011), Jaimovich and Rebelo (2009) and others.

More specifically, the idea is that agents in the market may learn about some production capacity that has been recently installed and will be implemented in the future, at which time they expect the supply to rise. Similarly, agents could learn that a commodity will be utilized with higher efficiency in the future at which time they expect the demand to shift. Such expectations have no effect on the current market supply and demand condition, but do affect agents' current inventory decision, the spot and expected future prices. It is such expectations that are referred to as the "expectations" in the model.

In addition to the dynamic shape, the analysis illustrates the key importance of the price elasticity of demand in the price dynamics, extending the views of Hamilton (2009b), Kilian and Murphy (2014) and Caldara et al. (2018). This paper finds that the less elastic the demand, the larger the price and inventory responses to changes in the market condition, everything else being equal.

The structural model also makes it straightforward to utilize the futures market data in the empirical application. For example, Tang and Xiong (2012) and Singleton (2014) discuss the role of commodity financialization in the commodity price dynamics. Recent theoretical work like Sockin and Xiong (2015) analyzes the informational frictions and illustrates the informational feedback effects of commodity futures prices in a tractable model. Cheng and Xiong (2014) argue that relying on only the inventory data for identifying effects of speculation ignores the futures prices which contain information of agents' expectations. Jin (2017) show that crude oil futures prices contain valuable information on spot price movements. In the empirical application of this model, both inventory and futures market data have been used to identify market expectations.

To the best knowledge of the author, this paper is the first to quantify the effect of expectations by solving and estimating a dynamic rational expectations model and introducing a mathematical definition of "expectations". The structural framework allows for the precise mapping of mathematical expression to economic interpretation, and thus the refined identification of the expectations. This is different from the structural VAR models in this literature epitomized by Kilian and Murphy (2014) and Kilian and Lee (2014), and other work like Juvenal and Petrella (2014) and Beidas-strom and Pescatori (2014). Beidas-strom and Pescatori (2014) discuss the dynamic dimension, however argue instead the price effect of the speculative demand shock is "monotonically declining" after the initial period. Knittel and Pindyck (2016) constructs an analytical framework for a storable commodity, but the model is not solved dynamically. In terms of the modeling and empirical methodology, Unalmis et al. (2012) is closely related. They incorporate oil storage into a DSGE model, but do not have an expectation component in the shocks and cannot comment on the cumulative contribution of expectations to the price movements.

[3] Throughout the paper, to differentiate the two types of shocks the terms "expectations" or "forwarding-looking" shocks are used versus "contemporaneous" shocks. More discussion and their definitions are provided in Section 2.3.

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