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Limits to arbitrage and hedging: Evidence from commodity markets ☆

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ABSTRACT

We build an equilibrium model of commodity markets in which speculators are capital constrained, and commodity producers have hedging demands for commodity futures. Increases in producers' hedging demand or speculators' capital constraints increase hedging costs via price-pressure on futures. These in turn affect producers' equilibrium hedging and supply decision inducing a link between a financial friction in the futures market and the commodity spot prices. Consistent with the model, measures of producers' propensity to hedge forecasts futures returns and spot prices in oil and gas market data from 1979 to 2010. The component of the commodity futures risk premium associated with producer hedging demand rises when speculative activity reduces. We conclude that limits to financial arbitrage generate limits to hedging by producers, and affect equilibrium commodity supply and prices.

1. Introduction

The neoclassical theory of asset pricing has been confronted by theory and evidence highlighting the numerous frictions faced by financial intermediaries in undertaking arbitrage, and the consequent price effects of such frictions (see, for example, Shleifer and Vishny, 1997). These price effects appear to be amplified in situations in which financial intermediaries are substantially on one side of the market, e.g., when intermediaries bear the prepayment and default risk of households in mortgage markets or when providing catastrophe insurance to households, as in Froot (1999).

In this paper, we consider an implication of such limits to arbitrage for commodity spot and futures prices. Our main point is that when speculators are constrained in their ability to deploy capital in the commodity futures

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market, commodity producers experience *limits to hedging*. In particular, limits on the risk-taking capacity of speculators imply that aggregate producer hedging impacts futures prices adversely from the producers' perspective. Such hedging costs, arising from producer hedging demands, affect the equilibrium supply of the commodity, which in turn affects the commodity spot price. Thus, limits to arbitrage combined with producer hedging demand provides a rationale for how speculator risk appetite in the commodity futures market can affect commodity spot prices.

We present a model that formalizes the above argument, in which we derive the effects of the interaction between producer hedging demand and speculator capital constraints on commodity spot and futures prices and expected price changes. To understand the comparative statics generated by the model, consider the following scenario: assume that producers as a whole need to hedge more by shorting futures contracts, say, on account of their rising default risk. Given that speculators are limited in their ability to take positions to satisfy this demand, this increased demand depresses current futures prices and thus makes hedging more expensive. Consequently, producers scale back on the amount of inventory they carry forward. As this inventory hits the spot market, it depresses current spot prices, but increases future expected spot prices. In this case, the futures risk premium and the expected percentage change in the spot price have a common driver—the hedging demand of producers. Increases in speculators' capital constraints have similar effects.

To test the implications of the model, we employ data on spot and futures prices for heating oil, crude oil, gasoline, and natural gas over the period 1979–2010. We pair these data with two sets of micro-data on individual commodity producer hedging. First, we hand-collect Crude Oil and Natural Gas (Standard Industrial Classification (SIC) code 1311) producing firms' reported hedging policies from their Financial Accounting Standards (FAS) 133 disclosures from 2000Q1 to 2010Q4. Second, we employ two different measures of the default risk of oil and gas producers in our work: a balance-sheet-based measure—the Zmijewski (1984) score, and a measure that combines market data with balance-sheet data—KMV's expected default frequency. We use these measures of default risk to identify changes in commodity producers' propensity to hedge, an identification strategy driven by extant theoretical and empirical work on hedging.[2]

Using the FAS 133 disclosures, we first document that most producers hedge part of their inventory and future production. The propensity of commodity producers to hedge using commodity derivatives is strongly and positively related to their default risk—when *firm-specific* default risk is high, these firms are more likely to hedge. Second, an increase in measures of the *aggregate* default risk of commodity producers forecasts a statistically and economically significant increase in the excess returns on short-term futures of the relevant commodities. A one standard deviation increase in aggregate commodity-specific producer default risk is, on average, associated with a 4% increase in the respective commodity's quarterly futures risk premium. Third, this effect of aggregate default risk on futures risk premiums increases with the volatility of the corresponding commodity prices, which is consistent with a downward-sloping speculator demand curve. Fourth, we find that the fraction of the futures risk premium attributable to producers' default risk is higher in periods in which broker-dealer balance-sheets are shrinking.[3] In other words, when speculator risk tolerance is low, hedging pressure has a larger impact on the futures risk premium. Finally, increases in the default risk of oil and gas producers positively predict commodity spot price changes. This is consistent with the prediction from our model that when producers' inclination to hedge increases, current spot prices will be depressed relative to future spot prices.

We check the robustness of our results, and verify that they are driven by changes in producer hedging demand in a number of different ways. First, we control for the possibility that default risk of commodity producers may be related to business-cycle conditions that also drive risk premiums. In particular, we add into our forecasting regressions variables commonly employed to predict the equity premium, such as changes in forecasts of gross domestic product (GDP) growth, the risk-free rate, and the aggregate default spread, and confirm that our results are unaffected by this addition. Second, we try to account for the possibility that producer default risk, an endogenous variable, is related to future supply uncertainty caused by the likelihood of inventory stock-outs or other production shocks that might affect the futures risk premium. We do so by employing commodity-specific controls such as the futures basis and the realized variance of futures returns in our regressions, and we find that default risk, our proxy for the hedging desire of producers, survives the introduction of these controls.[4] Third, we employ a "matching" approach to determine that the predictive power that we identify is driven *only* by the default risk of firms that hedge, and *not* by the default risk of firms that do not hedge. In particular, using the FAS 133 disclosure data, we

[2] A large body of theoretical work and empirical evidence on hedging has attributed managerial aversion to risk as a primary motive for hedging by firms (Amihud and Lev, 1981; Tufano, 1996; Acharya, Amihud, and Litov, 2011; Gormley and Matsa, 2008; among others); and has documented that top managers suffer significantly from firing and job relocation difficulties when firms default (Gilson, 1989; Baird and Rasmussen, 2006; Ozelge, 2007). Fehle and Tsyplakov (2005) argue, both theoretically and empirically, that firms hedge more actively when default risk is higher.

[3] The broker-dealer balance-sheet measure that we employ was proposed as an inverse measure of speculator capital constraints by Adrian and Shin (2010) and, as shown by Etula (2009), it strongly predicts commodity futures returns—a finding that our model also predicts.

[4] Note that supply uncertainty will tend to *decrease* the variance of commodity prices, as a supply disruption due to a negative economic shock would in general decrease supply. Negative demand shocks are therefore offset by negative supply shocks, which would lead to lower price variance than if these demand shocks were not accompanied by a supply disruption. In other words, supply uncertainty would tend to make the futures risk premium *smaller* as it is the long side of the trade that benefits from supply shortages.