EQUILIBRIUM RELATIONS BETWEEN THE SPOT AND FUTURES MARKETS FOR COMMODITIES: AN INFINITE HORIZON MODEL

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Overview

Despite the long standing existing literature on the behavior of commodity markets, initiated by Keynes (1930), Kaldor (1940), Brennan (1958) and Working (1949) there is still a lack of a dynamic model, general enough to cover the different existing strands of the literature (the hedging pressure theory vs the storage theory, risk-neutral vs risk-averse agents...), simple enough to be intuitive without being unrealistic, and offering the opportunity to draw results on a large set of issues (dynamic behavior of commodity prices, impact of the speculative activity...) for a wide range of commodities.

Such a model is needed for academics, practitioners and regulators, in order to better understand what drives the individual behavior of participants in commodity markets, how they interact with each others and how these interactions impact the behavior of the price. In other words, the issue is to know the link between the structure of the market in term of repartition of the different agents and the behavior of the prices. It is also interesting to understand how different markets are impacted by the level of supply. Does every commodity market reacts in the same way when it is over/under supplied, or does this reaction depend on the characteristics of the market? Finally, such a model can reaffirm the importance in term of risk-sharing of the existence of a well defined, liquid futures market. Overall, having a model which brings results on these issues can help regulators to adapt their policy to each specific commodity market and not to treat all commodities as equal.

Methods

We develop a general stationary model for spot and futures commodity prices, which is the dynamic natural extension of the one by Ekeland, Lautier and Villeneuve (2015). This infinite horizon rational expectation equilibrium model features: i) Heterogeneous agents (processors, storers and speculators) with relevant economic functions and more importantly, naturally different (opposite) positions in the futures market. Their names represent our vision of the market and can be changed, what matters the most is their economic functions and the associated futures demands for hedging; ii) simultaneous equilibrium on the spot and the futures markets. Because we explicitly model the behavior of the agents on both markets, the prices and the risk premium are endogenous. They come from the clearing of the markets at the equilibrium; iii) non negativity constraint on inventories. This is important since it creates a non linearity in the model and the prices; iv) random production at each period.

Compared to Ekeland, Lautier and Villeneuve (2015), this model can not be solved analytically. We do get known functions for the equilibrium prices and quantities, but those are functional equations of two unknown functions, the esperance and the variance. We use numerical methods to find them and to perform simulations.

Results

After having found the proper set of parameters, we solve and simulate our model to study different issues. First, on the basis of a set of parameters designed for a storable commodity, inspired by the crude oil market, we show that our model is able to replicate the behavior of real commodity markets. The following stylized facts are reproduced: i) the mean reverting behavior of spot prices, ii) the asymmetric behavior of the basis in backwardation and in contango, iii) the link between the basis and the storage cost, iv) the Samuelson hypothesis and its possible violations. We also show that the general structure of the model does not prevent it to perform well for specific markets. We look at the characteristics of the gold market (high level of inventories) and the electricity market (non storability). Finally, we perform an analysis of the impact of the speculative activity on different quantities, and find that the impact on the level of prices (spot, expected spot and futures) depends not only on inventories, as stressed, among others, by Newberry (1987) but also on the supply that is expected for the physical commodity.

Conclusions

Our infinite horizon rational expectation equilibrium model shows the interaction, in a dynamic setting, between spot and futures markets for commodities. It exhibits a surprising variety of behaviors. In equilibrium, there might

be a contango or a backwardation, the futures prices might be higher or lower than the expected spot price, inventories might be held or not, the commodity might be processed or not, and adding speculators might increase or decrease the hedging benefits. This variety of situations is found in real commodity markets. Moreover, this model is able to reproduce the dynamic behavior of spot and futures prices for a wide range of commodities including non-storable ones like electricity. It also gives insights about the some important stylized facts for which the theoretical literature is scarce (Samuelson hypothesis, link between the volatility of the basis and the storage costs).
Our model explains why speculation can stabilize or destibilize markets, by moving expected prices or volatilities. We show that the functioning of a commodity market depends on the fundamentals of the physical market, the realization of shocks, and on past decisions. The predictions on the effect of speculation and financialization can be much more precise once these elements are considered.

References

Brennan, M. J. 1958. The Supply of Storage. *American Economic Review* 48:50–72.

Ekeland, I., Lautier, D. and Villeneuve, B. 2015. Speculation in Commodity Futures Markets: a Simple Equilibrium Model. Working Paper, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2323560

Kaldor, N. 1940. A Note on the Theory of the Forward Market. *Review of Economic Studies* 7:196–201.

Keynes, J. M. 1930. A Treatise on Money, volume 2. Macmillan.

Newbery, D. M. 1987. When do Futures Destabilize Spot Prices? *International Economic Review* 28:291–297.

Samuelson, P.A., 1965 Proof that Properly Anticipated Prices Fluctuate Randomly. Industrial Management Review, 6:41–49.

Working, H. 1949. The Theory of the Price of Storage. *American Economic Review* 31:1254–1262.