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The Inconvenience Cost:

A Portfolio Theory Approach to Non-Convergence Between Cash and Futures Prices

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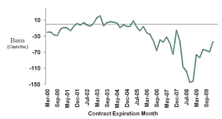
Why haven't prices converged?

Cash and futures prices for storable commodities should reach equality, or converge, upon contract maturity. Traders can impose convergence during the delivery month through arbitrage behavior: either making or taking delivery on futures contracts. If convergence is not predictable, a futures market fails to provide a clear storage signal to potential inventory holders and reduces the attractiveness of hedging [1], which can threaten its own viability [2]. Recent convergence problems in domestic commodity markets [3] demonstrate the existence of persistent, significant arbitrage opportunities over the second-half of the last decade. Yet, terminal elevator operators—perhaps the only participants with the capacity to do so [4]—have not arbitraged away these riskless returns by making enough deliveries.

This model demonstrates conditions under which a profit-maximizing warehouseman foregoes available arbitrage. We find that making delivery involves substantial opportunity costs [4], which stem from the loss of managerial control over warehouse space. We refer to the inconvenience of losing such control as the **inconvenience cost.**

Figure 1: Arbitrage Opportunities for CBOT Wheat? Basis on the First Delivery Day in Chicago



The elevator operator's portfolio

A terminal elevator operator allocates his available warehouse space (**I**=1) between making delivery (**I_f**) and other business (**I_a**).

Making delivery earns a riskless return (**r_f**), but the operator loses control of the space he allocates to this behavior [4], since the taker of the delivery instrument is a passive trader, and earns only a storage fee over the period. The risk-free return is a combination of the arbitrage from the delivery-month basis (**b**) and storage fees (**F**).

Warehouse space can also be allocated to alternative business, such as providing throughput to regular turnover customers, storing this or some other commodity [5], whether hedged or unhedged, or a combination of these, to earn a risk return (**r_a**) with some variance (**σ_a**).

The total expected utility for the portfolio return (**r_p**) is a linear combination of the expected return of delivery and the alternative, weighted by the relative allocation of available warehouse space, plus an adjustment for any risk aversion (**A**):

$$U(r_p) = I_f r_f + I_a r_a - \frac{1}{2} A (I_a \sigma_a)^2$$

Optimal allocation of space

The warehouse maximizes expected utility, subject to

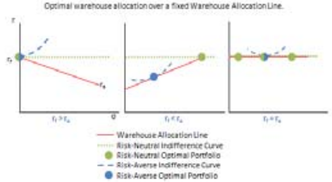
$$I_j \geq 0, \; for \; j = f, a$$

$$I_f + I_a = I$$

If **b** is exogenous, a risk-neutral, price-taking elevator will simply choose to allocate all space to the asset with the highest return. Risk-aversion will bias the choice towards arbitrage, even if its return is dominated by the alternative, so that making delivery becomes more likely.

Figure 2: Exogenous Basis

Optimal warehouse allocation over a fixed Warehouse Allocation Line.



Making delivery prevents the operator from taking advantage of potentially more profitable opportunities.

An endogenous basis

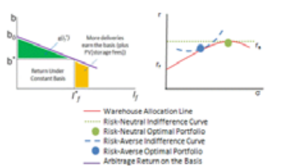
Re-specify the return on the delivery-month basis as an linear function of the arbitrage behavior by the warehouse:

$$b = b_0 - DI_f$$

If the elevator operator delivers enough, he will force the basis to zero and impose convergence, assuming **$b_0 < D$**.

Figure 3: Endogenous Basis

Arbitrage surplus and optimal portfolio over a non-linear Warehouse Allocation Line.



When does an elevator force convergence?

Portfolio utility now includes the arbitrage surplus, **$g(I_f)$**, from a strengthening basis:

$$U(r_p) = I_f r_f + I_a r_a - \frac{1}{2} A (I_a \sigma_a)^2 + g(I_f)$$

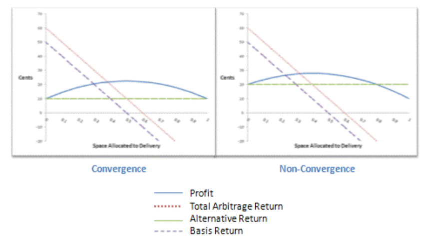
A **risk-neutral** elevator operator will choose to deliver until the arbitrage return is just equal to the alternative return, or where

$$I_f^* = \frac{b_0 + F - r_a}{D}$$

Futures and cash prices will :

- Converge if **$F = r_a$**
- Not converge otherwise

Figure 4: Convergence Conditions



A **risk-averse** operator will choose to deliver until the arbitrage return is equal to the risk-adjusted alternative return. Risk-aversion makes delivery more attractive. The optimal delivery allocation is now:

$$I_f^* = \frac{b_0 + F + A\sigma_a^2 - r_a}{D + A\sigma_a^2}$$

Under **risk-aversion**, futures and cash prices will :

- Converge if $r_a = \dfrac{DF - A\sigma_a^2 (b_0 - D)}{D}$
- Not achieve convergence if **r_a** is higher

Conclusion

•The possibility of arbitrage does not necessarily lead to convergence, even without accounting for grade and location differences in the commodity.

•The opportunity cost of making delivery, or the **inconvenience cost**, entails a loss of control of warehouse space, and may be too high for the elevator operator to arbitrage away non-convergence.

•Although risk aversion may lead to more deliveries, convergence is still dependent upon opportunity costs.

Limitations

•We do not explain the source of non-convergence, but instead only attempt to show why arbitrage does not necessarily result in convergence.

•In future work, we intend to explore the motivations of other actors in these markets, particularly those that agree to stand for delivery and pay storage fees.

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For further information

Please contact **madjemian@ers.usda.gov**. More information on this and related projects can be obtained at *www.ers.usda.gov*

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