The Industrial Organization of Commodity Trading

Craig Pirrong
Bauer College of Business
University of Houston

June 3, 2025

Abstract Commodity trading firms intermediate the flow of physical commodities between large and heterogeneous populations of producers and consumers. In performing this intermediation trading firms generate and obtain diffuse information about relative prices that they use to optimize the transformation of commodities in space, time, and form: in these respects commodity traders are examples of entrepreneurial firms as conceived by Mises, Kirzner and others. This private information allows traders to exercise more profitably the options inherent in many transformation assets, thereby providing a motive to control such assets. Transactions cost considerations determine whether firms obtain this control *via* contract or ownership. The ability to hedge price risks makes private ownership of firms more prevalent in commodity trading than in other sectors. Key management functions of commodity traders-designing and implementing high powered incentive schemes to permit "delegated entrepreneurship" and the allocation of capital-require accurate measurement of risk. However, since such risk models are inherently imperfect in unknown ways, trading firm managers operate under Knightian uncertainty.

1 Introduction

Commodity trading is one of the world's oldest industries: consider, for example the long-distance trade in copper and tin (extending from Afghanistan to Cornwall) that was essential for the Bronze Age. It continues to be an important economic cog. As of 2023, commodities account for approximately 15 percent of international trade.[1]

Despite the economic salience of commodity trading, a set of firms that are central to this process–commodity trading firms ("CTFs")–have received scant attention from economists. This is likely due in large part to the secretiveness of many CTFs, a secretiveness which is facilitated by their being privately owned enterprises rather than public corporations.[2] (As will be seen below, the economic benefits of secretiveness are one reason for private ownership).

This article attempts to fill this gap by answering salient questions about CTFs. What functions to they perform? What determines the scope of their activities, both horizontally (across commodity classes) and vertically (at different stages of the value chain)? What assets do they employ? How do they obtain control of these assets (or attributes thereof), by ownership or by contract? What determines these choices? How are commodity trading firms organized, and specifically why is private ownership so prevalent in this

[1]The commodities included here are: aluminum, coal, cocoa, coffee, copper, corn, cotton, crude oil and refined petroleum products, lead, nickel, palm oil, rape seed and oil, rice, soybeans and soy oil, sugar, tin, wheat, and zinc. International Trade Council data accessed at trademap.org. Of course, commodities are also traded domestically, particularly in the United States, where exports represent 34 percent of agricultural products (19 percent of grains), 23 percent of crude oil and refined products and 30 percent of refined petroleum products. Thus, approximately 66 to 80 percent of U.S.-produced commodities were traded domestically.

[2]Even publicly traded firms that engage in commodity trading, such as BP and Shell, provide only limited information regarding their trading operations.

industry?

To determine the scope of this analysis, it is necessary to define "commodity trader" (or "commodity trading firm"). Hereafter, a commodity trader is a firm that both buys and sells physical commodities in the ordinary course of business. The "physical commodities" qualifier excludes, for example, hedge funds that participate in oil futures markets but do not routinely handle physical crude oil. The "both buys and sells" qualifier excludes as an example farmers, who deal in commodity markets but almost exclusively as sellers. It also excludes firms like Kraft that are major purchasers of wheat but are seldom sellers. They transform wheat into Oreos and Triscuits, which they sell, but these are highly differentiated consumer products, rather than commodities.

As with any taxonomy, there are close cases that could reasonably fall on one side of the line or the other. However, there are firms that are firmly on-side. In grains and oilseeds, these would include the "ABCD" firms Archer, Daniels, Midland; Bunge; Cargill; and Dreyfus. In energy, these would include Vitol, Glencore, Trafigura, Gunvor, and Mercuria, but also major oil companies such as Shell and BP, and prior to regulatory changes, major financial institutions like Morgan Stanley and JP Morgan.

The main potential source of ambiguity and confusion is that some traders also engage in commodity production. Glencore is a prominent example. It is the largest trader of non-ferrous metals and coal, and traces its origin to one of the pioneering oil and metals traders (Marc Rich & cie), but it is also a major miner of non-ferrous ores and coal. One objective of this article is to explain the integration between trading *qua* trading and the production or processing of commodities.

In what follows, the nature and consequences of trading *per se* will prove

to be decisive in understanding how the commodity sector is organized and operates. The two-sided participation of traders generates information about supply and demand and the idiosyncratic characteristics of commodity producers and consumers that permit them to identify matches between producers and consumers, and transformations of commodities in space, time, and form that generate, and arguably maximize, the gains from trade.

Informational considerations alone create a niche for specialized trading intermediaries. They also have implications for the assets that traders control. Furthermore, when transactions cost considerations such as *ex post* opportunism and incomplete contracts are introduced it is possible to understand the patterns of asset ownership and contracting.

The remainder of this article is organized as follows. Section 2 identifies crucial attributes of commodities and shows how these attributes encourage the development of specialized intermediaries. This section also demonstrates that the fundamental nature of this intermediation generates information: information will prove to be an important determinant of other aspects of the organization of commodity trading and of CTFs. It also has important implications for the determinants of CTF profitability. Section 3 shows how information generated in trading allows trading firms to operate some assets more profitably than others, thereby incentivizing them to control these assets. That section also analyzes how the characteristics of particular types of assets that are complementary to the information generated by trading affect transactions costs, which in turn affect CTF decisions on whether to obtain control of assets *via* ownership or contract, and the forms of contracts utilized in the latter instance. Section 4 analyzes the ownership form decision, and shows how the nature of the assets owned by a CTF affect whether it is a public or private firm. Section 5 evaluates the economics of the internal

organization of CTFs. Section 6 summarizes.

2 Commodity Trading

2.1 Commodity Basics

Contrary to the common understanding that "commodity" connotes something undifferentiated and homogeneous, physical commodities such as oil, copper, and wheat are in fact extremely heterogeneous. For example there are over 100 different streams of crude oil currently in production. These streams very substantially by their sulfur content, "gravity" (i.e., lightness or heaviness), and other physical characteristics that affect how they can be refined and the refined products that they yield. Copper ores produced in different mines have different physical characteristics (including copper content and impurities). Wheat produced in a single field may differ from wheat produced in the same field in a different year due to weather differences, and wheat produced in different fields in the same year can also differ.

Furthermore, both the production and consumption of commodities is highly spatially dispersed, and it is typically the case that producers are located far from consumers. Moreover, for most commodities there are large numbers of producers and consumers. In addition, the producers and consumers of a particular commodity may be differentiated *inter alia* by location, the characteristics of their output, and what they produce from inputs of the commodity.

Commodities are seldom produced in the form that they are ultimately consumed. No one consumes crude oil directly: instead, it is refined into products that can be used in automobiles or airplanes. Similarly, soybeans are not consumed directly: they are processed into oil and meal.

These various features of commodities means that they must be transformed in myriad ways. There are three basic types of transformation: in space, time, and form.

Spatial transformation is straightforward: commodities must be transported from where they are produced to where they are consumed.

Time transformation is less intuitive, but important. The time patterns of production and desired production are seldom aligned. This is most clearcut for agricultural products that are produced seasonally in short periods of time, but are consumed throughout the year. Storage–a transformation in time–is necessary to match the patterns of production and consumption. Another commodity for which seasonality is important is natural gas. It is produced at a relatively consistent rate over time, but consumption varies substantially by season, peaking in the winter months. Again, storage is necessary to match these disparate patterns, with inventories accumulating during low demand periods like spring and autumn, and being drawn down during peak demand periods like the winter.

Storage can be economically valuable even when seasonality is not important. Random fluctuations in supply and demand can affect the relative abundance of a commodity over time. A negative demand shock tends to make the commodity more abundant in the present than it is expected to be in the future. Under these circumstances, adding to storage is valuable. Conversely, an adverse supply shock (e.g., the outage of a refinery) makes supply relatively scarce today relative to what is expected in the future. Here, removing the commodity from storage and consuming it cushions the effect of the supply shock (Pirrong, 2012).

Some transformations in form (refining oil and "crushing" soybeans) have already been mentioned but there are many others, such as removing natural

gas liquids (like propane) from the production of a natural gas well. Another under appreciated form of transformation is mixing. For example, the copper ores produced by two mines may differ, and neither may meet the needs of a particular smelter, but a mixture of them might. Mixing is in fact ubiquitous in commodity markets.

Given the plethora of commodity producers and consumers and the myriad transformations that can be made to commodities, there is an extremely large network of producers and consumers, and of potential matches between them. How can such matches be coordinated?

Coordinating flows in large and dense networks is typically facilitated by intermediaries that serve as nodes in the network. Rather than each producer being connected directly with multiple consumers (and *vice versa*), a given node connects multiple producers and consumers, and flows occur *via* the nodes. Moreover, nodes may perform various functions to facilitate flows. In what follows I identify conditions that favor the development and survival of specialized intermediaries in commodities.

Commodity trading firms ("CTFs") are intermediaries who serve as nodes in the commodity producer-consumer network that coordinate flows between them. These nodes identify matches and carry out the transformations necessary to coordinate the movement of commodities from producers to consumers.

2.2 The Search Function of Commodity Trading Firms

Given the vast number of possible matches between the producers and consumers of a particular physical commodity, the heterogeneity of producers and consumers, the large number of potential transformations that can be used to match them, and the potential for random shocks to preferences and

costs, finding the optimal matches is a non-trivial task. Further, optimal matches can change over time in response to both systematic and idiosyncratic economic shocks.

CTFs play a vital role in this matching process. They search for sellers, make bids to them, and receive offers from them. They search for buyers, make offers to them, and receive bids from them. This process gives them information about the potential benefits of matching a given seller with a particular buyer. It also gives them information regarding market supply and demand. CTFs also have knowledge about possible transformations, and search for information regarding the costs of these transformations (e.g., by contacting different ship owners or brokers determine the cost of a vessel to move a cargo from the seller to the buyer). This information allows them to identify profitable matches and transformations that facilitate these matches.

Precisely because of the extreme heterogeneity of physical commodities there are few centralized markets for them (although there are for futures on commodities, a subject I will discuss later) so these searches take place in opaque ("dark") markets (Duffie, 2012). Moreover, comprehensive search is prohibitively costly, so traders must balance the costs of search against the benefit, where the benefit is measured by the difference between the price received from the buyer and the price paid to the seller, net of any costs of transformation. Searching more may identify a more valuable match, but incurs additional costs. The trader must balance the expected gain from a better match against the cost of finding it.

Search generates information about the values of commodities in alternative uses. For example, what is the value of soybeans shipped from Brazil to a buyer in China, as opposed to one in Europe? Are there more gains from trade to be captured from shipping copper concentrate from producer

C to smelter A or B? As will be seen subsequently, this information can be combined with the control of assets in order to choose the transformations made with those assets in order to maximize value. Crucially, this is mainly information about relative prices.

CTFs are in many ways the archtypal Misean (Mises, 1949) or Kirznerian (Kirzner, 2011) "entrepreneur." That is, they are economic agents that seek out opportunities created by price dispersion that results from incomplete knowledge and information, and who use these price signals to coordinate the flow of resources to generate gains from trade. In the words of Demsetz (1983), by searching across sellers and buyers, they "generate[] information about all the benefits of employing resources in alternative uses," and the profitability of discovering value enhancing transformations motivates them "to take account of this information."

In commodity trading this process is described as "identifying and exploiting arbitrages." These are not arbitrages in the strict academic sense of transactions with no possibility of loss and a positive probability of gain, but instead sets of transactions and transformations such that the difference between the prices of the transformed and untransformed commodities is expected to exceed the cost of the transformation by an amount sufficient to compensate for the risks.[3]

Several factors favor specialization in search by intermediaries. The first is that specialization economizes on the number of searches. Consider a set of M producers and N consumers. Without specialization in search to an intermediary, comprehensive search would require $M \cdot N$ searches. If the M producers and N consumers effectively delegate to search to an intermediary to whom they sell to or buy from, comprehensive search by the intermediary

[3]And as discussed below, the uncertainty.

requires only $M + N$ searches.

The second is that by having an enduring presence in the market, an intermediary learns about the specific characteristics of producers and consumers, and thus what matches are likely to generate the greatest gains from trade. This permits economizing on search. Consider a situation where a trader receives an offer from a particular producer. Knowing the characteristics of potential consumers (due to his experience and acquired knowledge) the intermediary can focus his search for a counterparty to those whose characteristics best match the commodity offered by the producer.

This two-sided search/arbitrage function is what distinguishes all commodity traders from other firms that have some connection to commodities and commodity markets. Although as discussed further below CTFs are quite heterogeneous in terms of the commodities that they trade, the transformations they undertake, the assets that they own, and their ownership structures, all of them perform this role.

2.3 Transformations

For the reasons discussed above, matching commodity producers and consumers inherently requires intermediate transformations in space, time, or form, or more likely, some combination thereof. CTFs are quite diverse in the commodities that they transform, and the transformations they undertake.

Transformation technologies utilize physical assets, such as refineries, ships, pipelines, and storage facilities. To transform commodities, CTFs must control these assets. This raises questions regarding what assets they control, and how they obtain control rights. I discuss these issues in detail in section 3 below.

2.4 Other CTF Intermediation Functions

CTFs perform other intermediation functions. These functions are also complementary to the information production inherent in commodity trading.

One crucial intermediation function is the extension of credit to both sellers and buyers. The credit extended can vary on a variety of dimensions including maturity and complexity. For example, a commodity trader may extend credit on the purchase of a single cargo: this is a simple, short maturity transaction. As another example, a trader may extend credit to a commodity supplier on a long-term basis with complex terms (e.g., repayments linked to the price of the commodity).

Typically commodity traders take on only a fraction of the credit risk on the loans that they provide. Instead of taking all this risk on their own balance sheets, CTFs typically insure the credit risks with banks. It is common for CTFs to retain 10 to 20 percent of the exposure (Pirrong, 2014).

Intermediating credit exploits a CTF's knowledge of its counterparties that it generates through its dealings (usually repeat dealings) with them. The fact that CTFs lay off most of the performance risk associated with their credit transactions demonstrates that their primary intermediation function is not the bearing of such risk. Instead, banks bear the bulk of the default risk, and delegate the decision on credit extension and pricing to the CTFs who have better information on the debtors. The banks have information on the CTFs that they use to extend credit to them that they in turn extend to clients. CTFs' retention of some credit risk mitigates the moral hazard inherent in the banks' insuring credit risk.

CTFs also sometimes offer risk management services to clients. This takes advantage of the knowledge of (a) price dynamics that CTFs acquire due to their constant presence in the market, and (b) CTF investment in

risk management and measurement technology which as discussed below is an essential component of the management of a CTF.

2.5 CTF Profits

The foregoing analysis illuminates the determinants of CTF profitability, and demonstrates the invalidity of common beliefs regarding this profitability.

One common explanation of variations in CTF profitability is that that traders benefit from high "flat" prices of commodities and suffer from low ones.[4] This represents the common fallacy of "arguing from a price change" and ignores the economic functions that CTFs undertake as described above.

As economic agents engaged in the transformation of commodities, CTF profitability depends on the volume of transformations, and the margins earned on them. High prices can result from high demand or low supply. (A symmetric analysis applies to low prices). If the demand for a commodity is high, the volume of transformations (the output of CTFs) are also likely to be high. Furthermore, a greater volume of transformations results in more intensive utilization of CTF assets, which tends to increase margins.[5] Conversely, when supply of a commodity is low, the volume of transformations and the margin earned on transformations are commensurately low. Thus, the asserted relationship between the price level for a commodity and the profitability of CTFs is based on a misapprehension of what commodity traders do.[6]

[4]A flat price is the outright purchase/sale price of a commodity, e.g., $80 per barrel of crude oil. This is to be distinguished from a spread or basis, which is the difference between flat prices. For example, the Brent-WTI basis (or spread) is given by the differene between the Brent crude flat price and the WTI crude flat price.

[5]In essence, if the short run supply curve of transformations is upward sloping, higher demand leads to a higher price of transformations and greater producer surplus.

[6]Since CTFs are both buyers and sellers of commodities, they are to some extent nat-

Another common belief about CTF profits is that they benefit from higher price volatility. This belief implicitly assumes that commodity traders are effective market timers. Larger volatility in prices translates into higher profits from market timing.

Again, this is based on a misapprehension of the economic function of commodity traders. They are not first and foremost speculators timing the market (although CTFs do sometimes speculate): they are first and foremost arbitrageuers that identify relative price relationships that create gains from trade and transformation.

Even if there is no causal relationship between commodity price volatility and CTF profitability, there is plausibly a correlation between them driven by common causal factors. Specifically, economic shocks that cause large price movements can also increase relative price dispersion, increase the benefits of search, and increase the demand for CTFs' transformation, matching, and coordination services.

Two recent events–Covid and the Russian invasion of Ukraine–provide powerful illustrations of this phenomenon.

Consider first the Russian invasion of Ukraine. The invasion and the subsequent sanctions imposed on Russia by western nations led to substantial disruptions in the supply of commodities–especially corn and wheat from Ukraine and Russia, and oil and natural gas from Russia–that caused substantial volatility in the prices of these commodities. Moreover, these events led to large changes in relative prices, such as the price of natural gas in Europe relative to the price of natural gas in the United States, and the price of electricity in Europe relative to the prices of fuels used to generate

urally "hedged" to the levels of commodity prices. Profitabilty depends on the spread between transformed and untransformed commodity prices, and the quantity of transformations undertaken.

it (in particular coal and natural gas). Furthermore, the war and sanctions severely disrupted normal commodity flows, and thus disrupted pre-existing matches between commodity producers and consumers. In particular, consumers of Russia- or Ukraine-produced commodities had to obtain them from alternative sources and in many cases bid them away from other consumers.

These shocks increased the demand for CTF services as intermediaries that search out valuable matches and engage in complementary transformations to facilitate these matches. Furthermore, the shock to *relative* prices delivered by the war created profit opportunities for CTFs that specialize in searching to identify and exploit arbitrage opportunities.

Covid similarly disrupted pre-existing logistic chains and created opportunities for firms–like CTFs–that specialize in identifying and executing transformations that generate gains from trade. Moreover, Covid led to changes in the composition of demand away from services towards physical goods that also affected relative prices and the optimal set of transformations. These developments also increased the demand for CTF services and enhanced their ability to exploit their arbitrage specialization.

CTF profits reached record levels in the Covid-Russia Ukraine War era.[7] Commodity price volatility was also high in this era, but not because the volatility *per se* boosted CTF profits. Instead, the economic disruptions caused by Covid and the war allowed CTFs to exploit their comparative advantages to an arguably unprecedented degree.

The theory of CTFs also implies that their profitability should also be increasing in the rate of inflation. Inflation increases the dispersion of relative prices.[8] Moreover, these relative price distortions can create resource misal-

[7]Hook, Sheppard, and Dempsey, 2023.

[8]Benabou (1992); Bomberger and Makinen (1993); Carlton (1982); Fisher (1981.

locations. These conditions create arbitrage opportunities, and increase the demand for CTFs' services. Thus, inflation is generally beneficial to CTFs.

2.6 CTF Secrecy

CTFs are renowned–and indeed notorious–for their obsession with secrecy. This obsession is a quite understandable consequence of their function as information producers. Since the discovery of arbitrage and transformation opportunities is the source of CTF profits, disclosure or leakage of information regarding these opportunities would facilitate free riding that would erode the profitability of a CTF's search and intermediation activities. Put differently, trading inherently produces trade secrets that can only be protected through opacity.

3 Asset Control and Ownership

3.1 Introduction

Although it was once said that all that was necessary to become a commodity trader was a phone, a desk, and a Rolodex, the transformation of physical commodities requires physical assets. This raises several questions. What assets do commodity traders control? Why? How do they obtain control over assets? Through ownership? Contract? If through contract, what are the terms? How does the means of control vary by asset type?

There is considerable diversity of patterns of asset control in the commodity trading sector. Some firms are "asset heavy," meaning that they own or otherwise control large amounts of fixed assets. Other firms are "asset light," with few fixed assets and balance sheets consisting predominately of short term assets (such as inventory and trade receivables). Some commodity

sectors, such as petroleum and petroleum products, includes both asset light and asset heavy firms.[9] Why is there this diversity?

To answer these questions, I first show that there is considerable complementarity between the control of physical assets (such as an oil refinery or soybean processing plant) and trading when those assets have optionality. This complementarity arises from the information that traders obtain (as described above) in their function as price searchers and arbitrageurs. I then show how transactions costs of asset control vary by the type of transformational asset, and in turn, these variations explain the means by which traders control assets.

3.2 Asset Real Optionality and Trading

As noted above, the trading process generates private information about demand and supply for the traders. Crucially, this information is often related to *relative* prices. Through their interactions with commodity producers and consumers, traders learn about variations of supply and demand over space, time, and form. This information is valuable when the assets that a trader controls have some optionality over the transformations the assets can make.

Consider an oil refinery that transforms a commodity in form (from crude oil to refined products). Refineries–especially complex ones[10]–have some optionality in terms of the crude oils they they can refine, and the "slate" of outputs they produce. Optimizing refinery operations involves choosing the combination of crude oil inputs and product outputs to maximize value. Optimization requires information on relative prices of both inputs and outputs.

[9]Pirrong (2014) discusses fixed asset intensity, and provides data on the degree of asset-heaviness for major CTFs.

[10]Refineries are rated on a Nelson Complexity Index that measures their ability to produce "lighter" hydrocarbons (e.g., gasoline or diesel fuel) from crude oil.

A simple model demonstrates how the information on relative prices generated by trading can facilitate such optimization. Consider a simple asset that can produce either one of two outputs at a given time, A and B, but not both.[11] The operator of the asset must choose which product to produce.

The operator faces uncertainty regarding the values of A and B. With probability p, the state of the world is $X = A$ the value of A is $V_A = V$, and with probability $1-p$ the state of the world is $X = B$ it is $V_A = V - \delta$. With probability p, the value of B is $V_B = V - \delta$, and with probability $1 - p$ it is $V_B = V$.

The (risk neutral) operator's optimal choice is to produce A if:

$$pV + (1-p)(V-\delta) > p(V-\delta) + (1-p)V$$

The optimal choice is to produce B if the reverse inequality holds. Therefore, A (respectively, B) is chosen if $p > .5$ (respectively, $p < .5$). Without loss of generality, in what follows assume $p > .5$ and that given the operator's information he chooses A.

Now allow the asset operator to engage in trading. As discussed above, trading generates information about relative values. Formally, trading provides the asset operator a signal $\Theta = \{A, B\}$. Moreover,

$$q = Pr(\Theta = A|X = A) = Pr(\Theta = B|X = B)$$

with $q > p$. That is, the signal allows the asset operator that trades to ascertain the true state of the world more precisely than the non-trading asset operator.

By Bayes' Rule,

$$p^* \equiv Pr(X = A|\Theta = A) = \frac{Pr(\Theta = A|X = A)Pr(X = A)}{Pr(\Theta = A|X = A)Pr(X = A) + Pr(\Theta = A|X = B)Pr(X = B)}$$

[11] With joint production, as in oil refining, A and B may represent different bundles of output, e.g., different quantities of gasoline and middle distillates.

$$p^* = \frac{qp}{qp + (1-q)(1-p)} > p$$

The operator who receives a signal $\Theta = A$ chooses option A if $p^* > .5$ which holds because $p^* > p > .5$. Similarly, the operator receiving a signal $\Theta = B$ chooses B. Here

$$Pr(X = A|\Theta = B) = \frac{(1-q)p}{(1-q)p + q(1-p)}$$

To verify that this is less than .5:

$$\frac{(1-q)p}{(1-q)p + q(1-p)} < .5$$

$$2(1-q)p < (1-q)p + q(1-p)$$

$$\frac{q}{1-q} > \frac{p}{1-p}$$

verifying the claim that when observing $\Theta = B$ the operator will choose to produce B.

The value of output is greater with the signal than without. Regardless of whether $X = A$ or $X = B$, the value of the output is $(1-q)(V-\delta)+\delta V = V-(1-q)\delta$. In contrast, without the signal the expected value is $V-(1-p)\delta$. The incremental value produced by the signal is $(q-p)\delta$.

This has an intuitive interpretation. $(q-p)$ measures the information in the signal: the bigger the difference between the conditional and unconditional estimates of the likelihood that the state of the world is $X = A$, the more valuable the signal. Moreover, the signal is more valuable, the greater the loss in value due to producing the wrong output, which is measured by δ. Also note that for a given value of q, the signal is most valuable when there is the greatest unconditional uncertainty, which occur when $p = .5$.

This simple model demonstrates that real optionality in assets creates a complementarity between control of the asset and trading when trading produces information about relative prices.

The model can be enhanced to demonstrate a role for independent traders of the output of the asset in addition to the asset operator. Specifically, assume that the asset operator can affect the precision of the signal (measured by q) by the expenditure of real resources, and specifically by choosing the scale of the trading activity. Denote by f the fraction of the output that the asset operator trades. The signal precision is a function of f, $q(f)$ with $q'(f) > 0$ and $q''(f) < 0$. That is, the marginal benefit of trading is positive but decreasing in the scale of trading. The cost of trading is $C(f)$ with $C'(f) > 0$ and $C''(f) > 0$. That is, the marginal cost of trading is positive and increasing.

Here the asset operator chooses f to maximize:

$$\Pi(f) = (q(f) - p)\delta - C(f)$$

producing the first order condition:

$$q'(f)\delta = C'(f)$$

with $f \in [0, 1]$. If $0 < f < 1$, the firm trades only a fraction of its output. This creates a role for independent traders who market the remaining $1 - f$ of the asset's output.[12]

3.3 Asset Ownership vs. Control by Contract

The foregoing analysis provides an economic rationale for a CTF to control the operation of an asset: control allows a trader to utilize its information on relative prices to exercise asset optionality more efficiently. However, asset ownership is not a necessary condition for asset control. CTFs can–and do–obtain control of assets *via* contract rather than ownership.

[12]Fixed costs in trading can lead a firm to choose $f = 0$.

The large energy and metals trader Trafigura is an example: it obtains more than 50 percent of the fixed assets that it operates *via* lease (Trafigura, 2023).

In fact, control of many assets can be obtained by contract. CTFs obtain ocean shipping–an asset essential for transformation in space for commodities traded internationally–predominately through contract. Specifically, they charter ships under various terms, sometimes under voyage charters (for a single voyage) or time charters of various durations (ranging from months to years). Time charters in particular provide the charterer considerable optionality. Subject to some restrictions, time charters permit the charterer to choose the ports of loading and discharge, and to change ports at will. The charterer pays a daily amount for the the ship, and usually also pays operating costs (e.g., fuel).

It is possible to obtain control of other assets *via* contract as well. For example, under so-called tolling agreements a trading firm can obtain control of an oil refinery or power plant. Under a tolling agreement, the firm supplies inputs (e.g., crude oil to a refinery) and ownership of the output (e.g., gasoline and diesel) which it can then market. The specific control rights accorded to the tolling firm are specified in the contract, and can often extend rights that closely approximate those that ownership would produce.

Since control is not coterminous with ownership, how control rights (and the associated asset optionality) are obtained are driven by transactions cost considerations. Large, site-specific, long-lived assets (such as large complex oil refineries) are typically owned by the trading firm.[13] Ships are typically obtained by contract: Pirrong (1993) analyzes how transactions costs impact ship contracting practices generally, and these considerations apply to

[13]In oil refining, tolling agreements tend to be used for smaller, older, and less complex refineries.

CTFs.[14]

The ownership of one kind of asset–the commodities themselves–is usually taken for granted, but should not be. That is, why do traders take ownership of commodities? There are alternative ways of matching buyers and sellers that do not involve the intermediary that makes the match acquiring ownership of the commodity. In particular, brokers perform matching functions. Brokerage is not unknown in commodities[15] but it plays a relatively minor role in intermediating commodity flows from sellers to buyers.

However, brokerage does not allow the intermediary to profit from the quality of the match. Even if the broker has knowledge that some matches are more valuable than others, its compensation depends on the match being made not the value created by the match. A commodity trader that takes ownership can do so however. The value added by the match is the difference between the sales and purchase prices: a trader who takes ownership captures that difference. This also implies that a trader has a stronger incentive to develop information about the value of matches than a broker. So again, information generated by the trading process determines the form of intermediation, which entails commodity trading *qua* trading, rather than brokerage.

Given the diversity of assets employed in commodity trading, an asset-by-asset analysis is impractical. However, as noted above, storage is an important CTF function. An analysis of the transactions costs of storage

[14]There are exceptions to the rule that CTFs charter ships. For example, Trafigura purchased four bitumen carriers in 2014. Transaction cost considerations are relevant here. Bitumen carriers are highly specialized due to the characteristics of the commodity, and bitumen routes are not "thick" (using the terminology of Pirrong (1993)). Thus, holdup problems and contracting hazards favor ownership.

[15]It is widespread in steel, for instance. One reason for this is due to the heterogeneity of steel, there are no liquid futures markets. This means that the price risk of inventory cannot be hedged, which raises the cost of taking ownership.

provides insights on how these costs affect CTF asset ownership.

3.4 Asset Real Optionality, Transactions Costs, and CTF Asset Ownership: Transformation in Time–Storage

Transformation of a commodity in time *via* storage involves a crucial element of optionality, specifically when to add to storage, and when to draw down stocks. Pirrong (2012) demonstrates that optimal storage decisions are driven by short-term (transient) demand and supply shocks with half-lives measured in weeks or days, rather than long-term (persistent, and perhaps integrated) supply and demand shocks with very long half-lives: the long-term demand shocks are the main determinants of the "flat price" of a commodity like copper and oil, whereas the short term shocks are the main determinants of the price of the commodity today relative to its expected price in the future.

Trading that generates information about the structure of supply and demand shocks allows more efficient storage decisions. This creates a complementarity between trading and control of storage assets.

Indeed, trading is likely to produce such information. For example, a trader contacted by a buyer whose normal supplier has suffered a temporary production disruption learns about a temporary supply shock. Similarly, a supplier who has suffered such a disruption and contacts a trader to secure supplies to meet contractual commitments similarly provides such information.

There is empirical evidence that such informational considerations are important and that commodity traders in fact do obtain private information on storage-decision-relevant demand and supply shocks. On a weekly basis, the United States Energy Information Agency releases information about

inventories of crude oil, refined petroleum products, and natural gas. The EIA report discloses inventories as of the previous week. The storage statistics therefore reflect decisions made by those controlling storage assets prior based on information they had between a week and two weeks earlier than the release of the EIA report.

Futures prices of these products respond to the release of the storage statistics, meaning that they convey information that had not been public previously. This demonstrates that the storage decisions were based on private information relating to supply and demand conditions, and to short term supply and demand shocks in particular, possessed by those making the storage decisions.[16]

Storage is therefore complementary to price discovery and search by CTFs. The information generated by superior knowledge regarding values allows CTFs to optimize and obtain value from better decisions regarding the transformation of commodities in time.

The fact that optimal storage decisions are driven by information regarding demand and supply shocks with very short half-lives (on the order of weeks or days) implies that to exploit their information advantage CTFs

[16]Formally, assume that at time t traders observe a signal y_t related to the storage-relevant short-term demand/supply shock. Traders utilize this information to make a storage decision $X_t(y_t)$. When this storage decision is revealed at $t' > t$, other market participants can invert X_t to recover the traders' signal. The fact that prices move in response to release of the EIA data implies that the private information was not fully incorporated into prices as a result of futures trading with those in possession of the information. However, since it is likely that at least some of that private information was incorporated into prices as a result of informed trading on the futures market by those who observe the signal or the inventory decision before it was revealed publicly, the price movements that occur upon the release of the EIA report underestimate the amount of private information possessed by those making storage decisions at the time they made them. Since it is likely that in fact traders observe different (noisy) signals, imperfect competition between them and/or risk aversion can lead to incomplete revelation of their signals through their trading on the futures market.

must be able to have rapid and unhindered access to stored goods. This has important implications for the ownership and control of storage facilities. Specifically, it provides a strong incentive for CTFs to own storage facilities or to obtain control over them *via* contracts.

Consider storage in a public storage facility (i.e., a storage facility operated by an entity independent of those who store in it, and which stores for multiple parties). Once the owner of a commodity puts it in store in such a facility, the commodity undergoes a "fundamental transformation" (Williamson, 1985): the owner/storer and the storage facility operator are in a bilateral monopoly relationship. Such relationships are potentially fraught with potential for opportunism.

Crucially, in commodity storage the opportunism hazards are not symmetric: the public storage operator has greater scope for opportunism than the CTF (or other entity) who store their goods in this facility.

The storer's need to access his goods quickly in order to exploit information creates an opportunism hazard. The storage operator may attempt to extract rents from the storer through haggling over the speed of load-out.[17] Even if the operator does not attempt such a hold-up, the operator has the incentive to delay load-out for as long as possible because storage fees are proportional to time in store, and therefore delaying load-out increases the storage rents it collects.

An extreme case occurred in the aluminum market in the post-Great Financial Crisis period. During the GFC, large quantities of aluminum were moved into public storage facilities, most notably the Metro Warehouses in Detroit (which were owned by Goldman Sachs). When demand rebounded

[17]In essence, there is a temporal specificity in the storer-storage operator relationship. See Pirrong (1993) for an analysis of the impact of temporal specificity on contracting in bulk shipping markets.

owners of the stored metal wanted to load-out and consume the stored metal, and gave load-out orders to Metro. Metro used a specific interpretation of the London Metal Exchange rules (which governed operation of storage facilities where metal could be delivered on LME contracts) to load-out metal at a rate far lower than the storers had anticipated. As a result, there were warehouse "queues" months in length: at times storers would not receive their metal for over a year after they had submitted load-out orders. Metro (and hence Goldman) collected rents for these extended periods.[18]

Although the aluminum market post-2009 represents an extreme example, the entire history of public warehousing in virtually every commodity reveals conflicts between storers and public storage operators over the timeliness of performance.[19]

Foot-dragging is not the only potential form of opportunism. A public storage operator that also stores its own goods can free ride off a CTF's information: a CTF that makes a storage decision reveals at least part of the information motivating that decision, and the storage operator can profit by mimicking that behavior.[20]

Another form of opportunism that is feasible for some commodities involves mixing that exploits imprecision in quality measurement (Barzel, 2009). Consider the case of grains. In the United States, grains like corn are traded by numerical grades (e.g., #2 corn). There is variation of quality within these grades, and it is common to mix say, #2 corn of a quality at the high end of the grade with a sufficient quantity of #3 corn to create a mixture that

[18]It is also alleged that Metro engaged in various schemes to extend these queues. (U.S. Senate Permanent Subcommittee on Investigations, 2014).

[19]National Cotton Council (2010) documents the long-standing complaints regarding handling delays at public cotton warehouses.

[20]Proprietary storage by a CTF does not eliminate that problem. It is not unusual for competitors to monitor–spy on–CTF warehouse operations.

is at the bottom of the #2 grade. Therefore, a firm that puts top-of-grade corn in a public warehouse risks having the warehouseman expropriate some of its value by mixing the warehouseman's lower-grade corn to bring it down to bottom-of-grade.

Yet another form of opportunism is to skimp on maintaining warehousing conditions, resulting in the degradation of quality of the stored commodity. (This is most likely in agricultural products).

Further, outright fraud is not uncommon in public storage facilities. This ranges from theft (which may include replacing the stored commodity with a worthless one, as happened to J.P. Morgan when nickel it had stored in an LME warehouse was replaced by bags of rocks), or issuing multiple warehouse receipts on the same material.[21]

The chronic conflicts between storers and public warehousemen have a long history and have led to regulation of commodity storage. As a salient example, the conflicts between public warehousemen and those storing grain in Chicago in the 1860s ultimately led to the State of Illinois regulating grain warehouses. The public warehousemen challenged the law, and the seminal Supreme Court case of Munn v. Illinois that established the constitutionality of some regulations was the result.[22]

[21]Warehouse receipts are widely used as collateral in borrowing transactions. Fraudulent receipts can be used to secure borrowing. If the true owner demands load-out, the fraudster can repay the loan, or buy a replacement to cover the load-out obligation. This type of operation can continue unless the fraudster cannot pay the loans and creditors attempt to seize the collateral. The most infamous–and colorful–example of such a scheme was the Great Salad Oil Scandal in the 1960s.

[22]Pirrong (1995) describes and analyzes this historical episode in detail. Public storage operators are often subject to regulation, but regulation cannot constrain all opportunism, and especially the exploitation of temporal specificities due to the difficulty (and arguably impossibility) of writing sufficiently complete regulatory rules ("contracts") to induce efficient performance and control hold-ups. One regulation that can control some kinds of conduct is to prohibit commodity ownership or trading by warehousemen. But this cannot control, say, exploitation of temporal specificity.

Given all the bad things that can happen in public warehouses, CTFs have a strong incentive to own and/or control and operate their own proprietary storage facilities. And indeed, ownership or control *via* contract of storage facilities is common among CTFs, including "asset light" ones. This is readily explicable based on the transactions cost considerations detailed here.

But this same litany of opportunistic hazards also begs the question of why public storage still persists. The most plausible answer is economies of scale in storage. Many storers–especially commodity producers or consumers–do not operate at a scale commensurate with the efficient scale of storage facilities. For example, cotton growers need to store their bales before marketing them.[23] As another example, a copper fabricator may need to have in process inventories and find it more economical to store it in a large-scale public warehouse.[24]

In sum, transaction cost considerations provide an incentive for CTFs to own a particular kind of fixed asset–storage facilities. Temporal specificities

[23]Cotton warehousing provides an example of another way of handling opportunism. Grower cooperatives such as the Plains Cotton Cooperative Association often operate cotton storage facilities.

[24]The history of grain warehousing in Chicago is illustrative in this regard. In the early era of the grain trade in Chicago, most traders were of very small scale, and indeed were often brokers rather than proprietary traders. The disparity of scale economies between the traders and warehousing led to the dominance of public warehousing despite its inherent conflicts. In the years after Munn v. Illinois, the industry evolved and larger proprietary traders developed. These proprietary traders owned and operated their own warehouses, although they did do some public storage business. Throughout most of the 20th century, however, public storage business was mainly ancillary to the Chicago Board of Trade future delivery process. Warehouse (elevator) operators would deliver against futures, and those taking delivery would take ownership of grain in store in these warehouses. However, the duration of storage of delivered grain was typically quite short. Those taking delivery would do so in the anticipation of loading out. Moreover, elevators would often deliver opportunistically to drive down prices, then buy back their receipts at the depressed price. It was common wisdom among warehousemen not to deliver unless they believed it was highly likely that they could quickly re-acquire what they had delivered. Hieronymus (2022).

in particular encourage ownership. I note that CTFs often own other assets –such as handling terminals–where temporal specificities are important.

4 The Ownership of Commodity Trading Firms

The commodity trading sector is remarkable for the prevalence of privately owned firms relative to publicly traded corporations. Indeed, it is likely that private ownership is more important in commodity trading than any other large economic sector.

In broad strokes, two of the four largest agricultural traders–Cargill and Louis Dreyfus–are private firms, and two–ADM and Bunge–are publicly traded corporations.[25] In energy trading, all of the largest asset-light CTFs are private: these include Vitol, Trafigura, Gunvor, and Mercuria.[26] The asset-heavy energy traders are all public firms, but the same is not true in agriculture: Cargill and Dreyfus are also asset heavy.[27] In energy, asset-heavy Koch Industries is also private. Thus, although asset heaviness is not a perfect classifier for CTF ownership type, there is an association between asset heaviness and public vs. private ownership.

Understanding the trade-offs involved in ownership structure largely explains this rather distinctive distribution of CTF ownership structures.

The major advantage of private ownership is a superior alignment of incentives between owners and managers–because the owners are the managers. Private ownership has two major disadvantages, however.

The first relates to the allocation of risk. Public ownership permits man-

[25]I will refer to these as "public firms" but this does not mean that they are government-owned.

[26]Glencore was also private prior to its transformation into an asset-heavy firm.

[27]Pirrong (2014) presents data on the asset-heaviness/lightness of major commodity trading firms.

agement of risk through diversification: shareholders can largely eliminate the idiosyncratic risk of a particular firm by holding diversified portfolios in which a given firm represents only a small fraction of their wealth. In contrast, the owners of private firms tend to be highly undiversified: a large fraction of their wealth is tied up in the firm that they own.

An important reason that private ownership is viable for CTFs is related to risk. CTFs could potentially incur substantial price risk on the inventories of commodities they buy, sell, and transform. However, most heavily traded commodities, including grains and oilseeds, industrial metals, and energy products have large and liquid derivatives (futures) markets: commodity traders can hedge their price exposure by taking futures positions that offset their physical positions (e.g., sell oil futures to hedge oil inventories). These hedges are not perfect because due to the heterogeneity of commodities by time, place, and quality physical prices and derivatives prices are not perfectly correlated. However, the correlations tend to be high, meaning that CTFs can substantially reduce their exposure to price risk. Hedging exchanges "flat price" risk for "basis risk." Basis risk is determined by the variability of the difference between two prices (the price of what is being hedged and the price of the hedging instrument), and given high and positive correlation this difference is substantially less variable than is either "leg" of the difference.

Outside of commodities, hedging of price risk is infeasible, and a private corporation would perforce bear it. This inability to hedge price risk provides an impetus to go public: the impetus of CTFs to do so is commensurately less due to their ability to manage risk through hedging, rather than through shareholder diversification. In particular, the ability to hedge inventory price risk favors private ownership of asset-light CTFs whose assets

consist primarily of inventories.

A private CTF that hedges against flat price risk is left with various operational risks, credit risks, and non-diversifiable (business cycle) risks. Many operational risks (e.g., the sinking of a ship carrying cargo, theft, environmental accidents) can be managed through insurance. Credit risks can also be managed to a considerable degree through markets.[28]

Even though it is widely believed that the pro-cyclicality of commodity prices would make CTFs acutely exposed to business cycle risk, this is not the case. For one thing, as just noted, CTFs can shift much of their price risk exposure *via* hedging. For another, as noted above CTF profitability is driven by volumes and margins, both of which tend to be much less pro-cyclical than commodity prices. This is due to the inelasticity of commodity supply and demand (especially in the short run). Due to this inelasticity, supply and demand shocks (including aggregate shocks) tend to cause large price responses and smaller quantity responses. Since CTF profitability depends on quantities they are more insulated against business cycles than, say, industrial firms or financial intermediaries.[29]

Thus, CTFs can utilize a variety of non-diversification risk shifting mechanisms, notably hedging, to reduce their owners' risk exposure. The ability to shift risk *via* market transactions rather than by diversifying it away through dispersed share ownership allows CTFs to exploit the incentive benefits of private ownership without incurring large risk bearing costs.

[28]Some operational risks cannot be insured. For example, one risk of transforming commodities in space is a delay in unloading or loading a cargo due to port congestion, a port strike, or some other factor. In the event, the trader incurs demurrage charges and carrying charges on the inventory stuck on the ship. Another example of a non-insurable operational risk is "rogue trader" risk discussed below.

[29]Pirrong (2014) shows that the GFC did not have a large impact on CTF profitability, and indeed several firms' profits increased during this period.

Since private corporations typically have fewer disclosure obligations (especially when domiciled in jurisdictions like Switzerland), private ownership can also reduce the cost of protecting proprietary information that CTFs produce, and which is the source of the value that they create (as discussed above).

The second advantage of public ownership relates to the funding of large scale investments. Public firms can issue equity (a permanent form of capital) to fund large fixed investments (e.g., an oil refinery). Public firms often incur lower cost to access long-term debt capital. In contrast, private firms must rely on owner capital, retained earnings, or borrowing to fund investments. This costlier access to capital to fund large fixed investments limits the ability of private firms to be asset heavy.

Indeed, asset heaviness is a major determinant of ownership form, although there is not a one-to-one correspondence. There are no publicly traded CTFs that are *not* asset heavy. Relatedly, all of the major asset light firms (especially in energy) are privately owned. Thus, there is a relationship between the level of investment in fixed assets and ownership structure. However, there are some asset heavy firms–notably Cargill, Dreyfus, and Koch–that are private.

The transformation of Glencore illustrates the role of asset structure in driving ownership. One of the descendents of the original major oil trading firm–Marc Rich & cie–Glencore was originally an asset light pure trader concentrating in energy and industrial metals. In the 2000s, however, it moved into mining, notably in coal, copper, nickel and eventually battery metals. Roughly concurrent with this transformation, Glencore went public.

It should also be noted that price risk management is more difficult for long-lived assets. These assets are exposed to price variations over long

horizons. However, most derivatives markets are liquid only for relatively short horizons.[30] Even in crude oil, for which futures contracts are listed going out 10 years, the vast bulk of trading activity is concentrated in the first several (monthly) contracts. Thus, it is possible to hedge against price movements over horizons extending out months, it is not feasible to do so over horizons of years.

Moreover, real optionality in a long term asset (like a refinery) complicates risk management. Unlike hedging an inventory of crude oil, for which the quantity exposed to price risk is known and unvarying, for an oil refinery this exposure is time-varying. For a given refinery, this exposure is time varying because a refinery will adjust its input and output slates depending on relative prices. Moreover, the ability to adjust refining equipment and changes in technology affects the options available to the operator (and hence affects exposure). For example, a refinery can make investments that change the possible product slates.[31]

[30]This is an equilibrium, which is endogenous. What explains it? The nature of liquidity in centralized markets is an important driver. Due to network effects, there is a positive feedback loop in trading: liquidity attracts liquidity. (Pirrong, 2002). Thus, factors that create a demand to hedge short-term risks, such as inventory risks, generate liquidity in short-dated contracts which attracts trading of those contracts that reduces the cost of hedging short term risks. Conversely, if factors such as the need to access long-term capital to fund investments in long-lived assets cause firms to choose public ownership, the demand for hedging of long-term risk *via* derivatives is muted: sharing risk *via* equity is a substitute for sharing it *via* derivatives markets: indeed, it is somewhat of a puzzle why publically traded firms hedge at all (Smith and Stulz, 1985). This tends to make long-maturity derivative markets illiquid and hedging commensurately costly. Thus, liquidity considerations reinforce underlying demand conditions to generate an equilibrium in which short-term risks are hedged *via* derivatives and long-term risks are not.

[31]It is possible to conceptualize a long-lived asset like a refinery as a complex bundle of options and use option pricing theory to quantify price exposures and hedge them dynamically. The options are quite diverse in nature. For example, there is the option over which product to manufacture like that in the theoretical analysis above. This can be conceptualized as an option on the maximum of a variety of products, but given the myriad choices a refiner has this is a high dimension option. The ability to expand capacity, or

These factors make shifting price risk *via* hedging costlier and less effective for long-lived, complex assets. This makes it more likely that public firms will own these assets than private ones.

5 The Internal Organization and Management of Commodity Trading Firms

CTFs provide an exceptional example of what Foss-Klein (2012) call "delegated entrepreneurship." Trading firms typically are organized around trading desks. Each desk is responsible for trading particular commodities, particular regions, or particular commodities in particular regions. The assignment of commodities to desks varies across firms, but all employ this basic structure. The trading desks are often referred to as the "front office" of a CTF.

Compensation for the trading desks is high-powered. Specifically, it is performance-driven, and most compensation is in the form of bonuses rather than salary. In private firms compensation also typically incorporates payment in the form of shares based on overall firm performance: non-trading personnel may also receive shares, but front offices receive the bulk of this compensation. Senior management generally determines bonuses for senior traders and trading desks. Trading desk heads typically decide on bonuses for their reports.

---

to add new units (e.g., a hydrocracker) can also be modeled as an option and hedged accordingly. However, all of these option valuations (and resulting calculation of dynamic risk exposures) are predicated on models of the behavior of commodity prices. As is discussed in the section on the internal organization of CTFs, these models have severe limitations. Indeed, the limitations of these models grow with the time horizon (i.e., the maturity of the option being valued). Thus, hedging of a long-lived asset is an exercise in Knightian uncertainty (Knight, 1921). The experience of Metalgesellschaft illustrates the dangers of hedging long-term risks using short-term derivatives. Pirrong (1997).

The reliance on high-powered incentives for those who make trading decisions (the delegated entrepreneurs) is feasible because of the ability to measure some important dimensions of performance: a trader's contribution to firm profit and loss (P/L) is precisely measurable. However, high-powered incentives create several problems that induce organizational responses.

Some of these problems can be characterized with another Foss-Klein term: "destructive entrepreneurship." Specifically, there are agency problems because trader incentives are not fully aligned with firm interests, and high-powered incentives can exacerbate this tension.

Perhaps the most acute problem arises from the inherent option-like nature of the compensation system. Under this system, the trader's upside is potentially unlimited. However, the downside is the same regardless of the magnitude of the loss he incurs: being fired. This asymmetry creates an incentive to take on excessive risk.[32]

Perhaps the most spectacular manifestation of this compensation-induced destructive entrepreneurship is the "rogue trader" phenomenon, in which a trader circumvents firm controls (which I discuss in more detail below) to amass a position far larger and/or riskier than authorized and suffers a large loss–indeed, sometimes a loss that can threaten the viability of the firm. Many of the most egregious examples of rogue trading involve traders who had suffered a large loss and "gambled for resurrection." In commodities, arguably the most extreme example is Sumitomo's Yasuo Hamanaka–dubbed "Mr. Five Percent" and "Mr. Copper" because of his dominance of the world copper market in the 1990s–who engaged in a series of risky, and often unauthorized and manipulative, trades that eventually resulted in a

[32]There are methods for mitigating this hazard. In private firms, a trader who is fired may lose some or all of the previously issued restricted shares. "Clawback" provisions that allow a firm to recover some past compensation payments can also reduce the asymmetry.

loss exceeding $4 billion: Hamanaka embarked on this course of conduct in order to try to recover a much smaller loss (much of which had in fact been incurred by his predecessor).[33]

Other examples of destructive entrepreneurship include bribing foreign officials[34] and engaging in manipulative conduct.

CTFs (like firms engaged in trading generally) implement various control mechanisms to mitigate perverse incentives to engage in excessive risk taking and destructive entrepreneurship generally. In particular, they implement various risk control measures overseen by employees that are organizationally separated from the front office. These are generally referred to as the "middle office" and "back office." The middle office in particular has responsibility for monitoring and controlling risk, and implementing systems for these purposes. Senior management, however, is responsible for setting risk limits.

Controls include deal capture systems intended to ensure that all trades are properly entered into the CTF's systems, to prevent a trader from engaging in "desk trades" undertaken in the firm's name but without its knowledge or authorization. They also include marking to market each trader's position, typically on a daily basis. This is to prevent losses from accumulating without the CTF's knowledge. Large mark-to-market gains can also be indicative of excessive risk taking. They also include risk measurement systems, such as Value at Risk ("VaR"), that attempt to quantify a trading desk's risk exposure.

Trading desks/individual traders are subject to various restrictions re-

[33]Other examples, outside of commodities, but still illustrative are Nick Leeson at Barings and Toshihide Iguchi at Daiwa Bank.

[34]In the past several years major CTFs including Glencore, Trafigura, Vitol, and Gunvor have settled bribery and corruption charges with the U.S. government.

garding the sizes of the positions that they take and the amount of risk exposure (measured by VaR or similar methods) that they can take. Violations of these limits usually result in mandatory reductions in positions or risk, although sometimes management will waive restrictions (another illusration of the functions of senior managers).

These systems have their limitations, which can be severe. Measuring risk in particular is challenging: most quantitative risk measurement methods are based on historical data which may not reflect current circumstances. For example, models based on historical data did not correctly measure risk in the Global Financial Crisis, the Covid Crisis, or the Russo-Urkainian War. There are various ways of attempting to address these problems (e.g., stress testing based on plausible if unprecedented conditions) but these have their limitations as well.

Moreover, quantitative risk measurement systems can seldom capture all of the complexities of trader's positions, and traders have a strong incentive to find and exploit these lacunae. An example from personal experience. Some years ago a trading firm's new Chief Risk Officer had reservations about his firm's VaR system, and asked that I evaluate it. I quickly established that it was based on evaluating the risk of options positions based on options "delta" alone–essentially linearizing non-linear instruments: this is computationally simple, but leads to a severe underestimation of the risk of sold ("short") options (which have limited upside and unlimited downside). Sure enough, one of the firm's traders understood this gap, and had taken on huge short options exposures, all the while remaining within his VaR limits. A modification to the VaR calculation that took non-linearity into account showed that the trader had exceeded his limits by several times.[35]

[35]Many examples of large trading losses are associated with sales of options.

The nature of risk means that its estimation is typically a high-dimension problem, and the dimensionality depends on the scope of the CTF: firms that trade more commodities or more instruments on them face a higher dimension problem than narrower firms. The dimensionality of risk depends on firm scope because of dependencies ("correlations" crudely put) across different commodities. This is a consequence of basic portfolio theory. A CTF is essentially a portfolio of price risks, and the riskiness of the portfolio varies with the commodities/instruments in the portfolio and the dependencies between them.

Quantifying these dependencies is statistically challenging, and not just because a CTF must perforce rely on historical data to do it, but because *inter alia* these dependencies can be time varying and the quality of the available data can be quite variable. Price data for highly traded commodities is inherently more reliable than that for illiquid ones, or those lacking liquid futures markets. Moreover, the very opacity of prices that makes search valuable and generates arbitrage opportunities for traders implies that the quality and quantity of data on the prices of the physical exposures in a CTF's portfolio are limited, which reduces accuracy of any risk measurements.[36]

Risk measurement is important not just for mitigating agency problems/destructive entrepreneurship: it is also an essential input to a central function of a firm, specifically, the allocation of capital.

[36] Wilson *et al* (2025) argue that digitization has made information more widely available, thereby reducing the information advantages that CTFs traditionally possessed. Although said article identifies price information that has been digitized and more widely available, I beg to differ. Data on cash prices is still highly sketchy and incorporates only a fraction of transactions. Grain and cotton price data in the United States is an example. The digitially available data is primarily in the form of bids (e.g., bids by grain elevators) which may or may not approximate transaction prices, and indeed, I have observed situations in which there are huge gaps between reported bid prices and transaction prices. This means that digitization has not materially contributed to improving the quality of the historical price information input into risk measurement systems.

The primary purpose of capital in a CTF is guaranteeing contracts (Barzel, 2009). A CTF can perform on contracts if its losses do not exceed its capital: if they do, the firm is no longer able to enter into contracts or perform on those it entered previously.

Thus, in a CTF the allocation of capital among trading desks is equivalent to an allocation of risk. If risks are mismeasured, capital will be misallocated as well. Therefore, the quality of a CTF's risk measurement systems determine the quality of its capital allocation decisions.

A firm that underestimates the risk of a particular trading desk will allow it to take on too much risk (thereby consuming too much capital) thereby reducing its (properly measured) risk adjusted returns: symmetrically, firms will allocate too little risk exposure/capital to trading desks whose risks are overestimated. Similarly, use of a flawed risk measurement system to calculate risk adjusted performance for compensation purposes provides poor incentives to traders: they will tend to allocate too much capital to trades with low risk adjusted P/L.

Thus, risk measurement is an essential function for a CTF and its management. It is essential to making distributed entrepreneurship work by mitigating agency costs (and the hazards of high-powered incentives) and allocating capital more efficiently.

Distributed entrepreneurship poses challenges to central management's abilities to improve risk measurement. As those most informed about prices and their risks, front office staff have information that could be used to identify deficiencies in risk measurement systems and make improvements. However, their incentives to share this information are attenuated, and as the personal experience related above demonstrates, often have an incentive to conceal it because they can opportunistically exploit their knowledge of mis-

measured risks. Indeed, traders have an incentive to utilize their knowledge about the deficiencies of risk measurement systems to arbitrage against their employers by loading up on underpriced risks and avoiding taking overpriced ones.

In sum, the organization and management of CTFs must address a fundamental tension between incentives and risk control. Incentivizing employee-traders to exploit their information about prices, price relationships, and transformation options through high-powered incentives also creates agency problems that can be so severe as to threaten a firm's existence. Firms implement risk controls and risk measurement systems to mitigate these agency problems, and to improve capital allocation across trading desks. These controls, and in particular the risk measurement models on which they rely, are inherently flawed representations of true–but unobservable–risks.

That is, CTF managements face Knightian uncertainty which is often mischaracterized as risk. The imperfections of risk models create this uncertainty. Risk models are known to be wrong, but how they are wrong is unknown and essentially unknowable. Or, as described by Phelps (2006), managers of CTFs are "actors in the world [who] have to make judgments that are not fully implied by their formal models."

Thus, the management of a CTF is fundamentally Knightian–the exercise of judgment in the face of uncertainty. And to be more specific, the primary function of CTF management is the exercise of judgment in the face of uncertainty about risk: CTFs therefore provide a particularly illuminating example of the distinction between risk and uncertainty. Judgments about risk, although informed by models, are central to two crucial management functions: the design and implementation of compensation schemes to facilitate distributed entrepreneurship and the allocation of capital among the

distributed entrepreneurs. And these judgments are inherently challenged by uncertainty.

6 Summary and Conclusions

Many find commodity traders fascinating because of their buccaneering reputation (Blas and Farchy, 2023). This economist finds them fascinating because they are arguably the examples in nature closest to the entrepreneur as conceived by Knight, von Mises, Kirzner and others: entities operating in a price system characterized by diffuse information that seek out relative price disparities that create potential profit opportunities.

CTFs' interactions with dispersed and heterogeneous commodity producers and consumers generate information about relative prices and potential "arbitrages" to transform commodities in space, time, and form. This information discovery function has important implications. In particular, it implies that commodity trading firms can have comparative advantages in controlling assets with optionality. Moreover, it is the source of commodity traders' profits. Economic shocks (like the Russo-Ukraine War or Covid or inflation) that generate shocks to relative prices produce arbitrage opportunities and increase the demand for CTFs' services.

Adding transactions cost considerations to the analysis generates additional insights, in particular, what determines how traders obtain control over assets (by ownership or contract), the ownership form of commodity traders, and various aspects of their internal organization.

Also central to the analysis are risk and uncertainty (in the Knightian sense). The measurement and management of risk are central to the management of CTFs. Risk measurement is necessary to make distributed entrepreneurship and high powered incentives possible. Risk measurement is

also essential to the efficient allocation of capital in a trading firm. But exact risk measurement is impossible. That is, the measurement of risk is uncertain, again in the Knightian sense: risk models are wrong, but just how they are wrong is unknown and unknowable. Thus, the commodity trader embodies the Knightian entrepreneur in a way that makes the distinction between risk and uncertainty perhaps uniquely clear.

References

[1] Barzel, Yoram. *Economic Analysis of Property Rights.* Cambridge: Cambridge University Press (2009).

[2] Benabou, Roland. "Inflation and efficiency in search markets." 60 *Review of Economic Studies* 69 (1992).

[3] Blas, Javier and Jack Farchy. *The World for Sale: Money, Power, and the Traders Who Barter the Earth's Resources.* Oxford: Oxford University Press (2023).

[4] Bomberger, William and Gail Makinen. "Inflation and relative price variability." 25 *Journal of Money, Credit and Banking* 843 (1993).

[5] Carlton, Dennis. "The disruptive effect of inflation on the organization of markets" in: R.E. Hall, ed., Inflation: Causes and Effects. Chicago: University of Chicago Press (1982).

[6] Duffie, Darrell. *Dark Markets.* Princeton: Princeton University Press (2012).

[7] Demsetz, Harold. "The Exchange and Enforcement of Property Rights." 7 *Journal of Law and Economics* 843 (1964).

[8] Fischer, Stanley. "Relative shocks, relative price variability, and inflation." 2 *Brookings Papers on Economic Activity* 381 (1981).

[9] Foss, Noclai J., and Peter G. Klein. *Organizing Entrepreneurial Judgment.* Cambridge: Cambridge University Press (2012).

[10] Hieronymous, Thomas. *The Economics of Futures Trading.* Chicago: Ceres Books (2022).

[11] Hook, Leslie, David Sheppard, and Harry Dempsey. "Profits at commodity traders hit record in 2022, say finance chiefs." *Financial Times* (March 22, 2022).

[12] Kirzner, Israel. *Market Theory and the Price System.*Indianapolis: Liberty Fund (2012).

[13] Knight, Frank H. *Risk, Uncertainty, and Profit.* New York: August M. Kelley (1921).

[14] Mises, Ludwig von. *Human Action.* New Haven, CT: Yale University Press (1949).

[15] National Cotton Council of America. *Cotton Flow Study.* (2010).

[16] Phelps, Edmund P."Further Steps to a Theory of Innovation and Growth–On the Path Begun by Knight, Hayek, and Polyani. Paper for the 2006 ASSA Meeting (1986).

[17] Pirrong, Stephen C. "Contracting practices in bulk shipping markets: A transactions cost explanation." 36 *Journal of Law and Economics* 937 (1993).

[18] Pirrong, Stephen C. "The efficient scope of private transactions-cost-reducing institutions: The successes and failures of commodity Exchanges." 24 *Journal of Legal Studies* 229 (1995).

[19] Pirrong, Stephen C. "Metalgesellschaft: A Prudent Hedger Ruined, or a Wildcatter on Wall Street?" 17 *Journal of Futures Markets* 543 (1997).

[20] Pirrong, Craig. "Market Macrostructure: Property Rights and the Efficiency of Securities Trading." 18 *Journal of Law, Economics, and Organization* 385 (2002).

[21] Pirrong, Craig. *Commodity Price Dynamics: A Structural Approach.* Cambridge: Cambridge University Press (2012).

[22] Pirrong, Craig. *The Economics of Commodity Trading Firms.* Geneva: Trafigura (2014).

[23] Smith, Clifford W., and Rene M. Stulz, "The determinants of firm hedging strategies," 20 *Journal of Financial and Quantitative Analysis* 391 (1985).

[24] Trafigura Group Pte. Ltd. *2023 Annual Report.* (2023).

[25] United States Senate Permanent Subcommittee on Investigations. *Wall Street Bank Involvement With Physical Commodities: Majority and Minority Staff Report.* (2014).

[26] Williamson, Oliver. *The Economics Institutions of Capitalism: Firms, Markets, and Relational Contracting.* New York: Academic Press (1985).

[27] Wilson, William W., David W. Bullock, and Isaac Dubovoy, "Dynamic changes in the structure and concentration of the international grain and oilseed trading industry," *Applied Economic Perpectives and Policy* (2025) 1.