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ESSAYS CONCERNING THE IMPACT OF MEASUREMENT COSTS UPON
COMMODITY FUTURES MARKETS

by

Michael A. Bowe

B.A. (Hons.) Oxford., M.A. (Econ) Manchester

A THESIS SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY
in the Department
of
Economics

CARLETON UNIVERSITY

Ottawa, Ontario

November 1988

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ISBN 0-315-51133-8

The undersigned hereby recommend to
the Faculty of Graduate Studies and Research
acceptance of the thesis,
"Essays Concerning the Impact of Measurement Costs
upon Commodity Futures Markets"

submitted by

LEONARD J. COVE, B.A. (HONOURS), B.A. (HONOURS)
in partial fulfillment of the requirements
for the degree of Doctor of Philosophy

Shirley A. Chisholm
.....
CHAIRMAN, DEPARTMENT OF ECONOMICS

John Mark
.....
THESE SUPERVISOR

John Mark
.....
CHIEF, CO-SUPERVISOR

John Mark
.....
FACULTY EXAMINER

ARLON UNIVERSITY

February 22, 1989

ABSTRACT

Commodity futures markets are institutions designed to maximise a traders expected net gain from ownership of the right to transfer exclusivity. McManus and Acheson (1979, 1983) and Telser (1981, 1986) argue that to minimise the cost of transfer, trading in futures is confined to adopting only impersonal and objective specifications of contractual performance. Futures contract specifications will, therefore, be incomplete when traders in the cash market to which the futures contract pertains adopt additional idiosyncratic measures of contractual enforcement. The costs of this incompleteness imply a range of indeterminacy in the futures price within which settlement price changes cannot be constrained by arbitrage in the delivery market for contract goods. This creates an opportunity for manipulation of the futures price by traders with lower cost access to the market. Such a possibility could restrict potential order flow and may lead to the market's demise. This hypothesis, relating market failure and contractual incompleteness is designated the measurement cost hypothesis.

The three essays in this thesis attempt to identify empirical dimensions in which the measurement cost hypothesis can be adapted to make it amenable to empirical corroboration. Chapter II argues incompletely specified futures contracts may be opportunistically exploited in their delivery period by the delivery of contract goods. Exchange regulatory constraints on redelivery are interpreted as attempts to mitigate the effects of such informed trader opportunism. Their presence could, therefore, be interpreted as evidence of an inherent exploitable contractual weakness. The measurement cost hypothesis would predict regulations governing redelivery will be more restrictive in failed or dormant contracts than in more active markets. This conjecture is tested using qualitative response models, and results obtained which are consistent with the hypothesis.

Chapter III clarifies the consequences of the range of arbitrage indeterminacy in certain futures prices for the conventional theory of intertemporal price relationships for storable commodities. Specifically, the model develops testable propositions relating to the relative price variability of open and spread contract portfolios. By relating contract price variability to the initial speculative margin requirements established by commodity exchanges, results of tests of the measurement cost hypothesis using contract market data on margin requirements for one hundred and eleven commodities for the period 1970-1984 are presented. Once more strong support for the hypothesis is evidenced.

The final essay in chapter IV extends the model of chapter III to analyse its implications for the behaviour of the price volatility of spread positions in futures as the spread's constituent contracts approach maturity. After a comparison of the models predictions with those of currently existing alternatives, tests are conducted in an attempt to distinguish competing theories. The test results are inconclusive, appearing sensitive to test specification, in particular the measure of price volatility adopted.

DEDICATION

To William P. McGough and Ethel A. McGough

ACKNOWLEDGEMENTS

My greatest debts, are to my thesis supervisors, Keith Acheson and John McManus. Not only did they nurse this project along from its conception, but their sustained enthusiasm during its evolution, greatly facilitated its completion. While they are to be absolved of responsibility for any flaws in the final product, their advice, expertise, and meticulous attention to detail, has contributed greatly to whatever merits this study may possess. Randy Geehan read various drafts of the manuscript and provided valuable comments.

Among those individuals at Commodity Futures Exchanges throughout the United States whose help was solicited in acquiring and interpreting data, the following merit special mention: Earlene Baptist (New York Mercantile Exchange); Christine Ehrke, Susan Saltzman, Carol Piergis, Paul Burreck and William Coccamis (Chicago Mercantile Exchange); Gilbert Heath and Donald Cheval (Chicago Board of Trade); Ann Roos (MidAmerica Commodity Exchange); Jon Hansen (Kansas City Board of Trade); Deborah Hogan (Coffee, Sugar and Cocoa Exchange); and Andrea Corcoran (Commodity Futures Trading Commission).

Debra Leo and Pepi Andolfatto are to be thanked for their fast and expert word processing, and patience through numerous revisions. Their ingenuity in deciphering the unintelligible and in constructing order out of chaos is greatly appreciated.

The generous financial support received in a grant from the Centre for the Study of Futures Markets, Columbia University Graduate School of Business, New York, is gratefully acknowledged.

Finally, I must express gratitude and admiration to my wife, Julie, not simply for tolerating a disconsolate husband for much longer than it should take to write a thesis, but for her qualities as a human being.

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CHAPTER 1

INTRODUCTION

One of the prevalent themes in recent microeconomic literature is that the gains from trade may be limited by the extent of asymmetric information across transacting parties. Differences in trader's costs of quantifying information relevant to contractual performance imply that the costs of enforcing exclusive rights will differ across transacting individuals. The potential then exists for better informed traders, acting opportunistically, to transfer wealth to themselves at the expense of less well-informed parties. A conclusion of this literature is that the revealed reluctance of the latter to suffer the consequent losses may ultimately be sufficient to lead to the failure of the market.

However, despite the threat of market breakdown, differences in trader knowledge are characteristic of most market environments. This specialisation (and thus asymmetric information) has been revealed profitable upon a close examination of the details of governance structures which have emerged in an attempt to reduce its associated costs. Specific investments by transacting parties, brand names (personal specification of contractual performance) and monitoring and bonding constraints, are commonly cited examples of mechanisms which preserve informational asymmetries across traders, yet provide sufficient incentives to enable markets to operate effectively.¹

The following essays are concerned with the effects of asymmetric information upon the operation of futures markets. Both McManus and Acheson (1979, 1983) and Telser (1981, 1986), have examined the costs associated with the transfer of ownership of futures contracts. The former argue that to enhance transferability, trading in futures is confined to adopting only impersonal and objective specifications of contractual performance. These enforcement measures effectively reduce differences in the costs to traders of enforcing contracts, thereby making a contract more uniformly enforceable over a wider range of potential holders.

Viewed from Teiser's perspective, this has the important effect of increasing the liquidity of the market.

Unfortunately, these restrictions imposed upon the measurement technology by transferability considerations are not without their cost, as they may deliberately suppress information which is of value to cash market traders when evaluating the objects of trade. Thus, futures contract markets adopt a transactional mode unable to offer traders the same contractual enforcement options they would possess when transacting in the regular cash market. Here, governance structures may supplement impersonal and objective specifications with additional, more idiosyncratic measures of contractual enforcement.² Those considered earlier are primary examples. When this suppression of information occurs, the specifications used to govern futures trading are termed contractually incomplete. Contractual incompleteness places the futures contract at a comparative disadvantage, relative to the cash market, as a method of transacting in the commodity.

How does this comparative disadvantage manifest itself? McManus and Acheson (1979, 1983) demonstrate that the net gains from trade foregone by using the relatively inferior mode of transacting, the futures market, will: (i) be directly reflected in the difference between the buy-sell spreads in the futures and cash markets, and (ii) imply a range of indeterminacy in the futures price within which price movements cannot be constrained by potential arbitrage transactions in the delivery market for contract goods. For contracts containing a delivery option, the delivery market is established by the measures specified in the futures contract determining satisfaction of contractual obligations at delivery. This range of arbitrage indeterminacy creates an opportunity for manipulation of the value of the contract by individuals with lower cost access to the contract market, specifically, exchange member brokers.³

Although commodity exchanges regulation of trading activity will attempt to restrict the potential for exploitation of the incompleteness of certain futures contracts, an inability to

perfectly constrain such activities implies non-exchange members are inherently at a disadvantage when assuming a position in the contract market. As the expected losses to such traders from their futures transactions are directly related to the inability of arbitrage to constrain futures settlement price changes, the more contractually incomplete the contract, the less likely it will be to attract non-member order flow. This reduction in the potential number of traders will diminish transferability of the contract, curtail trading interest in the market, and may be severe enough to lead to its failure. This hypothesis, relating contractual incompleteness to futures market 'thinness' and potential failure, first proposed in McManus and Acheson (1979), is henceforth designated the measurement cost hypothesis.

To place this hypothesis in context, one major deficiency in the theory of futures trading is the lack of a systematic analytical framework from which the necessary conditions for the feasibility and success of trading in a futures contract can be derived. A consistent theme emerging from an examination of the typical life cycle of a futures market is that the rate of contractual failure is significant. Carlton (1984) studies 184 contracts listed in the Wall St Journal between 1921 and 1983, and his findings will be used as illustrative.⁴ The majority (over 57 per cent) of new futures contracts become dormant within 10 years of their introduction on a commodity exchange, with over 40 per cent of all contracts falling dormant by the end of their sixth year. If a contract survives its sixth year, it then has a better than even chance of surviving for 20 years, by which time 70 percent of all futures contract innovations have become dormant or have been delisted. For those contracts in existence in 1921, and those introduced in the years through 1983, the average lifetime is less than 12 years and the median approximately seven years. Excluding futures contracts already in existence in 1921, which are above average in terms of their success rate, the average contract lifetime falls to nine years and the median to five.

Moreover, with the exception of financial contracts, whose introduction is too recent to enable current data to accurately reflect their life patterns, the similarities across commodity

groups are more evident than the differences.⁶ A cross-section examination of commodity classifications reveals that excepting the metals, 55 per cent of contracts possess life cycles under nine years. Of all commodity groupings, industrial materials have the longest average life (14.7 years), while metals have the smallest (9.1 years). Industrial materials also have the longest median life (13 years), while livestock have the shortest (5 years).

What theories have been advanced to explain the patterns of futures market 'thinness' and failure across different contracts? Working (1953, 1954) hypothesises the major reason for contractual failure is the lack of hedging interest in the contract market. Working argues that futures trading emerges only when there is a need for hedging facilities by those producing, handling, merchandising or processing the commodity. In turn, a hedging need arises when there are, or are expected to be, material fluctuations in the price of the commodity, for it is then that any price discovery function of the futures contract is enhanced.

The identification of this critical role played by commercial hedging interest stimulated the formation of several other theories in the literature, which although differing in their emphasis, have interconnecting themes. Carlton (1983) maintains that if, as evidence suggests (Fischer (1981)), periods of price inflation coincide with periods of increased relative price dispersion, one may expect inflation and futures trading volume to be positively correlated. This he attributes to the use of futures positions to mitigate the effects of real price uncertainty. Carlton finds that, all things equal, each one per cent increase in the rate of inflation is associated with a nine per cent increase in trading volume in oats futures, and a six per cent volume increase in both wheat and corn futures. It is suggested that trading volume would fall if the real price uncertainty associated with inflation diminished.

Given the importance of price fluctuations in creating hedging interest, there is likely to be a conspicuous lack of futures trading in commodities subject to certain specific government policies, such as price controls or price stabilisation schemes. Government price support programs in peanuts and tobacco appear to be a major factor in stifling trading interest in

these commodities. Trading in cotton was virtually eliminated at a time when government stocks were large and increasing, and did not revive until after the disappearance of the government inventory. During the World War II period, one would conjecture that government controls played a major role in the reduction of the number of futures markets from a pre-war level of over 50 to 17 in 1945. By 1946, when a number of restrictions had been relaxed, the number of active markets had grown to 36. More recently, acting through the Commodity Credit Corporation (CCC), the US government had been gradually decumulating grain stocks since 1973. This development was paralleled by a trading volume increase on grain futures contract markets. In the early 1980's CCC influence on grain prices began to reappear. For example, in 1981-1982 the CCC accumulated its largest stocks since 1973. Perhaps it is no coincidence that trading volume in grains in 1982 was significantly below that in 1981. Further evidence on the effect of government regulation on futures market trading activity is discussed in Telser and Higinbotham (1977), and Telser (1981).

It is also maintained that to be viable, a futures contract must succeed in attracting a sufficient body of non-hedging traders (scalpers and other speculators), to maintain sufficient market liquidity and trading continuity (Gray (1967) and Working (1967)). The activities of these traders facilitate the placing and lifting of hedge positions, and in their absence the execution costs of hedging could be driven high enough to reduce hedgers' interest in the contract.

Thus, viable futures trading is also seen to be dependent upon those factors likely to influence the level of speculative activity in the contract market. On the supply side, speculative interest is likely to be heavily influenced by the processes determining equilibrium contract market prices. Market structure considerations now become paramount. Generally, one would expect a conspicuous absence of futures trading in contracts were the cash market supply is concentrated in a small number of sources. Here, concern would relate to the possibility that individuals possessing market power could manipulate cash prices, or through

their control of deliverable supply, increase the risk of 'corners' and 'squeezes', in the contract market as delivery approaches. This activity would occur to the detriment of other market participants.' However, despite the threat of such practices, it appears market structure considerations, even in such heavily concentrated industries as aluminium and chemicals (petroleum), are themselves not sufficient to suppress the credibility of a futures market when either the existing pricing structure is perceived to be unstable (owing for instance to large excess capacity in the industry (Carlton (1984)), or when increased supply sources become temporarily available.

On the demand side, market structure will impact upon hedging use of the market through its effect upon the nature and availability of adequate substitutes for futures trading. The benefits accruing from the establishment of a futures market to allocate price risk and provide a price discovery mechanism for commodity traders, depend upon the existence of feasible alternative governance structures serving the same function. Consider the position of a risk averse grain elevator operator, storing wheat for future delivery via the cash market to a flour producer. The elevator operator may desire to hedge against the revenue loss which would result from a fall in the price of wheat while it is in storage. Several distinct options suggest themselves as a possibilities. The elevator operator could:

- (1) Assume a position in the appropriate futures contract.
- (2) Store a diversified portfolio of grains.
- (3) Sell shares in the equity market, and let the shareholders diversify away the risk.
- (4) Enter into a long-term forward contract with the flour producer.
- (5) Vertically integrate with the flour producer.

The general point is that traders with an interest in the cash market may be accustomed to, or prefer, other hedging arrangements which dispense with the need to engage in futures trading.' This points to a fundamental weakness in the price insurance theory of futures trading. This theory does not explain why an organised futures market is necessary to accommodate the hedging needs of cash market participants (Telser (1981)). Indeed, casual

empiricism would suggest that hedging by forward contracts is by far the most prevalent arrangement.

Nowhere in the essays to follow is it claimed that the measurement cost hypothesis provides the grand unification theory by which these diverse strands of thought on contract market 'thinness' and failure can be effectively synthesised. However, the choice of research strategy does reflect the belief that the analysis of one component of transaction costs, namely measurement costs, and their relationship to the structure of contracts and property rights, may provoke the insights, and eventually produce the research necessary to resolve the deficiencies in current approaches.

The central purpose of the essays which follow is to suggest ways in which the measurement cost hypothesis can be made amenable to empirical verification. In the process, several directions in which the existing analysis can usefully be generalised are also proposed. A direct test of the hypothesis is precluded as estimates of the potential gain to individual traders utilisation of idiosyncratic measurement devices across different cash markets cannot be ascertained directly. Although no claim is made that the tests proposed are definitive (given certain of the evidence alluded to may be explained using other existing theories), the consistency of test results across alternative independent specifications of the model attest to its robustness and potential generality.

The content of the essays to follow can be briefly summarised. Chapter II details the incentives for one class of informed traders, trading specialists in the relevant cash markets, to engage in the exploitation of incompletely specified contracts by the delivery of contract goods during the contracts delivery period. These incentives are argued to be directly related to the comparative disadvantage of transacting via futures. Given commodity exchanges have an interest in restraining such activity, it is argued that the regulatory constraints on redelivery procedures may be interpreted as attempts to prevent opportunistic behaviour by these more informed (i.e. lower measurement cost) traders. As such they are manifestations of

an inherent contractual weakness. The costs of attenuating the potential for such opportunism will, however, vary across contract markets, and in some will prove prohibitive. The hypothesis that failed and dormant contract markets are those which have exhibited the greatest difficulty in reducing the resource losses and wealth transfers from informed trader's exploitation of incompletely specified contracts, is then formalised and tested using qualitative response models. The results obtained are broadly consistent with the theory.

Chapter III clarifies the consequences of the range of arbitrage indeterminacy in certain futures prices for the conventional theory of intertemporal price relationships for storable commodities. Specifically, the model develops testable propositions relating to the relative price variability of open and spread contract portfolios. By relating this relative price variability to the initial speculative margin requirements established by commodity exchanges, results of tests of the measurement cost hypothesis using contract market data on margin requirements for one hundred and eleven commodities for the period 1970-1984 are presented. Again corroboration of the hypothesis is evidenced.

The final essay in chapter IV extends the model of chapter III to analyse its implications for the behaviour of the price volatility of spread positions in futures as the spreads constituent contracts approach maturity. After a comparison of the model's predictions with those of currently existing alternatives, tests are conducted in an attempt to distinguish between the empirical predictions of the various analyses. The results of the tests are inconclusive, and appear sensitive to their specification, in particular the measure of price volatility adopted. A future research agenda would be to attempt to refine the model further, enabling a more discriminating analysis of its implications to be conducted.

FOOTNOTES

1. For examples and further discussion see Klein and Leffler (1981), Barzel (1982), and Williamson (1983).
2. By assumption, the measures adopted in the cash market produce the maximum gains from trade, net of the costs of measurement.
3. Joseph Mehl ((1937), p. 314) as cited in McManus and Acheson (1979), commenting on regulation under the Grain Futures Act is instructive:

"An earlier case involved certain floor brokers who systematically injected themselves between the trades of customers for price cuts from 1/8 to 2 cents per bushel, depending upon the movement in the market while the orders were in their possession."
4. The markets listed in the Wall Street Journal account for the vast majority of all US futures trading, measured by the total volume of contracts traded. In 1983, the final year of the Carlton study, they accounted for 98 per cent of total trading.
5. Three contracts are listed continuously over the entire 1921-1983 period: wheat on the Minneapolis Grain Exchange, Oats on the Chicago Board of Trade, and cotton on the New York Cotton Exchange.
6. Carlton adopts the following commodity classifications: foodstuffs, grains, metals, industrial materials, livestock, oilseed products, and financial instruments.
7. For an explicit model, see Kyle (1984).
8. It is not suggested that a desire to hedge their cash market exposure would be the only, or even a major reason for grain elevator operators, or cash market participants in any commodity, to engage in trading futures. For alternative explanations, including the hypothesis that these traders take futures positions to speculate on the cash futures price differential (the basis), see Working (1953).

CHAPTER II MEASUREMENT COSTS AND REGULATION: DELIVERY PROVISIONS IN FUTURES CONTRACTS

INTRODUCTION

This essay is an investigation of the importance of measurement costs in the design of futures contracts. Measurement costs are defined as the costs of quantifying the information necessary to verify fulfillment of a contractual obligation in the absence of trust.¹ Adopting Williamson's (1979) perspective that the assessment of transaction (measurement) costs is a comparative institutional undertaking, an analysis of contractual arrangements existing during the delivery period of a futures contract provides an ideal opportunity to identify actual dimensions with respect to which measurement costs differ across transacting modes. For futures contracts possessing a delivery option, the delivery period encompasses two coincident spot markets dealing in the same commodity, the regular cash market and the delivery market for contract goods. However, as both McManus and Acheson (1979, 1983) and Telser (1981, 1986) argue, the former is an institutional mode designed to maximize the net gains to exclusivity, while the latter attempts to maximize the expected net gains from ownership of the right to transfer.² Perhaps Telser puts the argument most tersely in his conviction that futures markets exist to "facilitate trade among strangers."³

Section I of the essay demonstrates that the difference in ownership rights being transacted is not vacuous, indicating why transferability considerations may preclude the adoption of the most efficient measurement technology in futures contracts. When this occurs a market is designated contractually incomplete. The discussion is illustrated with evidence drawn from secondary sources describing market institutions in the cotton market. The importance measurement considerations play in a contract market's choice of delivery mechanisms, either cash settlement or a delivery option, is the subject of section II. A delivery option is shown to be necessary in certain markets to prevent manipulation of the settlement price of the contract. The manipulative activity considered differs from that almost

universally discussed in the literature, in that it does not emanate from monopoly power, in the sense of 'corners' or 'squeezes' resulting from concentration of deliverable supplies in the hands of a few traders, but from contractual constraints upon the measurement technology. Section III details the measurement procedures adopted by contract markets in the delivery period, and indicates the resulting incentives which may occur for traders to engage in the unhedged production of contract goods. These incentives are demonstrated to be directly related to the comparative disadvantage of transacting via futures. It is argued the self-regulatory constraints imposed by commodity exchanges in the delivery month, can be interpreted as attempts to minimize the losses resulting from contractual terms which may lead to incentives for the production of contract goods. The cost of attenuating the dissipation will, however, vary across contract markets, and be greatest in those futures which are contractually incomplete. These are also the markets argued to be most open to manipulation by traders with lower costs of measurement. This manipulative activity exploits other potential contract holders, reducing the transferability of contracts and possibly culminates in the failure of the contract market. The hypothesis that thin or dormant contract markets are those which have exhibited the greatest costs in reducing the resource losses resulting from such manipulative activity is formalised, and tested using qualitative response models in section IV. The results provide tentative support for the postulated relationship. Some concluding remarks follow.

I: MEASUREMENT COSTS AND ALTERNATIVE CONTRACTUAL SPECIFICATIONS

In order to examine the nature and incidence of measurement costs, this essay adopts a framework of analysis which provides an exhaustive classification of measurement procedures. The framework is first proposed in Acheson and McManus (1979), and certain of its relevant components are now outlined. The results of a measurement technology that the respective contracting parties agree may be verified by an independent third party replicating the

measurement procedure, is said to consist of objective measures. Although these measures may be explicitly incorporated into any contractual agreement, such an objective description of the rights to be transferred will often be incomplete. Trading parties will supplement them by subjectively (or idiosyncratically) monitoring certain elements of contractual performance. The characteristic feature of these measures is the inability of transacting parties to agree on their verification in a jointly satisfactory manner.⁴

Both methods of contractual enforcement indicated above may be supplemented by a further measure if the identity of one or both of the contracting parties is of importance in specifying the value of the contractual obligation. The monitoring technology then incorporates a personal measure, for example, when the seller or buyer is named in a contract. The distinguishing feature of such a contract is the inability of the designated principal(s) to unilaterally transfer their obligations to another individual. In contrast, when the bundles of rights owned by different individuals trade at the same price per unit as objectively described in the contract regardless of the principal's identity, the contract is said to be specified impersonally. An impersonal specification is, therefore, a necessary condition for contracting principals to possess the right to unilaterally transfer their contractual obligations.

As all measurement procedures involve costs, the gains from transacting will be a function of the procedures adopted by the contract governing the exchange process. By assumption, contracting parties select those measures, thus the form of contract, maximizing the gains from transacting in the relevant exclusive rights associated with ownership, net of the cost of specifying and enforcing performance.

Following Williamson (1976, 1979), Goldberg (1976) and Barzel (1982) it is clear that for many transactions, the enforcement of only impersonal and objective measures (or those markets normally termed price taking) are often revealed uneconomical compared to the more personalized, idiosyncratic alternatives adopted in price searching cash markets. However, in an effort to enhance transferability of the asset in question, governance structures sometimes

suppress these latter methods of trading. The associated costs are perhaps best illustrated by consideration of the relative costs of transacting in forward and futures markets. The definition of 'futures' and 'forward' this essay adopts, again proposed in McManus and Acheson (1979), and consistent with Telser's (1981, 1986) analysis, is particularly well suited to present purposes, as it incorporates explicit consideration of the measurement costs associated with the right to transfer an exclusive asset.

A contract is simply a promise or set of promises, the performance of which is recognized as a legal duty of the contracting parties. A futures contract is written so that it may be performed by unidentified third parties. This right to transfer contractual obligations accorded to both principals, is a feature which emerges as a produced attribute of the contract governing the exchange process. Specifically, to ensure bi-lateral transferability, futures contract specifications must be objective and impersonal.⁷ In contrast, in a forward contract, at least one of the contracting parties will agree to assume personal responsibility for performance of the promised obligation, and for that individual the contract is not transferable. A forward contract incorporates identity as a valued specification of performance, therefore embodying an explicit denial of the right to transfer. The parties to a forward contract may also agree to the use of subjective measures of contractual enforcement.

For our purposes, it is sufficient to note two characteristics of the alternative contractual forms governing exchange which are distinguished by the respective measurement devices employed. First, the contractual rights established by the futures contract will in general not correspond to those which would be adopted in a governance structure designed to maximize the net benefit from transferring exclusivity. A simple objective description of a commodity as transacted in the cash (spot and forward) market is usually incomplete, as it does not constrain all the characteristics of goods entering into sellers costs and buyers evaluations. Because of measurement costs, commodities designated to be of the same grade when classified accurately on the basis of the discrete objective measurement standards, may

vary considerably in quality and value. L.D. Howell's description of the imprecision of U.S.D.A. grading standards in cotton is illustrative:

"If the differences in value of cotton of different qualities within grade and staple length designations are proportionately about as great as the differences in value from one grade and staple length designation to another - and this appears to be a reasonable assumption - the differences between the market value of the highest quality of Low Middling 15/16-inch cotton and that of the lowest quality of Low Middling 15/16-inch cotton in Houston during the year ended July 1954 averaged more than 3 cents a pound." (emphasis added)

To circumvent such difficulties, trading in cash markets regularly supplements the use of objective and impersonal specifications with personal, subjective measures and relies upon subjective monitoring for contractual enforcement. The institutional features of cash markets (brand names, reciprocal dealing, the use of warranties, etc.) simply offer traders more measurement alternatives than a futures contract, and as such will usually possess a comparative advantage over the latter in organising the specified transaction. The ability of subjective monitoring techniques to more easily detect variations in quality within the range of qualities defined by the official standards in cotton, can again be clarified by reference to Howell:

"...unpublished data relating to prices of cotton sold on ex-warehouse terms in New Orleans during the seasons 1929-30 and 1930-31 ... show that cotton designated as "full" in grade or staple length sold at a premium over the price of cotton equal in quality to the average for the standard. These premiums amounted, on the average, to about one-half of the difference between the price of cotton of the next higher grade and longer staple.... Cotton sold on ex-warehouse terms in New Orleans and described as "shy" in grade or staple length sold at a discount from the price of cotton equal in quality to the average for the standard. The discount amounted, on the average, to approximately 30 per cent of the difference between the price of cotton of the specified grade and staple length and that of the next lower grade and shorter staple."

Second, measurement is not performed in any market with perfect precision. As Barzel (1982) indicates, if the cost of measurement rises with accuracy, there will exist some errors in measurement traders will not find it worthwhile to eliminate. A certain degree of imprecision will be tolerated by traders, who transact with the knowledge that the behaviour

of sellers will not perfectly conform to the preferences of buyers. These differences in the value of the commodity as a result of random variations in quality would exist even if classification, based on the discrete measurement standards, were absolutely accurate. Any constraints imposed upon the trading parties' choice of measurement techniques compounds the problem, in the present example serving to increase the range in the value of cotton included within a specified grade and staple length designation. The buyer and/or the seller may have an incentive to exploit this imprecision arising from inefficient measurement, by engaging in costly alterations of the traded commodity to their own advantage, without foregoing a loss in expected revenue equal to the market price per the units in which the commodity is being measured (McManus (1975)). Such wealth maximizing activity on the part of individuals, resulting from costly measurement and random errors therein, takes place at the expense of joint maximization. The following discussion demonstrates why transferability considerations imply the existence of such opportunities in futures markets, indicates the effects upon trader behaviour, and attempts to identify the governance structures which emerge to minimize the losses from the dissipating exploitation of measurement errors.

II: THE CHOICE OF PERFORMANCE MECHANISMS IN CONTRACT MARKETS

a: Cash Settlement and Price Taking Markets

The delivery month of a futures contract is that specified period of time within which parties to outstanding contracts must fulfill their contractual obligations. All futures contracts specify one of two forms of contractual performance. Trading principals are either required to make and take delivery of the asset designated in the contract, subject to enforcement of the contractual specifications indicated therein, or the contract will specify performance through cash settlement.

McManus and Acheson (1979, 1983) and Garbade and Silber (1983a,b), while differing significantly in their emphasis, both argue that the mechanism underlying the contractual choice between cash settlement and physical delivery as the method of performance, can be clarified by consideration of the ability of the futures contract to incorporate the measurement devices adopted in cash market trading. A stylized synthesis of their insights follows. In essence, when the futures contract enters the delivery month it becomes a spot contract. Effectively, there are then two coincident spot markets in operation, the contract goods market and the regular cash market. If the relevant cash market is price taking, futures contract specifications can perfectly duplicate, at the same measurement cost, those used in the cash market.⁹ Except for the timing of the transaction, which shall be ignored, the two markets are ostensibly equivalent and the seller (buyer) will be indifferent between making (taking) delivery and a cash sale (purchase). Arbitrage by risk neutral traders ensures that prior to the delivery month, the futures price will be an unbiased estimate of the spot price expected on the first delivery day, and during the delivery month the price to buyers will be identical in the cash and futures markets.⁹ Clearly, once a procedure for drawing and utilising cash market price observations has been stipulated, outstanding futures contracts written on commodities trading in price taking cash markets, are amenable to performance by a transfer of cash payments. These payments are calculated as the difference between the value of a traders contractual obligation and the final settlement price when the contract matures.¹⁰

b: The Delivery Option and Price Searching Markets

The problems encountered by cash settlement are revealed upon consideration of futures contracts which relate to price searching cash markets. A characteristic feature of such markets is that buy sell spreads differ across trading principals.¹¹ One result of these differences in measurement costs is that price searching markets do not provide a price that traders would all agree on is the market price at any moment of time. Once more, Howell's analysis of certain of the existing cash market trading procedures operative in the cotton market is

enlightening:

"Much of the cotton in designated markets is sold in mixed lots of various sizes composed of two or more grades and staple lengths at an average price for all cotton included in the lot. Differences in terms and conditions of sale, in size and composition of the lots sold, in bargaining power of traders in the market, in quality and value of cotton of the same grade and staple designation, and in other factors affect the markets. Therefore, prices of cotton of the same grade and staple designation, sold in the same market on the same day vary widely.... Under such conditions, it is obviously difficult to arrive at quotations that accurately reflect actual commercial values or price differences for cotton of the various grades and staple lengths."¹²

A cash settlement procedure is unfavourable to the fair determination of a price at which contractual obligations can be settled in such futures markets. Transferability and enforcement considerations require the exclusion of subjective measurement procedures from the terms of the futures contract. The problem with cash settlement arises in attempting to establish an acceptable rule for drawing upon and utilising cash prices at contract maturity in the construction of a cash settlement index. The relative incompleteness of the measures incorporated in the futures contract may create an incentive for the production of commodities with attributes chosen to deliberately affect the final settlement price. Market participants when observing cash market prices at contract expiry, will encounter difficulties in distinguishing between:

- (i) prices relating to trading in commodities which have been produced incorporating only those attributes objectively specified in the futures contract, and
- (ii) prices relating to trading in goods which is designed to generate revenue from the subjective and personal monitoring of cash market traders.

A trader in possession of this information, could take a position in futures which would generate a sufficient (risk-adjusted) return to more than offset its cost. As futures trading is a zero-sum game, this return is made at the expense of other futures market participants.

The function of the delivery option now becomes clearer.¹ This provision establishes a delivery market where transactions are negotiated and enforced subject to the measures

adopted in the futures contract. The settlement price of the contract is then revealed, through arbitrage, by potential transactions in the delivery market, and not from transactions on the pertinent cash market.

Traders in futures will take into account the cost and value of contract goods, defined as those commodities incorporating the minimum attributes necessary to meet futures contract specifications. Production of contract goods would generate commodities with different attributes, and/or levels of attributes, than would be planned for cash market delivery. Attributes left unspecified in the futures contract or measured with less precision than in the spot market will be less intensively produced in contract goods.¹⁴ If the market price does not appear a true reflection of the market value of these contract goods, either shorts can plan to acquire or produce the commodity below the futures price and deliver on their obligations for a clear gain, or longs may take delivery of commodities they expect to be worth more than the price they will pay.

The delivery option, therefore, attempts to enforce against informed traders manipulation of the value of the futures contract. This enforcement is attained at a cost, as trading in contract goods is confined to a transactional mode which is relatively inefficient, being unable to offer traders the same enforcement options they possess in the regular cash market. Over the range of reduction in quality attributes, the fall in the cost of production and measurement for delivery to sellers, must be less than the corresponding reduction in value to buyers. Otherwise futures contract specifications would be utilised in cash markets.

In equilibrium the losses associated with competition in the planned delivery of contract goods cannot persist. As it involves an ex ante loss to one class of trading principal (either longs unaware of the quality of eligible deliveries, or shorts mistakenly planning deliveries in the belief longs are uninformed), the misinformation upon which such production is based will be self-correcting.¹⁵ As such, the final settlement price of the contract with a delivery option, will reflect the value of the lowest quality goods sold in regular cash markets which

meet the delivery specifications stipulated in the futures contract.¹⁰

The net gains from trade foregone by using this relatively inferior mode, will be directly reflected in the difference in the buy-sell spreads between the futures and cash markets. This difference creates a range of indeterminacy in the futures price, within which price movements cannot be constrained by potential arbitrage via delivery. An opportunity then exists for manipulation of the value of the contract by traders with lower cost access to the contract market. The greater the contractual incompleteness of the futures contract, and the less sensitive the futures price to arbitrage, the greater the expected loss to other potential traders of taking a position in the contract. These individuals will avoid the market, inhibiting transferability of the contract. Consequently, one may expect the contract market to become thin or even dormant.

As estimates of the potential gains to traders' use of subjective measures in different cash markets cannot be ascertained, a direct test of this measurement cost hypothesis relating contractual failure to informed traders' exploitation of measurement errors is prohibited. The next two sections argue that, as an alternative, the severity of futures exchange restrictions on the redelivery of contract goods may be used as a proxy measure for the degree to which the futures contract is incomplete. Empirical evidence, linking the severity of redelivery restrictions to contract failure is then examined, and argued to lend tentative corroboration to the hypothesis.

The emphasis of this analysis is to be contrasted with that of Edwards and Edwards (1984) who write:

"Neither contracts with a cash delivery feature or those written on stock indices are intrinsically more susceptible to manipulation than are other, more traditional, types of futures contracts. Indeed, such contracts are likely to be less prone to manipulation."¹¹

The authors contend that the cash settlement feature of such contracts reduces the transaction costs associated with specifying a broader deliverable supply, thereby permitting the contracts to be written on a 'large enough' cash market to sufficiently discourage manipulative activity. From the context of their argument (p.345), it is clear that by manipulative activity, the authors are referring to the potential for the exercise of temporary monopoly power as manifest in "corners" or "squeezes" near or in the delivery period of the contract. Although the occurrence of such activity appears to be a non-trivial problem,¹⁸ it is not of direct relevance to the present analysis. Here the concern is upon informational asymmetries resulting from differential costs of measurement, rather than monopoly power as the source of any manipulation.¹⁹ These effects can be isolated through consideration of futures contracts pertaining to commodities which trade in open, competitive cash markets, i.e., those with no exclusive right to trade. Such markets are not necessarily price taking.²⁰

III: THE DELIVERY PERIOD OF A FUTURES CONTRACT

To examine the incidence and specific nature of the measurement difficulties encountered in transacting via the futures market, attention is confined to a consideration of the relevant institutional procedures governing trading in the delivery period of futures contracts containing a delivery option. Once trading enters the delivery (or maturity) period, each contract holder with a short position has the contractual right to sell (deliver) the quantity and quality of the specified commodity at the location(s) stipulated in the futures contract. To implement delivery, the short issues a formal delivery notice, or notice of intent to deliver to the exchange clearing house on the position day of his choice. This can be at any time from the first notice day to the last day of trading in the delivery month. It is understood that when tendering the delivery notice, the seller has complied with all the obligations imposed by the delivery procedures of the exchange clearing house. Foremost among these, is having the grade and quality of the commodity certified by officially

approved exchange inspectors.

The measures utilised in certifying contract goods are, of course, those objective measures specified in the futures contract. The procedures adopted by the Chicago Mercantile Exchange are typical and will be used for illustration. All agricultural commodities delivered through the exchange carry an Exchange Inspection Certificate bearing the signature of the President or Executive Vice-President and the seal of the Exchange. If the contract grades are based on USDA standards, the commodity is inspected by government inspectors, and the government inspection certificate is attached to that of the exchange.²¹ In the case of non-agricultural commodities, certification is undertaken by an exchange approved refiner, assayer or other authority.²² The exchange itself is not liable for any error or negligence of any inspector, and all claims for liability relating to inspections are waived by the application for an Exchange Inspection, Weighing or Testing certificate.²³ Moreover, the exchange assumes no responsibility and disclaims all liability on account of the grade, quantity or specifications of any commodity delivered on the basis of an U.S.D.A. or other required inspection certificate.²⁴ In addition, the delivery notice will generally stipulate the name and business address of the issuer (clearing member), the date of issue, the date of delivery, a description of the negotiable instrument by which title to the commodity will be transferred, and any other information exchange regulations and contractual specifications require in regard to any particular commodity. It is important to note, that all deliveries on maturing contracts are made through the exchange clearing house.²⁵

On receipt of the delivery notice, the clearing house promptly (the same business day) informs a designated long (clearing member) that they are obligated to take delivery of the contract goods from the short issuing the notice. The procedure for apportioning notices varies from exchange to exchange. On some exchanges the clearing member with the oldest open long position receives the notice; on others, it is assigned to the member with the oldest net long position. Finally, some clearing houses allocate notices according to the percentage of the

gross long position in the delivery month held by their clearing firms. In turn, the clearing firm informs the long trading principal with the oldest open position (as of close of trading the previous day), that they are bound to accept delivery.

Once in receipt of the names of the buyers (clearing member(s)) obligated to receive delivery, the seller prepares invoices containing the net invoicing price, which is the last settlement price plus or minus allowances and adjustments, provisions for which are made in the futures contract. Ownership of the commodity is transferred on the delivery day, at which time the buyer is entitled to all documents required by the delivery notice, with such endorsements as may be necessary to convey title and possession. One may note at this juncture that unlike trading on the regular cash market, the buyer is not free to inspect the commodity prior to delivery and refuse any tendered unit which they do not perceive to be of contract quality.

(i) Production of Contract Goods: Incentives and Effects

The next task is to develop a model to analyse under what circumstances traders' participating in the exchange of goods during the delivery period of a futures contract, obtain net gains from engaging in the unhedged production of contract goods. This will facilitate the derivation of the equilibrium cash-futures price relationships existing during the delivery period of the futures contract. It is also central in explaining this essay's rationale as to the nature and purpose of the regulations imposed by commodity exchanges on the redelivery of goods during the futures delivery period.

a: The Cash Market

Production and sale in the cash market is assumed to be undertaken by risk neutral individuals and occurs in unit size bundles, at a constant cost of c_c per bundle. Each unit produced for cash market delivery contains two quality categories of goods, high quality with

an expected value q_h , and low quality (contract goods), with an expected value q_l . High and low quality goods differ only in the amount of subjectively valued attributes they contain. In general, the quantity of q_h and q_l goods varies across bundles. This variation in quality is a result of exogenous factors effecting the production function of cash market goods. For simplicity, it is assumed that the values of bundles of cash market goods are uniformly distributed over the interval $(q_h - q_l)$. Thus, if the average proportion of q_h and q_l goods in each bundle is p and $(1-p)$, respectively, then $p = 0.5$. The expected value of the average quality bundle produced for sale in the cash market is $q_a = pq_h + (1-p)q_l = 0.5q_h + 0.5q_l$.

To motivate the requirement of a variety of qualities being exchanged in a single cash market transaction, it is assumed that on a stand-alone basis, a cash market in contract goods would not be viable. If low quality goods could be produced at a cost of say, c_l per bundle, where $c_c > c_l$, this requires that the production and delivery costs of a unit of contract goods exceeds their value, $c_l + x > q_l$, which in turn implies $c_c + x > q_l$. The difference $c_c - c_l$ will be directly related to the contractual incompleteness of the futures contract.

Individuals trading in the cash market all possess the same cost of objective measurement, $\$x$. In addition, idiosyncratic measurement may be undertaken by traders to form an estimate of the proportion of high and low quality goods in each bundle. This subjective measurement cost is fixed at $\$f$ per unit, where $f < q_a - (c_c + x)$. To motivate buyers spending $\$f$ to subjectively evaluate cash market purchases, they are assumed to be risk averse with respect to variations in wealth.

Individual buyers are assumed to differ in their ability to measure quality proportions in cash market bundles. They fall into two categories, designated informed (or I type), and uninformed (or U-type). At any given cost of idiosyncratic measurement, a representative I-type trader is assumed to assess the value of a given bundle more accurately, and with

lower variability, than a U-type trader. Specifically, at a measurement cost of \$f, an i-type trader ($i = I, U$), accurately estimates the quality of a bundle with probability z_i . They believe a bundle to be above (below) average quality in proportion to the average amount of q_h (q_l) goods in each bundle. As bundles are drawn from a uniform distribution over the interval $(q_h - q_l)$, the probabilities of over- and undervaluation are equal, at the level $0.5(1 - z_i)$. To reflect the assumption that informed traders perform measurement with greater accuracy and precision, $z_I > z_U$, which in turn, implies $0.5(1 - z_I) < 0.5(1 - z_U)$.

Cash market trading procedures are designed to capture competition for tendered bundles between I- and U-type traders, and are represented as follows. Once a buyer has subjectively estimated the quality of a bundle, they submit a bid price, b_{ij} , ($i = I, U$; $j = h, a, l$), to the seller. The bid price may be thought of as derived from a marginal willingness to pay schedule (inverse demand schedule) b_i , which is dependent upon a certainty equivalent measure q_c , reflecting the buyer's subjective assessment of a given bundle's quality, $b_i = b(q_c)$, $db/dq_c > 0$. Thus, the bid price represents the maximum price that an i-type trader will pay for the bundle, and is made privately and independently by buyer to seller. This is the simplest way to explicitly rule out the possibility of informational free-riding across different buyer-types. Bids may be considered as average bids within their class, and are assumed to fall into three categories; high b_h , low b_l , and accurate b_a . The bid levels are defined in relation to the (unknown) actual quality level of the bundle, with $b_h > b_a > b_l$. The earlier assumption that the quality of goods within each quality category is stochastic, is sufficient to rule out the possibility that buyers find it profitable to submit low bids, b_l , without incurring the fixed measurement cost, \$f. In addition, bids satisfy the following restrictions:

(i) the accurate bid price is a weighted average of the high and low bids, with weights corresponding to the average proportion of high and low quality goods in each bundle. This implies $b_a = 0.5b_h + 0.5b_l$. More will be said regarding the specific level of bids later in the chapter. Clearly, given positive costs of subjective assessment, $b_a < q_a - f$.

(ii) the difference between high and low quality bids is positively related to the difference in traders' valuation of high and low quality goods;

$$(2.1) \quad b_h - b_l = f(q_h - q_l), \quad f'(\cdot) > 0.$$

Once bids have been received, the bundle is sold to the highest bidder. In the event two individuals submit identical bids, the bundle is assigned randomly.

In general, goods delivered on the cash market will be measured to the extent that an additional unit of expenditure devoted to measurement yields a unit increment in expected value to the seller and buyer jointly (Barzel 1982). The commodity will then have been sorted optimally in that by assertion, any further expenditure on measurement will increase the expected value of the commodity by less than that unit. In the above model, absent a mechanism whereby sellers can credibly signal to buyers the precise quality of any delivered bundle, competition ensures that in equilibrium, sellers will refrain from assessing the quality of their goods prior to sale. Bundles of goods of mixed quality will be sold in the cash market.

b: The Futures Market

Concurrent with the operation of the cash market, at time T , individuals may also make and accept delivery of the commodity in the delivery market created by a futures contract. The objective specifications governing quality standards for delivery in the futures market, are identical to those used in cash trading, and contract size is one unit. Thus, traders may deliver both high and low quality goods, or a mixture thereof, to satisfy any futures delivery obligations at a cos. of $\$x$ above the per unit production cost. If no production of contract goods q_l occurs, production and delivery via futures will cost a minimum of $c_c + x$ per unit delivered, and in the absence of quality sorting, goods tendered in satisfaction of futures obligations will have an expected value of q_a .

(ii) Equilibrium in the Cash Market

Consider a representative informed and uninformed buyer engaged in a bidding competition to secure a bundle of cash market goods. The task is to determine which trader will secure the bundle, and to calculate the average bid price they will pay.

a: Informed Traders

Informed buyers obtain the bundle if $b_I > b_U$, or $b_I = b_U$ and they are awarded the bundle via the random allocation procedure. The possible bid prices of informed buyer's, together with the associated probability of obtaining the bundle at each price, y_{Ij} , ($j = h, a, l$), are given by:

- (i) price b_h : probability $y_{Ih} = 0.125(1 - \tau_I)(1 - \tau_U) + 0.5(1 - \tau_I)(1 - 0.5(1 - \tau_U))$
- (ii) price b_a : probability $y_{Ia} = 0.5(\tau_I/\tau_U) + 0.5\tau_I(1 - \tau_U)$
- (iii) price b_l : probability $y_{Il} = 0.125(1 - \tau_I)(1 - \tau_U)$

b: Uninformed Traders

Uninformed buyers obtain the bundle if $b_U > b_I$, or $b_U = b_I$ and they are awarded the bundle via the random allocation procedure. The possible bid prices of uninformed buyer's, together with the associated probability of obtaining the bundle at each price, y_{Uj} , ($j = h, a, l$), are given by:

- (i) price b_h : probability $y_{Uh} = 0.125(1 - \tau_U)(1 - \tau_I) + 0.5(1 - \tau_U)(1 - 0.5(1 - \tau_I))$
- (ii) price b_a : probability $y_{Ua} = 0.5(\tau_U/\tau_I) + 0.5\tau_U(1 - \tau_I)$
- (iii) price b_l : probability $y_{Ul} = 0.125(1 - \tau_U)(1 - \tau_I)$

Several features of this allocation mechanism are worth comment. First, for any given τ_I, τ_U , the probabilities of informed and uninformed traders obtaining the bundle are equal. In this model, this is a consequence of the assumption that the average bundle contains q_h .

and q_l goods in equal proportions. In general, if y_i is the probability an i -type trader ($i = I, U$) obtains the bundle, then $y_I - y_U = (1 - 2p)(r_I - r_U)$. Restricting p to be 0.5 in the present model, simplifies the analysis without effecting the qualitative conclusions.

Second, as $y_I = y_U = 0.5$, the average price paid per bundle is, for i -type buyers:

$$2\{y_{ih}(b_h) + y_{ia}(b_a) + y_{il}(b_l)\}$$

Substituting for y_{ih} , y_{ia} , and y_{il} , the average bid prices paid by informed and uninformed traders which secure a cash market bundle are, respectively:

$$I\text{-type: } b_I = b_h\{0.5 - 0.5(r_I - r_U) - 0.5(r_I r_U)\} + b_a\{0.5 + 0.5(r_I - r_U) + 0.5(r_I r_U)\}$$

$$U\text{-type: } b_U = b_h\{0.5 - 0.5(r_U - r_I) - 0.5(r_U r_I)\} + b_a\{0.5 + 0.5(r_U - r_I) + 0.5(r_U r_I)\}$$

The difference in average winning bids is, therefore:

$$(2.2) \quad b_U - b_I = (b_h - b_a)(r_I - r_U) > 0.$$

The average winning bid of the uninformed buyer exceeds that of the informed buyer, and the latter gain more surplus than the uninformed buyers from their cash market trading activities. The reason is that the uninformed buyers are more likely than the informed to win the bidding when their subjective estimate of the quality of the bundle is too high, and lose when it is too low. Moreover, $d(b_U - b_I)/d(r_I - r_U) > 0$: for any given distribution of quality levels in a cash market bundle, the difference in average winning bids of uninformed and informed traders, $(b_U - b_I)$, is positively related to the difference in accuracy of traders' subjective measurement capabilities, $r_I - r_U$.

Third, it was earlier assumed that the difference between average high and low bids is positively related to the difference in the expected quality valuation of high and low quality goods, $b_h - b_l = f(q_h - q_l)$, $f(\cdot) > 0$. Substituting for b_a in equation (2.2) from (2.1) implies:

$$(2.3) \quad d(b_U - b_I)/d(q_h - q_l) = 0.5(r_I - r_U) f'(\cdot) > 0.$$

The natural way to depict an increase in contractual incompleteness in the present model, is by way of a mean-preserving spread increase in the range of qualities comprising the q_a

bundle. Thus, equation (2.3) indicates that the difference between the average cash market prices paid by informed and uninformed traders increases, the greater the comparative disadvantage of engaging in transactions governed simply by the objective specifications of the futures contract relative to those governed by cash market trading procedures.

If the cash market continues to attract participants:

- (i) buyers' gross purchase price (winning bids plus costs of idiosyncratic measurement) must not exceed the expected value of the average quality bundle, $b_i + f \leq q_a$, and
- (ii) sellers' net revenue must cover their cost of production plus objective measurement, $c_c + v \leq b_i$.

Consider one possible scenario:

$$c_c + v < b_i + f < b_U + f \leq q_a.$$

As described, informed buyers obtain a surplus from their cash market transactions of magnitude $(q_a - b_i - f)$, while, in the limit, uninformed traders pay a price for the average quality bundle equal to its expected value ($b_U + f = q_a$). Rather than continue to trade at a disadvantage to informed individuals, uninformed traders may prefer to trade in the delivery market established by the futures contract for goods of the same objective description as those trading in the cash market. By trading in the futures market, uninformed traders save \$f, and will obtain, on average, a better price for each bundle purchased (it is later demonstrated that in equilibrium the maximum futures price, $f(T,T) = q_a$). However, given the quality of a bundle delivered in the futures market can vary between q_l and q_h , by foregoing the opportunity to idiosyncratically (albeit imperfectly) ascertain the quality of delivered goods, uninformed traders have increased their wealth variability in relation to quality for the bundles they actually purchase.

The revealed outcome is that two governance structures for delivery of the same objectively defined commodity may be in operation simultaneously. Informed buyers do not find it profitable to migrate to the delivery market established by the futures contract, and

would trade with each other, adopting conventional practices, in the regular cash market. Uninformed buyers would be active in the delivery market established by the futures contract.

The reader may inquire why, given the potential benefits to uninformed individuals, an equivalent governance structure to the delivery market in contract goods is not established in conjunction with the existing cash market. This would preclude the necessity of taking delivery via futures. The revealed absence of such a market implies that the costs of establishing this governance structure exceed the discounted benefits uninformed traders derive from its existence. The futures exchange may, however, be prepared to subsidise the existence of the delivery market with the returns generated from futures trading activity. The reason is that earlier indicated. The presence of a delivery market is, for some contracts, necessary to prevent manipulation of the futures settlement price, thereby promoting trading activity in the contract market. The circumstances under which a commodity can sustain deliveries in both cash and futures markets are analysed in the next section.

(iii) Equilibrium in the Futures Market

Earlier discussion, following Acheson and McManus (1979, 1983), related the constraints on the bounds of the futures settlement price of a futures contract possessing a delivery option to potential arbitrage transactions in the delivery market for contract goods. Clearly, therefore, such bounds will be sensitive to variations in the unit cost and delivery of contract goods. While the dynamics of settlement price behaviour are considered more fully in Chapter IV, an appreciation of its central features is crucial to the present analysis, and are briefly summarised.

Specifically, assume a cost function for contract goods, $c_f + x$, with the properties discussed in Alchian (1953), namely; (i) for a given total volume of production, the minimum per unit cost of production increases with the rate of production at an increasing rate; (ii) for a given rate of production, over some range of output, minimum per unit costs

decline with planned volume of output; (iii) minimum per unit costs of production with respect to increased rates of production decrease as the total contemplated volume of output increases. Under these conditions, movements in the futures settlement price will be sufficient to deter the competitive hedged production of contract goods. As no contract goods are expected to be available, the higher costs of producing and sorting goods closer to the delivery period, implies a tendency for the futures price to rise as the maturity period of the contract approaches. This increase in the futures price will continue until $c_1 + x = c_c + v$, i.e. the cost of production and delivery of contract goods, equals that of the lowest quality goods meeting contractual specifications which are produced for delivery on the regular cash market. If no contract goods are produced for delivery, this synthesis of pricing relations in cash and futures will occur at/by contract maturity. Under this scenario, in the present model, goods of quality q_a are traded in the futures market, where they are purchased by uninformed individuals. They sell for a maximum price, $f(T,T)$, equal to their expected value, q_a , while their minimum sale price $b_1 \leq q_a - f$, cannot fall below the average price received by sellers for goods of the same average quality trading in the regular cash market. (As uninformed individuals trade in the delivery market for contract goods, this will be the average cash market price paid by informed traders.) If the futures settlement price fell any further, the delivery market could not induce any cash market goods to be presented for delivery. The equilibrium cash futures price relationship during the delivery period is dictated by the value of the average quality of the most profitable grades of the commodity available for delivery under the respective governance structures.¹⁶ Notice that as goods are not sorted by sellers prior to futures delivery, unless $f(T,T) = q_a$, uninformed traders generate surplus from taking delivery via the futures market.

(iv) Market Failure in the Futures Market

Clearly, as earlier discussed, if the production of contract goods is expected, the existence of a price taking futures market equilibrium is precluded. However, consider another

case where potential producers of contract goods are small enough to be treated as a monopolist. Additionally, assume the cost function for contract goods is such that their supply is perfectly inelastic during the delivery period.

Now the concern is that the dynamics of the futures settlement price may be unable to deter unhedged production of contract goods, prior to the delivery period, at the lowest cost volume and rate of production, $\min\{c_1 + x\}$, with the intention of selling them during the maturity period, by which time the futures price will have risen sufficiently to make the activity profitable on average. The presence of two conditions is necessary for this unhedged production of contract goods to occur. First, as indicated above, the delivery of contract goods must be unexpected. Any transactions in goods produced as a result of the existence of an incomplete futures contract generate ex post losses to traders. Under full information, the associated trading losses cannot persist in equilibrium, as they may be avoided by dealing in the regular cash market. Second, the level of open interest in the contract market must be sufficient to sustain the level of planned deliveries. Given the assumed properties of the cost function, any constrained volume effects may serve to raise production costs sufficiently to make planned production of contract goods unprofitable (even for risk neutral traders).

In the presence of these two conditions, a producer of contract goods could potentially benefit by assuming a short position in the futures market in excess of their planned deliveries in the contract market. Their resulting gain derives from two sources. First they obtain the difference between the futures settlement price at the time delivery is initiated, and the per unit cost of production and delivery of contract goods, $(c_1 + x)$. Second, as the production of contract goods is unexpected, their presence will only be revealed after delivery has occurred. After this information becomes available, under circumstances to be demonstrated later, the futures price will have a tendency to fall to the maximum buyers will be prepared to pay for low quality goods, $f(T,T) = q_1$. This generates a further positive return to any residual short position (i.e. that in excess of deliveries) held by traders delivering contract

goods. This short position may be closed-out by assuming an equal and opposite long position in the contract market at the favourable lower futures price. Traders must offset against these gains, any losses arising from increases in the futures price, at a time prior to the delivery period, during which they held a net short position.

From the perspective of uninformed traders accepting delivery via futures, the unhedged production of contract goods creates an adverse selection problem, which acts to severely mitigate their incentives to participate in the futures delivery market. As discussed earlier, although a trader would not willingly take delivery of contract goods at a price above q_1 , longs accepting delivery via futures are unable to inspect goods prior to receipt. Consequently, when a commodity bundle is tendered for futures delivery, they possess no mechanism by which they can distinguish between: (i) a randomly selected commodity bundle, with an average quality equivalent to that exchanged in the cash market, and (ii) contract goods. Clearly, the potential unhedged production of contract goods, will have far reaching implications for the nature of the equilibrium in the futures contract delivery market.

Once the existence of contract goods is revealed after delivery, there may be no sustainable equilibrium cash-futures price relationship during the remainder of the delivery period which involves continuous delivery under both governance structures. Note, that once a delivery of contract goods has been effected, their producer has an incentive to reveal their existence (if not their origin) to market participants. This publicity given to the presence of contract goods, will induce buyers to revise downwards their expectations concerning the average quality of goods they expect to be delivered via the futures market, in the process causing a decline in the equilibrium futures settlement price. This fall in price would lead to a positive return to the monopoly producer's residual short position.

(v) Redelivery Regulations and Futures Market Equilibrium

This essay argues that the degree to which information on the existence of contract goods can impact upon the futures settlement price, is directly related to the extent contractual provisions place restrictions on the redelivery of goods that have already been tendered during the delivery period. Redelivery on futures markets is undertaken when a long who has previously accepted delivery assumes a short position in the contract and reissues a notice of intent to the clearing house in the same delivery period. Provided contract goods have not been removed from their initial delivery location, and their exchange inspection certificate has not been invalidated,²⁷ redelivered commodities are assured of fulfilling contractual specifications.

a: Redelivery Permitted

If unconstrained redelivery is allowed, once information attesting to the unexpected presence of contract goods is received in the market, the futures price which formerly reflected the average quality of the most profitable grade of the commodity available for delivery, will exhibit a tendency to fall towards q_1 . The magnitude of this fall reflects the extent to which traders continuing to participate in the contract market, expect further futures deliveries within the delivery period, to consist of contract goods. A critical point in the decline of $f(T,T)$ is reached at $f(T,T) = b_1$, after which the futures settlement price falls below the average price received by sellers for goods trading in the regular cash market. Once the price declines below this level, sellers no longer have an incentive to deliver any goods produced for the cash market via futures, as they can obtain a higher expected return in the regular cash market. Any further deliveries in the futures market will be comprised entirely of redelivered bundles of contract goods. Buyers will not be prepared to reward the delivery of such goods, and the futures price will fall to q_1 . Concern regarding potential redelivery of contract goods has effectively eliminated the futures contract delivery market. This eliminates the benefits accruing to both the uninformed traders, who customarily take delivery via futures, and to the exchanges own members, who suffer from the reduction in

contract market trading volume.

b: Redelivery Constrained

Trading in all existing futures contracts is governed by the rules of formally organised commodity exchanges, established explicitly for the purpose of earning revenue for their membership from the trading of contracts. Ideally, the commodity exchange would like to mitigate the incentives for unhedged production of contract goods, while preserving the delivery market in futures. This they can do to some degree, through the self-regulatory constraints they impose on trading activity, specifically redelivery, during the delivery period of a contract. Consider an exchange invoking the ultimate sanction, outright prohibition of redelivery. Market participants have then received a credible commitment that in the event of any unanticipated deliveries of contract goods, such commodities could not be recirculated to satisfy further contractual obligations later in the delivery period.

The advantages to market participants are easily enumerated. First, as further deliveries of contract goods will be unexpected, the probability that average quality bundles will be delivered via futures over the remaining duration of the delivery period is increased relative to a situation in which redelivery is unconstrained. Second, the equilibrium futures price will no longer be sensitive to the delivery of contract goods. The failure of the futures price to fall consequent to the delivery of contract goods, eliminates the returns to holders of any residual short positions (i.e. producers of contract goods) from wagering on the futures price. Although this will reduce the incentives for traders to engage in the unhedged production of contract goods, such activity is unlikely to be totally precluded. A monopoly producer may still find it profitable to produce and deliver just enough contract goods to reduce the value of the average quality bundle delivered via futures by an amount sufficient to dissipate some, or all, of the surplus which is otherwise obtained by uninformed buyers taking delivery in the contract market.

Against these benefits must be offset the costs associated with overly constraining trading activity in the delivery market for contract goods. As the time during which delivery can be undertaken is reduced, shorts desiring to make delivery run an increased risk that cash market supplies in the delivery locations specified in the contract, will become concentrated in the hands of traders holding long positions. This monopolisation of the cash market allows the longs to 'squeeze' the shorts, by temporarily withholding supplies of goods from the cash market. Shorts, anxious to purchase goods to fulfil delivery obligations, will increase their bid prices for goods, thereby driving up both cash and futures market prices, realising immediate gains to the longs. As a result of these trade-offs, faced with the possibility of a squeeze, one would conjecture that redelivery constraints would only be imposed by the exchange, to the minimum degree necessary to mitigate the effects of the unhedged production of contract goods. A total ban on all redelivery activity would not generally be predicted.

In the context of the present model, the maximum magnitude of the redelivery constraints required to preclude contract goods production is equal to $q_a - \min(c_j + \lambda)$, the difference between the average value of cash commodities, and the cost of production of contract goods. This difference will be larger, the less completely the measures governing fulfillment of the futures contract constrain the range of qualities which may be offered in satisfaction of futures delivery obligations. In other words, the greater the contractual incompleteness of the futures contract, the greater the severity of the delivery restrictions that have to be imposed to vitiate the incentives for unhedged production of contract goods.

The redelivery constraints also serve as a signal to uninformed buyers that they are entering a fair game when transacting for delivery in the contract market. In particular, they ensure that any sorting errors on redelivered goods are random not biased. Absent such constraints on behaviour, the transferability of contractual obligations will be impeded, and the volume of futures trading diminished.²⁴ Thus, this analysis is consistent with the view

expressed by Grossman:

"it is in the interest of an exchange to self-regulate some types of informed trading...the negative consequence of informed trading is that it can decrease the participation of traders. That is, there are some types of informed trading that increase the risk of participation and hence will lead to a decrease in the volume of trade that takes place on the floor of the exchange."²⁹

It should be stressed that unlike previous studies addressing the issue of incomplete contractual specifications, the use of implicit governance structures such as warranties, brand names, various forms of long term contracts, or vertical restraints are not advocated as a response to the dilemma.³⁰ The distinguishing feature of these contractual forms is their reliance upon personal attributes of at least one of the trading parties. As transferability considerations require futures contracts are specified impersonally, their use in this transactional mode is effectively precluded. Reliance must instead be placed upon the explicit self-regulatory constraints exchanges impose upon the trading activities of individuals wishing to take a position in the contract market. These regulations are considered to be among the most restrictive of those applying to any class of commodity transactions.³¹ With respect to the reduction of the losses deriving from the unhedged production of contract goods, the regulatory constraints will be confined to the maturity period of the contract, when traders attempt to exploit the gains from such activities.

Caution must be exercised not to interpret the preceding analysis too narrowly. Recall that incentives for production of contract goods have been argued to be directly related to the comparative disadvantage of trading via the futures contract. As a consequence, the severity of the regulations at delivery are simply a maturity period manifestation of, thus may be utilised as a proxy for, a fundamental contractual weakness, namely its inability to cost effectively replicate cash market measurement procedures. More importantly, in this capacity they reflect opportunities for informed traders manipulation of the value of futures obligations which have existed throughout the life of the contract. The implication of the latter consideration is that for some commodities, trading in the contract market will not be a fair

game at any stage in the life of the contract. Despite the best efforts of the exchange to constrain such trader behaviour, the most obvious being the arbitrage opportunity present in the delivery option, the reluctance of other trading parties to risk their wealth by participation in the market may ultimately be revealed directly by its failure.

IV: EMPIRICAL PROCEDURES

The following empirical work is intended to analyse the nature of the nexus between the commodity futures market's choice of contractual constraints governing trading in the delivery period of a contract, and the perceived success or failure of the contract market. The variety of contractual restrictions governing redelivery procedures, both intraexchange and interexchange on U.S. contract markets is striking, ranging from attempts at discouragement by making redelivery more costly, to outright prohibition. A study of fifty-three contracts, representative of those possessing a delivery option¹² and which traded on a U.S. commodity exchange during the 1970-84 period, revealed the most common delivery restrictions to be as follows:

R1: Nontransferability of Delivery Notices:

Certain contracts totally preclude the possibility of redelivery, by postulating that delivery be undertaken by means of a non-transferable delivery notice. The provisions of such contracts stipulate only one day on which notices of intent can be issued, almost universally the last trading day in the expiring contract month. These notices are then assigned to buyers in the manner indicated earlier, without any opportunity for retendering of delivered goods in the same delivery period. A sample contract is as follows:¹³

(a) Initiation of Deliveries: Deliveries shall be initiated by the presentation to the Clearing House by the seller by 5 p.m. on the last day of trading in the delivery month of a signed delivery notice.

(b) Notice Day: The Clearing House shall pass the delivery notice to the oldest buyer on the morning of the next Exchange business day. The day the buyer receives the delivery notice shall be referred to as the Notice Day.

(c) Delivery Notices are Non-Transferable: The buyer who thus receives a Delivery Notice from the Clearing House shall accept delivery. Delivery Notices are not transferable.

R2: Redelivery Fee:

This categorisation covers two contingencies. Certain contracts allow redelivery concomitant with payment of a fee by the retendering short. This fee is attached to the delivery notice and is payable to the long who accepts or is designated redelivery. Other contracts permit redelivery only after the retendering short has assumed legal ownership of the goods for a twenty-four hour period, implying they are responsible for all holding costs associated with the commodity for that period of time. The fees will deter the redelivery of contract goods if they exceed the potential gain the retendering short expects to extract from engaging in it. There follows a representative contractual stipulation of the redelivery fee:³⁴

- (a) A clearing member representing a long that is assigned a Certificate of Delivery may retender that Certificate.
- (b) A Certificate may not be retendered after the last trading day of the contract month. In order to retender, a long assigned a Certificate must establish a short position in the delivery month.
- (c) The retendering short will be assessed a retender charge of \$x per contract. The retender charges accrue to the Certificate and are payable to the long assigned the Certificate.

R3: Time Limits on Redelivery:

For these contracts, provision is allowed for redelivery only within a certain period following the time the notice of intent to deliver was first issued. A technical reason for setting a time limit on the validity of certificates is that the commodity is perishable in the sense that its quality and grade deteriorate with time. The Fresh Eggs and Live Cattle contracts trading at the Chicago Mercantile Exchange would be examples of such goods. Generally, these stipulations will curtail the redelivery of contract goods if the time during which the retendering short can profitably conduct the activity exceeds that available under the contract. A typical provisions states:³⁵

- (a) A Certificate of Delivery that has been assigned to a clearing member may be retendered only up to the Nth business day after assignment. In order to retender the assignee must establish a short position in the contract month by

10:30 a.m. on the day of retender. Retender is made at the settlement price on the day of retendering less accrued carrying charges.

(b) A clearing member who is assigned a Certificate that is eligible for retender must inform the Clearing House by 10:40 a.m. on the day of retender whether it is: (1) exercising the Certificate; (2) retendering the Certificate; (3) postponing the retender. To be eligible for postponing retender one day, the clearing member must have entered a market order between 9:30 a.m. and 10:30 a.m. and have not received a fill, and by 10:40 a.m. submit to the Clearing House a copy of this unfilled market order.

(c) A clearing member who has delayed retender as a result of being unable to establish a short position cannot subsequently exercise the Certificate, except that if retender cannot be made on the last day of trading, the Certificate must be exercised.

a: Data and Test Procedure

The hypothesis under consideration maintains that the degree of contractual incompleteness of the futures contract, as reflected in the severity of exchange imposed delivery/redelivery restrictions, is inversely related to the trading success of the contract. The fifty-three contracts alluded to earlier are utilised as the data sample. The contracts are listed in Appendix 2.1.

Probability models of qualitative choice are estimated for the following binary dependent variable: whether the commodity exchange has chosen to delist the commodity contract over the 1970-84 period, or has allowed it to continue trading. A value of one indicates that the contract was delisted during the 1970-84 period; the variable equals zero otherwise.

The explanatory variables consist of commodity exchanges restrictions on delivery/redelivery which are serving as proxy measures for the extent of contractual incompleteness. Also included as an explanatory variable is the smallest ratio of open to spread initial margin requirements operative at delivery over the 1970-84 period, the rationale for the inclusion of which is discussed in Chapter III.¹⁰ Specifically, the vector of independent variables utilised in the study is defined as follows:

REDEL = one, indicates that the contract goods delivered by the short first effecting delivery, can be utilised for subsequent delivery within the same maturity period; the variable equals

zero otherwise.

REFFEE = minimum accrued fees and allowances attached to retendering of certificates of delivery, and redelivery of contract goods in the same delivery period, payable by the retendering short. The fees are initially classified in terms of a dummy variable assigned a value of one for fees greater than one days storage charges, and zero otherwise. However, as these fees are conditional upon goods being redeliverable, in the estimation equation they are represented by an interactive dummy variable, obtained by multiplying the current dummy variable with the value for the dummy variable representing REDEL. This procedure follows a suggestion in Johnston (1972).

RETIM = maximum operative time limit within which goods initially tendered in satisfaction of a delivery obligation may be redelivered. The time is defined both as a percentage of eligible delivery days within the delivery period, RETIM(1), and as the absolute time, in days, within which redelivery can be made, RETIM(2).

MARGIN = ratio of open to spread initial speculative margin requirements on the last day of trading in the contract.

PERISH = one, indicates that either the quality or the grade of the commodity initially delivered is time dependent, in the sense such commodities are effectively prohibited from being subsequently redelivered within the same delivery period; the variable equals zero otherwise.

A minimum degree of perishability has been enumerated as a prerequisite characteristic for a commodity to be successfully traded on a futures market (Baer and Saxon (1948)). As recent experiences with such commodities as live cattle, fresh eggs, and live hogs indicates, the reasoning behind such arguments has been revealed to be flawed. Perishability per se, appears to have no role as a necessary condition for the trading success of an efficiently designed futures contract.

From previous discussion the expected signs of the estimated coefficients are as follows:
 REDEL < 0; REFEED > 0; RETIM < 0; MARGIN < 0; PFRISH < 0.

b: Test Specification

The data on futures contracts are examined using two alternative but closely related techniques, employed when the dependent variable of interest is dichotomous rather than continuous. The first procedure adopted is a simple linear probability specification, a methodology related to linear regression. The dependent variable, whether the contract is dormant/delisted or still trading, is observable only in a 0 or 1 state. The model creates predicted values for each sample point (y_i) equating the predicted probabilities of group membership, where the estimated model is $E(y_i) = f(x_i) + u_i$, and $E(u_i) = 0$. Its distinguishing feature in relation to other binary choice models lies in the specification of the $f(x_i)$ function. Under a linear probability specification, one performs ordinary least squares on the dichotomous dependent variable and interprets the estimated coefficients as measuring the effect on the probability of the dependent variable equalling one, of a unit change in the explanatory variable. That is, the model assumes the true functional form of $f(x_i)$ to be $\alpha + \beta x_i$.

The advantage of the linear probability model is the straightforward interpretation of the coefficients. However, the methodology has several major shortcomings. First, and most serious, is that the predicted probabilities need not necessarily fall between 0 and 1. Second, the Bernoulli character of y_i implies a variance for u_i of $(\alpha + \beta x_i)(1 - \alpha - \beta x_i)$. Since the variance of u_i depends on i , the u_i are heteroscedastic, implying ordinary least squares will result in inefficient estimates, and although the estimated coefficients are unbiased, the estimated standard errors are not consistent, and the usual tests of significance for the coefficients (t-tests) do not apply. Correction for heteroscedasticity is undertaken, however, following a procedure outlined by White (1980) which provides a consistent estimate of the variance-covariance matrix that is positive definite. Third, the fitted relationship is very

sensitive to the values taken by the explanatory variables, especially when they are bunched. Finally, since the y_i 's are not normally distributed, no method of estimation that is linear in the y_i 's is generally efficient. That is an estimator that is linear in the y_i 's such as ordinary or generalized least squares can be improved upon.

Although Amemiya (1981) suggests using a linear probability specification to obtain estimates in the preliminary stages of econometric estimation, the difficulties associated with its use point to the need for alternative model specifications.¹⁷ Since the most serious set of difficulties arise from the fact that predictions be outside the {0, 1} interval, searching for distributional assumptions confining the predictions to within the appropriate interval would appear the natural alternative. The contract data are, therefore, also analysed utilising a logit model, which differs from the linear probability model in its specification of the $f(x_i)$ function, setting $f(x_i) = 1/(1 + e^{-(\alpha + \beta x_i)})$, with e representing the base of natural logarithms. A simple transformation of this model yields a functional relationship which is linear in its parameters, and a maximum likelihood estimation process may then be employed which yields consistent and asymptotically efficient estimations. (Amemiya (1981), Maddala (1983)).

c: Empirical Results

The results of the full sample estimations appear in Table 2.1. With the exception of the values of the RFTIM(.) coefficients in the logit specification, all of the signs in equations (1) - (4) confirm the expectations of the measurement cost hypothesis outlined earlier. Furthermore, again exempting the RETIM (.) variables, in all four equations the estimated coefficients are significantly different from zero at commonly accepted levels of significance. However, a potentially serious problem arises with the current specification and should be noted. Given both the RFTIM(.) variables are positive (zero) when REDEL is one (zero), these three explanatory variables are likely to be highly positively multicollinear. The resulting inefficiencies of the estimation procedure are well documented (e.g. Judges et al. (1982)). This

conjecture was confirmed on examination of zero-order and partial correlation coefficients. As neither the acquisition of new data or new information was considered likely to resolve the multicollinearity problem, a solution was sought in re-estimating the equations, omitting the RETIM(.) variables from one set of estimates, and the RFDFI and RFFFF variables from the other.

The results of the procedure adopted are presented in Table 2.2. In these estimates, all coefficients are significant and confirm prior expectations with respect to sign. This suggests the lack of explanatory power in the RETIM(.) variables in the full sample estimation may be a result of a multicollinearity problem.

Owing to the nature of the logit and linear probability models, as they stand the regression coefficients are not directly comparable, although a variety of options still exist for relating the different models. Comparing models in terms of goodness of fit, one may use the maximum likelihood results to obtain statistics analagous to R^2 . The results of the procedures suggested by McFadden (1974) and Cragg and Uhler (1970) are reported, both giving R^2 measures for the logit model in general slightly higher than the adjusted R^2 from the linear probability model, suggesting the former specification may be preferable. The significance levels for the logit model reported in the final row of Tables 2.1 and 2.2, are based upon likelihood ratio tests. Statistical significance is determined by comparing the log of the likelihood function of the models as estimated, with that generated by regressing the dependent variable only on a constant term. Using this criteria all logit models are significant at the 1% level. Row (12) presents an alternative measure of goodness of fit for the logit estimate, the in-sample predictive success of the model, which varies from 81.1 to 92.5 per cent.¹⁴

In the light of these findings, and the theoretical objections to the linear probability specification alluded to earlier, one is tempted to conclude that logit is the preferred specification. Independent of this consideration, whatever model one adopts, the measurement

cost hypothesis appears to perform tolerably well in explaining cross-sectional variation in the choice of contractual constraints in the delivery period of commodity futures contracts.

V: CONCLUDING REMARKS

One of the lessons which emerges from the recent literature examining efficiency properties of alternative contractual forms under conditions of imperfect information, is that attention to transactional detail is required in order to reveal the issues of interest. In general, this approach pioneered by Williamson (1976, 1979) and Goldberg (1976), emphasises identifying mechanisms for monitoring, adapting and terminating long-term relationships between trading principals, and in the process has criticised economic theory for excessive utilisation of the discrete-transaction paradigm in discussing exchanges of property rights.

While agreeing in substance with the aforementioned authors, the orientation of this essay is somewhat different. Interesting questions involving contracting modes, in particular the notion of transferability as a produced attribute of contracts, may be analysed absently from the presence of long-term relationships between trading principals. As Cheung (1974) and McManus and Acheson (1979, 1983) indicate, the right to exclude and the right to transfer exclusivity to others should be considered as separate elements in the generation of rents obtainable from ownership. The present study of futures and forward contracts reveals this distinction also has comparative institutional significance. An analysis of commodity futures contracts isolated certain difficulties inherent in the adoption by futures contracts of measurement and contractual enforcement procedures designed to maximise the net gains to transferability. These problems arise explicitly from the inability of these contracts to adopt idiosyncratic and subjective measurement procedures. One avenue through which they are manifest, is the resulting incentives that certain trading principals possess to engage in the privately beneficial, but socially inefficient production of contract goods, for delivery when the

futures contract matures. These activities tend to dissipate the net gains from the right to transfer. Competition among contract markets will secure the evolution of contractual forms serving to minimise these losses, including where appropriate the imposition of regulations on trading activity which appear difficult to comprehend otherwise. Despite the best efforts of futures exchanges, the costs of attenuating this behaviour will vary across commodity contracts and the evidence presented in the analysis seems to indicate that in some cases, these costs are high enough to lead to the markets eventual failure. The results of this essay are preliminary, but suggest further empirical work assessing the importance of measurement costs in the organisation of markets, will yield important insights into issues of comparative institutional choice.

Table 2.1

The Effects of Independent Variables on Commodity Exchange Policy Choice

Independent Variable	ESTIMATION METHOD			
	Linear 1	Probability 2	Logit 3	4
REDFI	-0.6971** (-3.05)	-0.6058** (-2.16)	-5.0681** (-2.43)	-4.4453** (-1.99)
RIFFF	0.4770** (2.87)	0.4427** (2.37)	3.0905** (2.13)	2.9274* (1.94)
RETIM(1)	--	-0.0393 (-0.18)	--	0.2276 (0.12)
RETIM(2)	-0.0048 (-0.42)	--	0.0739 (0.61)	--
PERISH	-0.4524** (-3.31)	-0.4582** (-3.36)	-3.2157** (-2.71)	-3.2171** (-2.72)
MARGIN	-0.0226** (-2.52)	-0.0217** (-2.44)	-0.8055** (-2.04)	-0.7684* (-1.95)
CONSTANT	1.0223** (8.25)	1.0221** (8.22)	5.6715** (2.91)	5.5522** (2.86)
R ²	0.55	0.55	--	--
SFF	0.349	0.349	--	--
McFadden R ²			0.57	0.54
Cragg Uhler R ²			0.73	0.72
Percent of Correct Predictions			90.5	92.5
Likelihood Ratio Test			41.28**	40.92**

Note: Student t-values appear in parentheses under respective coefficients; t-tests for significance are two tailed tests. Population size equals 53 contracts.

a: Percentage of correct classifications using the following rule: classify in dormant group ($P = 1$) if $P > .5$; classify to active group ($P = 0$) if $P < .5$ where P is predicted probability above and P is observed value.

b: χ^2 statistics with ν degrees of freedom, where ν is the number of constraints embodied in the hypothesis being tested minus the number of constraints in the alternative hypothesis.

** 5% level of significance

* 10% level of significance

Table 2.2

The Effects of Independent Variables on Commodity Exchange Policy Choice

Independent Variable	ESTIMATION METHOD					
	1	Linear Probability 2	3	4	Logit 5	6
REDFI.	-0.6402** (-3.77)	--	--	-4.2457** (-2.82)	--	--
RFFFF	0.4568** (2.97)	--	--	2.8513** (2.08)	--	--
RFTIM(1)	--	--	-0.4816** (-3.38)	--	--	-2.667** (-2.33)
RFTIM(2)	--	-0.0265** (-2.87)	--	--	-0.1325* (-1.91)	--
PERISH	-0.4563** (-3.36)	-0.4012** (-2.83)	-0.4220** (-3.13)	-3.2208** (-2.72)	-2.229** (-2.47)	-2.6127** (-2.54)
MARGIN	-0.2180** (-2.40)	-0.0323** (-2.86)	-0.0312** (-4.32)	-0.7584** (-1.97)	-0.5318** (-1.94)	-0.5712** (-1.97)
CONSTANT	1.0216** (8.23)	0.9640** (8.93)	1.0078** (9.62)	5.5228** (2.88)	3.6604** (2.99)	4.2170** (3.07)
R ²	0.55	0.45	0.49	--	--	--
SFF	0.346	0.378	0.365	--	--	--
McFadden R ²				0.56	0.45	0.49
Cragg Uhler R ²				0.72	0.61	0.65
Percent of ^a Correct Predictions				92.5	81.1	84.9
Likelihood ^b Ratio Test				40.90**	32.69**	35.96**

Note: Student t-values appear in parentheses under respective coefficients; t-tests for significance are two tailed tests. Population size equals 53 contracts.

a: Percentage of correct classifications using the following rule: classify in dormant group ($P = 1$) if $P > .5$; classify to active group ($P = 0$) if $P < .5$ where P is predicted probability above and P is observed value.

b: χ^2 statistics with ν degrees of freedom, where ν is the number of constraints embodied in the hypothesis being tested minus the number of constraints in the alternative hypothesis.

- ** 5% level of significance
- * 10% level of significance

APPENDIX 2.1

The 53 contracts included in the sample, listed following the Commodity Exchange on which they trade(d) are:

New York Mercantile Exchange: Gold, Aluminium, Butter, Idaho Potatoes, Apples, Plywood, Nickel, Imported Boneless Beef;

New York Cotton Exchange: Cotton #2;

Coffee, Sugar and Cocoa Exchange: Sugar #12, Coffee 'C';

Commodity Exchange Incorporated: Silver;

Chicago Board of Trade: Wheat, Corn, Oats, Soybeans, Soybean Oil, Soybean Meal, Gold, Silver;

Chicago Mercantile Exchange (incl. IMM): Russets, Stud Lumber, Skinned Hams, Turkeys, Milo, Plywood, U.S. Silver Coins, U.S. T-Notes, Copper, Platinum, Frozen Eggs, Eggs, Frozen Pork Bellies, Leaded Regular Gas, No 2, Fuel Oil, Broiler Chickens, Feeder Cattle, Live Cattle, 90-day T-Bills, Domestic C.D.'s, Gold;

Mid-America Commodity Exchange: Live Cattle, Live Hogs, Refined Sugar, Oats, Silver (Chicago), Silver (New York), Gold, Rough Rice, Wheat, Soybeans, Corn;

Kansas City Board of Trade: Sorghum.

APPENDIX 2.2

A Definition of Variables

Dependent Variable	Redel	Margin	Refec	Retim(1)	Retim(2)	Perish
1	1	2	1	0.64	11	0
1	1	2.5	1	0.011	0.125	0
1	0	1.67	0	0	0	1
1	0	3	0	0	0	1
1	0	2	0	0	0	1
1	0	2.5	0	0	0	0
1	1	3	1	0.011	0.125	0
1	0	2	0	0	0	0
1	0	1.33	0	0	0	0
1	0	1.67	0	0	0	1
1	1	1.14	0	0.64	9	0
1	1	3	1	0.875	13	0
1	1	4	0	0.875	13	0

1	0	3	0	0	0	1
1	0	5	0	0	0	0
1	0	3.25	0	0	0	0
1	1	1.67	1	0.8	12	0
1	1	6	1	0.8	12	0
1	1	2.2	0	0.8	12	0
0	1	3.1	0	0.98	9	0
0	1	1.75	1	0.98	13	1
0	1	2.18	0	0.92	14	0
1	0	3.67	0	0	0	0
1	0	3.67	0	0	0	0
0	0	5	0	0	0	1
0	1	2.1	0	0.92	13	1
0	1	2.1	1	0.153	2	1
0	1	2.1	1	0	0	1
0	1	20	0	0.94	16	0
0	1	20	0	0.94	16	0
0	1	20	0	0.94	16	0
0	1	20	0	0.91	12	0
0	1	20	0	0.91	12	0
0	1	20	0	0.91	12	0
0	1	20	0	0.94	16	0
0	1	20	0	0.94	16	0
0	1	3.3	0	0.97	5	0
0	0	2.6	0	0	0	0
0	0	4.37	0	0	0	1
0	1	20	0	0.92	13	0
0	1	4.5	1	0.153	2	1
0	1	3	1	0.86	13	1
0	0	4	0	0	0	0
0	1	6	0	0.94	16	0
0	1	6.67	0	0.94	16	0
0	1	7	0	0.94	16	0
0	1	20	0	0.94	16	0
0	1	15	0	0.94	16	0
0	1	15	0	0.9	10	0
0	1	15	0	0.94	16	0
0	1	18	0	0.91	12	0
0	1	10	0	0.94	16	0
1	0	5	0	0	0	0

FOOTNOTES

1. Measurement (Transaction) costs can tentatively be divided into the costs of enforcing exclusive rights to valued attributes, and the cost of enforcing agreements made to transfer rights from one owner to another. Any voluntary exchange relationship between two individuals requires that the partners exclude others from the use of the attributes being exchanged, and that both parties are sufficiently certain of what they are buying and selling to expect that the trade will generate mutual gains.
2. The distinction between the right to exclude and the right to transfer exclusivity to others, is meaningful "only if rights are costly to enforce and only if enforcement costs vary for different individuals." McManus and Acheson (1983 p.1). For purposes of the present study, the issue is that the gains to exclusivity and transferability are not, in general, joint products.
3. Telser (1981 p.1). Telser develops his theme by drawing an analogy between the theory of futures markets and the theory of money. A measurement costs explanation of the emergence of money as a medium of exchange may be found in Alchian (1977).
4. Specific examples of such arrangements are described in Klein and Leffler (1981), and Barzel (1982).
5. Thus, although the emphasis in this essay is upon measurement costs, the importance of transferability serves to highlight certain common ground with the approaches taken by Telser (1981, 1986) and Carlton (1984). The former's discussion of the liquidity and fungibility of futures contracts (1986 p. 524) is illustrative of the similarities.
6. I.D. Howell (1956, p. 18).
7. I.D. Howell, *op. cit.*, p. 14.
8. Garbade and Silber (1983b, p. 252) make a parallel argument in their discussion of the structure of premiums and discounts for nonpar delivery. The use of equivalence systems to determine nonpar pricing rules is used when the underlying attribute of a commodity on which the differential is based "can be isolated through a technological extraction process." In the present terminology, this corresponds to traders' ability to measure the valued attribute objectively.
9. This analysis ignores the possibility broached by McManus and Acheson that as the existence of a futures contract raises the gain to manipulation of the settlement price by trading at 'false prices', an otherwise price taking equilibrium may not survive the presence of a futures market near the expiry time of the contract. See also Newberry (1984).
10. A necessary condition for the viability of a futures contract market, is the ability of contractual specifications to reduce basis risk, measured by the coefficient of stochastic variation of the difference between the current spot and futures price, to a level acceptable to commercial hedging interests. See Working (1954), Gray (1961), Powers (1967), Crow, Riley and Purcell (1972), and Sandor (1973). For contracts pertaining to price taking cash markets, hedgers bear no basis risk attributable to the futures contract per se, although some residual basis risk may be incurred if any of the costs

of having the commodity available at the delivery date and location are unhedged. For a discussion of the relationship of basis risk to cash settlement see Garbade and Silber (1983a).

11. See Alchian (1977), for an analysis of buy-sell spread differences resulting from the distribution of measurement costs across traders in a personal market.
12. Howell, *op. cit.*, p. 22-23. The conclusions of the analysis parallel Garbade and Silber (1983a) when they state (p. 456) that "the desirability of mandatory cash settlement depends upon the accuracy with which the settlement index measures the commercial value of the commodity." Their reasoning differs substantially from that given here.
13. It is noted in passing that a delivery option was once believed to have been necessary in U.S. futures contracts to avoid them being interpreted legally as wagering agreements.
14. For further clarification see Barzel (1976). This problem, of course, arises with any method of allocation.
15. Moreover, the majority of traders can avoid the associated losses by transacting in the cash market.
16. One qualification should be made at this point. Although the futures price during the life of the contract will be below the cost of producing for delivery to eliminate the incentive for the hedged production of contract goods, the possibility still remains that risk neutral individuals will produce contract goods unhedged, intending to deliver at maturity when the futures price increases to reflect the value of the lowest quality cash goods, as it would if (f) traders mistakenly believe no contract goods are available for delivery. This issue is discussed later in the essay.
17. Edwards and Edwards (1984 p. 349).
18. See the cases discussed in Edwards and Edwards, *op. cit.*, and Easterbrook (1986).
19. In this respect the model in this section is closer to Kyle (1984), who also posits informational asymmetries as the source of manipulative activity.
20. Contrast this result with Telser (1986, p. 515) who concludes "provided there is a competitive spot market, cash settlement works at least as well as delivery." On closer examination it appears Telser is equating competitive and price taking, in which case the inconsistency between the present analysis and his disappears. However, it could then be argued his analysis is left incomplete.
21. Chicago Mercantile Exchange, (1985), Rule 707.
22. Chicago Mercantile Exchange, *op. cit.*, Rule 3405 provides an example.
23. Chicago Mercantile Exchange, *op. cit.*, Rule 710.
24. Chicago Mercantile Exchange, *op. cit.*, Rule 711.
25. There is a practice involving a partial cash settlement known as a transfer of cash for futures in which a stock of the commodity which is not deliverable under the terms of the contract is used to liquidate a short position. The long must agree

voluntarily to accept delivery, including if necessary a privately negotiated cash adjustment to reflect the difference between the price of the standardized commodity and whatever grade is delivered. These transactions are permitted only after termination of trading in the contract, and are cleared through the clearing house in accordance with normal procedures. For example, see Chicago Mercantile Exchange, op. cit., Rule 718.

26. Longs may reasonably expect that, in general, the shorts will select for delivery the lowest quality of goods available which satisfy contractual stipulations. As the delivery of such goods will be expected, the difference in value between the average and poorest grade of the most profitable grade of the commodity to deliver, will be reflected in the relationship between cash and futures prices in the delivery month. Thus, costs of measurement serve to rationalize the randomness of the basis during the maturity period, assumed to exist by Anderson and Danthine (1981, 1983b) in their analysis of hedging strategies in contract markets.
27. Chicago Mercantile Exchange, op. cit., Rule 708.
28. This is of concern to exchange members as both commission revenue and the appreciation in value of a commodity exchange seat have been demonstrated to be positively related to the volume of trade on the contract market. See Rystrom (1982).
29. Grossman (1986 p.S143-S144)
30. See Williamson (1979), Barzel (1982), Kenney and Klein (1983), Goldberg and Erickson (1987), and the references cited therein.
31. In essence this is an efficiency argument for self-regulation. As persuasively argued by Edwards (1983), Easterbrook (1986) and Grossman (1986) there is no reason to believe that under the forces of competition, commodity exchanges will systematically adopt suboptimal precautions against practices which impose real losses upon their members. See also Working (1953).
32. Each contract in the sample, therefore, represents the potential for excess measurement.
33. For example, see the provisions of the Apple Futures Contract on New York Mercantile Exchange, (1971), Chap. 20, Rule 200.10.
34. e.g., Chicago Mercantile Exchange, op. cit., Rule 2505.
35. e.g., Chicago Mercantile Exchange, op. cit., Rule 1503.
36. Briefly, the argument is that contractual incompleteness reduces the correlation between price movements of different delivery months in the same commodity contract. This increases the price volatility of a spread position relative to an open position in that contract market. Assuming initial speculative margin levels are directly related to contractual price volatility, the more incomplete the measures utilized in the futures contract the lower the ratio of open to spread initial speculative margin requirements.
37. A further consideration in favour of preliminary estimation by a simple linear probability specification, is that unbiased estimates may be derived even for small samples (Kendall and Stuart (1979, p. 83). Certain maximum likelihood logit estimators have been examined in Monte Carlo studies, and discovered to be satisfactorily well behaved only with sample sizes of about fifty. (D. McFadden (1974 p. 123)).

38. An alternative method of comparing specifications, is to re-estimate each model after normalizing each variable to have zero mean and unit variance. The resulting standardized coefficients are comparable. A second, suggested by Amemiya (1981 p. 1488) is to examine the derivatives of the probabilities with respect to the independent variables. The relative significance of the explanatory variables can then be compared across specifications. However, it is not clear what the relevance of this procedure is when some of the independent variables are dummies, as they are in this case.

CHAPTER III

MEASUREMENT COSTS, MARGIN REQUIREMENTS AND MARKET FAILURE IN FUTURES MARKETS

INTRODUCTION

The analysis of this chapter investigates the relationship between the costs of quantifying information, or measurement costs, the behaviour of commodity futures prices and the trading success of futures contract markets. The framework adopted builds naturally upon the theoretical outline proposed in chapter II, and its development can be briefly summarised.

In section I the effects of introducing a range of arbitrage indeterminacy in the settlement price of a futures contract are clarified in the context of the conventional theory of intertemporal pricing relationships for storable commodities. Section II develops a more formal framework in which the consequences of the contractual incompleteness of futures for the behaviour of commodity futures prices is examined. Specifically, the analysis derives testable propositions relating to the relative price variability of portfolios comprising open and spread futures positions. These propositions are utilised as the basis for an indirect test of the measurement cost hypothesis. Recall that a direct test is precluded owing to the difficulty of estimating the potential gains to traders use of subjective measures across different cash markets. Finally, by relating contractual price variability to the initial speculative margin requirements established by commodity exchanges, results of tests of the hypothesis conducted using contract market data from the period 1970 - 1984 are presented. Some concluding remarks follow.

I. THE THEORY OF STORAGE AND CONTRACT PRICE RELATIONSHIPS

Since Kaldor (1939) and Working (1948, 1949) first developed the theory of the price of storage, it has become accepted in the literature that the relationship between intertemporal futures price spreads for storable commodities is determined by the marginal (net) carrying

cost associated with the holding of physical stocks over the interval between delivery dates T_1 and T_2 , of the two futures contracts comprising the spread.¹ This relationship can be represented in two ways, which are distinguished by the definition of the marginal (net) carrying cost they adopt. It is emphasised that the implications of the analysis which follows are invariant to whichever of the two interpretations is adopted. Formally, invoke the following assumptions: (i) no transaction (measurement) costs; (ii) no brokerage costs of trading; (iii) no taxes; (iv) no limitations on borrowing, (v) risk neutrality. Define:

- i) $f(t, T_i)$ as the futures price at time t for a contract maturing at time T_i ; and
- ii) $c(t, T_i)$ as the marginal net cost of carrying the commodity from time t to T_i .

One class of models (see Fama and French (1987)) defines this cost as identically equal to the marginal expenditure on rent for storage space, handling charges, interest, insurance and allowances for depreciation, less any benefits from having the commodity available in inventory, customarily termed the convenience yield. The implication which follows is that the futures market is in equilibrium when:

$$(3.1a) \quad f(t, T_2) - f(t, T_1) = c(t, T_2) - c(t, T_1)$$

The advantage of the parameter definitions incorporated in equation (3.1a) is that it now becomes an identity, defined to hold for any intertemporal futures price difference. This facilitates theoretical discussion of arbitrage activity. The disadvantages derive from the fact that the convenience yield is unobservable, and is usually considered as the residual when the relationship between the observable parameters in equation (3.1a) has been established. The influence of any other unobservable variables which may affect the futures price spread is, therefore, suppressed. The present analysis argues this perspective generally leads to incorrect conclusions.

There is, following Working (1949), a second class of models with a more applied focus that have omitted the convenience yield from the definition of $c(t, T_i)$. The analysis

then implies that the left-hand side of equation (3.1a) represents a 'full carrying charge' (Working 1949), or an upper limit to the intertemporal futures price spread. This is a value which can be reported given values for the parameters which now comprise net carrying costs. It is also the preferred interpretation in the context of the present analysis. This implies:

$$(3.1b) \quad \max \{f(t, T_2) - f(t, T_1)\} = c(t, T_2) - c(t, T_1)$$

A protracted violation of either equation (3.1a) or (3.1b) is conventionally precluded by discussing the impact of such a breach upon the activities of the class of speculative intramarket arbitrageurs commonly termed spread traders. A spread position is defined as the simultaneous holding of equal numbers of long and short positions in different maturity dates of a single commodity contract.² Given the earlier assumptions these potential transactions serve to maintain the equality in equations (3.1a) or (3.1b) through the following simple arbitrage mechanism.

Consider the scenario which violates both (3.1a) and (3.1b), namely:

$f(t, T_2) - f(t, T_1) > c(t, T_2) - c(t, T_1)$. By going long T_1 contracts at time t , and simultaneously selling an equal number of T_2 contracts, a spread position earns a riskless return of $f(t, T_2)$

$- f(t, T_1) - c(t, T_2) + c(t, T_1)$ per spread. A trader long in T_1 contracts has the right to take delivery at time T_1 , contract for storage, and redeliver in satisfaction of their delivery obligation at time T_2 . The pressure exerted by such trading activity upon the respective contract prices, will eventually restore the equality in equations (3.1a) and (3.1b). The point is, that the assumptions underlying equations (3.1a) and (3.1b) guarantee they cannot be violated in the manner indicated, because they dictate an infinitely elastic supply of spread services whenever the relationships are not satisfied.

The arguments of this essay are predicated upon deviations from the equilibrium described in equations (3.1a) and (3.1b) occasioned by the contractual incompleteness of certain futures contracts. The nature of this contractual incompleteness is first identified in McManus

and Acheson (1979, 1983). An analysis of its effects on intertemporal futures price relationships is one major contribution of this essay. Before proceeding, the reasons for, and effects of, such deviations are briefly outlined.

Consider as a benchmark the situation if the impersonal and objective measures adopted in the futures contract can duplicate at the same cost of transacting those utilised in cash trading, in other words, a futures contract relating to a price taking cash market.¹ Arbitrage ensures the two markets will be analytically indistinguishable with respect to price movements,² necessitating equality of their buy-sell spreads.

Relaxing the price taking assumption introduces interesting complexities into the analysis. As McManus and Acheson (1979, 1983) demonstrate, for futures relating to price searching cash markets, the inability to cost effectively replicate cash measurement procedures implies a mutual loss to any transactions adhering strictly to futures contract stipulations. The model can be represented as follows.

Consider a price searching commodity market. Define,

- (i) $p_b(t,T)$ as the expected price to be paid by a buyer for one unit of the commodity in the cash market at time T . Expectations are taken at time t .
- (ii) $p_s(t,T)$ as the expected price to be received by a seller for one unit of the commodity in the cash market at time T . Again, expectations are taken at time t .
- (iii) $c_c(t,T)$ as the time t unit cost of producing goods for delivery at time T in the cash market.

Competition in the production of cash market goods ensures $p_s(t,T) = c_c(t,T)$.

- (iv) $m_c(T)$ as the unit cost incurred for measuring valued attributes of commodities for delivery in the cash market at time T .

Clearly $m_c(T) = p_b(t,T) - p_s(t,T)$. The total unit costs of measurement include the costs of objective attribute measurement, $\lambda(T)$, and the costs of idiosyncratically measuring valued characteristics, $m_i(T)$. Thus, $m_c(T) = \lambda(T) + m_i(T)$.

A futures market, which requires delivery at time T is also concurrently operating with the cash market. In specifying the characteristics of goods eligible for delivery, the futures contract adopts the same objective measures used in cash market trading, but does not present any opportunity for purchasers to idiosyncratically assess commodity values. Define:

(v) $c_f(t, T)$ as the time t cost of producing contract goods for delivery at time T , at the volume and rate of output yielding lowest per unit production costs. Contract goods are those commodities adhering strictly to the objective specifications in the futures contract.

The cost of measurement for delivery via futures is, therefore, $\lambda(T)$, which following universal practice in futures markets (see chapter II), is assumed to be borne by the seller. The minimum price at which the seller will be induced to produce and deliver via the futures contract (the minimum sell price), is, therefore:

$$(3.2) \min f_{\zeta}(t, T) = c_f(t, T) + \lambda(T).$$

An individual's valuation of the cash market commodity:

$$(3.3) v_{\zeta}(t) = v_{\lambda}(t) + v_m(T) > p_b(t, T) = c_c(t, T) + \lambda(T) + m_i(T)$$

is the sum of the values placed on commodity attributes from an ability to objectively and idiosyncratically measure characteristics when purchasing in the cash market. These values are denoted $v_{\lambda}(t)$ and $v_m(T)$ in equation (3.3). As a price searching market is the revealed preferred governance structure for cash market transactions, the implication is that the costs of transacting via contracts incorporating only the commodities objectively measured attributes, must exceed the value to market participants:

$$c_f(t, T) + \lambda(T) > v_{\lambda}(T).$$

Subtracting this relationship from equation (3.3) gives:

$$(3.4) v_m(T) > \{c_c(t, T) - c_f(t, T)\} + m_i(T).$$

The right hand side of equation (3.4) is the additional cost of production and measurement of the idiosyncratic components exchanged in cash market transactions, relative to that level of attributes incorporated in contract goods. The relationship implies that individuals generate a surplus from an opportunity to subjectively assess the characteristics of commodities

transacted via a price searching governance structure. This surplus is greater the lower the per unit cost of trader's idiosyncratic measurement in the cash market, $m_i(T)$.

As the delivery market in contract goods is assumed to adopt the same objective measures used for cash market delivery, absencing complementarities in the valuation of objectively and idiosyncratically measured characteristics, the valuation of objectively measured characteristics will be identical independent of the market in which delivery is taken. It follows that the maximum that buyers accepting delivery of contract goods would be prepared to pay is:

$$(3.5) \max f_b(t,T) = p_b(t,T) - v_m(T).$$

This implies from equations (3.3) and (3.4):

$$\max c_f(t,T) + v(T) > f_b(t,T)$$

Substituting from equation (3.2) yields:

$$(3.6) \min f_s(t,T) > \max f_b(t,T).$$

The maximum price buyers are prepared to pay to take delivery of contract goods is less than the minimum acceptable to sellers. This difference in buying and selling prices, from the derivation of equation (3.6), is equal to the net gains from trade foregone by engaging in a delivery of contract goods, $v_m(T) - \{c_s(t,T) - c_f(t,T)\} = m_i(T)$, and is exactly reflected in the difference in traders' buy-sell spreads in the cash and futures markets. Buy sell spreads in the market for contract goods will also differ between traders if per unit costs of idiosyncratic measurement differ across market participants. All else equal, $f_b(t,T)$ varies directly with $m_i(T)$. In the limiting case where $m_i(T)$ is sufficiently high to exhaust every traders surplus from using idiosyncratic measures for cash market transactions, equation (3.6) holds with equality. A price taking cash market will then be the preferred governance structure for organising exchange.

The analysis has implications for the equilibrium settlement price of futures contracts. The bounds upon the final settlement price of the futures contract are determined by

potential arbitrage transactions between the futures price and the delivery market for contract goods created by the terms of the futures contract. Any difference between the cost of production and delivery of contract goods and their value will, therefore, necessarily result in a range of indeterminacy in the futures settlement price. The more contractually incomplete the contract, the greater this range of indeterminacy. From the intertemporal perspective of the present analysis, it is clear that the attainable difference between the two futures prices in a spread portfolio, prior to the inducement of arbitrage transactions, will in general, no longer simply reflect the level of net carrying costs between delivery periods. It will also incorporate an element reflecting the higher cost of transacting via the incomplete futures contract. The deterministic relations in equations (3.1a) and (3.1b) no longer necessarily obtain.

A simple numerical example will clarify the intuition. Let the time t expected prices/receipts per contract unit to buyers/sellers be \$100 and \$90 on the relevant cash market at time T_1 . Of the \$10 cost of measurement, let \$7 be the cost of objective enforcement and \$3 the cost of idiosyncratic monitoring. Assume the delivery market in contract goods adopts the same objective measures as the cash market. The cost of measurement for delivery is then \$7. Let the time t per unit cost of production of contract goods for delivery at time T_1 , exclusive of measurement, be \$85. The minimum price at which sellers will be induced to plan production and deliver via the futures contract is, from equation (3.2), equal to \$92.

If buyers derive any surplus from transacting in price searching cash markets, from equation (3.6), their valuation of contract goods must be less than \$92, say \$88. This is the maximum price a buyer would pay at time t , for a delivery of contract goods via futures at time T_1 . The futures settlement price can, therefore, vary between \$88-\$92 without inducing arbitrage transactions in the delivery market for contract goods. The range of arbitrage indeterminacy in the settlement price is \$4, which is equal to the net gains from trade foregone by transacting in the delivery market for contract goods rather than the regular cash

market.

Now introduce a per unit cost of storage from T_1 to T_2 at \$10 ($= c(t, T_2) - c(t, T_1)$). Using analogous reasoning to that above, the maximum price buyers will pay at time t for a planned delivery of contract goods at time T_2 is \$98. The minimum price at which sellers will produce and deliver that unit is \$102. Once more, there is a \$4 range within which $f(t, T_2)$ can fluctuate without inducing delivery transactions via futures.

The implications of this arbitrage indeterminacy for the price behaviour of intertemporal spread transactions in the futures market can now be understood. Consider the situation facing a trader if the nearby and distant futures prices are at the levels represented by the maximum buy and minimum sell prices in the numerical example, i.e. $f(t, T_1) = \$88$ and $f(t, T_2) = \$102$. With marginal net carrying costs of \$10, this situation violates both equations (3.1a) and (3.1b).

Conventional analysis would abstract from any range of arbitrage indeterminacy in $f(t, T_2)$, which is analytically equivalent to assuming the contract relates to a price taking cash market. In that case, a spread trader facing these futures prices could earn a riskless return of \$4 per spread position from the simultaneous execution, at time t , of a long position in the nearby contract at a price of \$88, a short position in the distant contract at a price of \$102, together with a contract to store goods delivered at T_1 until T_2 at a cost of \$10 per unit. This conventional approach is equivalent to assuming that buy-sell spreads in each contract market are zero. Alternatively, arbitrage activity in the delivery market for contract goods sufficiently constrains the futures price to enable the spread trader to execute buy and sell orders in the market at the prevailing futures price.

Returning to the original numerical example of a contractually incomplete contract, with a \$4 range of settlement price indeterminacy per contract, this assumption is no longer warranted. Consequently, the perceived returns to arbitrage activity are likely to be altered

significantly. Consider the limiting case where potential arbitrage transactions represent the only effective market constraint upon futures settlement prices. A spread order to buy nearby and sell distant contracts at the market, would be executed at \$92 and \$98, respectively. These order execution prices would totally mitigate the profitability of the arbitrage transaction. If executed, the trading strategy would yield a return of -\$4 per spread position. Notice that the absolute magnitude of the negative return is equal in size to the range of arbitrage indeterminacy in the futures price. This is not coincidental, but as the structure of the example makes clear, will be a general result which holds in every market where arbitrage transactions in the delivery market for contract goods are the only constraints on futures price changes. To conclude, the analysis suggests that the reluctance of spread traders to engage in intertemporal arbitrage as a result of the incompleteness of the futures contract, will not only increase the price variability of spread positions, but may, in general, preclude the restoration of the equilibrium conditions, equations (3.1a) and (3.1b).

This measurement cost phenomena, to the present author's knowledge, has not been previously analysed in discussions of the intertemporal relationship between futures prices, although Working's (1949) discussion of equilibrium cash-futures price differences makes the following observation:

"In general a carrying charge, defined as a market difference between prices of a commodity for different dates of delivery, should be a difference between prices for essentially the same quality, in the same location, at different dates. Most cash price quotations on grades of wheat deliverable on futures contracts in American markets apply to a quality superior to that which will be delivered on the futures contracts. Cash-future price differences therefore usually reflect quality differentials as well as time differentials. But in such cases it should be said that the price difference is a combination of carrying charge and quality differential, not a pure carrying charge."

Note that if the relevant cash market were price taking, the measurement devices used to enforce the futures contract would be able to detect variations in quality, over a range of qualities, with the same efficiency as the cash market. Thus, discounts and premiums for the delivery of non par goods (those deviating from the quality specified by the base grade to

which the futures contract and price pertain) could be established exactly in accordance with the commercial differences found in the regular spot market. In this case, Working's "quality differential" component in the price spread could be calculated exactly, and the residual would be the pure carrying charge. However, the widespread use of fixed rather than commercial differences to price non-par deliveries suggests that the increased enforcement and measurement efforts required to implement such commercial differences are not cost effective. The quality differential cannot then be calculated with precision.

A proposed solution to the difficulties this introduces for the calculation of net carrying charges is suggested by Brennan (1958) who writes:

"Rather than compare a current cash price with the current quotation of a distant futures price, the current quotation of the futures price for delivery in a distant month was subtracted from the current quotation of the futures price for delivery in the current month or a near month. This was done to ensure that the prices being used referred to identical commodities."

In Brennan's view, the resulting price spread reflects marginal net carrying costs.⁷ Prior discussion indicates two conditions are required for this solution to be correct, neither of which Brennan stipulates. First, net carrying costs must be constant across different quality grades of the commodity between T_1 and T_2 . Second, and more importantly, the commodity contract must be written on a commodity trading in a price taking cash market. Otherwise, the calculated price spread may, as the previous example makes clear, in general contain an element deriving from the range of arbitrage indeterminacy in the pricing of futures contracts. Thus, even if Brennan's procedure is implemented, for contractually incomplete contracts the observed spread is unlikely to reflect a pure carrying charge.

II. MEASUREMENT COSTS AND FUTURES PRICE BEHAVIOUR

In an attempt to more formally examine the relationship between intertemporal futures prices in the presence of incomplete contracts, this analysis specifies a simple model of the variation of prices of storable commodities. A model with similar structural affinities is used by Garbade and Silber (1983b) to study the hedging properties of futures contracts relating to commodities with heterogeneous cash market varieties.

Consider a commodity exchange trading futures contracts pertaining to a storable commodity. Apart from stipulation of the maturity or delivery period (the time during which parties to outstanding futures contracts are obligated to undertake the promised transaction), the objective specifications governing contractual performance are identical across contracts.

Suppose at time t only two active contracts exist, trading for delivery at time T_1 (nearby contract) and T_2 (distant contract), respectively. The contracts are for a commodity with a seasonal harvest, and both delivery periods fall within the same crop year. The futures price at time t for a contract maturing at time T_1 is $f(t, T_1)$. The intention is to formulate a general model of the dynamic interaction between $f(t, T_1)$ and $f(t, T_2)$ encompassing both contractually complete and incomplete contracts.

The analysis begins by assuming that within a trading period, the average value of the price ratio $f(t, T_1)/f(t, T_2)$ is $1 + c$. In general $c > 0$, but the analysis would not change for $c < 0$. Rearranging equation (3.1a), it is clear that $c = [c(t, T_2) - c(t, T_1)]/f(t, T_1)$, the ratio of net carrying costs to the price of the nearby contract.

For simplicity, the following discussion assumes c is non-stochastic within a trading period. This assumption is uncontroversial in an environment of stationary interest rates, and when carry costs are absolute, or fixed in monetary value per unit of time. It is more contentious when carry costs are relative, meaning they depend upon the value of the

commodity, in which case c would vary with the futures price level of the nearby contract. The fact that the model is specified in terms of the logarithm of futures prices helps to reduce the overall impact of price level changes on the value of c , and such considerations are suppressed in the remainder of this essay. This would appear to be customary practice (Williams (1986)). However, it should be recognised that at some sacrifice in terms of expositional clarity, the average value of the futures price ratio could be allowed to follow a seasonal or cyclical pattern, and the substantial conclusions of the analysis would be unaffected. The distinction between relative and absolute carry costs is further discussed in chapter 4.

The model specifies that the logarithm of the price of the nearby contract and the logarithm of the price of the distant contract, the latter reduced by $1 + c$ are composed of two components, a component ϕ , representing the value of commodity attributes which can be measured objectively, and an idiosyncratic component ψ , which is divided between the two contracts:

$$(3.7) \quad \ln f(t, T_1) = \phi + \alpha \psi$$

$$(3.8) \quad \ln f(t, T_2)/(1 + c) = \phi - \beta \psi$$

where $\alpha + \beta = 1$.

One could call $\ln f(t, T_2)/(1 + c)$ the nearby equivalent price for the contract maturing at T_2 , as it is the futures price (net of carrying costs) for the contract maturing at T_1 , which would prevail at time t given the validity of the assumptions underlying equations (3.1a) and (3.1b).

The ϕ element of the model is the price taking component of the futures price. Its value is determined from the contract market's processing of information flows, deemed to affect the value and cost of commodity characteristics, that are objectively specified in the terms of the futures contract. From equations (3.7) and (3.8), ϕ is a weighted average of

the two contract prices:

$$(3.9) \quad \phi = \beta \ln f(t, T_1) + \alpha \ln f(t, T_2) / (1 + c)$$

and as the content of information flows occasioning traders price revisions cannot be expected to follow a systematic pattern, is specified to vary as a random walk:

$$(3.10) \quad d\phi = \sigma_\phi \cdot dz_\phi$$

where:

- i) dz_ϕ is a Gauss-Weiner process,
- ii) σ_ϕ^2 is the variance of the change in the common component per unit of time. As ϕ is the price taking component of the information flow, any changes therein will be effectively arbitrated across the entire constellation of futures prices.

The component ψ constitutes what shall be termed the idiosyncratic element of futures price variability. Changes in ψ are designed to capture variations in settlement prices occurring within the range of arbitrage indeterminacy in the futures price resulting from the incompleteness of the contract. From equations (3.7) and (3.8) the idiosyncratic component is:

$$(3.11) \quad \psi = \ln f(t, T_1) - \ln f(t, T_2) / (1 + c)$$

Viewed from the perspective of the outside modeler, the idiosyncratic component is also specified to vary as a random walk:¹⁰

$$(3.12) \quad d\psi = \sigma_\psi \cdot dz_\psi$$

where:

- i) dz_ψ is a Gauss-Weiner process, uncorrelated with dz_ϕ .
- ii) σ_ψ^2 is the variance per unit of time of the idiosyncratic component.

A description of the behaviour of contract market clearing prices is contained in the model of equation (3.7)-(3.12).¹¹ From the processes assumed for the common and idiosyncratic components of the settlement prices given by equation (3.10) and (3.12), the

stochastic differential equations for changes in the nearby and distant contract futures prices may be written:

$$(3.13) \quad df(t, T_1) = f(t, T_1) \sigma_\phi dz_\phi + f(t, T_1) \alpha \sigma_\psi dz_\psi$$

$$(3.14) \quad df(t, T_2) = f(t, T_2) \sigma_\phi dz_\phi - f(t, T_2) \beta \sigma_\psi dz_\psi$$

with instantaneous variances:

$$(3.15) \quad \text{var}(F_1) = \text{var}(df(t, T_1)/f(t, T_1)) = \sigma_\phi^2 + \alpha^2 \sigma_\psi^2$$

$$(3.16) \quad \text{var}(F_2) = \text{var}(df(t, T_2)/f(t, T_2)) = \sigma_\phi^2 + \beta^2 \sigma_\psi^2$$

This specification of the model has determinate implications for the interaction between nearby and distant contract prices, and consequently for the behaviour of the intracommodity spread, $S_{12} = \ln f(t, T_2) - \ln f(t, T_1)$, during any period of trading. In particular, from (3.14) the difference between the distant and nearby settlement prices will exactly reflect the sum of net carrying costs and the idiosyncratic element of futures price variability, ψ . Assuming net carrying costs are nonstochastic, it follows from (3.12) that σ_ψ^2 will also be equal to the variance of changes in the intracommodity spread, $\text{var}(S_{12})$, per unit time. The model therefore, postulates a simple mechanism directly linking intracommodity spread variability and the contractual incompleteness of futures. Notice that for a contract pertaining to a price taking cash market, $\psi = 0$. The intertemporal futures price spread will equal net carrying costs, and assuming the latter are constant, the implied infinite elasticity of arbitrage services ensures the variability of changes in the spread will be zero throughout the trading period.

Prior to a consideration of the testable implications generated by the model, two further consequences of the contractual incompleteness of certain futures contracts warrant brief mention. First, the information set necessary to conduct profitable arbitrage transactions has increased, as individual spread traders must now form an estimate of the range of arbitrage indeterminacy in the futures price. In turn this requires access to information concerning the cost function for the production of contract goods, which is likely to be complementary with

activities such as producing, storing and processing the commodity for cash market delivery. At any particular time, the relationship exhibited by contract market prices obtaining specifically from desired arbitrage transactions will reflect the information set of the trader with the lowest buy-sell spread currently active in the market. As it is a characteristic of price searching markets that buy-sell spreads vary among trading principals, the intertemporal futures price spread may be expected to vary as more informed traders enter and leave the market.

Second, the range of arbitrage indeterminacy increases the potential opportunity for manipulation of the value of the contract by traders with lower costs of access to the contract market. On all existing commodity exchanges, only exchange member-brokers may become parties to, and effect transfers of, contractual obligations. Although Commodity Futures Trading Commission (CFTC) rules require futures exchanges to prohibit member-brokers from taking the opposite side of a clients order without consent, brokers may still trade for their own account, a practice termed dual trading.¹³ One mechanism through which member-brokers are alleged to be able to manipulate settlement prices is by comparing order books and trading cooperatively on the exchange floor. Constraints on such practices, serving to make the futures market more of a fair game, emanate from two sources, CFTC and futures exchange regulations and more importantly, the sensitivity of the futures price to potential arbitrage transactions.¹⁴ Costly enforcement implies the former will be imperfect. With respect to the latter, a greater range of arbitrage indeterminacy in $f(t, T_1)$ allows member-brokers more discretion in establishing prices within the bounds established by arbitrage order flow, thus increasing the expected costs to non-members (outsiders) of their trading activities. The potential for this redistributive exploitation of other contract holders increases the risk of market participation, reduces liquidity, and inhibits the transferability of contracts. In the limit the execution costs of outside order flow may be severe enough to lead to failure of the contract market.

a: Testable Implications

Although the parameters of the model previously outlined are themselves unobservable directly, the prior measurement cost analysis does generate simple empirical predictions which are amenable to testing, relating to the nexus of pricing relationships exhibited between open and spread commodity portfolio's in futures.

Specifically, consider the price volatility of changes in a spread relative to an open position contract portfolio in a particular futures contract:

$$(3.17) \quad \text{var}(S_{12}) / \text{var}(F_1) = \{\text{var}(F_1) + \text{var}(F_2) - 2 \text{cov}(F_1, F_2)\} / \text{var}(F_1).$$

Assume for simplicity that open position variability is equal across contracts.¹⁵ It is evident that as the measures stipulated in the futures contract more closely approximate those utilised in cash market trading, or the more contractually complete the futures contract, the lower the variability of price changes in a spread position relative to an open position portfolio. An intuitive demonstration follows. Setting $\text{var}(F_1) = \text{var}(F_2)$ implies the ratio relating spread to open contract price volatility may be written $2(1-\rho)$, where ρ is the correlation coefficient between contractual price changes. From equations (3.13) and (3.14):

$$(3.18) \quad \text{cov}(F_1, F_2) = \text{cov} (df(t, T_1)/f(t, T_1), df(t, T_2)/f(t, T_2)) = \sigma_\phi^2 - \alpha\beta\sigma_\psi^2$$

which together with (3.15) and (3.16) gives:

$$(3.19) \quad \rho = (\sigma_\phi^2 - \alpha\beta\sigma_\psi^2) / (\sigma_\phi^2 + \alpha^2\sigma_\psi^2)^{1/2}(\sigma_\phi^2 + \beta^2\sigma_\psi^2)^{1/2}$$

Thus, from (3.19) $\partial\rho/\partial\sigma_\psi^2 < 0$ which directly implies $\partial\{\text{var}(S_{12})/\text{var}(F_1)\}/\partial\sigma_\psi^2 < 0$ as earlier maintained.

III. EMPIRICAL VERIFICATION

As developed, the measurement cost model of futures price behaviour maintains that any contractual incompleteness of futures contracts is manifest in the pricing relationships, outlined above, exhibited between different portfolios of commodity futures. In lieu of direct measurement of futures price volatility this analysis adopts the minimum initial speculative margin requirements established by the respective commodity exchanges on open and spread positions as proxy measures for the price variability of contract portfolios.¹⁶ This proxy not only enables a large data set to be compiled at comparatively low cost, but also has the advantage of generating results without imposing strong assumptions concerning the class of possible processes governing observed futures price volatility. In particular, it does not require futures price changes are normally distributed. The margin requirements are incorporated into the model as follows.

Denote the exchange minimum margin requirements on a spread position between delivery months T_1 and T_2 as m , and those on an open position as $\delta_i m$ ($\delta \geq 0$, $i=1,2$). Consider a spread portfolio consisting of q_s positions, with total margin requirements $\bar{m}$ equal to those on an open portfolio containing q_i contracts:

$$(3.20) \quad q_s m = q_i \delta_i m = \bar{m}$$

Existing evidence (footnote 16) suggests that in establishing m and δ_i , exchanges concern themselves almost exclusively with the default risk on a traders contractual obligations, as reflected by the positions price variability. The earlier theoretical model utilises the positions own price variance as an appropriate measure of this perceived default risk implying from (3.17):

$$(3.21) \quad q_s^2 \text{var}(S_{1,2}) = q_i^2 \text{var}(F_1).$$

Substituting for q_s^2 and q_i^2 from (3.16) and (3.17) gives:

$$(3.22) \quad (m^2 - m^2) \text{var}(S_{1,2}) = (\bar{m}^2 - \delta_i^2 m^2) \text{var}(F_1)$$

thus:

$$(3.23) \quad \delta_i = (\text{var}(F_i)/\text{var}(S_{12}))^{1/2}.$$

From (3.22), δ_i can be interpreted as the number of spread positions in delivery month 1_i with equivalent (perceived) default risk to one open position. Earlier analysis established that the denominator in the right hand side of equation (3.23) tends to zero as the comparative disadvantage of trading via futures diminishes, thereby increasing δ_i for a given open contract price variability. In the context of margin requirements, therefore, the implication of the measurement cost hypothesis is that the ratio of the level of open to spread position margin requirements will be inversely monotonically related to the proportion of contractual price variability attributable to price fluctuations within the range of arbitrage indeterminacy in $f(t, T_i)$. As a range of arbitrage indeterminacy is argued to reduce the trading interest in a contract, corroboration of the hypothesis would be evidenced if higher values of δ_i were associated with the more actively traded futures contracts.

a: Data Description and Test Procedures

Data on exchange minimum margin requirements is examined for a representative set of commodity contracts all of which traded on U.S. commodity exchanges for some interval during the 1970-1984 period. The one hundred and eleven commodities for which data could be solicited from the respective exchanges and/or clearing houses are listed in Table 3.1

The test procedure employs the non-parametric Wilcoxon Mann-Whitney $W(U)$ statistic to test the null hypothesis that the value of δ_i is not associated with the subsequent failure of the contract market, against the alternative hypothesis that δ_i is negatively related to subsequent market failure. Market failure is defined as either: (i) actual delisting of the commodity contract by an exchange during the 1970-1984 period; or (ii) dormancy of the contract at the end of 1984.

Clearly, this choice of test hypothesis employing the market success/failure dichotomy may be interpreted as somewhat severe, given the measurement cost hypothesis does not imply market failure is a necessary outcome of contractual incompleteness. Conceivably a hypothesis test could have been structured relating δ_1 to a continuous variable. Average open interest or trading volume in the contract over the period of observation would have been the obvious possible choices.

This procedure may be objected to on several grounds. First, the choice of a level of volume or open interest below which a contract market is deemed to be 'thin' is completely arbitrary, and imparts an unnecessary degree of ad hocery to the test procedure. Contract dormancy or delistment is uncontroversial. Moreover, reported volume statistics as indicators of overall trading interest in a futures contract are potentially misleading. A large reported volume may simply be reflecting the trading activities of either traders with large futures positions, or exchange floor traders. To this extent they are not a true indicator of the width of participation in the market, and the degree to which it is succeeding in its function of promoting the transferability of contracts through broadening the base of market activity.

Second, even presuming an acceptable definition of 'thinness' for the contract market could be found and associated with the level of the continuous variable, the fact that the degree of trading interest in a contract is sensitive to the stage in the contract's life cycle at which it is measured must be allowed for. For example, the more recently introduced contracts universally exhibit below average levels of trading interest, as potential commercial and hedging order flow ascertains both the need for the instrument, and its ability to fulfill its intended function. Trading interest is also sensitive to developments in the relevant cash market (e.g. government policy). Any continuous variable that is adopted must be able to distinguish between 'thinness' arising from an inherent contractual weakness, and that stemming from the environment existing at the time the measurement is taken.

The recorded value of δ_i for each commodity is calculated using one of two procedures.

Procedure 1:

For contracts with continuously active trading and those introduced during the 1970 - 1984 period remaining active until the end of 1984, δ_i is measured as a weighted average of the relative open/spread (minimum) exchange speculative margin requirements in effect for that commodity over the observation interval. The weight allotted to each ratio of margin requirements is the length of time for which it was operative. For contracts delisted or becoming dormant during the observation period, δ_i is the ratio of margin requirements effective at the time of the contracts dormancy or delisting. This procedure was necessitated by the inability to obtain continuous observations for many of the delisted contracts over the complete period of interest.

Utilising procedure 1, the values obtained for δ_i in the total contract sample vary widely. Some indication of the variation of δ_i can be obtained by sub classifying the contracts into further sub-samples. Seven common commodity groupings are selected. They are presented below, together with their values for δ_i (in parenthesis).

- (1) Financial (incl. stocks): 2-year T-Notes (3) - Composite Index (18);
- (2) Currencies: Italian Lira (1.5) - Swiss Francs (10.96);
- (3) Grains: Oats (1.5) - Wheat and Corn (mark to market);
- (4) Foodstuffs: Skinned Hams (1.14) - Rough Rice (15);
- (5) Metals (incl. coins): Copper (1.67) - Gold, Silver (mark to market);
- (6) Fuel Oils: Heating Oil, Industrial Oil (2.5) - Propane Gas (6);
- (7) Woods, Fibres: Stud Lumber (1.3) - Cotton (3.1).

The computed W(U) statistic for the total commodity sample is presented in the first row of Table 3.2, together with the associated probability value assuming validity of the null

hypothesis. The evidence indicates rejection of the null hypothesis (at a 99% significance level) for the full commodity sample in favour of the postulated alternative, a negative association between δ_i and the subsequent failure of the contract market. Almost identical results are obtained repeating the procedure using a subset of the full sample which excluded the seven non-redeliverable contracts (the second row of Table 3.2).

The difficulty inherent in procedure 1 is that a possible bias is incorporated into the results if, on average, times of contractual delistment correspond to periods in which δ_i was low across all futures contracts. The effect of this bias is to favour an unwarranted rejection of the null hypothesis. Consequently, a second procedure is also utilised to calculate δ_i in an effort to remedy the possible effects of such a bias.

Procedure 2:

Procedures 1 and 2 differ in their treatment of the continuously active contracts. Under procedure 2, δ_i is measured as the minimum relative open/spread exchange speculative margin requirement in effect for continuously traded commodities over the 1970-1984 period. Adopting this procedure has one of two effects. If the conditions giving rise to the possible bias under procedure 1 do in fact hold, then the bias will be removed. Under any other conditions, this second procedure imparts a bias in the opposite direction, favouring acceptance of the null hypothesis when statistical rejection may in fact be justified. In this respect, the test conditions under this latter procedure could be described as more conservative than the former, as they favour rejection of the measurement cost hypothesis.

Once more, adopting procedure 2 produced wide variation in δ_i values. The ranges across the seven commodity sub-groupings are:

- (1) Financial (incl stocks): 90-Day T-Bills (2.5) - Value Line (16.5);
- (2) Currencies: Mexican Peso (1) - British Pound (3.75);
- (3) Grains: Oats (1.5) - Wheat and Corn (mark to market);

- (4) Foodstuffs: Skinned Hams (1.14) - Rough Rice (15);
- (5) Metals (incl. coins): Copper (1.67) - Gold, Silver (mark to market);
- (6) Fuel Oils: Heating Oil, Industrial Oil (2.5) - Gulf No.2 Oil, Leaded Gas (5);
- (7) Woods, Fibres: Stud Lumber (1.33) - Plywood (3).

Test results utilising this second procedure are presented in Table 3.2 for the total commodity sample and the associated storables subset. Once again, for both samples the results indicate rejection of the null hypothesis with a high (99%) degree of confidence, confirming earlier findings.

An assessment of the sensitivity of the findings to the aggregation process adopted can be ascertained by sub-classification of the non-deliverable contracts into the seven commodity groupings in Table 3.3. Classification by commodity grouping could be perceived as somewhat ad hoc, in that a priori, there may not be any convincing rationale for contracts within a particular category to exhibit similar attribute measurement characteristics. However, given that such sub-classification procedure is often adopted in analysing futures contracts, the results may provide certain insights by facilitating comparison with other studies.

Calculation of δ_i using procedure 1 generates results which systematically require rejection of the null hypothesis in favour of the alternative, at least at a 95% level of significance. Noting the potential bias inherent in this method, this is perhaps not surprising. Invoking the second procedure to compute δ_i , two interesting departures from the familiar pattern are evident. First, the test is unable to reject the null hypothesis for financial commodities. Second, the results for currency contracts suggest that actively traded commodities have lower values for δ_i , exactly the opposite prediction of the present theory. Two explanations for such findings suggest themselves. They could be simply manifestations of the bias alluded to earlier; this possibility is particularly likely with respect to the currency results.¹⁵ Another possibility, which serves to confirm rather than contradict the preceding arguments, is that of all commodity classes in Table 3.3, the contractual specifications adopted

in the financial (and currency) contracts could be argued to most closely conform to those utilized in cash trading. In other words these are the commodities most likely to possess price taking cash markets. If such conjectures are viable, one would not, a priori, expect rejection of the null hypothesis in these contracts, as $\psi = 0$. No range of arbitrage indeterminacy exists in their settlement price.

IV: CONCLUSION

This essay attempts to further articulate, and formalise in a form amenable to empirical verification, recent theories proposing a systematic connection between transferability, as a produced attribute of contracts, and the perceived trading success of commodity futures contract markets. A brief comparative study of the contractual differences between cash and futures markets highlighted the costs associated with attempts to enhance transferability in futures. Generally these attempts take the form of changing the contractual measures which serve to enforce exclusivity, in an attempt to make such constraints more uniformly enforceable over a wider range of potential trading principals.

An arbitrage model of futures price determination is constructed, which explicitly incorporates measurement considerations, and the costs of increasing the extent of the market are identified as being reflected in the nexus of pricing relationships exhibited between certain commodity futures portfolio's. By linking portfolio price variability to commodity exchange margin requirements, a test of the model is proposed and conducted using data on one hundred and eleven futures contracts which traded during the 1970 - 1984 period. The results obtained are broadly consistent with the measurement cost theories of futures price behaviour proposed by McManus and Acheson, and Telser.

The fact that the observed features of so many futures contracts fit within the proposed framework is encouraging and attest to its generality. Moreover, the importance of

the role played by enforcement costs in the organisation of economic activity is confirmed. However, it is not expected that the simple economizing framework proposed here can capture anything more than certain major features, and an elaboration to include additional dimensions, for instance studying the evolution of σ_{ψ}^2 through time, should be both feasible and rewarding to students of market organisation. It is just such a refinement to the model which is considered in the next chapter.

Table 3.1

Commodity Futures Contracts and Exchanges

CHICAGO MERCANTILE EXCHANGE

Fresh Broilers, Euro Dollar, U.S. Silver Coins, Copper, Potatoes, Nest Eggs, Hogs, Butter, Skinned Hams, Stud Lumber, Cattle, Feeder Cattle, Pork Bellies, Frozen Eggs, Boneless Beef, Lumber, Canadian Coins, Turkeys, Plywood, Gasoline, No. 2 Oil, Milo.

INTERNATIONAL MONEY MARKET (Chicago Mercantile Exchange)

British Pound, Deutschmark, Swiss Franc, French Franc, Canadian Dollar, Yen, Dutch Guilders, Mexican Peso, Italian Lira, 90-day T-bills, 1-yr T-bills, 4-yr T-notes, Domestic CD's, S & P 500.

CHICAGO BOARD OF TRADE

Wheat, Corn, Oats, Soybeans, Soybean Oil, Soybean Meal, Broilers, Silver, GNMA-CD's, GNMA CDR's, Commercial Paper, Domestic CD's, 4-yr T-notes, 2-yr T-notes, 10-yr T-notes, T bonds.

MID AMERICA COMMODITY EXCHANGE

Rough Rice, Wheat, Gold, Corn, T bonds, T-bills, Silver: Chicago, Silver: New York, Oats, Soybeans, Hogs, Refined Sugar, Live Cattle, Silver Coins.

NEW YORK MERCANTILE EXCHANGE

Palladium, N.Y. No. 2 Oil, Leaded Gas (N.Y.), Gulf No. 2 Oil, Leaded Gas (Gulf), Crude Oil, Yen, Deutschmark, Plywood, Heating Oil, Industrial Oil, Aluminium, Round White Potatoes, U.S. Silver Coins, Platinum, Gold (400 oz), Mexican Peso, Belgian Franc, Italian Lira, Gold (kilo), Imp. Boneless Beef, Apples, Wool, Swiss Franc, Nickel, Idaho Potatoes, British Pound, Canadian Dollar, Butter.

KANSAS CITY BOARD OF TRADE

Soybeans, Sorghum, Corn, Oats, Value Line Index.

NEW YORK COTTON EXCHANGE

Cotton #2, Frozen Conc. Orange Juice, Propane Gas.

COFFEE SUGAR AND COCOA EXCHANGE

Sugar #12, Cocoa.

NEW YORK FUTURES EXCHANGE

Composite Index.

AMEX COMMODITY EXCHANGE

GNMA.

COMMODITY EXCHANGE INCORPORATED (COMEX)

Gold, Silver, Copper, Zinc.

Table 3.2

Results of Wilcoxon-Mann-Whitney U-Test:
Full Sample

Commodity Sample	W	U	d	a	Z
<u>Procedure 1</u>					
All Markets	1793.5	617.5	48	63	-5.34**
All Storables	1625	449	48	56	-5.94**
<u>Procedure 2</u>					
All Markets	2142	966	48	63	-3.26**
All Storables	1925	749	48	56	-3.74**

** Significant at 1% level

* Significant at 5% level

a: is the number of active contracts

d: is the number of dormant contracts

W: is the Wilcoxon-Mann-Whitney W-statistic

U: is the Wilcoxon-Mann-Whitney U-statistic

Z: is a standard normal random variable

Table 3.3

**Results of Wilcoxon-Mann-Whitney U-Test:
Commodity Sub-Samples**

Commodity Sample	W	U	d	a	Z
<u>Procedure 1</u>					
Financial (Incl.Stock)	36	8	7	10	2.711**
Metals (Incl.Coins)	58	13	9	10	2.30*
Currencies	69	14	10	8	1.91*
Grains, Food Oils	15	0	5	10	2.84**
Foodstuffs	76	10	11	8	2.41**
Fuel Oils	3	0	2	8	1.96*
Woods, Fibres ¹	-		4	2	
<u>Procedure 2</u>					
Financial (Incl.Stock)	62	34	7	10	0.88
Metals (Incl.Coins)	59.5	14.5	9	10	2.17*
Currencies	117	62	10	8	2.46
Grains, Food Oils	15	0	5	10	2.84**
Foodstuffs	84	18	11	8	1.74*
Fuel Oils	3	0	2	8	1.96*
Woods, Fibres ¹	-		4	2	

**Significant at 1% level

*Significant at 5% level

¹insufficient data

W, U, a, d, and Z as in Table 3.2.

FOOTNOTES

1. The analysis confines itself to spreads between contracts maturing in the same crop year to avoid the complications introduced by the level of stock carryover relative to new crop production when examining spreads across crop years. Nor is this essay concerned with the explanation of the difference between contemporaneous futures and spot prices (the basis) which is controversial. Disagreement centers upon whether the basis reflects simply storage cost variables or the futures price contains an expected premium and a forecast of the maturity period spot price. The expected premium is usually defined as the bias of the futures price as a forecast of the future spot price. For an excellent recent survey of the two hypothesis (and some empirical evidence which favours the former) see Fama and French (1987).
2. Our usage of the term spread is more specific than that generally encountered in the literature, where a spread or straddle is often vaguely defined as the simultaneous purchase and sale of "similar" futures contracts, in which the offsetting contracts may involve intertemporal, intermarket, or intercommodity transactions. That is, the purchase (sale) of a futures contract on a given exchange is made in conjunction with the sale (purchase) of a different delivery month in the same commodity contract (the present usage); in a different exchange for the same (cash) commodity, either in the same or different delivery months; or in a different but related commodity, where the exact connotation of "related" is often not clearly specified.
3. A price taking cash market is one where some traders purchase goods subject only to an impersonal, objective description. If traders subjectively monitor some attributes of the transaction, and/or if one trading principal's identity is of value to the other contracting parties, the market is said to be price searching.
4. The analysis is referring to futures prices net of marginal carrying costs.
5. While arbitrage activity in the delivery market for contract goods determines the limits of the competitive constraints impacting on settlement price movements, it is not the only relevant constraint. A second major influence is the trading activity of floor traders (exchange member-brokers) on the commodity exchange itself. Indeed, settlement price changes occasioned by floor traders assuming the opposite side to non member market orders when trading for their own account, would likely be distributed within the limits set by the range of arbitrage indeterminacy in the settlement price. An analysis of the exact distribution of settlement price changes resulting from floor trader activity, while germane for certain problems (Silber (1984)), is not relevant to the present analysis. It is sufficient to assume that floor traders positions are not bound away from the competitive constraints imposed by outside order flow, and their individual behaviour does not differ systematically across contract markets. On existing evidence (Working (1967, 1977)), both appear reasonable assumptions. Under these conditions, the conclusions reached above will continue to hold.
6. Working (1949 p.4). This statement could be constructed as supportive of the McManus-Acheson view. Presumably the spread is being quoted in this manner because a cash quotation for the commodity described in the futures contract cannot be obtained.
7. See the discussion in McManus and Acheson (1979 p. 39f). Garbade and Silber (1983) also discuss the procedures specified in contracts to price non par deliveries and is

2 of/de 2

Micro-D

relevant in this context.

8. Brennan (1958 p. 65 fn. 9).
9. Brennan's procedure can perhaps be defended on the grounds that since there is no independent measure of the marginal convenience yield it is suitably defined as the residual in equation (3.1a). This being the case, as earlier discussed, equation (3.1a) becomes an identity and cannot be violated. This paper's contention is that such a procedure is erroneous. There is further discussion of this and related issues later in the essay.
10. At this point the model differs from that of Garbade and Silber (1983). Their counterpart to the present idiosyncratic component is a 'difference component' which they assume to follow a transitory, stable first-order process around zero. Their formulation implies the existence of a correlation between settlement price changes within the range of arbitrage indeterminacy in the futures price, which would not be consistent with the current approach.
11. In this simple model, both σ_ϕ^2 and σ_f^2 are assumed time invariant. A rationale for the time independence assumption for σ_ϕ^2 is provided in Anderson and Danthine (1983) and Richards and Sundaresan (1980). For an alternative perspective arguing σ_ϕ^2 will increase as the delivery period of the contract approaches see Samuelson (1965) and Stein (1979). The parameter σ_f^2 will clearly be sensitive to the unit cost of production and delivery of contract goods, which in general could be expected to vary over the life of the contract. The justification for holding σ_f^2 constant in this analysis is an empirical one, arising from a later use of initial speculative margin requirements as proxies for contractual price variability. It is universally the case that prior to the delivery month, the levels of such margin requirements are invariant with respect to time to contract maturity. Volatility issues are considered more fully in chapter 4.
12. This abstracts away from the buy-sell spread existing in price taking markets, which has been effectively normalised to zero.
13. See 17 C.F.R. reg. 155.2.
14. Additional to those restrictions on trading activity indicated above, CFTC rules require trading days of exchanges be divided in 30-minute segments, and trades must be recorded in particular segments (17 C.F.R. reg. 1.35(g) and 1.35(d)). Although at the time of writing, customer orders need not be time stamped immediately upon execution, they must be recorded at the time received on the exchange floor to the nearest minute (17 C.F.R. reg. 1.35(a-1)). For recent discussions of the nature and adequacy of current futures market regulation in preventing manipulation see Fischel and Grossman (1984), Edwards and Edwards (1984) and Grossman (1986).
15. This involves setting $\alpha=\beta$ although this assumption is not necessary for validity of the argument which follows.
16. A detailed survey of the literature discussing the establishment of the exchange minimum margin requirements, indicates that the central role in their determination must be ascribed to contractual price volatility. Moreover, a submission by Commodity Exchange Inc. contained in Senate Committee Hearings (1980) incorporates the explicit formula used by the Exchanges margin committee to establish margins as:

$$2.6t \sum_{i=1}^n (f^c(t, T_i) - f^0(t, T_i))^2 / nt^{1/2}$$
 where $f^c(t, T_i)$ is the closing price for contract I_i on

day t ; n is the number of trading sessions over which the calculation is performed. Effectively, the Commodity Exchange Inc. procedure assumes contract price changes are independently distributed random variables, then, based on historical data calculates price changes having less than a 1% chance of being exceeded in any given trading session. For recent work on margins see Telser (1981), and Brennan (1986). Insightful early empirical work on the determinants of margin requirements includes McCain (1969) and Kuhn (1976).

17. Telser (1986 p. S18)
18. The currency results under Procedure 2, reflect the low value of δ_i for the Mexican Peso, which was equal to one over the period 19–24 July 1979, and from 21 August 1981 to the end of the sample period. While classified as an active contract in this study, the Peso contract was delisted by the International Money Market on 20 November 1985.

CHAPTER IV MEASUREMENT COSTS AND PRICE VOLATILITY: EVIDENCE FROM FUTURES MARKETS

INTRODUCTION

In a recent manuscript, J. Williams (1986) expresses the belief that:

"...volatile, distinct spreads are a necessary condition for a viable futures market... it follows that the study of futures markets must ultimately become a study of spreads, and by extension, a theory of futures markets must rest upon an explanation of spreads."¹

This chapter utilises the model developed in chapter III to analyse the behaviour of the price volatility of futures spread positions as the constituent contracts approach maturity. The novel feature of the analysis, lies in its explicit incorporation of measurement cost considerations as a determinate element in explaining the dynamics of futures price behaviour. The contribution of the chapter is the formulation of testable implications with respect to the behaviour of commodity spread portfolios, which complement and extend the current literature. The results of the analysis indicate that measurement costs impact not only upon questions of comparative institutional choice,² but also have determinate implications for the behaviour of financial asset prices.

Section 1 outlines the model drawing selectively on the analysis of the preceding chapter. Throughout, the discussion is motivated by the desire to clearly identify testable implications of theoretical results. In section II, a comparison is made between the empirical predictions of the analysis and existing alternatives. Finally, section III specifies and summarises the results of an attempt to empirically corroborate the measurement cost hypothesis, and compares the findings of the analysis to those of other studies having occasion to examine the volatility of commodity spread portfolios'. A brief conclusion follows.

I: THE DYNAMICS OF SPREAD BEHAVIOUR

In Chapter III, the bounds upon the final settlement price of futures contracts possessing a delivery option were shown, following McManus and Acheson (1979, 1983) to be determined by potential arbitrage transactions in the delivery market for contract goods. The model of futures market equilibrium developed in an attempt to examine the theoretical implications of measurement cost considerations on price behaviour is summarised in equations (3.8) – (3.12). Inspection of the parameters of the pertinent expressions for open and spread portfolio price change volatility indicate any general dynamic theory of contractual price changes must be able to account for the evolution of σ_{ϕ}^2 , and σ_{ψ}^2 over the life of the contract.

In its present form, the model is agnostic regarding changes in the variance per unit time of the common component, σ_{ϕ}^2 . This is sufficient to guarantee an inability to provide clear predictions concerning the price variability of open positions overtime.³ Any testable implications of the model are, therefore, necessarily confined to an examination of the dynamic volatility of commodity spread portfolio's, which are dictated by changes in σ_{ψ}^2 as the contracts approach maturity.

At any moment in time, an upper bound is placed on σ_{ψ}^2 by the range of arbitrage indeterminacy in the futures price. One of the determinants of this range is the difference in the cost and value of contract goods. A priori, therefore, neglecting unobservable changes in the valuation schedule of contract goods, σ_{ψ}^2 will be sensitive to variations in their unit cost of production and delivery. To clarify, assume a cost function for contract goods with the properties discussed in Alchian (1953); (i) for a given total volume of production, the minimum per unit cost of production increases with the rate of production at an increasing rate; (ii) for a given rate of production, over some range of output, minimum per unit costs decline with planned volume of output; (iii) minimum per unit costs of production with

respect to increased rates of production decrease as the total contemplated volume of output increases. Two cases have been analysed:⁴

a: The Production Process is certain, and Input Commitments maybe fully Hedged.

To begin, assume no production of contract goods occurs. There then exists a time interval $(T_i - t)$, $(T_i - t \leq T_i - \bar{t})$ where $\bar{t}$ is the time the futures contract begins trading) through which the upper bound on the range of arbitrage indeterminacy will increase, reflecting the higher cost of producing and delivering contract goods closer to the maturity period. There is a constraint impacting upon the increase in the range of arbitrage indeterminacy in the settlement price. This is provided by the cost of delivery of the lowest quality goods, produced for sale on the regular cash market, which meet the terms of the contract. Once this constraint is reached, the lower bound on the range of arbitrage indeterminacy will also increase, to equal the expected value to buyers of the lowest quality cash goods meeting contractual specifications. If no contract goods are produced for delivery, this synthesis of pricing relations in cash and futures will occur at/by contract maturity. Formally, to capture the effect of the increase in the upper bound of the range of arbitrage indeterminacy overtime, the model specifies $\partial \psi / \partial (T_i - t) < 0$, $\partial \sigma_\psi^2 / \partial (T_i - t) < 0$ where $T_i - t$ is the time left to maturity of the contract maturing in delivery month i , and $t - \bar{t} \geq 0$.

b: The Production Process is certain, and Input Commitments are not fully Hedged.

One notable implication of the analysis is the tendency for futures prices to rise over the life of the contract. An incentive therefore, exists to produce contract goods ahead of time at the lowest cost volume and rate of production, and sell them during the maturity period by which time the futures price will have risen sufficiently to make the activity profitable on average. As discussed in Chapter II, the presence of two conditions is necessary for production of contract goods to occur. First, potential holders of contracts must be unaware of its occurrence, as transactions in goods produced as a result of the existence of

an incomplete futures contract generate ex post losses to traders. Under full information, the associated trading losses cannot persist in equilibrium as they may be avoided by dealing in the regular cash market. Second, the level of open interest in the contract market must be sufficient to sustain the level of planned deliveries. Given the assumed properties of the cost function, any constrained volume effects may serve to raise production costs sufficiently to make planned production of contract goods unprofitable (even for risk neutral traders). Absent either of these two conditions, futures price movements will follow the pattern identified in (a).

c: The Maturity Effect and Spread Volatility

This analysis consciously ignores the possibility that contract goods are produced for delivery. Attention is primarily concentrated upon the consequences for spread portfolio volatility of:

- (i) an increase in the level of arbitrage indeterminacy dictated by the approach of the maturity period of its constituent contracts, and
- (ii) changes in spread length. The reader is left to judge whether the restrictions so imposed on the generality of the analysis preclude its usefulness.

The effects of time to maturity on spread volatility are first summarised in a simple form amenable to empirical testing. The fact there is no range of arbitrage indeterminacy in their futures price i.e. $\sigma_{\psi}^2 = 0$, implies spread positions in contracts with specifications exactly duplicating the governance structures in price taking cash markets will exhibit no systematic tendency for changing volatility with the approaching maturity of their constituent contracts. Any variability in spread positions arises simply from unexpected changes in the parameters constituting marginal net carrying costs.

The properties of spread contracts relating to price searching cash markets evidence two relevant features. Earlier discussion maintained $\partial \sigma_{\psi}^2 / \partial (T_1 - t) < 0$, which as $\text{var}(S_{12}) = \sigma_{\psi}^2$

implies $\partial \text{var}(S_{12})/\partial(T_1-t) < 0$. This provides the first testable implication of the analysis:

H1: For contracts relating to price searching cash markets, the variability of a spread portfolio increases with the approach of the maturity period of its component contracts.

The form of the model also permits conjectures as to the relative volatility of the spreads constituent contracts as they approach maturity. Prior analysis addressed to the discussion of the production technology underlying the cost function, dictates that increases in the range of arbitrage indeterminacy will first manifest themselves in the nearby futures price $f(t, T_1)$ comprising the spread. This has implications for the distribution of σ_{ψ}^2 across contracts. Specifically, if one assumes that the cost function for deliverable goods depends on remaining time to maturity T_1-t and is independent of the time of year during which production takes place, increases in the variance of the idiosyncratic component σ_{ψ}^2 over the time interval T_1-t ($i=1,2$) will have a greater impact on the open contract variability of the nearby relative to the distant future, implying $\alpha^2 > \beta^2$. From equations (3.10) and (3.11) the derived testable implication is:

H2: The ratio nearby/distant open contract price volatility $\text{var}(F_1)/\text{var}(F_2)$, will be positively related to spread variability.

d: Further Implications

A.B. Paul (1986) reports:

"a curious statistical finding. During the last few weeks of trading in most commodity futures contracts, there has been an unmistakable tendency for their prices to rise relative to prices for the next maturity.. Specifically, an analysis of data for twenty-two contracts... show that in two-thirds of the cases the price of the expiring contract has risen relative to the price for the next maturing futures by a small but statistically significant and financially rewarding amount."⁵

Paul christens this phenomena the liquidation bias in futures price spreads, and attributes its occurrence to one (or some combination) of four possible explanations (i) an inventory

squeeze; (ii) a delivery expense squeeze; (iii) a congenital weakness on the demand side of the market; and (iv) the fact futures prices behave like cash prices during the delivery month of the futures contract.⁶ Although expressing a belief that the final reason (iv) may be a major explanation for the liquidation bias, Paul recognises it cannot apply to non-storables or to commodities with non-overlapping trading and delivery periods.

This essay building on McManus and Acheson (1979, 1983) identifies a fifth alternative. We argue that understanding the measurement costs inherent in futures trading provides a key to unlocking the possible source of certain statistical regularities that have been identified in commodity futures price movements. The liquidation bias identified by Paul is one such pattern. The Paul study determined the average percentage-point increase in the relative price of the nearby to the distant future, was significantly greater than unity in:

- (i) three of the twenty-two contracts examined, over the period from the fifth to the seventh week prior to the end of trading in the nearby contract,
- (ii) four of the twenty-two contracts, in the period from the fifth to the third week prior to the end of trading, and
- (iii) fifteen of the twenty-two contracts, from the third to the first week before the end of the trading period.

In nine cases the increase in the nearby price was between 0.25% - 0.75% of the distant, in two cases between 0.75% - 1.25% and in four cases between 1.25% - 4.00%. Gains to spread traders with long positions in the nearby contract would have been substantial if they did not pay commissions i.e. if they were exchange member-brokers.

The empirical evidence cited by Paul is consistent with the measurement cost model if certain conditions hold. First, all the commodities showing evidence of the liquidation bias must trade in price searching cash markets. Given the measurement cost model maintains the major factor occasioning the relative increase in the nearby futures price is the rise in the upper bound of the range of arbitrage indeterminacy impacting on its settlement price, Paul's

evidence would suggest that for many contracts in the sample analysed this increase does not occur until around the third week prior to delivery. Second, in the absence of the production of contract goods, at/by the commencement of the delivery period, the range of arbitrage indeterminacy will disappear. Thus, the measurement hypothesis implies the liquidation bias effect is absent during times when trading and delivery overlap. Sufficient conditions for the two explanations to be complementary are either:

- (i) that trading in the commodities in Paul's sample expires prior to the delivery period (e.g. potatoes), or in situations where this requirement is not met,
- (ii) the relative price increase constituting the liquidation bias occurs prior to the delivery period of the contract.

Ideally, one would like to be able to infer from this discussion some concrete predictions regarding the relationship between spread length and spread volatility, which evidently depends on the interaction between $T_2 - T_1$ and $T_1 t$. Unfortunately no clear cut hypothesis emerge from the model in its present form, unless $T_2 t$ the time at which the range of arbitrage indeterminacy in the distant contract begins to increase exceeds $T_2 - T_1$. As this is more likely the closer together the contracts mature, one may hypothesise $\partial \text{var}(S_{12}) / \partial (T_2 - T_1) < 0$. However, the above evidence from Paul suggests $T_1 t < T_2 - T_1$ in which case the model remains agnostic as to the sign of $\partial \text{var}(S_{12}) / \partial (T_2 - T_1)$.

II: ALTERNATIVE HYPOTHESIS REGARDING SPREAD BEHAVIOUR

a: The Maturity Theory

One may compare the empirical implications of this measurement cost theory of commodity spread behaviour with the alternatives currently existing in the literature. Castelino and Vora (1984) utilise Samuelson's (1965) model of futures price volatility to construct a well-defined hypothesis for the behaviour of commodity spreads. Their theory, outlined below,

is dependent upon two restrictive assumptions. First, the stochastic process characterising spot prices must be of a specific form. In particular, the non-deterministic component of spot prices must follow the mean-reverting process:

$$(4.1) \quad \tilde{p}_t = a p_{t-1} + \tilde{\mu}_t$$

where:

- (i) $\tilde{p}_t$ = the non-deterministic component of the spot price at time t
- (ii) a = damping factor < 1
- (iii) $E(\tilde{\mu})_t = 0$ $E(\tilde{\mu}_t \tilde{\mu}_{t+n}) = 0$ if $n \neq 0$, $= \sigma_{\mu}^2$ if $n = 0$.

Second, futures prices must be unbiased estimates of expected spot prices at maturity, such that the non-deterministic component of the futures price observed at time t , for a contract maturing at time T , is given by:

$$(4.2) \quad f(t, T) = E_t(p(T)).$$

Given these assumptions, at time t , the mean and variance of changes in open and spread positions are given by:

$$(4.3) \quad E(S_{12}) = E(df(t, T)) = 0$$

$$(4.4) \quad \text{var}(df(t, T)) = a^{2(T-t)} \sigma_{\mu}^2$$

$$(4.5) \quad \text{var}(S_{12}) = a^{2(T_1-t-1)} (1-a^{(T_2-T_1)})^2 \sigma_{\mu}^2$$

Considered in terms of measurement costs, this theory becomes a special case. The unbiasedness assumption underlying equations (4.3) - (4.5) dictates its relevance is limited to futures contracts associated with price taking cash markets, within which spot prices must follow the specific process indicated.

To clarify, Rutledge (1976) points out that if $a = 1$, the spot price follows a random walk, the variance of futures price changes is constant, and the variance of a spread position is zero. Moreover, alternative specifications of the process generating spot prices, for instance the second order difference equation:

$$(4.6) \quad p_t = (1 + b)p_{t-1} + bp_{t-2} = \tilde{\mu}_t$$

with $\tilde{\mu}_t$ possessing the same properties as in equation (4.1) and $|b| < 1$, yield contrasting results for the variability of futures prices. In particular from (4.6):

$$(4.7) \quad \text{var}(df(t, T_1)) = \sigma_\mu^2 (1-b^{T-t+1})^2 / (1-b)^2$$

implies $\text{var}(df(t, T_1))$ decreases as the contract approaches maturity, the opposite prediction to that derived from (4.4).

Noting the theoretical limitations, the Castellino and Vora analysis highlights the influence of three factors simultaneously effecting spread variability in equation (4.3). These are: (i) the volatility of cash prices, σ_μ^2 , (ii) the time left to maturity of the nearby contract $T_1 - t$, and (iii) the length of the spread, $T_2 - T_1$. The effects of time left to maturity and spread length on spread volatility can be obtained by differentiating equation (4.5) with respect to $T_1 - t$, and $T_2 - T_1$ respectively to obtain:

$$(4.8) \quad \partial \text{var}(S_{12}) / \partial t = -2a^{2(T_1-t-1)} (1-a)^{(T_2-T_1)-2} \sigma_\mu^2 \ln(a) > 0$$

$$(4.9) \quad \partial \text{var}(S_{12}) / \partial (T_2 - T_1) = -2a^{2(T_1-t-1)} (1-a)^{(T_2-T_1)-2} \sigma_\mu^2 \ln(a) > 0$$

The volatility of the spread increases the closer to maturity the nearby contract and the greater the time period between maturity of its constituent contracts. Comparing equation (4.8) with the propositions advanced earlier, the 'maturity' model and the measurement costs model yield similar predictions with respect to the effect of time to maturity on spread variability, if and only if the futures contracts relate to price searching cash markets. When the cash market is price taking, in contrast to equation (4.8), the measurement cost model implies $\partial \text{var}(S_{12}) / \partial t = 0$. Of course, application of the 'maturity' model to price searching cash markets involves something of a paradox. This is because the theory, by assumption, requires the current futures price to be an unbiased estimator of the expected cash price at contract maturity. In general, as the measurement cost model makes clear, this could be true only for contracts relating to price taking cash markets.

b: The Convenience Yield Theory

Prior discussion indicated the importance accredited to marginal net carrying costs as a determinant of intracontract price spreads for storable commodities. One component of such costs which has attracted extensive discussion, is the tangible benefit derived from having the commodity available in inventory, for which Kaldor (1939) coined the term the (marginal) convenience yield. The sources of the convenience yield to holding inventory are succinctly described by Telser (1958).

First, the availability of stocks permits a processor or producer to maintain a given level of output at a lower cost than would be required without stocks. Similarly, an inventory firm can maintain a given rate of sales at lower cost. Second, holding stocks permits the rate of production or sales to be varied at a lower cost than would be incurred if the firm attempted to purchase the stocks as they were needed. Immediate purchases are more expensive than leisurely purchases that permit the firm to learn the state of the market and to make the best transaction it can.⁶

From the description, it is evident that the marginal convenience yield is a stochastic variable, which arises because holding stocks in inventory can have productive value. The theoretical prediction is that its importance is inversely related to the stock of the commodity held in storage. According to Brennan (1958), "the smaller the level of stocks on hand the greater will be the convenience yield of an additional unit."⁷ Thus, the marginal convenience yield is, over some range, responsive to changes in the level of inventory. It is essentially zero for commodities when inventory levels are high, and would acquire greater importance in the pricing of storable commodities with seasonal supplies, particularly agricultural crops. In the present context, the expectation is that fluctuations in the marginal convenience yield will have a more prominent effect on the futures prices of contracts which mature later in the crop 'year'.⁸ Thus, controlling for the length of spread, one would expect more variability in spread price changes arising from fluctuations in the marginal convenience yield, the closer the delivery period of the distant contract to the end of the crop year. Neither the maturity or measurement theory contains such a prediction.

c: The State Variable Hypothesis

Anderson and Danthine (1983) provide perhaps the most general model of futures price behaviour in a multiperiod, partial equilibrium setting, in which agents make production decisions in the cash market and simultaneously assume positions in futures to maximise the expected utility of end-of-period wealth. During the holding period, production and demand uncertainty are progressively resolved through the realization of publicly observable random variables. Their model demonstrates that the ex ante volatility of futures prices is higher (lower) during the periods when a relatively large (small) amount of supply and demand uncertainty is resolved. Anderson (1985) refers to this theory as the state variable hypothesis.

In its current form, the theory is elegant and theoretically consistent as an explanation of price determination. However, the present essay contends that to date it has not been refined to a form suitable for empirical corroboration. The design of procedures to implement the hypothesis depends crucially upon assumptions made regarding the specific nature of the supply and demand uncertainty impinging upon particular commodity markets. Anderson (1985 p.333) proposes that for most commodities, the resolution of uncertainty tends to occur at the same time during the calendar year, and consequently follows a strong seasonal pattern which should manifest itself in the data. This approach is replete with methodological dangers. Unless one has developed a theory of the seasonal patterns one is attempting to explain, the temptation may be to conclude that the variability is higher at certain times simply because, ex post, that is the time the majority of the information relating to the uncertainty in supply and demand factors must have become publicly available. In this sense, the state variable hypothesis currently lacks predictive content and is simply descriptive of the phenomena it purports to explain. Consider the following:

"Identifying the sources of seasonality in a nonagricultural commodity such as silver is more complex. Since silver stocks are usually large relative to production, the sources of volatility are likely to come mostly from the demand side. Here then is a complex mixture of factors affecting demand for use in photographic materials, for jewelry and silverplate, and for bullion as a store of

value. We find the net result of these factors tends to be relatively high volatility in May, October and November and relatively low volatility in January, February and March."¹¹

In this respect the measurement cost, maturity and convenience yield theories may be considered refinements of the state variable hypothesis allowing for empirical refutation of ex ante predictions. In view of these considerations, the state variable hypothesis is not explicitly considered in the remainder of this essay as an independent theory of futures price determination.

III: EMPIRICAL VERIFICATION

a: The Behaviour of Spread Positions in Futures Contracts

Before the refinement of empirical procedures which attempt to discriminate between the three models of commodity spread behaviour outlined earlier, a brief summary of prior investigations may help clarify the context and contribution of the current study. Previous analysis of the volatility of spread positions (Meyer (1979), Breeden (1983)), and Castelino and Vora (1984)) either test mechanical trading rules to discover if spread positions can reduce the risk of investors positions in commodity futures contracts, or attempt to identify the relationship between spread length, defined as the number of months between delivery periods of the component contracts, and spread price variability. The studies differ with respect to the nature and number of the markets they analyse, the frequency of observations, the measurement of variability, and choice of statistical tests.

Meyer (1979) derives and tests the profitability of three sets of mechanical trading rules based on the relationship between contract prices and carrying charges for pork-belly spreads over the 1964-71 period. Using weekly observations of Friday closing prices for five contract months;¹² February, March, May, July, August, he concludes not only that spreading would have been profitable for each of the three strategies utilised, but also that spread length is

positively related to profitability.

Breeden (1983) investigates the relationship between spread volatility and spread length for twelve futures contracts; corn, oats, soybeans, soybean oil, soybean meal, wheat, plywood, silver, commercial paper, GNMA, GNMA-CD, and Treasury bonds all trading on the Chicago Board of Trade. The study uses month-end closing prices and examines spreads within the period January 1960 - April 1980. Two measures of variability are adopted: (i) right cumulative frequency; in which an $x\%$ frequency of $\$y$ means that $x\%$ of the months examined showed a price change greater than or equal to $\$y$, and (ii) spread standard deviations. Breeden concludes that for both measures of spread variability there is a pronounced pattern of significant increases in spread volatility with increases in the spread length. He also indicates that spreads involving contracts nearer maturity tend to be "slightly more variable" than those for distant contracts.¹³ Although his last comment could be interpreted as supportive of the maturity hypothesis, no statistical tests are conducted to determine the significance of his results. Moreover, as the measurement theory would predict, the pattern is not uniform across commodities and on casual inspection appears more pronounced in the "thinner" contract markets.

Castelino and Vora (1984) also examine the relationship between spread volatility and spread length for six contract markets; wheat, corn, soybeans, soybean oil, soybean meal trading on the Chicago Board of Trade, and copper trading on Commodity Exchange Incorporated (COMEX). Several spreads are constructed, all involving the July contract. Using daily prices, and adopting the variance of spread price changes as the measure of volatility, their study concludes that spread volatility increases as spread length increases.¹⁴

The findings of the latter two studies in particular, are consistent with the maturity hypothesis, in that they can be theoretically rationalised using the Samuelson (1965) model of futures price behaviour. However, they also vindicate other hypothesis, including both the measurement cost and convenience yield models. Therefore, as they stand, they do not

facilitate discrimination among alternative theses regarding the behaviour of spread portfolio volatility. Moreover, the test procedures adopted rely heavily upon the assumption that the standardized sample variances are distributed normally or lognormally. Not only is this assumption open to question, it is also analytically separate from the spread length effect, and should not be part of the maintained relationship. This raises the question of whether the results of the tests are robust to different assumptions relating to the distribution of futures price changes.¹⁵

A further consideration not previously accounted for also distinguishes the present from prior analyses. Jones (1981) correctly points out that; "spreads and the values of spreads behave quite differently depending upon whether the carry costs are absolute or relative."¹⁶ Absolute carry costs are fixed dollar costs of carry per unit of time. They depend on the quantity but not the value of the commodity being stored. The main component of such costs are physical storage costs. Relative carry costs are those which depend upon the value of the commodity. The financing costs of both physical and financial commodities are relative carry costs. Their main determinants are the price level of the commodity and the rate of interest.¹⁷ Considerations of the distinction between relative and absolute carry costs introduces a complexity into the analysis of spread behaviour not explicitly accounted for in previous literature. Namely, with relative carry costs, the value of contractual price relationships changes with the level of prices and interest rates as well as with the level of absolute storage costs. Some market commentators dismiss this phenomena as unimportant. Williams (1986) is typical:

"... movements in storage fees cannot account for the observed volatility of spreads....Nor are movements in interest rates, and by extension capital costs, large enough to explain the magnitude of movements in spreads....As a first approximation, therefore, a theory of futures markets can ignore interest expenses and physical storage costs....They are trivial and essentially constant components of spreads."¹⁸

Although support for such statements must ultimately be sought empirically, on present evidence one is reluctant to concur with William's contention. In a recent study, Fama and

French (1987) utilise the theory of storage to identify factors affecting the variability of the basis (the future-spot price differential) over the life of the futures contract. For metals, one commodity classification in which relative carry costs are important, the behaviour of prices is found to be "consistent with the hypothesis that the basis tracks nominal interest rates".¹⁹ The latter explain 83% of the six-month variance for gold and 60% for silver. The analytical similarities between basis and spread volatility are sufficient to merit the conclusion that failure to account for volatility effects of changes in the relative carry cost component of spreads could conceivably mitigate the usefulness of the empirical results.

b: Data Description and Test Procedure

This study examines the spread behaviour of four commodity contracts; cocoa trading on the Coffee, Sugar and Cocoa Exchange, cotton trading on the New York Cotton Exchange, and copper and silver, both trading on COMEX. The price series were obtained from three sources. The cocoa and cotton data were made available on a magnetic tape supplied by the Center for the Study of Futures Markets, Columbia Business School supplemented by issues of the Wall Street Journal. The silver and copper data were transcribed from COMEX statistical yearbooks for 1980-84. Daily closing prices for the four contracts are used over the 1980-84 period to construct the spreads. As the concerns of the model are with storage (rather than production) arbitrage, the analysis of the cocoa and cotton data is confined to an analysis of spreads between contracts settling in the same crop year.²⁰ The crop year for cocoa begins on October 1st, for cotton on September 1st. The first observation on the price spread is taken the trading day following expiration of the trading period in the distant contract the preceeding crop year. The last observation is taken the trading day prior to the delivery period of the nearby contract comprising the spread. Thus, the study excludes delivery month price observations from calculations of spread volatility.

The results are based on estimates of the model:

$$(4.10) \quad V_{j,t}(S_{12}) = a_0 + a_1(T_1 - t) + a_2(T_2 - T_1) + a_3(T_2 - T_c) + a_4 (V_j df(t, T_1) / V_j df(t, T_2)) + u_t$$

where:

- i) V_j is a measure of the variability of contract price changes in commodity j , and
- ii) T_c is the first month of the crop or calendar year.

All the other notation is as previously defined. As in Castelino and Vora (1984) and most other recent studies of futures price volatility²¹, the basic unit of observation is the change in the natural logarithm of the daily settlement price. Spread changes are measured as $\ln(f(t+1, T_2)/f(t, T_2)) - \ln(f(t+1, T_1)_e/f(t, T_1)_e)$. The distant equivalent price, $\ln f(t, T_1)_e = \ln f(t, T_1) + \ln(1+r \cdot n/360)$, where n is the number of days between the first eligible delivery day of the two contracts, and r is the actual or implied 90-day Treasury Bill futures price on the International Money Market of the Chicago Mercantile Exchange at time t for a 90-day Treasury Bill deliverable in period T_1 .²²

The reason for using log differences is that a priori, one would expect the dispersion of prices to change in the same direction as the price level. Using log differences corrects for this obvious source of nonstationarity. This study is the first in the futures literature attempting to explicitly control for changes in the level of relative carry costs arising from price level or interest rate changes during the contract holding period. Evidence solicited from commodity exchange officials indicate changes in factors affecting absolute carry costs were insignificant for the commodities examined over the period of observation.²³

The choice of a measure of variability to employ raises the perennial question of the nature of the distribution of commodity futures prices. Two tests are performed on the current data sample to characterize spread price changes relative to the normal distribution, namely kurtosis and the ratio of the range to the standard deviation. The specifics of the tests are documented in Hudson, Leuthold and Sarassoro (1987), with the results from the present sample given in Table 4.1. The kurtosis test rejects the normality assumption for

about 46% of the contracts examined. Cocoa appears to be the least normally distributed, the null hypothesis of normality being rejected about 63% of the time. Examination of individual contracts revealed that positive kurtosis occurred more frequently than negative by a factor of about three to one. These results suggest some degree of leptokurtosis, more observations in the tails than expected theoretically.

As with kurtosis, the cocoa results show the most non-normality of all the commodities in tests using the ratio of the range to the standard deviation. (For more information on this test see David, Hartley and Pearson (1954)). As distributions with an excessive number of extreme observations in either tail translate into a high R/S value, this test may show more normality than the kurtosis test, as triggering of daily price limits could prevent price moves of the magnitude required by the informational shock occasioning them. The R/S test indicates that about 62% of the spread distributions studied could be classified as normal.

As a consequence of these relatively inconclusive results, two measures of variability are utilised in this study. First, results based on the variance of daily price changes are reported. It is recognised that if futures price changes are not (log) normally distributed, and instead conform to a member of the non-Gaussian family of distributions better than to the normal distribution, then the sample variance is an inefficient measure of volatility. Despite the qualifications, the variance is utilised as that is how the maturity and measurement costs hypothesis are derived.²⁴ Moreover, many recent studies Castellino and Vora (1984), Anderson (1985), and Milonas (1986) included, are similarly undeterred by these considerations and also adopt the variance. Use of the same dispersion measure facilitates comparison of results. To corroborate findings obtained using the variance, a measure of variability based upon the .28 to .72 interfractile range is also constructed, following the procedure in Fama and Roll (1968, 1971). This measure of variability has been incorporated into recent studies, notably by Miller (1979) and Grauer (1977). They find largely the same patterns of dispersion for interfractile ranges as for variances.

The variability measures are obtained by pooling price observations from a single contract for a single calendar month, of a single year. In effect the assumption is that the daily log changes of futures prices conform to a stationary distribution within the month, but are nonstationary over time periods greater than one month. This is consistent with models of asset price determination, to the degree that these models do not imply the mean and variance of prices change drastically over short time intervals. One could specify a model in which the distribution of the log change of daily prices varied gradually (daily) over time. Implementation of this approach requires specification of the functional form of the time path of the mean and variance of the distribution. This introduces a possible source of misspecification bias.

The vector of independent variables utilised in the study is defined as follows:

- (i) $T_1 - t = \text{MAT} =$ time, in months to maturity of the nearby contract comprising the spread.
- (ii) $T_2 - T_1 = \text{LENGTH} =$ the number of months between the first delivery day of the component contracts constituting the spread.
- (iii) $T_2 - T_c = \text{CONVEN} =$ the number of months into the crop (calendar) year the distant contract in the spread matures.
- (iv) $\text{Vdf}(t, T_1) / \text{Vdf}(t, T_2) = \text{RATIO} =$ the ratio of the price volatility (appropriately measured) of the nearby to the distant contract comprising the spread.

The rationale for the inclusion of the MAT and LENGTH variables has been explained. The maturity hypothesis would expect a_1 to be negative in equation (4.10), while the measurement cost hypothesis states that for contracts relating to price searching cash markets $a_1 < 0$, but for those pertaining to price taking cash markets $a_1 = 0$.

The coefficient on the spread length variable a_2 is expected to be positive under the maturity hypothesis. Unfortunately, both the measurement cost and convenience yield theories are agnostic regarding the sign of this estimate.

The CONVEN variable attempts to capture the effect of fluctuations in the marginal convenience yield. The convenience yield model argues this variable will have a more pronounced effect on futures price volatility the later into the crop year the contract matures as this is when inventories are low and the variable assumes prominence. Thus, for storable commodities expected to possess a convenience yield, cocoa and cotton in the present study, a_3 is expected to be positive.²⁴

Finally, the RATIO variable attempts to further discriminate between the maturity and measurement cost hypothesis. The former requires a_4 to be positive for all four contracts, as it evolves from the Samuelson (1965) model which specifies (using the notation of equation (4.10) that:

$$\ln\{\text{var}f(t, T_i)\} = \ln\sigma_\mu^2 + 2(T_i - t - 1)\ln(a).$$

Thus:

$$\partial \ln\{\text{var}f(t, T_i)\} / \partial (T_i - t) = 2\ln(a) < 0.$$

In effect, testing the maturity hypothesis involves testing the joint restriction $a_1 < 0$, $a_4 > 0$. The measurement costs hypothesis also predicts $a_4 > 0$ for contracts relating to price searching cash markets. However, the sign of a_4 for futures contracts in which the related cash market is price-taking, depends on the assumption one makes concerning the behaviour of σ_ϕ^2 over the life of the contract. For theoretical tractability, the preceding analysis held σ_ϕ^2 to be time independent. If this assumption is relaxed, then a_4 would be > 0 (< 0) if one believed $\partial \sigma_\phi^2 / \partial (T_i - t) < 0$ (> 0).

c: Classification of Cash Markets

With respect to the four contracts in the current data sample, can anything constructive be ascertained regarding the extent to which their pertinent cash markets may be said to be price taking or price searching? This information would at least enable the formulation of prior conjectures as to the significance of the parameters in equation (4.10). Two considerations are relevant. The first relates to the empirical results of chapter 3. There it

was argued δ_i , the ratio of the level of open to spread position initial speculative margin requirement is inversely related to the comparative disadvantage of transacting via futures, or the degree to which the relevant cash market is price searching. The computed values of δ_i for the present four commodities are cocoa 2.75, cotton 3.1, while copper and silver must simply be marked to market daily. This suggests that the futures contracts are better able to duplicate cash market trading methods in silver and copper than in cocoa and cotton.

Supporting evidence is presented in Garbade and Silber (1983) in their discussion of the structure of premiums and discounts for non-par delivery. They maintain that the use of equivalence systems in futures contracts to determine non-par pricing rules is used when the underlying attribute of the commodity on which the differential is based "can be isolated through a technological extraction process."²⁶ In the terminology of this essay, this corresponds to a traders ability to measure the valued attributes objectively. Thus, the more contractually complete the futures contract, the greater its ability to adopt equivalence systems in its settlement procedures. Both the silver and copper contracts on COMEX utilise equivalence system pricing for nonpar deliveries, while the cocoa and cotton contracts adopt fixed (non-commercial) differentials, or what Garbade and Silber term a penalty system. Recalling the comments made in the introduction to chapter 3, one would, a priori, expect the idiosyncratic element of contractual price variability to be larger in the two latter than the two former contracts. With these considerations in mind, one may tentatively refer to the silver and copper cash markets as price taking, and the cocoa and cotton cash markets as price searching.

d: Empirical Results

What follows are the results of the parametric tests of equation (4.10) based on least squares estimation procedures. The principal reason for adopting a parametric approach is that it allows the employment of statistical tests that have greater power than the nonparametric approaches (chiefly Rank tests) embraced by other researchers addressing related issues. The

approach has a further advantage in that it augments ones ability to introduce additional factors that are believed to influence futures price volatility, the interaction of which cannot be accommodated by rank tests.

Before discussing the results, I draw the readers attention to a potentially important source of nonstationarity bias, arising from the fact that the information flow into the contract market is not random. This effect is perhaps more pronounced for seasonal commodities as forecasts of crop size, inventory levels and such, are made at specific times during the year by government agencies and independent analysts. As mentioned earlier in discussion of the state variable hypothesis, one may expect the effect of the information flow is to create increased price volatility at around the time the information becomes public.

A procedure to correct for these effects, suggested in Castellino (1981), and utilised in this study, is to divide the spread price variability measure by the geometric average price variability of its component contracts.²⁷ The underlying assumption is that the variability of each futures price is subject to a uniquely defined information set, which is a function of the current time period t , and the maturity period of the contract T_j . This function is assumed to be the same across crop years. This normalising procedure allows the variability measure to be independent of the month and year in which it is estimated.

The results of the linear regressions are reported in Tables (4.2) - (4.5). For the two contracts cocoa and cotton to which a price searching cash market is tentatively ascribed, the signs of coefficient estimates are largely in conformity with both the maturity and measurement cost hypothesis. The t -statistics (given in parentheses) suggest that the MAT, SLENGTH and RATIO coefficients are significantly different from zero at a 5% level of significance. The only exception is the MAT variable for the normalised variance equation in cocoa, which although of the expected sign is not significantly different from zero.

The convenience yield theory performs relatively poorly. In cocoa, the estimated coefficients are positive as the theory predicts, but in all cases appear insignificantly different from zero. In the cotton equation, all the estimates are of the opposite sign to that predicted, and in one case (cotton(4)) significantly so, suggesting spread volatility diminishes as the maturity date of the distant contract approaches the end of the crop year. The temptation is to conclude that at least for cotton and cocoa, fluctuations in the marginal convenience yield are not empirically important as determinants of the volatility of commodity spreads.²⁸

The more interesting results are those relating to the silver and copper contracts. Potentially they enable one to discriminate between the maturity and measurement cost hypothesis. Perhaps the most striking conclusion to be drawn on examination of the findings, is that the results appear sensitive to the measure of volatility employed. Consider the silver results in Table (4.4). Using the variance as the variability measure, they apparently lend strong support to the maturity hypothesis. However, the estimated MAT coefficient in the normalised interfractile range equation, silver(4), is insignificantly different from zero as the measurement cost hypothesis would expect. The coefficient on MAT in the non-normalised interfractile range equation, silver(3), would suggest silver spread volatility decreases significantly with time to maturity of the nearby contract, a result neither theory can explain. The SLENGTH coefficients are signed in accordance with the maturity model. Thus, it appears the variance results are in conformity with the maturity model, and the interfractile range estimates are either ambiguous, or support the measurement cost model. As an attempt to assess the validity of either theory, one must conclude the silver results are somewhat inconclusive.

With the copper regression estimates, a clearer pattern emerges. Three of the four MAT coefficients are insignificantly different from zero, which supports the measurement cost hypothesis. The fourth, copper(3) is significantly positive, corroborating neither model. As for

all the silver estimates, the *RATIO* variable is significantly positive in the regression estimates using the variance. However, when the interfractile range is utilised, the *RATIO* coefficient is insignificantly different from zero. In the context of the present model, the behaviour of the *RATIO* variable in silver and copper is difficult to explain. One plausible suggestion is that seasonal factors may account for its behaviour, as the state variable hypothesis would lead one to believe. Once again in the copper equations, the *LENGTH* variable is significant and positive as expected under the maturity hypothesis. However, given the *LENGTH* variable is not the critical one for purposes of hypothesis discrimination, the copper results may be interpreted as supportive of the measurement cost as opposed to the maturity hypothesis.

The findings of this analysis may be briefly compared to those of other related studies employing the same commodities. Rutledge (1976) conducts a test of the hypothesis of an inverse relationship between open contract price variability and time to maturity implied by the process described in equations (4.1) - (4.4).¹² He uses daily price observations, and measures variability as the absolute value of (log) price differences. A goodness of fit test for a three-way contingency table is employed, with data grouped by volatility of cash price, volatility of futures price and time to maturity. He accepts the Samuelson hypothesis for cocoa and silver, which is consistent with our findings for the former commodity, and for the latter employing the variance as the volatility measure.

Grauer (1977) using month-end futures prices for open contracts in ten commodities, one of which is silver, rejects the Samuelson hypothesis. Adopting the variance and the interquartile range as the variability measures, the study derives Friedman's non parametric test statistic for a two way analysis of variance. The present silver results with the interfractile range volatility measure are consistent with his conclusions.

Finally, the universal positive relationship between spread length and spread volatility confirms the findings of Breedan (1983) for silver, and Castelino and Vora (1984) for copper. This study provides additional positive evidence for the relationship in the case of cocoa and

cotton.

Table 4.1

Kurtosis and Ratio of Range to the Standard Deviation Tests

Commodity	Number of Spread Distributions	Number (%) of Cases Exhibiting Non-Normality ^a	
		Kurtosis	R/S ^b
Cocoa	46	29 (63%)	22 (48%)
Cotton	43	21 (49%)	17 (40%)
Silver	54	18 (33%)	16 (30%)
Copper	54	24 (44%)	19 (34%)

a: All tests were concluded at a 0.01% level of significance.

b: R/S is the ratio of the range to the standard deviation.

Table 4.2

Linear Model Results: Cocoa Spreads

Independent Variable	Cocoa (1)	Cocoa (2)	Cocoa (3)	Cocoa (4)
INTERCEPT	-7.173-05 (-6.93)	-0.2594 (-8.22)	-0.0012 (-2.66)	-0.1605 (-3.34)
MAT	-1.141-06 (-1.98)	-0.00113 (-0.61)	-1.458-04 (-6.18)	-0.0098 (-4.01)
SLFNGTH	2.795-06 (2.93)	0.0120 (4.15)	4.217-04 (11.44)	0.0342 (9.47)
CONVEN	7.165-07 (1.00)	0.00175 (0.79)	2.411-05 (0.71)	0.0049 (1.58)
RATIO	5.570-05 (7.99)	0.2151 (10.38)	0.00101 (3.73)	0.1254 (4.27)
R ²	0.63	0.66	0.60	0.54
F-STAT (4/305)	30.80	50.34	42.12	31.96
D W	1.99	1.99	2.11	2.02
SFR	2.11-05	0.0629	8.29-04	0.0884
SSR	1.350-07	1.205	2.089-04	2.374
NOB	310	310	310	310

The following cocoa spreads are analysed: Dec.-Mar.; Dec.-May; Dec.-July; Dec.-Sept.; Mar.-May; Mar.-July; Mar.-Sept.; May-July; May-Sept.; July-Sept.
 The first price observation is taken on the March 1980 -May 1980 spread on 1 June 1979.
 The last, on the July 1984 -Sept 1984 spread, on 30 June 1984.

Table 4.3

Linear Model Results: Cotton Spreads

Independent Variable	Cotton (1)	Cotton (2)	Cotton (3)	Cotton (4)
INTERCEPT	-1.705-05 (-2.04)	-0.10047 (-2.67)	0.00139 (3.02)	-0.1516 (-1.85)
MAT	-1.0784-06 (-2.05)	-0.00598 (-2.38)	-1.055-05 (-4.34)	-0.01669 (-3.07)
SLENGTH	4.548-06 (4.44)	0.01965 (5.67)	2.53-04 (4.95)	0.0435 (4.79)
CONVEN	-3.769-07 (-0.46)	-0.00176 (-0.68)	-9.303-05 (-2.07)	-0.00708 (-1.03)
RATIO	1.134-05 (4.35)	0.1791 (12.20)	6.481-04 (2.73)	0.2797 (6.59)
R ²	0.58	0.59	0.57	0.62
F-STAT (4/212)	14.847	59.96	9.24	19.91
D-W	2.12	2.01	2.15	1.94
SER	1.53-05	0.0794	8.77-04	0.1565
SSR	4.948-08	1.329	1.62-04	5.171
NOB	217	217	217	217

The following cotton spreads are analysed: Oct.-Dec.; Oct.-Mar.; Oct.-May; Oct. July; Dec.-Mar.; Dec.-May; Dec.-July; Mar.-May; Mar.-July; May-July.

The first price observation is taken on the March 1980 -May 1980 spread on 1 June 1979

The last on the May 1984 -July 1984 spread, on 30 April 1984.

Table 4.4

Linear Model Results: Silver Spreads

Independent Variable	Silver (1)	Silver (2)	Silver (3)	Silver (4)
INTERCEPT	-2.699-04 (-32.93)	-0.2138 (-11.35)	-0.0014 (-5.74)	-0.1475 (-8.49)
MAT	-1.060-06 (-2.64)	-0.0022 (-2.47)	3.013-05 (4.71)	2.826-04 (0.80)
SLFNGTH	3.108-06 (7.39)	0.00241 (2.63)	1.22-05 (13.76)	0.0677 (20.82)
CONVEN	3.768-07 (1.46)	6.149-04 (1.10)	9.768-06 (1.58)	1.937-04 (0.87)
RATIO	2.816-04 (43.8)	0.2399 (15.89)	0.00124 (5.17)	0.1491 (8.819)
R ²	0.76	0.51	0.59	0.55
F-STAT (4/627)	399.9	57.02	51.79	153.7
D-W	2.01	1.99	2.21	2.11
SFR	2.10-05	0.0492	2.99-04	0.0192
SSR	2.748-07	1.513	5.613-05	0.23
NOB	632	632	632	632

The following silver spreads are analysed: Jan.-Mar.; Jan.-May; Jan.-July; Jan.-Sept.; Mar.-May; Mar.-July; Mar.-Sept.; Mar.-Dec.; May-July; May-Sept.; May-Dec.; May-Jan.; July-Sept.; July-Dec.; July-Jan.; July-Mar.; July-May; Sept.-Dec.; Sept.-Jan.; Sept.-Mar.; Sept.-May; Sept.-July; Dec.-Jan.; Dec.-Mar.; Dec.-May; Dec.-July; Dec.-Sept..

The first price observation is taken on the May 1980 -July 1980 spread on 2 Jan. 1980. The last on the Sept. 1984 -Dec. 1984 spread, on 31 August 1984.

Table 4.5

Linear Model Results: Copper Spreads

Independent Variable	Copper (1)	Copper (2)	Copper (3)	Copper(4)
INTERCEPT	-2.457-04 (-5.11)	-0.293 (-4.97)	1.468-04 (0.52)	-0.0294 (-0.84)
MAT	1.183-05 (1.7)	0.0112 (1.08)	2.479-05 (2.2)	0.00138 (1.01)
SLENGTH	1.033-05 (3.51)	0.00762 (1.38)	1.808-04 (13.55)	0.0199 (12.65)
CONVEN	7.117.06 (2.61)	0.0059 (1.78)	1.479-05 (1.75)	0.00199 (2.01)
RATIO	8.402-05 (12.31)	0.1785 (21.31)	-4.123-04 (-1.7)	0.0214 (0.71)
R ²	0.51	0.59	0.45	0.45
F-STAT (4/627)	34.02	92.6	43.62	41.74
D-W	2.00	2.06	2.23	2.12
SER	2.42-04	0.297	5.38-04	0.0664
SSR	3.668-05	5.5227	1.813-04	2.76
NOB	632	632	632	632

The following copper spreads are analysed: Jan.-Mar.; Jan.-May; Jan.-July; Jan. Sept.; Mar.-May; Mar.-July; Mar.-Sept.; Mar.-Dec.; May-July; May-Sept.; May-Dec.; May Jan.; July-Sept.; July-Dec.; July-Jan.; July-Mar.; July-May; Sept.-Dec.; Sept.-Jan.; Sept. Mar.; Sept.-May; Sept.-July; Dec.-Jan.; Dec.-Mar.; Dec.-May; Dec.-July; Dec.-Sept..

The first price observation is taken on the May 1980 -July 1980 spread on 2 Jan. 1980. The last on the Sept. 1984 -Dec. 1984 spread, on 31 August 1984.

FOOTNOTES

1. Williams (1986 p.22). Peck (1981) expresses similar sentiments.
2. See Williamson (1979) and Barzel (1982) for a discussion of this literature.
3. If demand uncertainty dominates supply, and if factors affecting ultimate demand are subject to progressively larger shocks as the demand date approaches, one may expect σ^2 to increase overtime. This is clearly a special case and cannot be rationalised in the present context. Stein (1979) constructs a model where open contract price variability increases as the delivery date approaches. Also see Samuelson (1965, 1976)
4. McManus and Acheson (1979 p. 49f, 1983 p. 15f). The exchange may have the option of using relatively more expensive objective measures as proxies for the excluded subjective, personal measures to define a product equivalent to that traded in the regular cash market. As contract goods deliverable become more narrowly defined, the contract becomes increasingly susceptible to corner problems. Evidence indicates (Garbade and Silber 1983b) that exchanges commonly incorporate the objective measures used in cash trading supplemented with little else when specifying deliverable goods, not wishing to impose higher costs on traders than they would incur in regular spot trading. Consequently, the implications of such (costly) complete contracts are ignored in the remainder of this essay.
5. A.B. Paul (1986 p. 313).
6. The third explanation could be interpreted as a version of the Keynes-Hicks theory of normal backwardation in which commercial interests hedging inventories, who are typically net short, pay a risk premium to speculative longs as an inducement to take the opposite side of the transaction.
7. Both of these assumptions are open to criticism. The assumption of a first-order autoregressive process for spot prices is very restrictive, and is not supported empirically (see Labys and Granger, 1970 ch.3). Samuelson (1976) constructing an exact ergodic model weakens his own earlier proposition by establishing that for very long-lived futures contracts, the variance of the contractual price changes when delivery is very distant will necessarily be less than the variance of the same contract sufficiently close to delivery. This prediction is much less precise, and its empirical usefulness questionable. Non-stationarity of cash prices (including trends), causing α to exceed unity, or nonconstancy in σ^2 over time will also violate the results. (Rutledge (1976), Miller (1979), Anderson (1985)). Finally, Cox, Ingersoll and Ross (1978) demonstrate the hypothesis that the current futures price equals the expected spot price at contract maturity does not generally hold for a wide class of assets. A similar conclusion, for contracts relating to price searching cash markets is obtained utilising a measurement approach in McManus and Acheson (1979). Nevertheless, it maybe of interest to test the Castelino and Vora hypothesis in its own right, the approach taken in this chapter.
8. Telser (1958 p. 253).
9. Brennan (1958 p.54). French (1986 p.541) is more precise, maintaining that "at low inventory levels, the convenience yield is relatively high. As the inventory rises, the marginal convenience yield falls at a decreasing rate."

10. From the description, it is evident that the marginal convenience yield is a stochastic variable which arises because inventory can have productive value. The theoretical prediction is that its importance is inversely related to the stock of the commodity held in storage. Clearly, incorporating the influence of the convenience yield, there is no presumption that the net carrying costs premium is positive, a conclusion Kaldor (1939, p.3) expresses in general terms stating:
 "stocks of all goods possess a yield...and this yield which is a compensation to the holder of stocks, must be deducted from carrying costs proper in calculating net carrying costs. The latter can, therefore, be negative or positive."
 Indeed, the phenomena of negative net carrying costs, or market inversion ($f(t, T_2) < f(t, T_1)$) has been extensively documented and discussed in the literature, much of the clearest analysis building upon Working (1949). For a recent discussion see Williams (1986), which is essentially a convenience yield theory of spread price volatility couched in terms of a discussion of the demand for accessibility to inventories.
11. Anderson (1985 p. 341 fn.7).
12. When a range of closing prices is given, Meyer uses the average price within the range.
13. Breeden (1983 p. 30).
14. It is unclear from the context whether the Castelino and Vora study uses closing or settlement prices.
15. These issues are considered in somewhat more detail a little later.
16. Jones (1981 p.6).
17. The difference between absolute storage carry costs and relative financing carry costs can be illustrated by gold. The storage costs for gold have recently been \$12.5 per kilogram per month, obviously quoted as an absolute carry cost. The financing costs for gold are typically 0.5% over the Eurodollar rate, quoted as a relative carry cost.
18. Williams (1986 p. 31).
19. Fama and French (1987 p. 61).
20. Castelino and Vora (1984) select July as the front end contract in constructing their spreads as "it either represents prices for the new crop year, or new crop year information is heavily discounted into its price." This statement is somewhat contentious. The crop years for three commodities are relevant, wheat, corn, and soybeans. Soybeans are harvested from September to November with yield estimates appearing in crop reports from August 10th through December 10th. The corn crop year begins on October 1st. Thus, for four of the six spreads (soybean, soybean meal, soybean oil, corn) Castelino and Vora take spread price observations across crop years. This could significantly bias the results if crop carry-overs and supply shocks are a significant price factor.
21. See for instance Miller (1979), Castelino (1981), Anderson (1985) and Milonas (1986).
22. I experimented with several alternative methods of calculating the distant equivalent

price, the main difference from the present procedure being in the interest rate used to calculate holding charges for spreads with component contracts maturing more than 90 days apart. The differences did not impart any qualitative changes at all to the results.

23. Public warehouse fees for agricultural commodities appear stable over periods as great as several years. For example, Continental Grain is one of four companies running registered grain warehouses in Chicago. As of late 1982 they had not changed their storage fee in three years. (Information courtesy of Thomas Dreps, Cash Grain Department, Continental Grain). Over the last decade, warehouse fee's on copper have only changed a couple of times (Ronald Andresen, Director, Metal Services, COMEX.) Warehouses registered with the London Metal Exchange change their rates only every few years (Williams (1986)).
24. The most recent studies that the present author is aware of are Helms and Martell (1986), and Hudson, Leuthold and Sarassoro (1987). The former, using transaction-to-transaction data for selected wheat, corn, GNMA and Treasury Bond contracts traded on the Chicago Board of Trade in the period May 1974 - March 1979, conclude that the normal distribution fits the data better than any non-normal stable distribution. However, their results also suggest that the underlying generating process does not appear to be stationary. The latter examine the distribution of futures price changes during the period January 1974 through December 1982 for wheat, soybeans and live cattle. Their results suggest a distinct move to normality and independence of commodity futures price changes in these contracts, particularly since 1976. Among other things, they attribute this tendency to the decline in the number of limit moves in the post 1976 period in these contracts. Both papers contain succinct summaries of previous work in the same area, beginning with Mandelbrot (1963), to which I refer the interested reader.
25. One would not expect the CONVEN variable to be significant for the metal contracts, as for any reasonable inventory level, the marginal convenience yield is essentially zero. See French (1986).
26. Garbade and Silber (1983b p. 252).
27. Details of the procedure are available in Castelino and Vora (1984, Appendix B).
28. This is not to deny the convenience yield may occupy the central role in any explanation for why futures price spreads rarely reach full carrying costs, defined as the total storage, insurance and financing expenses of holding the commodity in inventory. See Williams (1986) for clarification.
29. This phenomena has been noted by several authors including Telser (1958). Anderson (1985 p. 332) terms it the Samuelson hypothesis, as Samuelson (1965) provides the first theoretical argument supporting its validity. This nomenclature is somewhat unfair to Samuelson for the reasons Samuelson (1976) himself indicates.
30. The feature of the model providing a rationalisation for the liquidation bias is discussed in section I(c).

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