ASPECTS OF HEDGING THEORY

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In this paper, interpretative comments are offered on some established aspects of the economics of futures trading, including the nature of the equilibrium condition in the case of an inverse carrying charge, some inferences about traders' market positions made from estimates of returns, and the implications of the normal backwardation hypothesis in cases where hedgers are net long. The paper also includes a survey of the recent literature on the forward pricing function of futures markets, with a discussion of, *inter alia*, the methods used to investigate the hypothesis that futures prices are anticipations of delivery date spot prices, and the possible reasons why some markets perform this function better than others.

Introduction

Futures contracts are financial instruments relating to commodities or other financial instruments for forward delivery or settlement, on standardised terms. These contracts are traded on exchanges where a clearing house interposes itself between buyer and seller, and guarantees all transactions, so that the identity of the buyer or seller is a matter of indifference to the other party. The main economic functions of futures markets include the following: first, they facilitate stockholding, because the forward premium acts as a guide to inventory control. Second, futures markets facilitate risk management because they provide facilities for hedging. Recently the performance of futures markets as a hedging medium has been studied from the portfolio viewpoint for some individual commodities (Rutledge 1972; Ederington 1979) and for a total asset portfolio (Dusak 1973). Third, futures markets act as centres for the collection and dissemination of information and, if this information is fully reflected in current prices, these markets are said to be efficient. Futures markets have been subjected to weak-form tests for efficiency, and while Praetz (1975) found virtually no evidence of dependence on past prices in the case of Australian wool, the opposite conclusion has been drawn for several United States commodities (Cargill and Rausser 1975). Futures markets have also been subjected to semi-strong form tests for efficiency, either by use of 'own' and related forecast errors, or by comparison of predictive performance of futures prices and a rival forecast. The results for U.S. Treasury Bills (Hamburger and Platt 1975) and some currencies (Hansen and Hodrick 1979) have been more favourable than those for U.S. hogs (Leuthold and Hartmann 1979). Fourth, futures markets perform a forward pricing function, and futures prices have been interpreted as market anticipations of delivery date cash prices. Empirical evidence supports the view that markets for continuous inventory commodities perform this function better than do markets for discontinuous or non-inventory commodities (Tomek and Gray 1970; Kofi 1973).

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In this paper some aspects of futures market research are reviewed under three particular headings. In the next section, which is concerned with summarising developments in the hedging literature for nonspecialist readers, it is suggested that the equilibrium condition which is said to be met in the case of short hedging in the presence of a spot premium requires further development. In the section on Returns to Hedgers and Speculators it is suggested that inferences about traders' behaviour can be drawn from the important paper by Gray (1961), as well as the inferences about bias in futures prices, drawn by Gray himself. It is further suggested in this section that Houthakker (1957), in estimating returns to hedgers and speculators, assumed away an important problem, and that Rockwell (1967), who applied the method of Houthakker to wider data, interpreted some aspects of the normal backwardation hypothesis unsatisfactorily. This section also refers to returns to hedgers and speculators in Australian wool estimated by Goss (1980*b*) using newly generated data.

The forward pricing function of futures markets and the reasons why markets for noncontinuous inventory commodities perform this function less well than do markets for continuous inventory commodities, the methods used to obtain the available evidence, and recent Australian evidence on this question are all discussed in the penultimate section.

Routine and Discretionary Hedging

Hedging may be defined as the pursuit of an expected return from dealing in futures, in conjunction with an actuals market position of opposite sign, subject to a risk constraint. By routine hedging, one usually means matching an open position in actuals[1] with an equal and opposite position in futures for the purpose of risk reduction only. In terms of *ex post* outcomes, it is clear that the short (seller) hedger gains if the spot premium (the amount by which the spot price exceeds the futures price) rises or if the forward premium declines (apart from the costs of dealing and stockholding). Until the 1970s, the literature on futures trading had treated the outcome for a routine long hedger, that is, an economic agent who sells forward a product not covered by inventory, and who hedges by a purchase of futures of the product or its inputs, as the exact mirror image of the outcome of a short hedge. Yamey (1971, p. 423), however, argued that '. . . the price quoted for the forward delivery of the actual commodity will tend to approximate that of the similarly-dated futures contract, and, save coincidentally, not that of the actual commodity for current delivery.' Hence, the difference between the forward actuals price and the futures price at the time the hedge is opened cannot be treated as a *spot premium,* and so the outcomes for a short hedger and a long hedger are not entirely symmetrical.[2]

[1] The term 'actuals' is more general than the term 'spot'. A spot transaction is a current transaction in the physical commodity for current delivery, while a forward actuals transaction refers to deferred delivery of the physical commodity.

[2] The seeds of this position were present in the work of Working (1953) where he wrote, with reference to the aims of hedging, '. . . in the case of a flour miller, he sells flour for forward delivery because he can get a price that is favourable *in relation to* the price of the appropriate wheat future; therefore he sells flour *and* buys wheat futures. (Here the arbitrage, it may be noted, is between two forward prices, that for flour and that for wheat.)' (p. 325, italics and parentheses in original).

Working (1953) criticised empirical work based on the concept of routine hedging for not stressing that in practice the volume of stock on which a hedged loss is taken is likely to be much smaller than that on which a hedged profit is taken. Accordingly, he redefined hedging as 'the *purchase or sale of futures in conjunction with another commitment, usually in the expectation of a favourable change in the relation between spot and futures prices*' (Working 1953, p. 326, italics in original): to Working, hedging was a speculation on the basis.[3] Among the various categories of hedging distinguished by Working are carrying-charge hedging, in which the price spread is a guide to inventory control, operational hedging, used to facilitate product pricing, and selective hedging, where stocks are held partly hedged according to the trader's expectations of the price *level.*

This last category left open the theoretical question of the proportion of stock to be hedged, and subsequent literature has responded to this question with models of individual decision making based on subjective expectations and output variability. The first approach has been used by Johnson (1960), Stein (1961, 1964) and others. Stein's model, using the variance of return as a measure of risk, determines the proportion of stock to be hedged for a risk-averse individual whose assumed aim is maximisation of expected utility. This model, while allowing for the adjustment of equilibrium in response to changes in both current and expected spot and futures prices, has the limitation, *inter alia,* that it does not precisely determine the individual's spot market position (this criticism does not apply to the more recent work of Stein (1979)). Moreover, while the model explains that an economic agent may underhedge, it does not incorporate the possibility of over-hedging, nor does it permit a trader to be long in both spot and futures (Goss and Yamey 1978). The model does not, however, have the limitation attributed to it by Snape (1970) who argued that Stein did not allow fully for substitution between hedged and unhedged stock so that there is a possibility of unstable market equilibrium (Goss 1979). Johnson examined the behaviour of a risk-averse utility maximising individual assumed to be long (only) in spot, but who may under- or over-hedge or go long in futures. The expected return on the individual's market position was shown to be a function of the expected price changes in the spot and futures markets, while the risk equation included the same risk measure as that of Stein. Johnson defined a hedge as a futures market position which minimises risk at any given spot market position. He used the model to show, *inter alia,* that, if both spot and futures prices are expected to rise, the trader will, for any given expected return, face a smaller risk if he carries his stock partially hedged, or if a relatively large rise is expected in the futures price, he will be long in spot and long in futures. Ward and Fletcher (1971) extended the analysis of Johnson to the case of long hedging, and also provided for the long hedger to go short in futures; this may occur, for example, when the trader expects a substantial fall in both actuals and futures prices.

McKinnon (1967) extended this approach by allowing for variability of

[3] Working (1962) later stressed that hedging was done for a variety of reasons and defined hedging as 'the use of futures contracts as a temporary substitute for a merchandising contract, without specifying the purpose' (p. 432).

primary producer output, treating both spot price and output as random variables. The optimum (short) hedge is defined as that which minimises risk as measured by the variance of income. While this is a discretionary hedging decision, it is not reached by a combination of hedging and speculative elements as in the models of Stein and Johnson. Indeed, if the assumption of output variability is dropped, the producer behaves as a routine hedger. McKinnon argued that if the relative variability in output is sufficiently large, then the optimal hedge becomes a futures purchase. Again, this result is not speculative in that no account is taken of *subjective* price expectations. Moreover, the model is oriented toward income stability rather than profit. Peck (1975) considered the discretionary hedging problem from the viewpoint of a primary producer whose production decision is dependent upon an expected actuals price at harvest time. Her point of departure was a concept of risk measured in terms of nonpredicted price variation: that is, by the difference between realised and expected actuals prices. Using Chicago egg data, discretionary hedging was found to reduce this risk, the expected prices being provided by market agency forecasts.

The volume of hedging by discretionary short hedgers is likely to be an increasing function of the forward premium for at least two reasons. First, traders may believe that the larger the forward premium, the more likely it is to decline in the future (it must disappear at maturity), and a forward premium which declines gives a gain to short hedgers. Second, if holders of hedged inventory are a competitive group independently seeking to maximise profits, they will equate the marginal net cost of storage (assumed to be an increasing function of stocks) with the forward premium (the return on a hedge held to maturity). The holding of such stocks at time of spot premium is usually explained in terms of the convenience yield, because a spot premium which narrows over time results in losses to short hedgers. One may question, however, the nature of the equilibrium condition which is supposed to be met in the last case. It seems that the whole burden of adjustment is thrown on the marginal convenience yield, which can make marginal net storage costs negative. The convenience yield is a subjective variable which has been estimated only as a compound residual with another subjective variable, the marginal risk premium (Brennan 1958). We may question whether the convenience yield has the degree of flexibility required. On the nature of the convenience yield, guidance is apparently given only by Kaldor (1939/1961, pp. 20–1) who wrote, '. . . this yield which is a compensation to the holder of stocks, must be deducted from carrying costs proper in calculating net carrying cost . . . [which] can be negative or positive', Yamey (1971, p. 419) who called it the advantage 'of being open to sell', and Working (1942, p. 42) who said, 'A miller or a merchandiser risks losing money if he allows his stocks of wheat to fall so low that he can not handle business that may be offered to him'. We are left with no assurance, however, that the marginal convenience yield is able to explain a large spot premium, and Working (1948) indicated that our knowledge here is far from complete, observing that '. . . the largest inverse carrying charges . . . have never prevented the carrying of substantial aggregate quantities of wheat hedged in the Chicago market. The reasons, which have never been carefully explored, doubtless vary with the . . . individual or firm that carried the stocks' (p. 21).

Returns to Hedgers and Speculators

Proponents of the concept of hedging for the purpose of risk reduction have usually argued that under 'normal' conditions the spot-futures price relation would be one of spot premium equal to the marginal risk premium of speculators. Advocates of the concept of discretionary hedging, on the other hand, have argued that the prediction of spot premium does not generally hold, and that, if any particular spot-futures price relation is 'normal', it is one of forward premium. Empirical work based on these rival hypotheses has tended to concentrate on the estimation of returns to hedgers and speculators, and I wish to comment here on the interpretation of three key papers concerned with the estimation of these returns.

Gray (1961) investigated whether a spot premium ('downward bias') existed in Chicago corn and wheat futures, by using a routine buying program which was taken to represent the position of a persistent long speculator. This program did not yield significant profits and Gray concluded that the results did not support the normal backwardation hypothesis. Significant profits for corn, however, were found to result from a 'buy-discounts-sell-premiums' program (the future second closest to maturity was bought if priced below the maturing future and sold in the reverse case), a hypothesis which can be interpreted as an application of Working's concept of discretionary hedging.

While Gray drew conclusions about the price spread from these results, it is suggested here that it is also possible to make inferences about traders' behaviour from Gray's paper, which refers, of course, to hypothetical transactions. First, it would seem reasonable to infer that, since a persistent long position in futures did not yield significant gains, it is unlikely that professional speculators, considered as a subset of all speculators, would have adopted such a position, although the possibility is not ruled out for speculators as a group. Indeed, we might reasonably infer that professional speculators, being an informed sub-group, would perhaps be short in futures at times of forward premium and long in futures at times of forward discount; that is, their program may well have approximated Gray's 'buy-discounts-sell-premiums' program. These two suggestions, as we shall see, received support from two separate studies (in which different methods were used) considered later in this section.

Second, since the 'buy-discount-sell-premium' hypothesis yielded gains in the case of corn, we might infer that short hedgers, behaving in a discretionary manner, would over-hedge, or at least extend their positions at times of forward premium, and would under-hedge, or at least contract their positions, at times of forward discount. This suggestion is in part supported by a separate piece of evidence reported by Gray (1961, p. 255) that '. . . the premium relationships occur when short hedging is heavy and the discount relations when it is light'. These comments apply to corn only and not to wheat, where Gray found that a 'sell-discounts-buy-premiums' program gave significant profits. This result, however, is difficult to interpret for the hypothesis implies an expectation that the current price spread will increase. The outcome for wheat may perhaps be explained in part by selling pressure of short hedgers in the face of a forward discount. (Gray (1960) discussed a similar outcome for New

York coffee, a market which, at the time studied, was thin and biased downwards due to a low speculative ratio, in turn attributed to the stockholding policy of the Brazilian Government.)

A different and more direct approach to the estimation of returns to hedgers and speculators was that of Houthakker (1957) who used U.S.D.A. Commodity Exchange Authority data for wheat, corn and cotton for the period 1937–51. He calculated monthly profit for the three groups there distinguished and found that 'large speculators' (mostly long) gained on average at the expense of 'large hedgers' (mostly short) with 'nonreporting traders' (essentially small speculators, mostly long) making insignificant gains except for one sub-period in cotton where they received relatively large gains. The important question, of course, is how large speculators made their profits, and Houthakker tended to assume this problem away with his assertion that 'The essence of futures trading, however, is the transfer of price risks from the hedgers to the speculators in return for a risk premium . . .' (p. 148).

Moreover, this statement does not appear to fit well with Houthakker's calculation that only large speculators had 'special' (forecasting) skill, which implies that part of the returns of large speculators was due to this skill. Hence the reader wonders first, whether hedgers are primarily risk-avoiders rather than speculators on the basis in the sense of Working, and second, what proportion of the gains of large speculators is attributable to their forecasting skill and how much can be attributed to their risk-bearing function.

The second point was taken up by Rockwell (1967) who applied the method of Houthakker to data from 25 markets in the U.S.A., including the large Chicago wheat and soybeans markets, for the period 1947–65. Rockwell found, overall, that large speculators made gains at the expense of large hedgers, while small speculators made insignificant gains, although in some markets large speculators gained at the expense of small speculators, with hedgers breaking even. To answer the question of whether large speculators' returns are due to risk-bearing or forecasting skill, Rockwell calculated the profits for a speculator who is long when hedgers are net short and short when hedgers are net long (a hypothesis not reported by Houthakker). The gains from this last program being insignificant, Rockwell concluded that large speculators earned their profits by their forecasting skill, the risk-bearing function being performed essentially by small speculators who, for the period studied, held 46 per cent of open positions.

The same method has recently been employed by Goss (1980*b*) to obtain estimates of returns to traders in Australian wool for the period 1972–77. Using floor member interview data on transactions and clearing house turnover data, it was estimated that long hedgers gained at the expense of short hedgers with an average rate of return of 16 per cent per annum, and that long speculators in futures gained at the expense of short speculators in futures with an average rate of return of 19 per cent per annum. Short hedgers, with absolute losses virtually equal to the gains of long hedgers, had a rate of return estimated at -4 per cent per annum, while short speculators in futures had a rate of return estimated at -1 per cent per annum. As in other similar studies, these estimates of returns to hedgers refer to their futures transactions only.

Two comments may be made on Rockwell's paper. First, we can see that the estimates of Houthakker and Rockwell lend some support to the first inference about speculative behaviour made above in connection with Gray's (1961) paper, although there is only partial overlap between these three papers with respect to commodities and time period. It was inferred above that, because a persistently long position in futures did not yield significant gains, professional speculators were unlikely to have adopted such a position. Both Houthakker and Rockwell found that 'large' (assumed to be essentially professional) speculators, who made significant gains, were not persistently long. Of course, both Houthakker and Rockwell found that small speculators did not doggedly pursue long positions either, although they did not do as well on the short side as the professionals.

A second inference drawn above from Gray's paper was that the programs of professional speculators may well have approximated Gray's 'buy-discount-sell-premium' program which was found to be profitable for corn. What support for this suggestion is there in the direct estimate studies? Rockwell found that, when hedgers were net short, a long speculative position in futures gave insignificant profits. From this we would infer that, for part of this time at least, professional speculators were short in futures. This seems to correlate well with Gray's result that forward premiums, which occurred when short hedging was 'heavy', yielded profits to short positions in (corn) futures. Similarly, Rockwell's result, that, at times when hedgers were net long, a speculative short position in futures did not yield significant gains, gives rise to the inference that, for part of this time at least, professional speculators were long. This appears to fit well with Gray's result that forward discounts, which occurred when short hedging was 'light', resulted in gains for long positions in futures (for corn).

The second comment is that, while one can agree that Rockwell's estimates are important evidence against the normal backwardation hypothesis, there are two aspects of his interpretation of that hypothesis which are difficult to understand. The first is his suggestion (p. 133) that the normal backwardation hypothesis can be interpreted to predict a fall in futures prices as maturity approaches, for the case where hedgers are net long. It is suggested that this is not a logical extension of the normal backwardation hypothesis, at least in the form in which that hypothesis was developed by Keynes (1930) and Kaldor (1939/1961).

If P_f is the current futures price, P^* is the expected actuals price[4] and r is the marginal risk premium, Rockwell's suggestion requires the equilibrium condition for speculators in futures to be

$$P_f = P^* + r. \tag{1}$$

The Kaldor model, however, has the equilibrium condition for speculators in actuals (P is the current actuals price) that

$$P^* = P + m + r, \tag{2}$$

where m is the marginal net cost of storage. Substitution for P^* from (1) into (2) gives

$$P_f = P + m + 2r. \tag{3}$$

Equation (3) is not consistent with arbitrage (Goss 1972).

[4] The model incorporates an assumption of uniform expectations.

One possible modification to cope with this difficulty is to permit the expected price of short speculators in futures (P^*_f) to differ from P^*. Equation (1) would then be written

(1a) $$P_f = P^*_f + r.$$

Arbitrage requires $P_f \leq P + m$ so that $P^*_f \leq P^* - 2r$. With this modification this model can be used to determine that the current futures price lies between P^*_f and P^*, but this, of course, is not an unequivocal prediction of a fall in the futures price.

The other aspect of Rockwell's interpretation of the normal backwardation hypothesis which seems to require clarification is his suggestion (p. 112) that there is a significant difference between Keynes and Hicks in the treatment of speculators' price forecasting activities. Rockwell quotes from Keynes in the *Manchester Guardian* 1923 where he referred to the potential profits available to speculators from risk-taking *alone*, while Hicks (1953) in *Value and Capital* saw the risk premium which accrued to speculators as the difference between the futures price and the expected price. It is this latter treatment only which Rockwell interprets to mean that speculators make price forecasts. This interpretation, however, is difficult to accept for two reasons. The first is that for a speculator to take a persistently long position, as discussed by Keynes in the *Manchester Guardian*, implies some price expectation, unless the speculator is irrational and this expectation is a forecast in the same sense as Hicks' expected price. Second, Hicks' position does not differ in any material way from that of Keynes (1930) in the *Treatise on Money* where he says (in the case of surplus stocks) '. . . the present spot price, must fall below the anticipated future spot price by at least the amount of the normal backwardation.' (Vol. 2, p. 144).

The Forward Pricing Function of Futures Markets

The predictive accuracy of the futures price was first studied with respect to the expected spot price in the context of the normal backwardation hypothesis. Telser (1958), using a runs test, looked for an upward trend in U.S. cotton and wheat futures prices (under conditions of stable actuals prices) in the period 1926–54. Telser did not discover such a trend, and concluded that the futures price is an unbiased estimate of the expected spot price. Hence he felt free to substitute futures prices for expected spot prices in his speculative storage model, and argued that his results were inconsistent with the normal backwardation hypothesis. This analysis did not satisfy Cootner (1960) who sought an upward trend in the same wheat futures prices (after the peak of hedging activity had passed). He reformulated the expected prices of speculators in futures in terms of present values, although there were other ways around Telser's perfectly elastic demand function for speculators, for example by assuming increasing risk aversion at the margin.

More recently, the hypothesis that the futures price is an unbiased estimate of the delivery date spot price has been studied. If all information, including traders' expectations, is fully reflected in current prices, then both spot and futures prices may each be regarded as market anticipations of subsequent spot prices. Hence, if the market shows a forward premium in relation to a future date, this is not a prediction that prices will rise, but a market-estimated carrying charge (Working 1942). Similarly, if the market exhibits a spot premium, this is not a prediction that spot prices will fall, but a market-estimated inverse carrying charge. This at least was the interpretation offered for continuously storable commodities, based on the price-of-storage theory (Working 1949).

Recently, the hypothesis that the current futures price is an unbiased estimate of the spot price at the delivery date of the future has been investigated for both continuous and noncontinuous inventory commodities. In the advancement of this hypothesis it is assumed that: the market is competitive; economic agents are risk neutral; information is used rationally. The hypothesis also is conditional upon the information available at the time the futures price is formed. If the market under consideration is efficient, we would expect the unbiased prediction hypothesis to be accepted, although rejection of the hypothesis does not necessarily imply that the market is inefficient because, for example, the risk neutrality assumption may not apply, or there may have been unexpected intervention in the market during the period studied.

Two main methods have been employed in testing the unbiased estimation hypothesis. First, regression methods have been used to estimate a linear relationship between maturity date spot prices and lagged futures prices, the results being employed to test the hypotheses that the intercept is zero and the slope is unity. If such a relationship is under-specified and, if ordinary least squares (OLS) regression is used, we would expect to find serious autocorrelation among the residuals, particularly if monthly average data are used. Moreover, with autocorrelated errors and a lagged endogenous variable, the OLS parameter estimates will be both biased and inconsistent. For these reasons a more appropriate method of estimation is by instrumental variables, and this method has been used by Giles and Goss (1980*a*, 1980*b*) and Goss (1980*a*). Several authors have used OLS regression with daily data selected on a middle or end of month basis, and generally, in the case of United States data, little evidence of first-order autocorrelation has been found (Tomek and Gray 1970; Kofi 1973; Leuthold 1974), although Gellatly (1980) found the opposite to be true of OLS regressions with Australian live beef price data selected in this way.

An alternative procedure which has been employed is to regress the current forecast error upon lagged forecast errors for the same commodity, a procedure which may be extended by regression of the current forecast error for a particular commodity on recent own and related forecast errors. The former of these alternatives, which has been used by Hamburger and Platt (1975) for U.S. Treasury Bills, is a test for dependence in past prices and is thus a weak form test of market efficiency; the latter alternative, which has been used by Hansen and Hodrick (1979) for foreign exchange, addresses the question of whether the market is fully utilising all publicly available information and is a semi-strong form test of market efficiency.

The evidence to date supports the view that lagged futures prices are unbiased predictors of maturity date spot prices for a range of U.S. continuous inventory agricultural commodities including corn, soybeans and coffee (Tomek and Gray 1970; Kofi 1973), for tin, copper and zinc on the London Metal Exchange (LME) (Goss 1980*a*) and for some currencies including the Pound Sterling (Hansen and Hodrick 1979).

On the other hand, the evidence does not support the unbiased prediction hypothesis for noncontinuous inventory commodities such as potatoes (Kofi 1973; Tomek and Gray 1970) or finished live beef cattle (with lags greater than three months, Leuthold 1974; Giles and Goss 1980*b*), nor for U.S. Treasury Bills (Hamburger and Platt 1975), lead on the LME (Goss 1980*a*) or the Deutschemark or Canadian Dollar (Hansen and Hodrick 1979).

The reasons for this differential performance, especially that between continuous and noncontinuous inventory commodities, are still under discussion in the literature. Leuthold (1974) has offered an explanation for the brief (three months) unbiased prediction period for beef in terms of the typical hedging period, and Kofi (1973) proposed an explanation in terms of the quality of information on supply and demand conditions. This latter interpretation is supported by the results of Cox (1976) which are consistent with the view that economic agents in the live beef and potato markets are less well informed than their counterparts in markets for onions, hogs and pork bellies. Tomek and Gray (1970) attempted to account for this difference (in the case of potatoes) with the suggestion that the futures price represents expectations only, although this explanation is perhaps incomplete because the expectations are always wrong and exhibit no learning process. (Elsewhere Gray (1972) has given a more complete explanation for potatoes.)[5]

Another reason suggested for this difference in forward pricing performance is that the markets for discontinuous and non-inventory commodities are newer, with relatively smaller trading volumes. This hypothesis was tested by Giles and Goss (1980*a*) who compared the predictive performance of Sydney wool futures prices for 1963–67 (a youthful period for the exchange) with that for 1968–78, the former performance being inferior. Another suggestion advanced is that the absence of inventories increases the possibility of expectational error, because there is less opportunity for arbitrage between the spot and futures markets.

Two further possible reasons for rejection of the unbiased prediction hypothesis are that economic agents may require a risk premium, or that there may have been unexpected changes in government policy affecting the relevant markets during the sample period. These two possibilities were discussed by Hansen and Hodrick (1979) in their study of forward exchange rates.

In addition, Acheson and McManus (1979) have argued that futures prices may be distorted relative to spot prices when the spot market is personal (the identity of the other contracting party is of relevance to a trader), so that spot contracts will be incomplete, some commodity attributes being subjectively evaluated by traders. Futures markets, however, are always impersonal in this sense because a clearing house interposes itself between buyer and seller. In such case, if the futures contract attempts to describe the good fully, higher measurement costs will be imposed on the seller, thus raising the ask-bid spread. Alternatively, if

[5] In the case of potatoes, the spring futures price is a poor predictor and varies little, while the harvest spot price varies substantially from year to year. In this case area and hence production respond to spot prices of the immediate past, so that a high-price season calls forth increased plantings and a lower price in the following season, which is not predicted by the spring futures price.

the futures contract incompletely describes the good, any buyer taking delivery will receive the cheapest eligible grade, so that futures prices will be relatively depressed. This suggestion was considered by Goss (1980*a*) in connection with the rejection of the unbiased estimation hypothesis for lead on the LME.

While some of the suggestions outlined above for the inferior forward pricing performance of some markets may imply that those markets are inefficient (e.g. because they are thin), it must be stressed that, because of the conditional nature of the hypothesis, rejection of the unbiased prediction hypothesis does not *necessarily* imply that the market under consideration is inefficient.

Finally, two implications would seem to follow in those cases where futures prices are unbiased anticipations of maturity-date spot prices. First, economic agents using those futures prices for pricing of forward contracts, or for tendering for such contracts, will be as well off on average as if they had known the realised maturity date spot prices in advance. On the other hand, economic agents who use futures prices which are not unbiased predictors for forward pricing purposes will find themselves taking unexpected profits or losses. This does not mean that economic agents should not use markets in the latter category for hedging purposes although, if they do, they will have to trade off the hedging costs of those markets against the risks of being unhedged. Moreover, it does not follow that futures prices in the latter case should not be used for forward pricing purposes because, although biased, these prices are likely to be more accurate forecasts of subsequent spot prices than the price expectations of individual economic agents.

Second, futures prices which are unbiased predictors will achieve better co-ordination of plans, which futures trading facilitates, than futures prices which are biased predictors. If plans are poorly co-ordinated, then revision of plans will be necessary in the light of *ex post* errors and the consequent misallocation of economic resources. Improved co-ordination of plans means that these adjustment costs will be smaller.

Conclusion

Following these comments on some aspects of hedging in commodity futures markets, including some recent developments in hedging theory and behaviour, this section will be employed to project those developments into the future, rather than to summarise points already made.

In the first half of the 1970s the U.S.A. experienced an almost exponential growth in turnover of futures markets. This was due partly to the persistence of world-wide inflation so that asset holders faced an incentive to switch from liquid to other assets, and partly to the expanded scope of futures trading so that it now includes financial instruments and currencies as well as agricultural products and basic raw materials. Australia is now experiencing such a growth in turnover, although with a substantial lag and in a more subdued fashion, and may continue to do so if the two underlying (necessary but not sufficient) conditions continue to be met. The expanded scope of futures trading has been facilitated by recent theoretical and empirical work on the feasibility conditions for organised futures exchanges, wherein a 'maximisation of net benefits approach' appears to be absorbing the previous 'commodity characteristics' approach. Net benefit is the difference between total benefit from and total costs of futures trading, and net benefit has been studied as a function of, *inter alia*, turnover, open positions and the standard deviation of market clearing prices (Telser and Higinbotham 1977). Although not discussed in the present paper, this development, which may be expected to continue, is vital to a deeper understanding of futures markets. It is discussed elsewhere (Goss 1980*b*).

Second, we can expect the study of the forward pricing function of futures markets, which is discussed in this paper, to be extended in several ways. In particular, further attention is likely to be given to the forecasting performance of futures prices compared with other predictors of cash prices, as in recent studies by Leuthold and Hartmann (1979) and Hamburger and Platt (1975). These studies, of course, are concerned with the utilisation of publicly available information and are therefore semi-strong form tests of market efficiency, an area of investigation which is likely to increase for futures markets. Moreover, with further emphasis on the utilisation of available information, we are likely to see more use made of the rational expectations hypothesis in models of determination of futures prices.

In the area of returns to traders, aspects of which are discussed in this paper, no important new single market studies have been generated for some time. New developments in this area may well follow the initiative of Dusak (1973) who employed the Capital Asset Pricing Model to estimate the returns and systematic risk (contribution to risk of a diversified portfolio) for some individual futures contracts. A possible difficulty with this approach is that the interpretation of a futures contract as an asset may not be valid: some writers have argued (e.g. Acheson and McManus 1979) that a futures contract is a wager which is settled daily (not strictly true for gains). In any case this difficulty remains, and was not happily overcome by Dusak.

Finally, we can expect further attention to be paid to the public goods aspects of futures markets, which are just beginning to emerge. Powers and Tosini (1977) have drawn attention to the financial externalities generated by futures market deposits and margins, and further work can be expected on the externalities generated by the provision of information by futures markets.

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