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HEDGING AS "SPECULATION ON THE BASIS"*

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ABSTRACT

      Holbrook Working has described hedging as "speculation on the
basis" and has argued that traders engage in hedging because they
believe they can do better from hedging than from not hedging, in
contrast to the Keynes-Hicks-Kaldor view that hedging is an activity
undertaken to shift risk to other traders.

      In this paper, we derive necessary and sufficient conditions
for hedging ("speculation on the basis") to be preferred by all risk
averse traders to speculating on the cash market. When the futures
market is in fact a forward market, then short hedging is preferred to
not hedging by all risk averse traders if and only if there is a
contango on the market. In the case of a "true" futures market, it is
shown that short hedging is preferred to an unhedged position by all
risk averse traders if and only if the "Houthakker effect" is
sufficiently strong. These results are derived for the "all or
nothing" case of comparisons between an unhedged and a completely
hedged position.

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1. INTRODUCTION

There are two distinct schools of thought in the classical literature dealing with hedging and the futures markets. The older tradition stems from Keynes (1930), Hicks (1939), and Kaldor (1940), all of whom viewed hedging as behavior engaged in with the objective of transferring price risk from the hedger to some other trader. When short and long hedging are balanced on the futures market, then no risk premium arises on the market, but if short hedging dominates, as these earlier authors assumed, then backwardation emerges on the futures market (current futures price is less than its expected value at the termination of the futures contract), and short hedgers pay a risk premium on average to long hedgers and to speculators.

A completely different view of hedging emerges in the writings of Holbrook Working (1953), and later in Houthakker (1968) and Cootner (1960). As Working points out, the Keynes-Hicks-Kaldor approach in effect treats hedging as an afterthought on the part of a trader who has taken some (risky) position in the cash market and only then begins to think about the possibility of "laying off" a part or all of his price risks through hedging. In contrast, Working argues that a rational trader makes a simultaneous choice of a cash and futures position, taking into account hedging possibilities at the time a cash position is entered into.

There is one other critical difference between Working's approach and that of the earlier authors. Implicit in the Keynes-Hicks-Kaldor approach is the notion that hedgers can attain "perfect hedges" through their dealings in the futures market, so that hedging can completely eliminate price risks. But in order for this to occur, the futures contract would have to be a forward contract, that is, a contract such that the price of the futures contract at the maturity date of the contract is identically equal to the cash price. This is not the case in commodity futures markets; in order to avoid problems of thinness of the market and/or cornering, futures contracts provide for a range of grade-location delivery options, the option to be selected by the seller of the contract at the maturity date of the contract.

The consequence is that hedging through use of the futures market cannot eliminate all price risks for hedgers. Working emphasizes this by referring to hedging as simply another kind of speculation, namely, "speculation on the basis." The basis at any point in time is defined as the difference between the cash price and the futures price at that point in time. In effect, a trader who decides to engage in a cash commitment coupled with a hedging commitment in the futures market does so, according to the Working view, because he expects to do better from this decision than from the alternatives, namely, an unhedged cash position, or no cash or futures position at all.

Hedging is a wide spread phenomenon among elevator operators

and millers, and is also occasionally engaged in by farmers. Working's view of hedging raises the general question as to why, or under what conditions, speculation on the basis by these or other traders will offer advantages over speculation in the cash market. In the recent theoretical literature dealing with futures markets (for example, see Anderson and Danthine (1983)), the emphasis has been on the simultaneity of choice of cash and futures commitments, but in the context of a forward market, one in which hedges are perfect. In the present paper, we turn to Working's argument that hedging is in fact a form of speculation, because of the existence of several delivery options under the futures contract. The point of the paper is to derive conditions necessary and/or sufficient such that any risk averse trader would prefer speculating on the basis to the other alternatives available to him. We do this in a simplified setting, namely one in which the cash commitment is taken as given, with the choice of the trader of the "all or nothing" variety, that is, a choice between an unhedged or a completely hedged position. In this setting, identification of the circumstances under which speculation on the basis is preferred by a trader to speculating in the cash market is relatively straight forward; moreover, analysis of this problem provides a sufficient (but not necessary) condition for a mixed portfolio of hedged and unhedged stocks to be preferred to an unhedged position.

We examine the hedging problem in the context of a model in which there are two delivery options admissible under the futures contract. Extension of the results to the case of many delivery options creates some notational clutter, but involves no new conceptual problems. We look separately at two cases: first, the case of a forward market (in effect the two delivery options are perfect substitutes for one another); and second, the case of a "true" futures market, one in which the options are less than perfect substitutes for one another. This is a two period model, one in which the cash and futures markets open at time t = 0, and again at time t = 1. There is only one futures contract available, maturing at time t = 1. In a rational expectations framework (see Lien and Quirk (1984)), and given only a single futures contract, the two period model represents no substantive restriction on an n-period model, but the restriction to only one futures contract does limit the applicability of the results (see Anderson and Danthine (1983)). Throughout the paper, it is assumed that all traders are risk averse.

The basic conclusions of the paper are these. When the futures contract is in fact a forward contract, then hedges are perfect and speculating on the basis is preferred to speculating on the cash market by every risk averse trader contemplating a short hedge if and only if there is a contango on the futures market (expected value of the futures price is less than or equal to the current futures price); speculating on the basis is preferred to speculating on the cash market by every risk averse trader contemplating a long hedge if and only if there is backwardation on the futures market (expected value of the futures price exceeds or is

equal to the current futures price). When we turn to a true futures
market, then the necessary and sufficient condition for hedging to be
preferred to speculating on the cash market for every risk averse
trader is obtained by an application of the Hadar and Russell (1969)
result on stochastic dominance. Given this dominance condition, it is
shown that the Houthakker effect (see Houthakker (1968)) plays a
pivotal role in determining the desirability of speculating on the
basis versus speculating on the cash market. By the Houthakker effect
we mean the idea that the cash and futures prices are more highly
correlated at low than at high cash prices. If the Houthakker effect
is "sufficiently strong," than speculating on the basis is preferred
to speculating on the cash market. Thus the approach adopted in this
paper represents a way of bringing together the contributions of
Working and Houthakker, extending some results derived in a recent
paper (see Fort and Quirk (1983)).

2. THE MODEL

Consider a futures contract under which two delivery (grade-
location) options are admissible under the contract. This is a two
period world in which trading in the cash and futures markets occurs
at $t = 0$ and $t = 1$. There is only one futures contact, which matures
at $t = 1$.

Let p_t^c, q_t^c, $t = 0,1$ denote the cash prices of the two delivery
options, and let p_t^f, $t = 0,1$ denote the futures price. Because choice
of the option to deliver at the maturity date of the futures contract
is up to the seller of the contract, we have:

$$p_1^f = \min(p_1^c, q_1^c) \tag{1}$$

Let $f(p_1^c, q_1^c)$ be the joint probability density function held by
a trader at $t = 0$ over the cash prices at $t = 1$, and let $\phi(p_1^c, p_1^f)$
denote the joint pdf over the $t = 1$ cash price of the first option and
the futures price, held by the trader at $t = 0$. Then from (1),
$\phi(p_1^c, p_1^f)$ is given by:

$$\phi(p_1^c, p_1^f) = \begin{cases} 0 & p_1^f > p_1^c \\ \int_{p_1^c}^{\infty} f(p_1^c, q_1^c) dq_1^c & p_1^f = p_1^c \\ f(p_1^c, p_1^f) & p_1^f < p_1^c \end{cases} \tag{2}$$

Similarly, we can construct the pdf over the basis for the
trader, using (2). Let b_t denote the basis at time $t = 0,1$, with
respect to the first delivery option, so that

$$b_0 \equiv p_0^c - p_0^f, \quad b_1 \equiv p_1^c - p_1^f \tag{3}$$

Let $\psi(b_1)$ be the pdf over b_1 held by the trader at $t = 0$,
given by

$$\phi(b_1) = \begin{cases} 0 & b_1 < 0 \\[2ex] \int_0^\infty \int_{p_1^c}^\infty f(p_1^c, q_1^c)\,dq_1^c\,dp_1^c & b_1 = 0 \\[2ex] \int_0^\infty f(p_1^c, p_1^c - b_1)\,dp_1^c & 0 < b_1 \leq p_1^c \\[2ex] 0 & b_1 > p_1^c \end{cases} \tag{4}$$

The link between the basis and hedging comes through the profit function for the trader. Consider the case of a trader contemplating taking a long position of W bushels in the cash market for the first delivery option at t = 0, as in the case of an elevator operator. Let k(W) be a strictly convex function representing the "carrying costs" for the trader, including interest, insurance, storage losses, and normal profits. If the trader takes an unhedged position, then his profits are given by $(p_1^c - p_0^c)W - k(W)$. Let $\bar{k}$ denote per bushel carrying costs, and let π_u denote the per bushel profit from an unhedged commitment of W bushels. Then we have

$$\pi_u = p_1^c - p_0^c - \bar{k} \tag{5}$$

In contrast, consider the case of a trader who takes the same long position in the cash market, but hedges the commitment by going short in the futures market. Let π_H denote the per bushel profit from short hedging, so that π_H satisfies

$$\pi_H = p_1^c - p_0^c + p_0^f - p_1^f - \bar{k} \tag{6}$$

Rearranging (6) we have

$$\pi_H = b_1 - b_0 - \bar{k} \tag{7}$$

so that Working's description of hedging as speculating on the basis is an apt one.

Similarly, traders such as millers who take a short position in the cash market (accepting orders for processed wheat products before buying the wheat to fill those orders), can hedge the short cash position by going long in the futures market. Under the conventional assumption that wheat requirements are met through purchases at t = 1 followed by instantaneous processing, and that the wheat equivalent price of the milled product is the t = 0 cash price plus carrying cost, the corresponding unhedged and hedged profit functions for a miller with a commitment of W bushels, can be written as

$$\pi_u^* = p_0^c - p_1^c + \bar{k} \tag{8}$$

$$\pi_H^* = b_0 - b_1 + \bar{k} \tag{9}$$

where the asterisk is used to identify traders short in the cash market.

In what follows, we will concentrate on the case of traders long in the cash market. We are interested in deriving conditions under which speculating on the basis is preferred by any such trader,

to speculating on the cash market, given a commitment of W bushels of wheat. For such a trader, let $g(\pi_u)$ denote the pdf over per bushel profits from speculating in the cash market, and let $h(\pi_H)$ denote the pdf over per bushel profits from speculating on the basis. Using (2)-(7), we have the following:

$$
g(\pi_u) = \begin{cases} 0 & \pi_u < -(p_0^c + \bar{k}) \\[2ex] \int_0^\infty f(\pi_u + p_0^c + \bar{k}, q_1^c)dq_1^c & -(p_0^c + \bar{k}) \leq \pi_u \leq \infty \end{cases} \tag{10}
$$

$$
h(\pi_H) = \begin{cases} 0 & \pi_H < p_0^f - (p_0^c + \bar{k}) \equiv -(b_0 + \bar{k}) \\[2ex] \int_0^\infty \int_{p_1^c}^\infty f(p_1^c, q_1^c)dq_1^c dp_1^c & \pi_H = p_0^f - (p_0^c + \bar{k}) \\[2ex] \int_0^\infty f(p_1^c, p_1^c - (\pi_H + p_0^c + \bar{k} - p_0^f))dp_1^c & p_0^f - (p_0^c + \bar{k}) < \pi_H \end{cases} \tag{11}
$$

(Note that $f(\cdot,\cdot) = 0$ for $\pi_H > p_1^c + p_0^f - (p_0^c + \bar{k})$).

Let $G(\pi_u)$, $H(\pi_H)$ denote the cdf's associated with g and h. These can then be written as

$$
G(\pi_u) = \begin{cases} 0 & \pi_u < -(p_0^c + \bar{k}) \\[2ex] \int_{-(p_0^c+k)}^{\pi_u} \int_0^\infty f(x + p_0^c + \bar{k}, q_1^c)dq_1^c dx & -(p_0^c + \bar{k}) \leq \pi_u \leq \infty \end{cases} \tag{12}
$$

$$
H(\pi_H) = \begin{cases} 0 & \pi_H < p_0^f - p_0^c + \bar{k} \\[2ex] \int_0^\infty \int_{p_1^c}^\infty f(p_1^c, q_1^c)dq_1^c dp_1^c \\[2ex] \quad + \int_{p_0^f-(p_0^c+\bar{k})}^{\pi_H} \int_0^\infty f(p_1^c, p_1^c - (x + p_0^c + \bar{k} - p_0^f))dp_1^c dx & \text{for} \\[2ex] \hspace{4cm} p_0^f - (p_0^c + \bar{k}) \leq \pi_H \end{cases} \tag{13}
$$

We are interested in examining the conditions under which h is preferred by any risk averse trader to g, so that speculating on the basis for a given long cash commitment is preferred to speculating on the cash market. Because of the way in which the problem has been posed here, it is possible to apply directly the Hadar-Russell (1969) result on second degree stochastic dominance, that is, h is preferred to g for every risk averse trader if and only if

$$
\int_{-\infty}^\pi H(t)dt \leq \int_{-\infty}^\pi G(t)dt \quad \text{for all } \pi , \tag{14}
$$

with strict inequality for some π.

We proceed to apply this to the problem of our paper.

3. THE CASE OF A FORWARD MARKET

It is instructive to consider first the admittedly unrealistic case of a forward market, a market in which perfect hedges occur. In the context of the model of this paper, the forward market case is one in which our two delivery options are perfect substitutes for one another in the sense that

$$f(p_1^c, q_1^c) = 0 \text{ for } p_1^c \neq q_1^c$$

Under this condition, the expressions for G and H given above reduce to

$$G(\pi) = F(\pi + p_0^c + k) \qquad -(p_0^c + \overline{k}) \leq \pi \leq \infty$$

$$H(\pi) = \begin{cases} 0 & \pi < p_0^f - (p_0^c + \overline{k}) \\ \\ 1 & \pi \geq p_0^f - (p_0^c + \overline{k}) \end{cases} \qquad (15)$$

In (15), $F(\pi + p_0^c + k)$ is the cdf of f evaluated at $p_1^c = q_1^c$ = $\pi + p_0^c + \overline{k}$. (In what follows, in dealing with forward contracts we will use the notation $f(x) \equiv f(x,x)$ and $F(x) \equiv F(x,x)$ for any x.)

Then, in the case of a forward market, we have the following result concerning necessary and sufficient conditions for speculating on the basis to be the preferred alternative for any risk averse trader contemplating a particular long position on the cash market:

Proposition 1. (See also Anderson and Danthine (1983)). Given a forward market, then every risk averse trader with a long commitment of W bushels in the cash market will prefer to "speculate on the basis" rather than to speculate on the cash market if and only if $p_0^c + \overline{k} < Ep_1^f \leq p_0^f$; that is, expected per bushel profit from the cash commitment is positive, and there is a contango on the futures market.

Proof: To lessen the notational clutter, let $a = p_0^c + \overline{k}$. We wish to show that

$$\int_{-a}^{\pi} G(t)dt \geq \int_{-a}^{\pi} H(t)dt \qquad (16)$$

for all $\pi \geq -a$, with strict inequality for some π, if and only if $Ep_1^f \leq p_0^f$.

From (15), we know that (16) holds for $-a \leq \pi < p_0^f - a$. Consider then $\pi \geq p_0^f - a$, where we wish to show that

$$\int_{-a}^{\pi} G(t)dt \equiv \int_{-a}^{\pi} F(t + a)dt \geq \pi - [p_0^f - (p_0^c + \overline{k})] \equiv \int_{-a}^{\pi} H(t)dt$$

if and only if $Ep_1^f \leq p_0^f$.

Define β by $p_0^f - (p_0^c + \overline{k}) = \beta E_g \pi = \beta \int_{-a}^{\infty} \pi f(\pi + a)d\pi$, and let

$$J(\beta;\pi) = \int_{-a}^{\pi} F(t + a)dt - [\pi - (p_0^f - (p_0^c + \overline{k}))]$$

$$= \int_{-a}^{\pi} \{F(t + a) + \beta t f(t + a)\} dt + \beta \int_{\pi}^{\infty} t f(t + a)dt - \pi$$

Adding and subtracting $t f(t + a)$ inside the first integral, we have

$$J(\beta;\pi) = \int_{-a}^{\pi} \{F(t + a) + t f(t + a)\} dt + (\beta - 1) \int_{-a}^{\pi} t f(t + a)dt$$

$$+ \beta \int_{\pi}^{\infty} t f(t + a)dt - \pi$$

$$\therefore J(\beta;\pi) = \pi F(\pi + a) + (\beta - 1) \int_{-a}^{\pi} t f(t + a)dt + \beta \int_{\pi}^{\infty} t f(t + a)dt - \pi$$

$$= (\beta - 1) \int_{-a}^{\pi} t f(t + a)dt + \int_{\pi}^{\infty} (\beta t - \pi) f(t + a)dt$$

Note that $\frac{\partial J}{\partial \pi} = -\int_{\pi}^{\infty} f(t + a)dt \leq 0$, so that $J(\beta;\pi) \geq 0$ for all

$\pi \geq -a$ if and only if $\lim_{\pi \to \infty} J(\beta;\pi) \geq 0$. But $\lim_{\pi \to \infty} J(\beta;\pi) = (\beta - 1)E_g\pi$.

$E_g\pi \equiv Ep_1^f -(p_0^c + \bar{k}) > 0$ if a risk averse trader is to take a

commitment in the cash market, and hence $\lim_{\pi \to \infty} J(\beta;\pi) \geq 0$ if and only

if $\beta \geq 1$, that is $p_0^f -(p_0^c + \bar{k}) \geq E_g\pi$, or $p_0^f \geq Ep_1^f$.

<div align="right">Q.E.D.</div>

Similarly, it can be shown that in a forward market, any risk
averse trader short in the cash market will prefer hedging his
commitment to speculating in the cash market if and only if his
expected profits are positive and there is backwardation on the
futures market, that is, $Ep_1^f \geq p_0^f$.

But of course the case of a forward market was not the case
that Working was interested in, nor is it our main concern here. Next
we turn to the case of "true" futures market, one in which there is a
nondegenerate joint pdf over the cash prices p_1^c, q_1^c.

4. THE CASE OF A "TRUE" FUTURES MARKET

Necessary and sufficient conditions for speculating on the
basis to be preferred to speculating on the cash market, for any risk
averse trader with a given long commitment in the cash market, can be
derived through a specialization of the Hadar-Russell condition, as
indicated in Proposition 2.

<u>Proposition 2</u>. Given a futures market with $Ep_1^c > p_0^c + \bar{k}$, then every
risk averse trader with a long cash commitment of W bushels will

prefer speculating on the basis to speculating in the cash market if
and only if condition (*) obtains:

$$(*)J(\pi) \equiv \int_{-a}^{\pi} \int_0^{t+a} \int_0^{\infty} f(p_1^c,q_1^c)dq_1^c dp_1^c dt$$

$$- \int_{p_0^f-a}^{\pi} \left[\int_0^{\infty} \int_{p_1^c}^{\infty} f(p_1^c,q_1^c)dq_1^c dp_1^c \right.$$

$$\left. + \int_{t-p_0^f+a}^{\infty} \int_{p_1^c-t+p_0^f-a}^{p_1^c} f(p_1^c,q_1^c)dq_1^c dp_1^c \right] dt \geq 0$$

for $\pi \geq p_0^f -a$, where $a = p_0^c + \bar{k}$, and with strict inequality for some
π.

<u>Proof</u>: Change of variables, using (12), (13) and (14), together with
(5) and (6), and the constraint $q_1^c \geq 0$.

The question that arises is that of an interpretation of (*).
In particular, the approach to hedging taken by Houthakker (1968) is
suggestive. Houthakker was concerned with the problem of
backwardation, and argued that a preponderance of short over long
hedging can be expected on commodity futures markets (at least for
much of the inter-harvest period) because any cash price is more
closely correlated with other cash prices and hence with the futures
price, at low than at high cash prices. The reason for this is that
low cash prices tend to occur when inventories of all grade-location

combinations are large, and it is at this time that the prices of the
different grade-location combinations tend to be determined by their
common properties, rather than by those distinctive properties that
operate to produce premiums or penalties in specialized markets for
the various grade-location combinations. When a cash price is more
closely correlated with the futures price at low that at high cash
prices, then this tends to encourage short hedging, since the short
hedger hedges in part to protect himself against the possibility of
low cash prices.

In earlier work on this "Houthakker effect" (see Fort and
Quirk (1983), it was shown that from an analytical point of view, a
convenient specification of the Houthakker effect is in terms of the
probabilities of the cash and futures prices being "close" to one
another. In this version, a Houthakker effect is said to be present
if the probability of the cash and futures prices being "close" to one
another is large at low cash prices, relative to the probability of
the prices being close to one another at high cash prices.
Admittedly, this leaves things somewhat vague; in order to establish
restrictive propositions concerning the Houthakker effect and hedging,
it is necessary to specify just what is meant by the terms "close to
one another," "large," "small," etc. Nonetheless, the notion of a
Houthakker effect as thus specified does turn out to have an
interesting explanatory role in the analysis of backwardation, and, as
it turns out, in providing some insight into the interpretation of
condition (*).

To see this, let $s = t + a$ in (*), and rearrange and collect
terms in $J(\pi)$ so that (*) can be written as:

$$(*')J(\pi) = \int_0^{p_0^f} \int_0^s \int_0^\infty f(\cdot)dq_1^c dp_1^c ds$$

$$+ \int_{p_0^f}^{\pi+a} \left[\int_0^s \int_0^\infty f(\cdot)dq_1^c dp_1^c - \int_0^\infty \int_{p_1^c}^\infty f(\cdot)dq_0^c dq_1^c \right.$$

$$\left. - \int_{s-p_0^f}^\infty \int_{p_1^c+p_0^f-s}^{p_1^c} f(\cdot)dq_1^c dp_1^c \right] ds \geq 0 \text{ for } \pi + a \geq p_0^f$$

This can be rewritten as

$$(*'')J(\pi) = \int_0^{p_0^f} \int_0^s \int_{p_1^c}^\infty f(\cdot)dq_1^c dp_1^c ds$$

$$+ \int_0^{\pi+a} \int_0^s \int_0^{p_1^c} f(\cdot)dq_1^c dp_1^c ds - \int_{p_0^f}^{\pi+a} \left[\int_s^\infty \int_{p_1^c}^\infty f(\cdot)dq_1^c dp_1^c \right.$$

$$\left. + \int_{s-p_0^f}^\infty \int_{p_1^c+p_0^f-s}^{p_1^c} f(\cdot)dq_1^c dp_1^c \right] ds \geq 0 \text{ for } \pi + a \geq p_0^f$$

Suppose there is a martingale equilibrium so that $p_0^f = Ep_1^f$.
In this case we have the expected value of profits under hedging equal
to the expected value of profits from an unhedged position, that is,

$$Ep_1^c - p_0^c - \bar{k} = Ep_1^c - p_0^c + p_0^f - Ep_1^f - \bar{k} \ .$$

Hence when condition (*'') holds at a martingale equilibrium, g is a mean preserving increase in the spread of h, in the sense of Rothschild and Stiglitz (1970).

Using the fact that $p_1^f = \min(p_1^c, q_1^c)$, the first term in $J(\pi)$ under (*'') is the integral up to p_0^f of the probability that $p_1^c = p_1^f$, $0 \leq p_1^c \leq s$, $0 \leq s \leq p_0^f$. Treating $p_1^c < p_0^f$ as relatively "low" cash prices, then presence of a Houthakker effect implies that this term tends to relatively "large," and of course it enters into $J(\pi)$ with a positive sign.

Similarly, the third term in $J(\pi)$ is the integral from p_0^f to $\pi + a$ of the probability that $p_1^c = p_1^f$, $s \leq p_1^c \leq \infty$, $p_0^f \leq s \leq \pi + a$. Again viewing p_0^f as the dividing line between low and high cash prices, the presence of a Houthakker effect implies that this term is relatively "small," and it enters $J(\pi)$ with a negative sign.

Hence, ceteris paribus, the presence of a Houthakker effect, in the sense we have used this term, tends to increase $J(\pi)$ and hence increases the likelihood that speculating on the basis will dominate speculating on the cash market so far as risk averse traders are concerned. Needless to say, the condition (*'') requires more than simply the presence of a Houthakker effect; instead the effect must be "strong enough."

We formalize this as follows

<u>Proposition 3</u>. Given a futures market with $Ep_1^c > p_0^c + \bar{k}$, then every risk averse trader with a long cash commitment of W bushels will

prefer to speculate on the basis rather than to speculate on the cash market if and only if the Houthakker effect is "strong enough" in the sense that

$$\int_0^{p_0^f} \int_0^s \int_{p_1^c}^{\infty} f(\cdot) dq_1^c dp_1^c ds - \int_{p_0^f}^{\pi+a} \int_s^{\infty} \int_{p_1^c}^{\infty} f(\cdot) dq_1^c dp_1^c ds \geq$$

$$\int_{p_0^f}^{\pi+a} \int_{s-p_0^f}^{\infty} \int_{p_1^c+p_0^f-s}^{0} f(\cdot) dq_1^c dp_1^c ds - \int_0^{\pi+a} \int_0^s \int_0^{p_1^c} f(\cdot) dq_1^c dp_1^c ds$$

for all $\pi + a \geq p_0^f$, strict inequality for some π.

<u>Proof</u>: Immediate.

Clearly Proposition 3 could also be restated using a notion of "closeness" of p_1^c to p_1^f such as $p_1^c - p_1^f \leq \varepsilon$ for some given $\varepsilon > 0$, and similarly cut offs for "low" and "high" cash prices different from p_0^f could be employed. The important point is that the presence of a Houthakker effect as thus specified provides a simple and intuitive interpretation to the dominance condition (*'') which represents a formalization of conditions under which Working's view of hedging as speculation on the basis represents an activity that is preferred to speculation on the cash market by any risk averse trader. Furthermore, condition (*'') utilizes all of the information that a trader brings to the market, namely his joint density over the cash prices and his knowledge of the effects of arbitrage on the determination of the futures price.

Finally, we should note that (*'') provides a necessary and sufficient condition for a fully hedged position to be preferred to an unhedged position, given a long cash commitment of W bushels. This means that (*'') also provides a sufficient condition for the optimal choice of a trader with a long cash commitment of W bushels to involve some speculating on the basis, although of course the condition is not necessary in the case of such a diversified portfolio.

SUMMARY

This paper has been concerned with identifying conditions under which any risk averse (short) hedger would prefer to speculate on the basis than to speculate in the cash market. In the case of a forward market, hedging in fact involves no speculation at all, and we arrive at the usual condition that short hedging is preferred to an unhedged commitment by all risk averse traders if and only if there is a contango on the market.

The case of a forward market has little in the way of predictive validity for functioning futures markets, however, and Working's contributions to the literature on futures markets are aimed at analyzing how these markets operate, rather than the idealized forward markets of the theoretical literature. What has been derived here is the stochastic dominance condition (*) (or (*'')) under which speculating on the basis is preferred by any risk averse short hedger to an unhedged long cash position with the same cash commitment. It has been shown that this is equivalent to the statement that the Houthakker effect is "sufficiently strong." The Houthakker effect

thus appears to play a central role in the analysis of hedging on functioning futures markets, and in particular provides an insight into how one may interpret Working's comments concerning the view that traders speculate on the basis when they feel that they can do better from that operation than from other alternatives available to them.

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