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THE EXECUTION COST OF TRADING
IN COMMODITY FUTURES MARKETS†

A critical issue in the performance of commodity futures markets is whether there are regular profit opportunities in time series of futures prices. In particular, students of futures markets have long questioned whether statistical dependence in futures prices regularly exists and whether profits may be earned consistantly from following a trading rule based on any such regularity in price behavior. If profit opportunities are embodied in price behavior, then a market may be considered informationally inefficient. For a review of this general issue, see Kamara (1982).

The evidence regarding statistical dependence indicates that certain price changes in futures markets are typically serially correlated. As the time period between price observations shortens, price changes have a tendency to be increasingly negatively dependent. In studies using intra-day prices, Working (1954), Brinager (1970), Martell and Helms (1979), Trevino and Martell (1984), and Thompson (1984), all found a significant degree of negative dependence in price changes. However, while this evidence may suggest inefficiency, numerous authors—Working (1954), Gray (1979), Trevino and Martell (1984), Brorsen and Nielsen (1986)—have argued that negative dependence in intra-day price changes indicates the presence of active market-making, or scalping, in a futures market. They argue that prices determined in futures markets follow a discernable pattern of negative dependence because buy orders are filled by scalpers at a slightly higher price than sell orders. This pattern of negative dependence can be

expected in all markets where market-makers earn a return for providing liquidity even if the market's underlying information process is random and the market quickly incorporates information into price. Furthermore, they argue that scalping in futures markets is efficient because it competitively provides immediate liquidity to off-floor traders, thereby minimizing the transactions costs of trading in futures markets.

The primary purpose of this paper is to show that the profits earned by following a trading rule based on negative dependence in price changes are less than the transactions costs that would be incurred by most off-floor traders attempting to profit from such a trading rule. The profits earned following the trading rule will be compared to estimates of the transactions costs incurred in placing a market order, the execution costs of trading. Data from coffee and cocoa futures markets will be used in the analysis. It will be demonstrated that the only traders who can routinely profit from negative dependence in intra-day price changes are scalpers whose trading behavior and economic role in futures markets impart the characteristic non-randomness in price changes. Their profits are directly derived from the execution fees earned in providing liquidity to off-floor traders. Hence, evidence of non-randomness in futures prices contained in intra-day price changes does not indicate inefficiency in futures markets because it does not indicate the availability of profit opportunities to any traders except those who provide liquidity to the market.

This paper will also show that the execution cost of trading is smaller in more heavily traded markets and larger in markets that are more thinly traded. Liquidity in a market is the primary determinant of the size of the bid-ask spread, the difference between the scalper's buy and sell offers.[1] The size of the bid-ask spread in turn determines the execution cost of trading by influencing the amount price changes between buy and sell orders.

Finally this paper will present a method for estimating execution costs of trading in a market from a time series of intra-day price changes. Determining a method that may be used to estimate this cost may provide necessary and helpful information to traders as well as academicians. This information will be especially useful in estimating the profitability of trading rules or other trading strategies based on either fundamental or technical analysis of price behavior.

The next section presents a brief review of scalping-related literature. The method for estimating execution costs of trading is then described

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[1] Other determinants of the bid-ask spread are discussed by Garbade and Silber (1979), Silber (1984), and Copeland and Galai (1983). Copeland and Galai examined the effect of information on the bid-ask spread and found that the size of the spread in options markets is positively related to price levels and return variance, and negatively related to the degree of competition, market activity, and continuity.

along with the trading rule used to estimate scalper returns. The following section describes the data and presents the estimates of execution costs and the results of the trading rule analysis. The final section presents a summary of the study.

BACKGROUND

As noted in many studies, negative dependence in price changes may be largely a function of the existence of a bid-ask spread. Demsetz (1968) stated that the existence of such a transaction cost paid by certain traders to market-makers does not indicate that a market is inefficient. Instead, the matter of major concern should be whether or not this cost is properly economized.

The return to scalpers has been investigated by Working (1954) and Silber (1984). Working reported that the gross scalping profits of an "able trader" in cotton futures ranged from a low of $.14 per contract in one month to a high of $8.35 per contract in another month. On average this trader entered approximately 70 round-trip scalping transactions per day. These data were compiled at least 30 years ago and thus might be substantially different if inflated to today's dollars. More recently Silber found that gross scalping profits of two successful scalpers trading the composite stock index on the New York Futures Exchange ranged between $10.56 and $13.59 per contract. These traders traded approximately 100 contracts per day with a typical transaction comprising roughly three contracts.

Trevino and Martell (1984) have estimated returns to following filter-type trading rules that approximate scalper trading behavior. Returns were greatest for smallest filters and varied substantially in each commodity depending on the contract traded. For instance, using the smallest filter and trading only one contract per position, returns ranged between an average of −$8.09 and $954.25 per week in different wheat contracts and −$259.12 and $2,241.34 per week in different soybean contracts. Under Trevino and Martell's trading rule, positions are taken at the price of the transaction that signals a profitable trading opportunity. Hence, their results do not hold for traders who must pay for immediate liquidity and incur execution costs in trading. Elton, Gruber, and Kentzler (1984) take execution costs into consideration in assessing the efficiency of the treasury bill futures market. They apply various trading strategies to intra-day prices to test for the existence of profitable trading opportunities. They find significant profits exist from following a variety of strategies even when trades are not executed at the prices which indicate a profit opportunity but are instead executed at a later price.

Both Roll (1984) and Thompson (1984) have proposed a technique to measure liquidity in a market. Roll's technique measures the implicit

bid-ask spread and is based on the negative dependence in price changes resulting from market-making at the bid-ask spread. Specifically, Roll's measure of the spread is twice the square root of the opposite sign covariance of price changes: $2\sqrt{-Cov(\triangle P_o, \triangle P_1)}$. His measure is valid only when the market is informationally efficient, that is, when the only source of non-randomness in price changes is movement between the bid-ask spread. Thompson's technique does not exactly measure the bid-ask spread, but instead measures the execution cost of trading which is directly related to the bid-ask spread. This measure is presented below. Her measure is valid even when the market is not informationally efficient.
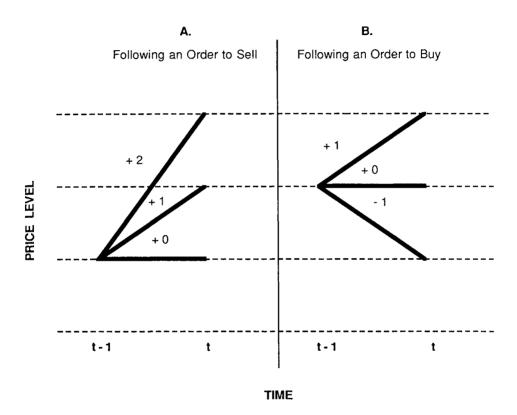
METHODOLOGY

All futures traders incur some amount of transactions costs. The trader on the floor of the exchange pays trading fees to the exchange plus any other fees associated with acquiring exchange membership. Off-floor traders pay transactions costs in the form of brokerage fees and "execution costs" when price changes with the placement of a market order. Generally, when a market order to buy enters the trading pit immediately after a sell order has been executed, the buy order is executed at a slightly higher price than the previous sell order. The bid-ask spread at any point in time is the difference between the active bid and offer prices quoted by scalpers in the pit.

Estimating Execution Costs of Trading

Besides price changes associated with movements between bid and offer prices, new information may arrive to disturb the level of bids and offers in the pit. The diagrams in Chart 1 illustrate the possible changes in price that may occur with the placement of a buy order if new information is also allowed to affect the level of the bid-ask spread.

Chart 1 shows changes in price possible with the placement of a market order to buy after the execution of an order to sell (A) or after an order to buy (B). The price of the transaction at $t-1$ in A represents the most recent bid price quoted by scalpers in the trading pit. The price of the transaction in $t-1$ in B represents the scalpers' most recent ask price and is one unit greater than the bid. If, as in A, the price of the last transaction is at the bid and no new information enters the market, then a buy order causes a unit increase in price between $t-1$ and t, representing a movement between bid and ask prices. If, as in B, the previous price is the ask price, then price remains unchanged between $t-1$ and t as the new buy order is filled by another scalper's offer to sell. If new information arrives at the market causing an increase in the average price level between $t-1$ and t, the bid-ask spread shifts up. Price then increases by two units in A and

Chart 1.—Possible Changes in Price with the Execution
of a Market Order to Buy

A.

Following an Order to Sell

B.

Following an Order to Buy

+ 2

+ 1

+ 0

+ 1

+ 0

- 1

PRICE LEVEL

t - 1   t   t - 1   t

TIME

by one unit in B. If new information causes a decline in the average price
level, the bid-ask spread shifts down. Price then remains unchanged in A
and drops by one unit in B.

In Chart 1 price changes are restricted to increments of the bid-ask spread, here standardized to take a value of one. In many liquid markets, this increment is equal to the size of the minimum allowable price change in the market, or the minimum "tick." In less liquid markets, or in markets where the minimum tick is too small a price change to attract trading interest, the bid-ask spread will be greater than the minimum tick.

Assuming that a buy order is as likely to follow a buy order as it is to follow a sell order (or that the changes in A are as likely as those in B), and that an increase, decrease, or no change in the average price level is equally likely to occur between the transactions, the expected value of the execution cost of trading in placing an order to buy is .50 with variance .92. Analogous charts and reasoning indicate that the expected execution cost of placing an order to sell is −.50 with variance also of .92.

Because of the information contained in the order itself, it is more likely that an increase in the average price level, rather than a decrease, will occur with the placement of a buy order. A decrease in the average price level with the placement of a sell order is also more likely to occur than an increase. Therefore, the value of the execution cost of trading is likely to be greater than .50 with the placement of a buy order, and less than −.50 with the placement of a sell order. If decreases in the average price level do not occur with the placement of buy orders and increases in the average price level do not occur with sell orders, then the expected execution cost of trading is equal to 1 (or −1 for sell orders), the size of the bid-ask spread.

When transaction-to-transaction price data are available, execution costs may be estimated by the average of the absolute value of observed price changes, $|\overline{\Delta P}|$.[2] When increases in the average price level are as likely as decreases, the mean absolute value price change is .83, with variance .47. Thus, the absolute value approximation of execution costs is slightly greater than the expected value of actual costs when decreases in the average price level are possible with the placement of a buy order and when increases in the price level are possible with a sell order. However, when no decreases in the price level are possible with the placement of a buy order and no increases are possible with the placement of a sell order, the mean absolute value price change is an unbiased estimate of execution costs (mean of 1 and variance of .50). Nonetheless, if the likelihood of price changes follow-

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[2] While the value of the average price change (zero in this example) yields no information about transaction or execution costs, some information is contained in the variance of price changes across transactions (1.16 in this example). The variance is directly related to the average absolute value of price changes under conditions of symmetrically distributed price changes. Under these circumstances the average absolute value of price changes is equal to four-fifths of the standard deviation of price changes.

ing the placement of a market order is constant across time and markets, comparisons of execution costs may be reliably based on comparisons of $|\overline{\triangle P}|$. That which determines the magnitude of execution costs similarly determines the magnitude of $|\overline{\triangle P}|$.

The Trading Rule

A filter type trading rule is applied to weekly series of intra-day coffee and cocoa futures prices to determine the size of filter, if any, that generates profits. A negative dependence-type filter is used because it is hypothesized to reflect the trading behavior of scalpers. Such a rule is also suggested by evidence of negative dependence in price changes found in an autocorrelation analysis of intra-day price changes in coffee and cocoa futures contracts. Appendix Table 1 presents the first order autocorrelation coefficients and statistics related to the autocorrelation analysis.

The trading rule is an inverse rule similar to that used by Trevino and Martell. The rule assumes that if price declines (rises) by X cents or more, then a long (short) position is established and held until price increases (decreases) by X cents at which time the long (short) position is liquidated and a short (long) position taken. Once the first position is taken during the day the system trades continuously throughout the day with either one long or one short position until the last trade of the day when the final position is liquidated. Several different filters are applied to both coffee and cocoa contracts. Daily profits in each contract week are summed for each filter. Average profits per trade for each trading rule are then compared to estimates of the execution cost of trading.

DATA AND RESULTS

The data are transaction-to-transaction prices from coffee and cocoa futures contracts traded in the New York Coffee, Sugar, and Cocoa Exchange. Contract size is 37,500 pounds (lb) in coffee contracts and 10 metric tons (mt) in cocoa contracts. There are twelve weekly sets of price data (six from the coffee market and six from the cocoa market), which include quotes from four contract months—March, July, September, and December—over a three-year period, 1981–83. The price quotes for the March and September contracts for each commodity are from the second week in January of each year, while the quotes for the July and December contracts are from the second week in June of each year. Therefore, in each case the March or July contract represents the nearby contract while the September or December contract represents the distant contract. The prices do not include the opening or the closing ranges. Also, no overnight price changes are included in the difference series. Table 1 shows the time periods over which the price series were recorded as well as the contract

months used and the number of transactions recorded for each contract during each week.

Table 1.—Description of the Data Used in the Analysis
of the Execution Cost of Trading in Coffee and Cocoa Contracts

Period	Futures contract		Number of transactions[a]	
	Near	Distant	Near	Distant
Coffee				
Jan. 12–16, 1981	Mar.	Sept.	1,023	193
June 8–12, 1981	July	Dec.	882	447
Jan. 11–15, 1982	Mar.	Sept.	1,281	35
June 7–11, 1982	July	Dec.	1,360	258
Jan. 10–14, 1983	Mar.	Sept.	1,192	98
June 6–10, 1983	July	Dec.	1,222	352
Cocoa				
Jan. 12–16, 1981	Mar.	Sept.	1,019	151
June 9–12, 1981[b]	July	Dec.	598	476
Jan. 11–15, 1982	Mar.	Sept.	1,359	53
June 7–11, 1982	July	Dec.	831	200
Jan. 10–14, 1983	Mar.	Sept.	1,992	114
June 6–10, 1983	July	Dec.	1,840	856

[a]Sum of daily transactions between opening and closing ranges.
[b]Only four days in sample.

Estimates of the Execution Cost of Trading

Values of the average of the absolute value of price changes, $|\overline{\Delta P}|$, as well as the actual average price change, $\overline{\Delta P}$, for each weekly period and each contract month studied are presented in Appendix Table 2. Standard deviations of the series of price changes are also presented in Appendix Table 2. Averages of these results are presented in Table 2.

The most noticeable aspect of the results is the difference in estimates between near and distant coffee and cocoa contracts. For both coffee and cocoa, the estimate of the execution costs, $|\overline{\Delta P}|$, is generally much larger in distant contracts than in near contracts. On average $|\overline{\Delta P}|$ in distant contracts is roughly twice $|\overline{\Delta P}|$ in near contracts. The average $|\overline{\Delta P}|$ is 8.6¢ per 100 lb in near coffee contracts and 18.5¢ per 100 lb in distant coffee contracts. In cocoa contracts the average $|\overline{\Delta P}|$ is \$1.26 per mt in near contracts and \$2.18 per mt in distant contracts. The average price

Table 2.—Average Estimates of the Execution Cost
of Trading in Coffee and Cocoa Contracts*

	$\overline{P}$	$\overline{\Delta P}$	Standard dev. ΔP	$\overline{|\Delta P|}$	Standard dev. $|\Delta P|$
Coffee (¢ /100 lb)					
Distant	12,237	.18	28.4	18.5	21.5
Near	12,768	.00	12.5	8.6	9.1
Cocoa ($/mt)					
Distant	1,890	−.06	3.95	2.18	3.28
Near	1,778	−.01	1.95	1.26	1.49

*See Appendix Table 2 for contract-specific results.

change, $\overline{\Delta P}$, is close to zero in both coffee and cocoa near contracts. In contrast, in many of the distant contracts $\overline{\Delta P}$ is much further from zero. Finally, the standard deviations of both $|\Delta P|$ and ΔP are much larger in distant contracts than in near contracts.

The differences in average price changes and standard deviations between near and distant contracts is a function of the thinness in distant contracts. Thinness is manifested in a smaller number of transactions, larger values of $\overline{\Delta P}$ and $\overline{|\Delta P|}$, and greater standard deviations. The longer time that scalpers must hold positions in less active markets results in greater bid-ask spreads and higher execution costs for the off-floor trader. Between transactions the scalper is exposed to the risk that new information may enter the market and change the price level. Because of these added risks, and because scalpers hold futures contracts for longer periods of time and therefore devote more time and resources to market-making, the bid-ask spread is wider in thin markets than active markets. Thus, the contrast in execution costs between near and distant contracts is primarily determined by the difference in the number of transactions in those contracts. When the number of transactions is approximately equal in near and distant contracts (see, for example, the July and December cocoa contracts traded in June 1981), the estimated execution costs and standard deviations are relatively close.

The relationship between execution costs and thinness as reflected in the number of transactions can be summarized in the correlation between $|\overline{\Delta P}|$ and transactions in the contract weeks analyzed. Values of $|\Delta P|$ are standardized by average price to allow for correlations across coffee and cocoa contracts. Correlations between $|\overline{\Delta P}|/\overline{P}$ and number of transactions as well as correlations with volume and open interest are presented in Table 3. Number of transactions appears to be most strongly related to execu-

tion costs although both average daily volume and open interest are also significantly related to this measure of execution costs. There is no significant difference between the correlations using number of transactions and average daily volume. When the effect of the number of transactions is removed, the partial correlation between execution costs and average daily open interest is .02. These results support the hypothesis that liquidity is directly related to daily or weekly trading activity. It is possible that trading activity is described more accurately by number of transactions than by volume. Volume measures only the number of contracts traded, not the time rate of transactions. Because a large volume may conceivably represent few transactions, volume may not always indicate the pace of trading activity, although in these data their relation was very strong.

Table 3.—Correlations Between Trading Activity Statistics

Activity	$\dfrac{\|\overline{\Delta P}\|}{\overline{P}}$	Average daily volume	Average daily open interest
Transactions	−.74	.95	.86
Average daily volume	−.69	1.00	.88
Average daily open interest	−.64	.88	1.00

Finally, when standardized by average price, estimated execution costs in comparable coffee and cocoa futures contracts are approximately equal. Execution costs are on average .15 percent of contract value in distant coffee contracts and .12 percent of contract value in distant cocoa contracts. Average execution costs are .07 percent of value in both near coffee and cocoa contracts. The similarity in standardized execution costs suggests that the bid-ask spread may be proportional to price in comparably liquid contracts. These values also highlight the slight amount traders pay for immediate liquidity even in illiquid futures markets.

Trading Rule Analysis

Table 4 presents averages of profit per trade and number of trades in near and distant coffee and cocoa futures contracts. Near and distant contracts are grouped separately in the analysis to identify differences between these categories in profits derived from trading filters. Average profit per trade as well as number of trades executed are presented for each week and for each filter analyzed in Appendix Table 3. Average profit per trade is presented in the same units as the execution cost estimates presented in Table 2.

Table 4.—Average Profit Per Trade and Number
of Trades in Coffee and Cocoa Contracts*

Filter size	Distant		Near	
	Ave. profit per trade	Number of trades	Ave. profit per trade	Number of trades
Coffee (¢ /100 lb)				
5	4.5	77.7	.9	348.5
10	5.1	71.7	1.6	255.0
15	5.7	61.3	.9	183.8
20	5.7	53.7	.3	144.2
25	6.0	47.3	−1.1	110.8
30	6.1	31.0	−4.1	69.5
35	7.2	29.3	−4.0	60.5
Cocoa ($/mt)				
1	.11	94.3	.35	380.3
2	.62	71.7	.48	257.3
3	.58	54.8	.40	162.2
4	.59	41.2	.46	112.0
5	1.21	36.2	.40	83.3
6	2.44	27.0	.24	59.3
7	2.50	23.5	1.07	48.5

*See Appendix Table 3 for contract-specific results.

Seven different filter sizes were applied to both coffee and cocoa price changes. The filters used for cocoa ranged from the minimum tick of $1 through $7 per metric ton. This range includes the highest average absolute value price change in cocoa contracts ($2.85/mt). The filters used for the coffee contract do not begin with the minimum tick of 1¢ per 100 lb, because price changes of less than 5¢ were very rare in all of the coffee contracts studied. Therefore the seven filters used for coffee ranged from 5 through 35¢ in multiples of 5¢ per 100 lb. This ranges from the minimum $|\overline{\Delta P}|$ to well above 27.2¢ per 100 lb, the largest observed value.

Table 5 presents average total weekly profits and average profit per trade per contract for coffee and cocoa contracts by filter size. Levels of statistical significance for these averages are also indicated. T-statistics were computed over the weeks within each group to test the two null hypotheses that total weekly profits are on average equal to zero for each filter and that average profit per trade is equal to zero.

For near cocoa contracts the smaller filters yield the most significant profits. The $1 filter produces the greatest profits per week ($1,331.05 = $.35 x 380 x 10), while the $2 filter produces the greatest average profit per

Table 5.—Average Total Weekly Profits and Average Profits
Per Trade Per Contract in Coffee and Cocoa Contracts
(*Profits in dollars*)

| Filter size | Distant | | Near | |
	Average total weekly profits	Average profit per trade per contract	Average total weekly profits	Average profit per trade per contract
Coffee (¢ /100 lb)				
5	1,322.84[a]	17.02[b]	1,228.46	3.19
10	1,357.82[a]	18.94[b]	1,568.25	6.15
15	1,314.89[b]	21.45[b]	634.11	3.45
20	1,141.80[b]	21.26[b]	167.63	1.16
25	1,060.70[b]	22.42[c]	−448.74	−4.05
30	706.80[c]	22.80[c]	−1,065.96	−15.33
35	795.50	27.15[c]	−905.23	−14.96
Estimated execution costs	69.75			32.25
Cocoa ($/mt)				
1	103.73	1.10	1,331.05[a]	3.50[a]
2	444.54	6.20	1,235.04[a]	4.80[a]
3	317.84	5.80	648.80[b]	4.00[b]
4	243.08	5.90	515.20[c]	4.60[c]
5	438.02	12.10	333.20	4.00
6	658.80[c]	24.40	142.32	2.40
7	587.50[b]	25.00	518.95[b]	10.70[b]
Estimated execution costs	21.80			12.60

[a]Statistically different from zero at $\alpha = .01$.
[b]Statistically different from zero at $\alpha = .05$.
[c]Statistically different from zero at $\alpha = .10$.

trade ($.48 x 10). This return per contract exceeds the scalper's round-trip trading costs (exchange and clearing fees) of approximately $2.00. Only the $5 and $6 filters do not yield profits significantly greater than zero in near cocoa contracts.

In the near coffee contracts the 10¢ filter yields the highest t-statistic on both a total and per trade basis ($\alpha = .13$ and .11, respectively). However, none of the t-statistics from near coffee contracts is high enough to reject the null hypothesis at the .10 level that profits are on average zero. This lack of statistical significance in average profits does not necessarily indicate that scalpers do not trade in a manner similar to the trading rule in near cocoa contracts. It is likely that scalpers would accept a strategy that is

profitable less than 90 percent of the time. Indeed, scalpers may follow a trading strategy that yields positive profits that are statistically significant only 75 percent of the time. However, the low level of statistical significance in average profits in near coffee contracts may contribute to higher liquidity costs in coffee contracts because scalpers may require a higher return for providing liquidity in a riskier trading environment.

As in near coffee contracts, in distant coffee contracts the 10¢ filter yields the highest and most significant weekly profits. Nearly all profits in distant coffee contracts are significantly different from zero. Average total profits per week in distant coffee contracts using the 10¢ filter are approximately $1,358 ($.05 x 72 x 375), or $18.94 per contract per trade.

Distant cocoa did not follow the above pattern. Average profit per trade per contract did not significantly differ from zero with any filter size. Furthermore, only the $6 and $7 filters yielded total weekly profits that were significantly different from zero. Given the absence of serial dependence in distant cocoa contracts along with the lack of significant trading rule profits, it may be questionable whether scalpers are active in these contracts, or if active, what sort of trading rule best describes their behavior. It is also likely that the lack of significant profits explains the high execution costs in these contracts.

These estimates of scalping profits based on the application of a naive trading rule are similar to average total weekly profits estimated in grain futures with a similar trading rule by Trevino and Martell (1984). They are also in the neighborhood of per contract profits obtained from scalping reported by Working (1954) and Silber (1984). Silber's traders did generally earn more per contract than those obtained by our naive trading rule. However, Silber's scalpers followed a more sophisticated trading rule. According to Silber, the "scalper's expertise permits him to gauge accurately the short run imbalance of buy and sell orders"(p. 942). This implies that in the real trading world scalpers follow a modified filter-type trading rule whereby they do not always quote a two-sided bid-ask spread. They may not enter into a position if the stream of orders entering the pit suggests that price is likely to move further in the direction of the initial price change.

Comparison of Trading Rule Profits with Estimated Execution Costs

To investigate whether execution costs approximate the return scalpers earn for providing liquidity, it is reasonable to compare $|\overline{\Delta P}|$ to average profit per trade although $|\overline{\Delta P}|$ is probably greater than the amount that price changes on average with the placement of a market order. However, because traders incur execution costs both when entering and exiting a futures position, $|\overline{\Delta P}|$ is probably a modest, or understated, estimate of true "round-trip" execution costs even though it may be biased upward as

an estimate of true "one-way" costs.

The last line in each section of Table 5 reports the average estimated execution costs per contract. Estimates of execution costs from Table 2 have been converted to a per contract basis by multiplying the $|\overline{\Delta P}|$ in cocoa contracts by 10 and by multiplying the $|\overline{\Delta P}|$ in coffee contracts by 375. For both near and distant coffee and cocoa contracts the average profit per trade is substantially less than per contract execution costs in all cases when profits are significantly greater than zero. Filters that yield average profits per trade greater than execution costs (see the $6 and $7 filters in distant cocoa contracts) may be largely discounted because, although total weekly profits were significantly greater than zero, average profit per contract per trade from these filters were not found to be significantly different from zero. Moreover, average profits are still very close to execution costs.

These results provide strong evidence that the profits which are implied by negative dependence in price changes are not available to most traders. Moreover, those who may profit from this price behavior, scalpers, frequently incur losses by providing liquidity. On average they earn far less than the bid-ask spread on market-making positions. The difference between execution costs and the profits estimated here is probably accounted for by adverse movements in the price level during the period that scalpers hold futures positions.

These results also provide some information about the size of the bid-ask spread in coffee and cocoa contracts. Judging by the size of filter that yields the greatest average profit, the bid-ask spread appears to be in the neighborhood of 10¢ per 100 lbs in both near and distant coffee contracts. Much larger spreads in distant coffee contracts are possible, however, due to the similarity in returns for larger filter sizes. In near cocoa contracts the spread may be either $1 or $2 per mt given the similarity in returns between filters of $1 and $2. However, because the average value of $|\overline{\Delta P}|$ is greater than $1 ($1.16/mt), it is likely that the spread is greater than $1. The bid-ask spread in distant cocoa contracts may be in the neighborhood of $6 per mt. However, because this value is so far in excess of the maximum $|\overline{\Delta P}|$ in distant cocoa contracts ($2.85/mt), it is questionable whether the most profitable filter size is in this case a good indication of the size of the bid-ask spread.

Finally, these results indicate that the amount of the return necessary to attract market-makers to a futures contract appears to vary across commodities. In the cocoa market the legal minimum price change is $1 per mt, or $10 per contract. This size change seems to occur quite often. In the coffee market the minimum legal price change is 1¢ per 100 lb or $3.75 per contract, but this change seems to occur very infrequently. The most common coffee price change is 5¢ per 100 lb or greater. This may be an indication that returns from smaller price changes in coffee are insuf-

ficiently profitable to coffee scalpers. The gross return of $18.75 implied by a 5¢ price change may be a more appropriate charge for market-making in coffee contracts. That this amount is greater than the amount implied by the most common cocoa price change indicates either that scalpers face greater risks in coffee trading than in cocoa trading, or that scalpers earn higher net profits in coffee trading than in cocoa trading. Here it is worth noting that the average profit per trade in near coffee contracts using the 5¢ filter is $3.19 while in near cocoa contracts using the $1 filter it is $3.50. The similarity of these net returns as well as the high variability in coffee returns suggests that scalping is riskier in coffee markets than in cocoa markets.

SUMMARY

Using data from coffee and cocoa futures markets, this study has shown that the execution costs of trading as measured by the average absolute value of price changes exceed the return earned following a trading rule based on negative dependence in intra-day price changes. Several important implications follow from this result:

1. Off-floor traders generally pay execution costs for immediate liquidity and therefore cannot profit from the negative dependence in price changes typically found in intra-day price series in commodity futures markets.

2. The scalper, who uses the bid-ask spread when pricing trades, earns significantly less than the bid-ask spread when following a trading style of simple market-making

3. Assuming that scalping is competitive and that the return earned by scalpers is the minimum cost the market needs to pay for liquidity, the characteristic negative dependence in intra-day price changes found in futures markets is a sign of efficiency rather than inefficiency.

Another important finding of the study is that execution costs are small, even in the most illiquid futures contracts, relative to contract value. Nonetheless, execution costs are greater in thinly traded contracts than in actively traded contracts. The number of transactions in a futures contract, rather than the volume of trading, appears to most strongly influence execution costs.

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Appendix Table 1.—Summary of the Autocorrelation Analysis
of Intraday Price Changes in Coffee and Cocoa Contracts

Contract	r_1	(Standard deviation)	Q^a	$(Pr(Q))$
Coffee				
Distant				
Sept. 1981	−.06	(.07)	6.45	(.38)
Dec. 1981	−.09	(.05)	11.10	(.09)
Sept. 1982	−.05	(.19)	2.89	(.82)
Dec. 1982	−.02	(.06)	5.26	(.51)
Sept. 1983	−.11	(.10)	6.34	(.39)
Dec. 1983	−.03	(.05)	4.94	(.55)
Average	−.06		6.16	
Near				
Mar. 1981	−.16	(.03)	28.92	(.00)
July 1981	−.02	(.03)	13.38	(.04)
Mar. 1982	−.21	(.03)	59.85	(.00)
July 1982	−.07	(.03)	32.66	(.00)
Mar. 1983	−.15	(.03)	27.81	(.00)
July 1983	−.12	(.03)	25.52	(.00)
Average	−.12		31.36	
Cocoa				
Distant				
Sept. 1981	−.01	(.08)	5.32	(.50)
Dec. 1981	.02	(.05)	6.877	(.33)
Sept. 1982	.04	(.14)	3.92	(.69)
Dec. 1982	.10	(.07)	11.07	(.09)
Sept. 1983	.14	(.10)	6.21	(.40)
Dec. 1983	−.01	(.03)	5.29	(.51)
Average	.05		6.45	
Near				
Mar. 1981	−.09	(.03)	13.31	(.04)
July 1981	−.09	(.04)	10.03	(.12)
Mar. 1982	−.13	(.03)	28.36	(.00)
July 1982	−.04	(.04)	2.74	(.84)
Mar. 1983	−.11	(.02)	40.84	(.00)
July 1983	−.07	(.02)	18.84	(.00)
Average	−.09		19.02	

[a]

$$Q = n \sum_{k=1}^{K} r_k^2(\triangle P)$$

where K is the number of lags considered. Q is distributed χ^2, with K degrees of freedom. $K = 6$.

Appendix Table 2A.—Estimates of Execution Costs of Trading
in Coffee Contracts
(Cents per 100 lb)

Contract	$\overline{P}$	$\overline{\triangle P}$	Standard deviation $\triangle P$	$\overline{|\triangle P|}$	Standard deviation $|\triangle P|$
Distant					
Sept. 1981	13,750.1	−1.59	29.9	19.9	22.3
Dec. 1981	10,008.3	.10	28.0	18.2	21.2
Sept. 1982	12,689.7	3.90	40.7	27.2	30.1
Dec. 1982	12,503.9	.34	29.1	20.6	20.5
Sept. 1983	11,844.7	−2.10	28.3	15.2	24.0
Dec. 1983	12,622.0	.45	14.6	9.6	11.0
Near					
Mar. 1981	13,294.3	.05	12.5	8.1	9.6
July 1981	9,973.7	.02	21.2	14.9	15.1
Mar. 1982	13,798.7	.05	9.3	6.5	6.6
July 1982	13,930.4	.22	14.0	9.5	10.3
Mar. 1983	12,851.3	−.12	8.5	5.9	6.2
July 1983	12,760.0	−.21	9.4	6.4	7.0

Appendix Table 2B.—Estimates of Execution Costs of Trading
of Trading in Cocoa Contracts
(Dollars per metric ton)

Contract	$\overline{P}$	$\overline{\triangle P}$	Standard deviation $\triangle P$	$\overline{|\triangle P|}$	Standard deviation $|\triangle P|$
Distant					
Sept. 1981	2,116.2	−.09	3.71	2.38	2.85
Dec. 1981	1,601.5	−.18	2.51	1.46	2.02
Sept. 1982	2,161.2	−.73	6.07	2.48	5.58
Dec. 1982	1,529.3	.02	3.33	2.02	2.65
Sept. 1983	1,745.1	.60	5.11	2.85	4.27
Dec. 1983	2,187.2	.03	2.97	1.89	2.28
Near					
Mar. 1981	1,963.0	0	1.87	1.16	1.48
July 1981	1,419.2	−.10	2.64	1.69	2.03
Mar. 1982	2,114.9	−.01	1.69	1.08	1.30
July 1982	1,423.8	.03	1.89	1.27	1.40
Mar. 1983	1,651.9	.02	1.44	0.97	1.07
July 1983	2,095.9	.02	2.16	1.41	1.63

Appendix Table 3A.—Results of Trading Rule Analysis: Coffee
(Cents per 100 lb)

Contract	Average profit/ trade: 5¢ filter	Number of trades	Average profit/ trade: 10¢ filter	Number of trades	Average profit/ trade: 15¢ filter	Number of trades	Average profit/ trade: 20¢ filter	Number of trades
Distant								
Sept. 1981	10.1	64	10.1	64	12.9	54	11.5	50
Dec. 1981	3.0	157	2.5	143	3.6	135	5.7	123
Sept. 1982	−2.3	8	−2.3	8	−2.3	8	−2.3	8
Dec. 1982	3.3	93	4.3	85	1.4	75	.1	65
Sept. 1983	5.0	28	6.8	28	12.9	21	12.9	21
Dec. 1983	4.9	116	6.2	102	7.6	75	5.3	55
Near								
Mar. 1981	2.2	313	3.4	235	3.9	167	3.5	135
July 1981	−2.7	266	−2.1	242	−4.9	203	−6.4	179
Mar. 1982	3.2	421	4.7	267	4.5	177	6.5	134
July 1982	−1.7	395	−2.2	303	−2.6	239	−5.2	183
Mar. 1983	2.6	351	4.0	226	3.6	146	4.2	103
July 1983	1.2	345	2.8	257	3.9	171	4.5	131

Appendix Table 3A.–Results of the Trading Rule Analysis: Coffee
(Cents per 100 lb)
(Continued)

Contract	Average profit/ trade: 25¢ filter	Number of trades	Average profit/ trade: 30¢ filter	Number of trades	Average profit/ trade: 35¢ filter	Number of trades
Distant						
Sept. 1981	12.7	50	15.7	38	21.3	36
Dec. 1981	6.5	113	−2.8	62	−5.9	57
Sept. 1982	−2.3	8	1.2	6	1.2	6
Dec. 1982	1.3	59	7.8	40	10.8	40
Sept. 1983	13.4	19	23.1	16	26.3	16
Dec. 1983	.4	35	1.0	24	−.5	21
Near						
Mar. 1981	1.4	100	8.1	68	7.6	57
July 1981	−7.0	164	−21.8	91	−24.1	82
Mar. 1982	9.0	93	6.1	57	6.8	45
July 1982	−7.7	149	−6.3	99	−6.6	90
Mar. 1983	4.2	69	4.7	50	9.6	43
July 1983	3.5	90	−4.5	52	−.5	46

Appendix Table 3B.—Results of the Trading Rule Analysis: Cocoa
(Dollars per metric ton)

Contract	Average profit/ trade: $1 filter	Number of trades	Average profit/ trade: $2 filter	Number of trades	Average profit/ trade: $3 filter	Number of trades	Average profit/ trade: $4 filter	Number of trades
Distant								
Sept. 1981	.06	49	.76	37	.58	33	1.75	28
Dec. 1981	−.02	123	−.29	92	−.37	57	−.38	45
Sept. 1982	−1.60	20	−5.80	10	−7.50	8	−6.00	8
Dec. 1982	−.02	55	.04	47	−.46	35	1.26	27
Sept. 1983	−1.97	35	3.37	30	3.17	24	−.89	18
Dec. 1983	.54	284	1.04	214	1.12	172	1.18	121
Near								
Mar. 1981	.31	269	.48	188	.49	136	.57	106
July 1981	.77	191	.94	153	1.40	113	1.99	71
Mar. 1982	.62	420	.82	272	.60	155	.45	104
July 1982	.33	271	.47	173	.36	107	.84	75
Mar. 1983	.17	573	.27	346	.01	209	−.71	121
July 1983	.24	558	.29	412	.12	253	.50	195

Appendix Table 3B.—Results of the Trading Rule Analysis: Cocoa
(Dollars per metric ton)
(Continued)

Contract	Average profit/ trade at $5	Number of trades	Average profit/ trade at $6	Number of trades	Average profit/ trade at $7	Number of trades
Distant						
Sept. 1981	1.72	25	4.33	12	5.17	12
Dec. 1981	.16	37	.97	30	.96	26
Sept. 1982	−7.50	6	−5.33	6	−13.00	3
Dec. 1982	2.00	25	2.32	22	2.50	20
Sept. 1983	1.67	18	3.50	18	4.28	18
Dec. 1983	1.68	106	3.14	74	2.85	62
Near						
Mar. 1981	−.63	59	.07	45	−.35	34
July 1981	2.24	63	1.63	40	2.67	36
Mar. 1982	.75	79	−.27	48	.86	42
July 1982	.45	53	.28	40	1.17	36
Mar. 1983	−.26	95	−1.04	68	.07	54
July 1983	.36	151	.98	115	1.72	89