The Execution Cost of Trading in Commodity Futures Markets

by

Sarahelen Thompson and Mark Waller

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Demsetz defined transaction costs in a very brief statement as the cost of exchanging ownership titles. He also noted that economists have largely overlooked studying the cost of transacting. However, though largely overlooked, it is a topic of concern which may provide meaningful and much needed information for traders, as well as bear directly on the study of efficiency in markets.

The transaction costs considered in this paper are the costs incurred in making a quick exchange of a futures contract for money in futures markets. Transactions costs are actually composed of three major components: (1) brokerage fees, (2) transfer taxes, and (3) the execution costs of trading (bid-ask spread). Although brokerage fees vary widely across commission houses, an average across the industry may be used to measure these costs. These figures as well as transfer taxes can be relatively easily obtained or estimated. However, an estimate of the execution cost of trading typically is not readily available to the off-floor trader. Moreover, this cost is usually ignored in the study of commodity markets and trading behavior (for an exception see Working).

The execution cost of trading may be defined as the amount that price changes with the placement of a market order. It will be shown that this cost is smaller in more heavily traded markets, and larger in markets that are more thinly traded. It will also be shown that execution costs are positively associated with the variance of expected trading profits. Determining a method that may be used to estimate this cost may provide necessary and helpful information to traders as well as academicians. The 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. It will also further the theoretical understanding of pricing efficiency and liquidity in commodity futures markets.

Objectives

The three major objectives of this study are:

1. To determine and employ a method for estimating the expected execution cost of trading.

2. To show that in most markets the expected execution cost of trading is not equal to zero, but instead is equal to some positive value.

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3. To show that the execution cost of trading may reduce or negate the profitability of some trading strategies based on negative serial dependence in price changes. Furthermore, under efficient market conditions, only scalpers earn a return equal to the execution cost of trading from market-making, or providing immediate liquidity to the market.

Literature Review

A number of studies have examined the behavior of prices in commodity futures markets to determine whether prices follow a random walk or martingale process. Peterson and Leuthold; Stevenson and Bear; Smidt; Cargill and Rausser; and Leuthold have applied a number of different testing methods including spectral analysis, runs test, index of continuity, filters, and other tests to daily prices. Martell and Helms; Trevino and Martell; Working; and Brinager have used similar tests on intra day prices. The results of these tests have been used to judge the efficiency of futures markets. In studies using intra day prices, Brinager; Working; Martell and Helms; Trevino and Martell; and Thompson all found a significant degree of negative dependence in price changes. However, as noted in many studies, negative dependence may largely be a function of the existence of a bid-ask spread. Demsetz stated that the existence of such a transaction cost does not indicate that a market is inefficient. Instead, the matter of major concern should be whether or not this cost is properly economized.

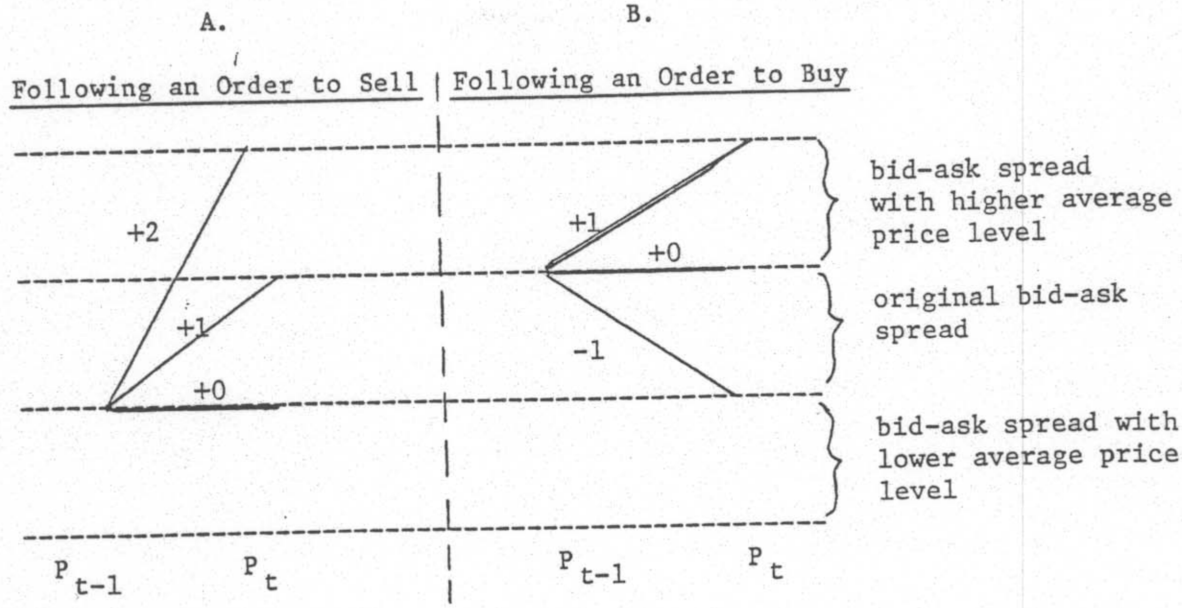
Demsetz divided transaction costs into three components: 1) brokerage fees, 2) transfer taxes, and 3) the bid-ask spread. Later researchers (Garbade and Silber; Silber; Copeland and Galai; and Thompson) have been more concerned with the factors that determine the size of the bid-ask spread and how those factors influence market maker behavior. 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, depth, and continuity. Roll and Thompson have both developed methods to estimate the size of bid-ask spread, and thereby measure liquidity in a market.

Methodology

Estimating Execution Costs of Trading

Execution costs of trading are incurred when a market order to buy or sell is executed. If an order to buy is placed after a trade occasioned by an order to sell, the buy transaction will usually be executed at a higher price than the previous sell transaction. In general, the bid-ask spread is the difference between the price at which buy and sell orders are executed if there is no change in the average price level. If price levels change, price changes are not restricted to the size of the bid-ask spread. Consider the following diagrams which illustrate possible changes in price that may occur with the placement of a market order to buy.

Figure 1. Possible Changes in Price With The Execution of a Buy Order



+2	Price change following an increase in the average price level	+1
+1	Price change following no change in the average price level	0
+0	Price change following a decrease in in the average price level	-1

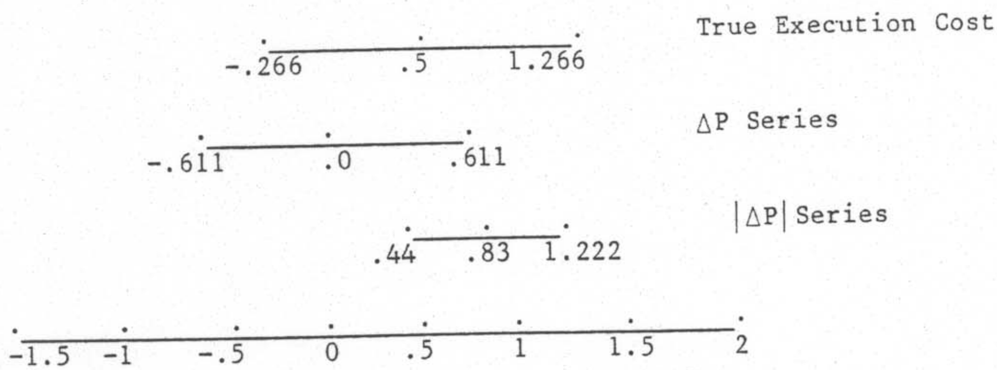
In diagrams A and B price changes are restricted to increments of the bid-ask spread. In many liquid markets, this increment is equal to the size of the minimum tick. Assuming that a buy order is as likely to follow a buy order as a sell order, and that an increase, decrease, or no change in the average price level is equally likely to occur between transactions, the expected value of the execution cost of trading in placing an order to buy is .5 with variance .916. If a buy order is more likely to be associated with an increase in the average price level than a decrease, then the expected execution cost of trading in placing a buy order is greater than .5..

Analogous diagrams and reasoning may be used to determine the expected execution cost of placing an order to sell. Using the same assumptions, it is easily shown that the expected execution cost from a sell order is -.5, with variance .916. If a sell order is more likely to be associated with a decline in the average price level, then the expected execution cost is less than -.5.

The price changes observed in commodity markets are the sum of changes occasioned by buy and sell orders. If buy and sell orders are equally likely to occur, and if an increase in the average price level is as likely as a decrease and as no change in the price level, the expected price change is zero, with variance 1.16. Hence, a naive estimate of transactions costs will not include an execution cost component, as these appear to be zero on average. A slightly more sophisticated treatment may however consider the variance of price changes and may therefore include execution costs in transactions costs under conditions of risk aversion.

An approximation of mean execution costs may be achieved by taking the average of the absolute value of observed price changes, $|\overline{\Delta P}|$. Using the same set of assumptions as above, the mean absolute value price change is .83, with variance .472. The mean absolute value is greater than the absolute value of the mean execution cost because it is possible for negative price changes to occur upon the placement of a buy order, and positive price changes to occur with a sell order, thereby moderating the size of the expected price change from a buy or sell order. However, under the restrictive assumptions of this example regarding the probability of price changes, the average absolute price change maintains a constant proportionate (5/3) relationship with average execution costs regardless of the size of the price change increment. Therefore, that which determines the magnitude of execution costs similarly determines the magnitude of $|\overline{\Delta P}|$. Differences in $|\overline{\Delta P}|$ across futures contracts thus represents proportionately equal differences in execution costs.

Execution costs of trading in coffee and in cocoa futures contracts are estimated by the sample moments of observed $|\Delta P|$ and ΔP. Probability, or "confidence" intervals for both $|\overline{\Delta P}|$ and $\overline{\Delta P}$ together approximate a confidence interval for the execution cost of trading. The 95% confidence intervals for the execution cost of trading using our representative buy order are presented below.



The absolute value interval is clearly more narrow and contains a higher mean than the true execution cost interval. This narrowness is in part due to the greater number of observations in the absolute value series (twelve), versus in the true execution cost series (six). However, the true mean execution cost of trading is bounded by $|\overline{\Delta P}|$ and $\overline{\Delta P}$, as is the true interval approximately bounded by the $|\overline{\Delta P}|$ and $\overline{\Delta P}$ intervals.

The Trading Rule

A filter type trading rule is applied to weekly series of intraday coffee and cocoa futures prices to determine the size of filter, if any, that generates profits. Given evidence of negative dependence in price changes found in an auto-correlation analysis (see Appendix 1 for a summary) it was decided that a negative dependence type filter is most likely to yield substantial trading profits.

The trading rule used here is an inverse rule similar to that used by Trevino and Martell. The rule assumes that if price moves down from the recent high by (X) cents then a long position is established and held until price moves up from a low by (X) cents at which time the long position would be liquidated and a short position taken. Once the first position is taken during the day the system will trade continuously throughout the day always having a position of one contract either long or short 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

The data are transaction-to-transaction prices from coffee and cocoa futures contracts traded on the New York Coffee, Sugar, and Cocoa Exchange. There are twelve weekly sets of price data (six coffee and six cocoa) which include quotes from four contract months--March, July, September and December--over a three year period, 1981-1983. 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.

Results

Estimates of the Execution Cost of Trading

As shown earlier, the execution cost of trading is approximated by the average of the absolute value of price changes $\overline{|\Delta P|}$. This value as well as the actual average price change, $\overline{\Delta P}$, were estimated over each weekly period for each contract month studied. The results of these estimates are presented in Table 2. Figures 2-5 show plots of the 95% confidence intervals for both $\overline{|\Delta P|}$ and $\overline{\Delta P}$ for each contract analyzed.

The most noticeable aspect of the results is that confidence intervals for $\overline{|\Delta P|}$ and $\overline{\Delta P}$ do not in general overlap. The $\overline{|\Delta P|}$ intervals are above the $\overline{\Delta P}$ intervals. This result is due to the large number of observations (transactions) in each contract week analyzed. Where intervals nearly overlap the number of observations in those contract weeks is relatively small (see, for instance, the September 1982 coffee and cocoa contracts). This finding does not suggest that $\overline{|\Delta P|}$ is a poor estimate of the execution cost of trading. Instead, it merely indicates that the mean of $\overline{|\Delta P|}$ is significantly different from the mean of $\overline{\Delta P}$. The true value of the expected execution cost of trading lies somewhere between $\overline{|\Delta P|}$ and $\overline{\Delta P}$. Therefore, these results confirm that the "true" value of execution costs is indeed positive, although probably less than $\overline{|\Delta P|}$.

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				
January 12-16, 1981	March	September	1023	193
June 8-12, 1981	July	December	882	447
January 11-15, 1982	March	September	1281	35
June 7-11, 1982	July	December	1360	258
January 10-14, 1983	March	September	1192	98
June 6-10, 1983	July	December	1222	352
Cocoa				
January 12-16, 1981	March	September	1019	151
June 9-12, 1981[b]	July	December	598	476
January 11-15, 1982	March	September	1359	53
June 7-11, 1982	July	December	831	200
January 10-14, 1983	March	September	1992	114
June 6-10, 1983	July	December	1840	856

a/Sum of daily transactions between opening and closing ranges.

b/Note only four days in sample.

Table 2. Estimates of Execution Costs of Trading in Coffee and Cocoa Contracts

Contract	$\overline{P}$	$\overline{\Delta P}$	$\widehat{\text{var.}}\ \Delta P$	$\overline{\lvert\Delta P\rvert}$	$\widehat{\text{var.}}\ \lvert\Delta P\rvert$
Coffee ¢/lb.					
Distant					
Sep. 81	137.50	-.0159	.08932	.199	.04981
Dec. 81	100.08	.00104	.07818	.182	.04517
Sep. 82	126.90	.039	.1656	.272	.09083
Dec. 82	125.04	.00336	.08466	.206	.04215
Sep. 83	118.45	-.02097	.08033	.152	.05744
Dec. 83	126.22	-.0045	.02145	.096	.01217
Averages	122.37	.00034		.186	
Near					
Mar. 81	132.94	.00045	.01574	.081	.00924
July 81	99.74	.00023	.04503	.149	.02276
Mar. 82	137.99	.00049	.00861	.065	.0044
July 82	139.99	.00218	.01964	.095	.01053
Mar. 83	128.51	-.0012	.00727	.059	.0038
July 83	126.60	-.00213	.00892	.064	.00484
Averages	127.62	.0000033		.086	
Cocoa $100/m.t.					
Distant					
Sep. 81	21.16	-.00089	.00138	.0238	.00081
Dec. 81	16.02	-.00184	.00063	.0146	.00041
Sep. 82	21.61	-.00729	.00369	.0248	.00312
Dec. 82	15.29	.00021	.00111	.0202	.0007
Sep. 83	17.45	.00596	.00261	.0285	.00182
Dec. 83	21.87	.00026	.00088	.0189	.00052
Averages	18.90	-.0006		.0218	
Near					
Mar. 81	19.63	.0001	.00035	.0116	.00022
July 81	14.19	-.0099	.0007	.0169	.00041
Mar. 82	21.15	-.00011	.00029	.0108	.00017
July 82	14.24	.00029	.00036	.0127	.0002
Mar. 83	16.52	.00023	.00021	.0097	.00011
July 83	20.96	.00017	.00047	.0141	.00027
Averages	17.78	-.000067		.0126	

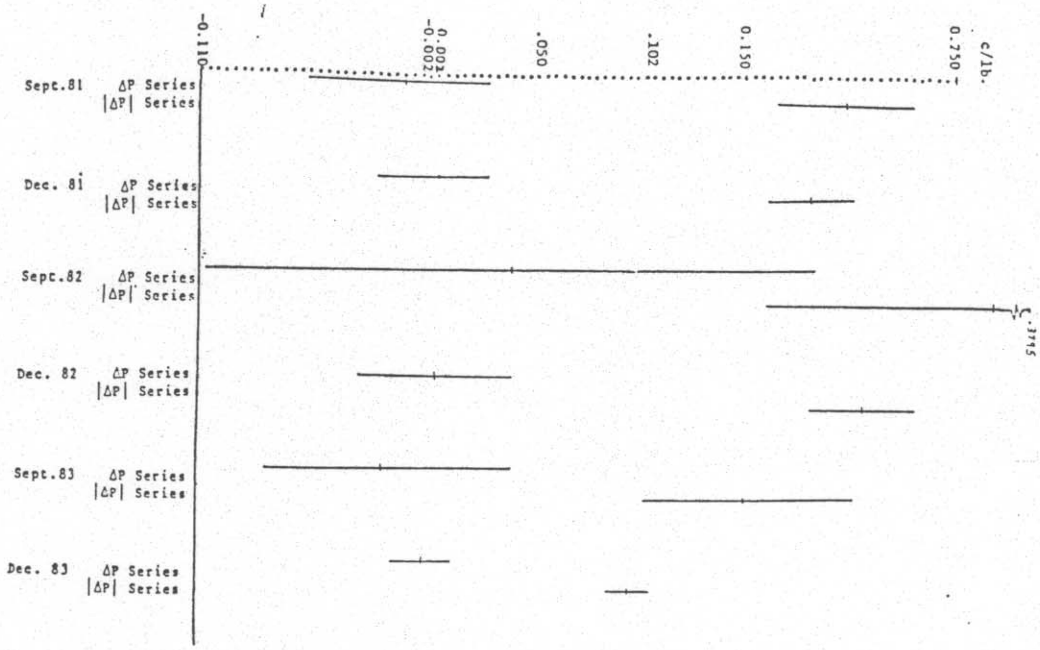


Figure 2
Confidence Intervals for Execution Costs
in Distant Coffee Contracts

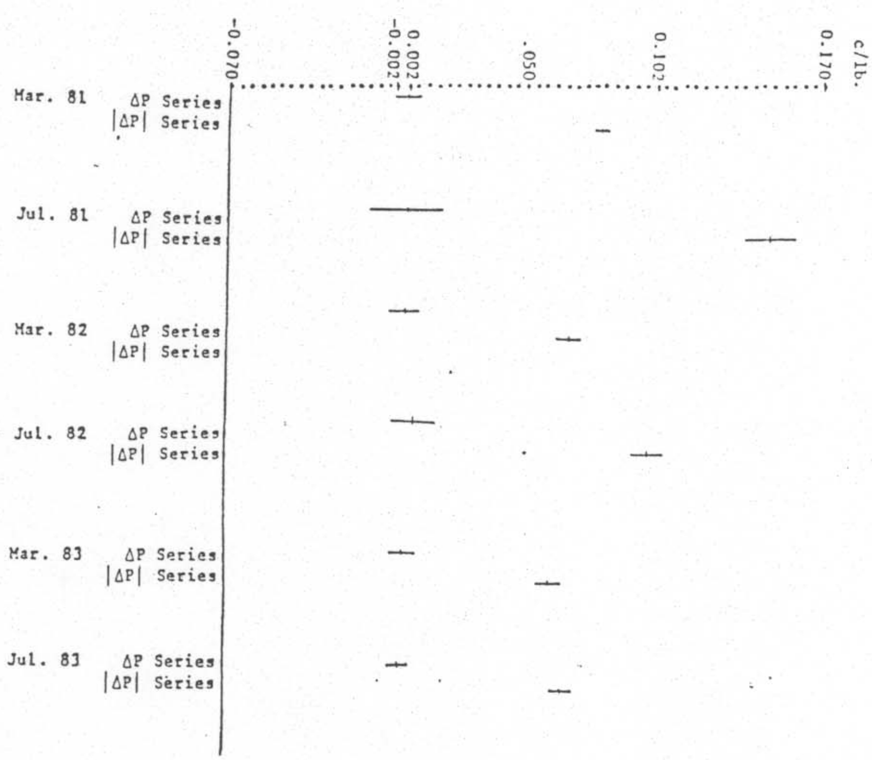


Figure 3
Confidence Intervals for Executions Costs
in Near Coffee Contracts

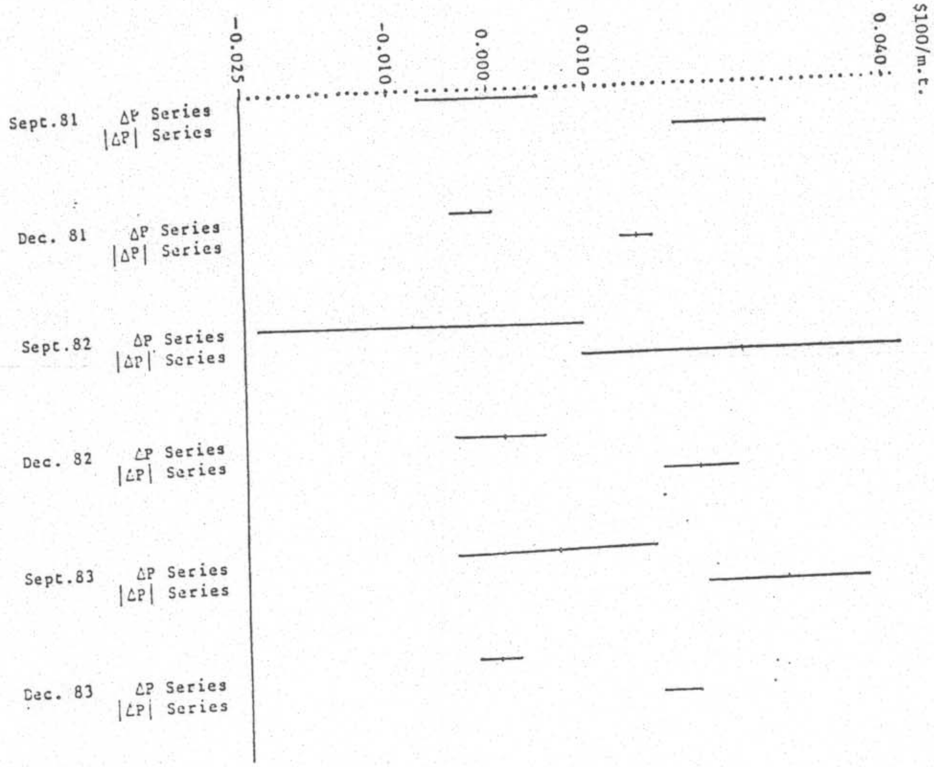


Figure 4
Confidence Intervals for Execution Costs
in Distant Cocoa Contracts

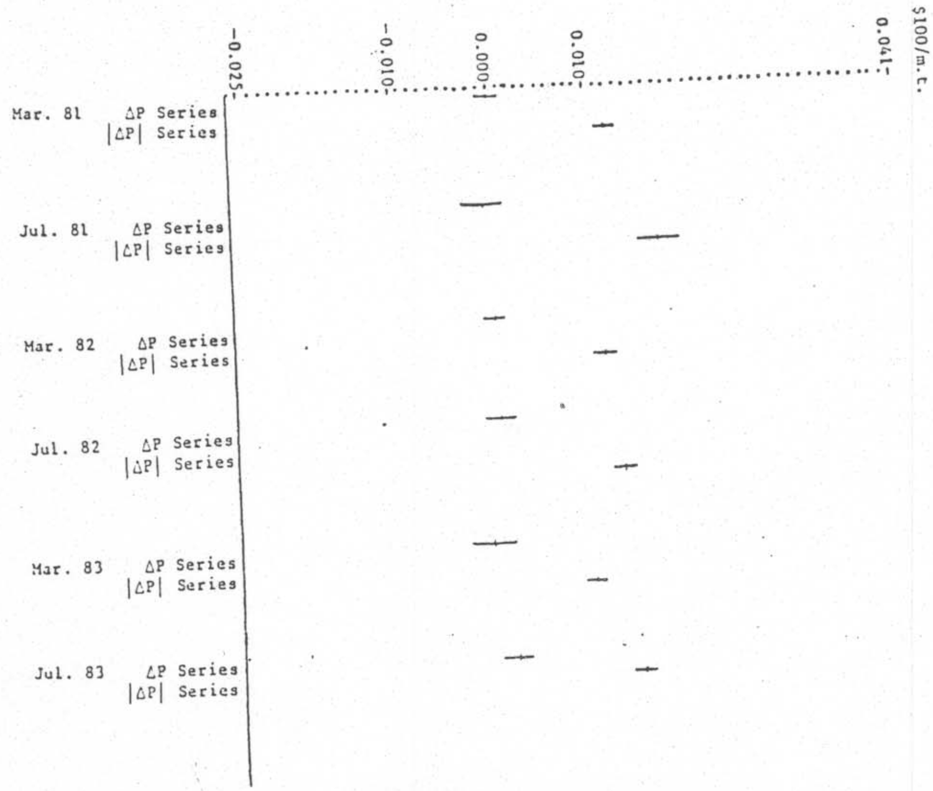


Figure 5
Confidence Intervals for Execution Costs
in Near Cocoa Contracts

Table 3. Results of the Trading Rule Analysis

			filter	#trades	filter	#trades	filter	#trades	filter	#trades	filter	#trades	filter	#trades	filter	#trades
Coffee	¢/lb.		.05		.10		.15		.20		.25		.30		.35	
Period		Contract														
Jan. 81	distant	Sep. 81	6.46	64	6.46	64	6.96	54	5.76	50	6.36	50	5.96	38	7.66	36
June 81	distant	Dec. 81	4.77	157	3.51	143	4.81	135	6.99	123	7.33	113	-1.76	62	-3.38	57
Jan. 82	distant	Sep. 82	-.18	8	-.18	8	-.18	8	-.18	8	-.18	8	.07	6	.07	6
June 82	distant	Dec. 82	3.08	93	3.68	85	1.08	75	.08	65	.78	59	3.10	40	4.30	40
Jan. 83	distant	Sep. 83	1.40	28	1.90	28	2.70	21	2.70	21	2.55	19	3.70	16	4.20	16
June 83	distant	Dec. 83	5.64	116	1.34	102	5.69	75	2.90	55	.15	35	.24	24	-.11	21
			21.17	466	21.71	430	21.06	368	18.25	322	16.99	284	11.31	186	12.74	176
Ave.profit/trade (prob. > T)			.0454	(.028)	.0505	(.022)	.0572	(.031)	.0567	(.036)	.0598	(.052)	.0608	(.060)	.0724	(.076)
Jan. 81	near	Mar. 81	7.04	313	7.90	235	6.54	167	4.77	135	1.44	100	5.51	68	4.31	57
June 81	near	July 81	-7.23	266	-5.03	242	-9.91	203	-11.39	179	-11.54	164	-19.86	91	-19.76	82
Jan. 82	near	Mar. 82	13.28	421	12.63	267	7.97	177	8.66	134	8.41	93	3.50	57	3.05	45
June 82	near	July 82	-6.70	395	-6.71	303	-6.32	239	-9.56	183	-11.51	149	-6.26	99	-5.97	90
Jan. 83	near	Mar. 83	9.06	351	8.97	226	5.19	146	4.29	103	2.87	69	2.36	50	4.12	43
June 83	near	July 83	4.20	345	7.27	257	6.73	171	5.88	131	3.13	90	-2.32	52	-.25	46
			23.65	2091	25.03	1530	10.02	1103	2.65	865	-7.20	665	-24.27	417	-14.5	363
Ave.profit/trade (prob. > T)			.0113	(.229)	.0164	(.111)	.0092	(.219)	.0031	(.311)	-.0108	(.227)	-.0582	(.32)	-.0399	(.413)
			filter	#trades	filter	#trades	filter	#trades	filter	#trades	filter	#trades	filter	#trades	filter	#trades
Cocoa	$100/m.t.		.01		.02		.03		.04		.05		.06		.07	
Jan. 81	distant	Sep. 81	.03	49	.28	37	.19	33	.49	28	.43	25	.52	12	.62	12
June 81	distant	Dec. 81	-.03	123	-.27	92	-.21	57	-.17	45	.06	37	.29	30	.25	26
Jan. 82	distant	Sep. 82	-.32	20	-.58	10	-.60	8	-.48	8	-.45	6	-.32	6	-.39	3
June 82	distant	Dec. 82	-.01	55	.02	47	-.16	35	.34	27	.50	25	.51	22	.50	20
Jan. 83	distant	Sep. 83	-.69	35	1.01	30	.76	24	-.16	18	.30	18	.63	18	.77	18
June 83	distant	Dec. 83	1.66	284	2.22	214	1.92	172	1.43	121	1.78	106	2.32	74	1.77	62
			2.02	566	2.68	430	1.90	329	1.45	247	2.62	217	3.95	162	3.59	141
Ave.profit/trade (prob. > T)			.00357	(.357)	.00623	(.455)	.00578	(.356)	.00578	(.219)	.01207	(.492)	.02438	(.174)	.02546	(.434)
Jan. 81	near	Mar. 81	.65	269	.83	188	.68	136	.48	106	-.51	59	-.19	45	-.12	34
June 81	near	July 81	1.48	191	1.44	153	1.58	113	1.41	71	1.41	63	.65	40	.96	36
Jan. 82	near	Mar. 82	2.62	420	2.24	272	.93	155	.47	104	.59	79	-.13	48	.36	42
June 82	near	July 82	.90	271	.82	173	.38	107	.63	75	.24	53	.11	40	.42	36
Jan. 83	near	Mar. 83	1.00	573	.95	346	.03	209	-.86	121	-.25	95	-.71	68	-.04	54
June 83	near	July 83	1.34	558	1.20	412	.30	253	.98	195	.54	151	1.13	115	1.53	89
			7.99	2282	7.48	1544	3.90	973	3.11	672	2.02	500	.86	366	3.11	291
Ave.profit/trade (prob. > T)			.00350	(.007)	.00484	(.003)	.00401	(.029)	.00463	(.075)	.00404	(.179)	.00235	(.317)	.01069	(.043)

For near contracts the smaller filters yield the largest t-statistics. The .02 filter produced the most significant profits in near cocoa contracts in terms of both profits per week and average profit per trade. Average total profits per week are \$1250 (7.48/6 x \$100 x 10) or \$4.84 per contract per trade. Filters of .01, .03, and .07 also yielded profits significantly greater than zero in near cocoa contracts. In the near coffee contracts the .10 filter yielded the highest t-statistic on both a total and per trade basis. However, none of the t-statistics from near coffee contracts were high enough to reject the null hypothesis that profits are on average zero. In the distant coffee contracts the .10 filter also yielded the highest t-statistics, and profits were significantly different from zero for filters up to .20. Average total profits per week in distant coffee contracts using the .10 filter are approximately \$1350 (21.71/6 ÷ 100 x 37500), or \$18.94 per contract per trade. Distant cocoa did not follow the above pattern; profits did not significantly differ from zero with any filter size.

For both near and distant coffee and cocoa contracts the average profit per trade is less than the expected execution cost of trading ($\overline{|\Delta P|}$) in all cases when profits are significantly greater than zero. It is reasonable to compare $\overline{|\Delta P|}$ to average profit per trade given that traders incur execution costs both when entering and exiting a futures position. Therefore, although $\overline{|\Delta P|}$ is biased upward as an estimate of true "one-way" execution costs, it is certainly a modest, or understated estimate of true "round-trip" costs. Those filters which yield average profits per trade greater than $\overline{|\Delta P|}$ can be ignored because profits from these filters were not found to be significantly different from zero.

Implications

The implications of these results to traders are that the profits from seemingly profitable trading strategies may elude traders due to the existence of a bid-ask spread. The profits from any strategy that relies on fills at the price of a recent transaction will on average be reduced by execution costs. However, because the scalper uses the bid-ask spread in pricing his trades, his behavior may be described as profiting from the use of small filter type trading rules. The scalper's round trip costs are less than \$2.00 per trade (exchange and clearing fees) in these markets. Therefore, the returns from following a filter-type trading rule will in general cover scalper trading costs but not other traders' costs unless they can buy at a bid price and sell at the ask. Even if traders buy at scalpers' bid prices or sell at scalpers' asks, perhaps by placing limit orders, their profits will be reduced by any brokerage fees required to trade.

These results also have implications with respect to the efficiency of futures price behavior. The existence of profitable trading rules may first lead to the spurious conclusion of price inefficiency. However, consideration of the execution costs of trading suggests that these profits are not available to most traders. Nonetheless, the efficiency question may still arise if scalpers are able to obtain profits from such trading rules. In order to determine conclusively whether these markets are efficient, it must be shown that the return to scalpers is the minimum cost the market needs to pay for liquidity and that the cost of liquidity is exceeded by its benefits. Some may conclude that the market's willingness to pay indicates the value to traders of liquidity. However, definitive resolution of this issue is outside the scope of this paper.

The size 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 .01 or $10.00 per contract. This size change seems to occur quite often. In the coffee market the minimum legal price change is .01 or $3.75 per contract, but this change seems to occur very infrequently. The most common coffee price change is .05 or greater. This may be an indication that returns from smaller price changes in coffee are insufficiently profitable to coffee scalpers. The return of $18.75 implied by a .05 price change may be a more appropriate charge for the scalper's inventorying function 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 inventorying risks or costs 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 .05 filter is $4.24 while in near cocoa contracts using the .01 filter it is $3.50. The similarity of these returns as well as the high variability in coffee returns suggests that scalping is riskier in coffee markets than in cocoa markets.

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

Contract	r_1 (std.dev.)	Q (Pr(0)) [a]
Coffee		
Distant		
Sep. 81	-.055 (.073)	6.45 (.375)
Dec. 81	-.093 (.046)	11.10 (.085)
Sep. 82	-.049 (.183)	2.89 (.822)
Dec. 82	-.022 (.063)	5.26 (.511)
Sep. 83	-.112 (.104)	6.34 (.386)
Dec. 83	-.025 (.054)	4.94 (.552)
Averages	-.059	6.16
Near		
Mar. 81	-.157 (.031)	28.92 (.000)
July 81	-.016 (.034)	13.38 (.037)
Mar. 82	-.205 (.028)	59.85 (.000)
July 82	-.067 (.027)	32.66 (.000)
Mar. 83	-.148 (.029)	27.81 (.000)
July 83	-.123 (.029)	25.52 (.000)
Averages	-.119	31.36
Cocoa		
Distant		
Sep. 81	-.012 (.083)	5.32 (.503)
Dec. 81	.022 (.046)	6.87 (.333)
Sep. 82	.043 (.144)	3.92 (.687)
Dec. 82	.104 (.072)	11.07 (.086)
Sep. 83	.139 (.096)	6.21 (.400)
Dec. 83	-.005 (.034)	5.29 (.507)
Averages	.045	6.45
Near		
Mar. 81	-.091 (.031)	13.31 (.038)
July 81	-.092 (.041)	10.03 (.124)
Mar. 82	-.131 (.027)	28.36 (.000)
July 82	-.043 (.035)	2.74 (.841)
Mar. 83	-.114 (.022)	40.84 (.000)
July 83	-.074 (.023)	18.84 (.004)
Averages	-.091	19.02

a/ Q is based on K = 6

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