Do Professional Traders Exhibit Loss Realization Aversion?

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comments welcome

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Abstract

Recent evidence (e.g. Odean, 1998a) describes investor behavior that is at odds with traditional economic theory. These alternative behaviors, such as loss realization aversion and overconfidence, form the basis for recent "behavioral" explanations for asset returns (e.g. Daniel, Hirshleifer and Subrahmanyam 1998a and 1998b, Odean 1998b, and Shumway, 1998). Notably, the evidence of alternative investor behavior is based largely on retail customer accounts - those of amateur traders.

In this paper we examine trades by populations of professional futures traders for patterns which are best described by the "behavioral finance" literature. The data provide some support for the existence of a disposition effect (derived from the prospect theory of Kahneman and Tversky 1979) among professional traders: futures floor traders hold losing trades significantly longer than winning trades. Our findings are tempered by a brief analysis of the 'benchmark' issue in prospect theory, and whether traders focus on gross or net revenues..

However, our evidence also suggests that discipline, or "self control" (Shefrin and Statman 1985) enables successful professional traders to mitigate "behavioral" traits. If professional traders exhibit discipline and successfully control alternative behaviors, then the impact of alternative behaviors on asset pricing is not likely to be pervasive.

Introduction

Recent evidence suggests that some investors and experimental subjects exhibit behaviors that are somewhat at odds with the predictions of economic and financial theory. For example, Odean (1998a and 1999) provides evidence that small investors trade "too much", and that while trading, they sell winners and hold losers, interpreting the results as supporting alternative behavioral theories, particularly the disposition effect (Kahneman and Tversky 1979). These striking results have been received passively, perhaps because retail investors (noise traders) are not expected to have an impact on price.

Much of the early evidence on alternative behavioral models comes from either experimental settings or interpretation exercises. Experimental subjects consistently exhibit behavior inconsistent with traditional expected utility maximization (e.g. Kahneman and Tversky 1979). Many recent papers interpret observed empirical regularities as consistent with alternative behaviors, including Benartzi and Thaler (1995), Barberis, Shleifer and Vishny (1998), Daniel, Hirshleifer and Subrahmanyam (1998a and 1998b), Odean (1998b), and Shumway (1998). However, as noted by Fama (1998), "observational" evidence is subject to various, often conflicting, interpretations.[1]

In addition to Odean (1998a and 1999), several other current papers provide direct evidence on the trading behavior of retail customer samples. Barber and Odean (1998a and 1998b), Heisler (1996), and Odean (1998a and 1999) examine small nonprofessional traders and find evidence of alternative behaviors, including observed behaviors consistent with the disposition effect - an excessive tendency to sell winners and hold losers. The case appears to

[1] Campbell, Lo and Mackinlay (1997, Chapter 8) and Bernstein (1998, Chapters 15, 16, and 17) provide additional background and insights on "behavioral finance".

have been made, then, that retail investors as a group are following some alternative behavioral strategy.

The documentation of behavioral traits in investors leads to obvious concerns about the pervasiveness of these alternative behaviors. In particular there should be a concern as to the extent to which such behavior appears in a more professional setting, which leads to the present research, in addition to a broader concern regarding asset pricing in the face of alternative trading behaviors, which we do not address here.

Empirical evidence of alternative trading behaviors by small investors should not be surprising, since practically every text offering investors trading advice warns against exactly the type of behaviors which have been documented. In an attempt to mitigate the potential investment harm caused by such behavior, the trading literature proposes "disciplined" approaches, through which investors lay out contingency plans, and are instructed to follow the plans somewhat blindly. Typical strategies incorporated into disciplined trading include predetermined exit points (for example, entering stop-loss orders when opening a position) and other decision rules designed to eliminate emotion from decision making.

While such advice appears to be required for small investors, the conventional wisdom among professional traders suggests that "disciplined" trading is pervasive, as the following quotations illustrate.

> "...to be a successful trader, I must love to lose money and hate to make money. ...The first loss is the best loss; there is no better loss than the first loss….Trading is a discipline."
> *From EEK, (memoirs of CBOT member Everett Klipp (1995))*

> "One of the critical criteria I use in judging my traders is their ability to take a loss. If they can't take a loss, they can't trade."
> *John Mack, Morgan Stanley CEO, in a 1991 deposition.*

> "If you have bad inventory, mark it down and sell it quickly."

Attributed to Bear Stearns Chairman Alan "Ace" Greenburg, describing his penchant for quickly selling losing trades, in the Wall Street Journal article: If Wall Street were Olympian, He'd Ace the Marathon, March 8, 1999.

"...so, as our discipline requires, we sold."
J. Stowers, CEO, American Century Funds, in a 12/10/97 letter to investors.

'"Never meet a margin call.' (In other words, if the market is going against you, concede defeat quickly and liquidate before you really lose your shirt)"
James Grant, editor, Grant's Interest Rate Observer, quoted in Business Week article: Failed Wizards of Wall Street, September 21, 1998.

If professional traders are indeed disciplined in the sense that the term is used in the above quotations, it would seem inappropriate to generalize evidence of behavioral problems by small investors and extend the results to making inferences about market professionals. Based on their need for continuing success, the natural presumption should be that market professionals are disciplined traders who are less prone than retail investors to exhibit alternative and costly behavioral tendencies. If professional traders use trading discipline to minimize behavioral traits, then alternative behavioral models may describe only small numbers of investors or small capitalized investors who together have little impact on price formation. In other words, behavioral problems may be an annoying but essentially harmless anomaly. On the other hand, evidence that professional floor traders also exhibit alternative behavioral tendencies would provide increased support for research on the behavioral approach to finance. Such evidence would impact many areas of finance, in addition to its obvious direct impact on asset pricing theory.

In this paper we study trade histories for professional floor traders (locals) trading for their own account in four active futures contracts on the Chicago Mercantile Exchange ("CME") over a six-month period. We examine the trading of these professionals using high frequency analysis, where trades are completed in a matter of minutes. These locals, who trade in a

competitive environment, and who trade for primary income rather than for long-run investment or as an avocation, are likely to be forced into disciplined trading, abstaining from emotion-tinged trading in order to succeed.

Our findings reveal that these traders do consistently hold losing trades longer than winning trades. In addition, this behavior is evident among all subgroups of traders, where the subgroups are defined by the trader's overall success at trading. Tempering these results is our analysis using a mean adjusted benchmark. Since these traders have explicit transactions, time and foregone earnings costs associated with trading, their benchmark for gains and losses may be centered on some positive revenue per contract. Using mean adjusted benchmark alters our results considerably. Comfort for critics of the behavioral literature may be found as well in an additional result that the more successful traders in our sample exhibit the disposition effect to a lesser degree than do their less-successful rivals. In addition, we find that trader success is related to minimization of "status-quo bias" - successful traders complete trades more rapidly, both for gains and for losses.

The paper's structure is as follows. Section 2 reviews behavioral theories and evidence. Section 3 describes the data and methodology. In section 4 we present the results, and section 5 concludes.

2. **Behavioral models: theory and existing evidence.**

2.1. The disposition effect.

The second rule of trading could be termed "Cut your losses, ride your gains." (With the first rule being, of course, "Buy low, sell high.") However, recent evidence provided by Odean (1998a and 1999), Heisler (1996), and Barber and Odean (1998a and 1998b) shows that small

investors often ignore this well-known rule, and tend to hold losses longer than gains. What sort of behavioral model would result in investors holding losing trades for extended periods while cashing in winning trades early? Shefrin and Statman (1985) introduce the disposition effect, based on the prospect theory of Kahneman and Tversky (1979), as an explanation for the perceived anecdotal evidence at that time of investor reluctance to realize losses. Prospect theory proposes that investors perform "mental accounting", assigning a reference point to each position from which gains and losses are calculated, rather than following a portfolio choice model. The theory proposes that agents evaluate opportunities to close existing positions as either gains or losses, measured against the reference point.

Prospect theory modifies expected utility theory in two areas, and leads to predictions which are consistent with investor loss realization aversion. First, utility is assumed to be a function of gains and losses relative to a benchmark, rather than a function of absolute wealth. This benchmark is critical to the model, and may be a dynamic variable. Second, while standard utility functions are concave, prospect theory assumes for utility functions that are concave for gains and convex for losses (but steeper so that overall risk aversion is attained). The prediction of a disposition effect relies on these two wrinkles to expected utility theory. Figure 1 provides a possible prospect theory utility function suggested by Campbell, Lo and Mackinley (1997).[2]

Figure 1 can be used to illustrate the behaviors predicted by prospect theory. Consider, for example, an investor confronted with prices that are equally likely to increase or decrease a given amount. The prediction of the disposition effect is that investors holding positions with gains compare smaller utility increases associated with extended gains to larger utility decreases associated with reduced gains (or losses), maximizing utility by realizing the current gain. On the

[2] The specific functional form uses revenue of x , is $v(x) = \{ x^{(1-\gamma)}/(1-\gamma)$, for $x \geq 0$; $-\lambda [x^{(1-\gamma)}/(1-\gamma)]$ for $x < 0\}$, where x is revenue (gain/loss), $\gamma = 0.55$, and $\lambda = 2.5$. The choice of γ and λ is for illustrative purposes only.

other hand, when investors hold losses, they are projected to compare larger utility increases from potential gains to smaller utility reductions from further losses, and maximize utility by holding the position.

Early evidence supporting prospect theory is largely experimental (Kahneman and Tversky (1979), Kahneman, Knetsch, and Thaler (1990)). Others examine volume patterns for stocks conditioned upon prior price levels, including Shefrin and Statman (1985) and Ferris, Haugen and Makhija (1988).

Recent evidence provided by Odean (1998) and Heisler (1996) examines speculative trades made by retail investors. Heisler studies trades by what he describes as small speculators, and finds that the speculators hold losing positions longer than positions with gains. Odean studies accounts at a discount brokerage, and finds that the investors in the sample are much more apt to liquidate winning positions than losing positions.

2.2 Status-quo bias (regret aversion)

Shefrin and Statman (1985) describe regret aversion as another "alternative behavior" related to loss realization aversion: "Regret is an emotional feeling associated with the ex post knowledge that a different past decision would have fared better than the one chosen" (page 78). Shefrin and Statman, suggest that regret aversion leads inaction to be preferred to action. Regret aversion thus leads to a reluctance to realize both gains and losses. Samuelson and Zeckhauser (1988) use the term "status quo bias" to describe similar behaviors – a bias towards maintaining a current position. They find experimental evidence that "…individuals disproportionately stick with the status quo." (page 7).

To summarize this brief review of behavioral finance literature, early anecdotal and experimental evidence led to the development of prospect theory. This was extended to finance in the form of the disposition effect. Overwhelming empirical evidence supports the finding of a disposition effect in retail investors.

3. Data and Methodology

3.1 The data.

We use Chicago Mercantile Exchange (CME) transaction data (also known as CTR data) supplied by the CFTC. We use data from the first six months of 1995 for the two most active currencies (Deutsche mark and Swiss franc) and the two most active non-financial commodities (Live cattle and Pork bellies). We select all traders that traded at least five contracts for their personal account on at least ten different days during the sample period, resulting in a sample of 330 traders.

The data are rich in detail, providing trader identification, trade direction (buy/sell), and information about the trade counter parties, including the trade customer type indicator, or CTI type. There are four possible CTI types: CTI 1 trades are trades executed by the floor trader for personal account, and these personal account trades are the focus of this study. The other three CTI types are: CTI 2, trades executed on behalf of a clearing member (generally commercial members); CTI 3, trades executed on behalf of other exchange members (often delta hedging trades executed on behalf of futures options traders); and CTI 4 trades, which are customer trades. We restrict the analysis exclusively to CTI 1 trades, executed by traders for their personal account.

Table 1 provides descriptive statistics for the traders and the volatility of the instruments traded. Price volatility (as measured by the daily trading range of the most active contract) is highest for the Swiss franc futures and lowest for cattle. The mean daily price range for the franc, at $1229, is almost 100 times the minimum price increment, or tick, of $12.50. While cattle futures have the lowest volatility, the mean daily range, at $353, is still over 35 times the

tick. In addition to volatility statistics, Table 1 also provides gross trading income for personal account traders included in the sample, as well as daily volume and income statistics.

Note that while aggregate trading income is lower for the two agricultural commodities, the highest median trader income is in bellies, while the lowest is in cattle, with the currencies in between. Also note that per contract income is also highest in bellies, which has the lowest volume. We point these interesting facts out to alert the reader to potential differences among traders in the various commodities.

3.2 Trade histories.

We construct trade sequences for each trader (and also for each different contract delivery month in which the trader executes personal account trades) for each trading day of the six-month sample period. The transactions data provide trades sequenced to the minute. For each minute of the trading day (for each contract) we determine the quantity of contracts that traders buy and sell.

If a trader buys contracts at two different prices during a minute, we consolidate the trades and use the quantity-weighted mean price as the trader's purchase price for the minute. We treat sales analogously so that for each minute, we track each trader's buy volume and mean purchase price as well as the trader's sell volume and mean sales price.

We construct daily trade histories for each trader implicitly assuming that all trades are closed out at the end of each day, so that traders carry no overnight position (Kuserk and Locke 1993, and Manaster and Mann 1996, present evidence that floor traders rarely hold overnight positions).

3.3 Defining gains, losses, and holding times.

Trading language typically refers to how much was made or lost on 'a trade.' For a simple trade, in which something is purchased, then later sold (or vice versa), the trade is easy to define, as are any revenues associated with it. Floor trader transactions typically exhibit much more complicated trade sequences. Therefore, average cost allows trades, and their associated revenues, to be defined without resorting to either specific identification accounting (attempts to match specific contract purchases with specific sales), or a LIFO/FIFO scheme.

We use simple average cost accounting methods to measure revenues, as contracts are completely fungible. Our method is essentially the same as in Silber (1984). We employ analogous methods to calculate the length of time that positions are held. We briefly review the methodology below, while providing a complete description, with numerical examples, in Appendix 1.

Cost Basis

The cost (per contract) for a trader's position at the beginning and the end of each minute is defined as the quantity-weighted average price for the position. We use cost in a generic sense: long position cost is the average purchase price and short position cost is the average sale price (at any particular time a trader's position is either long or short). When trades add to an existing position (long traders that buy or short traders that sell), average per contract cost is adjusted; when a trader reduces a position the per-contract average cost of the remaining position is unchanged.

Realized revenues

We refer specifically to realized revenues as gains or losses obtained by offset. Realized revenues are the result of either paired-offset trades (purchase and sale in the same minute) or position reductions. For paired-offsets, we calculate the realized revenue as the sale price less the purchase price times the quantity.

Holding Times.

We calculate the average holding time for all trades except for end-of-day open positions in a manner analogous to the cost basis accounting. The holding time for a trade increases by one minute at the start of each minute. As a trader adds to a position, the average hold time for each contract in the position is reduced to reflect the shorter holding time of the newest contracts. As positions are reduced but not eliminated, the hold time of the remaining position increases since additional time has passed. Paired offsets have a hold time of zero, and do not change the average holding times of previous positions.

Round trips (trips)

The term "round trip" describes the purchase and sale, in either order, of one contract: for a particular trade, the number of round trips is the quantity of contracts in a sale that offset prior purchases, or the number of purchased contracts that offset a prior sale. Thus we use round trips to indicate the number of contracts in a 'completed trade'. Position reductions and offsets generate round trips.

Marking positions to market

When traders reduce their position, they realize revenues. Existing positions typically have either unrealized gains or unrealized losses. We calculate the daily sequence of each trader's unrealized revenues by marking the trader's positions to market each minute, performing

this calculation for all minutes that they trade as well as all minutes that they are not trading. We mark positions to market by comparing the position average cost to the average pit price each minute. The average pit price is the quantity weighted average transaction price for all traders. If the average pit price is higher than a long position's average cost, then the position has an unrealized gain, and a positive mark-to-market. A positive mark-to-market indicates that at that time, the position could probably be closed for a gain; a negative mark-to-market indicates that the position would be closed at a loss.

4. Empirical results.

4.1 Paired-offset trades compared to other trades

Our goal is to make inferences about trader decision processes regarding existing positions. However, traders may occasionally execute offsetting transactions (buys and sells) during a minute while leaving their position unchanged; sometimes traders change their positions while executing some offsetting trades as well. For purposes of accounting for revenues we are forced to distinguish between offsetting intra-minute trades (paired offsets) and all other trades. We defined paired offsets in section 3 to be a set of transactions that are matched by offsetting transactions (buying and selling the same contract) within the same minute. Prior to examining trader decisions regarding positions held for at least a minute, we examine differences between offsetting trades and other trades. Table 2 reports descriptive statistics for paired offsets (offsets) compared to all other trades.

Table 2 shows that such paired offsets comprise roughly 20% of trades for the four pits, ranging from a high of 23% for the deutsche mark to a low of 17% for pork bellies. Comparing paired offset trades to other trades that are held longer, three results bear particular notice. First,

paired offset trades are much more likely to be executed with realized revenues equal to zero than are trades that are held at least one minute (other trades). For example, 22% of deutsche mark paired offsets exhibit no revenues, compared to only 5.22% for other trades. Second, considering only trades that exhibit a gain or a loss, we see that paired offsets are predominantly gains, to a much greater extent than trades with longer holding times. For example, the proportion of gains for paired offsets ranges from 66.6% (mark) to 81.1% (bellies) compared to gains proportions ranging from 57.6% (mark) to 60.3% (bellies) for other trades. Third, as we would expect, trades that are held longer exhibit more revenue volatility than do the offsets. The interquartile range of per contract gains and losses is three to five times wider for trades held for a minute or longer than for paired offsets.

4.2 Differences in holding times for losses compared to gains

In this section we examine whether professional traders, as a group, exhibit "loss realization aversion," by comparing trader holding times for winning trades to their holding times for losing trades. As a first pass, we compare holding times for gains versus losses, with no control for the relative magnitude of absolute revenues. However, insofar as the distribution of *sizes* of gains and losses may differ, these aggregate results may be misleading for our purposes. With that in mind, we further examine the holding times in more detail by examining holding times for subsamples selected on the basis of the absolute revenue per contract for the trade. The categories are for illustrative purposes, and the following break points are somewhat arbitrary, although we did seek a sufficient sample size in each category. The six categories are: 1) trades with zero revenue (no gain or loss);[3] 2) absolute revenue less than $10 per contract; 3) at least

[3] Also included in the zero revenue category are trades with miniscule absolute revenue, defined as all trades with absolute revenue per contract less than $0.0000001.

$10 but less than $25; 4) at least $25 but less than $50; 5) at least $50 but less than $100; and 6) any trades with absolute revenue of at least $100 per contract.

Table 3 provides descriptive statistics for revenues, aggregated (all gains and all losses) in Panel A, and broken down by absolute revenue in Panel B. Both panels provide the raw number of trades with gains and losses (first two columns), the number of round trips (second two columns), the percentage of trades with gains versus losses, the mean trade size, and the mean revenue per contract for gains and losses. For example, Panel A shows that mean trade sizes were virtually identical for gains and losses, that roughly 60% of all trades with nonzero revenue were gains, and that losses are larger in magnitude than gains for all four commodity markets. Panel B reports statistics for trades separated by absolute revenue per contract. Rather than reporting percentages of gains versus the percentage of losses *within* each absolute revenue category, Panel B reports the percentage distribution of gains and losses *across* the absolute revenue categories.

Examination of the Panel B columns labeled "percent of trade totals" reveals the reason that the average loss is larger in magnitude than the average gain: the *percentage* of large magnitude losses is higher than the percentage of large magnitude gains. For example, consider trades with absolute revenues over $100 for the Deutsche mark. While the mean loss is barely larger than the mean gain ($225 compared to $223), the percentage of large losses (14.5%) exceeds the percentage of large gains (11.8%).

Table 4 reports the results of holding time comparisons. Panel A reports comparisons without regard to absolute revenue magnitude, while Panel B compares gain and loss holding times for trades with similar absolute revenues. The median hold times range from three to twenty-three minutes across the four commodities. These numbers might appear somewhat high

given the claim by Silber (1984) that holding a trade longer than 2 minutes would result in a expected loss. The difference could be due to the different time periods and different exchanges. However, our sample is much more comprehensive; we analyze entire trading populations over a six-month period, rather than selected individuals. Comparing gains to losses, the results are striking: professional traders as a group hold losses significantly longer than gains. Panel A shows that overall, losses are held substantially longer than gains for all four commodities. Median and average holding times for losses range from 25% to 100% longer than counterpart holding times for gains.

As noted above, we were concerned that different gains and losses might be treated differently depending on the size of the absolute revenue. Panel B provides convincing evidence that gains are realized more quickly than losses regardless of the magnitude of the absolute gain. Clearly, the professional traders in our sample appear to exhibit loss realization aversion as a group - in that they hold losing trades longer than winning trades.

Comparing "trade quality" for position-closing trades with gains versus losses.

The evidence shows that floor traders hold losses longer than gains. However, holding time does not imply trade quality. One of more interesting findings in Odean (1998a) is that the stocks sold, at a gain, by the small investors in his sample subsequently outperform the stocks held, at a loss. Unfortunately, we cannot replicate such an experiment with the floor traders due to the nature of the positions - the vast majority of floor traders are trading a single position (where we include spreaders in that definition). However, we do examine position reducing trade quality by defining two measures of trade quality and comparing quality for gains and losses.

We define two measures to quantify trade quality; one measure is forward-looking and the other is backward -looking. The forward measure we label "foregone". The foregone measure simply compares a trade to the price that could have been obtained if the trade had been held to the end of the day. For position reduction accomplished by selling, the foregone measure is defined as the end-of-day price (the settlement price) less the actual selling price obtained. For position reductions via purchase (i.e. covering a short position) the foregone measure is defined as the purchase price less the end-of-day price. Thus, for both purchases and sales, "foregone" measures the dollars per contract that were lost by trading at that time rather than closing the position at the end of the day. Positive foregone means that the position-reducing trade was - in effect - poorly timed (looking forward to the end of the day).

The backward-looking measure of trade quality for position reductions we label the "percent realized". For trades with gains, the percentage gain realized is defined as the revenue divided by the maximum potential (market-to-market) revenue available on the trade. For losses, the percentage gain realized is defined as the absolute revenue per contract divided by the maximum absolute potential loss per contract.

Table 5 compares the foregone and percent realized statistics for gains and losses (aggregated across all trades for each commodity). In contrast to the striking difference between holding times for gains and losses, the foregone measure exhibits no systematically significant variation between gains and losses. There is slightly stronger evidence that traders realize a higher percentage of their possible gains than they do their losses, but the overall message of the comparisons of trade quality is ambiguous. The evidence does not suggest that the history of the trade (whether it is a gain or a loss) influences the quality of the decision to close the trade.

Benchmark sensitivity

The comparisons of gains and losses provided in Tables 3 and 4 are based on a classification of gains and losses in the most natural way: a gain is gross positive and a loss is gross negative. Recall that prospect theory implies that utility is driven by mental accounting, in where traders are assumed to derive utility from gains and losses, as compared to a benchmark. While defining gains and losses against a zero benchmark is natural, it is impossible to know if the zero benchmark is correct (or even if there is a benchmark). Odean (1998a), Heisler (1996), and Silber (1984) also define gains and losses using a zero benchmark. Odean acknowledges the importance of the reference point choice, but suggests that the use of imperfect proxies bias against finding empirical support for the disposition effect.

In order to examine the sensitivity to the benchmark, we examine an alternative, economically relevant, reference point: we adjust the income on a trade by a proxy for its expected value, the mean revenue per contract for the sample period.[4] Table 1 reports the mean revenue per contract for each commodity; for example, for the Deutsche mark the mean revenue per round trip is $6.23. When defining trades as gains and losses using the mean revenue benchmark, if the revenue per contract is not larger than the mean revenue, it is classified as a loss. Table 5 reports comparisons of holding times for normalized, or net revenue per contract, gains and losses after adjusting for mean revenue per contract. The message of Table 5 is that the overwhelming evidence presented in Table 4 - losses are held longer than gains – is obscured when costs are considered in addition to revenues. The choice of benchmark, net versus gross revenue, is clearly a significant factor in this type of analysis.

[4] Some intuition for this is as follows. Floor traders have fixed (and some variable) costs associated with trading. These include foregone wages, seat rental, overhead, taxes and fees, and so forth. If on average these costs are covered by the average return on a trade, as in a competitive environment, then anything less than this earned on a trade is a loss, and anything more is a gain.

While stressing the sensitivity of the results to the benchmark, we proceed to investigate the role of trader success in the evidence supporting the disposition effect. Perhaps additional theoretical work in the area of the disposition effect will offer help in choosing an *appropriate* benchmark. The next section examines variation in trading behavior across trader success categories.

4.3 Trader success and loss realization aversion

The previous section suggests that these professional traders as a group exhibit loss realization aversion. Given prior research findings that retail investors are reluctant to realize losses (Odean 1998, Heisler 1996), the results suggest that the disposition effect is a widespread phenomenon. However, the results presented in section 4.2 aggregate all traders, and the floor trading population is not a homogenous group. Traders vary by experience, capitalization, and trading strategies. If conventional wisdom about trading has validity, then successful traders presumably have more discipline than their less successful peers, where discipline is taken to mean minimization of alternative and costly behavioral tendencies such as loss realization aversion.

Defining success

To determine whether success is related to discipline, we first require a definition of success. Intuitively, trading revenue ought to be directly related to trading success. However, in the short run the amount of risk undertaken in order to achieve the revenue is certainly vital to long-run survival. Therefore we utilize two related measures of success. The first is total income for the six-month sample period. The second measure, which we label "risk-adjusted performance", or RAP, measures a trader's daily return on an estimate of the economic capital

required by the trader to cover potential losses that the trader undertook in order to trade the position. The RAP measure will give low rankings to traders who may have been successful in terms of income, but were in fact taking on risky strategies.

We estimate a trader's required economic capital by considering the trader's marked-to-market position for each minute of each day that the trader trades. We define the maximum exposure for each trader each day as the absolute value of the trader's maximum unrealized loss for each day. A trader's maximum exposure for the day therefore is a reasonable measure of the largest potential loss to which the trader was exposed on that day. We then define the economically required capital as the 95^{th} percentile daily maximum exposure for the trader. If a trader trades 100 days, we take the 5^{th} largest maximum exposure as the economically required capital, or *ex post* value at risk.

Given our "value *that was* at risk" estimates of trading capital requirements, we define the RAP as the average daily income divided by economically required capital. Table 7 reports distributional statistics for RAP rankings. From this table, it is clear that traders with similar average trading incomes vary widely in the amount of risk they take in order to earn the income. The first two columns report median incomes and median 95^{th} percentile potential losses for the traders within each quartile. The median trader in the highest RAP-ranked quartile for the deutsche mark earned a daily average of $755, and the 95^{th} percentile potential loss for traders in the highest ranked deutsche mark group was $2,971. The last column of Table 7 provides the RAP for the median trader within each group. The median trader in the highest-ranked deutsche mark group has an RAP of 0.296.

A natural interpretation of the RAP ratio is the comparison of income to potential loss. In this sense, traders with a RAP of 0.20 risk at least 5 times their average daily trading income

around once every 20 days. From this table it appears that lower-ranked traders expose themselves to much more risk for a given level of income. For example, the median traders in the second- and third-ranked deutsche mark groups have RAPs of 0.076 and 0.007, respectively, which indicates that they risk about thirteen times and one hundred and forty times, respectively, their mean income every twenty days.

Success and discipline

Given these two definitions of success, we examine the relationship between success and alternative behavioral tendencies, specifically loss realization aversion (section 2.1) and regret aversion, or status quo bias (section 2.2). Conventional wisdom (e.g. "cut your losses") suggests that more successful traders exhibit more discipline, where discipline indicates a relative absence of harmful alternative behavioral tendencies. We investigate success and discipline by comparing the profitability of trades for various holding times across trader success groupings.

We examine trade profitability across these various holding times because loss realization aversion, or the disposition effect, implies declining profitability as holding time increases. The disposition effect predicts that, all else being equal, gains are realized sooner than losses, so that as trade holding time increases, the proportion of losses should increase as well. If a subset of traders are more prone to the disposition effect, then the profitability of their trades should decline relative to other traders who are less prone to such behavior as holding times increase.

Table 8 reports mean revenue per contract for trades classified by holding times, across trader success quartiles. The first five columns report average income per contract results for traders ranked by risk adjusted performance (RAP); the second five columns use trader ranks determined by total income. Figures 2 and 3 present the results graphically. As Table 8 and the

figures show, profitability remains relatively constant across holding times for higher ranked traders, in striking contrast to the lowest ranked traders. For example, the lowest RAP quartile for deutsche marks earn $5.21 per contract on average for trades held less than 1-minute, but lose $26.43 on average for trades held longer than 10 minutes. Compare those numbers with the highest RAP quartile for deutsche marks, where the comparable revenue per contract are $8.21 and $8.15. These results are clearest in figures 2 and 3. The lowest ranked traders earn revenues comparable to their more successful peers for holding times up to 10 minutes. But trades held longer than 10 minute are especially unprofitable for less successful traders. The least successful traders seem particularly subject to the disposition effect.

We examine the relationship between discipline, loss realization aversion, "status-quo bias," and success in another manner by comparing gain and loss holding times across trader success levels. In order to compare holding times for gains and losses across traders with different gain/loss distributions, we normalize holding times by dividing trade holding times (in seconds) by the trade's absolute revenue (in dollars) for non-zero gains and losses.[5] The resulting ratio we label "time per dollar" for gains and losses. The time per dollar metric has natural economic interpretations, as it measures the time it takes for the position to gain or lose a dollar. Consider a trade held for two minutes, with a revenue of $12 per contract. The trader held the trade 120 seconds to earn $12, so the time per dollar is 10 seconds.

Table 9 reports mean holding time per dollar for winning and losing trades executed by traders within success-ranked quartiles, where success is defined as RAP (first eight columns) or total income (second eight columns). For every quartile, we consolidate all sample period trades by traders ranked within the quartile. There are three notable trends exhibited in table 9. First,

[5] We perform this analysis on all trades with absolute gain per contract greater than $10 to avoid empirical complications due to dividing by small numbers.

for every pit, traders in every success quartile hold losses longer than gains, on average. Or, from another perspective, it takes these all of these groups of traders longer to lose a dollar than to gain a dollar. From these data, loss realization aversion appears pervasive in the set of professional traders. Second, successful traders close their losing trades more quickly than less successful compatriots. For example, for Swiss francs, the highest RAP quartile uses 10 seconds to lose a dollar, while the fourth quartile uses almost 22 seconds. Third, successful traders also close winning trades more quickly than their peers. Again for francs, the highest RAP uses 7.75 seconds to make a dollar, while the fourth RAP quartile uses 16.05 seconds. Thus, more successful traders seem to offset their trades relatively soon, whether the trade results in a gain or a loss. The results are somewhat mixed for the rankings based on overall income, which we believe lends support to our use of the RAP quartiles.

Overall, Table 9 shows that when traders are ranked on the basis of risk-adjusted performance, successful traders close both winning and losing positions more quickly than less successful traders. This result appears more faithful to Silber's finding, at least in a relative sense. The successful traders (in terms of RAP) close positions more rapidly than do the less successful traders. The information sources associated with floor trader profitability are undoubtedly order-flow related and thus of short duration (Ito, Lyons and Melvin (1998) label order-flow information as "semi-fundamental" information). The evidence suggests that traders able to act on the information and avoid "status quo bias", or the tendency to become wedded to a position, are more likely to be successful. However, when success is defined as total income, the relationship between position holding time and success is less clear.

5. Summary and Conclusion

In this paper we provide evidence that professional futures floor traders exhibit loss realization aversion, as they hold losing trades longer than gains. Taken as a group, the professional traders appear to be subject to the disposition effect. These results are tempered somewhat by questions and analysis about the choice of a revenue benchmark, gross versus net. As previous research documenting loss realization aversion focuses on small retail customers and experimental subjects, these findings - that professionals also exhibit the disposition effect - provide evidence that behavioral attributes are pervasive in the population. This should be reassuring, in the sense that professional traders are really no different than the rest of us, but also troubling, in the sense that these behaviors may affect asset pricing through market microstructure.

An examination of differences in trading activity across trader success levels shows that the least successful traders appear to exhibit most strongly the characteristics described as "behavioral". Specifically, while traders at every success level hold losses longer than gains, the least successful traders hold losses the longest while the most successful traders hold losses for the shortest time. Thus there is evidence that trading success is negatively related to the degree of loss realization aversion.

The most successful traders close out their gains, as well as their losses, much more quickly than do their less successful peers. This is consistent with the best traders being less subject to regret aversion (status quo bias), as well as being less subject to loss realization aversion. The evidence suggests that relative trading "discipline" is related to a minimization of the influence of "behavioral" or emotional attributes, and instead focus on the competitive advantages (if any) that the trader has. For floor traders, who likely operate on short-term

'information' related to order flow (Manaster and Mann (1998)), it appears that the most successful traders close positions quickly upon either achieving their target or updating their information.

Appendix 1. Accounting Methodology

In order to facilitate our exposition of the methodology, we refer frequently in this appendix to Chart 1, which provides illustrative examples for an imaginary trader, Trader Z .

Chart 1: Hypothetical Trade history for Trader Z

Time	Trade	Price	Position Average cost		Mean hold time (minutes)		Realized Revenue	Round trips	end of minute marking to market:		
			Start	End	Start	End			pit price	Total Mark	Mark/ contract.
9:10	Buy 1	$100	-	$100.00	-	0	-	-	$100	0	0
9:11	Buy 1	99	$100.00	99.50	1.0	0.5	-	-	99	-$1.00	-$0.50
9:12	Buy 1	98	99.50	99.00	1.5	1.0	-	-	98	-3.00	-1.00
9:13	Buy 1 Sell 1	96 97	99.00	99.00	2.0	2.0	1.00	1	97	-6.00	-2.00
9:14	Sell 1	96	99.00	99.00	3.0	3.0	-3.00	1	96	-6.00	-3.00
9:15	-	-	99.00	99.00	4.0	4.0	-	-	93	-12.00	-6.00
9:16	-	-	99.00	99.00	5.0	5.0	-	-	98	-2.00	-1.00
9:17	Sell 1	100	99.00	99.00	6.0	6.0	1.00	1	100	1.00	1.00
9:18	Sell 2	102	99.00	102.00	7.0	0.0	3.00	1	102	0	0
9:19	Buy 1 Sell 2	102 103	102.00	102.50	1.0	0.5	1.00	1	103	-1.00	-1.00
9:20	Buy 2	101	102.50	-	1.5	-	3.00	2	101	-	-

Cost Basis

The per contract cost for each trader's position at the beginning and the end of each minute is defined as the quantity-weighted average price for the existing position. We use the

term cost in a generic sense, so that long position cost is the average purchase price and short position cost is the average sale price (at any particular time a trader's position is either long or short). When trades add to an existing position (long traders that buy or short traders that sell), average per contract cost is adjusted; when a trader reduces a position the per-contract average cost of the remaining position is unchanged.

For example, focusing on the first 5 columns of chart 1, Trader Z opens a position at 9:00 by buying a contract at $100; the end-of-minute average cost of the position is $100. In each of the next two minutes Z adds to the position, buying one contract each minute at declining prices. The average per contract cost declines with each trade building the position: after 9:12 (the third minute), the average cost is $99.00, which is the average price of the three purchased contracts (the price of each trade weighted by trade quantity). Continuing with the example, as Trader Z liquidates the position by selling, the average cost of the remaining position is unchanged until 9:18, when the trader "switches" positions, moving from long (positive) to short (negative). At that point, the end-of-minute average cost is adjusted to the average sale price of the new short position, $102.

We illustrate "paired-offset" trades in minutes 9:13 and 9:19. At 9:13, Z buys 1 at $96 and sells 1 at $97. Z starts the minute long three contracts and ends the minute long three contracts. For these accounting purposes, we consider the paired offsets to be distinct trades from the existing position and therefore the offsetting trades do not change the position average cost. Paired offsets may occur simultaneous to a position change, as at 9:19. In situations such as this, we define the minimum of intra-minute buy and sell quantities as the paired-offset trades, and adjust the average cost only for the net change in position. In the example, Z's trades at 9:19 result in an (absolute) increase in her short position. The mean sales price is 103, so the cost

basis is adjusted to reflect one contract (the pre-existing position) sold at 102 and one new contract (the net change in position) sold at 103, for and end-of-minute position cost basis of 102.5.

Trading language typically refers to how much was made or lost on 'a trade.' For a simple trade, in which something is purchased, then later sold (or vice versa), the trade is easy to define, as are any gains or losses associated with it. Floor trader transactions typically exhibit much more complicated trade sequences. Therefore, average cost accounting, as used previously by Silber (1984), allows trades, and their associated gains and losses, to be defined without resorting to either specific identification accounting (attempts to match specific contract purchases with specific sales), or a LIFO/FIFO scheme.

Realized revenues

We refer specifically to realized revenues for gains and losses obtained by offset. Realized revenues are thus the result of either paired-offset trades or position reductions. For paired-offsets, we calculate realized revenues as the sale price less the purchase price times the quantity. In the example, the 9:13 paired-offsets result in a revenue of 1 (97 less96), while the 9:19 paired offsets result in a revenue of 1 also. For position reductions, we calculate realized revenues as the difference between the trade price when the offset occurs and the average cost of that trade times the quantity. Finally, for daily income totals any open position after the day's last transaction are offset using the exchange's settlement price, with the resulting revenues added to intraday revenues to obtain daily income. We do not include these end-of-day mark-to-market trades for any analysis other than total income, due to the artificial nature of the trade "end".

Holding Times.

We calculate the average holding time for all trades except for end-of-day open positions in a manner analogous to the cost basis accounting. The holding time for a trade increases by one minute at the start of each minute. As a trader adds to a position, the average hold time for each contract in the position is reduced to reflect the shorter holding time of the newest contracts. As positions are reduced but not eliminated, the hold time of the remaining position increases since additional time has passed. Paired offsets have a hold time of zero, and do not change the average holding times of previous positions. Consider the illustration in chart 1, now focusing on columns 6 and 7. At the end of minute 9:11, trader Z has a long position of two contracts, one which was purchased at 9:11, one purchased at 9:10. The first contract has been held one minute and the second has just been purchased, thus the mean contract holding time is 0.5 minutes. As Trader Z sells to reduce the (absolute) position (beginning at 9:14), the hold time continues to increase, since position reductions do not affect the time that the remaining position has been held.

Round trips (trips)

The term "round trip" describes the purchase and sale, in either order, of one contract: for a particular trade, the number of round trips is the quantity of contracts in a sale that offset prior purchases, or the number of purchased contracts that offset a prior sale. Thus we use round trips to indicate the number of contracts in a 'completed trade'. Position reductions and offsets generate round trips.

Marking positions to market

When traders reduce their position, they realize revenues. Existing positions typically have either unrealized gains or unrealized losses. We calculate the daily sequence of each

trader's unrealized revenues by marking the trader's positions to market each minute, performing this calculation for all minutes that they trade as well as all minutes that they are not trading. We mark positions to market by comparing the position average cost to the average pit price each minute. The average pit price is the quantity weighted average transaction price for all traders. If the average pit price is higher than a long position's average cost, then the position has an unrealized gain, and a positive mark-to-market. A positive mark-to-market indicates that at that time, the position could probably be closed for a gain; a negative mark-to-market indicates that the position would be closed at a loss.

The example portrayed in Chart 1 illustrates this marking-to-market technique. At 9:15, trader Z has a long position of two contracts with a cost basis of $99.00. The 9:15 average pit price is $93.00, so Z's unrealized loss is $6.00 per contract, and the end-of-minute position mark-to-market for the two contracts is a $12.00 unrealized loss. Position marks are indicative of unrealized revenues at a point in time; rapid price changes can lead to observed unrealized losses becoming realized gains, and unrealized gains can become realized losses. The chart 1 example shows that trader Z enters the minute 9:17 with an unrealized loss on the long position, but rapid increase in the pit price allows Z to liquidate some of the position at a gain.

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Figure 1. Typical prospect theory utility

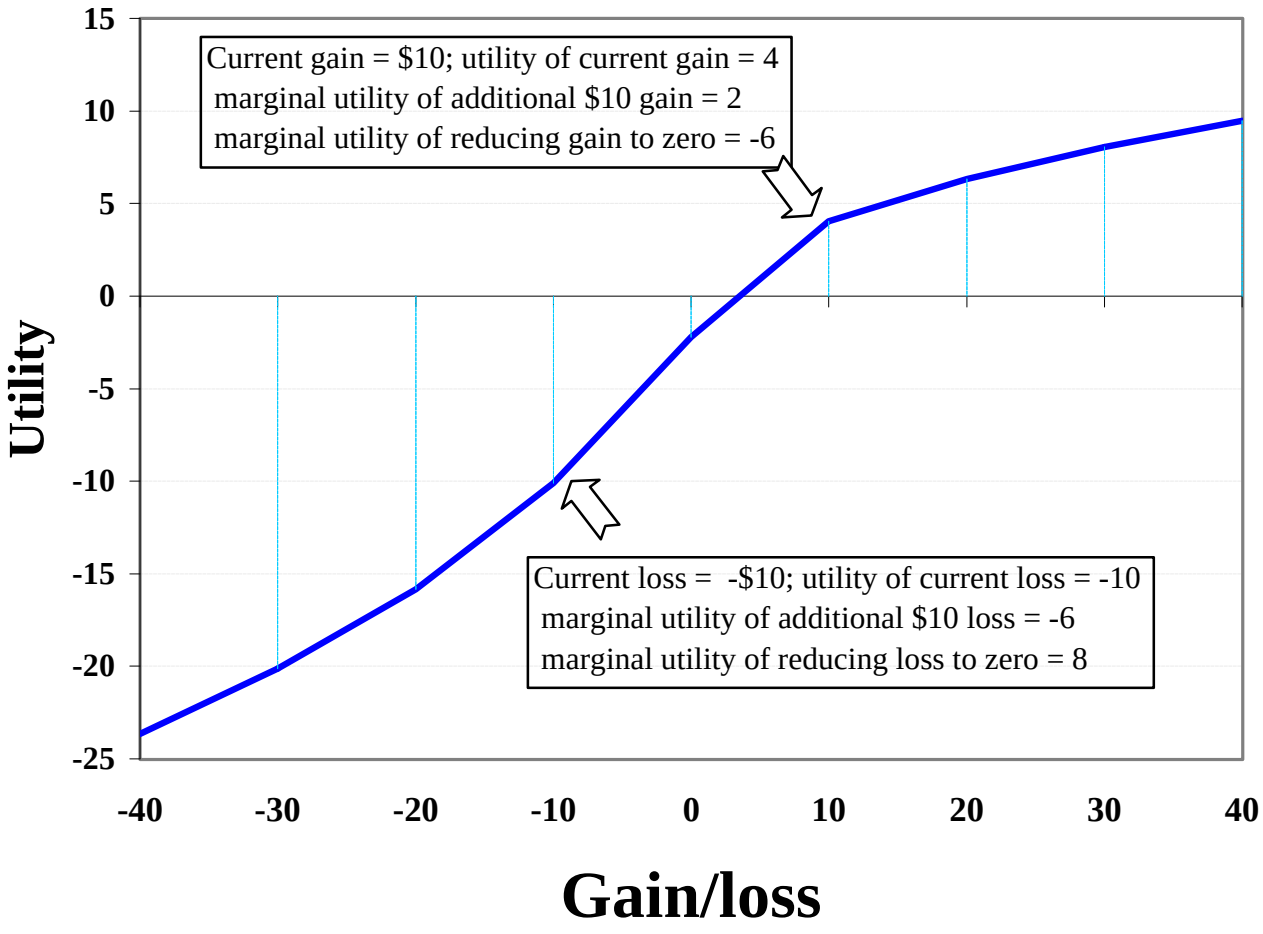
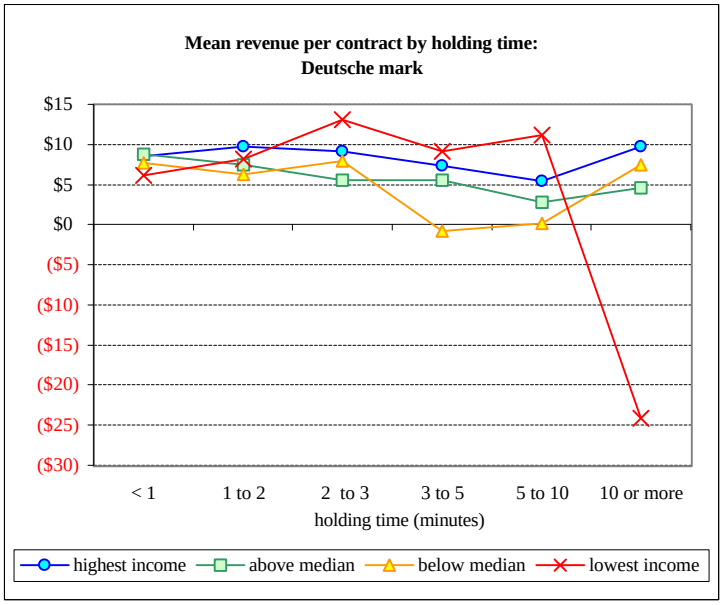
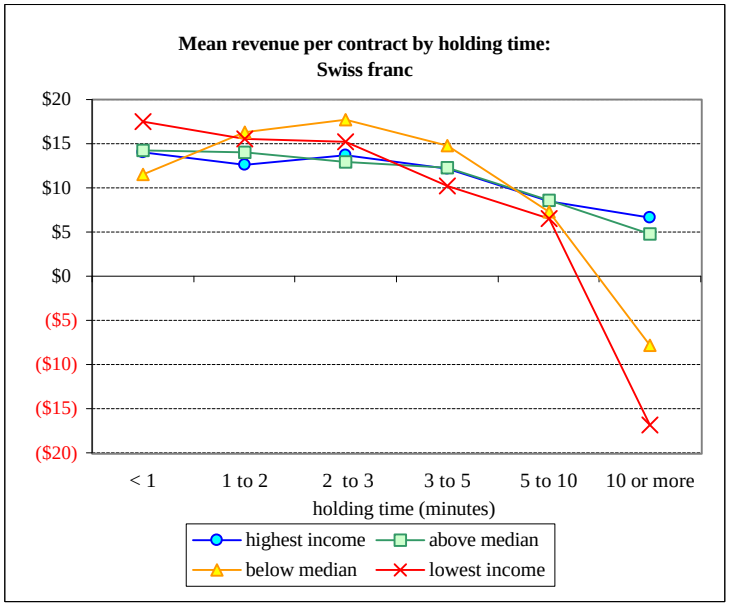
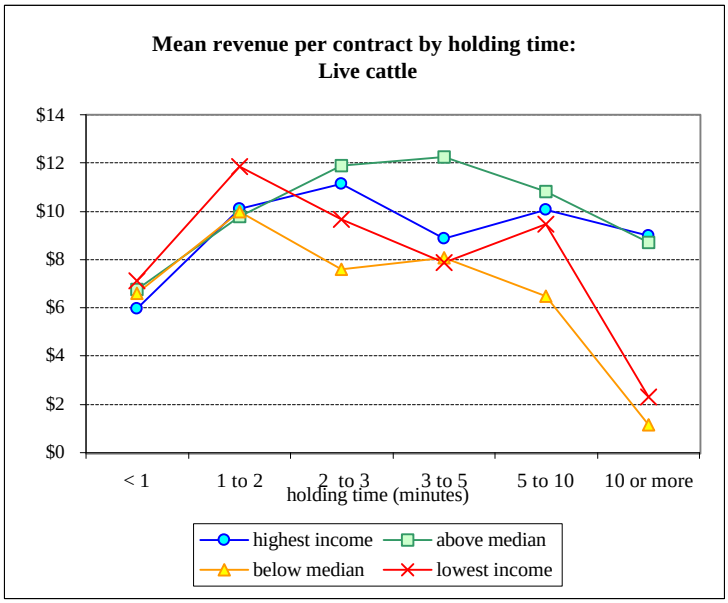


Figure 1

Figure 2. Mean revenue per contract by holding times for trade: Traders ranked into quartiles based on total income







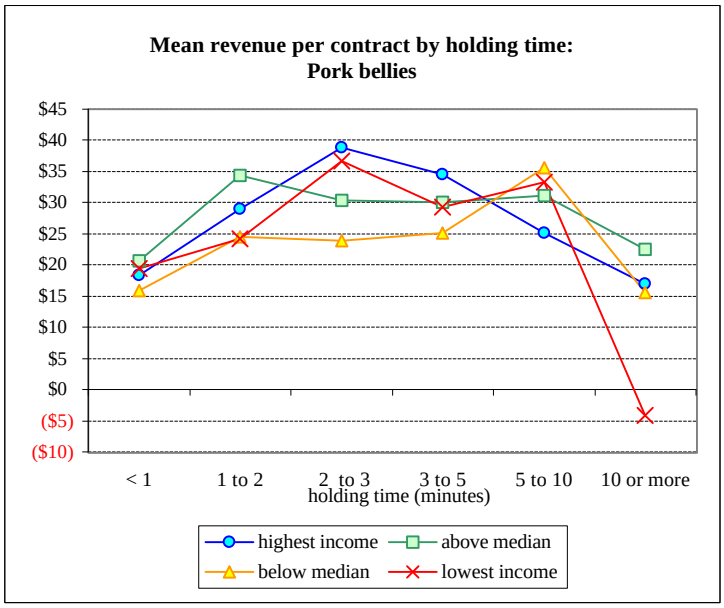
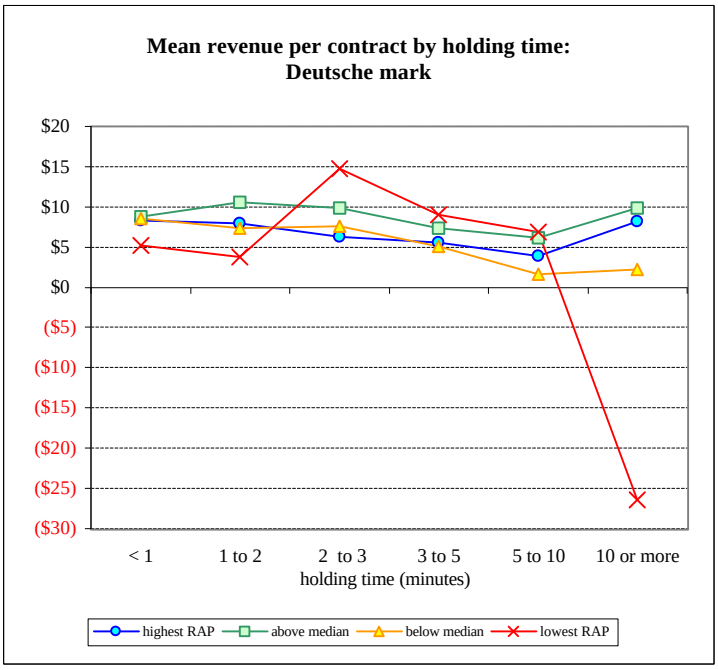
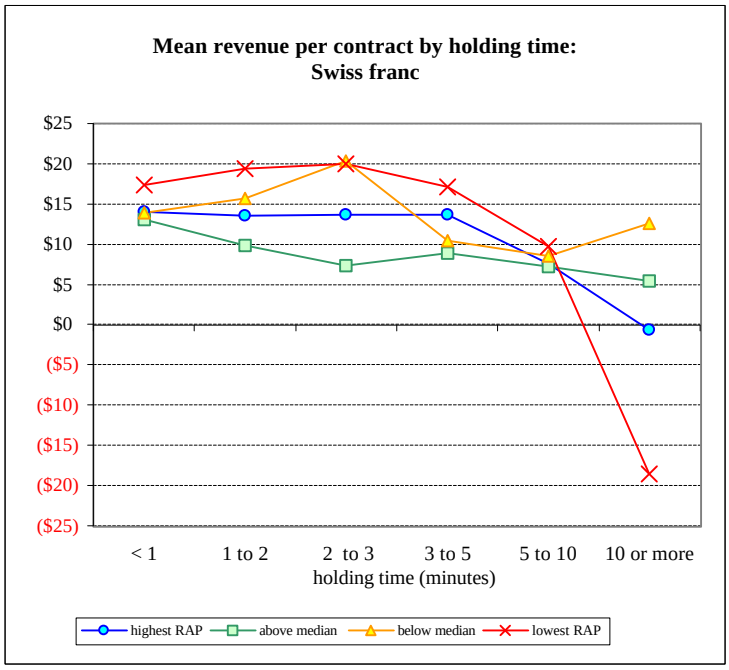
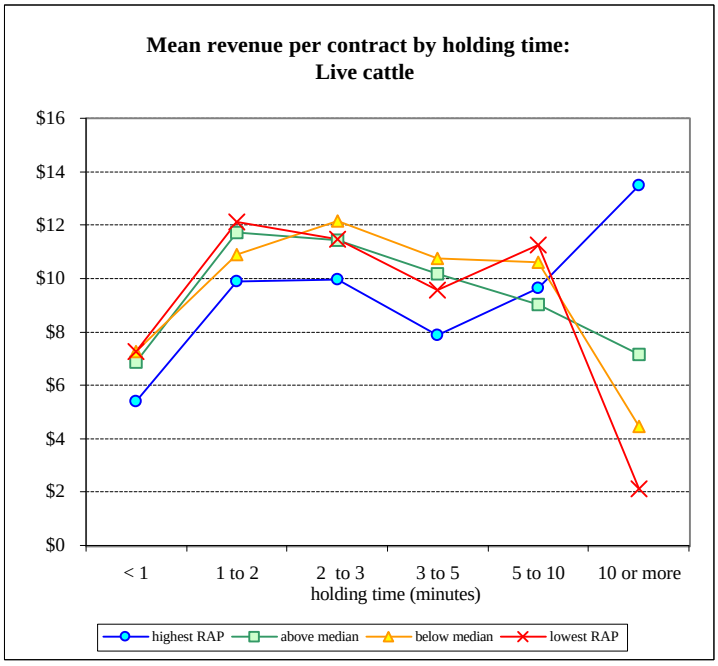


Figure 3. Mean revenue per contract by holding times: Traders ranked into quartiles based on Risk-adjusted performance (RAP)







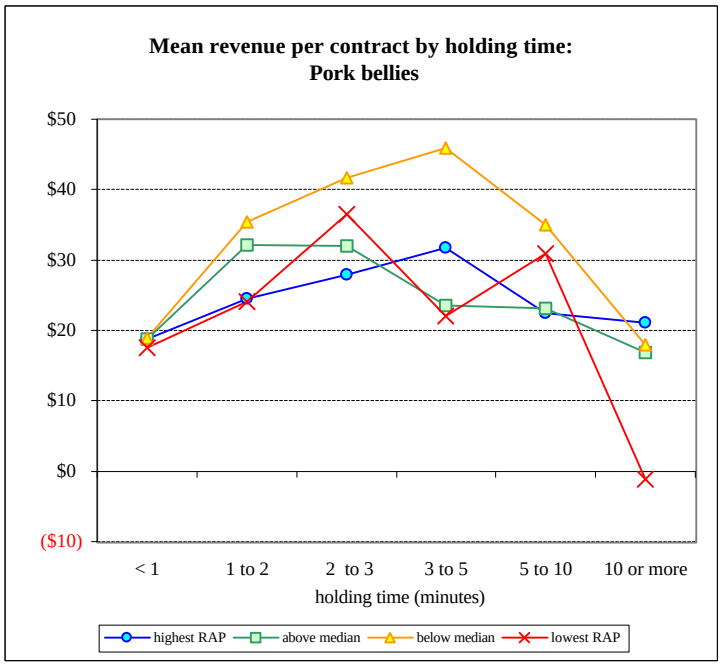


Table 1. Sample descriptive statistics

	Deutsche mark	Swiss franc	Live cattle	Pork bellies
mean daily price range ($)	905.56	1229.46	352.54	512.06
median daily price range ($)	787.5	1118.75	330.00	480.00
number of traders	120	84	94	32
trader mean total contracts traded	11,190	10,352	7,512	3,875
daily mean contracts traded per trader	109	106	77	38
mean revenue per contract - all traders	$6.23	$8.93	$6.02	$17.65
total trader gross trading income	$8,366,558	$7,762,648	$4,251,651	$2,189,178
trader mean daily trading incomes:				
lower quartile trader	-$42	$43	$81	$252
median trader	$444	$536	$225	$662
upper quartile trader:	$1,091	$1,568	$580	$1,035

Note: Data are for floor traders on the Chicago Mercantile Exchange, the first six months of 1995. The sample includes all traders that executed at least five personal account trades on at least ten different trading days. The price range statistics are calculated using the contract month with the highest volume for any given day, while other statistics combine all contract months. Income figures are based on daily trader incomes calculated by marking any end-of-day positions to market with contract settlement prices.

Table 2. Descriptive statistics for paired offset trades compared to trades held at least one minute (other).

	Deutsche mark		Swiss franc		Live cattle		Pork bellies	
	offsets	others	offsets	others	offsets	others	offsets	others
number of round-trip trades	70,196	214,198	52,410	168,547	28,445	105,154	7,975	36,159
mean trade size (contracts)	4.2	4.4	3.4	3.8	4.1	4.3	2.1	2.1
mean revenue per contract	6.26	6.61	10.72	8.72	7.16	4.40	13.58	17.74
quantity-weighted mean revenue per contract	7.58	7.08	12.99	7.27	8.24	5.44	16.11	19.21
median revenue per contract	2.08	7.50	12.00	12.34	9.06	0.00	7.50	20.00
gain/loss interquartile range	13.89	61.81	25.00	90.00	10.00	50.00	20.00	106.53
percentage of round-trip trades with zero revenue	21.1%	5.3%	15.8%	3.0%	38.5%	4.3%	34.9%	3.7%
percentage of nonzero trades with positive revenue	66.1%	57.6%	71.0%	58.0%	73.6%	59.7%	80.9%	60.3%

Note: A paired offset (offset) is a round trip where the puchase and sale occur in the same minute; the quantity of paired offset round trips is the non-zero minimum of the quantity bought and the quantity sold during a minute. If there are only purchases or sales but not both within a minute, then there are no paired offsets. Trades labeled 'other' are round trip transactions where the position is held at least one minute.

Table 3. Detailed trade statistics

Panel A: Trades with non-zero revenues

	number of trades		number of round trips		percent of trades:		mean trade size		mean revenue/contract	
Pit:	gains	losses	gains	losses	gain%	loss%	gains	losses	gains	losses
Deutsche mark	151,720	102,951	682,080	461,330	60%	40%	4.5	4.5	52.59	-59.48
Swiss franc	125,126	80,514	467,046	303,950	61%	39%	3.7	3.8	70.70	-84.75
Live cattle	72,950	45,138	320,646	197,459	62%	38%	4.4	4.4	36.61	-39.72
Pork bellies	25,191	14,802	53,753	31,717	63%	37%	2.1	2.1	75.81	-78.37

Panel B: Revenue categorized by the size of revenue per contract

	absolute revenue per	number of trades		number of round trips		percent of trade totals		mean trade size		mean revenue/contract	
Pit	contract ($)	gains	losses	gains	losses	gains	losses	gains	losses	gains	losses
Deutsche mark											
	more than 100	17,887	14,881	90,170	74,713	11.8%	14.5%	5.0	5.0	222.63	-225.13
	50 to 100	23,376	18,036	102,688	80,063	15.4%	17.5%	4.4	4.4	71.29	-71.48
	25 to 50	32,363	22,181	141,524	95,974	21.3%	21.5%	4.4	4.3	37.70	-37.68
	10 to 25	60,233	33,958	244,480	132,967	39.7%	33.0%	4.1	3.9	16.79	-16.96
	0 to 10	17,861	13,895	103,218	77,613	11.8%	13.5%	5.8	5.6	5.58	-5.17
	0	29,721		101,504				3.4			
Swiss franc											
	more than 100	22,760	19,324	96,611	85,774	18.2%	24.0%	4.2	4.4	231.76	-237.83
	50 to 100	24,259	16,628	90,453	62,151	19.4%	20.7%	3.7	3.7	71.89	-72.67
	25 to 50	28,365	16,304	103,286	57,499	22.7%	20.2%	3.6	3.5	38.09	-38.18
	10 to 25	39,496	20,551	130,666	65,807	31.6%	25.5%	3.3	3.2	17.68	-17.30
	0 to 10	10,246	7,707	46,030	32,719	8.2%	9.6%	4.5	4.2	5.58	-5.37
	0	15,317		39,588				2.6			
Live cattle											
	more than 100	5,014	3,824	26,974	19,836	6.9%	8.5%	5.4	5.2	157.12	-158.58
	50 to 100	10,686	7,578	52,336	35,263	14.6%	16.8%	4.9	4.7	70.55	-70.61
	25 to 50	17,284	10,431	74,534	45,505	23.7%	23.1%	4.3	4.4	36.44	-36.48
	10 to 25	19,307	10,654	84,137	45,242	26.5%	23.6%	4.4	4.2	18.11	-17.79
	0 to 10	20,659	12,651	82,665	51,613	28.3%	28.0%	4.0	4.1	7.25	-6.42
	0	15,511		47,280				3.0			
Pork bellies											
	more than 100	6,000	3,756	14,889	9,122	23.8%	25.4%	2.5	2.4	187.34	-190.28
	50 to 100	6,145	3,655	12,732	7,773	24.4%	24.7%	2.1	2.1	73.56	-73.54
	25 to 50	5,933	3,123	11,865	6,201	23.6%	21.1%	2.0	2.0	38.07	-37.73
	10 to 25	4,756	2,561	9,251	5,129	18.9%	17.3%	1.9	2.0	18.98	-18.44
	0 to 10	2,357	1,707	5,016	3,492	9.4%	11.5%	2.1	2.0	7.42	-6.75
	0	4,141		7,434				1.8			

Note: The table reports statistics for traders in these four contracts of the Chicago Mercantile Exchange for the first six months of 1995. A trade is the completion of a buy-sell combination, in any order. The number of round trips in the trade are the number of contracts offset at the time of the completion of the trade. Revenue per contract is the income generated by the trade divided by the number of round trips for the trade.

Table 4. Holding times

Panel A: Holding times for trades with nonzero revenues: gains versus losses

	median trade holding time		average trade holding time			
Pit:	gain	loss	gain	loss	t-stat	Wilcoxon
Deutsche mark	3.00	4.67	10.98	14.53	30.2	119.7
Swiss franc	3.00	5.42	11.23	16.20	37.1	35.0
Live cattle	8.00	14.38	22.37	30.17	35.7	111.9
Pork bellies	11.00	23.00	27.17	38.77	27.5	37.3

Panel B: Holding times for trades: gains versus lossses by size of revenue per contract

	absolute per contract	median trade holding time		average trade holding time			
Pit	trade revenue ($)	gain	loss	gain	loss	t-stat	Wilcoxon
Deutsche mark							
	more than 100	17.65	21.62	39.68	44.20	**7.6**	**13.0**
	50 to 100	6.00	8.00	14.27	16.83	**9.6**	**20.0**
	25 to 50	3.00	4.55	8.25	10.58	**13.2**	**25.4**
	10 to 25	1.00	2.00	4.03	5.62	**17.7**	**31.4**
	0 to 10	2.10	3.00	6.35	7.87	**7.9**	-38.5
	0	0.00		1.88			
Swiss franc							
	more than 100	14.00	19.00	32.20	36.72	**9.7**	**20.4**
	50 to 100	4.50	7.00	11.08	14.85	**15.4**	**29.09**
	25 to 50	2.00	4.00	6.58	9.92	**18.5**	**34.16**
	10 to 25	1.00	2.00	3.72	5.93	**19.0**	**33.07**
	0 to 10	2.25	3.00	6.92	8.43	**6.0**	-26.33
	0	0.00		1.78			
Live cattle							
	more than 100	56.05	60.23	64.83	69.43	**4.5**	**4.9**
	50 to 100	23.95	33.00	37.70	46.13	**13.8**	**16.4**
	25 to 50	10.68	16.83	22.87	30.67	**18.4**	**24.8**
	10 to 25	5.30	10.33	15.40	22.43	**19.9**	**31.1**
	0 to 10	2.00	5.00	10.23	14.83	**16.7**	**27.0**
	0	0.00		3.12			
Pork bellies							
	more than 100	35.08	52.25	49.35	63.27	**14.0**	**16.3**
	50 to 100	13.67	25.45	27.57	39.07	**14.5**	**19.4**
	25 to 50	6.00	15.67	18.58	30.08	**15.2**	**22.6**
	10 to 25	2.50	10.05	14.37	23.07	**11.7**	**20.2**
	0 to 10	4.33	10.50	17.05	23.67	**6.7**	**9.8**
	0	0.00		4.18			

Note: The holding time for a position increases by one minute at the start of each minute. As a trader adds to a position, the average hold time for each contract in the position is reduced to reflect the shorter holding time of the newest contracts. As positions are reduced but not eliminated, the hold time of the remaining position increases since additional time has passed. Paired offsets have a hold time of zero, and do not change the average holding times of previous positions.

Table 5. Forward and backward-looking measures of position-reducing trade quality

	Forgone Revenues			Percentage of revenue realized		
Trade sign	number of trades	mean	median	number of trades	mean	median
Swiss franc						
Positive	93,301	-4.47	-2.84	77,495	58.33%	27.97%
Negative	66,662	-6.05	0.00	57,574	44.69%	15.60%
		t-test	-0.78		t-test	-8.79
		Wilcoxon	3.81		Wilcoxon	-41.96
Deutsche mark						
Positive	115,007	-3.26	-1.25	96,342	78.35%	27.73%
Negative	83,578	-3.65	0.28	70,748	52.08%	17.60%
		t-test	-0.32		t-test	-2.09
		Wilcoxon	5.25		Wilcoxon	-34.97
Live cattle						
Positive	57,574	1.44	0.00	54,890	47.11%	20.81%
Negative	38,094	-4.74	-0.33	36,564	54.19%	13.67%
		t-test	-9.87		t-test	0.44
		Wilcoxon	-7.24		Wilcoxon	32.44
Pork bellies						
Positive	20,369	-11.56	-5.00	19,636	48.17%	23.25%
Negative	12,889	-0.66	0.00	12,344	43.98%	18.93%
		t-test	5.42		t-test	-2.24
		Wilcoxon	5.86		Wilcoxon	-10.41

Foregone income represents potential regret on the part of the trader, if they buy back a short position and the closing price is higher than their offset price, or if they sell a long position and the closing price is lower. A negative value for foregone indicates the trader got out at a better price than the closing price. Percent realized is a measure of how well the trader could have done if they had gotten out earlier. If they close out at the peak, the percent realized is 100. If they make zero on a trade then the percent realized is 0, unless the trade was never in the money. For negative revenue trades, the opposite is calculated; e.g. was the trade executed at a better price than the worst mark. If a losing trade is closed out at the bottom, the percent realized is 100.

Table 6. Holding times for trades: mean-adjusted revenue per contract

Panel A: Holding times for trades: gains versus losses

Per contract revenues normalized by the mean

Pit:	median holding time net gains	median holding time net losses	mean holding time net gains	mean holding time net losses	t-stat	Wilcoxon
Deutsche mark	3.00	3.00	11.23	11.42	1.8	-0.5
Swiss franc	3.00	4.00	11.58	13.32	14.5	24.7
Live cattle	8.5	7.25	23.20	22.38	-4.3	-20.7
Pork bellies	12.00	12.98	28.42	29.45	2.8	-2.2

Panel B: Holding times for trades: gains versus lossses by size of revenue per contract

Per contract revenues normalized by the mean

Pit	absolute per contract trade revenue ($)	median holding time net gains	median holding time net losses	mean holding time net gains	mean holding time net losses	t-stat	Wilcoxon
Deutsche mark							
	more than 100	18.18	19.73	40.73	41.93	2.1	**6.1**
	50 to 100	6.33	7.00	14.82	15.10	1.1	**7.0**
	25 to 50	3.28	3.50	8.67	8.75	0.5	0.7
	10 to 25	2.00	2.00	5.87	5.88	0.1	-4.1
	0 to 10	1.00	1.00	3.72	3.80	1.2	-10.9
	0	1.00		5.48			
Swiss franc							
	more than 100	14.73	17.40	33.55	34.82	2.8	**11.95**
	50 to 100	4.75	6.00	11.70	13.32	**7.1**	**15.29**
	25 to 50	2.33	3.00	7.05	8.23	**7.4**	12
	10 to 25	1.12	2.00	5.13	6.35	**8.6**	**11.22**
	0 to 10	1.00	1.00	3.83	3.88	0.5	-5.29
	0	1.50		6.40			
Live cattle							
	more than 100	57.00	57.47	65.70	67.12	1.4	1.6
	50 to 100	25.20	29.80	39.35	43.28	**6.5**	**8.5**
	25 to 50	**13.50**	**12.75**	**26.18**	**25.93**	-0.6	**-4.2**
	10 to 25	5.52	7.00	15.37	17.88	**8.5**	**8.1**
	0 to 10	**2.33**	**0.00**	**11.17**	**8.30**	**-13.9**	**-32.3**
	0	1.00		9.72			
Pork bellies							
	more than 100	36.25	46.72	50.75	59.02	**8.6**	**11.1**
	50 to 100	17.62	19.88	31.62	34.40	**3.6**	4.2
	25 to 50	**12.18**	**10.32**	**25.85**	**23.45**	**-3.2**	**-5.1**
	10 to 25	**4.82**	**0.00**	**15.53**	**11.55**	**-7.9**	**-20.7**
	0 to 10	2.00	4.00	13.17	16.68	**4.9**	**6.4**
	0	1.00		7.23			

Note: For each trade, the revenue per contract is adjusted by subtracting the mean pit wide revenue per contract for the six-month sample period. Thus gains and losses are net of the mean, a proxy for the long run cost of trading. The holding time for a position increases by one minute at the start of each minute. As a trader adds to a position, the average hold time for each contract in the position is reduced to reflect the shorter holding time of the newest contracts. As positions are reduced but not eliminated, the hold time of the remaining position increases since additional time has passed. Paired offsets have a hold time of zero, and do not change the average holding times of previous positions.

Table 7. Risk-adjusted performance (RAP) distributions.

	number of traders	mean daily income for the median trader within the quartile	95th percentile potential loss for the median trader within the quartile	RAP for the median trader within the quartile
Deutsche mark	**120**			
lowest quartile RAP		(587.52)	5,052.88	(0.034)
below median RAP		533.96	84,453.92	0.007
above median RAP		1,010.23	15,057.39	0.076
highest quartile RAP		755.39	2,971.34	0.296
Swiss franc	**84**			
lowest quartile RAP		(108.98)	45,399.48	(0.009)
below median RAP		758.55	88,934.72	0.009
above median RAP		603.47	8,890.62	0.051
highest quartile RAP		1,299.41	3,910.94	0.292
Live cattle	**94**			
lowest quartile RAP		(64.95)	2,463.29	(0.027)
below median RAP		252.84	3,050.52	0.079
above median RAP		398.06	1,870.43	0.140
highest quartile RAP		526.78	1,433.19	0.355
Pork bellies	**32**			
lowest quartile RAP		102.25	5,458.40	0.023
below median RAP		752.13	4,735.11	0.143
above median RAP		881.42	3,142.50	0.250
highest quartile RAP		672.18	1,582.88	0.537

Note: RAP is trader mean daily income divided by the trader's 95th percentile potential loss. The 95th percentile potential loss is found by finding the largest negative marking to market on each day the trader traded in the sample. Then the 95th percentile of the distribution of these daily statistics is the 95th percentile potential loss.

Table 8. Income and holding times across trader success rankings

	Quartiles defined by RAP ranking					Quartiles defined by Income ranking			
holding time (minutes)	highest RAP traders	above median traders	below median traders	lowest RAP traders	holding time (minutes)	highest income traders	above median traders	below median traders	lowest income traders
	mean revenue per contract ($)					mean revenue per contract ($)			
Deutsche mark									
< 1	8.28	8.83	8.57	5.21	< 1	8.57	8.74	7.67	6.13
1 to 2	7.96	10.54	7.30	3.77	1 to 2	9.75	7.43	6.24	8.20
2 to 3	6.31	9.90	7.56	14.79	2 to 3	9.12	5.57	7.91	13.03
3 to 5	5.57	7.41	5.09	8.98	3 to 5	7.29	5.50	(0.82)	9.12
5 to 10	3.88	6.11	1.65	6.90	5 to 10	5.37	2.80	0.17	11.14
10 or more	8.15	9.83	2.17	(26.43)	10 or more	9.78	4.58	7.51	(24.11)
Swiss franc									
< 1	13.98	13.08	13.89	17.36	< 1	13.98	14.23	11.53	17.54
1 to 2	13.57	9.89	15.67	19.45	1 to 2	12.59	13.97	16.28	15.57
2 to 3	13.72	7.40	20.31	20.00	2 to 3	13.67	12.90	17.67	15.27
3 to 5	13.61	8.92	10.41	17.09	3 to 5	12.16	12.23	14.83	10.21
5 to 10	7.53	7.19	8.54	9.78	5 to 10	8.50	8.56	7.24	6.51
10 or more	(0.69)	5.48	12.55	(18.60)	10 or more	6.66	4.80	(7.78)	(16.87)
Live cattle									
< 1	5.41	6.87	7.27	7.27	< 1	5.97	6.78	6.61	7.11
1 to 2	9.87	11.71	10.90	12.10	1 to 2	10.12	9.80	9.98	11.86
2 to 3	9.96	11.44	12.14	11.47	2 to 3	11.14	11.89	7.60	9.68
3 to 5	7.87	10.17	10.75	9.55	3 to 5	8.86	12.27	8.08	7.88
5 to 10	9.64	9.02	10.59	11.25	5 to 10	10.08	10.82	6.47	9.48
10 or more	13.48	7.15	4.47	2.11	10 or more	9.01	8.71	1.14	2.30
Pork bellies									
< 1	18.71	18.78	18.94	17.60	< 1	18.41	20.70	15.92	19.47
1 to 2	24.50	32.12	35.44	24.06	1 to 2	28.94	34.36	24.48	24.15
2 to 3	27.85	31.99	41.63	36.56	2 to 3	38.80	30.35	23.85	36.70
3 to 5	31.76	23.48	45.88	22.03	3 to 5	34.53	30.06	25.14	29.33
5 to 10	22.40	23.20	34.96	30.93	5 to 10	25.11	31.18	35.54	33.22
10 or more	21.08	16.81	17.95	(1.09)	10 or more	16.90	22.48	15.63	(4.22)

Note: The table reports mean gains per contract for trades, sorted by holding times, for traders grouped by success ranking. The first five columns report mean gains for trader ranks based on total income for the six-month sample period; the second five columns report mean gains for trader ranks based on risk-adjusted income (mean daily income divided by ex-post 95th percentile Value-at-Risk).

Table 9. Holding times for trades across trader success rankings

		Quartiles defined by RAP ranking							Quartiles defined by Income ranking							
		mean time			Difference from first Quartile:					mean time			Difference from first Quartile:			
	Trader RAP	per dollar (secs)			gains		losses		Trader income	per dollar (secs)			gains		losses	
Pit	Quartile	gains	losses	t	difference	t	difference	t	Pit	Quartile	gains	losses	t	difference	t	difference	t
Deutsche mark									**Deutsche mark**							
	First (highest)	9.54	12.07	*16.4*						First (highest)	13.55	16.53	*13.2*				
	Second	17.33	21.03	*10.5*	7.80	*33.5*	8.96	*29.2*		Second	12.41	16.34	*15.4*	-1.14	*-5.8*	-0.19	*-0.7*
	Third	16.38	19.71	*8.7*	6.84	*23.0*	7.64	*27.6*		Third	17.33	21.04	*6.3*	3.78	*10.2*	4.51	*8.9*
	Fourth (lowest)	38.73	42.00	*1.3*	29.19	*16.4*	29.93	*17.4*		Fourth (lowest)	30.88	35.20	*2.5*	17.33	*15.5*	18.67	*13.5*
Swiss franc									**Swiss franc**							
	First (highest)	7.75	10.18	*16.0*						First (highest)	10.64	15.18	*16.7*				
	Second	14.24	18.79	*12.4*	4.70	*28.5*	6.72	*26.3*		Second	9.71	12.30	*11.2*	-0.93	*-4.8*	-2.88	*-9.6*
	Third	11.78	15.74	*10.9*	2.25	*19.0*	3.67	*16.7*		Third	12.77	16.78	*12.0*	2.13	*8.6*	1.60	*4.2*
	Fourth (lowest)	16.05	21.62	*9.4*	6.52	*22.9*	9.55	*23.2*		Fourth (lowest)	16.40	22.42	*9.2*	5.76	*14.2*	7.24	*12.5*
Live cattle									**Live cattle**							
	First (highest)	24.03	33.55	*14.6*						First (highest)	43.44	56.76	*17.2*				
	Second	50.07	65.35	*14.3*	26.04	*37.8*	31.80	*30.4*		Second	37.85	52.63	*12.9*	-5.59	*-7.4*	-4.13	*-3.6*
	Third	42.16	52.80	*10.9*	18.13	*27.3*	19.25	*19.8*		Third	43.00	56.16	*10.8*	-0.44	*-0.5*	-0.60	*-0.5*
	Fourth (lowest)	71.45	84.61	*6.6*	47.42	*36.0*	51.06	*30.9*		Fourth (lowest)	49.51	60.32	*5.3*	6.07	*2.0*	3.56	*4.7*
Pork bellies									**Pork bellies**							
	First (highest)	18.08	28.04	*11.0*						First (highest)	35.19	49.53	*12.3*				
	Second	29.51	43.95	*12.8*	11.43	*15.0*	15.91	*12.9*		Second	24.63	37.53	*10.6*	-10.56	*-11.6*	-12.00	*-8.4*
	Third	37.24	54.46	*10.0*	19.16	*18.4*	26.42	*16.0*		Third	18.95	30.63	*9.5*	-16.24	*-17.7*	-18.90	*-13.3*
	Fourth (lowest)	41.89	52.08	*4.4*	23.81	*16.0*	24.04	*12.1*		Fourth (lowest)	37.99	50.20	*5.4*	2.80	*1.9*	0.67	*0.3*

Trade times are defined as seconds per absolute dollar gain per contract for the trade: we divide each trade's holding time (in seconds) by the trade's absolute gain. Trades with absolute gains less than $10 are not included.