function for the one-to-one intra-commodity spread, a calendar spread involving equal position sizes on the two legs of the spread. Without loss of generality assume that this trade is initiated at $t=0$ and closed out at $t=1$ and that the trader goes ***short-the-nearby (N)*** contract and ***long-the-deferred (T)*** contract. Taking $F(t,N)$ and $F(t,T)$ to be the futures prices observed at time t, the associated trading profile is given in the text-box. Spread profitability depends on the change in the *futures* basis (not to be confused with the future basis of Sec. 2.4). More precisely, the one-to-one intra-commodity spread that is short-the-nearby and long-the-deferred will be profitable if the difference between the deferred and nearby prices widens. The opposite would be true for the alternative spread, long-the-nearby and short-the-deferred.[10]

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*Figure 3.3* **Profit Function for an One-to-One Intra-commodity Futures Spread Position**

| ***DATE*** | ***Nearby Position*** | ***Deferred Position*** |
|---|---|---|
| $t=0$ | Short $Q$ units at $F(0,N)$ | Long $Q$ units at $F(0,T)$ |
| $t=1$ | Close out position with Long $Q$ units at $F(1,N)$ | Close out position with Short $Q$ units at $F(1,T)$ |

Taking $Q$ to be always positive, the profit function $(\pi)$ can be specified by observing that the profit for each leg of the spread is equal to the contract selling (short) price minus the purchase (long) price:

$$\begin{aligned}\pi/Q &= \{F(0,N) - F(1,N)\} + \{F(1,T) - F(0,T)\} \\ &= \{F(1,T) - F(1,N)\} - \{F(0,T) - F(0,N)\}\end{aligned} \tag{3.1}$$

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Analysis of (3.1) proceeds by introducing the general cash-and-carry arbitrage condition for futures contracts, e.g., Dubofsky (1992), Poitras (1991), Siegel and Siegel (1990), Allen and Thurston (1988), Hegde and Branch (1985), Kawaller and Koch (1984):

$$F(t,T) \equiv F(t,N)\ \{1 + ic(t,N,T)\} \tag{3.2}$$

In (3.2), the ***implied carry***, $ic(t,N,T)$, is defined as the ***net*** cost of carrying the commodity from $t=N$ to $t=T$ observed at time t implied in the futures prices $F(t,N)$ and $F(t,T)$. The cash-and-carry arbitrage interpretation of $ic(t,N,T)$ can be motivated by taking $F(t,N)$ to be $S(t)$, the price of the spot commodity, and examining the mechanics of the arbitrage connecting spot and futures prices. While somewhat more abstract, the futures-futures cash-and-carry arbitrage has the same logical mechanics as the spot-futures arbitrage. The functional determinants of the $ic(t,N,T)$ term will depend on the cash-and-carry arbitrage for a specific commodity. For example, gold will have an *ic* that depends primarily on interest charges of carrying gold through time while Treasury bonds will have *ic* dependent on the both interest charges of carrying Tbonds as well as a carry return arising from interest earned on the underlying security.

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*Exhibit 3.1* **A Taxomony of Spread Trades**

Spread trades are sometimes referred to as ***straddle*** trades but this terminology is also used to describe a specific option trading strategy and can create semantic confusion. Schwager (1984, Part 5) provides a useful and practical introduction to spread trading.

***Calendar Spread,*** also referred to as an inter-delivery spread, is a trade composed of a short and a long position in the same commodity involving different delivery dates. The number of contracts used for the short and long positions can be equal, a one-to-one spread, or unequal.

***Tailed Spread*** is a calendar spread where an unequal number of contracts is used for the short and long positions. The number of short and long contracts is chosen to achieve a specific type of trade payoff. It is possible to set the tail to have a spread trade payoff that depends on changes in the implied repo rate, an important feature for stereo and turtle trades.

***Tandem Spread*** is a trade combining calendar spreads in two different commodities, e.g., Kilcollin (1982), Poitras (1987). The component spreads can be either one-to-one or tailed. The trade involves a hedge ratio to be calculated, usually to equalize the starting values of the positions in the two commodities. There are a wide range of possible rationales for doing tandem trades.

A ***Stereo*** trade is a specific type of tandem trade designed to speculate on changes in the implied repo rates for different commodities, e.g., Yano (1989). Hence, a stereo is a specific type of tailed tandem where the tails are determined to have the calendar spread payoffs depend on changes in implied repo rates. The trade is usually triggered when the implied repo rates for different commodities are observed to deviate from typical historical relationships.

A ***Turtle*** trade combines a tailed spread in one commodity with a short or long position in an interest rate future. The tail is determined to have the calendar spread payoff depend on changes in implied repo rates. The rationale for a turtle varies depending on the specific commodity. For Tbonds and Tnotes, the turtle is triggered when the implied repo rate is observed to deviate significantly from the cash repo rate, e.g., Jones (1981), Rentzler (1986).

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Making appropriate substitutions of the arbitrage condition (3.2) into the profit function (3.1) and dropping the $N,T$ notation for $ic$ gives the result:

$$\pi/Q = F(1,N)\ ic(1) - F(0,N)\ ic(0)$$

Observing that $\Delta\ ic = ic(1) - ic(0)$ and $\Delta\ F = F(1,N) - F(0,N)$, basic algebra provides the fundamental result for the one-to-one spread profit function:

$$\pi/Q = ic(0)\ \Delta\ F(N) + F(1,N)\ \Delta\ ic \tag{3.3}$$

This demonstrates that $\pi$ for the one-to-one spread depends on the change in two variables, $\Delta F$ and $\Delta ic$. Except in special cases, the need to predict the behavior of two random variables in order to ascertain profitability can be problematic. Significantly, the technique of ***tailing*** the spread, e.g., Jones (1981), involves altering the relative sizes of the nearby and deferred positions in such a way that the $\Delta\ F$ term disappears. In this fashion, tailed intra-commodity spreads can be used to speculate on changes in the implied ***net*** cost of carry without needing to adjust for changes in price levels. In addition, tailed spreads can be combined with other positions to create trading strategies such as the turtle.

As an example of how price level changes can affect spread profitability, consider the case of gold for the period Nov. 9, 1979 to Feb. 15, 1980. Over this period, interest rates were relatively unchanged, the benchmark three month Tbill rising only 11 basis points from 12.25 to 12.36. During this period the Handy and Harmon spot price rose from \$389.75 to \$667. Examining the June 80-June 81 COMEX gold futures spread for this period, the June 80 contract rose from \$420. 80 to \$703.50 while the June 81 contract rose from \$471.20 to \$843. This resulted in a change in the futures spread from \$50.40 to \$139.50. Remembering that the futures spread $ic$ for gold is primarily determined by interest rates, the impact of interest rate changes on the gold spread was reflected over the period Mar. 3, 1980 to Aug. 25, 1980. Over this period the Handy and Harmon spot price was relatively unchanged, going from \$633.75 to \$634.75. During this period, interest rates, as reflected in the three month Tbill rate, fell from 13.38 to 9.41. Examining the Oct 80-Oct 81 COMEX gold futures spread over this period, the Oct 80 contract fell from \$709.50 to \$629.70 while Oct 81 fell from \$849.50 to \$719.40. This reflects a decline in the gold futures spread from \$140 to \$89.70.