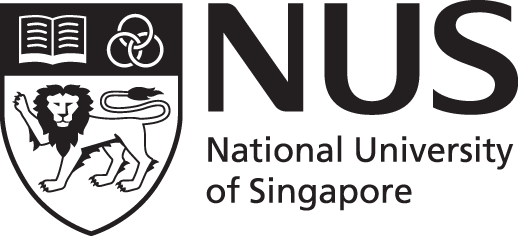
Turtle Trading Rules (TTR)

Examine and validate the Turtle Trading Rules (TTR) - a strategy to follow in order to make profits in financial markets.

FE5110 - Financial Engineering Project



Contents

[Executive Summary 2](#_Toc414650913)

[I. TTR Overview 4](#_Toc414650914)

[II. Implementation and Adjustment 6](#_Toc414650915)

[III. Evaluation 8](#_Toc414650916)

[IV. Improvement 10](#_Toc414650917)

[V. Result and Comparison 11](#_Toc414650918)

[VI. Conclusion 18](#_Toc414650919)

[VII. Original Contribution 19](#_Toc414650920)

Turtle Trading Rules (TTR)

# Executive Summary

This is a paper in module FE5101 – Financial Engineering Project. The purpose of this paper is to examine and validate the Turtle Trading Rules (TTR) which provides traders with a strategy (or a set of rules) to follow in order to make profits in financial markets.

The paper consists of the following sections:

1. **TTR Overview:**

A brief overview of the entire trading rules and specifications

1. **Implementation and Adjustment:** 
   1. Data source and data selection to implement TTR
   2. Assumptions and adjustments during the implementation of TTR.
2. **Evaluation:**

A discussion about strengths and weaknesses of TTR

1. **Improvement:**

A suggestion on improving TTR performance

1. **Result and Comparison:**

Results from original TTR and improved TTR and comparison between the 2 models

1. **Original Contribution**

# TTR Overview

The complete details of the Turtle Trading Rules can be downloaded free at

* <http://bigpicture.typepad.com/comments/files/turtlerules.pdf>
* <http://www.dailystocks.com/turtlerules.pdf>

The TTR is a complete trading system which covers all aspects of a trading decision and this section describes briefly key components of TTR

1. Markets

TTR focuses on trending markets and the targeted instruments are future contracts with the underlying of good liquidity and trading volume.

1. Position Sizing

This is the heart of TTR on which all of the following components depend. The position sizing algorithm normalizes the dollar volatility of a position by adjusting the position size based on the dollar volatility of the market.

Position sizing calculates the quantity N which represents the underlying volatility of a market. N is simply the 20-day exponential moving average which is now known as the ATR.

TTR defines a position as a collection of pieces which is called Units. Units are sized so that one N is equal to 1% of the account equity.

1. Entries

Generally speaking, traders enter a trade when a breakout happens. A breakout is defined as the price exceeding the high or low of a particular number of days. In TTR, there are 2 entry systems:

1. Short-term system based on 20-day breakout
2. Long-term system based on 55-day breakout
3. Stops

Turtle traders stop loss when the position risk is at 2% which would be equal to two N of price negative movement.

1. Exits

Turtle traders also use breakout-based exits to make profits from profitable positions. Similar to Entries, Exits are also based on 2 systems

1. 10 day low/high for long/short positions
2. 20 day low/high for long/short positions

# Implementation and Adjustment

The entire TTR model is written in R programming language from scratch by the author of the paper. One of the main supporting libraries is the XTS (eXtensible Time Series) package which stores time-series data from the beginning to the end for the purpose of back testing.

1. Data Source and Data Selection

All future data including high, low, settlement, and etc. are sourced from Quandl (<https://www.quandl.com/c/futures>).

Quandl provides one R package which allows to download a future contract data as an XTS object.

Following the future contract list detailed in the original document, future contracts of

* + heating oil
  + cocoa
  + copper
  + silver

are selected in this paper for back testing and experiments (details in the following sections).

1. Adjustment

During implementation, there are a few adjustments and assumptions which lead to better analysis yet make minimal deviation from the original models.

* We assume that on a day, there is only one breakout which is either high breakout or low breakout. If both types of breakout happen on a day, high breakout is in preference.
* Breakouts are checked at end of the day with settlement price, therefore traders can enter a trade at the next day open price should breakout happen.
* All of entry, exit and stop-loss trades are made at breakout even though original rules define particular levels of price at which exit and stop-loss trades can happen.

For the purpose of better back testing, we allow traders to re-enter a position of the same future contract even after the position has already realized its profit and loss. This kind of re-entering is possible until the last day of future contract.

All of profit/loss and capital of the previous position will be used for the re-entering. Profit and loss are accumulated during the entire life of future contract.

In the Result and Comparison section, the accumulated profit and loss is used to examine TTR performance.

# Evaluation

Like all other trading systems, TTR model has its own strengths and weaknesses which are covered as follow

1. Strengths

The first noticeable strength is that TTR takes volatility into account. At the time of 1980s, volatility was not really well-known to most traders.

The dollar volatility of markets used in TTR was quite advanced at that time because it normalized the volatility of a position, which made it easy for traders to compare and adjust position sizes across different markets. During actual trading activities, specific details of particular contracts do never confuse traders’ actions.

The second remarkable strength of TTR is its completeness. TTR is one of the first trading systems which cover markets, position sizing, entries, stops and exits.

The immediate benefit of a complete trading system is that it rules out trading emotion. In markets, being emotional when price goes against the position is the number one cause to make bad trading decisions. Thanks to the model’s completeness, traders could make a trade emotionlessly, which eventually generate profits most of the time.

Last but not least, with advanced technology today, such a complete trading system like TTR can be easily implemented in algorithm and automated trading machines.

1. Weaknesses

Perhaps, the biggest weakness of TTR is that it relies on trending markets and trending contracts. In the original specification document, trending feature is the most important aspect for which traders look to pick up markets and contracts to trade.

This is arguably the reason which TTR is no longer in use in modern markets which are less and less trending in a long enough period for TTR to make profits. The actual coding implementation of this paper has a clear result of TTR’s failure in today market.

This paper addresses this issue to see if the modified TTR would perform better in today market. It is discussed in the following “Improvement” section.

# Improvement

From technical view point, TTR depends on a few parameters which are:

1. The number of days on which ATR is calculated
2. The number of days for Entry breakout
3. The number of days for Exit breakout

Since the weakness of TTR pinpointed in the previous section is the trending feature which requires long enough periods, one way to reduce the trending dependence is to shorten the 3 parameters.

The purpose of shortening the number of days in 3 parameters is to enable TTR to better catch shorter trends of modern markets. By doing so, TTR should not miss short trends, thereby entering and exiting a position more frequently to make profits.

Adjustments to the 3 parameters, proposed in this paper, are to halve all 3 parameters. The next sections will show and compare the performance of TTR before and after tweaking its parameters.

# Result and Comparison

In this section, we are going to pick a few future contracts, of which underlying is listed in the original documents, to examine the TTR performance under 2 cases: original parameters and adjusted parameters.

4 selected future contracts are

* CME/SIH2000 (silver)
* CME/HGG2002 (copper)
* ICE/CCH2000 (cocoa)
* CME/HOK2002 (heating oil)

For each future, 2 charts are presented: one of original parameters and the other of adjusted parameters. All charts show contract price of red line mapped to the left y-axis and profit/loss of blue bar mapped to the right y-axis.

1. Silver – CME/SIH2000

Figure 1

Figure 2

The entire price line did not show any trending feature, which resulted in many losses represented by blue bars of negative values. It is predictable because TTR depends much on trends.

However, there was a very short trend highlighted in green. Along this trend, TTR with original parameters exited positions 2 times and realized profit of about 60% even though they were still losses but the second position cut the loss by 60%.

In figure 2, TTR with adjusted parameters exited positions 4 times and realized profit of about 80% in the last position, compared with the first one.

In this case, in the short trending period, TTR of adjusted parameters performed better than original TTR. We will study more in the next 3 contracts to see if that better performance happens again.

1. Copper – CME/HGG2002

Figure 3

Figure 4

Similarly in this copper future contract, price did not show a great trending feature except for 1 short steep slope highlighted in green.

In figure 3, TTR actually did make profit 2 times; however profit/loss in second time was not much different from that in the first. It means, TTR did not make any profit because profit/loss was accumulated.

In contrast, TTR of adjusted parameters turned a loss at the beginning of the trend into a huge profit at the end of the trend.

In this case, adjusted parameters show absolutely enormous improvement.

1. Cocoa – ICE/CCH2000

Figure 5

Figure 6

This cocoa future contract is another case in which TTR of adjusted parameters outperformed the original one.

The cocoa future price showed a great trend along the contract’s life. However with jaggy trend toward the end of contract, original TTR did not perform well, realizing a big loss at the end.

On the other hand, TTR of adjusted parameters made huge profits constantly; in fact, they did turn losses in the first half to profits in the second half.

Adjusted parameters, one more time, demonstrate a great performance.

1. Heating oil – CME/HOK2002

Figure 7

Figure 8

Unfortunately, adjusted parameters did not really work on all future contracts and this heating oil contract is an example.

In figure 7, although original TTR made losses over the entire life of the future, it did make a small profit at the beginning highlighted in green. In fact, there was a trending period near the end of future life but TTR failed to catch that (no profit/loss was realized during the trend).

In figure 8, adjusted TTR perform even worst, realizing greater losses. Adjusted TTR did not catch the small profit at the beginning like the original TTR. Similarly, during the trend near the end of future life, adjusted TTR also failed to catch it.

# Conclusion

Turtle Trading Rules is a great complete trading system and it generated huge profits during 1980s when prices have trending features. However, it loses its capability in the modern market because prices now have various features other than trending which appears less and less, for example mean reverting, seasonal, and etc.

This paper aims to improve TTR by adjusting its parameters to be more reasonable to price movement. Following are a few findings:

1. Adjusting does not have improvements on all contracts.

As shown in the previous section, there are contracts, for example copper and cocoa, that adjusted TTR performs so well and some other, for example heating oil, that it has poor performance.

1. Contracts need to be thoroughly selected when applying adjusted TTR.

The first finding leads to the second one. Among all contracts listed in the original document of TTR, we can still choose some of them in a careful manner to trade and make profits.

1. Trending assumption is not completely relaxed.

Although TTR parameters have been adjusted, trending assumption (dependency) is the biggest challenge to overcome.

There are a few promising adjustments which can be studied further, for example:

* The criteria to indicate breakout for entries and exits.
* Replacement of ATR: other rules in calculating dollar volatility N could be possible.
* A much more responsive stop-loss indicator.

# Original Contribution

1. The entire R program to implement the TTR
2. The parameter adjustments to improve TTR performance