



## Improving Accuracy of High-Frequency Trading Forecasts

Irene Aldridge  
July 12, 2009

*Presentation to:*



## Presentation Outline

### Outline

---

1. What is high-frequency trading?
2. Trading Strategy Accuracy (TSA) method
3. Applying TSA to development of new high-frequency strategies

### References

---

- Aldridge, I., "Measuring Accuracy of Trading Strategies." *Journal of Trading* 4, Summer 2009, 17-25.
- Aldridge, I., [High-Frequency Trading: A Practical Guide to Algorithmic Strategies and Trading Systems](#). (Wiley Trading, ISBN: 978-0470563762), available for pre-order on Amazon.com

## 1. Foundation of high-frequency trading – Definitions

### High-frequency defined

---

- High-frequency trading is an umbrella term
- Industry consensus: high-frequency trading means
  - Systematic,
  - Quant-based models
  - With holding periods from a fraction of a second to 1 day (no positions held overnight)

### Core strategies

---

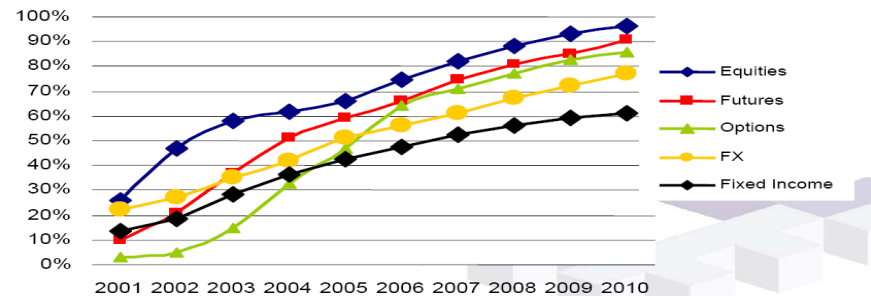
- Automated liquidity provision:
  - Quantitative algorithms for optimal pricing and execution of market-making position
  - Position holding time: < 1 minute
- Market microstructure trading:
  - Identifying trading party order flow through reverse engineering of observed quotes
  - Position holding time: < 10 minutes
- Event trading:
  - Short-term trading on macro events
  - Position holding time: < 1 hour
- Deviations Arbitrage
  - Arbitraging deviations from equilibrium: triangle trades, basis trades, etc.
  - Position holding time: < 1 day

# 1. What is high-frequency trading?

## Evolution of trading

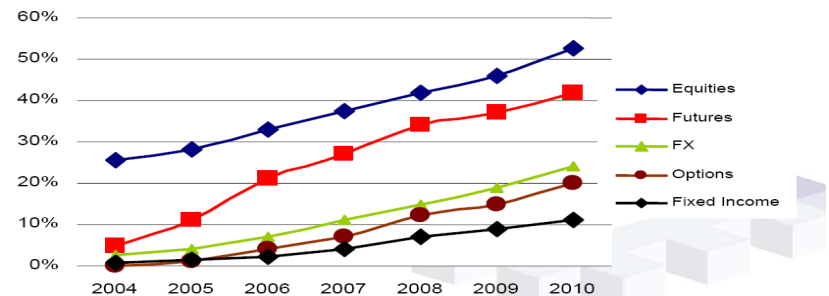
- Open outcry method of trading
- Virtual trading floor electronically
- Disintermediation
- Stock market booms and crashes
- Shorter settlement cycles
- Wall Street decimalization
- Standardization using FIX protocol
- Program trading
- Digitalization of trading – Algorithmic trading

## Adoption of electronic trading



Source: Aite Group Estimates

## Algorithmic trading adoption by asset class



Source: Aite Group estimates

High-frequency trading is rapidly becoming the trading standard

## 2. Trading Strategy Accuracy (TSA) method – Overview

### Current strategy performance metrics

- Available performance measures do not account for available market opportunities
- Return-based measures:
  - Raw returns, simple volatility, maximum drawdown
  - Can be used for comparative strategy evaluation
- Risk-adjusted metrics
  - Sharpe Ratio, Jensen’s Alpha, Sortino ratio, Calmar ratio, VaR, ...
  - Immensely popular, easy-to-use, great for comparative strategy evaluation
- Forecast/realized comparative measures:
  - Mean-squared error (MSE), mean absolute deviation (MAD), mean absolute percentage error (MAPE)
  - Produces the “hit” ratio: what percentage of time was the forecast correct

### Why TSA?

- Available performance measures do not account for available market opportunities
- TSA measures strategy performance relative to the opportunities available on the market

### TSA: Main questions

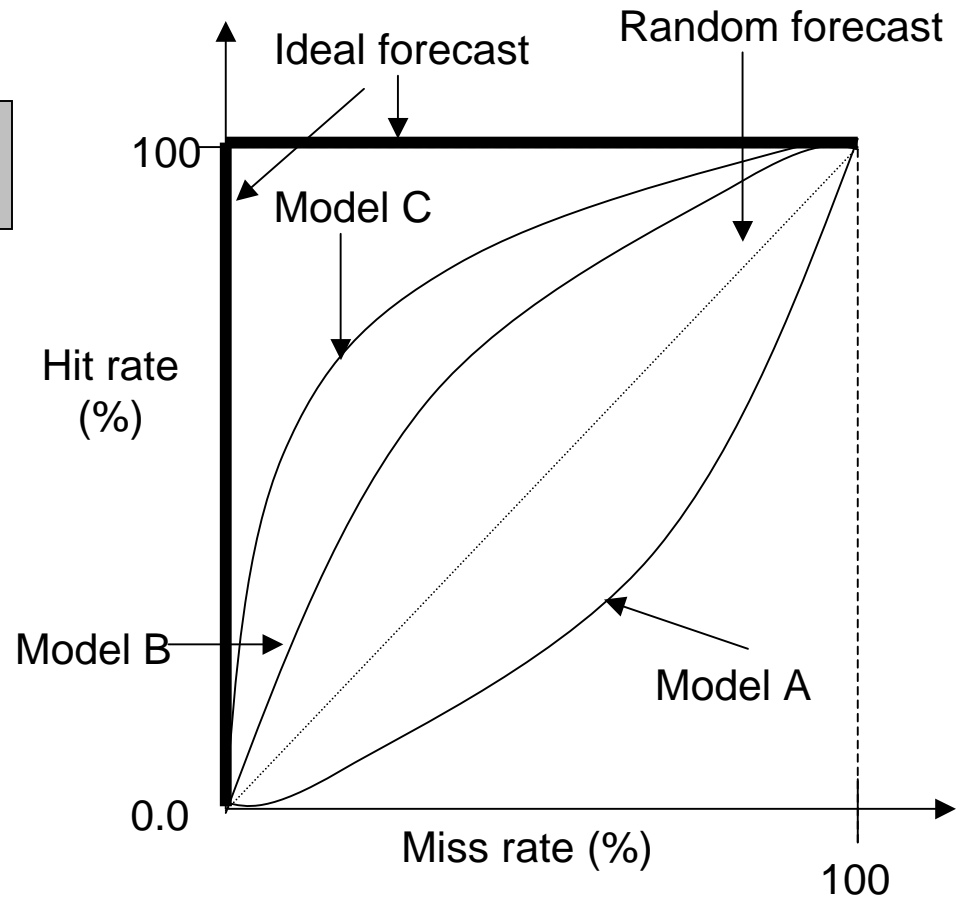
- How well does the trading strategy anticipate market moves?
- How much money does the strategy leave on the table?

## 2. Trading Strategy Accuracy (TSA) method – Output

### TSA

*TSA = area under the curve*

- Compares performance of trading strategies to:
  - Ideal forecast
  - Random forecast
  - Other trading strategies
- Can be used in
  - Back test
  - Production (live capital)
- Easy graphical interpretation
- The higher the TSA, the better the strategy



## 2. Trading Strategy Accuracy (TSA) method – Methodology

### Three step methodology

---

1. Determine strategy-driven trade signals.
2. Identify ex-ante successful and unsuccessful trades in the historical data
3. Compute marginal probabilities of the trade signals obtained in step 1 predicting trading outcomes obtained in step 2.

### Step 1: Strategy-driven signals

---

- Run the model on data of selected frequency.
- Recorded buy and sell decisions in the table:
  - 1 is a decision to execute (buy or sell)
  - 0: do nothing

Date	Time	Buy?	Sell?
3/9/2009	8:00 AM	1	0
3/9/2009	9:00 AM	0	0
3/9/2009	10:00 AM	0	0
3/9/2009	11:00 AM	0	1
3/9/2009	12:00 PM	0	0

## 2. Trading Strategy Accuracy (TSA) method – Methodology

Step 2: Ex-ante successful and unsuccessful trades in the historical data

- Classify all trading opportunities in the historical data into profitable and unprofitable buys and sells
  - Strategy profitability dependent on a priority defined rules: stop gain and stop loss
  - Success: reach stop gain

Date	Time	Buy?	Sell?
3/9/2009	8:00 AM	0	0
3/9/2009	9:00 AM	0	0
3/9/2009	10:00 AM	1	0
3/9/2009	11:00 AM	0	1
3/9/2009	12:00 PM	0	0

Step 3: Marginal probabilities of correct trade signals

- Compute the “hit” (“miss”) ratio, % of trading signals that resulted in positive (negative) gain
  - # of matched (unmatched) signal-trade pairs divided by the total # of periods

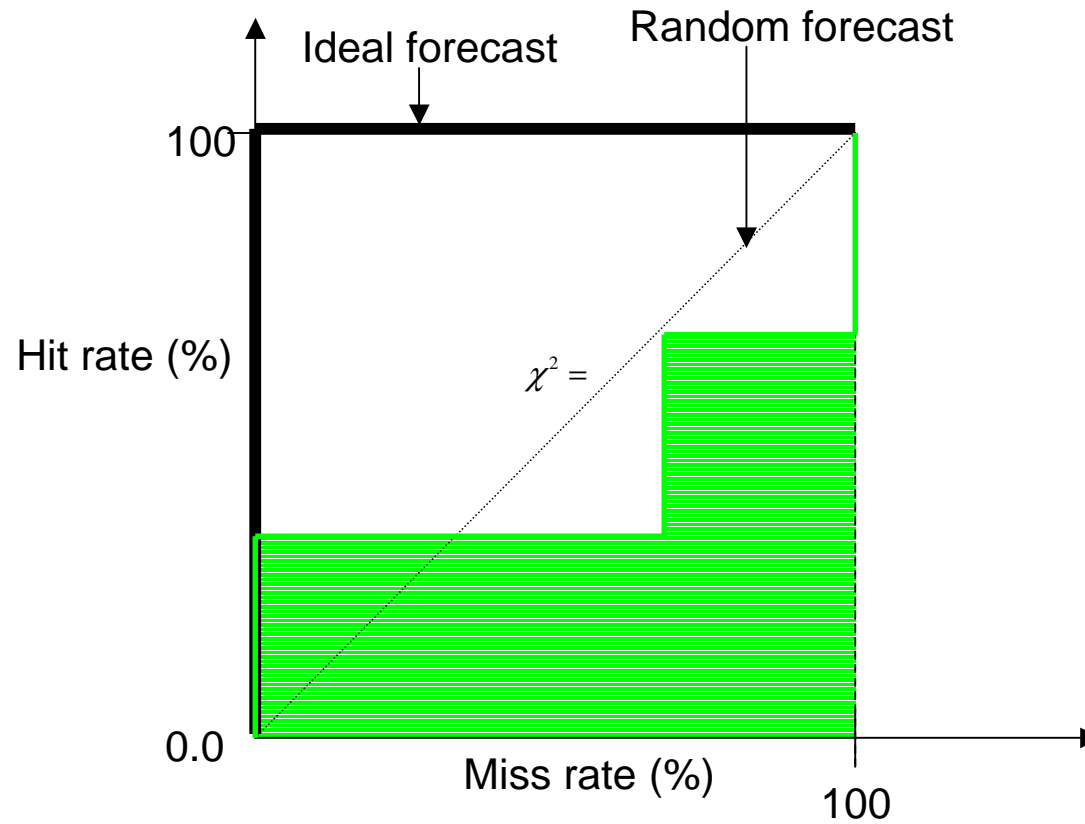
$$H_i = \begin{cases} H_{i-1} + 1/N & \text{if } i^{\text{th}} \text{ trade is a hit} \\ H_{i-1} & \text{otherwise} \end{cases}$$

$$M_i = \begin{cases} M_{i-1} + 1/N & \text{if } i^{\text{th}} \text{ trade is a miss} \\ M_{i-1} & \text{otherwise} \end{cases}$$

- Plot the results on the graph



## 2. Trading Strategy Accuracy (TSA) method – Methodology



### 3. Applying TSA to development of new high-frequency strategies

#### Three step methodology

1. Identify ex-ante successful and unsuccessful trades in the historical data,  $Y_t$
2. Determine which factors and/or model components are most significant in correctly predicting hit and miss trading opportunities;
3. Determine the optimal rule-based strategies with the components identified as most predictive of future outcomes:

- Logit specification for binary LHS

$$Y_t = 1 / (1 + \exp(-(\alpha + \beta_1 X_{1,t-1} + \dots + \beta_n X_{n,t-1} + \epsilon_t)))$$

- Estimate using MLE

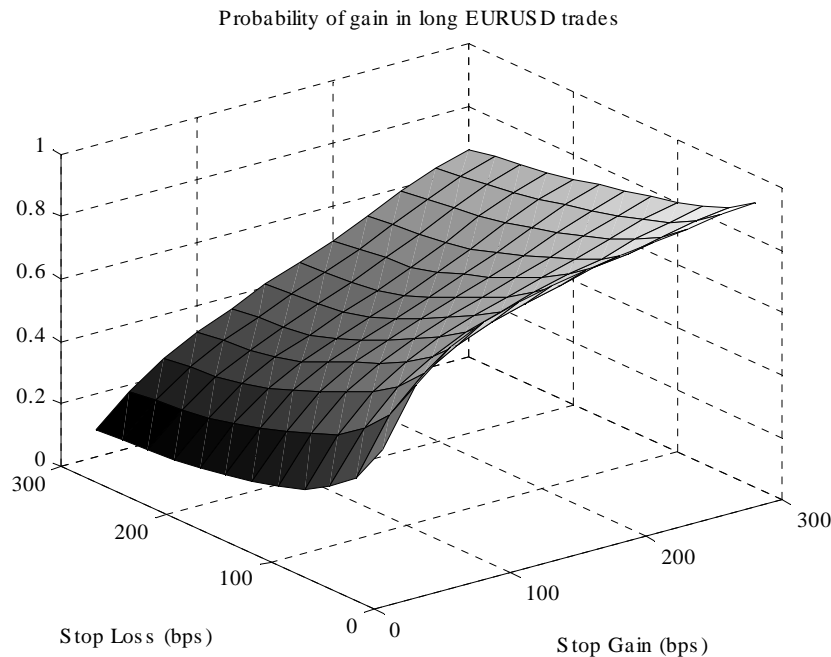
#### TSA = fast strategy development

- Quick and efficient identification of strategies that drive market oscillations
- Individual strategy factors can be added to and subtracted from the model to optimize explanatory power
- Economic intuition is still important!

### 3. Applying TSA to development of new high-frequency strategies

#### An example

Data: hourly EUR/USD spot rate  
January 2001 - December 2008



#### Defining success

- A trade is a success if EUR/USD encounters a stop gain of 2% (200 “pips”) before it hits a stop loss of 0.5% (50 pips) relative to the position open price
- A buy is a success if EUR/USD rises 2% (200 pips) before dropping 0.5% (50 pips)
- A sell is a success if EUR/USD falls 2% (200 pips) before rising 0.5% (50 pips)
- Position holding time is irrelevant

### 3. Applying TSA to development of new high-frequency strategies

#### Sample model factors

- Basic technical indicators
  - MA\_20: Moving average of 20 hours immediately preceding but excluding the hour of estimation
  - MA\_48
  - RSI\_10: Relative strength index
    - $RSI = 100 - [100 / (1 + RS)]$
    - $RS = \text{Average of up day's closes} / \text{Average of down day's closes}$
  - RSI\_48
  - A “stochastics” indicator for the past hour:

$$S_t = \frac{Close_{t-1} - Low_{t-1}}{High_{t-1} - Low_{t-1}}$$

#### Logit estimation results

- Marginal probabilities of a profitable buy:
  - A 1% decrease in the hourly stochastics indicator increases the probability of a successful buy of EUR/USD by 0.584%.
  - A 1% increase in RSI10 increases the probability of a successful buy of EUR/USD by 0.337%.

### 3. Applying TSA to development of new high-frequency strategies

#### Logit estimation results

	Intercept	Stochastics	MA20	MA48	RSI10	RSI48
Model 1	-0.9587* (-54.7187)	-0.5840* (-19.2717)				
Model 2	-0.3568* (-3.7665)		-0.6520* (-8.9628)			
Model 3	-0.3594* (-3.7935)			-0.6501* (-8.9348)		
Model 4	0.3672 (0.0881)				0.3371* (8.4370)	
Model 5	0.2858 (0.0724)					0.3364* (8.8966)
Model 6	-0.5942* (-4.0275)	-0.3905* (-8.6632)		-0.9562* (-8.5314)		

### 3. Applying TSA to development of new high-frequency strategies

#### Logit estimation results

- For each realization of X, determine the forecast of a successful buy  

$$\hat{Y}_{t+1} = 1 / (1 + \exp(-(\hat{\alpha} + \hat{\beta}_1 X_{1,t} + \dots + \hat{\beta}_n X_{n,t})))$$
- Problem: predicted probability values Y do not span the standard [0, 1] probability range
- Distribution of Y estimates from Model 6 is shown in the table below

	Min	2.5%	25%	50%	75%	97.5%	Max
Successful Buy Trades	0.0770	0.0864	0.1053	0.1164	0.1288	0.1486	0.1640
Unsuccessful Buy Trades	0.0753	0.0849	0.1059	0.1168	0.1293	0.1471	0.1634
All Buy Trades	0.0753	0.0853	0.1058	0.1167	0.1292	0.1476	0.1640

### 3. Applying TSA to development of new high-frequency strategies

#### Forecasting

---

- Set “thresholds” for the estimated values of  $Y$ 
  - If  $\hat{Y}_{t+1} \geq Y_{threshold}$ , buy
  - Else, do nothing.

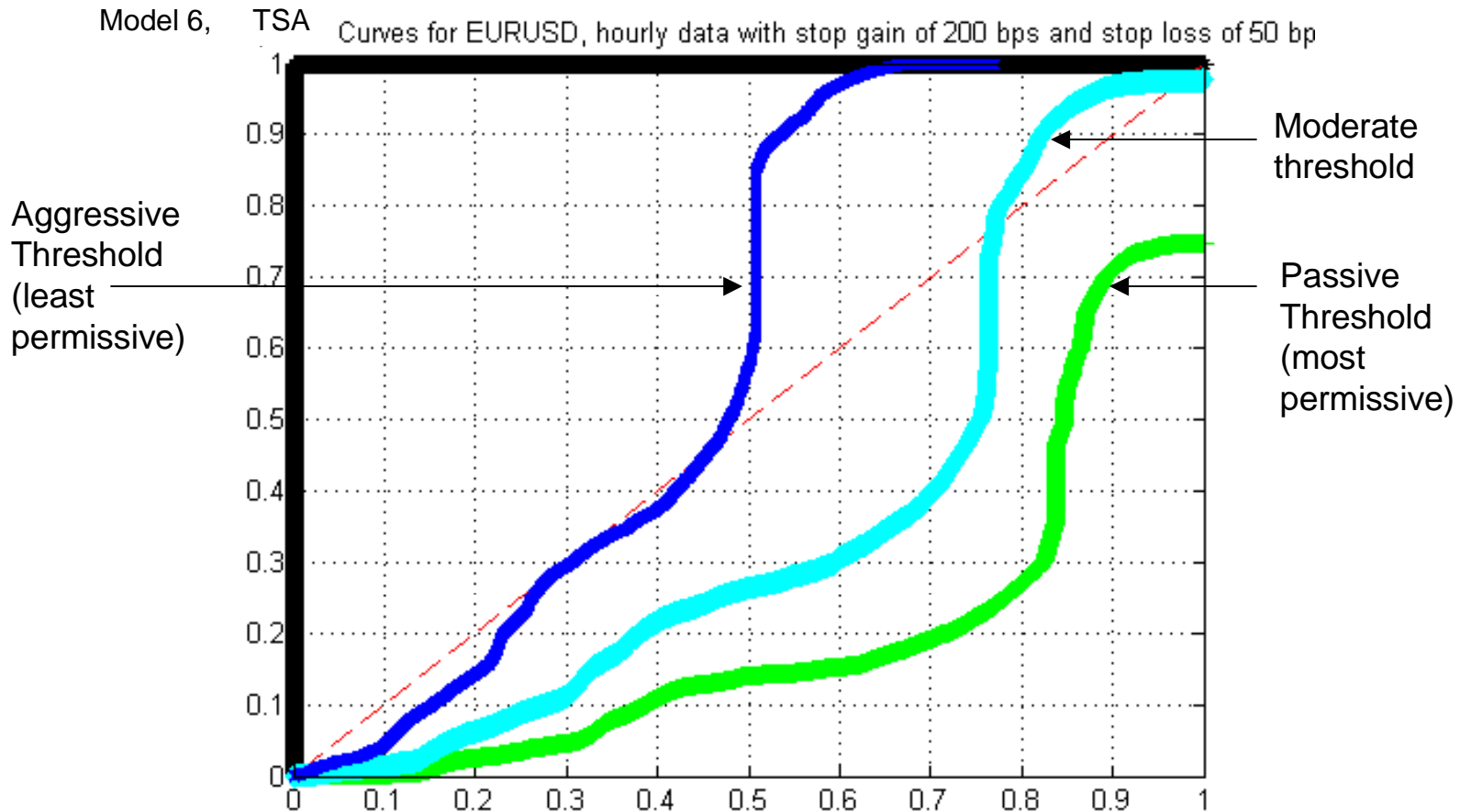
#### Probability thresholds

---

- Test different thresholds:
  - “Aggressive”: the midpoint between the median  $\hat{Y}_{t+1}$  of the “bad” trades and the 75<sup>th</sup> percentile of  $\hat{Y}_{t+1}$  of the “good” trades (0.1228 in this example).
  - “Moderate”: the midpoint between the medians for  $\hat{Y}_{t+1}$  for the “good” and “bad” trades (0.1166)
  - “Passive”: the midpoint between the 25<sup>th</sup> percentile of the “bad” trade  $\hat{Y}_{t+1}$  and the median of the “good” trade probabilities (0.1111)

### 3. Applying TSA to development of new high-frequency strategies

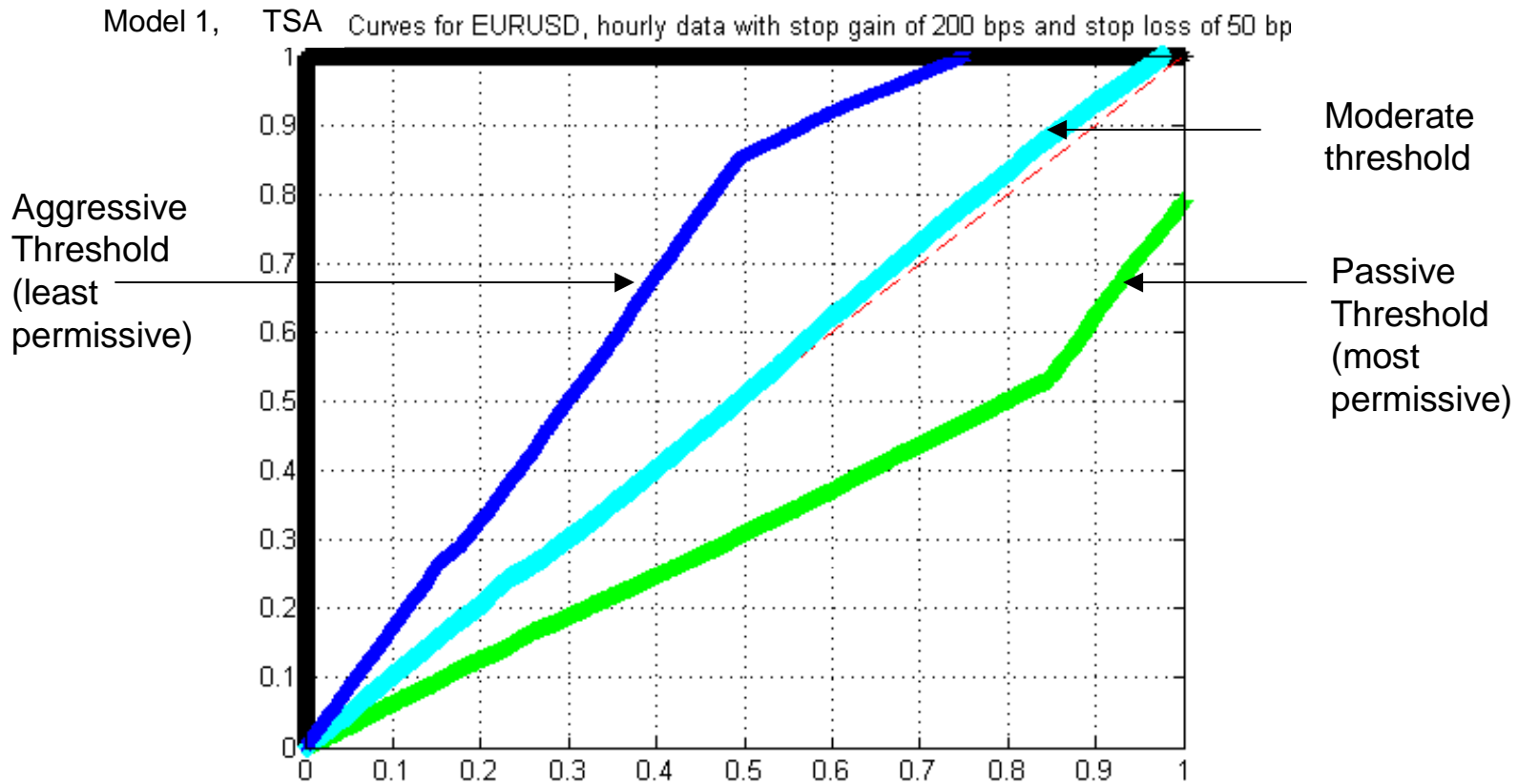
#### TSA for different thresholds, Model 6: Stochastics and MA48





### 3. Applying TSA to development of new high-frequency strategies

#### TSA for different thresholds, Model 1: Stochastics



### 3. Applying TSA to development of new high-frequency strategies

- The TSA methodology is
  - Easy to use
  - Measures whether the strategy leaves money on the table
  - Flexible:
    - Allows to measure the impact of any trading strategy
    - Allows to measure the impact of a portfolio of multiple trading strategies
  - Can be applied to any financial instrument
  - Is robust to any strategy complexities
  - Can be used for in-sample, out-of-sample and production (live) performance evaluation
  - Provides an intuitive graphical roadmap.

## IMPORTANT DISCLOSURE INFORMATION

No representation, warranty, or undertaking, expressed or implied, is given as to the completeness of the information contained in this material by any person; no reliance may be placed for any purpose on such information.

This document is for information only and is not intended as an offer or solicitation with respect to the purchase or sale of any security.

Past performance is not an indication of future performance and there can be no assurance that ABLE will meet its investment objectives or achieve results in line with those presented in these materials. Future performance may be materially worse than past performance.

For further information please contact:

Irene Aldridge  
Managing Partner  
ABLE Alpha Trading, LTD  
1067 Park Ave.,  
New York, NY 10128, USA

+1 646-233-3513  
ialdridge@AbleAlpha.com