

*'Technical analysis using Heiken Ashi Stochastic: To catch a trend, use a HASTOC' is published in International Journal of Finance and Economics (IJFE), Wiley , 21 August 2020 (online first edition: <https://doi.org/10.1002/ijfe.2245> )*

## **Technical analysis using Heiken Ashi Stochastic (HASTOC): To catch a trend, use a HASTOC**

**Dr. Smita Roy Trivedi \***

### **Abstract:**

The study develops a new technical analysis indicator, HASTOC, which reflects in a single number the likelihood of trend generation and momentum in the market. The indicator is developed using the basic characteristics of the Japanese Heiken Ashi (HA) candles. We backtest strategies using HA and HASTOC for three currencies, one index and one stock for three major time frames in each market and find that the strategies give consistent positive returns for select timeframes and markets. The contribution of this study extends to the practical trading scenario and literature on technical analysis.

**Key Words:** Technical analysis, Backtesting, Heiken Ashi, Stochastic, Trend following, Momentum.

**JEL codes:** G15, G19, F47

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**The data that support the findings of this study are available from the corresponding author upon reasonable request.**

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The study develops a new technical analysis indicator, HASTOC, which reflects in a single number the likelihood of trend generation and momentum in the market. The indicator is developed using the basic characteristics of the Japanese Heiken Ashi (HA) candles. We backtest strategies using HA and HASTOC for three currencies, one index and one stock for three major time frames in each market and find that the strategies give consistent positive returns for select time frames and markets. The contribution of this study extends to the practical trading scenario and literature on technical analysis.

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### **1. INTRODUCTION**

As always, there is good news and there is bad news. The good news, the one that you have heard ever since you began trading, is that 'trend is your friend'. The bad news, the one you understood

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soon into the game, is that the illusory friend 'trend' is equally difficult to catch. While trend following strategies have historically proven to be profitable (Hurst et al., 2017), the challenge for the trader at the desk is to understand the trend early on. To be what Murphy (1999) calls the 'astute trader', you have to be the proverbial early bird who understands the trend generation before others in the market. How to be the early trend catcher has remained a perennial question for traders and it explains in part the popularity of technical analysis amongst practitioners.

The purport of technical analysis is to forecast future prices based on past market movement and identification of the trend remains the cornerstone of technical analysis. Technical analysis is an 'obstinate passion' for traders (Menkhoff, 1997), notwithstanding the conflicting academic evidence on technical analysis profitability. It is hardly surprising then that most technical analysis indicators are trend-following. However, a major shortcoming of the trend following indicators are the lagged signals generated, so that traders find it difficult to 'catch the trend early on'. Can then momentum-based indicators work? Momentum-based indicators identify the trend earlier than trend-following indicators, but the signals generated often turn out to reflect swings in the trend, rather than the underlying movement. To be effective, indicators should optimally blend in an understanding of trend and momentum.

Heiken Ashi (HA), the variant of the Japanese candlestick technique, gives a good indication of the trend in the market. I develop an indicator, the HA Stochastic or HASTOC, based on Heiken Ashi candles, which can give a unique insight into the trend as well as momentum in the market. The HASTOC gives a numerical value to show if the trend is changing and how much is the momentum in the market. Further, I develop strategies using the HA candles and HASTOC and backtest them on data from five markets: three currencies, GBP/USD, EUR/USD, USD/INR; one

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index, NIFTY 50<sup>1</sup>, and one equity, State Bank of India<sup>2</sup>. In each market, three time frames are taken to understand how well the strategies work during intraday and daily time frames. The backtesting results on two representative strategies show consistent profits in majority of markets and time frames. The returns are statistically significant for most markets and risk adjusted returns are high for select markets. A comparison with Moving Average Crossover and Relative Strength Index strategies show that HASTOC outperforms these commonly used indicators in most of the markets. An analysis of pre-COVID and post-COVID pandemic markets show that mean returns from the HASTOC strategies are much larger in the post pandemic period.

The contribution of this study extends to the practical trading scenario as well as to the literature on technical analysis. First, it gives a new indicator which is effective in understanding trend generation and momentum. The strategies developed on the basis of this indicator is found to be effective in backtests involving major markets, across securities, involving popularly traded time frames. It extends the evidence on profitability of technical analysis through backtesting of indicators. We add on to the existing evidence in this context, albeit with a new indicator.

## 2. TECHNICAL ANALYSIS PROFITABILITY AND A NEW INDICATOR

Are technical analysis strategies profitable? The academic verdict on this is yet to be given. In one of the major early studies on profitability of technical analysis indicators, Brock et al (1992) showed, using technical analysis based on filter techniques, that profit can be generated substantially in excess of buy and hold returns. A significant number of studies thereafter have found technical analysis to be profitable (Pinches, 1970, Le Baron 1999; Menkhoff & Taylor,

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<sup>1</sup> Nifty 50 is the National Stock Exchange of India (NSE)'s index for the Indian equity market

<sup>2</sup> SBI is India's largest commercial bank. It is a public sector bank

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2007, Hsu et al 2016, de Souza et al.2018), but questions on treatment of transaction costs, data frames used and data snooping errors have remained (Sullivan, Timmermann, & White, 1999, Neely & Weller, 2003; Irwin & Park, 2007).

While the issue of technical analysis profitability has remained contentious (Irwin & Park, 2007), there is extensive use of technical analysis amongst traders (Menkhoff, 1997, Cheung and Wong, 2000). Cheung and Chinn (2001) reported, for a survey of US dealers, technical trading best describes 30% of trading behavior, a slightly greater proportion than that attributed to fundamental analysis (25%). Menkhoff (2010) shows in a survey of 692 fund managers in five countries that not only do a majority of them use technical analysis, at a forecasting horizon of weeks, technical analysis is the most important form of analysis and considered more important than fundamental analysis. Technical analysis seems to largely dominate over fundamental analysis in shorter trading horizons (Allen and Taylor 1990, Cheung and Chinn, 2001, Gehrig and Menkhoff, 2003, Menkhoff, 2010).

How do we align this seemingly discordant findings: of the extensive use of technical analysis by traders, on one hand, and conflicting evidence on technical analysis profitability on the other hand? It suggests that profitability of technical analysis tools depends on market conditions (Taylor, 2014) and may be different in different time periods (Kung and Wong, 2009). Menkhoff & Taylor (2007) point to the belief among traders that technical analysis can represent changes in market psychology and provide information about 'non-fundamental influence'. If technical analysis does better in interpreting both the reaction to newer information and consequent generation of new trends, professionals would find it useful.

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This also find resonance in a number of studies which find technical analysis generates profits in presence of central bank intervention (Silber, 1994, Andrew C. Szakmary & Mathur , 1997, Neely 1998). Le Baron (1999) points out that central bank intervention would introduce noticeable trends into the evolution of exchange rates making it possible for market participants to gain from trading. Technical analysis indicators plausibly can detect trends in asset prices and the duration of these trends allow for above-average profits even with transaction costs (Stanković et al. 2015, de Souza et al.2018). This suggests we need to understand under what conditions technical trading works for professionals.

The success of technical analysis indicators in the presence of any market event, like central bank intervention, comes from the ability to recognize trend creation. The basic premise of technical analysis is that market move in trends which can be recognized through suitable indicators (Murphy, 1999). However, as any trader knows, the onset of trend and the reversal of trend remain difficult to predict even with a wide variety of technical analysis indicators. While trend following indicators have long been used and are proved to be profitable (Hurst, et al, 2017), the interpretation of such signals to take positions in live trading is far from easy. This explains the wide variety of indicators used by traders, from moving averages which give lagged signals, to momentum indicators, which give fast signals.

Indicators based on moving averages try to understand the start of a new trend by comparing the present price movement to longer term averages. While the signals generated are effective in recognizing major trends, the lagged nature of the indicator makes the signals late. This is shown in Figure 1. A trader would like to get the entire uptrend market, between points 1 & 3, in the chart. However, with moving average crossover the signal would come at 2, which would make the trader

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lose half the market movement. The downtrend that starts at point 3, also gets the signal much later at point 4.

Momentum indicators are too sensitive to price changes and cannot distinguish between a small correction in the trend and a reversal. In live trading, the trader is often confused when with small correction in an uptrend, the momentum indicator goes negative, suggesting a change in position. The second panel in Figure 1 shows Relative Strength Index (RSI)<sup>3</sup>, a popular momentum indicator. As can be seen, RSI gives the signal for trend generation early. RSI going up and above 50 can be taken as a buy signal and RSI going down and below 50 as a sell signal. As is seen by points B and D, the trend reversal may not be captured by the move with reference to mid-point line. RSI moves up and down too often as market corrects for us to stay with the trend. Even if we enter market at point A or C, as RSI starts moving up (down) from oversold (overbought) range, the frequent sharp moves in RSI at points like C would be confusing to trader.

Is it possible to combine trend generation and momentum identification in a single indicator? In fact loss of momentum in a market is an early sign that trend change may be underway. Effective trading in live markets requires an indicator that can predict the trend generation, and momentum changes. Heiken Ashi Stochastic developed in the next segment addresses this gap in technical analysis by providing an indicator which expresses in a single number both the likelihood of trend generation as well as the momentum in the market. The paper adds to the existing literature of technical analysis by development of a new indicator, HASTOC, and presents empirical evidence

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<sup>3</sup> RSI, like any other momentum indicator, gives the strength in the market. It is given by  $RSI_{\alpha} = 100 - 100 / (1 + RS)$  .....(12)  
Where  $RS = \text{Up closes} / \text{Down closes}$  over a period of  $\alpha$  days

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on the profitability of strategies based on the HASTOC through backtesting. For practitioners, the paper contributes by developing a new indicator, effective in live trading in understanding trend reversal as well as momentum generation.

### **3. HASTOC: CONCEPTION AND METHODOLOGY FOR BACKTESTS**

#### **3.A. Construct of HA candles**

Heiken Ashi is a variant of the very popular Japanese candlestick technique. Similar to a bar construct, the Japanese candlestick technique also records the four important information that technical analysis traders are seeking namely, open, high, close, low. On the candlestick chart, the open and close is reflected in the broad portion of the bar of the candle. The high and close for the day is reflected in the shadows or the wicks of the candle. Let us look at Figure 2 to understand the candlestick technique. The wide portion shows the body of the candle, with the upper and lower lines reflecting either the open or close for the day. If the close is on the higher side as compared to the open, the candle is a bull candle. If the close is on the lower side as compared to the open, the candle is a bear candle. The wicks of the candle show the high and low as shown in the Figure 2.

Heiken Ashi uses a form of averaging to smooth out the movement in the market. As with the traditional candlestick pattern, Heiken Ashi also uses the open, high, low, close prices. However, in the Heiken Ashi candlesticks, this information is a derived one. The calculation formula for Heiken Ashi candle is as follows (Kuepper, J, nd), demonstrated in Figure 3

Close = (Open Price + High + Low + Close) / 4, each price being of the current period;

Open = Average of Open and Close Price of the previous HA candle;

High = Maximum value of the (High of the Period, Open of HA, Close of HA);



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Low = Minimum value of the (Low of the Period, Open of HA, Close of HA).

For EUR/USD data, Table 1 gives a sample HA candle calculation from raw data. The open of the Heiken Ashi candlestick is the average of the open price and close price of the previous HA candle, which implies that it reflects the average movement that the asset has seen previously. The close of the Heiken Ashi is average of the entire price movement during the period. As HA Open of each period requires knowledge of the prior period HA Open and Close, for the initial period we assume, HA Open = Market Open for the first period.

The Heiken Ashi close would be greater than the Heiken Ashi open (resulting in a HA bull candle) only when the average prices for the period exceeds the average of the previous period HA. Denoting  $HAC_t$  as the Heiken Ashi Close in period t and  $HAO_t$  as the Heiken Ashi Open of period t, we can write for a bull candle,

$$HAC_t - HAO_t > 0 \dots \dots \dots (1)$$

$$HAC_t - \{(HAO_{t-1} + HAC_{t-1})/2\} > 0 \dots \dots \dots (1a),$$

$$HAC_t > \{(HAO_{t-2} + HAC_{t-2})/4\} + HAC_{t-1}/2 \dots \dots \dots (1b)$$

$$HAC_t > \{(HAO_{t-3} + HAC_{t-3})/8\} + \frac{HAC_{t-2}}{4} + HAC_{t-1}/2 \dots \dots \dots (1c) \text{ and so on}$$

So for a t=5,

$$HAC_5 > \frac{HAO_1}{16} + \frac{HAC_1}{16} + \frac{HAC_2}{8} + \frac{HAC_3}{4} + \frac{HAC_4}{2} \dots \dots \dots (2),$$

Where  $HAO_1$  = Open for period 1

Generalising for t=n,

$$HAC_n > \frac{HAO_1}{2^{n-1}} + \sum_{t=1}^{n-1} \frac{HAC_t}{2^{n-t}} \dots \dots \dots (3)$$

Similarly, a bear candle in HA can be expressed as

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$$HAC_n < \frac{HAO_1}{2^{n-1}} + \sum_{t=1}^{n-1} \frac{HAC_t}{2^{n-t}} \dots\dots\dots(4)$$

Thus for the HA bull or bear candle to show up, prices of a close exceed the detrended past series, helping HA candles to identify the general trend in the market. The HA candles would show bull candles with no lower shadow if the momentum is high in the market. No lower shadow means the open of the HA is also the lowest the prices have reached in that period, which in HA parlance implies that the low of the period has exceeded the average of HA open and close of the previous period. Similarly a HA bear candle with no upper shadow represents that the open of the period is also the highest of the period, which in HA parlance would mean that the high of the period is lower than the average of the previous HA open and close.

### 3. B. HASTOC: CONCEPTION

For developing an indicator based on HA candles, we do a preliminary visual chart analysis of reversal for select time frames as reported in Appendix A. For each market and time frame, ten reversal points are noted, and confirmed by either moving average crossover or visual chart analysis. Visual chart analysis is used where the crossover has not given a signal in spite of a prominent trend reversal. The observation on the Heiken Ashi Candle and the wick length is given in Appendix A. For a majority of reversal, the following points were noted:

1. Trend reversal is marked by small body HA candles, along with reduced length of shadows in majority of the cases.
2. HA candles are of greater size, and shadows long in a strong uptrend or downtrend.

The visual analysis suggests that we can use the difference between the HA candles open and close to predict the reversal pattern. However, the problem with using the  $D_t$ , (difference between the

HA candle open and close) as an indicator for chart analysis is that it gives absolute values, which tend to differ across securities and markets.

To address this issue we develop the Heiken Ashi stochastic (HASTOC), given as:

$$\text{HASTOC}_t = \frac{D_t - \text{Min}(D_t)}{\text{Max}(D_t) - \text{Min}(D_t)} \dots \dots \dots (5)$$

Where  $D_t$  = Difference between HA Open and HA Close

The HASTOC puts the HA Open and Close difference in the context of the average difference over the last ten periods. By comparing the present average prices to prior detrended series, HA can indicate the trend directly. HASTOC by taking into account the magnitude of difference  $D_t$ , and using it in context of the prior difference noted in the market, adds the information of the momentum. HASTOC necessarily take the values between 0 to 100%. Any value greater than 70% is taken to be trend momentum while any value less than 10% is considered to indicate trend reversal.

We also calculate the wick length of HA candles and use it to derive a stochastic HASTOC (W).

The wick length (WL) is given by the difference between the high and close (open) added to the difference between the low and open (close) for a bull (bear) candle. HASTOC (W) is given by

$$\text{HASTOC}(W)_t = \frac{WL_t - \text{Min}(WL_t)}{\text{Max}(WL_t) - \text{Min}(WL_t)} \dots \dots \dots (6)$$

### 3 C. METHODOLOGY FOR BACKTESTING HASTOC

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Ten strategies were developed and backtested. For brevity, two most representative ones are explained and the backtesting details reported here. The complete results for all ten strategies are presented in Appendix B.

1. Strategy 1: If the trend is down or up for three consecutive periods, and HASTOC is less than 10%, we buy or sell. This is done to differentiate between beginning-of-trend small HA candles and the end-of-trend small HA candles. It is noted from chart analysis that as the trend changes, for a few periods initially the candles appear small. For exit we stipulate the condition as prior buy (or sell) decision and HASTOC above 50%, for a sell (or buy) decision.

2. Strategy 2 imposes a volume condition, requiring the trend change to be confirmed by high volume. If the difference of HA, HA (Dt) changes from positive (negative) to negative (positive), a downtrend (uptrend) is assumed to have started. The volume condition is that volume in that particular period should exceed the moving average volume of the previous ten periods.

The strategies attempt to utilise the ability of HASTOC to locate trend generation by a smaller value as well as the ability to identify high momentum with values exceeding 50%. Further, we keep the simplest one with HA difference and volume, which itself is effective in trend identification as well as predicting the next reversal.

The indicator HASTOC was tested on three currencies Pound (GBP/USD), Euro (EUR/USD), Indian Rupee (USD/INR), India's benchmark equity index (NIFTY50) and stock of State Bank of India (SBI), India's leading public sector bank. The time frames taken was daily, 60 minutes and 30 minutes. As technical analysis strategies are more used extensively for the intra-day and smaller time frames (Neely and Weller, 2003; Gehrig and Menkhoff, 2003), two intraday periods were taken. For the intraday period roughly the data of last one year was taken. However, the number

of observation differ across securities according to the trading hours in each market. The daily data is taken for all securities from 2010 or 2012 to 2020 depending from when the count (taken as a proxy for volume) data is available. The details of the time period for each security is given in Table 2.

For understanding the profitability of HASTOC strategies, I adopt the following methodology: First, I backtest the securities across all time frames. As discussed, ten strategies are backtested, of which the results of the two most representative strategies are presented in the results section. Results for the all the ten strategies are presented in Appendix B. Second, I look into the risk-adjusted returns (Marney et al. 2001). I incorporate the risk free rate and calculate Sharpe ratios for the strategies across all time frames. Third, I compare the profitability of HASTOC strategies to Moving average and RSI strategies using t-tests. This helps to understand if HASTOC strategies are better in gauging the change in trend compared to the Moving average and RSI, two most commonly used indicators for understanding trend and momentum respectively (Details on the strategies are given in Appendix C). Fourth, I present an analysis of two sub-samples of the pre and post COVID pandemic periods.

#### **4. RESULTS AND DISCUSSION**

With the tests underlined in the methodology section, we question if the indicator developed, HASTOC and the strategies based on it can help to understand trend reversal better while trading. Table 2 gives the descriptive statistics for the securities across the time frames used. We have used the last one year data for all intra-day time frames, with slight variation given availability and weekends. For Daily data was taken from 2010 or 2012, given the availability of count data. The backtesting results for strategies 1 and 2 are presented in Table 3a. The average and standard

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deviation of returns for Strategy 1 and 2, as well log returns and standard deviation of market returns for the security are presented. We can see that average market return is positive in 33% of the time frames, but for both the strategies returns are positive for more than 60% of the time frames. Strategy 1 exceeds market returns in 47 % time frames and Strategy 2 exceeds market returns in 60% of the time frames.

Strategy 1 represents the incorporation of trend in the HASTOC strategy. We recognise trend generation through small body candles and confirm the presence of the trend for taking this entry position. For the exit position the momentum is reflected in HASTOC taking a value higher than 50%. The second strategy is a simple understanding of the trend behind the market, based on the difference between a HA candles or HA (Dt) which is further confirmed by higher volumes. In majority of time frames for any security, the HASTOC strategies give positive returns. Moreover, Strategy 2 which is a simple strategy can exceed market returns majority of the time.

I present the annualized returns and risk adjusted returns for Strategy 1 and 2 in Table 4 (a & b), respectively. We can see for some markets and time frames, for example, GBP and Euro 30 minute, INR 30 minutes, Nifty hourly and SBI hourly the annualized returns are high. To allow for a more objective comparison, I present the risk adjusted returns, the Sharpe ratio, assuming risk free rates of 1, 2 and 4 %. Since we cover both forex and equity markets, we assume the US 10 Year Treasury Rate to be the risk free rate, which has ranged from the maximum of 3.46 to a minimum of 0.64% in the last ten years<sup>4</sup>, and accordingly take three risk free rates. Using annualized returns and standard deviation, the Sharpe ratio is calculated and results are presented in Table 4 (a & b). We

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<sup>4</sup> <https://www.treasury.gov/resource-center>

present only those time frames and markets which have given positive average returns for valid comparisons.

We see that Strategy 1 performs very well in SBI 60 minute, Nifty 60 minute and GBP 30 minute time frame. Strategy 2 performs very well in SBI 30 minute, Nifty 60 minute and SBI D minute time frame. The Sharpe ratios above 1 are marked in bold. It can be seen that Strategy 1 has given a Sharpe ratio of around 3 for Nifty hourly time frame and greater than 1 for GBP 30. Strategy 2 has also recorded higher than 1 Sharpe ratios for Nifty 60 and GBP 30. It is evident that in these two markets the HASTOC strategies have performed well.

Table 4c give the one sample t test results (one-tailed) for markets with positive returns for the strategies. The null hypothesis tested is mean returns equals zero, against the alternate hypothesis of mean returns greater than zero (one tailed test). We see that for both the strategies the mean returns are statistically significant in the GBP 30 minute time frame. The same is noted for Nifty 60. This corresponds to the Sharpe ratio analysis showing both the HASTOC strategies have performed well in GBP 30 and Nifty 60 time frame. Similar to the findings for Sharpe ratio we see mean returns are statistically significant for EUR Daily, Nifty 60, Nifty daily, and SBI daily.

Table 5 compares the two HASTOC strategies with Moving Average (MA) Double Crossover and Relative Strength Index strategies. We see in a majority of markets the HASTOC returns from the two strategies exceed the MA and RSI returns: GBP 30 minute and daily; EUR all time frames; INR 30 and 60 minute, NIFTY 60 minute and daily; SBI 60 minute and daily. The last four columns of Table 5 show if the HASTOC returns are greater than the MA and RSI returns and if the difference is statistically significant (two-Sample t-Test for Equal Means, one-tailed).

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Finally, Table 6 gives the sub-sample mean and standard deviation for pre March 2020 and post March 2020 time frames, to understand in the strategies are performing differently in the post pandemic markets. As we can see for a majority of the cases the returns are much higher in the post pandemic period than pre pandemic period for both strategies. This is not surprising given the utility of technical analysis indicators in trending markets (Le Baron, 1999) Given that the post pandemic markets have seen a sharp trend, it suggests HASTOC strategies have performed well in trend identification.

## **5. CONCLUSION**

While technical analysis profitability has been explored by a host of academic studies, the results are far from conclusive. There is however evidence that technical analysis is profitable under certain market conditions, and in this context the strong evidence on technical analysis profits in trending markets is noted. Professional traders consistently use technical analysis tools for trading, suggesting further research is required on the effective use of technical analysis indicators under different market conditions and timeframes.

This paper adds to the present literature in technical analysis in two distinct ways. First it adds on to the professional traders' kitty of technical analysis tools, developing an indicator which can effectively show trend generation as well as the momentum in the market. To the best of our knowledge, there has been no such studies on development of an indicator based on the Heiken Ashi candles. The indicator developed, HASTOC helps in identification of trend using the basic principle of HA candles and the use of a Stochastic blends in momentum recognition. It gives in a single value trend generation and momentum which can be effectively used for a host of trading strategies. Secondly the paper adds to the literature on back testing of technical analysis strategies,



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by presenting evidence on new strategies developed on the basis of the indicator HASTOC and HA candles.

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**Table 1: Calculation of HASTOC and HASTOC (W) for sample EUR data**

Timestamp	open	high	low	close	HA open	HA close	HA high	HA low	D(HA)	HASTOC
1/2/2012	1.2937	1.2967	1.2915	1.2928	1.2933	1.2937				
1/3/2012	1.2933	1.3076	1.2930	1.3050	1.2935	1.2997	1.3076	1.2930	0.0063	
1/4/2012	1.3050	1.3072	1.2896	1.2940	1.2966	1.2990	1.3072	1.2896	0.0024	
1/5/2012	1.2944	1.2947	1.2768	1.2780	1.2978	1.2860	1.2978	1.2768	-0.0118	
1/6/2012	1.2787	1.2812	1.2696	1.2720	1.2919	1.2754	1.2919	1.2696	-0.0165	
1/9/2012	1.2691	1.2785	1.2664	1.2765	1.2836	1.2726	1.2836	1.2664	-0.0110	
1/10/2012	1.2765	1.2818	1.2741	1.2772	1.2781	1.2774	1.2818	1.2741	-0.0007	
1/11/2012	1.2773	1.2789	1.2661	1.2703	1.2778	1.2732	1.2789	1.2661	-0.0046	
1/12/2012	1.2705	1.2844	1.2697	1.2825	1.2755	1.2768	1.2844	1.2697	0.0013	
1/13/2012	1.2822	1.2878	1.2623	1.2677	1.2761	1.2750	1.2878	1.2623	-0.0011	4.3%
1/16/2012	1.2637	1.2687	1.2624	1.2661	1.2756	1.2652	1.2756	1.2624	-0.0103	60.9%
1/17/2012	1.2662	1.2808	1.2647	1.2737	1.2704	1.2714	1.2808	1.2647	0.0010	1.5%

Raw Data Source: Thomson Reuters Eikon; Author's calculations

**Table 2: Securities across Time Frames**

	Sample time period	Number of observations	Average
GBP30	7/1/2019 0:30 hours to 29/6/2020 16:00 hours	12867	1.261
GBP60	7/1/2019 0:30 hours to 29/6/2020 16:00 hours	6524	1.261

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GBPD	1/2/2012 to 6/29/2020	2216	1.437
EUR30	7/1/2019 0:30 hours to 29/6/2020 16:00 hours	12867	1.106
EUR60	7/1/2019 0:30 hours to 29/6/2020 16:00 hours	6480	1.1058
EURD	1/2/2012 to 6/29/2020	2196	1.1937
INR30	27/6/2019 11:30 hours to 27/6/2020 2:30 hours	4010	72.43
INR60	1/7/2019 7:30 to 26/6/2020 13:30	4009	72.48
INRD	23/4/2012 to 26/2/2020	2135	64.49
NIFTY30	26/6/2019 13:00 hours to 26/6/2020 13:00 hours	3830	10963.26
NIFTY60	26/6/2019 13:00 hours to 26/6/2020 13:00 hours	2117	10957.56
NIFTYD	1/4/2010 to 26/6/2020.	2598	7820.14
SBI 30	1/7/2019 10.00 to 26/6/2020 to 17.00.	3681	273.77
SBI60	1/7/2019 10.00 to 26/6/2020 to 17.00.	1976	273.85
SBID	1/4/2010 to 26/6/2020	2598	243.89

**Table 3: Average returns and volatility of returns of HASTOC strategies**

	Average Returns			Standard Deviation of Returns			Returns exceed market returns	
	Strategy 1	Strategy 2	Market	Strategy 1	Strategy 2	Market	Strategy 1	Strategy 2
GBP30	0.0007%	0.0005%	-0.0002%	0.040%	0.037%	0.098%	Yes	Yes
GBP60	-0.0215%	0.0013%	-0.0005%	0.302%	0.159%	0.139%	No	Yes
GBPD	0.0056%	0.0042%	0.0350%	0.244%	0.210%	0.539%	No	No
EUR30	0.0003%	-0.0001%	-0.0001%	0.032%	0.03%	0.07%	Yes	No
EUR60	-0.0003%	0.0004%	-0.0001%	0.042%	0.04%	0.09%	No	Yes
EURD	0.0077%	-0.0019%	-0.0060%	0.232%	0.19%	0.54%	Yes	Yes
INR30	0.0004%	0.0001%	0.0022%	0.047%	0.034%	0.130%	No	No
INR60	0.0000%	0.0000%	0.0023%	0.000%	0.000%	0.130%	No	No
INRD	-0.0078%	-0.0059%	0.0172%	0.192%	0.23%	0.45%	No	No
NIFTY30	-0.0021%	-0.0009%	-0.0034%	0.170%	0.129%	0.478%	Yes	Yes
NIFTY60	0.0117%	0.0068%	-0.0077%	0.093%	0.095%	0.316%	Yes	Yes
NIFTYD	0.0112%	0.0223%	0.0263%	0.560%	0.359%	1.108%	No	No
SBI 30	-0.0131%	0.0050%	-0.0182%	0.346%	0.235%	0.843%	Yes	Yes
SBI60	0.0266%	-0.0020%	-0.0337%	0.959%	0.325%	1.178%	Yes	Yes

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SBID	-0.0096%	0.0330%	-0.0082%	1.032%	0.859%	2.162%	No	Yes
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**Table 4 a: Annualised returns, standard deviation, Sharpe ratios (SR) for Strategy 1**

	Annualized returns	Annualized standard deviation	SR (1%)	SR (2%)	SR (4%)
SBI60	70.89%	0.75	0.94	0.88	0.90
NIFTY60	26.57%	0.07	<b>3.53</b>	<b>2.98</b>	<b>3.12</b>
GBP30	8.70%	0.04	<b>1.77</b>	0.85	<b>1.08</b>
INR30	4.92%	0.05	0.76	-0.01	0.18
EUR30	3.41%	0.04	0.68	-0.45	-0.17
NIFTYD	2.85%	0.09	0.21	-0.24	-0.13
EURD	1.96%	0.04	0.26	-0.83	-0.55
GBPD	1.42%	0.04	0.11	-0.92	-0.67
INR60	0.00%	0.00	0.00	0.00	0.00

**Table 4 b: Annualised returns, standard deviation, Sharpe ratios (SR) for Strategy 2**

	Annualized returns	Annualized standard deviation	SR (1%)	SR (2%)	SR (4%)
SBI 30	22.17%	0.26	0.82	0.66	0.70
NIFTY60	14.79%	0.07	<b>1.88</b>	<b>1.33</b>	<b>1.47</b>
SBID	8.68%	0.14	0.56	0.27	0.34
GBP60	8.26%	0.12	0.59	0.26	0.34
NIFTYD	5.79%	0.06	0.84	0.14	0.31
GBP30	5.68%	0.04	<b>1.16</b>	0.17	0.42
EUR60	2.26%	0.03	0.45	-0.97	-0.62
GBPD	1.07%	0.03	0.02	-1.18	-0.88
INR30	0.68%	0.04	-0.09	-1.14	-0.88
INR60	0.00%	0.00	0.00	0.00	0.00

**Table 4 c: One sample t-Tests results for Strategy 1 and 2<sup>+</sup>.**

	Strategy 1	Strategy 2	ST1	ST2
<b>GBP30</b>	<b>0.0007%</b>	<b>0.0005%</b>	1.420	1.987
			<b>0.078***</b>	<b>0.023**</b>
GBPD	0.0056%	0.0042%	1.079	0.948
			0.140	0.172
EUR30	0.0003%	-0.0001%	0.979	-0.283

			0.164	0.389
EUR60		0.0004%		0.821
				0.206
<b>EURD</b>	<b>0.0077%</b>	-0.0019%	1.560	-0.458
			<b>0.059***</b>	0.324
INR30	0.0004%	0.0001%	0.535	0.103
			0.296	0.459
INR60	0.0000%	0.0000%	0.696	0.222
			0.243	0.412
<b>NIFTY60</b>	0.0117%	0.0068%	1.808	1.776
			<b>0.035**</b>	<b>0.038**</b>
<b>NIFTYD</b>	0.0112%	<b>0.0223%</b>	1.014	3.176
			0.155	<b>0.001*</b>
SBI60	0.0266%	-0.0020%	1.231	-0.277
			0.109	0.391
<b>SBID</b>		<b>0.0330%</b>		1.959
				<b>0.025*</b>

+t-tests significance levels are reported as \*, \*\*, \*\*\* for significance levels of 1, 5, and 10% respectively

**Table 5: Comparison of Strategy 1 (St 1) and Strategy 2 (St 2) with Double Crossover Moving Average (MA) and Relative Strength Index (RSI)<sup>+</sup>**

		MA	RSI	St1 > MA	St 1> RSI	St2 >MA	St2 > RSI
GBP30	Mean	0.000	0.000	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>
	Std	0.099	0.098	0.190	0.205	0.263	0.281
GBP60	Mean	0.001	0.000	0	0	0	1
	Std	0.138	0.139				
GBPD	Mean	-0.020	-0.013	<b>1**</b>	<b>1***</b>	<b>1**</b>	<b>1***</b>
	Std	0.458	0.560	<b>0.009</b>	<b>0.074</b>	<b>0.011</b>	<b>0.086</b>
EUR30	Mean	-0.001	-0.001	<b>1**</b>	<b>1**</b>	<b>1***</b>	<b>1**</b>
	Std	0.059	0.067	<b>0.018</b>	<b>0.016</b>	<b>0.057</b>	<b>0.048</b>
EUR60	Mean	-0.002	-0.002	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>
	Std	0.084	0.092	<b>0.069***</b>	0.136	<b>0.017**</b>	<b>0.046**</b>
EURD	Mean	-0.017	-0.013	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>
	Std	0.411	0.496	<b>0.008**</b>	<b>0.038**</b>	<b>0.064***</b>	0.163
INR30	Mean	-0.001	-0.001	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>
	Std	0.091	0.098	0.190	0.186	0.186	0.234
INR60	Mean	-0.001	-0.001	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>
	Std	0.091	0.098	0.940	0.949	0.733	0.752
INRD	Mean	0.009	0.022	0	0	0	0
	Std	0.442	0.385				
NIFTY30	Mean	0.011	0.008	0	0	0	0

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	Std	0.410	0.478				
NIFTY60	Mean	0.011	0.019	<b>1</b>	0	0	0
	Std	0.552	0.659	0.019			
NIFTYD	Mean	-0.007	0.016	<b>1</b>	0	<b>1</b>	<b>1</b>
	Std	0.979	1.106	0.212		0.429	0.382
SBI 30	Mean	0.034	0.012	0	0	0	0
	Std	0.739	0.843				
SBI60	Mean	0.033	0.013	0	1	0	0
	Std	0.989	1.178		<b>0.070***</b>		
SBID	Mean	0.024	0.053	0	0	1	0
	Std	2.475	2.156			<b>0.090***</b>	

<sup>^</sup>1=Yes, 0=No, <sup>+</sup>t-tests significance levels are reported as \*, \*\*, \*\*\* \*for significance levels of 1, 5, and 10% respectively

**Table 6: Sub-sample analysis of HASTOC strategies**

	Pre March 2020				Post March 2020			
	Strategy 5		Strategy10		Strategy 5		Strategy10	
	Average Returns	Standard Deviation	Average Returns	Standard Deviation	Average Returns	Standard Deviation	Average Returns	Standard Deviation
GBP30	-0.007%	0.143%	0.000%	0.070%	<b>0.024%</b>	0.255%	<b>0.006%</b>	-0.223%
GBP60	-0.014%	0.261%	0.004%	0.119%	-0.037%	0.373%	-0.004%	0.221%
GBPD	0.056%	1.020%	0.027%	0.578%	<b>1.629%</b>	1.704%	<b>0.207%</b>	0.577%
EUR30	-0.003%	0.150%	-0.001%	0.076%	<b>0.026%</b>	4.1%	<b>0.001%</b>	2.5%
EUR60	0.008%	0.110%	0.002%	0.079%	-0.033%	0.296%	0.005%	0.137%
EURD	0.147%	0.993%	-0.014%	0.541%	-0.106%	0.088%	-0.050%	0.380%
INR30	0.00%	0.087%	0.00%	0.079%	<b>0.001%</b>	0.122%	<b>0.002%</b>	0.143%
INR60	0.005%	0.192%	0.000%	0.080%	<b>0.022%</b>	0.247%	<b>0.004%</b>	0.142%
INRD	-0.150%	0.794%	-0.012%	0.430%	<b>0.535%</b>	0.311%	-0.221%	0.561%
NIFTY30	-0.010%	0.475%	0.001%	0.260%	-0.099%	1.140%	-0.014%	0.566%
NIFTY60	-0.061%	0.774%	0.019%	0.261%	<b>0.730%</b>	2.217%	<b>0.057%</b>	0.763%
NIFTYD	0.421%	2.220%	0.220%	1.046%	-4.243%	10.087%	-0.345%	2.325%
SBI 30	-0.206%	1.398%	0.019%	0.529%	-0.294%	1.491%	<b>0.096%</b>	0.966%
SBI60	-0.291%	1.867%	-0.014%	0.624%	<b>0.591%</b>	4.701%	<b>0.013%</b>	1.676%
SBID	-0.418%	4.674%	0.266%	2.728%	-2.674%	5.640%	<b>0.695%</b>	3.170%

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