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Article

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FINANCIAL ECONOMICS | RESEARCH ARTICLE

Replicating the CBOE VIX using a synthetic volatility index trading algorithm

Dayne Cary¹ and Gary van Vuuren^{2*}

Abstract: This article tests whether a correlation exists between a stochastic synthetic volatility index (SVIX) and the Chicago Board Options Exchange (CBOE) volatility index (VIX) and assesses the success of the indicators' application by pairing an undeveloped trading strategy to gauge its forecasting accuracy. The SVIX aims to address the scaling limitations of the CBOE VIX. The SVIX allows traders to graph volatility as a 100% scale on securities that do not have an official CBOE VIX ticker symbol. The SVIX shows high correlation with the CBOE VIX. Backtesting indicators with an investment strategy using US stocks proved successful. The winning percentage of trades and net profit are positive only for long strategies and fail in short strategies.

Subjects: Applied Mathematics; Finance; Business, Management and Accounting

Keywords: volatility index; VIX; correlation; trading strategy

1. Introduction

The CBOE VIX (VIX) is a useful and popular tool for estimating market risk and short-term (30-day) volatility expectations. It is calculated using a complex methodology and is only available for the S&P 500 plus a few+ stocks (CBOE, 2017). The VIX is one of the simplest technical indicators: investors trade its movements through derivative products. The VIX cannot be traded directly as an instrument: exchange-traded funds track the VIX as closely as possible and allow investors to

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PUBLIC INTEREST STATEMENT

The Chicago Board Options Exchange volatility index (VIX—based on S&P500 prices) is a popular tool for estimating market risk and short-term volatility. It is one of the simplest technical trading indicators: investors follow and trade its movements using derivatives. Exchange traded funds also track the VIX, thereby allowing investors to trade the volatility of the S&P500. The VIX is, however, inapplicable to most stocks. Other indicators such as the VIX fix (a synthetic indicator applicable to any price time series) also have drawbacks. Stochastic volatility indicators (SVIXs) explore momentum and price ranges relative to relevant stock closing prices over a prescribed period. Implementing an SVIX allows a simplified trading strategy to be modelled using an indicator without the need for additional indicators to gauge a reference point. We explore which index produces the most profitable trading results for US and South African stocks.

trade the volatility of the S&P 500. A limitation of the VIX is, however, its inapplicability to most individual stocks (Hestla, 2015).

Williams (2007) created an alternative indicator known as the VIX fix (VIX_f). This indicator allows volatility to be plotted against any variable which has price data (Williams, 2007). It is effectively a synthetic VIX which allows the VIX to be duplicated on anything from treasury bonds to soybean futures. Unlike the VIX (which is based on future option prices), VIX_f is based on prior price information (Williams, 2007).

The use and creation of a synthetic VIX (VIX_f) is a thinly covered topic in relation to its application in technical trading and predictive abilities. A VIX_f exhibits predictive timing properties, which allows insight into the timing of indicators and assists traders in enhancing long-term fundamentals to better execute their market entries. A strategy requires decision points where trades will be fulfilled based on predetermined criteria. In the perfect scenario, it would not matter if the trader or the algorithm made the trade as the result would be the same. Humans make mistakes and act irrationally, which clouds judgements and distracts traders from planned strategies (Anderson, 2008). The dilemma appears when a few trades have been successful prior to the one that turns to a loss. A common mistake is to keep the losing position, which causes many investors to then refuse to cut their losses. This is due to the belief that the market will turn around (Anderson, 2008). Previous wins are often offset by one significant loss.

Knowing when to enter a trade is crucial, yet it is just as important to know when to exit. Stop-loss features are imperative at minimising large potential losses, if the trader does not deviate from his rules and strategies. Algorithm trading is even less susceptible to these mistakes as emotions are eliminated. Trade Navigator (Genesis Financial Technologies, 2017) executes only rule-based trading rules (i.e. the trading system is governed by rules which, when triggered, enter into the trade (or exit from it, depending on the rule). An example of a rule-based trade might be to sell a stock when its price exceeds a predetermined value.

Stochastic volatility indicators (SVIX) explore momentum and the highest high/lowest low range of prices relative to the closing price over a prescribed period. Implementing an SVIX allows a simplified trading strategy to be modelled using indicator without the need for additional indicators to gauge a reference point.

The main aim of this work is to demonstrate that the CBOE VIX may be duplicated (without the associated drawbacks) by the VIX_f and an SVIX. If a correlation is present between the VIX, the VIX_f and an SVIX, major accelerations and decelerations¹ in stock prices may be deduced.

This article proceeds as follows: Section 2 provides the relevant background to the problem and summarises the work that has preceded it. Section 3 presents the data and methodology, Section 4 the results and Section 5 concludes.

2. Literature study

In 2003, the CBOE with assistance from Goldman Sachs demonstrated a new and more accurate way to compute the VIX using option prices on the S&P 500, as opposed to implied volatility which had been used previously (Sloyer & Tolkin, 2008). This transformed the VIX into a useful indicator that heralded more liquidity (Chicago Board Options Exchange, 2009). Applying the VIX to any form of security that exhibits price information is of great importance to technical traders, allowing them to gauge the current market level and highlighting possibilities of future price trends.

Technical trading employs numerical modelling to identify trends and breakouts based on current and past price data. When indicators are used in conjunction with a trading strategy,

they identify more reliable trends that would be otherwise invisible by just observing price information or one specific indicator (Folger, 2012).

Volatility indicators provide great value to a technical trader's tools as they demonstrate insight into the trading range as well as acceleration and deceleration of a product's price (The Economic Times, 2017). This aids in timing the trade and the momentum behind its direction (Folger, 2012). Since the VIX is modelled on a minimal number of indices and products, it is of limited use to most technical traders as it cannot be applied to specific stocks or commodities. The VIX has specific volatility time frames from one month and, more recently, up to three months (called the VIX3M), which is less volatile than its relatively shorter time framed indicators from the CBOE suite of VIXs. The advantage of the SVIX is that its duration may be entirely customised. A timing tool which can be altered to long-term fundamental traders enables them to include a timing indicator into their strategy.

2.1. William's VIX_f

Williams (2007) described a volatility indicator that could be applied to securities without using option prices and illustrated his findings using comparative graphs between gold, the VIX and stocks. A look-back on price data was used to develop a VIX_f graphed which claimed to reproduce the performance of the VIX (Williams, 2007).

Prior to 2011, the CBOE only provided a few volatility indices on major indexes and frequently traded commodities. In 2011, the CBOE launched a set of new products where a total of five major stocks within the S&P 500 received their own VIX from the CBOE (CBOE, 2017)—some four years after Williams (2007) released his findings on the SVIX (Williams, 2007).

Hestla (2015) argued that the VIX_f can be used in conjunction with a basic metric such as the Moving Average (MA) indicator to generate returns and base strategies thereon. The method explores the S&P 500 rather than individual stocks. Hestla (2015) used a 20-day look back in Williams (2007) VIX_f formulation which does not cover all the days in most months when using a daily time frame. The goal is to include look-back periods of up to 23 days in backtesting results on specific stocks instead of the index in its entirety.

Hestla (2015) highlighted that the VIX_f does work when coupled with an MA, as positive results were observed when backtesting this strategy. This article aims to further that investigation using a group of stocks coupled with a fresh look at the VIX_f achieved by removing the MA indicator and adding a percentage scale (stochastic oscillator). A stochastic volatility indicator explores momentum and the highest high/lowest low range in relation to the closing price over a set timescale. It is often used to identify the best entry and exit points (Investing Answers, n.d.). The aim is to limit the lag time seen with the MA indicator which could cause delayed buy and sell setups. To compare results obtained using the various VIXs robustly and accurately, we employed the same strategies as those used by Hestla (2015).

2.2. Limitations of the VIX_f

The scaling of the VIX_f is not ideal and reverts to the limitations of the VIX. The level of volatility represented by a specific number on the graph needs to have meaning in relation to itself over a period. The same problem exists with Hestla's (2015) in the way the buys and sells are triggered. They cannot be triggered on any level of the VIX_f on its own as its meaning and value are irrelevant unless compared for a reference.

"To develop a test of the effectiveness of the VIX_f , an MA can be added to the indicator" (Hestla, 2015). Hestla (2015) solved that problem by using an MA to compare the VIX_f to create a reference when the volatility is in high or low periods (mean reverting volatility was assumed) (Hestla, 2015).

The trading strategy of buying in a period when the VIX_f falls below the MA has merit when markets are in a constant up and downtrend. A stock price rarely exhibits only definitive up or downtrends: they can also move sideways² (Domm, 2014). A sideways movement is not always favourable if leveraged through a contract for difference (CFD) products or spread betting, as lending interest rates limit profits. Even if no leverage is used, changing from cash into an equity trade for a sideways movement limits the amount of interest return that could have been generated if it were held in cash. The idea is to distinguish between negligible volatility spikes and definitive ones. Timing is key before major swings in the market.

“A buy will be triggered when the VIX_f falls below the MA and a sell will be generated when the VIX_f rises above the MA” (Hestla, 2015). The VIX_f buy strategy with the MA can oscillate at times when a stock is in a sideways movement causing unnecessary entries and exits, which will incur pointless commissions. The buy and sell trigger in this strategy is linked to the indicator which is a limitation as huge spikes in a stock price can trigger an exorbitant amount of entries and exits. These false signals can cause a sell due to an anomaly of the previous day’s trading data when in fact the stock is still on an upward trend and is experiencing short-term volatility. Thus, exits are often executed too early and potential profits are left in the market.

An adjustment to this strategy would only look at indicators for an entry into the market based on the indicator, regardless of position direction. Exits will not be based on indicators but instead, with a trailing stop loss³ based on account size, they will be triggered on profit taking or risk management strategies which can be tailored to the markets that one is operating in. Profits can be taken at first profitable opening or in staggered stages. Stage one would include bringing the stop loss up to the opening price when in profit. Profits would be locked in on one-third of the position, leaving two-thirds in play to ride the trend and let profits run. Coupled with a trailing stop loss behind with the remainder of the position. Swings in the market will be captured through triggers based on indicators and exits will rely on strategies that are predefined on price movement.

2.3. Risk management

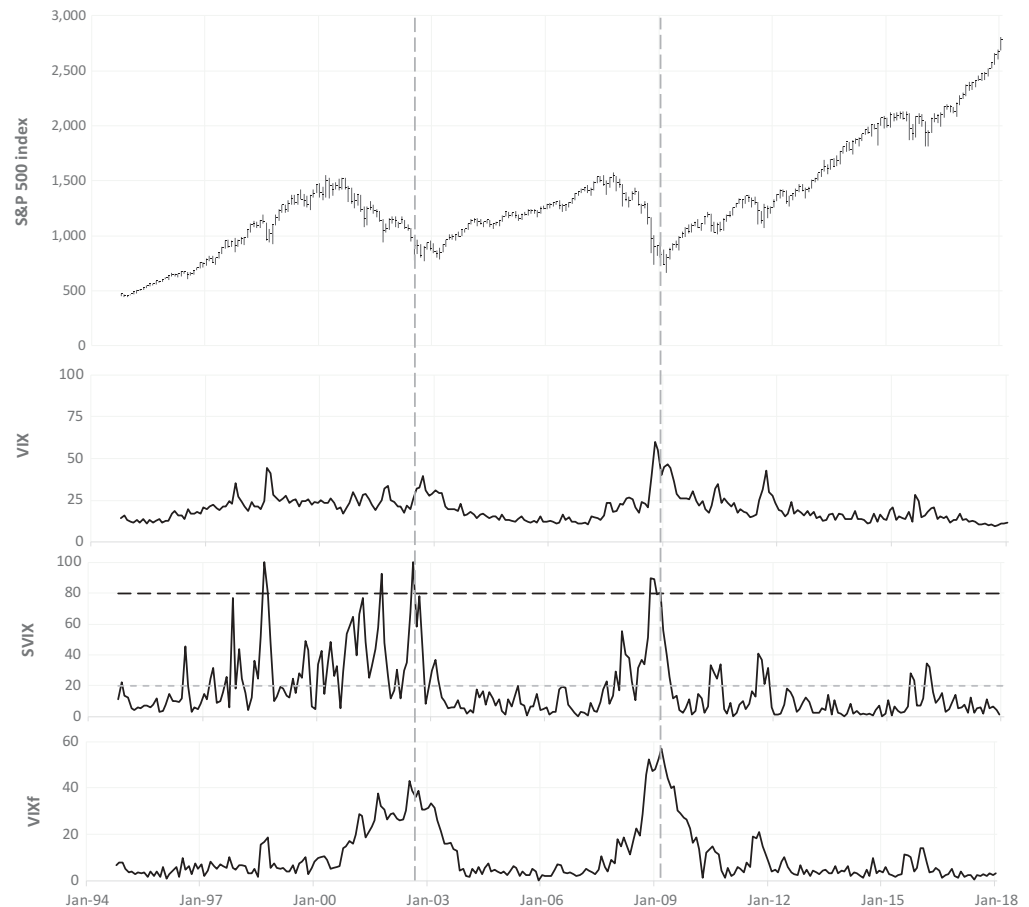
Indicators are sometimes inaccurate: they are influenced and affected by market noise. Traders can optimise indicators in a way that they are less likely to be affected by market noise, yet this is not a fool-proof approach. Risk management strategies are needed to quell large potential losses if the market turns in the opposite direction. Setting the amount of risk per trade is the first step. (Mitchell, 2016). Determine the percentage that an investor is willing to forgo on each trade, usually, 1% of the trading account value. Therefore, the strategy would need to fail 100 times for the account to cease. An account size of \$45 000 would entail an investor risking \$450 per trade as a maximum dollar value stop loss (Mitchell, 2016).

On each trade made, the difference between the opening price and stop loss multiplied by position size equals the risk amount. This determines the price for which the stop loss equals the maximum-risked amount. Note that each trade is different depending on the stock’s volatility. The stock’s price, whether high or low, will affect how close the open price and stop loss price are in dollar terms. “You want your stop loss as close to your entry point as possible, but not so close that the trade is stopped out before the price move you’re expecting occurs” (Mitchell, 2016). Scenarios are set out in the methodology regarding how different shares and how volatile stocks require stop losses further away from the opening position.

3. Data and methodology

The data used in the following test are daily price data of the relevant indices (such as the S&P500), the investigated stocks (such as Amazon, etc.) and the daily values of the CBOE VIX. These data span the period January 1995 to January 2018, supplied by Genesis Financial Technologies (Genesis Financial Technologies, 2017). The reason why price data—rather than option data—were chosen is because option prices may not be available for certain assets, such as stocks. The value in the VIX_f is if it can be traded, may then be graphed.

Figure 1. S&P500 and the VIX, VIX_f and SVIX on the same timescale. There is a strong correlation between the volatility indices: SVIX: VIX_f 0.82, and SVIX: VIX 0.76 and VIX: VIX_f 0.81. The SVIX displays the highest volatility over 80% (at S&P500 bottoms).



In Figure 1, the S&P 500 index was used as a starting point from which the CBOE VIX could also be graphed on the index. From there the SVIX, VIX and VIX_f used in Hestla's report were displayed using monthly S&P 500 price data.

The VIX_f formula designed by Williams (2007) and used by (Hestla, 2015) is:

$$VIX_f: \frac{(\text{Highest}(\text{Close}, 20) - \text{Low})}{(\text{Highest}(\text{Close}, 20))} \times 100 \quad (1)$$

where the terms in (1) represent the highest closing bar of the last 20 bars and the low of the current bar, respectively (Williams, 2007).

The look-back period is kept at 20 bars so that it can be of comparison to Hestla's (2015). Working with a set number of bars makes scaling interchangeable when observing longer or shorter time frames on any graphing program, as each bar can represent either hourly or weekly time frames.

The formula for the stochastic VIX (SVIX) is (Stock Charts, 2009):

$$SVIX: \frac{\text{Current Close} - \text{Lowest Low}}{\text{Highest High} - \text{Lowest Low}} \times 100 \quad (2)$$

where current close is the current closing bar value and the lowest low the lowest value observed and the highest high the highest value observed over the relevant period. The purpose of adding the

stochastic is to allow a simplified trading strategy to be modelled on the indicator without the need for additional indicators to gauge a reference point as to where the VIX_f is in relation to itself (Figure 1).

Williams (2007) VIX_f tracks highs and lows: many of the displayed market highs are above 80% (i.e. a buy set up) with lows below 20% (i.e. sell set up) (Williams, 2007).

The SVIX allows for easier manipulation into a trading strategy using a fixed percentage moving range (0%—100%) (this will be used later in the strategy stage). Dashed lines in Figure 1 (SVIX) display the 80% and 20% zones which may be used to indicate buy and sell set-up zones. These are only useful on the stochastic as it is percentage scaled. The same spike in volatility is captured on the VIX_f but numerically it signals at just over 50.

The vertical-dashed lines represent periods of extreme volatility (i.e. buy setups, over 80%): significant up trends from those points are apparent. The triggering buy and sell zones help limit the number of false signals a trading strategy will take. They also indicate major acceleration and declaration swings in the market (Figure 1). Sell setups are not viable in long time frames due to most stocks markets having constant uptrend since market inception, therefore low volatility is exhibited due to its inverse relationship with the S&P 500 (Cox, 2017). Sell setups are favourable in the shorter periods where major downward swings can be captured, backtesting will determine if the strategy is profitable.

4. Results

4.1. Correlation

The same idea as displayed in Figure 1 may be applied to daily data (rather than monthly). Greater volatility is seen due to the reduced period with more highs and lows through the trigger regions (i.e. over 80% buy setups). Figure 2 displays the S&P 500 using daily data for a period of one year, from 01.1.2014 to 01.1.2015. Correlation between the SVIX and the VIX is still present, with both indicators signalling S&P 500 bottoms effectively.

In Figure 2 increasing volatility is present with more signals appearing than in the monthly period. Major uptrend moves appear to originate in periods of high stochastic volatility (above 80%).

The SVIX replicates the VIX using price data. If the same technique is applied to an individual stock from the S&P 500 index, the VIX will generally perform adequately in emphasising periods of high and low volatility. Even though the VIX only applies to the entire S&P 500 volatility and not individual stocks (Hestla, 2015). The VIX_f “can be used to identify volatile stocks during periods of relative calm in the broad market” (Hestla, 2015). There are stocks in the S&P 500 which have lower correlation with the index than most and where the VIX would not represent the volatility of those specific stocks correctly. These stocks allow investors to diversify their portfolios and with a niche tool such as an SVIX, high volatility stocks may be identified simply when the general market is not in a volatile period (Benninton Investment Ideas, 2014).

The rationale behind major stocks having similar trends to the index of the S&P 500 is due to the weighting calculation of the index. The S&P 500 is weighted by market capitalisation. Larger companies, therefore, move the index more than smaller ones (FTSE Russell, 2017). Which in turn has the same effect on the VIX, as a majority of the stocks will negatively correlate with the VIX, rendering the VIX irrelevant the SVIX would be implemented instead.

The SVIX aims to identify volatile stocks when most of the market is composed, along with other indices around the world which do not have volatility indicators. In Figure 3, the VIX is compared with the SVIX volatility to illustrate a stock that has volatile movements when the general market is stable.

Figure 2. Daily chart of the S&P 500. SVIX displays consistent correlation with the VIX.

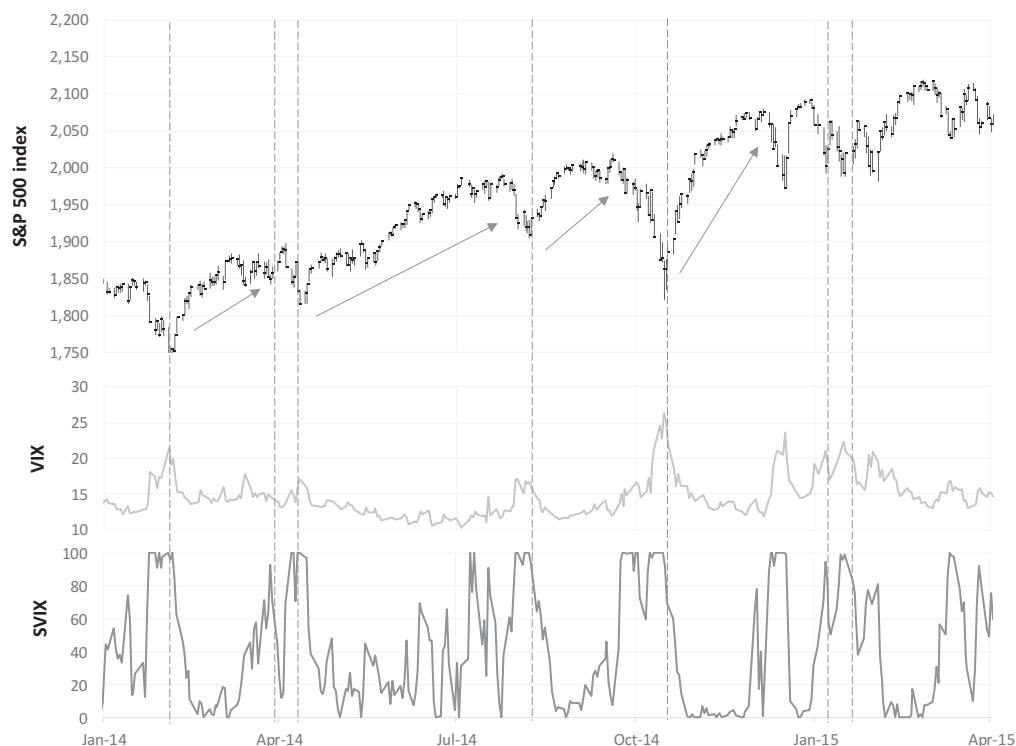
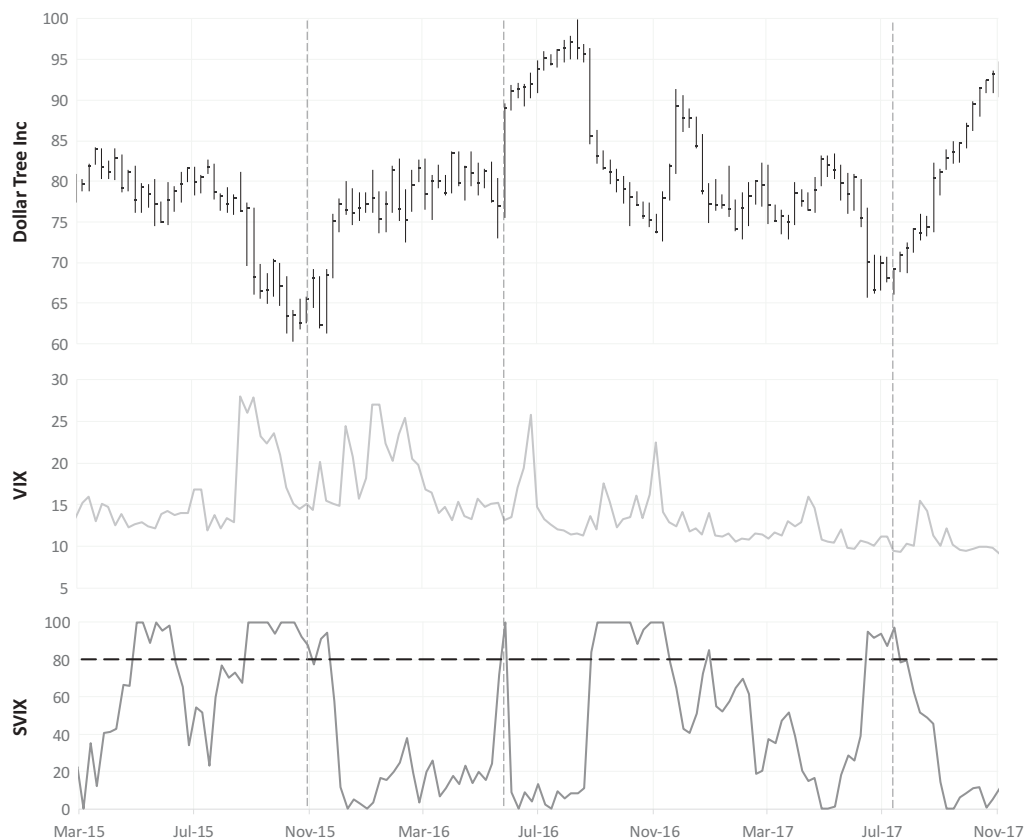


Figure 3. Dollar tree's volatility according to VIX and the SVIX comparison. The VIX fails to signal highs and lows as accurately as the SVIX fix causing potential buy set ups to be missed.



CBOE created individual equity volatility indices on five major S&P 500 stocks, four of them are from the technology sector. “A quartet of tech heavyweights (Apple, Microsoft, Amazon and Facebook) collectively make up more than 10% of the S&P 500” (Ungarino, 2017). Significant correlation exists between Apple, Amazon, IBM, and Google since they all operate in the same sector and represented some of the most influential stocks in the S&P 500. The initial methodology was to compare CBOE’s equity volatility indices for Apple and Amazon against the SVIX but to prevent results from being correlated and biased, further tests would be tried and backtested without CBOE’s equity indices. Figure 4 shows the VIX, VXAZN (Amazon’s VIX) and VXAPL (Apple’s VIX) indicating the correlation between the three ticker symbols created by the CBOE.

4.2. Sideways market movements

Previously, attention was brought to the signals Hestla’s (2015) strategy took and how they could struggle in a sideways market. Figure 5 displays the daily price movement of Goldman Sachs stock price over a period of five months. Prices in Figure 5 are in a sideways trend. The SVIX is shown with Hestla’s (2015) VIX_f and MA strategy to highlight the range of signals gathered between the two indicators. The strategy implemented by Hestla (2015) encompasses an entry and exit strategy based on the indicator’s signals. One aims to encompass an entry based on SVIX signals and an exit based on profit taking with a fixed stop-loss.

The aim of the SVIX is to represent and track the VIX accurately and decrease the amount of trading signals down to definitive and less volatile ones. In Figure 5, Hestla’s (2015) strategy is shown in the bottom indicator box. The buy is executed when the VIX_f falls below the 20-day MA and exits when the VIX_f rises above the 20-day MA (Hestla, 2015). Entry points (arrows) indicate where the VIX_f crosses below the MA. The strategy indicates it would have entered the market on a long position nine times.

Volatility above 80% signifies a buy signal (Williams, 2007): the SVIX shows lower volatility in trade signals. The tops (>80%) are six buy signals versus Hestla’s (2015) nine. Over a longer period, commission costs are reduced, and overall efficiency increased as fewer signals indicate decreased movements in stock prices. Equity can be thus used in more profitable trades elsewhere.

4.3. MA limitation

A limitation in Hestla’s (2015) strategy is the loss of profits before the exit on a trade is signalled. When the VIX_f falls below the MA, an exit is taken, and the long position is closed. Although the substantial gains that were acquired can be lost whilst waiting for the exit signal (MA to cross below the VIX_f), this is due to the smoothing of the MA as 20 days of price information is used. This can be seen in Figure 6 along with the lagged MA coupled with the VIX_f .

In Figure 6, two examples are shown where large uptrend movements are captured by both indicators. The solid vertical lines represent the SVIX at its highest point and dashed vertical lines

Figure 4. Quarterly price data for Amazon’s VIX, Apple’s VIX and the VIX (Market Watch, 2017).

Signals

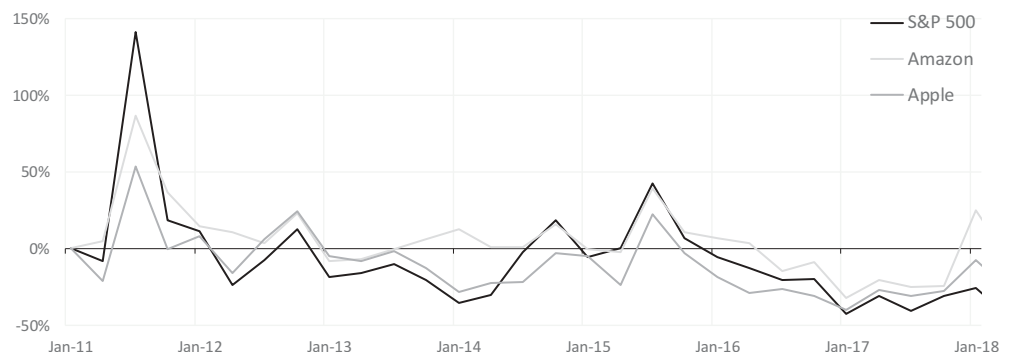
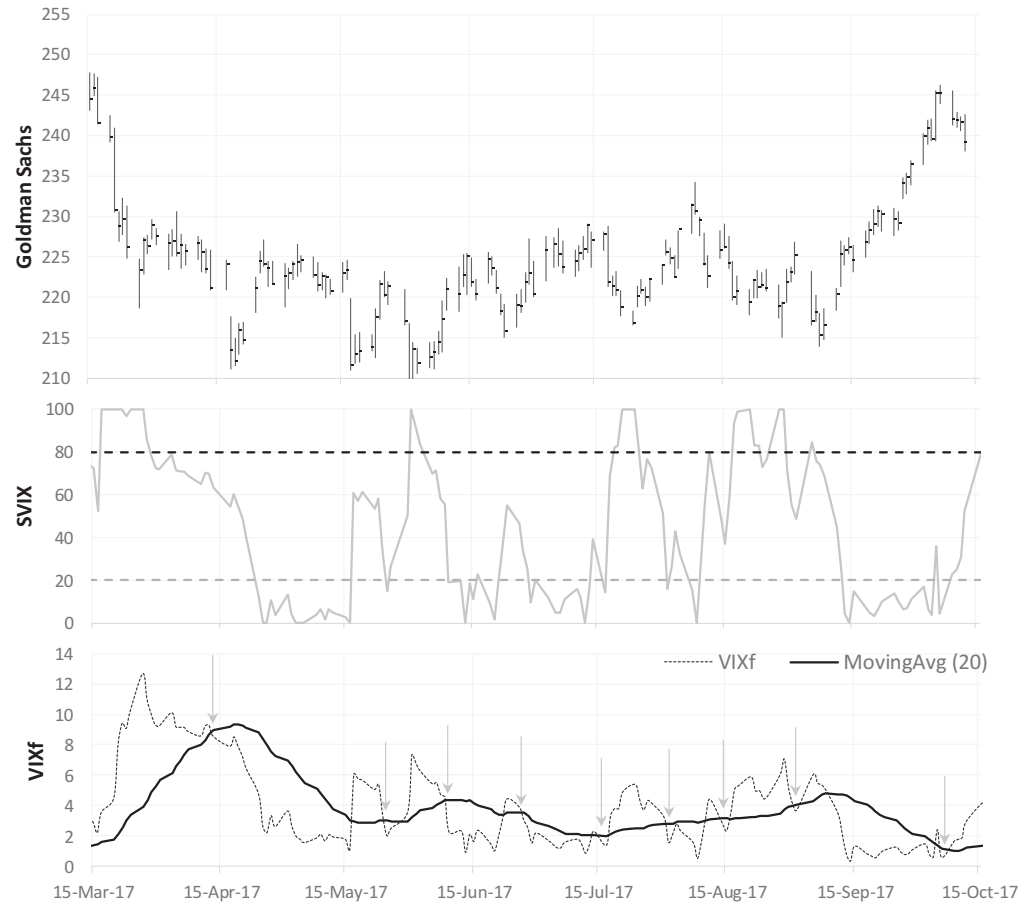


Figure 5. Daily price information for Goldman Sachs over a period of five months.



indicate when Hestla's (2015) strategy is in a buy zone, meaning MA is higher than the VIX_f . Connecting the signals to the stock price history by means of corresponding vertical lines enables a look back at when and if major moves were signalled.

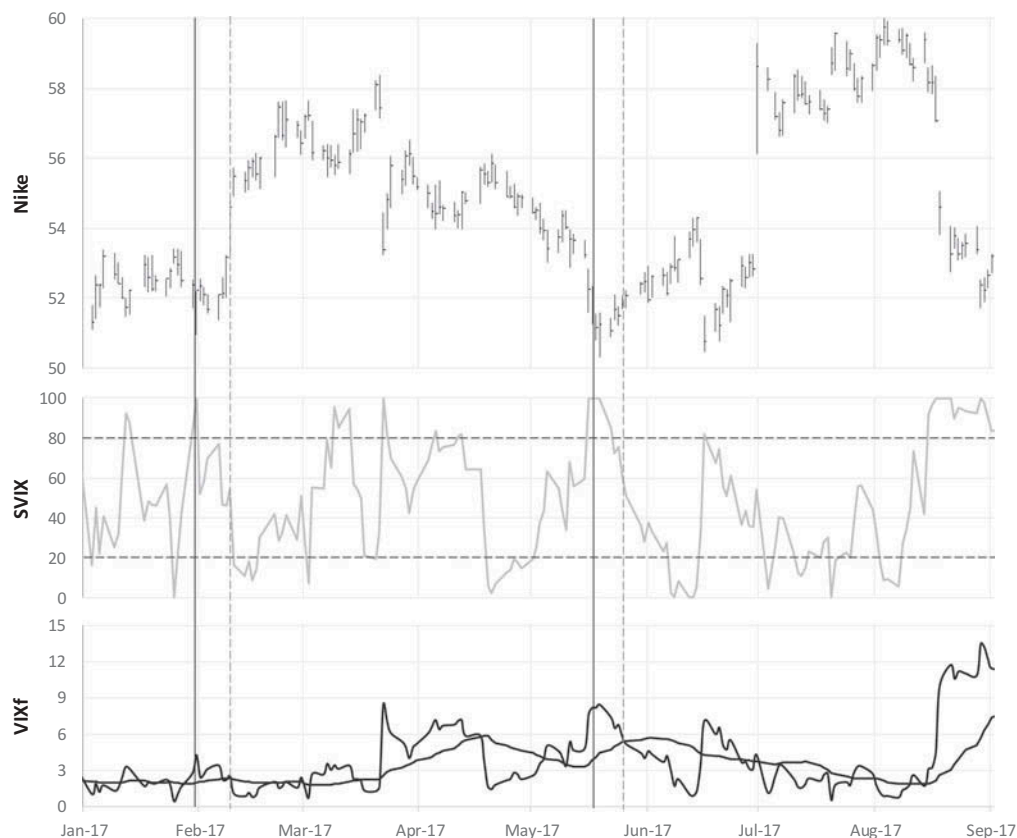
Both indicators signalled the first uptrend on the left of Figure 6, yet the SVIX inhibits some of the VIX's forward-looking characteristics. Observing the second indicators (MA and VIX_f), the strategy implemented by Hestla (2015) indicates lagging. The signals provided are delayed and some of the upward movements have been lost due to the lag, approximately between 4 and 6 bars. This is not always the case, but it does have an impact on the profitability of over longer periods.

4.4. Entry techniques

This brings about the entry technique that shall be used with the SVIX. The aim is to disallow the indicators to preselect the entry and exit points as seen with the second indicator set in Figure 6. In place of buying when the two indicators cross, entries into the market will take place when the SVIX is $>80\%$. The algorithm places a buy stop order at the previous day's high (the previous daily bar's highest point) given it is above the current market value which captures the signalled uptrend of the stocks price if it occurs. If it does not do so for a period of five to seven bars the order is deleted. This protects a trader from the so-called "falling knife", in which a stock price falls sharply no matter how accurate the indicators display the setup.

Indicators are not a foolproof system but coupled with entry and risk management techniques they can be used as powerful tools. Using the entry on the previous day's high (when the SVIX is $>80\%$), mitigates the risk of holding shares whose prices are still falling. During the back-testing,

Figure 6. Daily Nike price information. Leading and lagging attributes are highlighted.



parameters are changed to determine which favours a more profitable strategy, opening on the previous day's high or at next day's market close.

Exit strategies are more challenging as each trade is unique in its self and is dependent on which market and what security is being analysed. Some are more volatile than others causing profit taking to be later or earlier. Greed can also affect the portfolio's profits and sometimes having predetermined exit rules help. Since an algorithm will be used that factor is less problematic. Exit strategies are not be based on indicators at all, they are price denominated as the aim is to prove the SVIX is profitable with a basic strategy. The fixed stop-loss percentage is unique to the market in which the algorithm trades. A low volatility market can have a closer stop loss as there is less chance that the normal daily trading range will unnecessarily trigger the stop loss.

4.5. Characterising south african stocks

Stocks in emerging markets typically have additional volatility in their markets (Lydon, 2017). This is the case in South Africa, as many stocks on the Johannesburg Stock Exchange (JSE) can move as much as 10% in a trading day, which is not uncommon. This can be a problem for an algorithm with a set stop loss. The daily trading range is likely to be high. The aim is not to let the trade get stopped out before it has the chance to move in the indicated direction. Limiting risk on single trades is also important. Figure 7 displays a stock within the JSE Stock Exchange that inhibits a relatively high daily trading range. This limitation of the trading algorithm is its inability to adapt to the market it is operating in. Slight adjustments need to be made to position taking in every market through a consensus of selected parameters.

Figure 7. Anglo American Platinum price information, displaying high trading ranges.



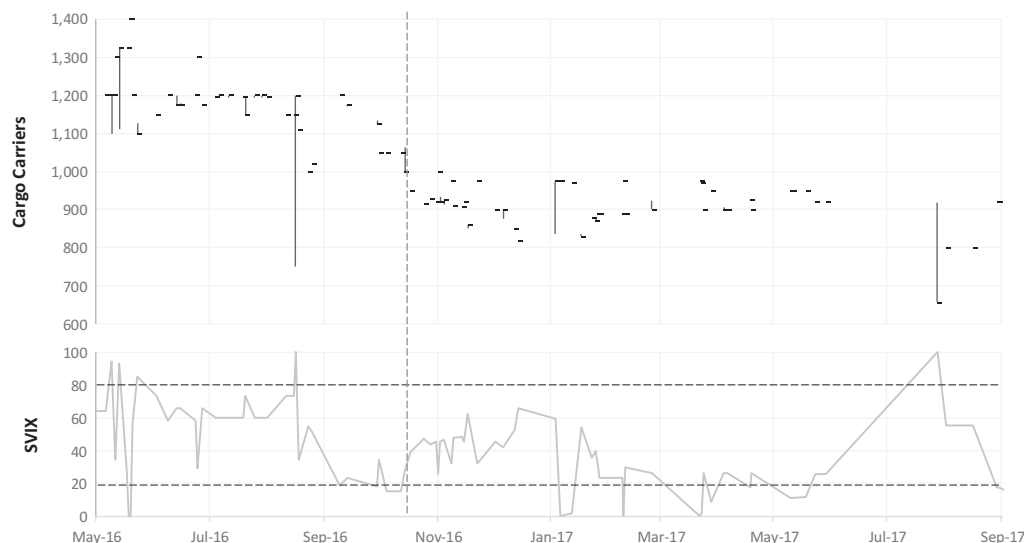
Observing Figure 7, a buy signal is triggered at the solid vertical line. If buys are consistent with previously discussed strategies, then the buy stop order is placed on the previous trading day's high (Lateral dotted line). The importance of using a buy stop order in place of the market or limit order is to ensure the stock is at its swing point and in an upward trend, thus limiting the risk of buying when it is still in a downward direction. The lateral dotted line connecting the solid vertical signal line and the trading bar before it signifies the high point of the previous day before the signal and is the price of the buy stop order. The following day after the signal (solid vertical line), the trigger price the lateral black dotted line is hit which is signified by the dashed vertical line. This is the point where the order is filled due to the price rising through the buy stop order, a long position is now held in this security.

Figure 7 displays how a stock with a wide trading range can cause early exits to occur if one does not take notice of the market's characteristics. In the US market such as the S&P 500, stop losses of a few percent would suffice. In this instance, the stock price plunges about 8% of four trading bars after the entry line. In this example, a stop loss too close to the opening price would cause a premature exit, disallowing the stock to run and earn profits as anticipated. Comparing the 8% bar to many other trading bars indicates that this stock can often move between 7% and 8% in a daily trading day. Although the stock price increases for two months after the signal, this demonstrates how some stocks may need wider stop losses than others due to their trading traits.

A limitation of trading in emerging markets is the lack of liquidity in certain securities (Lesmond, 2002). Some stocks within the JSE will not trade a single share for a few days. There is inherently a higher chance of price manipulation on these stocks due to the lack of consistent volume and trading information. Technical trading is not advised in market conditions such as these, due to a wide variety of outside factors that could potentially skew the signals of indicators.

Volatility is inherently high on these stocks which adds to the riskiness when trading them, as market jumps are expected on open and close. Market fluctuations cause chaos for traders that place buy stop orders, as there is inherit risk of the trade being filled above the predetermined price if the next trading bar gaps up. Markets such as the JSE encapsulate many of these stocks. One of

Figure 8. JSE Cargo Carriers display the lack of trading activity on daily price information.



the major limitations is the lack of tradable stocks, as at least half are untradeable as a technical trader. Figure 8 displays an example and how indicator signals cannot be used due to the lack of frequent price information.

Figure 8 is a prime example of multiple stocks on JSE that cannot be traded on a technical indicator. On most days, the stock has not moved within the trading hours which is explained by a dash. The dashed vertical line indicates price jumps from open to close with no daily trading range either. Since the indicators being used have been derived from price information, it is imperative that consistent and frequently traded securities are used to generate signals from. Market jumps are evident between dashes that change levels with no bar. There are no significant patterns nor is continuity apparent during this time. Price charts should look like Figures 6 and 7 before any analysis is undertaken.

4.6. Backtesting

The objective of the back-test section is to show the effectiveness of the SVIX with a basic trading strategy and simple profit taking. The use of the SVIX in the trading strategy by a trader could not be tested due to the time it would take to capture the results in real time hence the use of backtesting. If results were favourable while back testing with the utmost mundane strategies, then it would be highly effective with more complicated and efficient algorithms. The first initial backtesting was done over a 10-year period (1 November 2004 to 31 October 2014). The reason for this period is due to its inclusion of the 2007 financial crash, as opposed to the last 10 years from 2017 where markets have exhibited a constant bull trend.

Backtesting a strategy with no human input poses challenges. Although fewer human mistakes occur, the algorithm is relatively inflexible. All predefined parameters must be decided before backtesting. The human element can allow staggered stages of profit taking with little ease, allowing small amounts of profits to be taken early on. Further actions can be made by moving stop losses that were set at percentages below the open price to the breakeven price. This limits a trader's risk by covering expenses once the trade has moved into the green. The initial stop loss provides breathing room for the trade.

When the trade opens and has not moved into a profit position, an appropriately set stop loss allows the trade to move around without being stopped out early. For example, when the trade

first exhibits a profit, one third⁴ can be sold with the stop loss brought up to breakeven, reducing risk and allowing the trade to run on the remaining two-thirds in the market. This style of trading is entirely possible with algorithm trading, yet there needs to be extensive coding to assemble this complicated exit strategy. While the aim was not to have developed the best exit strategies but to highlight the effectiveness of an SVIX in its accuracy and predictive abilities.

The exit strategy will be taken on the first profitable opening. First profitable opening exits whenever there is profit, no matter how big or small, if one dollar has been made the profit will be taken and the position existed. The exit is extremely inefficient which leaves a large amount of profits behind on purpose, to gauge worst case scenario results. This aims at stress testing the indicator and its signals. The test in Figure 9 was performed on daily data and used 20 days as a look back in the SVIX formula. The test was performed on an S&P 500 ETF (electronic-traded fund) tracker. The ticker symbol for the ETF is IVV (iShares S&P 500 Index Fund). The test results should be positive, but no expectation of great profits as the strategy is not optimised for maximisation, the aim is to display its potential.

Trades were taken when the SVIX breached the 80% threshold and exited at first profitable opening. Trades were not taken on a fixed number of shares as comparing stocks with different stock prices would influence the results. Selecting a fixed amount of dollars per trade allows the same percentage change in the stock as the amount of profit. In Table 1, a \$1 000 trade would take place each time a signal was given, provided no long position was already in play on that stock. A fixed stop loss of \$140 was chosen.

The annual return percentage assumes an investment of \$1 000 on each trade with no risk management and pre-existing equity. After each trade is exited the balance is held in a cash position which assumes no interest rate. The balance position never falls below the \$1 000 mark. The stop loss is triggered three times during the duration with the first stop loss triggering in 2008. Table 2 displays the annual account size and stop loss occurrences.

Table 1. Backtest results for IVV (S&P 500 ETF) over 10 years

Daily	Total net profit	Winning %	Total trades made	% time invested in market	Annual return rate
IVV ETF	\$846	98.3 %	176	24.2%	8.46%

Table 2. Annual strategy accounts over the 10-year period (Genesis Financial Technologies, 2017)

Y	T	W%	Wa	AT	ML	Pt	NPt 1,000	AB	%i
05	19	100.00	3	3	0	58	1,058	5.32	5.80
06	18	100.00	4	4	0	80	1,138	1.78	7.59
07	22	100.00	5	5	0	117	1,255	2.45	10.25
08	27	96.30	11	6	-140	155	1,410	2.04	12.37
09	21	100.00	11	11	0	237	1,647	2.24	16.78
10	14	92.86	10	0	-140	-7	1,640	4.36	-0.41
11	17	94.12	7	-2	-140	-30	1,610	3.29	-1.83
12	12	100.00	5	5	0	62	1,673	6.17	3.88
13	13	100.00	9	9	0	114	1,786	5.54	6.81
14	13	100.00	9	5	0	60	1,846	3.62	3.35

Key: Y—year, T—trades, W%—win%, Wa—win average, AT—average trade, ML—max loss, Pt—profit, NPt—net profit, AB—average bars, %i—percentage increase.

Table 2 shows the first stop loss occurred in 2008 when the account held a level of \$1 410 indicating that the account never went bust, ensuring there was always a \$1 000 to make the next trade. This strategy takes profits whenever they are available with a reasonable sample size of 174 trades over the 10-year period.

4.7. Testing individual US stocks

Testing the strategy on major and popular stocks within the US market displays the adaptability of the indicator across multiple sectors. The same strategy was used as above; exits were either at the stop loss or at first profitable opening. The stop loss was increased to \$270 which was optimised to the general stock market based on trading ranges. Ten large US stocks were selected. The dollar amount per trade on each stock is fixed at \$1 000, therefore the starting amount is \$10 000 as each stock would require a \$1 000 each if trades were opened concurrently on all 10 stocks. Transaction fees were set at \$2 per transaction. Transaction fees would affect profits less if the dollar amount traded were substantially larger.

In the case where each trade is \$2 000, larger profits would be made and the \$2 commission would have less of an effect on profitability as it would be fixed. Table 3 indicates the results that were obtained over the 10-year period. Table 4 displays each stocks performance individually over the backtesting duration.

Table 5 shows the stocks' full details, and Table 6 the combined performance of the top 10 US companies. Table 7 shows the coding used to create the backtest.

The strategy exhibited an abundance of winning percentages amongst the 10 companies with a profitable return. A strategy's profitability will always be subject to interpretation depending on end-user requirements. That the net profit is positive highlights the accomplishment of the SVIX, especially since a one size fits all approach was taken on the exit strategies and stop losses.

A fixed stop loss of the same value used amongst 10 large US stocks with varying trading ranges, highlights the resilience. The strategy is simple and is not optimised. Profits were reduced by transaction costs which would have less of an effect if larger amounts were traded. Opened

Table 3. Annual account of the strategy's performance on a basket of 10 US stocks. Each year represents the combined result of all 10 stocks (Genesis Financial Technologies, 2017). This maximum loss exceeds the stop loss of \$270 possibly because of the volatility severity that day an exit by day end that matched \$270 did not occur. This would then have been the closet available market price

Y	T	W%	Wa	P	AT	ML	Pt	NPt \$10,000	AB	%i
04	18	83.33	11	46.99	9	-2	161	10,161	2.50	1.61
05	135	61.48	9	2.22	3	-275	431	10,593	5.34	4.25
06	155	69.03	9	10.79	5	-4	834	11,427	5.79	7.87
07	134	76.12	12	4.00	7	-274	954	12,381	4.87	8.35
08	171	81.87	34	1.32	7	-308	1,165	13,546	7.66	9.41
09	166	86.14	27	6.52	19	-274	3,215	16,761	3.51	23.73
10	128	79.69	10	33.31	8	-3	1,039	17,800	7.78	6.20
11	163	82.21	12	2.84	7	-274	1,084	18,883	5.44	6.09
12	140	72.14	9	12.80	6	-4	792	19,675	7.24	4.19
13	126	66.67	11	2.57	4	-274	550	20,226	5.66	2.80
14	138	60.14	6	4.26	3	-4	370	20,596	6.75	1.83

Key: Y—year, T—trades, W%—win%, Wa—win average, P—profit factor, AT—average trade, ML—max loss, Pt—profit, NPt—net profit, AB—average bars, %i—percentage increase.

Table 4. Individual daily stock performance of the 10 US stocks (Genesis Financial Technologies, 2017) from 1 November 2004 to 31 October 2014 using the DC first profitable opening strategy

Test	Symbol	Net profit	Max drawdown	Profit factor	Trades	Avg trade	Payout	Win %
1	AAPL	\$1,163	-\$352	2.35	163	\$7	0.49	82.8%
2	C	\$1,642	-\$327	2.36	166	\$10	1.24	65.7%
3	CMCSA	\$740	-\$274	3.36	129	\$6	1.15	74.4%
4	F	\$1,439	-\$357	2.27	150	\$10	0.48	82.7%
5	GE	\$1,290	-\$12	15.05	170	\$8	7.2	67.6%
6	JPM	\$705	-\$454	2.13	139	\$5	1.02	67.6%
7	MA	\$692	-\$536	2.14	131	\$5	0.72	74.8%
8	TSM	\$1,141	-\$308	4.47	143	\$8	0.73	86.0%
9	UL	\$620	-\$274	2.93	113	\$5	0.97	75.2%
10	WFC	\$1,165	-\$274	2.80	170	\$7	1.34	67.6%

Table 5. Names and ticker symbols of the 10 stocks used in the backtesting strategy

Symbol	Stock
AAPL	Apple Inc
C	Citigroup Inc.
CMCSA	Comcast Corp
F	Ford Motor Co
GE	General Electric
JPM	JPMorgan Chase & Co
MA	MasterCard Inc.
TSM	Taiwan Semiconductor Manufacturing
UL	Unilever
WFC	Wells Fargo

Table 6. Overall combined performance of the top 10 US companies

Daily combined performance	Overall winning percentage	Total net profit	Annual percentage return	Total trades made
10 US Stocks	74.2%	\$10,596	10.6%	1474

Table 7. The coding used to create the back-test entries and exits. Formatted by TRADESENSE® (Genesis Financial Technologies, 2017)

Long entry code	IF SVIX (0.5) Of Daily > 80 THEN BUY NEXT Bar at MARKET ON CLOSE
First profitable opening code	IF Next Bar Open > Entry Price + (Tick Move * 1) And Bars Since Entry ≥ 0 THEN SELL Next Bar at Next Bar Open + (0 * Tick Move) LIMIT

positions were on the market close of the next day instead of a stop buy order to allow the algorithm to limit losses. This may have hampered the results slightly but increases the chance of the strategy failing.

The 10.6% annual return calculation assumes the worst case scenario, it assumes each share had a trade signal from the first day the algorithm started trading. Therefore, at \$1 000 per trade for each of the 10 stocks, requires an initial balance of \$10 000 if every stock opened a position at the same time. This is not always the case and rarely happens if stocks are from uncorrelated market sectors.

The Trade Navigator software (Genesis Financial Technologies, 2017) determines at the end of the backtesting what account size would have been required to make the strategy work. This includes drawdowns or decreases in the account that would need to be sustained before it rose again. According to the final report, an account size of \$2 642 would have been needed to acquire those net profits. This explains the 401% return in the summary report over the 10-year period in Table 8.

Table 8. Full summary report issued by Trade Navigator (Genesis Financial Technologies, 2017) on US stocks

Overall			
Total net profit:	\$10,596	Profit factor (\$Wins/\$Losses):	2.73
Total trades:	1,474	Winning percentage:	74.2%
Average trade:	\$7	Payout ratio (AvgWin/AvgLoss):	0.95
Max closed-out drawdown:	-\$1,349	CPC index (PF x Win% x PR):	1.92
Max intra-trade drawdown:	-\$1,450	Expectancy (AvgTrade/AvgLoss):	44.57%
Account size required:	\$2,642	Return pct:	401.0%
Open equity:	-\$127	Kelly pct (AvgTrade/AvgWin):	47.02%
Percent in the market:	35.3%	Optimal f:	0.68
Avg # of bars in trade:	5.94	Z-score (W/L Predictability):	-1.9
Avg # of trades per year:	147.7	Current streak:	1 Losses
Monthly profit analysis			
Average monthly profit:	\$88	Monthly sharpe ratio:	0.57
Std dev of monthly profits:	\$148	Annualised sharpe ratio:	1.99
		Calmar ratio:	0.73
Winning trades		Losing trades	
Total winners:	1,094	Total losers:	380
Gross profit:	\$16,724	Gross loss:	-\$6,128
Average win:	\$15	Average loss:	-\$16
Largest win:	\$429	Largest loss:	-\$308
Largest drawdown in win:	-\$259	Largest peak in loss:	\$27
Avg drawdown in win:	-\$25	Avg peak in loss:	\$0
Avg run up in win:	\$17	Avg run up in loss:	\$0
Avg run down in win:	-\$25	Avg run down in loss:	-\$31
Most consec wins:	60	Most consec losses:	5
Avg # of consec wins:	4.08	Avg # of consec losses:	1.42
Avg # of bars in wins:	5.14	Avg # of bars in losses:	8.24

Summary—All Trades Report

27 October 2017 16:32:08

Name:	10 Popular US stocks
Symbols:	AAPL, C, CMCSA, F, GE, JPM, MA, TSM, UL, WFC
Equity Filter:	OFF—All entries taken

Position selection All trades, from date 2004/11/08, To date 2014/10/31, Chart By Date, Ignore trades $\leq -999,999,999$, Ignore trades $\geq 999,999,999$, Ignore big wins 0, Ignore big losses 0, Profit is ≥ 0.00 , Show cents No, Show Max Intra No.

“% in the market” = 35.3% which indicates the amount of time during the year there are open positions. The lower the percentage, the less active the algorithm. The reason for a low percentage can be owing to the absence of trade signals or that the strategy exited the market quickly which transpired here as the number of trades were high (Genesis Financial Technologies, 2017).

The relation between profit factor and winning percentage illustrates the size of the profits/losses in relation to the number of times the strategy wins/losses. A high winning percentage with a low-profit factor can be indicative of large losses. The opposite occurs when winning percentage is low, but the profit factor is high, indicates it rarely wins but when winning trades occur, they often large (Genesis Financial Technologies, 2017). The combination of the winning percentage and profit factor generates the Kelly ratio. This shows what percentage of an account could be reasonably risked on the next trade (Tradimo, 2017); this may be used to compare strategies against one another. Traders would not risk that percentage of their account on a single trade. The ratio represents what could be risked to maximise the strategy (Genesis Financial Technologies, 2017).

The concept of applying the reverse strategy and shorting the instrument based on signals $< 20\%$, in theory, should work. The backtest proved that it was a losing and unprofitable trading algorithm over the long term. The duration affects the returns as most stocks have been in a constant uptrend. Although the dips in the market would need to be captured by powerful and efficient profit taking formulas to have any chance at yielding a positive result.

Changing the algorithm to take profit at a fixed dollar amount (i.e. \$30) in place of first the profitable opening coupled with a fixed stop loss is hardly an intelligent strategy. The purpose is to test whether the method is profitable with an overly simplified profit taking approach. The same 10 US stocks will be used in this back-test. Table 9 displays the returns for each stock on an annual basis, and Table 10 shows the overall combined results from the 10 US stocks with a fixed target profit and stop loss.

The algorithm generates higher returns than previously. A set target profit amount was set at \$200 with a fixed stop loss of \$270. The trade now only exits once a profit of \$200 is made or the stop loss was hit. The fees and commissions were set at \$2 per transaction. The strategy performed poorly during 2008 probably because of the financial crash. The profit target of \$200 may have been too high as profits were lost when the market collapsed. This is evident as seven stop losses were triggered during that time causing a major drawdown in that year.

Summary—All Trades Report

28 October 2017 15:52:41

Name:	10 Popular US stocks
Symbols:	AAPL, C, CMCSA, F, GE, JPM, MA, TSM, UL, WFC
Equity Filter:	OFF—All entries taken

Table 9. Annual performance when tied with a fixed profit taking exit in place of a first profitable opening (Genesis Financial Technologies, 2017)

Y	W%	\$Wa	P	\$AT	ML	Pt	NPt \$10,000	AB	%i
04	100.00	200	999	200	0	200	10,200	13.00	2.00
05	80.00	197	2.83	102	-278	508	10,708	105.40	4.99
06	88.24	197	5.28	141	-284	2,393	13,101	178.94	22.35
07	86.67	204	4.83	140	-275	2,099	15,200	149.53	16.02
08	50.00	217	0.78	-30	-295	-1,606	13,594	56.30	-10.57
09	79.17	214	2.91	111	-320	5,326	18,920	32.15	39.18
10	81.25	197	3.09	108	-278	1,729	20,649	101.56	9.14
11	61.54	205	1.18	19	-294	252	20,901	169.15	1.22
12	90.00	197	6.46	150	-274	2,994	23,895	141.05	14.32
13	94.12	201	11.71	173	-274	2,935	26,830	136.35	12.28
14	100.00	196	999	196	0	785	27,615	224.25	2.93

Table 10. The overall combined results from the 10 US stock with a fixed target profit and stop loss (Genesis Financial Technologies, 2017)

Overall

Total net profit:	\$17,615	Profit factor (\$Wins/\$Losses):	2.20
Total trades:	210	Winning percentage:	74.8%
Average trade:	\$84	Payout ratio (AvgWin/AvgLoss):	0.74
Max closed-out drawdown:	-\$3,026	CPC index (PF x Win% x PR):	1.22
Max intra-trade drawdown:	-\$3,186	Expectancy (AvgTrade/AvgLoss):	30.31%
Account size required:	\$4,308	Return pct:	408.9%
Open equity:	\$529	Kelly pct (AvgTrade/AvgWin):	40.79%
Percent in the market:	81.9%	Optimal f:	0.48
Avg # of bars in trade:	96.51	Z-score (W/L Predictability):	-2.3
Avg # of trades per year:	21.0	Current streak:	14 Wins

Position selection all trades, from date 2004/11/08, to date 2014/10/31, chart by date, ignore trades $\leq -999,999,999$, ignore trades $\geq 999,999,999$, ignore big wins 0, ignore big losses 0, profit is ≥ 0.00 , show cents no, show max intra no.

The strategy improved total net profit from \$10,596 to \$17,615. Profit factors decrease as the number of losses increases in relation to wins. The tight parameters reduce trade numbers thereby decreasing the Kelly ratio from 47.0% to 40.8%. Reduced trades are the result of the percentage increase of time in the market (81.9%) as trades are held for longer. With specific risk management and profit optimisation tailored to an individual stock or tradable instrument, superior results are expected but should be further tested.

The strategies' risk was not discussed due to focussing on the performance of the indicator and its results. The results obtained from the different tests support the notion that the SVIX can indicate market upswings and be used as a trading strategy to generate profits.

5. Conclusion

High correlation was observed between the SVIX, original VIX_f and VIX. The SVIX enables traders to quickly observe a stock's status, without the need for prior comparisons or MA indicators.

Entry signals on the SVIX were less frequent but still indicated significant price moves. The indicator proved its worth on stagnated trading bars in a sideways direction as less signals were produced than the comparative VIX_f and MA duo. Thus, limiting the amount of false entries and minimising commission costs. Trading signals on emerging market stocks indicated that to be successful, the parameters around that market would need to be customised if it exhibited abnormal traits.

Each backtest exhibited an abundance of winning percentage trades and net returns were substantial. The power of volatility indicators such as the SVIX in predicting market movements and trend breakouts was demonstrated. Profit optimisation was minimal and had not been optimised on individual items. The aim was to keep the strategy commercially viable and as simple as possible to determine how well the indicator performed in a real-world environment. The success of the indicator on multiple fronts was demonstrated, using some of the highest traded US securities. Future work could examine smaller indices and securities from different markets, testing the resilience of the SVIX. Emerging markets such as South Africa should provide enough liquidity to test the SVIX.

Further research could also apply intelligent profit taking strategies to the SVIX. Changing the market focus in the direction of the commodity sector will allow other influential indicators such as COT (commitment of traders) data, which can be used in conjunction with the SVIX, creating a powerful and robust strategy by reducing entry signal dependency from one to two indicators. The results show that there is a solution to the lack of applicability of the CBOE VIX to individual securities.

Adding a stochastic oscillator maintained many of the original VIX_f qualities. This simplified the indicator as there was no need for an MA indicator to gauge when entries should be taken. Changing the way the indicator was used in a strategy and the simplicity of the stochastic produced an indicator based on price information to indicate future uptrends. The indicator and strategy failed to indicate downtrends consistently nor did they produce net profit returns. Although long positions proved profitable, they also exhibited more accuracy in comparison to the original VIX_f and MA strategy, allowing more defined moves to be signalled amongst a noisy market.

This indicator should not be used in isolation to gauge buy entries. It is a supportive tool that should be added to a set of indicators that align with a chosen trading strategy with clear risk mitigation and profit taking strategies.

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Correction

This article has been republished with minor changes. These changes do not impact the academic content of the article.

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Notes

1. The speed—or rate of change—of the change in market prices. In technical analysis, accelerations and decelerations are referred to as momentum and used to identify trends.
2. A sideways market occurs when market prices trade within a range without any distinct upward or downward trends. Instead, the price oscillates in a narrow range, and neither bulls nor bears dominate prices.
3. A sell trailing stop order sets the stop price at a fixed amount below the market price with an attached “trailing” amount. As market prices increase, the stop price increases by the trail amount, and when

prices fall, stop loss prices remain the same. Market orders are only submitted when the stop price is reached.

4. There is nothing intrinsically special about the fractional sale and retention, this is just an example.

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