THE EFFECTIVENESS OF CONFIRMING INDICATORS: A CASE STUDY OF STOCKS IN THAILAND

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Abstract

This paper developed a model that tested trading signals (including double and triple indicators) on the security traded in the Stock Exchange of Thailand (SET). One indicator from each of the six groups of technical indicators, including MACD, Parabolic SAR (PSAR), RSI, Twiggs Money Flow, Volume Oscillator, and Bollinger Bands, were tested in order to determine whether their use could generate excess returns for investors. PSAR was the most profitable indicator as it alone or when used in combined with other indicators could generate excess returns. The findings showed that the AND function could be used to combine trading signals but with proper interpretation of inputs. Findings also showed that combined indicators increase abnormal profits above individual indicators. A combined indicators model had the best performance in terms of End of Period Wealth and the least downside risk which was measured by Maximum Drawdown. The significance of this research is that it identifies confirming indicators that can be used effectively to generate excess profits, although the findings do have some limitations which is discussed in this paper however further study on similar concept is highly recommended.

Keywords: Confirming indicators, Double Indicators, Technical analysis, Stock Exchange of Thailand, Parabolic SAR, Combined indicators

บทคัดย่อ

บทความฉบับนี้ได้พัฒนารูปแบบจำลองการทดสอบสัญญาณการซื้อขาย (โดยรวมถึงตัวชี้วัดคู่และตัวชี้วัดสามตัว) ในการซื้อขายหลักทรัพย์ในตลาดหลักทรัพย์แห่งประเทศไทย โดยได้มีการตรวจสอบตัวบ่งชี้ชนิดใดชนิดหนึ่งจากดัชนีชี้วัดทางเทคนิค 6 กลุ่ม ได้แก่ MACD, Parabolic SAR (PSAR), RSI, Twiggs Money Flow, Volume Oscillator และ Bollinger Bands เพื่อตรวจสอบว่าการใช้ตัวบ่งชี้ดังกล่าวสามารถก่อให้เกิดผลตอบแทนที่มากขึ้นสำหรับนักลงทุน PSAR เป็นตัวบ่งชี้ที่สามารถใช้ในการทำกำไรมากที่สุด ไม่ว่าจะใช้เพียงลำพังหรือเมื่อใช้ร่วมกับตัวบ่งชี้อื่น ก็สามารถทำให้เกิดผลตอบแทนที่มากขึ้น ผลการวิจัยแสดงให้เห็นว่าฟังก์ชัน AND สามารถใช้ในการรวมสัญญาณการซื้อขายเข้าด้วยกันได้แต่จำเป็นต้องมีการตีความข้อมูลให้เหมาะสมเสียก่อน ผลการวิจัยยังแสดงให้เห็นว่าการใช้ตัวบ่งชี้หลายตัวร่วมกันช่วยเพิ่มผลกำไรที่สูงเกินคาดหมายเหนือกว่าการใช้ตัวบ่งชี้แต่ละตัวเพียงลำพัง แบบจำลองที่ใช้ตัวชี้วัดหลายตัวรวมกันมีประสิทธิภาพสูงสุดในการให้ความมั่งคั่งเมื่อสิ้นสุดระยะเวลาและทำให้เกิดความเสี่ยงขาลงน้อยที่สุด ซึ่งถูกวัดค่าโดยวิธี Maximum Drawdown ดังนั้นความสำคัญของงานวิจัยนี้คือการระบุตัวชี้วัดที่ผ่านการยืนยันว่าสามารถนำมาใช้อย่างมีประสิทธิภาพเพื่อสร้างผลกำไร อย่างไรก็ดีแม้ว่าผลการวิจัยจะมีข้อจำกัดบางอย่างที่กล่าวถึงในเอกสารนี้ แต่กระนั้นการศึกษาเพิ่มเติมเกี่ยวกับแนวคิดที่คล้ายกันนี้ก็สมควรที่จะทำเป็นอย่างยิ่ง

INTRODUCTION

There is a fundamental conflict between different schools of thought on predicting market performance. One school of thought – the economic viewpoint - is that the market price of a single stock is essentially a random walk and cannot be accurately predicted (Ji, Zhang, & Guo, 2008) which is a follower of Eugene Fama's Efficient Market Hypothesis. In contrast, the technical analysis viewpoint holds that historical performance of the stock itself can be used to predict its performance (Ji, et al., 2008). A third viewpoint that of fundamental analysis, argues that indicators of the firm's fundamental performance characteristics, such as its profit ratio, can be used to predict stock performance (Ji, et al., 2008). This research is mainly concerned with the technical analysis viewpoint, which relies on the use of trading signals, or indicators that a given stock should be bought or sold based on some element of its current price performance (Kaufman, 2013). This research in a way also tested the Weak-Form Efficient Market Hypothesis which stated that "future prices cannot be predicted by analyzing prices from the past". Technical analysis techniques will not be able to consistently produce excess returns if the market is in Weak-Form Efficient Market state. The trading signal typically comprises the movement of a stock's price, based on some technical movement analysis, and is used by traders to determine trading positions on a given stock (Colby, 2002). Trading signals are not used in isolation, but are instead used in combination in order to determine trading movements (Kaufman, 2013). However, it is not at all clear that technical analysis, with its use of trading signals, is an effective approach to predicting price performance or generating excessive returns in exchange trading (Balsara, Chen, & Zheng, 2007; Bessembinder & Chan, 1998). While some research, such as the study conducted by Balsara, et al. (2007) does indicate some usefulness of trading signals, other research suggests that the technical analysis approach is not effective as a trading tool (Bessembinder & Chan, 1998).

The main objective of this research is to develop a model that integrates technical indicators and determine which of these indicators is effective at capturing market characteristics and generating excess returns from trading the security. This research addresses a number of different aspects of importance to the literature review. First, there has been relatively little research in the area of technical analysis on the SET, and the majority of this research compares the SET to other markets instead of analyzing it on its own terms (Ardliansyah, 2012; Chuang, Lee, & Wang, 2014). There has also been limited research conducted into the combined effect of multiple trading indicators, even though in practice traders do rely on multiple indicators (typically a small subset of those available) instead of single indicators (Grimes, 2012). Furthermore, improving algorithmic and computational approaches to technical analysis increase the potential for accurate forecasting from technical indicators (Atsalakis & Valavanis, 2009). Thus, given the lack of evidence for SET, the conflicting evidence on the utility of technical analysis in general, and the low level of research on the use of multiple indicators, there is a strong reason for conducting this research and examining the problem at hand.

REVIEW OF LITERATURE

Technical analysis

The technical analysis approach relies on data mining and statistical analysis of the performance of the stock price in order to identify trends, forecast price and identify appropriate

trading points (Edwards, et al., 2013). Technical analysis relies on technical indicators, or statistical transformations of standardized data (such as daily prices and fluctuation) (Edwards, et al., 2013). Technical indicators are typically accompanied by trading signals, or critical points where BUY/SELL is indicated (Colby, 2002; Wagner, 2011). Due to the complexity and resources required to compute and understand technical indicators, most traders use only a small number of indicators, often in combination with data derived from fundamental analysis and news (Edwards, et al., 2013; Kaufman, 2013).

The evidence for the efficacy of technical analysis is mixed. Theoretical models of technical analysis argue that historical prices reflect latent information that is otherwise poorly communicated or hidden beneath trading noise, making price and volume information the most reliable source of data (Blume, Easley, & O'Hara, 1994; Brown & Jennings, 1989). From a psychological perspective, technical analysis reflects the effect of confirmation bias, or traders making decisions based on what they already know (Friesen, Weller, & Dunham, 2009). A number of empirical studies do support that specific uses of technical analysis can be effective; for example, one study found that it was effective over a six and sixteen-month horizon, though not at one month (Abbodante, 2010). One group of authors has posited that technological advances in technical analysis, such as the use of standardized algorithmic techniques rather than hand-charting, could have made it more effective (Lo, Mamaysky, & Wang, 2000). However, there is also a bulk of studies, including recent studies deploying algorithmic techniques, that show that technical analysis is of limited utility (Chang & Osler, 1999; Marshall, Cahan, & Cahan, 2010; Menkhoff, 2010). These studies found for example heavy psychological biases in interpretation of technical indicators (Menkhoff, 2010) and equivalent returns for far simpler trading rules (Chang & Osler, 1999). Many studies have shown either high transaction costs for technical analysis that wipe out trading gains (Bessembinder & Chan, 1998) or conflicting or contradictory findings for different markets and technical analysis techniques (Atsalakis & Valavanis, 2009; Park & Irwin, 2007; Schulmeister, 2009). Thus, it cannot be stated that technical analysis *as a whole* is effective – instead, it needs to be considered as a body of techniques that are variably effective at delivering abnormal returns depending on usage context.

Technical indicators

There are thousands of technical indicators in use, although only a relatively small number of these indicators are commonly used (Marshall, et al., 2010). Six groups of technical indicators can be identified, each of which offers different information about the stock (Colby, 2002). These include: moving average oscillators; trend indicators; momentum oscillators; money flow; volume indicators, and volatility indicators.

Moving average oscillators

A moving average is the mean of the most recent X observations from a sequential series (Schizas, 2013). The moving average oscillator is calculated as a fixed window, typically of 10 to 200 days to capture short-term or long-term price trends. However, they can be calculated as a fluctuating window (Schizas (2013). Moving averages are generally calculated as simple moving average (MA) or exponential moving average (EMA) (Colby, 2002). MA and EMA indicators are popular with traders and analysts because they are relatively simple and easy to use (Chiarella, He, & Hommes, 2006). However, due to long-term destabilization of moving averages and tendency toward random walk behavior, recommendations for use of MA indicators are for short term trend detection and cyclical analysis, rather than in long-term

analysis (Chiarella, et al., 2006). Of the MA indicators, Moving Average Convergence Divergence (MACD) is the most reliable short-term indicator (Colby, 2002; Liu & Xiao, 2009).

Trend indicators

Like moving average oscillators, trend indicators identify trends in the movement of stock price and volume (Kaufman, 2013). However, it is different from an oscillator because the trend indicator does not oscillate around a zero axis, but instead indicates absolute value in the trend (Fernández-Blanco, Bodas-Sagi, Soltero, & Hidalgo, 2008). Trend indicators, the oldest class of indicators, are commonly simple and easy to calculate, though some like Average Directional Index (ADX) are more complex (Rosenbloom, 2010). Some common trend indicators include Simple Moving Average (SMA), ADX, and Parabolic Stop and Reversal (Parabolic SAR) (Rosenbloom, 2010). There is no clear evidence for which of these indicators is best, but Parabolic SAR is known to be commonly used, easy to calculate and generates a clear signal (Di Lorenzo, 2013). Thus, it was chosen for the analysis.

Momentum oscillators

Momentum is a change in price between the current price and the price in the past, most typically the most recent period (for example, comparing Ct with Ct-1) (Etzkorn, 1997). A momentum oscillator is designed to identify the extremes of a cyclical market, based on the momentum or speed of change in the underlying indicator such as price or volume (Etzkorn, 1997). Momentum oscillators typically revolve in a fixed range around 0 (Fernández-Blanco, et al., 2008). Relative strength index (RSI) is the ratio of the smoothed moving average of gains and losses over a period of some days (Colby, 2002). It has been supported as a profitable indicator in several previous studies (Adariani, 2012; Chong & Ng, 2008; Liu & Xiao, 2009; Stasinakis & Sermpinis, 2014; Wong, Manzur, & Chew, 2010). It is also simple to calculate on trading platforms and reduces problems from points dropping of the end of the scale, though it can also show significant volatility (Colby, 2002). Thus, it was chosen for the analysis.

Money flow indicators

Money flow is the price velocity times the volume of the underlying instrument (Colby, 2002). The money flow indicator, therefore, relates the price of the instrument to its trading volume (Colby, 2002). There are relatively few money flow indicator measures available, given the simplicity of the calculation (Colby, 2002). One of the most common money flow indicators is the Chaikin money flow indicator (Colby, 2002). However, a found that the Chaikin money flow, while it could deliver a profit, less profitable than all other indicators used, including Moving Average, Bollinger Bands, Relative Strength Index, and Stochastic Momentum Index (Kannan, Sekar, Sathik, & Arumugam, 2010). The Twiggs Money Flow is an adaptation of Chaikin money flow, which has been modified for substitution of daily high minus low with true range and using EMA instead of SMA (Twiggs, 2014b). These changes are designed to overcome problems with the original indicator, such as failing to identify price gaps and spikes or dips from inclusion or exclusion of data in the moving average window (Twiggs, 2014b). Thus, it was chosen for analysis.

Volume indicators

The volume of the stock or other traded instrument simply refers to the total number of units (in the case of stocks, shares) traded over a specific period, such as one trading day (Kaufman, 2013). Thus, volume indicators are those that measure stock performance based on volume

(Kaufman, 2013). Early volume indicators were unreliable and often did not have valuable information about performance (Penn, 2005). However, more recent evidence suggests volume indicators may be more informative in developing markets (Tsang & Chong, 2009). Common volume indicators include Volume, Volume Rate of Change (VROC), and Volume Oscillator (VO) (Kirkpatrick & Dahlquist, 2010). The Percentage Volume Oscillator (PVO) is a momentum oscillator for volume. PVO measures the difference between two volume-based moving averages as a percentage of the larger moving average. Increasing volume can validate a support or resistance break. This made it most appropriate to be used in conjunction with other indicators and was chosen for the analysis.

Volatility indicators

In mathematical or statistical terms, volatility is measured using the dispersion of an indicator such as price or volume between periods, using tools like standard deviation or variance (Freund, Mohr, & Wilson, 2010; Kaufman, 2013). Volatility communicates the extent of uncertainty or variation surrounding the instrument's performance (Grimes, 2012). Volatility indicators are commonly used in practice (Chen, 2011; Edwards, et al., 2013; Kaufman, 2013), though there is weak evidence for recommending their use based on technical analysis theory because it is complex and unpredictable (Kaufman, 2013; Northington, 2009). One of the most commonly used volatility indicators is Bollinger bands, which use a baseline of 20-day SMA, combined with resistance lines two standard deviations above and below this line (Colby, 2002). Bollinger bands are flexible and simple to interpret, and have other advantages like identifying points where instruments are in oversold or overbought conditions (Stasinakis & Sermpinis, 2014). Bollinger Bands have also been shown to reduce the associated risk of trades (Adariani, 2012). Thus, it was chosen for analysis.

Confirming indicators

A confirming indicator is a supplementary indicator that either reinforces or rejects the perception of a trend or otherwise deepens the information received from the original indicator (Kirkpatrick & Dahlquist, 2010). The purpose of the confirmatory indicator is to provide additional information about the technical indicators discussed above and the information they communicate (Kaufman, 2013). Convergence means the original and confirming indicator communicate the same signal, while divergence means they disagree (Bollinger, 1992). Confirming indicators have been used since the days of paper charting, as a double-check on identified trends (Chen, 2011; Etzkorn, 1997; Kaufman, 2013; Kirkpatrick & Dahlquist, 2010). Different confirming indicators may be used together. For example, RSI is commonly used as a confirming indicator with MACD (Adariani, 2012; Liu & Xiao, 2009; Stasinakis & Sermpinis, 2014). It is also common for authors to state that volume indicators provide valuable confirmatory evidence for price-based trend and oscillator indicators (Blume, Easley, & O'Hara, 1994; Kirkpatrick & Dahlquist, 2010; Penn, 2005). However, confirming indicators have not been studied in terms of their effectiveness or ideal combinations in the academic literature, even though it is known that they are used (Penn, 2005).

Methodology

Data collection and preparation

Data collection was conducted using three randomly selected SET50 firms, Inter Far East Energy Corporation Plc. (IFEC), PTT Exploration and Production Public Company Limited (PTTEP), and The Siam Commercial Bank Public Company Limited (SCB). Data was collected for the period of January 2008 to December 2014, including daily open, close, high, low, and volume which are required in the calculation of technical indicators. The source of the data was the SET market data database, which provides performance indicators and raw data for all firms traded on the Stock Exchange of Thailand.

The data preparation process used standard data mining data preparation techniques and practices (Chen, Liu, Chen, Cui, & Fang, 2008; Heaton, 2009; Maimon & Rokach, 2010). Data was manually and algorithmically checked for outliers and errors, and errors were cleaned.

Research model formation

The model formation was iterative, beginning from testing of single indicators in each of the six categories and through the other four stages of the testing process. This is similar to the techniques used by other authors that have used neural networks for model formation, as well as a general approach to model formation for different concepts (Atsalakis & Valavanis, 2009; Chen, et al. 2008; Fernández-Blanco, et al., 2008; Kordos & Cwiok, 2011; Lam, 2004; Maimon & Rokach, 2010). Each single indicator was tested using the algorithm. Then, the AND function was applied iteratively in order to combine indicators. The AND function is selected because it is a binary function that can detect non-simultaneous indicators (or those that are offering conflicting BUY/SELL signals). If both indicators are returning the same BUY/SELL signal, then AND will return TRUE. Otherwise, it will return FALSE. Multiple ANDs will work in the same way. Thus, using AND will generate a clear BUY/SELL signal from multiple indicators. The AND function was then used to combine two indicators (the double indicators stage) (15 indicators). Next, AND was used again to combine three indicators (triple indicators stage) (20 indicators). Models were specified and tested against the market simulation. This cyclical process gradually identified the most accurate models, including the specific indicators combined in the integrated indicator and whether the AND function performs more effectively.

Indicators included

There were six indicators included in the test. These included MACD, PSAR, RSI, Twiggs Money Flow, Percentage Volume Oscillator, and Bollinger bands. The indicators were selected as the most common representatives of the classifications of indicators identified by Colby (2002). The calculation and BUY/SELL conditions are explained in detail in Table 1.

These indicators were previously supported as potentially producting abnormal profits over the baseline (Adariani, 2012; Chong & Ng, 2008; Colby, 2002; Di Lorenzo, 2013; Edwards et al., 2013; Kordos & Cwiok, 2011; Liu & Xiao, 2009; Park & Irwin, 2007; Stasinakis & Sermpinis, 2014; Wong et al., 2010). In some cases, including MACD, RSI, Parabolic SAR, and Bollinger Bands, they have also been supported as complementary or confirming indicators for each other (Kirkpatrick & Dahlquist, 2010; Kordos & Cwiok, 2011; Liu & Xiao, 2009; Lo, et al., 2000; Stasinakis & Sermpinis, 2014).

Table 1: Summary of technical indicators and trading signals

Indicator Class	Technical Indicator	Trading Signal
Moving Average Oscillator	Moving Average Convergence Divergence (MACD)	• **BUY**: MACD crosses signal line from below • **SELL**: MACD crosses signal line from above
Trend Indicator	Parabolic Stop and Reversal (SAR)	• **BUY**: Stock Price > PSAR • **SELL**: Stock Price < PSAR
Momentum Oscillator	Relative Strength Index (RSI)	• **BUY**: RSI > Oversold line (30) • **SELL**: RSI > Overbought line (70)
Money Flow	Twiggs Money Flow	• **BUY**: Money flow > 0 • **SELL**: Money flow < 0
Volume Indicator	Percentage Volume Oscillator	• **BUY**: PVO crosses signal line from below • **SELL**: PVO crosses signal line from above
Volatility Indicator	Bollinger Bands	• **BUY**: Price is two standard deviations or below 20-day MA (LOWER BAND) • **SELL**: Price is two standard deviations or above 20-day MA (UPPER BAND)

Source: Developed for this study

Model Judgment Criteria

Maximum Wealth (Baht)

The first judgment criterion used will be the maximum portfolio wealth. During the simulation process the portfolio wealth will be calculated throughout as the number of shares in portfolio multiply with the price of shares add with the amount of money in the portfolio.

In this research, the portfolio wealth will be calculated per trade using an automated data collection technique. This will be calculated for all trades performed including single indicator, double indicators, and triple indicators. This will help determine which method performs better in this area. It will also help determine the overall effectiveness of each of the models.

Wealth at the End of Period (Baht)

The second judgment criterion that will be used in the analysis is the Wealth at the End of Period. The Wealth at the End of Period refers to the amount of equity collected over a series of trades. In other words, it represents the total profit associated with a trading decision. The Wealth at the End of Period shows the accumulation of equity or profits over a period of time. This is helpful in understanding how a given trading model is performing.

In this analysis, the Wealth at the End of Period will be calculated for the trades' simulations over the period of analysis. This will help determine which of the models is more effective in the sense that it leads to higher accumulations of net equity for the simulated study. This will show in a numeric representation which approach is better in the long run. It is also consistent with the visual representation of performance that is a feature of technical analysis.

Maximum Drawdown (%)

The third judgment criteria used is Maximum Drawdown. A maximum drawdown is one of the most important risk measures. It is the maximum loss from a peak to a trough of a portfolio (before a new peak is attained). Maximum Drawdown is an indicator of downside risk over a specified time period.

In this analysis, the drawdown will be calculated for the trades' simulations over the period of analysis. This will help determine which of the models is more effective in the sense that it minimizes the drawdown for the simulated study.

Results and Discussion

Model characteristics

The transaction cost for an entry-level investor (< THB5 million) is 0.2578%, excluding the Value Added Tax if traded with an exchange trader (Marketing Officer), or 0.2078% if the investor does Internet trading (Thanachart Securities PCL, 2015). The transaction cost is divided into Brokerage Fee, Trading/Regulatory Fee, and Clearing Fee. The 0.2578% figure was selected as the highest transaction cost. This simulation study includes the effect of transaction cost if there is any impact on the trades. To shorten the calculation process, for every purchases, the security price is multiplied by 1.00275846 (1 + 0.00275846), for every sale, the security price is multiplied by 0.99724154 (1 - 0.00275846).

The buy-and-hold strategy portfolio was created to compare with the developed models. It is the investment in the same security at the start of the period, holding it regardless of market conditions and calculating the net worth of the holding at the end of the period.

Results in Table 2 shows the performance of benchmark portfolio (Buy & Hold Strategy) for three securities. For IFEC, the portfolio's maximum wealth reached as high as Baht 21,383.629.11 The Wealth at the End of Period for benchmark portfolio was Baht 17,476,375.85 and the Maximum Drawdown which is a risk measures was -65.85%. For PTTEP, the portfolio's maximum wealth reached as high as Baht 1,304,577.13 The Wealth at the End of Period for benchmark portfolio was Baht 702,465.13 and the Maximum Drawdown which is a risk measures was -72.14%. For SCB the portfolio's maximum wealth reached as high as Baht 2,431,480.79 The Wealth at the End of Period for benchmark portfolio was Baht 2,240,660.29 and the Maximum Drawdown which is a risk measures was -64.37%.

Table 2: Simulation results of the benchmark portfolio

SECURITIES	Maximum Wealth of Buy & Hold Strategy (Baht)	Wealth at the End of Period of Buy & Hold Strategy (Baht)	Maximum Drawdown of Buy & Hold Strategy
IFEC	21,383,629.11	17,476,375.85	-65.85%
PTTEP	1,304,577.13	702,465.13	-72.14%
SCB	2,431,480.79	2,240,660.29	-64.37%

Source: Developed for this study

Simulation of a single indicator

The simulation results of single indicators on IFEC are presented in Table 3. The portfolio that used single indicator PSAR resulted in Maximum Portfolio Wealth of THB 24,109,581.68 (+2310.96%) which was higher than those of Benchmark Portfolio's. The Wealth at the End of Period for PSAR was also the highest at THB 16,586,067.32 (+1558.61%) which was lower than of Benchmark Portfolio's. 61.54% of the Buy/Sell signals generated from PSAR were profitable trades. Its Maximum Drawdown was -17.59% which was a very good improvement comparing to those of Benchmark Portfolio's.

Table 3: Outcome of single indicator tests for IFEC

MODEL	Max.Wealth (Baht)	Max.Gain (Percentage)	Total Number of Buy&Sell (times)	Total Number of Profitable Trades (times)	Percentage of Profitable Trade	Wealth at the End of Period (Baht)	Gain from Investment (Baht)	Maximum Drawdown
MACD	11,505,787.62	1050.58%	51	24	47.06%	8,309,224.45	730.92%	-34.37%
RSI	1,259,913.89	25.99%	17	9	52.94%	1,213,516.73	21.35%	-54.27%
PSAR	24,109,581.68	2310.96%	52	32	61.54%	16,586,067.32	1558.61%	-17.59%
TWIGGS	5,325,509.63	432.55%	49	19	38.78%	3,609,837.41	260.98%	-38.36%
BBANDS	1,566,423.01	56.64%	14	11	78.57%	1,372,546.56	37.25%	-44.41%
PVO	3,386,387.97	238.64%	109	52	47.71%	2,650,063.17	165.01%	-39.64%

Source: Developed for this study

The simulations results of single indicators on PTTEP are presented in Table 4. The portfolio that used single indicator TWIGGS resulted in Maximum Portfolio Wealth of THB 1,363,998.88 (+36.40%) which was higher than those of Benchmark Portfolio's. Wealth at the End of Period for BBANDS was the highest at THB 734,468.31 (-26.55%) which was higher than of Benchmark Portfolio's but in loss. 64.71% of the Buy/Sell signals generated from RSI were profitable trades. The Maximum Drawdown of BBANDS portfolio was -20.41% which was a very good improvement comparing to those of Benchmark Portfolio's.

The simulations results of single indicators on SCB are presented in Table 5. The portfolio that used single indicator BBANDS resulted in Maximum Portfolio Wealth of THB 1,628,213.04 (+62.82%) which was lesser than those of Benchmark Portfolio's. Wealth at the End of Period for BBANDS was also the highest at THB 1,555,175.36 (+55.52%) which was higher than of Benchmark Portfolio's. 66.67% of the Buy/Sell signals generated from RSI were profitable trades. The Maximum Drawdown of BBANDS portfolio was -18.65% which was a very good improvement comparing to those of Benchmark Portfolio's.

Table 4: Outcome of single indicator tests for PTTEP

MODEL	Max.Wealth (Baht)	Max.Gain (Percentage)	Total Number of Buy&Sell (times)	Total Number of Profitable Trades (times)	Percentage of Profitable Trade	Wealth at the End of Period (Baht)	Gain from Investment (Baht)	Maximum Drawdown
MACD	1,272,764.99	27.28%	63	22	34.92%	568,461.60	-43.15%	-45.75%
RSI	1,222,502.97	22.25%	17	11	64.71%	569,259.30	-43.07%	-45.54%
PSAR	1,178,247.96	17.82%	69	28	40.58%	470,992.21	-52.90%	-51.56%
TWIGGS	1,363,998.88	36.40%	128	42	32.81%	358,542.55	-64.15%	-64.80%
BBANDS	1,186,429.78	18.64%	15	9	60.00%	734,468.31	-26.55%	-20.41%
PVO	1,153,168.31	15.32%	140	63	45.00%	279,207.98	-72.08%	-70.09%

Source: Developed for this study

Table 5: Outcome of single indicator tests for SCB

MODEL	Max.Wealth (Baht)	Max.Gain (Percentage)	Total Number of Buy&Sell (times)	Total Number of Profitable Trades (times)	Percentage of Profitable Trade	Wealth at the End of Period (Baht)	Gain from Investment (Baht)	Maximum Drawdown
MACD	1,021,620.68	2.16%	72	22	30.56%	552,114.63	-44.79%	-64.58%
RSI	1,175,788.26	17.58%	18	12	66.67%	1,046,538.85	4.65%	-32.45%
PSAR	1,030,521.36	3.05%	66	27	40.91%	719,771.37	-28.02%	-42.02%
TWIGGS	1,155,929.45	15.59%	115	35	30.43%	479,365.55	-52.06%	-58.15%
BBANDS	1,628,213.04	62.82%	18	10	55.56%	1,555,175.36	55.52%	-18.65%
PVO	1,092,680.56	9.27%	134	62	46.27%	509,513.50	-49.05%	-57.70%

Source: Developed for this study

Integration of indicators using AND function

One problem arose for AND function integration during simulation study because the buy and sell signals for different indicators did not match on the same day. Therefore the integration using AND function failed and no trade simulations has occurred. To solve this problem a minor interpretation of signals needed to take place. There were two methods tested for the interpretation of signals.

For the first method, if two signals showed Hold Cash at the same time, then the function will result in Hold Cash. Everything else will result in Hold Asset. Results are shown in Table 6.

Table 6: Test of AND function (Method 1)

Trading Signal of Indicator 1	Position of Indicator 1	Trading Signal of Indicator 2	Position of Indicator 2	AND FUNCTION Method 1 (Position)	Action taken
	Hold Cash	Sell	Hold Cash	Hold Cash	
Buy	Hold Asset	Sell	Hold Cash	Hold Asset	Buy
	Hold Asset	Sell	Hold Cash	Hold Asset	
	Hold Asset	Buy	Hold Asset	Hold Asset	
Sell	Hold Cash	Buy	Hold Asset	Hold Asset	
	Hold Cash	Buy	Hold Asset	Hold Asset	
	Hold Cash	Sell	Hold Cash	Hold Cash	Sell

Source: Developed for this study

For another method, if two signals showed Hold Cash at the same time, then the function will result in Hold Cash. Everything else will result in Hold Asset. Results are shown in Table 7.

Table 7: Test of AND function (Method 2)

Trading Signal of Indicator 1	Position of Indicator 1	Trading Signal of Indicator 2	Position of Indicator 2	AND FUNCTION Method 2 (Position)	Action taken
	Hold Cash	Sell	Hold Cash	Hold Cash	
Buy	Hold Asset	Sell	Hold Cash	Hold Cash	
	Hold Asset	Sell	Hold Cash	Hold Cash	
	Hold Asset	Buy	Hold Asset	Hold Asset	Buy
	Hold Asset	Buy	Hold Asset	Hold Asset	
Sell	Hold Cash	Buy	Hold Asset	Hold Cash	Sell
	Hold Cash	Buy	Hold Asset	Hold Cash	

Source: Developed for this study

Table 8: Outcome of Double indicators (AND function) for IFEC

MODEL	Max.Wealth (Baht)	Max.Gain (Percentage)	Total Number of Buy&Sell (times)	Total Number of Profitable Trades (times)	Percentage of Profitable Trade	Wealth at the End of Period (Baht)	Gain from Investment (Baht)	Maximum Drawdown
MACD&RSI(1)	6,292,801.68	529.28%	46	23	50.00%	4,544,522.29	354.45%	-36.23%
MACD&RSI(2)	2,150,055.75	115.01%	22	14	63.64%	2,070,878.43	107.09%	-41.92%
MACD&PSAR(1)	20,067,653.16	1906.77%	48	27	56.25%	14,640,503.04	1364.05%	-17.97%
MACD&PSAR(2)	15,247,191.97	1424.72%	53	30	56.60%	10,383,130.86	938.31%	-25.69%
MACD&TWIGGS(1)	18,605,399.48	1760.54%	58	22	37.93%	13,876,351.86	1287.64%	-18.49%
MACD&TWIGGS(2)	3,329,895.67	232.99%	40	19	47.50%	2,185,572.02	118.56%	-41.38%
MACD&BBANDS(1)	10,617,533.38	961.75%	42	24	57.14%	9,232,800.32	823.28%	-31.90%
MACD&BBANDS(2)	1,435,245.12	43.52%	22	13	59.09%	1,242,082.53	24.21%	-53.51%
MACD&PVO(1)	13,094,506.25	1209.45%	85	39	45.88%	11,174,252.19	1017.43%	-23.90%
MACD&PVO(2)	6,300,126.25	530.01%	72	35	48.61%	4,625,153.04	362.52%	-36.08%
RSI&PSAR(1)	16,653,236.62	1565.32%	44	27	61.36%	11,456,512.03	1045.65%	-21.17%
RSI&PSAR(2)	2,011,927.42	101.19%	23	18	78.26%	1,937,836.77	93.78%	-42.59%
RSI&TWIGGS(1)	5,833,005.25	483.30%	50	21	42.00%	3,953,838.50	295.38%	-37.88%
RSI&TWIGGS(2)	1,130,580.25	13.06%	16	7	43.75%	1,069,731.00	6.97%	-56.47%
RSI&BBANDS(1)	1,550,587.07	55.06%	16	11	68.75%	1,358,670.60	35.87%	-45.99%
RSI&BBANDS(2)	1,183,637.29	18.36%	15	9	60.00%	1,183,637.29	18.36%	-54.43%
RSI&PVO(1)	6,925,444.70	592.54%	73	38	52.05%	6,007,721.21	500.77%	-35.89%
RSI&PVO(2)	1,508,968.33	50.90%	50	23	46.00%	1,172,618.61	17.26%	-55.38%
PSAR&TWIGGS(1)	24,685,297.06	2368.53%	54	27	50.00%	16,732,650.90	1573.27%	-17.59%
PSAR&TWIGGS(2)	5,832,847.57	483.28%	42	23	54.76%	4,012,679.94	301.27%	-37.88%
PSAR&BBANDS(1)	21,798,317.43	2079.83%	42	25	59.52%	17,874,220.54	1687.42%	-15.15%
PSAR&BBANDS(2)	1,621,055.78	62.11%	20	15	75.00%	1,420,417.55	42.04%	-44.12%
PSAR&PVO(1)	34,707,705.82	3370.77%	69	41	59.42%	30,108,421.94	2910.84%	-6.35%
PSAR&PVO(2)	5,433,434.08	443.34%	89	37	41.57%	3,737,905.03	273.79%	-37.94%
TWIGGS&BBANDS(1)	5,968,417.86	496.84%	54	25	46.30%	4,045,625.64	304.56%	-37.70%
TWIGGS&BBANDS(2)	1,421,015.57	42.10%	6	5	83.33%	1,245,136.81	24.51%	-53.29%
TWIGGS&PVO(1)	12,927,712.20	1192.77%	99	44	44.44%	9,801,458.57	880.15%	-31.21%
TWIGGS&PVO(2)	3,070,746.12	207.07%	52	26	50.00%	2,381,572.05	138.16%	-40.56%
BBANDS&PVO(1)	7,917,326.01	691.73%	72	36	50.00%	6,868,163.19	586.82%	-35.58%
BBANDS&PVO(2)	1,442,249.61	44.22%	45	22	48.89%	1,263,741.94	26.37%	-52.52%

Source: Developed for this study

Results of the double indicators using AND function for IFEC (Table 8) showed that double indicators combinations of PSAR&TWIGGS(1), PSAR&BBANDS(1) and PSAR&PVO(1) resulted in their Maximum Portfolio Wealth were higher than those of Benchmark Portfolio's. The Wealth at the End of Period of PSAR&PVO(1) combination was the highest of Baht

30,108,421.94 (+2910.84%). 59.42% of the trades following signals from PSAR&PVO(1) were profitable. Its Maximum Drawdown was -6.35% which was a very good improvement comparing to those of Benchmark Portfolio's and was much better than those of PSAR as a single indicator.

Results of the double indicators using AND function for PTTEP (Table 9) showed that double indicators combinations of MACD&BBANDS(1), MACD&PVO(1), RSI&PSAR(1), RSI&PVO(2), TWIGGS&BBANDS(2), TWIGGS&PVO(1), and BBANDS&PVO(2) resulted in their Maximum Portfolio Wealth were higher than those of Benchmark Portfolio's. The Wealth at the End of Period of RSI&BBANDS(1) combination was the highest of Baht 852,476.53 (-14.75%). 61.11% of the trades following signals from RSI&BBANDS(1) were profitable. Its Maximum Drawdown was -12.75% which was a very good improvement comparing to those of Benchmark Portfolio's and was much better than those of BBANDS as a single indicator.

Table 9: Outcome of Double indicators (AND function) for PTTEP

MODEL	Max.Wealth (Baht)	Max.Gain (Percentage)	Total Number of Buy&Sell (times)	Total Number of Profitable Trades (times)	Percentage of Profitable Trade	Wealth at the End of Period (Baht)	Gain from Investment (Baht)	Maximum Drawdown
MACD&RSI(1)	1,265,743.86	26.57%	45	18	40.00%	513,258.73	-48.67%	-46.18%
MACD&RSI(2)	1,018,353.36	1.84%	36	15	41.67%	560,955.07	-43.90%	-46.17%
MACD&PSAR(1)	1,233,041.88	23.30%	61	25	40.98%	598,238.89	-40.18%	-40.89%
MACD&PSAR(2)	1,264,656.99	26.47%	71	23	32.39%	465,424.32	-53.46%	-54.98%
MACD&TWIGGS(1)	1,264,299.16	26.43%	90	31	34.44%	512,753.04	-48.72%	-46.37%
MACD&TWIGGS(2)	1,098,700.31	9.87%	98	34	34.69%	406,378.82	-59.36%	-60.75%
MACD&BBANDS(1)	1,345,709.02	34.57%	37	18	48.65%	652,868.17	-34.71%	-36.20%
MACD&BBANDS(2)	1,044,093.52	4.41%	40	16	40.00%	646,576.97	-35.34%	-37.11%
MACD&PVO(1)	1,573,712.73	57.37%	91	41	45.05%	726,650.37	-27.33%	-21.55%
MACD&PVO(2)	1,156,876.82	15.69%	102	39	38.24%	489,446.16	-51.06%	-47.37%
RSI&PSAR(1)	1,400,833.63	40.08%	48	25	52.08%	448,405.90	-55.16%	-57.52%
RSI&PSAR(2)	1,101,777.63	10.18%	37	15	40.54%	651,396.31	-34.86%	-36.74%
RSI&TWIGGS(1)	1,193,746.65	19.37%	93	35	37.63%	284,371.18	-71.56%	-64.80%
RSI&TWIGGS(2)	1,121,871.91	12.19%	52	17	32.69%	669,025.96	-33.10%	-34.77%
RSI&BBANDS(1)	1,314,840.39	31.48%	18	11	61.11%	852,476.53	-14.75%	-12.75%
RSI&BBANDS(2)	1,009,409.48	0.94%	14	8	57.14%	497,748.87	-50.23%	-46.42%
RSI&PVO(1)	1,169,234.17	16.92%	85	43	50.59%	399,396.59	-60.06%	-63.34%
RSI&PVO(2)	1,561,192.32	56.12%	69	31	44.93%	774,207.26	-22.58%	-16.80%
PSAR&TWIGGS(1)	1,260,771.61	26.08%	91	26	28.57%	477,390.96	-52.26%	-50.69%
PSAR&TWIGGS(2)	1,161,626.07	16.16%	100	36	36.00%	396,143.05	-60.39%	-63.67%
PSAR&BBANDS(1)	1,283,494.70	28.35%	40	23	57.50%	614,773.71	-38.52%	-40.50%
PSAR&BBANDS(2)	1,000,000.00	0.00%	38	15	39.47%	630,074.76	-36.99%	-38.04%
PSAR&PVO(1)	1,266,207.74	26.62%	90	39	43.33%	473,298.81	-52.67%	-50.79%
PSAR&PVO(2)	1,188,194.69	18.82%	109	46	42.20%	628,128.89	-37.19%	-38.26%
TWIGGS&BBANDS(1)	1,080,875.64	8.09%	82	31	37.80%	410,350.25	-58.96%	-60.16%
TWIGGS&BBANDS(2)	1,411,829.41	41.18%	58	17	29.31%	652,502.96	-34.75%	-36.51%
TWIGGS&PVO(1)	1,770,468.07	77.05%	128	48	37.50%	490,182.10	-50.98%	-46.77%
TWIGGS&PVO(2)	1,113,996.83	11.40%	121	51	42.15%	478,288.84	-52.17%	-49.89%
BBANDS&PVO(1)	1,152,796.54	15.28%	73	37	50.68%	569,975.09	-43.00%	-43.03%
BBANDS&PVO(2)	1,616,410.57	61.64%	77	36	46.75%	779,929.06	-22.01%	-16.06%

Source: Developed for this study

Results of the double indicators using AND function for SCB (Table 10) showed that double indicators combinations of PSAR&BBANDS(1) resulted in its Maximum Portfolio Wealth were higher than those of Benchmark Portfolio's. The Wealth at the End of Period of PSAR&BBANDS(1) combination was the highest of Baht 2,484,619.46 (+148.46%). 61.54% of the trades following signals from PSAR&BBANDS(1) were profitable. Its Maximum

Drawdown was -7.36% which was a very good improvement comparing to those of Benchmark Portfolio's and was much better than those of BBANDS as a single indicator.

Table 10: Outcome of Double indicators (AND function) for SCB

MODEL	Max.Wealth (Baht)	Max.Gain (Percentage)	Total Number of Buy&Sell (times)	Total Number of Profitable Trades (times)	Percentage of Profitable Trade	Wealth at the End of Period (Baht)	Gain from Investment (Baht)	Maximum Drawdown
MACD&RSI(1)	1,021,620.69	2.16%	52	18	34.62%	693,615.35	-30.64%	-45.75%
MACD&RSI(2)	1,000,000.00	0.00%	37	18	48.65%	724,311.72	-27.57%	-44.39%
MACD&PSAR(1)	1,020,173.28	2.02%	69	25	36.23%	644,826.68	-35.52%	-49.43%
MACD&PSAR(2)	1,021,620.69	2.16%	68	22	32.35%	631,793.46	-36.82%	-52.10%
MACD&TWIGGS(1)	1,109,486.86	10.95%	101	29	28.71%	452,913.04	-54.71%	-63.67%
MACD&TWIGGS(2)	1,007,914.33	0.79%	85	27	31.76%	553,853.86	-44.61%	-63.67%
MACD&BBANDS(1)	1,529,896.40	52.99%	48	18	37.50%	1,289,713.20	28.97%	-19.65%
MACD&BBANDS(2)	1,000,000.00	0.00%	39	19	48.72%	676,892.57	-32.31%	-44.72%
MACD&PVO(1)	1,465,803.38	46.58%	96	44	45.83%	944,693.59	-5.53%	-38.43%
MACD&PVO(2)	1,038,155.03	3.82%	99	33	33.33%	440,627.49	-55.94%	-61.84%
RSI&PSAR(1)	1,570,526.32	57.05%	46	23	50.00%	1,288,912.14	28.89%	-21.43%
RSI&PSAR(2)	1,051,973.76	5.20%	37	19	51.35%	635,612.83	-36.44%	-49.91%
RSI&TWIGGS(1)	1,505,511.86	50.55%	66	25	37.88%	1,063,208.07	6.32%	-35.57%
RSI&TWIGGS(2)	1,051,973.76	5.20%	66	19	28.79%	458,832.92	-54.12%	-66.99%
RSI&BBANDS(1)	1,779,338.38	77.93%	19	12	63.16%	1,635,627.37	63.56%	-17.12%
RSI&BBANDS(2)	1,029,380.61	2.94%	17	10	58.82%	981,694.40	-1.83%	-35.05%
RSI&PVO(1)	1,066,170.90	6.62%	87	41	47.13%	602,912.97	-39.71%	-46.19%
RSI&PVO(2)	1,596,552.10	59.66%	63	31	49.21%	1,076,822.12	7.68%	-26.73%
PSAR&TWIGGS(1)	1,272,161.56	27.22%	92	30	32.61%	648,283.86	-35.17%	-46.09%
PSAR&TWIGGS(2)	1,088,456.76	8.85%	86	31	36.05%	585,272.84	-41.47%	-61.97%
PSAR&BBANDS(1)	2,853,569.50	185.36%	39	24	61.54%	2,484,619.46	148.46%	-7.36%
PSAR&BBANDS(2)	1,000,000.00	0.00%	40	18	45.00%	500,953.04	-49.90%	-56.78%
PSAR&PVO(1)	1,376,998.90	37.70%	91	41	45.05%	780,114.40	-21.99%	-38.83%
PSAR&PVO(2)	1,175,842.42	17.58%	96	38	39.58%	704,838.06	-29.52%	-49.04%
TWIGGS&BBANDS(1)	2,051,163.99	105.12%	56	22	39.29%	1,609,774.01	60.98%	-17.43%
TWIGGS&BBANDS(2)	1,089,779.26	8.98%	70	22	31.43%	481,345.04	-51.87%	-65.90%
TWIGGS&PVO(1)	1,159,618.97	15.96%	105	39	37.14%	696,999.92	-30.30%	-49.25%
TWIGGS&PVO(2)	1,189,399.63	18.94%	124	48	38.71%	504,908.37	-49.51%	-59.87%
BBANDS&PVO(1)	1,233,255.12	23.33%	79	42	53.16%	918,070.68	-8.19%	-36.61%
BBANDS&PVO(2)	1,702,176.45	70.22%	68	34	50.00%	1,235,532.65	23.55%	-25.10%

Source: Developed for this study

Results of the triple indicators using AND function for IFEC (Table 11), the best combination was model PSAR&TWIGGS&PVO(1), where the Maximum Portfolio Wealth reached Baht 35,711,020.15 (+3471.10%) higher than those of Benchmark Portfolio's, Single Indicator's and Double Indicators'. The Wealth at the End of Period for the same model was the highest of Baht 27,075,175.87 (+2607.52%) higher than of Benchmark Portfolio's, Single Indicator's but lower than Double Indicators model PSAR&PVO(1). Profitable trades under PSAR&TWIGGS&PVO(1) were 55.38%. Its Maximum Drawdown was -10.49% which was a very good improvement comparing to those of Benchmark Portfolio's and was much better than those of PSAR as single indicator. But not as good as Double Indicators of PSAR&PVO(1)

Table 11: Outcome of Triple indicators(AND function) for IFEC

MODEL	Max.Wealth (Baht)	Max.Gain (Percentage)	Total Number of Buy&Sell (times)	Total Number of Profitable Trades (times)	Percentage of Profitable Trade	Wealth at the End of Period (Baht)	Gain from Investment (Baht)	Maximum Drawdown
MACD&RSI&PSAR(1)	11,791,259.59	1079.13%	42	26	61.90%	8,602,401.01	760.24%	-34.37%
MACD&RSI&PSAR(2)	2,161,465.76	116.15%	22	16	72.73%	2,081,868.31	108.19%	-41.59%
MACD&RSI&TWIGGS(1)	11,722,272.47	1072.23%	47	21	44.68%	8,742,751.71	774.28%	-33.88%
MACD&RSI&TWIGGS(2)	1,286,503.25	28.65%	9	6	66.67%	1,239,126.86	23.91%	-54.04%
MACD&RSI&BBANDS(1)	7,885,384.30	688.54%	42	25	59.52%	6,856,976.98	585.70%	-35.86%
MACD&RSI&BBANDS(2)	1,607,275.48	60.73%	20	14	70.00%	1,607,275.48	60.73%	-43.78%
MACD&RSI&PVO(1)	10,536,766.65	953.68%	57	29	50.88%	8,991,594.92	799.16%	-31.90%
MACD&RSI&PVO(2)	1,771,538.17	77.15%	29	16	55.17%	1,706,300.02	70.63%	-42.68%
MACD&PSAR&TWIGGS(1)	24,072,568.13	2307.26%	53	24	45.28%	17,953,897.62	1695.39%	-12.86%
MACD&PSAR&TWIGGS(2)	4,326,972.17	332.70%	40	22	55.00%	2,946,609.69	194.66%	-38.60%
MACD&PSAR&BBANDS(1)	20,332,822.78	1933.28%	38	24	63.16%	17,681,027.69	1668.10%	-15.85%
MACD&PSAR&BBANDS(2)	1,761,880.72	76.19%	20	14	70.00%	1,535,318.51	53.53%	-43.78%
MACD&PSAR&PVO(1)	24,705,390.64	2370.54%	65	36	55.38%	21,082,450.14	2008.25%	-12.38%
MACD&PSAR&PVO(2)	5,942,761.36	494.28%	70	33	47.14%	4,046,941.64	304.69%	-37.70%
MACD&TWIGGS&BBANDS(1)	16,533,149.99	1553.31%	50	23	46.00%	12,330,819.16	1133.08%	-20.95%
MACD&TWIGGS&BBANDS(2)	1,142,718.23	14.27%	7	5	71.43%	995,775.83	-0.42%	-58.41%
MACD&TWIGGS&PVO(1)	17,682,959.02	1668.30%	81	36	44.44%	13,188,373.52	1218.84%	-19.45%
MACD&TWIGGS&PVO(2)	2,550,303.50	155.03%	42	23	54.76%	1,673,888.41	67.39%	-43.74%
MACD&BBANDS&PVO(1)	13,053,097.55	1205.31%	56	28	50.00%	11,138,916.59	1013.89%	-24.04%
MACD&BBANDS&PVO(2)	1,367,599.09	36.76%	26	15	57.69%	1,127,494.63	12.75%	-55.38%
RSI&PSAR&TWIGGS(1)	15,682,585.19	1468.26%	44	22	50.00%	10,630,264.87	963.03%	-24.75%
RSI&PSAR&TWIGGS(2)	1,173,428.15	17.34%	11	6	54.55%	1,130,215.90	13.02%	-55.38%
RSI&PSAR&BBANDS(1)	16,568,370.90	1556.84%	41	26	63.41%	13,585,760.02	1258.58%	-18.91%
RSI&PSAR&BBANDS(2)	1,496,176.86	49.62%	19	14	73.68%	1,496,176.86	49.62%	-44.08%
RSI&PSAR&PVO(1)	25,219,693.41	2421.97%	45	30	66.67%	21,877,711.03	2087.77%	-12.38%
RSI&PSAR&PVO(2)	1,486,979.79	48.70%	35	16	45.71%	1,409,996.82	41.00%	-44.13%
RSI&TWIGGS&BBANDS(1)	6,446,339.06	544.63%	49	25	51.02%	4,369,579.86	336.96%	-36.38%
RSI&TWIGGS&BBANDS(2)	1,186,668.88	18.67%	6	5	83.33%	1,186,668.88	18.67%	-54.43%
RSI&TWIGGS&PVO(1)	12,510,132.88	1151.01%	64	30	46.88%	9,484,861.27	848.49%	-31.21%
RSI&TWIGGS&PVO(2)	1,112,715.17	11.27%	14	6	42.86%	1,071,738.72	7.17%	-56.05%
RSI&BBANDS&PVO(1)	8,224,994.96	722.50%	68	37	54.41%	7,135,062.12	613.51%	-34.61%
RSI&BBANDS&PVO(2)	1,317,967.73	31.80%	41	21	51.22%	1,272,738.04	27.27%	-47.30%
PSAR&TWIGGS&BBANDS(1)	18,476,525.51	1747.65%	47	21	44.68%	12,524,106.17	1152.41%	-20.80%
PSAR&TWIGGS&BBANDS(2)	1,094,646.78	9.46%	6	4	66.67%	959,162.03	-4.08%	-58.90%
PSAR&TWIGGS&PVO(1)	35,711,020.15	3471.10%	65	36	55.38%	27,075,175.87	2607.52%	-10.49%
PSAR&TWIGGS&PVO(2)	3,384,115.23	238.41%	42	25	59.52%	2,328,087.11	132.81%	-40.86%
PSAR&BBANDS&PVO(1)	28,821,955.18	2782.20%	42	28	66.67%	25,002,620.63	2400.26%	-12.38%
PSAR&BBANDS&PVO(2)	1,245,134.81	24.51%	28	14	50.00%	1,062,334.73	6.23%	-56.77%
TWIGGS&BBANDS&PVO(1)	13,606,588.11	1260.66%	64	31	48.44%	10,316,165.00	931.62%	-31.21%
TWIGGS&BBANDS&PVO(2)	1,347,019.91	34.70%	6	4	66.67%	1,180,299.30	18.03%	-55.13%

Source: Developed for this study

Results of the triple indicators using AND function for PTTEP (Table 12), the highest Maximum Portfolio Wealth model was MACD&TWIGGS&PVO(1) which reached Baht 1,651,457.61 (+65.15%) higher than those of Benchmark Portfolio's and Single Indicator's. The Wealth at the End of Period for RSI&PSAR&PVO(2) was the highest of Baht 903,128.40 (-9.69%) Profitable trades under same model were 46.94%. Its Maximum Drawdown was -6.98% which was a very good improvement comparing to those of Benchmark Portfolio's and was much better than those of BBANDS as single indicator.

Table 12: Outcome of Triple indicators (AND function) for PTTEP

MODEL	Max.Wealth (Baht)	Max.Gain (Percentage)	Total Number of Buy&Sell (times)	Total Number of Profitable Trades (times)	Percentage of Profitable Trade	Wealth at the End of Period (Baht)	Gain from Investment (Baht)	Maximum Drawdown
MACD&RSI&PSAR(1)	1,256,454.99	25.65%	40	21	52.50%	572,841.03	-42.72%	-42.60%
MACD&RSI&PSAR(2)	1,018,353.36	1.84%	35	14	40.00%	659,501.01	-34.05%	-34.89%
MACD&RSI&TWIGGS(1)	1,285,273.11	28.53%	59	25	42.37%	468,539.46	-53.15%	-51.63%
MACD&RSI&TWIGGS(2)	1,068,523.45	6.85%	38	14	36.84%	684,644.22	-31.54%	-27.64%
MACD&RSI&BBANDS(1)	1,518,441.33	51.84%	37	19	51.35%	739,017.89	-26.10%	-20.30%
MACD&RSI&BBANDS(2)	1,044,093.52	4.41%	32	12	37.50%	627,410.14	-37.26%	-38.98%
MACD&RSI&PVO(1)	1,261,313.99	26.13%	52	30	57.69%	591,119.41	-40.89%	-41.62%
MACD&RSI&PVO(2)	1,045,073.39	4.51%	45	19	42.22%	713,128.22	-28.69%	-25.19%
MACD&PSAR&TWIGGS(1)	1,241,779.48	24.18%	78	26	33.33%	593,956.01	-40.60%	-41.47%
MACD&PSAR&TWIGGS(2)	1,165,400.31	16.54%	91	33	36.26%	436,093.06	-56.39%	-59.54%
MACD&PSAR&BBANDS(1)	1,422,367.22	42.24%	33	19	57.58%	753,431.36	-24.66%	-18.12%
MACD&PSAR&BBANDS(2)	1,003,941.52	0.39%	38	15	39.47%	687,081.77	-31.29%	-27.49%
MACD&PSAR&PVO(1)	1,299,177.55	29.92%	71	32	45.07%	587,639.63	-41.24%	-42.50%
MACD&PSAR&PVO(2)	1,156,876.82	15.69%	93	32	34.41%	480,029.06	-52.00%	-49.66%
MACD&TWIGGS&BBANDS(1)	1,236,015.97	23.60%	50	23	46.00%	569,968.41	-43.00%	-44.50%
MACD&TWIGGS&BBANDS(2)	1,149,143.93	14.91%	42	12	28.57%	642,002.20	-35.80%	-37.96%
MACD&TWIGGS&PVO(1)	1,651,457.61	65.15%	86	35	40.70%	624,706.90	-37.53%	-39.50%
MACD&TWIGGS&PVO(2)	1,053,960.44	5.40%	96	37	38.54%	441,023.23	-55.90%	-58.24%
MACD&BBANDS&PVO(1)	1,333,423.08	33.34%	46	28	60.87%	732,967.07	-26.70%	-20.53%
MACD&BBANDS&PVO(2)	1,143,085.72	14.31%	51	23	45.10%	730,045.23	-27.00%	-21.37%
RSI&PSAR&TWIGGS(1)	1,282,396.53	28.24%	59	21	35.59%	448,239.16	-55.18%	-57.91%
RSI&PSAR&TWIGGS(2)	1,090,658.82	9.07%	37	13	35.14%	784,035.41	-21.60%	-15.05%
RSI&PSAR&BBANDS(1)	1,380,642.75	38.06%	38	24	63.16%	716,601.53	-28.34%	-21.84%
RSI&PSAR&BBANDS(2)	1,000,000.00	0.00%	30	11	36.67%	680,979.92	-31.90%	-33.39%
RSI&PSAR&PVO(1)	1,266,207.74	26.62%	50	29	58.00%	449,719.08	-55.03%	-57.29%
RSI&PSAR&PVO(2)	1,199,895.84	19.99%	49	23	46.94%	903,128.40	-9.69%	-6.98%
RSI&TWIGGS&BBANDS(1)	1,193,746.65	19.37%	77	30	38.96%	460,093.86	-53.99%	-56.49%
RSI&TWIGGS&BBANDS(2)	1,224,603.82	22.46%	42	13	30.95%	711,518.75	-28.85%	-25.74%
RSI&TWIGGS&PVO(1)	1,163,251.09	16.33%	68	27	39.71%	405,632.60	-59.44%	-62.68%
RSI&TWIGGS&PVO(2)	1,229,053.48	22.91%	41	17	41.46%	877,191.45	-12.28%	-12.06%
RSI&BBANDS&PVO(1)	1,124,557.36	12.46%	71	36	50.70%	587,731.59	-41.23%	-42.39%
RSI&BBANDS&PVO(2)	1,643,499.84	64.35%	64	28	43.75%	799,861.01	-20.01%	-12.87%
PSAR&TWIGGS&BBANDS(1)	1,275,684.10	27.57%	47	19	40.43%	617,306.05	-38.27%	-39.68%
PSAR&TWIGGS&BBANDS(2)	1,207,871.24	20.79%	39	13	33.33%	715,858.97	-28.41%	-24.62%
PSAR&TWIGGS&PVO(1)	1,238,836.09	23.88%	84	29	34.52%	454,967.61	-54.50%	-56.72%
PSAR&TWIGGS&PVO(2)	1,128,269.44	12.83%	96	38	39.58%	483,370.99	-51.66%	-48.26%
PSAR&BBANDS&PVO(1)	1,266,207.74	26.62%	45	27	60.00%	594,470.77	-40.55%	-40.91%
PSAR&BBANDS&PVO(2)	1,264,115.92	26.41%	54	24	44.44%	845,064.52	-15.49%	-12.75%
TWIGGS&BBANDS&PVO(1)	1,163,251.09	16.33%	61	26	42.62%	490,147.14	-50.99%	-46.91%
TWIGGS&BBANDS&PVO(2)	1,240,154.13	24.02%	47	17	36.17%	716,151.95	-28.38%	-21.98%

Source: Developed for this study

Results of the triple indicators using AND function for SCB (Table 13), the highest Maximum Portfolio Wealth model was RSI&PSAR&BBANDS(1) which reached Baht 2,827,092.70 (+182.71%) higher than those of Benchmark Portfolio's and Single Indicator's. The Wealth at the End of Period for the same model was the highest of Baht 2,454,894.03 (+146.49%) Profitable trades under same model were 62.16%. Its Maximum Drawdown was -12.06% which was a very good improvement comparing to those of Benchmark Portfolio's and was much better than those of BBANDS as single indicator.

Table 13: Outcome of Triple indicators(AND function) for SCB

MODEL	Max.Wealth (Baht)	Max.Gain (Percentage)	Total Number of Buy&Sell (times)	Total Number of Profitable Trades (times)	Percentage of Profitable Trade	Wealth at the End of Period (Baht)	Gain from Investment (Baht)	Maximum Drawdown
MACD&RSI&PSAR(1)	1,165,497.46	16.55%	46	20	43.48%	983,601.40	-1.64%	-39.64%
MACD&RSI&PSAR(2)	1,000,000.00	0.00%	33	17	51.52%	748,635.43	-25.14%	-39.90%
MACD&RSI&TWIGGS(1)	1,291,939.81	29.19%	53	20	37.74%	922,426.35	-7.76%	-39.45%
MACD&RSI&TWIGGS(2)	1,000,000.00	0.00%	38	15	39.47%	717,590.68	-28.24%	-47.86%
MACD&RSI&BBANDS(1)	1,528,981.03	52.90%	44	17	38.64%	1,264,542.40	26.45%	-23.25%
MACD&RSI&BBANDS(2)	1,000,000.00	0.00%	33	18	54.55%	766,185.28	-23.38%	-41.67%
MACD&RSI&PVO(1)	1,579,975.35	58.00%	58	28	48.28%	1,117,412.35	11.74%	-24.76%
MACD&RSI&PVO(2)	1,397,841.97	39.78%	40	20	50.00%	1,030,314.49	3.03%	-34.64%
MACD&PSAR&TWIGGS(1)	1,053,390.04	5.34%	91	29	31.87%	552,935.81	-44.71%	-56.74%
MACD&PSAR&TWIGGS(2)	1,007,914.33	0.79%	80	27	33.75%	573,516.83	-42.65%	-58.09%
MACD&PSAR&BBANDS(1)	2,126,487.57	112.65%	39	21	53.85%	1,883,372.83	88.34%	-14.48%
MACD&PSAR&BBANDS(2)	1,000,000.00	0.00%	34	17	50.00%	626,371.86	-37.36%	-45.84%
MACD&PSAR&PVO(1)	1,546,329.66	54.63%	81	39	48.15%	969,757.75	-3.02%	-34.96%
MACD&PSAR&PVO(2)	1,038,155.03	3.82%	88	30	34.09%	606,029.87	-39.40%	-44.57%
MACD&TWIGGS&BBANDS(1)	1,925,198.77	92.52%	43	17	39.53%	1,523,750.74	52.38%	-19.00%
MACD&TWIGGS&BBANDS(2)	1,010,324.64	1.03%	37	16	43.24%	689,498.76	-31.05%	-47.37%
MACD&TWIGGS&PVO(1)	1,111,938.42	11.19%	83	30	36.14%	760,249.00	-23.98%	-39.84%
MACD&TWIGGS&PVO(2)	1,053,281.19	5.33%	89	28	31.46%	482,043.34	-51.80%	-63.69%
MACD&BBANDS&PVO(1)	1,921,155.22	92.12%	53	28	52.83%	1,521,920.42	52.19%	-19.40%
MACD&BBANDS&PVO(2)	1,148,186.80	14.82%	42	19	45.24%	875,605.20	-12.44%	-39.13%
RSI&PSAR&TWIGGS(1)	1,874,642.06	87.46%	48	22	45.83%	1,350,427.49	35.04%	-21.93%
RSI&PSAR&TWIGGS(2)	1,051,973.76	5.20%	41	16	39.02%	600,237.97	-39.98%	-50.14%
RSI&PSAR&BBANDS(1)	2,827,092.70	182.71%	37	23	62.16%	2,454,894.03	145.49%	-12.06%
RSI&PSAR&BBANDS(2)	1,000,000.00	0.00%	34	17	50.00%	601,173.75	-39.88%	-52.43%
RSI&PSAR&PVO(1)	1,430,423.15	43.04%	55	29	52.73%	1,029,979.80	3.00%	-33.50%
RSI&PSAR&PVO(2)	1,378,056.25	37.81%	40	19	47.50%	995,758.13	-0.42%	-38.28%
RSI&TWIGGS&BBANDS(1)	2,154,222.26	115.42%	51	21	41.18%	1,690,647.57	69.06%	-13.89%
RSI&TWIGGS&BBANDS(2)	1,000,000.00	0.00%	57	16	28.07%	475,213.99	-52.48%	-61.66%
RSI&TWIGGS&PVO(1)	1,406,320.54	40.63%	52	25	48.08%	1,067,613.79	6.76%	-30.31%
RSI&TWIGGS&PVO(2)	1,272,083.64	27.21%	52	21	40.38%	833,882.05	-16.61%	-43.29%
RSI&BBANDS&PVO(1)	1,272,447.82	27.24%	70	37	52.86%	981,148.21	-1.89%	-38.49%
RSI&BBANDS&PVO(2)	1,598,023.83	59.80%	53	27	50.94%	1,248,422.14	24.84%	-21.38%
PSAR&TWIGGS&BBANDS(1)	2,534,127.05	153.41%	39	19	48.72%	1,995,440.81	99.54%	-13.24%
PSAR&TWIGGS&BBANDS(2)	1,000,000.00	0.00%	43	15	34.88%	466,829.22	-53.32%	-65.51%
PSAR&TWIGGS&PVO(1)	1,347,166.04	34.72%	77	29	37.66%	825,044.16	-17.50%	-39.96%
PSAR&TWIGGS&PVO(2)	1,087,997.10	8.80%	89	32	35.96%	623,801.38	-37.62%	-45.89%
PSAR&BBANDS&PVO(1)	2,209,731.55	120.97%	45	28	62.22%	1,738,191.23	73.82%	-14.85%
PSAR&BBANDS&PVO(2)	1,178,026.03	17.80%	40	18	45.00%	906,504.79	-9.35%	-37.52%
TWIGGS&BBANDS&PVO(1)	1,688,140.95	68.81%	44	21	47.73%	1,378,518.94	37.85%	-21.27%
TWIGGS&BBANDS&PVO(2)	1,308,010.12	30.80%	54	20	37.04%	777,478.62	-22.25%	-41.29%

Source: Developed for this study

Discussion

The most noticeable finding of this research is that the performance of PSAR was noticeably better than other indicators in single, double, and triple indicators tests, and inclusion of PSAR in multi-indicator tests improved performance above the Benchmark Portfolio. This is consistent with other studies, which have also confirmed the efficacy of PSAR as a technical indicator, either a primary indicator or a confirming indicator (Di Lorenzo, 2013 Kirkpatrick & Dahlquist, 2010; Kordos & Cwiok, 2011; Liu & Xiao, 2009; Lo, et al., 2000; Metghalchi, Chang, & Garza-Gomez, 2012; Stasinakis & Sermpinis, 2014). This finding was consistent with the expectations set by the literature, although the literature did not show that the PSAR indicator would be so much more effective than the alternative technical indicators. This is likely because there is a dearth of comparative literature and literature that assesses multi-indicator models rather than single-indicator models.

The outcome of the technical indicators did somewhat support its use. The Weak-Form Efficient Market Hypothesis does not hold in this case. However, the other indicators did not perform as consistently well as PSAR. This supports the contention of other researchers, who have argued that in the long term, technical analysis cannot beat the performance of a buy and hold strategy (Chen & Metghalchi, 2012; Chong, Cheng, & Wong, 2010; Coe & Laosethakul, 2010). These authors have generally found that the performance of technical indicators compared to buy and hold strategies is not supported in the long term, and the findings of this study do not contradict those findings (although they do point to the short-term viability of technical indicators compared to buy and hold).

It can also be found that the better performed models of which had higher End of Period Wealth also had lower downside risk since its Maximum Drawdown was lesser. Using PSAR or BBANDS alone their Maximum Drawdown were much lower than those of Benchmark Portfolio, by using it with other confirming indicator the maximum drawdown changed in two directions, with proper-matched confirming indicators the Maximum Drawdown was reduced, with other indicators the Maximum Drawdown was increased.

Conclusion and Recommendations

This study provided a solution for an investor for use when the trading signals from different indicators do not match on the same day. Using the AND function, if the signal provided by confirming indicators does not match no trade can occur and there could be a loss of opportunity to trade for the entire period. This study considered the portfolio's position as a result of single indicators trading signal instead of the trading signals calculated.

The simulation study showed that the AND function can be used to combine the trade signals from technical indicators successfully. Combining the signals from multiple indicators improve the performance of trading model both in higher wealth and lower risk. This study has also included the highest transaction cost to the simulation process, which is important when considering the total cost of trade and the potential profits.

The results of this study do call into question the weak form of the efficient market hypothesis (EMH). The findings showed that technical indicators can be used to out-perform buy and hold strategies, although not all technical indicators had the same effectiveness. The conclusion of this research is that there is at least the potential that technical indicators could be used for effective trading with abnormal returns above those provided by a buy and hold strategy. However, this should not be taken as absolute proof, given the limitations of the study and the conditions under which it is undertaken. There is still a need for more research in this topic area, which has received little empirical support despite its active use on the trading floor.

The main implication of this finding is that, at least within the scope of this study, technical analysis can be an effective short-term trading strategy when using the right indicators and combinations. However, care must be taken in replicating The success of the study depended on several conditions, including include (1) inclusion of technical indicators from different categories, (2) daily data of the security using the highest market capitalization of each industry, (3) transaction cost was included in the calculation, (4) an alternative method of combining trading signals was used, and (5) the study period covers all economic circumstances. Thus, when attempting to replicate the results or use the established model in practice, these factors do need to be taken into account.

There are several limitations to this study. The main limitation is that only three securities were included in the analysis, and all securities were from the Stock Exchange of Thailand (SET) over a limited period. Another limitation is that not all industries are represented in the study. The study did not compare performance of technical indicators between industries. It also included a limited number of indicators, which was necessary because the potential list of technical indicators is too large for a single study. This study used closing price as price in the calculation where in real life trading you may or may not be able to buy stocks at closing price. The closing price is only useful during periods when a company has not issued any cash dividends or conducted any corporate actions, such as stock splits, reverse stock splits and stock dividends. This study assumed no dividend payment nor any impact from dividend payment on the closing price. The simulated model assumes that the investor can buy and sell at the informed price and the required volume but in reality the price may go up or down and the securities might not be available at the required volume.

This offers the opportunity for expanding research, including analysis of different indicators, different signals combination technique, comparison of developing versus developed markets, and more extensive long-term analysis of the effectiveness of technical indicators against other strategies. Similar ideas can also be adapted to other financial markets such as derivatives market, commodity market, and foreign exchange market.

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