Original Article

Efficiency of Bollinger Bands in Forward Operations for Agricultural Products in Vietnam

Nguyen Thi Nhung[*], Nguyen Thi Nguyet Nuong, Nguyen Ha Uyen

VNU University of Economics and Busines,144 Xuan Thuy, Cau Giay, Hanoi, Vietnam

Abstract: Using primary data collected from in-depth interviews with 11 practical experts who have been working in the commodity industry for 7 years on average and using the Bollinger Bands tool for 3 years at least, the article shows that Bollinger Bands' signs on price forecasts or making decisions to buy or sell in the future trading of agricultural products in Vietnam are highly appreciated because of their accuracy. In addition, by using the Analytical Hierarchy Process (AHP) approach, the research indicates that there is no big difference in the effectiveness of Bollinger Bands' application in future transactions for coffee, corn, wheat, soybean and soybean oil. However, applying Bollinger Bands in coffee futures' trading is the most effective. In addition, the study also emphasizes the combination of Bollinger Bands with other technical analysis tools such as RSI, MACD, Fibonacci, Ichimoku, and CCI, to improve transaction efficiency.

Keywords: Technical Analysis, Bollinger Bands, Commodity exchange, Agricultural products, Analytical hierarchy process.

1. Introduction

In Vietnam, commodity forward operations started to be introduced since 2000 through commercial banks or on some domestic commodity exchanges. However, a small number of investors was interested in future or forward trading, leading to the fact that trading value was very low and then Buon Ma Thuot Coffee Exchange Center (BCEC) and Vietnam Commodity Exchange (VNX) which were established in 2008 and 2011 respectively, were obliged to be closed some years later [1]. Since Decree 51, which amends and supplements some contents of Decree 158, takes effect from 1st June 2018, the Vietnam Commodity Exchange was revived with the new name of the Mercantile Exchange of Viet Nam (MXV) on 17th of

_____
[*] Corresponding author
   E-mail address: nguyenthinhung.1684@gmail.com
   https://doi.org/10.25073/2588-1108/vnueab.4604

August in 2018. MXV plays the role of an intermediary which connects domestic investors with international exchanges. Statistics from MXV strongly indicate that the number of investment accounts has significantly increased for three years. These days, approximately 10,000 lots of commodities are traded on average every day.

Besides fundamental analysis, technical analysis has become popular among Vietnamese investors who engage in agricultural futures for many years. In theory, technical analysis is a trading discipline employed to evaluate investments and identify trading opportunities by analyzing statistical trends gathered from trading activity, such as price movement and volume, instead of attempting to evaluate a security's value based on business results like fundamental analysis. Technical analysis is often used to generate short-term trading signals from various charting tools but can also help improve the evaluation of a security's strength or weakness relative to the broader market or one of its sectors. Along with the development of science and technology, technical analysis has become prevalent and very useful tools for investors. Among technical analysis tools, Bollinger Bands (BBs), which was born more than 30 years ago, is quite popular in the world as well as in Vietnam and is favored by many investors because of their simplicity and ability to quickly reflect price fluctuations on the securities market [2].

However, a literature review shows that there are very few academic studies on technical analysis in general and the BBs tool in particular, especially for derivative operations on commodity exchanges in Vietnam. Therefore, this article aims to compare the effectiveness of the BBs tool in three aspects, including price forecast, buying indicators and selling indicators by 5 main agricultural products in Vietnam, i.e. coffee, corn, wheat, soybean and soybean oil. To achieve the above goal, the study uses the Analytic Hierachy Process (AHP) with primary data collected from an in-depth survey of 11 experts who have an average of 7 years of working experience in the field of commodity derivatives and more than 3 years using BBs for decision-making when trading futures on agricultural products in Vietnam.

To the best of our knowledge, this is the first academic research that mentions the BBs tool and tries to evaluate its effectiveness in the field of commodities in Vietnam. The findings of this research will contribute to the literature on technical analysis in general and the use of BBs in particular. In addition, this article provides empirical evidence about the effectiveness of the BBs tool as well as gives recommendations to investors about how to use it more effectively when they participate in commodity exchanges.

The paper consists of 5 parts. The first part is an introduction. The second part reviews literature about BBs. Methodology and data used to evaluate NPLs resolutions are presented in the third part. The results are shown in part 4 and discussion is given in part 5.

2. Literature review

2.1. Overview of Bollinger Bands

The Bollinger Bands (BBs) tool was developed by famous technical trader John Bollinger in 1983 [3]. BBs include three fundamental lines, such as a simple moving average (or middle band) and an upper band and a lower band, which plotted two standard deviations (positively and negatively) away from a simple moving average of a security's price.

The middle band is usually a set of 20-day moving averages which average out the closing prices for the first 20 days.

$$SMA20 = \frac{\sum_{j=1}^{20} Pricing\ closes_j}{20}$$

The upper band can be calculated by multiplying a standard deviation value by two and adding that amount from each point along the SMA. In contrast, the lower band can be computed by multiplying a standard deviation value by two and subtracting that amount from each point along the SMA.

Upper band = Middle band + 2 * σ

Lower band = Middle band – 2 * σ

Standard deviation can be estimated by taking the square root of the variance, which itself is the average of the squared differences of the mean.

$$\sigma = \sqrt{\frac{\sum(Closing\ price_j - Average\ price)^2}{20}}$$

BBs is considered as an efficient tool to analyze price movements in comparison with other technical tools such as moving average convergence divergence (MCDM) or wave pattern. BBs can give signs about market movements and then, allow the prediction of possible trends. Firstly, BBs allow the determination of the trend of price movement or price forecast. To be precise, when the upper band and the lower band come close together, price is expected to have low volatility. Conversely, the wider apart the bands move, the more likely the chance of a decrease in volatility and the greater the possibility of exciting a trade. Moreover, when the price volatility decrease and the squeeze is small, price is predicted to significantly fluctuate in the coming time. Secondly, investors should buy securities when the price exceeds the upper band and then returns in the squeeze. In contrast, selling is recommended when the price exceeds the lower band and then the closing price is in a squeeze.

In general, investors always combine BBs with others tools like relative strength index (RSI) or moving average convergence divergence (MCDM)… to achieve the best investment results possible.

2.2. Studies about Bollinger Bands

Besides fundamental analysis, technical analysis also has attracted the attention of researchers. Most research focuses on clarifying the benefits or effectiveness of technical analysis in the transaction process. Some studies have focused on commodity markets such as Miffre and Rallis (2007) [4], Shen et al. (2007) [5], Marshall et al. (2008) [6], Szakmary et al. (2010) [7].

To be precise, Miffre and Rallis (2007) tested contrarian strategies and momentum strategies on the US commodity market [6]. The results showed that contrarian strategies were ineffective while momentum strategies could bring profits all year for investors. By comparing the efficiency of momentum strategies between commodity and stock markets, Shen et al. (2007) indicated that they were more useful on the commodity market than the stock market [5].

Strongly disagreeing with the point of view that technical analysis has brought many outstanding advantages on commodity markets where transaction costs are very low, Marshal et al. (2008) tested all 15 commodity futures and concluded that the realized profits cannot be higher than expected returns due to random phenomena on the market [6]. Similarly, Fuertes et al. (2010) confirmed that all momentum strategies and term structure trading signals were pretty good on commodity exchanges [8]. Meanwhile, Szkmary et al. (2010) argued that the purely trend-oriented investment strategies have many outstanding points rather than trend-following investment strategies [7].

In terms of BBs, despite the fact that they are widely popular tool for traders, there are few academic researches on it [2]. Lento et al. (2007) used data on stock indices and Forex markets to demonstrate that BBs couldn't bring greater returns than a buy-and-hold trading strategy [9]. Similarly, Leung and Chong (2003) also agreed that BBs were less efficient than moving averages [10].

In contrast, Lubnau and Todorova (2015) tested the effectiveness of technical tools in the futures' trading of crude oil, natural gas, gasoline and heating oil. Particularly, BBs were tested as buy and sell signals in trading. The results showed that buy signals from BBs only appeared in 5 to 70 transactions during 5 years. In other words, these indicators were not clear. Moreover, rules of using signals from the 20-day moving average are the best [2].

Using data of stocks which make up the Taiwan 50 index to consider whether investors can use BBs as buy or sell signals to gain profits from the market, Ni et al. (2019) confirmed BBs were completely effective. So, investors can buy when the price hits the lower band or the price is above the upper band. Moreover, investors can use momentum strategies instead of contrarian strategies when the price hits the upper band [11].

In brief, although BBs are a highly common technique for investors, there are very few researches on BBs and researches on their effectiveness are pretty different from market to market. In particular, there is not any academic research on this topic in Vietnam although BBs are mentioned by a number of securities' firms on their websites because of the tool's popularity among investors. The above practice provides us with a high motivation to examine if BBs are efficient when being applied on futures of agricultural products in Vietnam.

3. Methodology

3.1. Research design and data collection

The article focuses on 2 main objectives: (i) Evaluating the effectiveness of the BBs tool; (ii) Comparing the effectiveness of applying BBs in future transactions for 5 agricultural products, including coffee, corn, wheat, soybean and soybean oil. The research data are primary ones which are collected from experts' answers. Due to the fact that the AHP method highly requires the "quality" of the surveyed people but not big samples, the research only focuses on professionals with at least 5 years of experience in trading commodity futures and 3 years of experience in using BBs.

Before assessing and comparing the effectiveness of the BBs' in future transactions for 5 agricultural products, the research tries to find out evaluation criteria. Based on the literature review shown in the second part, the authors propose ideas and discuss about how to assess BBs, with 3 experts who are working in

commodity firms in Vietnam. The in-depth interviews allow exploring experts' perspectives on criteria which this assessment should be based on, as well as their content and components. Then, the authors decide to divide multiple criteria into 3 groups, including (i) Price forecast; (ii) Indicator of purchasing decision; (iii) Indicator of selling decision.

In the next step, the authors did pilot testing during the in-depth interviews in order to identify if the respondents understood the questionnaire, if they had any comments about both content and the format of the survey or any suggestions in order to make the survey clearer and more significant. Based on the sample group's feedback about how they understood and what they were still concerned about or questions, etc., the authors made necessary adjustments and amendments in order to make sure that the questions had face validity. To ensure the accuracy of responses, the research used various kinds of questions including closed-ended and open-ended questions as well as Likert scale questions with a five-point scale which allowed the individual to express how much they agreed or disagreed with a particular statement, by numbering from 1, the lowest (the worst), to 5, the highest (the best).

In fact, the survey included 5 question groups: The first question focused on the importance of three different application aspects of BBs. The second one included two questions, the third and fourth groups included three questions are proposed to ask criterion 1, 2 and 3 respectively. Moreover, the final question aimed to ask solutions to improve the effectiveness of BBs' application in forward operations for agricultural products in Vietnam. Appendix 1 presents in more detail the expert questionnaire survey.

After that, the authors sent a survey to experts who were working for commodity firms in Vietnam in January. So, data collection was carried out from the beginning of February until the end of February 2021 (one month). As the data collection phase was coming to an end, the authors had successfully received a total of 11 responses.

3.2. Research model

The Analytic Hierarchy Process (AHP) is used to compare the effectiveness of BBs in future operations of 5 different agricultural products. There are 5 distinct stages in the AHP model, beginning with calculations of the average weight of each criterion and ending with calculations of values of each alternative.

There are:

- m alternatives (futures for agricultural products) to assess. Call A_i with $i = 1, 2, 3, ..., m$

- n criteria to assess. Call C_j with $j = 1, 2, 3, ..., n$

- k groups of decision-makers. Call D_r with $r = 1, 2, 3, ..., k$

So, we have:

$-\widetilde{X_{ji}^r}$ is an assessment value of decision-maker D_r about criteria C_j for alternative A_i

- W_j^r is the weight of criteria C_j evaluated by decision - maker D_r

i) Step 1: Calculate the average weight of each criterion:

$$\widetilde{W_j} = \frac{1}{k}\, x\, (W_j^1 + W_j^2 + \cdots + W_j^k) \qquad (1)$$

Calculate the average value of each alternative:

$$\widetilde{X_{ji}} = \frac{1}{k} x\, (\widetilde{X_{ji}^1} + \widetilde{X_{ji}^2} + \cdots + \widetilde{X_{ji}^k}) \qquad (2)$$

We have the matrix related to decision making as follows:

$$\tilde{X} = \begin{matrix} & C_1 \;\; C_2 \qquad ..... \;\; C_j \qquad ..... \;\; C_n \\ \begin{matrix} A_1 \\ A_2 \\ \vdots \\ A_i \\ \vdots \\ A_m \end{matrix} & \begin{bmatrix} \widetilde{X_{11}} & \widetilde{X_{12}} & ..... & \widetilde{X_{1J}} & ..... & \widetilde{X_{1n}} \\ \widetilde{X_{12}} & \widetilde{X_{22}} & \cdots & \widetilde{X_{2J}} & \cdots & \widetilde{X_{2n}} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ \widetilde{X_{i1}} & \widetilde{X_{i2}} & \cdots & \widetilde{X_{iJ}} & \cdots & \widetilde{X_{in}} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ \widetilde{X_{m1}} & \widetilde{X_{m2}} & \cdots & \widetilde{X_{mJ}} & \cdots & \widetilde{X_{mn}} \end{bmatrix} \end{matrix} \qquad (3)$$

We have the matrix related to criteria weight as follows:

$$\widetilde{W} = \begin{bmatrix} \widetilde{w_1} \widetilde{w_2} & ..... & \widetilde{w_J} & .....\widetilde{w_n} \end{bmatrix} \qquad (4)$$

ii) Step 2: Establish the pairwise comparison matrix of criteria, the relative reciprocal matrix of criteria and calculate the EBQ ranking vector for the criteria.

We have t the pairwise comparison matrix of criteria as follows:

$$C_1 \;\; C_2 \qquad ..... \;\; C_j \qquad ..... \;\; C_n$$

$$\tilde{Y} = \begin{matrix} \begin{matrix} C_1 \\ C_2 \\ \vdots \\ C_t \\ \vdots \\ C_n \end{matrix} & \begin{bmatrix} C_{11} & C_{12} & ..... & C_{1j} & ..... & C_{1n} \\ C_{21} & C_{22} & ..... & C_{2j} & ..... & C_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ C_{t1} & C_{t2} & \cdots & C_{tj} & \cdots & C_{tn} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ C_{n1} & C_{n2} & \cdots & C_{nj} & \cdots & C_{nn} \end{bmatrix} \end{matrix} \qquad (5)$$

Where:

$$C_{tj} = \frac{\widetilde{w_t}}{\widetilde{w_j}}\; with\; t,j = 1, 2, ..., n \qquad (6)$$

We have t relative reciprocal matrix of criteria as follows:

$$C_1 \;\; C_2 \qquad ..... \;\; C_j \qquad ..... \;\; C_n$$

$$\widetilde{Y'} = \begin{matrix} \begin{matrix} C_1 \\ C_2 \\ \vdots \\ C_t \\ \vdots \\ C_n \end{matrix} & \begin{bmatrix} C'_{11} & C'_{12} & ..... & C'_{1j} & ..... & C'_{1n} \\ C'_{21} & C'_{22} & ..... & C'_{2j} & ..... & C'_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ C'_{t1} & C'_{t2} & \cdots & C'_{tj} & \cdots & C'_{tn} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ C'_{n1} & C'_{n2} & \cdots & C'_{nj} & \cdots & C'_{nn} \end{bmatrix} \end{matrix} \qquad (7)$$

Where:

$$C'_{tj} = \frac{C_{tj}}{\sum C_{tj}} \qquad (8)$$

And we calculate the derived priorities (weights) for the criteria as follows:

$$EBQ_j = \frac{\sum C'_{tj}}{n} \qquad (9)$$

With t is $1, 2, ..., n$ accordingly and j is from 1 to n for each value of t.

iii) Step 3: Check the consistency of judgments

The research calculates a consistency ratio (CR) comparing the consistency index (CI) of the matrix in question versus the consistency index of a random-like matrix (RI).

$$CR = \frac{CI}{RI} \qquad (10)$$

CI is calculated as follows:

$$Weighted\; sum\; [C_j] = \sum C_{tj}\, x EBQ_j \qquad (11)$$

$$Consistensive\; vector [D_j] = \frac{[C_j]}{[EBQ_j]} \qquad (12)$$

$$\alpha = \frac{Sum\; [D]}{k} \qquad (13)$$

$$CI = \frac{\alpha - k}{k - 1} \qquad (14)$$

According to Saaty (2012), the RI value for matrices of size 4 is 0.9. A consistency ratio (CR) of 0.10 or less is acceptable to continue the AHP analysis [12]. In contrast, it is necessary to revise the judgments to locate the cause of the inconsistency and correct it.

iv) Step 4: Establish the pairwise comparison matrix of alternatives for each criterion, the relative reciprocal matrix of alternatives, with respect to each criterion by using the numeric scale and calculate the EBQ ranking vector of alternatives for each criterion (EBQ_{ji}). This step is executed in a similar manner to the second step.

v) Step 5: Calculate the value of each alternative; the higher the value is, the better it is.

$$V_i = \sum EBQ_j x EBQ_{ji} \qquad (15)$$

4. Empirical results

4.1. Statistical description

The research received 11 responses from experts who are currently working as financial analysts (18%), investment consultants (37%), managers (9%) and directors (36%) for different commodity firms - members of the Mercantile Exchange of Viet Nam (Figure 1). Moreover, Figure 2 shows that on average, the experts have 5 experience years of using BBs.
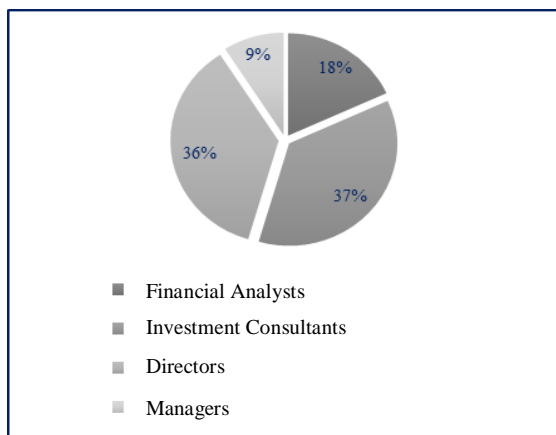
Figure 1: Positions of interviewed experts
Source: Survey results.
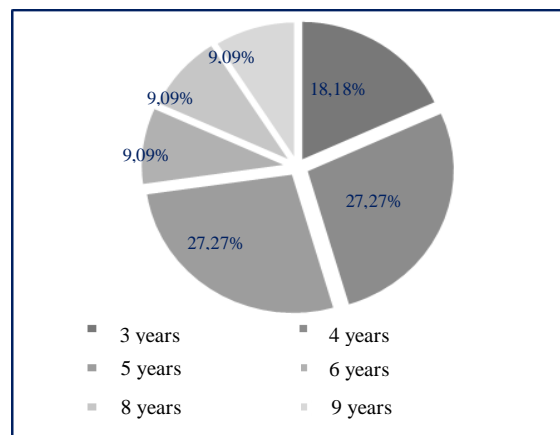
Figure 2: Years of experience of interviewed experts
Source: Survey results.
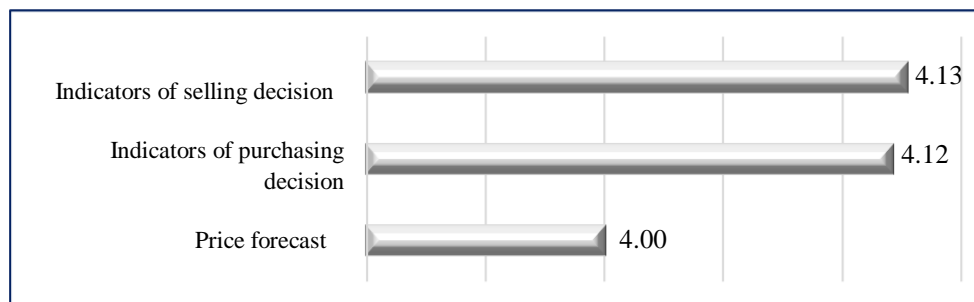
Figure 3: Overview of the effectiveness of BBs' application
Source: Authors.

4.2. BBs' application and effectiveness

Effectiveness of applying BBs in futures operations of agricultural products in Vietnam

Figure 3 indicates that in general, BBs are considered as an efficient technical tool which is used on commodity exchanges with the average marks bigger than 4. In particular, BBs are mostly useful to give signs for purchasing and selling decisions.

Figure 4 shows that indicators are generally considered to be quite good because their scores

are greater than 4. Only indicator "The price rises sharply when it is always in the interval between the upper band and SMA20" is lower than 4 (score of 3.96). Moreover, indicators "Selling when the close price is below the lower

band" are the most effective ones with a score of 4.40, followed by indicators "Buying when the price close is on the upper band after a bottleneck" and "Buying when the close price hits the lower band" with a score of 4.14.
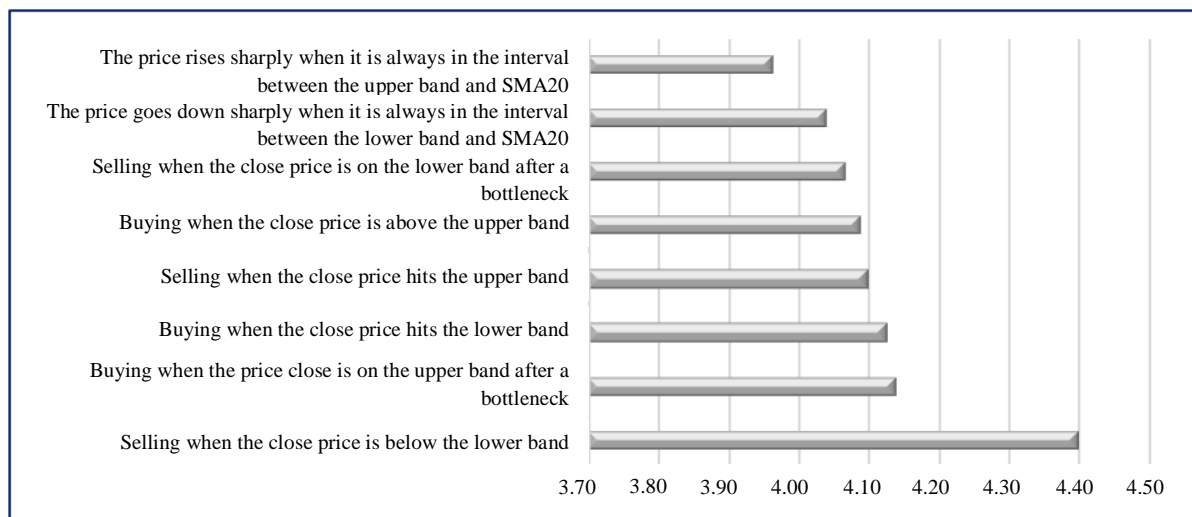

Figure 4: Effectiveness of BBs by indicators
Source: Authors.

Comparing the effectiveness of BBs which are applied in trading futures on agricultural products in Vietnam

Table 1: Importance of criteria

Criteria	Standardized criteria (%)
C1: Price Forecasting	32.64
C2: Buying signs	33.64
C3: Selling signs	33.71
	100.00

Source: Authors.

Table 1 shows that there is no big difference in roles of price forecast, indicators for purchasing decision-making and indicators for selling decision-making in trading futures on agricultural products in Vietnam. However, using BBs to make decisions about purchasing or selling is quite a bit more significant than that of price forecast (33.71% and 34.64% compared to 32.64%).

The research shows a consistency ratio of (0.08) - less than 0.10 (Appendix 2). This means it is acceptable to continue the AHP analysis. According to AHP analysis, it can be clearly seen that overall priorities of all alternatives are quite low. BBs give the best indicators for coffee (0.2068), which are followed by those for corn, wheat and soybeans (0.2000) and for soybean oil (Table 2).

In terms of indicators, Table 2 shows that:

- Using BBs to forecast prices: BBs can be used to estimate the best possible price for futures on coffee (0.2091), followed by futures for wheat (0.2023), futures for soybeans (0.2000), futures for corn (0.1977) and finally futures for soybean oil (0.1909).

- Using BBs to provide indicators for purchasing: BBs give the best indicators for decision-making of purchasing futures for coffee and corn (0.2059), followed by futures for soybeans (0.2000), futures for wheat (0.1985) and finally futures for soybean oil (0.1897).

- Using BBs to provide indicators for selling: BBs give the best indicators for decision-making of purchasing futures for corn (0.2085), followed by futures for coffee (0.2056), futures for soybeans (0.62), futures for wheat (0.1977) and finally futures for soybean oil (0.1850).

Table 2: Synthesis of the model

Futures	Price forecasting (C1)	Buying signs (C2)	Selling signs (C3)	Value
	0.3264	0.3364	0.3371	
Coffee	0.2091	0.2059	0.2056	0.2068
Corn	0.1977	0.2059	0.2085	0.2041
Wheat	0.2023	0.1985	0.1997	0.2001
Soybean	0.2000	0.2000	0.2012	0.2004
Soybean oil	0.1909	0.1897	0.1850	0.1885

Source: Authors.

5. Discussion and conclusion

Research results show that there is no big difference in the effectiveness of Bollinger Bands among future transactions for coffee, corn, wheat, soybean and soybean oil. Moreover, applying BBs in the futures transaction for agricultural products in Vietnam is quite effective. Most indicators for price forecast or purchasing or selling which are given by BBs are significant to investors. In addition, the application of BBs in futures transactions for agricultural products in Vietnam brings quite similar results. However, applying BBs for coffee futures is the most effective, followed by futures for corn, wheat, soybeans and soybean oil. The research result is totally logical with what Ni et al. (2019) found but different from the results of previous studies such as that of Lento et al. (2007) and Lubnau and Todorova (2015).

In fact, risk management for agricultural products (like coffee, corn, wheat) has been a big preoccupation in Vietnam for many years because these commodities play a very important role for the national economy and are strongly affected by price fluctuations on international markets. Through MXV, Vietnamese investors, including both producers and speculators have an opportunity of hedging their positions and earning money based on their ability to predict price movements, respectively. In other words, derivatives on agricultural products have become popular for many years in Vietnam. Therefore, it can be obviously seen that this study provides significant evidence on the importance of BBs for decision making of investors on the Vietnam commodity exchanges these days. Vietnamese investors can refer to this tool to improve their investment performance.

According to the principles of BBs, some predictions can be given to investors who are engaging in commodity operations in 2021. To be precise, the price of futures for coffee is estimated to go up from 111 to 140 since BBs was between 104 and 135 but closer to the upper band in 2020. By contrast, futures for wheat are expected to experience a downward trend in prices with the range from 450 to 600. Regards to futures for corn, soybean and soybean oil, BBs strongly show selling indicators. In fact, in 2020, the price of these three types of futures dramatically fluctuated with large ranges of 302-479, 807-1311, and 25.14-43.06 for corn, soybeans and soybean oil, respectively while these prices rose over the upper bands.

Moreover, experts recommend that BBs are mostly suitable during operation sessions in Europe and when the market experiences a flat price or signals for buying or selling are pretty clear. In order to improve the effectiveness of BBs' application in the futures transactions for agricultural products, investors should take into account some following recommendations: (i) Strictly observe price movements to accurately identify market trends; (ii) Combine BBs with other technical analysis tools such as RSI,

MACD, Fibonacci, Ichimoku, CCI, Zigzag, to forecast prices; (iii) Consult market news, fundamental and technical analysis, psychological control and capital control; (iv) Choose the appropriate time to enter an order.

References

[1] N.T.Nhung, "Commodity Exchange in Vietnam: Case of Forwards on Coffee," *VNU Journal of Science: Economics and Business*, 33 (2017) 3, 74-83 (in Vietnamese).

[2] T. Lubnau, N. Todorova, "Trading on Mean-Reversion in Energy Futures Markets," *Energy Economics*, 51 (2015), 312-319. https://doi.org/10.1016/j.eneco.2015.06.018

[3] Bollinger, J.A., *Bolinger on Bollinger Bands*, MacGraw-Hill Education, 2001.

[4] J. Mifre, G. Rallis, "Momentum Strategies in Commodity Futures Markets," *Journal of Banking Finance*, 31 (2007) 6, 1863-1886. https://doi.org/10.1016/j.jbankfin.2006.12.005

[5] Q. Shen, A. Szakmary, S.C. Sharma, "An Examination of Momentum Strategies in Commodity Futures Markets," *Journal of Futures Market*, 27 (2007) 3, 227-256. https://doi.org/10.1002/fut.20252

[6] B.R. Marshall, R.H. Cahan, J.M. Cahan, "Can Commodity Futures be Profitably Traded with Quantitative Market Timing Strategies," *Journal of Banking Finance*, 32 (2008) 9, 1810-1919. https://doi.org/10.1016/j.jbankfin.2007.12.011

[7] A. Szakmary, Q. Shen, S.C. Sharma, "Trend-following Trading Strategies in Commodity Futures: A Re-examination," *Journal of Banking Finance*, 34 (2010) 2, 409-426.

[8] A.M. Fuertes, J. Miffre, G. Rallis, "Tactical Allocation in Commodity Futures Markets: Combining Momentum and Term Structure Signals," *Journal of Banking and Finance*, 34 (2010), 2530-2548. https://doi.org/10.1016/j.jbankfin.2010.04.009

[9] C. Lento, N. Gradojevic, C.S. Wright, "Investment Information Content in Bollinger Bands?," *Applied Financial Economics Letters*, 3 (2007) 4, 263-267. https://doi.org/10.1080/17446540701206576

[10] J.M. Leung, T.T.L. Chong, "An Empirical Comparison of Moving Average Envelopes and Bollinger Bands," *Applied Economics Letters*, 10 (2003) 6, 339-341. https://doi.org/10.1080/1350485022000041032

[11] Y. Ni, M.Y. Day, P. Huang, S.R. Yu, "The Profitability of Bollinger Bands: Evidence from the Constituent Stocks of Taiwan 50," Physica A: Statistical Mechanics and its Applications, 551 (2019), 124-144. https://doi.org/10.1016/j.physa.2020.124144.

[12] T. Saaty, *Decision making for Leaders: The Analytic Hierachy Process for Decisions in a Complex World*, Pittsburgh: RWS Publications, 2012.

Appendix 1: Expert questionaire survey
Assessing Efficiency Bollinger Bands in Forward Operations for
Agricultural Products in Vietnam

Dear Madam or Sir,

As researchers at VNU University of Economics and Business (UEB-VNU), we are trying to investigating the efficiency of Bollinger Bands (BBs) applied it into forward operation for 5 agricultural items, including: coffee beans, corn, wheat, soybeans and soybean oil in Vietnam. Our assessment is based on 03 main criteria, including: (i) Ability to forecast future price; (ii) Ability to provide buying signals and (iii) Ability to provide selling signals.

We would greatly appreciate if you kindly give us some feedback on answering the below questions. All information on this survey will be used only for research but not for any other purposes.

A.   GENERAL INFORMATION

1.   Interviewee's name   : ....
2.   Organization   : ....
3.   Position   : ....
4.   Experience years   : ....
5.   Telephone   : ....
6.   Email   : ....

B.   SURVEY CONTENT

Please select the option that you consider the most appropriate by numbering from 1, the lowest (the worst), to 5, the highest (the best).

1.   How do you rate the importance of 3 different application aspects of Bollinger Bands?

3 application aspects of Bollinger Bands or 3 criteria	1	2	3	4	5
1. Ability to forecast future price	☐	☐	☐	☐	☐
2. Ability to provide buying signals	☐	☐	☐	☐	☐
3. Ability to provide selling signals	☐	☐	☐	☐	☐

2.   How do you evaluate the accuracy of the following signs in identifying the price trend for each specific agricultural product?

The price rises sharply when it is always in the interval between the upper band and SMA20	1	2	3	4	5
1. Coffee	☐	☐	☐	☐	☐
2. Corn	☐	☐	☐	☐	☐
3. Wheat	☐	☐	☐	☐	☐
4. Soybeans	☐	☐	☐	☐	☐
5. Soybeans oil	☐	☐	☐	☐	☐
The price goes down sharply when it is always in the interval between the lower band and SMA20	1	2	3	4	5

1.	Coffee	☐	☐	☐	☐	☐
2.	Corn	☐	☐	☐	☐	☐
3.	Wheat	☐	☐	☐	☐	☐
4.	Soybeans	☐	☐	☐	☐	☐
5.	Soybeans oil	☐	☐	☐	☐	☐

3.   How do you evaluate the accuracy of buying signals for each specific agricultural product?

Buying when the close price hits the lower band	1	2	3	4	5
Coffee	☐	☐	☐	☐	☐
Corn	☐	☐	☐	☐	☐
Wheat	☐	☐	☐	☐	☐
Soybeans	☐	☐	☐	☐	☐
Soybeans oil	☐	☐	☐	☐	☐
Buying when the close price is above the upper band	1	2	3	4	5
Coffee	☐	☐	☐	☐	☐
Corn	☐	☐	☐	☐	☐
Wheat	☐	☐	☐	☐	☐
Soybeans	☐	☐	☐	☐	☐
Soybeans oil	☐	☐	☐	☐	☐
Buying when the price close is on the upper band after a bottleneck	1	2	3	4	5
Coffee	☐	☐	☐	☐	☐
Corn	☐	☐	☐	☐	☐
Wheat	☐	☐	☐	☐	☐
Soybeans	☐	☐	☐	☐	☐
Soybeans oil	☐	☐	☐	☐	☐

4.   How do you evaluate the accuracy of selling signals for each specific agricultural product?

Selling when the close price hits the upper band	1	2	3	4	5
Coffee	☐	☐	☐	☐	☐
Corn	☐	☐	☐	☐	☐
Wheat	☐	☐	☐	☐	☐
Soybeans	☐	☐	☐	☐	☐
Soybeans oil	☐	☐	☐	☐	☐
Selling when the close price is below the lower band	1	2	3	4	5
Coffee	☐	☐	☐	☐	☐

Corn	☐	☐	☐	☐	☐
Wheat	☐	☐	☐	☐	☐
Soybeans	☐	☐	☐	☐	☐
Soybeans oil	☐	☐	☐	☐	☐
Selling when the close price is on the lower band after a bottleneck	1	2	3	4	5
Coffee	☐	☐	☐	☐	☐
Corn	☐	☐	☐	☐	☐
Wheat	☐	☐	☐	☐	☐
Soybeans	☐	☐	☐	☐	☐
Soybeans oil	☐	☐	☐	☐	☐

5. In your opinion, in order to improve the effectiveness of Bollinger Bands in forward operations for agricultural products in Vietnam, what should investor do?

Solution to improve the effectiveness of BBs in forward operations for agricultural products in Vietnam	1	2	3	4	4
1. Combining BBs with RSI	☐	☐	☐	☐	☐
2. Combining BBs with MACD	☐	☐	☐	☐	☐
3. Combining BBs with Fibonacci	☐	☐	☐	☐	☐
4. Combining BBs with Ichimoku	☐	☐	☐	☐	☐
5. Combining BBs with CCI	☐	☐	☐	☐	☐
6. Combining BBs with Zigzag	☐	☐	☐	☐	☐
7. Others..	☐	☐	☐	☐	☐

THANK YOU

Appendix 2: AHP results

Appendix 2.1: Matrix related to decision making in AHP approach

Future	Price forecasting	Buying signs	Selling signs
A1: Coffee	4.18	4.24	4.24
A2: Corn	3.95	4.24	4.30
A3: Wheat	4.05	4.09	4.12
A4: Soybean	4.00	4.12	4.15
A5: Soybean oil	3.82	3.91	3.82

Source: Authors.

Appendix 2.2: Pairwise comparison matrix with intensity judgments in AHP approach

	Price forecasting	**Buying signs**	**Selling signs**
Price forecasting	1.00	0.97	0.97
Buying signs	1.03	1.00	1.00
Selling signs	1.03	1.00	1.00

Source: Authors.

Appendix 2.3: Ranking vector for criteria in AHP approach

Ranking vector	Price forecasting	Buying signs	Selling signs
0.33	0.33	0.33	0.33
0.34	0.34	0.34	0.34
0.34	0.34	0.34	0.34

Source: Authors.

Appendix 2.4: Calculation of CR in AHP approach

Weighted sum	Priority	
0.98	0.33	3.00
1.01	0.34	3.00
1.01	0.34	3.00
Total		9.00
		0.82
	CI	(0.07)
	RI	0.9
	CR	(0.08)

Source: Authors.