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Full Length Article

Does short-term technical trading exist in the Vietnamese stock market?

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Abstract

The Vietnamese stock market provides an interesting and enriching test field for the application of trading expert systems as its economy is opening up, has high growth rate and may offer risk diversification opportunities. This paper examines the question of whether this frontier emerging market offers possibilities for statistical arbitrage through a financial expert system. Based on a sample of the most liquid stocks in the VN30 benchmark index, our results indicate that the index itself and some of its components offer moderate opportunities for statistical arbitrage even after considering transaction costs. It is also found that the purely momentum-based models already work satisfactorily for specific stocks, while the long-short strategies do not work more robustly than the long-only strategies. Overall, our findings hint into the direction of some exploitable inefficiencies, but the magnitude of the tradable volume is such that only comparatively small amounts can be traded.

JEL classification: G11; G14; G15; G17

Keywords: Vietnam; Stock market; Quantitative trading; Expert system; Trading strategy; Market efficiency

1. Introduction

Market efficiency has been an intriguing subject for policymakers, practitioners and academics for a very long time. According to the weak-form of the "Efficient Market Hypothesis" (Fama, 1970),[1] information captured by the historical prices are fully reflected in the current asset prices therefore future returns cannot be predicted on the basis of past price changes. However, starting with the pioneering work of Mandelbrot (1971) and then the seminal papers by Fama and French (1988); Lo and Mackinlay (1988); Poterba and Summers (1988); Brock et al. (1992) and Cochran et al. (1993), the weak-form efficiency of asset returns has been rejected. Such rejection comes with various implications: (i) investment horizon becomes a risk factor for market participants due to returns' predictability (Mandelbrot, 1997); (ii) derivatives pricing models, such as the Black and Scholes (1973) option pricing model, may not be useful any more. Indeed, Jamdee and Los (2007) demonstrate how the violation of the weak-form efficiency changes European option values compared to the Black-Scholes model; (iii) the mainstream asset pricing models such as the Capital Asset Pricing Model or Arbitrage Pricing Theory (Black et al., 1972) lose their validity since they assume uncorrelated return series; and finally, (iv) if the weak-form efficiency is violated, investors can then earn consistent higher returns than in a buy-and-hold strategy (Lo & Mackinlay, 1999); Lo et al. (2000).

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[1] Other forms are semi-strong efficiency, where the information set is publicly known, and the strong-form efficiency where prices reflect all kinds of information (public and private).

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The last item mentioned above usually attracts market participants the most since it opens up opportunities for obtaining excess returns through active trading. However, this is not an easy process as it sounds. There have been many academic studies in the literature showing that the weak-form efficiency is violated for various asset classes. These include equities (Di Matteo et al., 2005; Lo, 1991; Rizvi & Arshad, 2016; Sensoy, 2013b; Sensoy & Tabak, 2015; Tuyon & Ahmad, 2016), derivatives (Sensoy & Hacihasanoglu, 2014; Souza et al., 2008), exchange rates (Cheung, 1993; Urrutia, 1992), commodities (Kristoufek & Vosvrda, 2014; Tabak & Cajueiro, 2007), interest rates Cajueiro and (Tabak 2010, Sensoy, 2013a), and even (Bariviera, 2017; Bitcoin Urquhart, 2016). The main issue with these studies and alikes is that they reach a binary outcome stating that the weak-form efficiency is either rejected or cannot be rejected. While this finding is academically meaningful and has implications on portfolio management, it does not indicate how an investor can generate profits in case where the market is found to be inefficient. For instance, Ang et al. (2011) concur on the refinement of the EMH over recent years to reflect real market imperfections (e.g., trading costs related to transaction, information and liquidity as well as financing and agency cost) and argue that the evidence of inefficient markets must allow arbitrageurs to make trading profits from their comparative advantages (e.g., specialized knowledge, technical know-how and trading rules, and lower trading costs). Therefore, it is clear from a practical perspective that a more solid approach is required because investors and portfolio managers, among others, look for explicit instructions and methods to exploit the violation of the weak-form efficiency stated by the earlier academic studies. Yet, the strand of literature on how to exploit market inefficiencies is much more scarce compared to the works focusing on only the violation of the weak-form efficiency.

In this work, we contribute to this scarce literature through developing an explicit strategy that we apply to the Vietnamese stock market, which also can be generalized to other equity markets when the data are provided. Sensoy and Tabak (2016) show that emerging equity markets have much more exploitable patterns compared to the developed ones. Motivated by this finding, our selected market in this study is the Vietnamese stock market, which is one of the fastest developing and globally integrated emerging markets in the world. As a significant manufacturing hub, this country has recently shown one of the best growth stories in Asia both in financial and real economic terms.

The Vietnamese stock market was inaugurated on July 20, 2000 and then became increasingly important in allocating capital for the Vietnam's economy. Additionally, the fast growth and stable political system also attracted more and more foreign investors. Previously, foreign ownership limits were set at 49% for non-financial listed companies. As of 2016, the foreign ownership limit is 100% for non-restricted companies. Studies on the Vietnamese stock market therefore would have implications not only for other 20 frontier markets but also 11 standalone markets (ranked by MSCI).

Table 1
Main characteristics of the HOSE stock market.

Year	Number of stocks	Volume (bn.)	Market Cap (bn. VND)
2017	344	59.998	2614150
2016	320	49.389	1491778
2015	307	42.487	1146925
2014	305	33.019	985258
2013	301	26.945	842105
2012	308	24.850	678403
2011	301	18.883	453784
2010	275	15.290	591345
2009	196	10.423	494072
2008	170	5.740	169346
2007	138	3.805	364425
2006	106	1.406	147967

Notes: The volume refers to the number of shares traded and VND denotes the Vietnamese Dong, the national currency of Vietnam. Figures are sourced from the HOSE annual report.

The total value of the main equity markets in Vietnam, that are Ho Chi Minh Stock Exchange (HOSE), Hanoi Stock Exchange (HNX) and Unlisted Public Company Market (UPCoM), is around $222.91 billion or 102.22% of country's GDP as of mid-2018, with the HOSE accounting for $135.5 billion of this total value.[2] As of 2018, the number of companies in these markets are 365 on HOSE, 376 on HNX and 772 on the UPCoM. In the case of HOSE, there are 38 investment funds with net asset value of $847 million. Regarding the investor base, there are 2,054,773 and 23,633 domestic and foreign retail investors respectively, as of 2018. At the same time, foreign institutional investors are 3143 in comparison with 8900 domestic institutional investors according to the State Securities Commission of Vietnam. Table 1 gives an overview of the HOSE's development over the last decade.

Despite many potential benefits that it can provide to investors and the dramatic ten-fold (forty-fold) increase in its market-cap (trading volume) in the past ten years, the Vietnamese market has been mostly underrepresented in the academic literature. Especially, studies that quantitatively model the Vietnamese stock market are few and far between. Therefore, we aim to contribute to the related literature by: (i) providing a new trend-following quantitative trading rule in the shape of an expert system to exploit the market inefficiencies (that can be extended for other emerging markets as well), and (ii) examining the pricing dynamics of one of the fastest growing and most attractive emerging markets in the world.

Accordingly, we show that the trading rules introduced in this paper can be used to gain moderate levels of risk-adjusted returns. In particular, we find that index portfolio trading and individual stock trading (for a limited number of companies) provide opportunities for statistical arbitrage, even after taking transaction costs into account. We also find that pure

[2] Note however that five companies alone currently contribute to more than 40% of the value of the HOSE's benchmark index. Therefore, large moves by a few companies can swing the broader market significantly.

momentum-based models work satisfactorily for specific stocks, and the long-only strategies perform better and more robustly compared to the long-short strategies. Finally, even though our rules deliver attractive risk-adjusted returns, there are significant deviations in individual components of the benchmark index. Overall, the findings of this work imply the existence of exploitable inefficiencies, but the magnitude of the tradable volume is such that only comparatively small amounts can be traded. Moreover, investors should pay attention to short-term trends instead of long-term ones.

The rest of the paper is organized as follows. We present a brief literature review in Section 2. Section 3 introduces our data and methodology. Section 4 contains a detailed analysis of the results. Section 5 provides some concluding remarks and discusses possible directions for further research.

2. Literature review

There has been a growing interest in the Vietnamese stock market in the last few years with a number of studies exploring its characteristics such as the momentum effect, herding behavior and market efficiency, mostly at the benchmark index level. For example, Nguyen (2012) provides evidence for short-term momentum effect which disappears, however, after controlling for risks. Vo and Truong (2018) find that long-term momentum effects exist over the period from 2007 to 2015, especially for the portfolios based on the previous 6 months and held for 9 months. Regarding market efficiency, Truong et al. (2010) show evidence of a thin-trading market and conclude that the major Vietnamese stock exchange (HOSE) is not efficient in the weak form. Moreover, Luu et al. (2016) assert that the Vietnamese stock market is not fully efficient with respect to seasonal anomalies. Gunasekarage and Power (2001) analyze the performance of various trading rules using index data for four emerging South Asian capital markets and show that technical trading rules have predictive ability in these markets. Yu et al. (2013) revisit this issue and investigate whether the moving average and trading range breakout rules can forecast price movements in Asian emerging stock markets and outperform a simple buy-and-hold strategy after adjusting for transaction costs. Accordingly, their findings indicate that transaction costs can eliminate the trading profits implying weak-form efficiency.

Within the context of market efficiency, the herd behavior in stock markets takes an important place since it tends to create a momentum effect in the market through persistent trades initiated in the same direction. The presence of the herding behavior in the Vietnamese stock market is supported by the recent studies. Tran and Truong (2011) argue that within an immature stock market such as Vietnam, investor herding causes downward markets to have more return dispersion than in upward markets. In the same vein, Bui et al. (2018) confirm the existence of herding in the Vietnamese market and suggest that U.S. stock markets affect this phenomena. Vo and Phan (2017) go further and examine the presence of herd behavior in the Vietnamese stock market at the daily, weekly and monthly level. They find evidence of herding over the whole period, even after controlling for various other factors. Moreover, the degree of herding is found to be stronger for liquid stocks (Vo & Phan, 2019b), and is also dependent on idiosyncratic volatility (Vo & Phan, 2019a).

Nguyen et al. (2019) examine market efficiency for emerging Asian stock markets including Vietnam and show that increases in Google search volume have significant negative impacts on stock returns in these markets. Similarly, Nguyen et al. (2020) show that internet search intensity is positively associated with subsequent stock returns in the Vietnamese stock market. Moreover, the positive effects on stock returns are not temporary but remain for the long term. Hoang et al. (2020) show that when investors anticipate a piece of regulation on information disclosure in Vietnam, the stock market experiences negative reactions two and five days before the first announcement.

Another strand of research addresses stock returns in Vietnam in relation with liquidity, volatility, foreign investors, and rational multi-factor models. According to Fang et al. (2017), Vietnamese stock prices are affected by both idiosyncratic and systemic risks. Parallel to this result, Batten and Vo (2014) document a positive relationship between liquidity and stock returns in Vietnam. Furthermore, foreign investors are found to be positive feedback traders and have better timing ability as well as trading strategy in this market (Vo, 2017).

The distinct features of emerging markets, such as Vietnam, nonetheless attract investors who believe that they have better trading strategies. Ghysels et al. (2016) suggest to invest in emerging markets since their returns' skewness is mostly positive and idiosyncratic, and these markets have expectations of a higher upside rather than a downside. Investment strategies with technical indicators also seem to be effective in the Vietnamese market as shown by Phan and Nguyen (2018). Accordingly, technical indicators are found to potentially maximize returns during up-trend period and minimize the loss when the market declines. Metghalchi et al. (2013) apply several well-known and popular technical indicators to the daily data for the Vietnam Ho Chi Minh stock index from 2002 to 2012. Their empirical results strongly support the predictive power of technical trading rules, even beating the buy-and-hold strategy. Nguyen (2015) uses eight technical trading rules on the Vietnamese stock market for the period between 2002 and 2013, and successfully captures stock returns with these models. Nguyen and Yang (2013) consider whether the moving average (MA) rules can forecast stock price movements and outperform a simple buy-and-hold strategy for the Vietnamese stock market over the period 2000 to 2011. Accordingly, MA rules have strong predictive power in this market. Further, Chin and Nguyen (2015) provide a higher-level overview of different types of basic trading strategies on the Vietnamese market and show their profitability. Pham et al. (2014), on the other hand, apply a more sophisticated machine-learning type trading strategy on several markets, including the Vietnamese market, and report superior returns over the benchmark index.

Table 2
Descriptive statistics of the sample stocks' daily percentage returns.

	Mean	Stdev	Min	25%	50%	75%	Max
BAOVIET HOLDINGS	0.000702	0.023420	−0.070000	−0.010638	0.000000	0.010724	0.069959
FLC GROUP	0.000625	0.028861	−0.069869	−0.015385	0.000000	0.014870	0.069999
FPT	0.000660	0.014792	−0.069530	−0.006561	0.000000	0.008016	0.062753
GEMADEPT	0.000399	0.019883	−0.223529	−0.010536	0.000000	0.010532	0.069948
HAGL	−0.000703	0.023304	−0.069959	−0.012346	0.000000	0.009009	0.070000
HOA PHAT GROUP	0.001483	0.019702	−0.069767	−0.009288	0.000000	0.011387	0.069959
HOA SEN GROUP	0.000191	0.023163	−0.069880	−0.011181	0.000000	0.010595	0.069930
HOCHIMINH CITY INFR.INV.	0.000509	0.020487	−0.069959	−0.009975	0.000000	0.008909	0.069952
HOCHIMINH CTY.SECS.	0.001070	0.023124	−0.072607	−0.010526	0.000000	0.011342	0.070000
JST.CMLBK.FOR FRGN.TRD. OF VTM.	0.001049	0.019343	−0.069733	−0.007921	0.000000	0.009222	0.069959
KINH DO	0.000458	0.018417	−0.069532	−0.009009	0.000000	0.008334	0.069364
KINHBAC CTDEV.SHAREHLDG.	0.000572	0.022903	−0.070000	−0.011834	0.000000	0.011145	0.069307
MASAN GROUP	0.000348	0.018364	−0.070000	−0.007105	0.000000	0.007093	0.069608
MILITARY COML.JST.BANK	0.000767	0.016205	−0.068493	−0.007143	0.000000	0.007253	0.069204
PETROVIETNAM DRILLING	−0.000451	0.024760	−0.070000	−0.015402	0.000000	0.011529	0.070000
PETROVIETNAM FCM.	−0.000539	0.014901	−0.091727	−0.006734	0.000000	0.006250	0.069264
PETROVIETNAM GAS	0.000420	0.022083	−0.069971	−0.009368	0.000000	0.009901	0.069880
PETROVIETNAM PWR.NHON TRACH 2	0.001729	0.025395	−0.115772	−0.008547	0.000000	0.010080	0.126760
PHA LAI THERMAL PWR.	−0.000111	0.020094	−0.147368	−0.009524	0.000000	0.009196	0.068421
REFRIG.ELECT.ENGR.CORP.	0.000331	0.016408	−0.069498	−0.007905	0.000000	0.007844	0.069805
SAI GTT.COML.JST.BK.	0.000054	0.021371	−0.069841	−0.010257	0.000000	0.009259	0.093181
SAIGON SECURITIES	0.000721	0.019648	−0.069801	−0.009029	0.000000	0.010309	0.069307
TAN TAO INV.IND.	−0.000487	0.023892	−0.070000	−0.014706	0.000000	0.012346	0.069909
THANH THANH CONG TAY NINH	0.000496	0.020908	−0.069841	−0.008403	0.000000	0.008404	0.070001
VIETNAM DAIRY PRODUCTS	0.000659	0.013742	−0.067164	−0.007092	0.000000	0.007354	0.070000
VINCOM	0.001363	0.016736	−0.069963	−0.007015	0.000000	0.007966	0.069053
VN30 INDEX	0.000516	0.009957	−0.058717	−0.003910	0.000792	0.006123	0.038507
VTM.JST.CMLBK.FOR INTRD.	0.000336	0.019238	−0.089090	−0.008395	0.000000	0.007045	0.069815

We note, however, that trading strategy analyses of the Vietnamese stock market are few and far between compared to the analysis of mature stock markets in the United States or Europe. Moreover, almost all those studies on Vietnam use samples that end in 2013 or even earlier. In the meantime, the Vietnamese stock market has rapidly developed, and a new and comprehensive study will highlight the latest developments better.

Our proposed trading system is an expert system for trading in the Vietnamese stock market to exploit market inefficiencies. Earlier studies emphasize the importance and popularity of using automated systems in various fields, especially finance, using big data (Chen, 2019; Janssen et al., 2017; Seddon & Currie, 2017). However, since examples of financial expert systems are abundant, we limit ourselves to citing a few recent examples that are closely related in the spirit of our work. In particular, Kim and Won (2018) give an example of a hybrid expert system that uses a machine-learning approach. Nadkarni and Neves (2018) demonstrate the importance of isolating the most important factors first in algorithmic trading. Some expert systems are rather focused on predicting the future direction of asset prices instead of the actual returns themselves (Brasileiro et al., 2017; Feuerriegel & Gordon, 2018; Jeong & Kim, 2019; Karhunen, 2019; Malagrino et al., 2018; Nam & Seong, 2019). For instance, Jeong and Kim (2019) provide machine-learning applications in expert systems for quantitative trading. Brasileiro et al. (2017) propose a piece-wise aggregate approximation show that this model outperforms the alternatives for the US market. Finally, Avci et al. (2019) empirically test the impact of agents' attitudes on their price expectation through their trading behavior and consequently forecast the day-ahead electricity price in Turkey.

3. Data and methodology

We use the trading days' closing prices of the most liquid 27 stocks and additionally the benchmark index (VN30 INDEX) from July 1, 2013 to June 29, 2018, covering full five years.[3] The VN30 Index accounts for 80% market cap and 60% of trading volumes of the Vietnamese market. This Index is also used as a benchmark for derivatives products. Moreover, this study focuses only in high liquidity, high free float and big cap companies, so there is no need to take all the stocks into account. On top of that, VNIndex covers more than 700 firms which makes it impossible in practice to analyze every firm stock included in this index.

Since many studies on Vietnam within the context of technical trading use samples ending in 2013, we believe that it is opportune to start the sample with 2013 to capture the latest dynamics of this market which have not been reported in academic studies yet. Furthermore, the research approach of

[3] The data is obtained from Thomson Reuters Datastream. Our liquidity criteria starts with limiting ourselves to the stocks that belong to the benchmark index VN30. In the next step, we exclude those stocks with daily average traded volume below $1 million equivalent. Eventually, we end up with 27 company stocks.

Table 3
Buy-and-hold performance of the selected stocks and the benchmark index (annualized).

	Return	Stdev	RR	Skewness
BAOVIET HOLDINGS	0.177008	0.371788	0.476101	0.227532
FLC GROUP	0.157543	0.458161	0.343860	0.270595
FPT	0.166363	0.234818	0.708473	0.101288
GEMADEPT	0.100643	0.315640	0.318855	−0.917114
HAGL	−0.177062	0.369947	−0.478614	0.282308
HOA PHAT GROUP	0.373823	0.312756	1.195255	0.235686
HOA SEN GROUP	0.048174	0.367702	0.131015	0.044323
HOCHIMINH CITY INFR.INV.	0.128271	0.325221	0.394411	0.285870
HOCHIMINH CTY.SECS.	0.269578	0.367080	0.734385	0.097451
JST.CMLBK.FOR FRGN.TRD. OF VTM.	0.264291	0.307062	0.860710	0.176357
KINH DO	0.115477	0.292364	0.394976	0.425250
KINHBAC CTDEV.SHAREHLDG.	0.144239	0.363576	0.396723	0.197852
MASAN GROUP	0.087723	0.291524	0.300910	0.303298
MILITARY COML.JST.BANK	0.193321	0.257248	0.751495	0.276401
PETROVIETNAM DRILLING	−0.113562	0.393051	−0.288925	0.203127
PETROVIETNAM FCM.	−0.135949	0.236551	−0.574711	−0.511652
PETROVIETNAM GAS	0.105868	0.350561	0.301997	0.083203
PETROVIETNAM PWR.NHON TRACH 2	0.435707	0.403137	1.080791	0.485235
PHA LAI THERMAL PWR.	−0.028050	0.318978	−0.087936	−0.199351
REFRIG.ELECT.ENGR.CORP.	0.083503	0.260475	0.320580	0.065817
SAI GTT.COML.JST.BK.	0.013722	0.339248	0.040447	0.358527
SAIGON SECURITIES	0.181637	0.311895	0.582364	0.137164
TAN TAO INV.IND.	−0.122744	0.379275	−0.323629	0.298226
THANH THANH CONG TAY NINH	0.124950	0.331899	0.376470	0.180267
VIETNAM DAIRY PRODUCTS	0.166065	0.218153	0.761234	0.332745
VINCOM	0.343592	0.265682	1.293246	0.290692
VN30 INDEX	0.129994	0.158062	0.822425	−0.715132
VTM.JST.CMLBK.FOR INTRD.	0.084724	0.305394	0.277424	0.207616

this paper towards practical strategy that investors can implement with ease: we choose only the most liquid stocks, among the most biggest companies.

Table 2 shows the descriptive statistics and provides useful information on our dataset, including those for the aggregate index. We can see that HOA PHAT GROUP has the highest daily average return (0.1483%) over the sample period, followed by VINCOM (0.1363%). The mean returns also show the general uptrend of the Vietnamese stock market over the past five years. Among all 27 sample stocks, only five of them have a negative mean return. Median returns, on the other hand, are all very close to zero. Maximum and minimum daily returns for the sample stocks are on par with their emerging market peers. In a single day, it is possible to see a maximum return of 12.67% (PETROVIETNAM PWR.NHON TRACH 2) as well as to see a minimum return of −22.35% (GEMADEPT), values that are not so uncommon for emerging markets. The unconditional volatility of sample stocks, measured by standard deviations, varies between 0.013 (VIETNAM DAIRY PRODUCTS) and 0.028 (FLC GROUP), showing the big dispersion between the uncertainties of daily returns in our sample.

Table 3 shows financial measures of interest for investors and portfolio managers, including annualized return, standard deviation, Risk-Return Ratio (*RR*), and skewness of the buy-and-hold strategies for both individual stocks and the benchmark index. The results for the index is particularly important since it can, in some respect, be considered as our benchmark for the trading strategies that we develop later on.

Throughout the rest of this paper, we use the *RR* as our main performance measure, which is closely related to the original Sharpe (1994) ratio. We define the (annualized) *RR* as

$$RR = \frac{R}{S} \tag{1}$$

with R being the annualized return and S the annualized standard deviation respectively.[4] As it is clear from Equation (1), a strategy performs better if this ratio is higher. We are aware that RR is just one of many potential performance measures that can be used to assess a trading strategy. We choose this measure specifically for the following reasons. The first reason is that due to its close relationship with the Sharpe ratio, it is a measure that has been around for a long time and therefore our results are directly comparable to those resulting from other studies. Due to RR being a scale-less measure, it is intuitive to get an idea of what is considered a good or bad RR for equity strategies, with the generally accepted view that an RR over 1 will be considered good. A second reason can be found in the easy interpretability and the highly desirable property of characterizing an investment strategy: we combine higher returns with lower volatility and obtain a ratio that

[4] The annualization process is done for comparison purposes. Both the daily returns and their standard deviations are scaled up with the appropriate number of trading days in a calendar year. In particular, we suppose that there are 250 trading days in a calendar year. If r_d is the average daily return and σ_d is its standard deviation, then the annualized return r_a and standard deviation σ_a are obtained by $r_a = (1 + r_d)^{250} - 1$ and $\sigma_a = \sigma_d \times \sqrt{250}$ respectively.

makes immediate sense to even the just moderately financially literate. A third reason for using the RR as our main measure stems, for some of the authors, from their experience with asset management and investment advisory on real money portfolios: clients will, inevitably, inquire about the RR as one of their first steps in the due diligence process of assessing a proposed investment strategy. As such, the RR ticks several boxes when it comes to find a single number suitable to assess a trading strategy. Certainly, we shouldn't forget about RR's drawbacks, either: it will equally penalize upside and downside volatility. Also, it will only give an incomplete view on extreme events, which would be characterized by maximum drawdowns or worst n-day returns. With the benefit of hindsight, we notice that over the five year span, some stocks have shown attractive risk-return ratios above 1. The index itself shows a decent RR of 0.82.

A closer inspection of the index in Fig. 1 shows a mostly uptrending market until 2018, followed by a considerable downtrend that starts at the beginning of 2018. Drawdowns in-between are also noteworthy, especially in the year 2014. This will pose a challenge to any long-only trend-following strategy. As such, we will analyze how far this kind of strategy applied to individual stocks will actually be able to beat the index.

Now, we introduce the trading strategy developed in this paper. Fig. 2 provides an outline for the proposed expert system on the Vietnamese stock market. Our paper intends to use real-world error measures which, in the context of algorithmic trading, means risk-adjusted returns. As such, we will not focus on building a forecast by extrapolating the trend as well as determining the share of correctly predicted signs of returns. Rather, our main error measure is the above-mentioned risk-return ratio which combines desirable features of a financial return series from an investor's point of view, i.e., high return and low volatility. We are aware that no performance measure is perfect and the risk-return ratio has been (rightly) criticized for attributing the same weight to unwanted downside volatility and mostly neutral upside volatility. Nevertheless and despite the fact that many more sophisticated performance measures have been developed, the risk-return ratio and its variants remain an important tool for gauging returns among many practitioners.

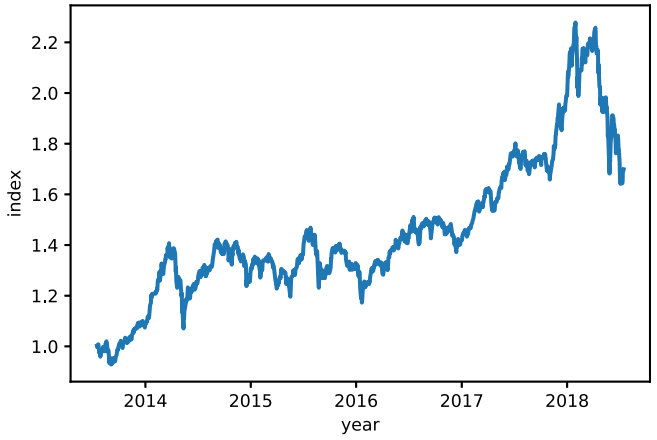

Fig. 1. Equally-weighted index of the 27 sample stocks.

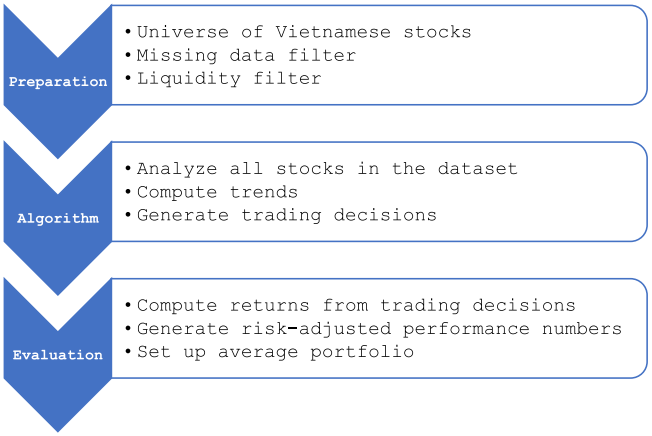

Fig. 2. Schematic outline of the proposed expert system.

We implement a basic trading strategy that takes the average of the past n-day returns to gauge momentum in the individual stocks. That is, we go long (buy) on the stock in case of a positive momentum, and short (sell) the stock in case of negative momentum. One should however note that shorting stocks on the Vietnamese stock market is not generally

Table 4
Annualized risk-return ratios for different lookback windows (long-only). The numbers in the column titles refer to the lookback windows in trading days.

	1 d	2 d	3 d	4 d	5 d
BAOVIET HOLDINGS	0.52	0.78	0.93	0.85	0.60
FLC GROUP	0.41	0.96	0.89	1.04	0.69
FPT	1.03	1.37	1.14	0.92	0.88
GEMADEPT	0.75	0.72	0.66	0.84	0.33
HAGL	0.71	0.39	0.23	0.19	0.39
HOA PHAT GROUP	1.46	1.34	1.07	1.57	1.38
HOA SEN GROUP	0.65	0.38	0.76	0.54	0.63
HOCHIMINH CITY INFR.INV.	−0.11	0.10	0.35	0.81	0.35
HOCHIMINH CTY.SECS.	1.38	1.64	0.83	0.50	0.73
JST.CMLBK.FOR FRGN.TRD. OF VTM.	0.63	1.43	0.99	0.95	0.88
KINH DO	1.38	0.81	0.67	0.67	0.22
KINHBAC CTDEV.SHAREHLDG.	0.25	0.75	0.31	0.33	0.06
MASAN GROUP	1.01	0.22	0.11	0.19	−0.22
MILITARY COML.JST.BANK	0.33	0.58	0.63	0.57	1.09
PETROVIETNAM DRILLING	0.72	0.57	0.20	0.19	0.62
PETROVIETNAM FCM.	−0.14	0.25	−0.19	−0.20	−0.72
PETROVIETNAM GAS	0.98	1.00	0.79	1.06	0.69
PETROVIETNAM PWR.NHON TRACH 2	0.38	0.62	0.42	0.49	0.72
PHA LAI THERMAL PWR.	0.07	−0.05	0.03	−0.18	−0.26
REFRIG.ELECT.ENGR.CORP.	0.75	0.31	0.48	0.27	0.22
SAI GTT.COML.JST.BK.	0.28	−0.29	−0.24	−0.29	−0.03
SAIGON SECURITIES	0.89	0.75	0.83	0.96	0.69
TAN TAO INV.IND.	−0.30	−0.29	0.13	0.25	−0.01
THANH THANH CONG TAY NINH	0.95	0.14	0.14	0.27	0.28
VIETNAM DAIRY PRODUCTS	0.96	1.03	0.84	0.78	0.69
VINCOM	1.72	1.19	0.89	1.12	1.14
VN30 INDEX	1.10	2.33	1.63	1.51	1.68
VTM.JST.CMLBK.FOR INTRD.	0.16	0.56	0.24	0.12	0.04
AVG	1.50	1.62	1.35	1.41	1.20

possible. To the extent that the Vietnamese market develops in the future, shorting stocks will be a much more flexible action, we decide to include a theoretically short-based strategy to analyze the potential advantages of this approach. Besides, it provides a generalizability of the trading strategy to other emerging markets as well.

More specifically, we define the following trend measure:

$$a_{t,n} = \frac{1}{n}\sum_{i=0}^{n-1} r_{t-i} \tag{2}$$

where r_t is the simple return at time t and n is the lookback window of the trend. We will therefore go long (buy the stock) if $a_{t,n} > 0$ and stay out of the market otherwise. In the case of a short strategy, we will additionally short the stock in case of $a_{t,n} < 0$. Finally, the case $a_{n,t} = 0$ will always lead to staying out of the market. Algorithm 1 shows a compact version of the trading procedure for the long-only case. Algorithm 2 shows the corresponding long-short version that allows for short-selling of stocks.

```
Data: time-series of Vietnamese stock prices
Result: risk-adjusted return measures
remove lines with missing data;
filter for top liquidity stocks;
while ts in time-series do
    compute percentage returns of ts;
    compute return averages for lookback n;
    if return > 0 then
        go or stay long;
    else
        go or stay flat;
    end
    compute risk-adjusted returns;
end
compute risk-adjusted returns for average portfolio;
```

Algorithm 1. Long-only trading version of the proposed expert system

```
Data: time-series of Vietnamese stock prices
Result: risk-adjusted return measures
remove lines with missing data;
filter for top liquidity stocks;
while ts in time-series do
    compute percentage returns of ts;
    compute return averages for lookback n;
    if return > 0 then
        go or stay long;
    else if return < 0 then
        go or stay short;
    else
        go or stay flat;
    end
    compute risk-adjusted returns;
end
compute risk-adjusted returns for average portfolio;
```

Algorithm 2. Long-short trading version of the proposed expert system

4. Results

This section analyzes the effectiveness of different moving average strategies applied to individual liquid stocks on the Vietnamese stock market and also to different portfolios of these stocks. The goals are twofold. On the one hand, we assess how robust the strategies are with respect to different lookback windows for building the average. On the other hand, we check whether the combined strategy truly delivers a diversification benefit.

Transaction costs are always a concern when dealing with relatively high-frequency strategies on developing and frontier emerging markets. In the case of short-term moving average strategies, holding periods range from a single day to a few weeks. Stocks included in the benchmark index can be assumed to be liquid. However, transaction costs of around 25 bps (0.25%) are a safe assumption for a single trade. Transaction costs around this level would be considered high or very high in the case of most developed markets. Therefore, our analysis of the average observed spread combined with brokerage commission makes this amount realistic, especially for emerging markets which usually suffer from illiquidity. In the rest of this paper, all results include transaction costs.

Table 4 presents risk-return ratios for applying the moving average rules to the following:

- 27 individual sample stocks
- an equally-weighted average portfolio of the 27 sample stocks (AVG)
- official market-cap weighted index composed of the top 30 stocks (VN30 INDEX)

At first, we start with a pure long portfolio strategy, meaning that the shorting of stocks is not allowed. As mentioned earlier, we focus on the risk-return ratios as they are a simple way of comparing risk-adjusted returns of different investment approaches without overly complicating the analysis. Conversely, Table 5 shows annualized returns that correspond to the risk-return ratios in Table 4. While the inclusion of Table 5 gives an idea of what kind of average returns can be expected from this strategy, we note that annualized returns, on their own, are rarely useful as a performance measure because they neglect any kind of “risk”.

An analysis of the risk-return ratios shows overall encouraging results for basing trading decisions on short-term momentum. Indeed, in only six cases, we witness negative risk-return ratios, meaning that the suggested system leads to a loss for a very few cases. risk-return ratios for the AVG portfolio are especially attractive, with risk-return ratios between 1.20 and 1.62 depending on the lookback window selection. The robustness of the results is also encouraging. risk-return ratios are evenly distributed for the lookback windows from 1 to 5 days. This reduces the importance of selecting exactly the “right” lookback interval. Doing this can always be

Table 5
Annualized returns for different lookback windows (long-only). The numbers in the column titles refer to the lookback windows in trading days.

	1 d	2 d	3 d	4 d	5 d
BAOVIET HOLDINGS	0.137	0.211	0.255	0.227	0.158
FLC GROUP	0.133	0.314	0.285	0.338	0.225
FPT	0.153	0.221	0.190	0.161	0.152
GEMADEPT	0.158	0.151	0.142	0.184	0.079
HAGL	0.177	0.100	0.058	0.046	0.099
HOA PHAT GROUP	0.330	0.304	0.242	0.357	0.323
HOA SEN GROUP	0.167	0.099	0.197	0.137	0.161
HOCHIMINH CITY INFR.INV.	−0.023	0.022	0.080	0.192	0.085
HOCHIMINH CTY.SECS.	0.357	0.410	0.216	0.127	0.191
JST.CMLBK.FOR FRGN.TRD. OF VTM.	0.140	0.313	0.223	0.208	0.189
KINH DO	0.283	0.174	0.148	0.148	0.048
KINHBAC CTDEV.SHAREHLDG.	0.059	0.198	0.079	0.084	0.017
MASAN GROUP	0.209	0.047	0.023	0.040	−0.046
MILITARY COML.JST.BANK	0.061	0.105	0.120	0.108	0.205
PETROVIETNAM DRILLING	0.195	0.153	0.056	0.052	0.167
PETROVIETNAM FCM.	−0.023	0.043	−0.033	−0.033	−0.122
PETROVIETNAM GAS	0.241	0.241	0.189	0.254	0.166
PETROVIETNAM PWR.NHON TRACH 2	0.101	0.184	0.126	0.155	0.234
PHA LAI THERMAL PWR.	0.015	−0.011	0.007	−0.041	−0.059
REFRIG.ELECT.ENGR.CORP.	0.132	0.056	0.086	0.050	0.040
SAI GTT.COML.JST.BK.	0.064	−0.070	−0.056	−0.073	−0.008
SAIGON SECURITIES	0.194	0.157	0.185	0.213	0.154
TAN TAO INV.IND.	−0.075	−0.074	0.033	0.067	−0.003
THANH THANH CONG TAY NINH	0.223	0.035	0.036	0.068	0.068
VIETNAM DAIRY PRODUCTS	0.148	0.169	0.134	0.128	0.115
VINCOM	0.338	0.245	0.187	0.238	0.243
VN30 INDEX	0.125	0.234	0.162	0.153	0.167
VTM.JST.CMLBK.FOR INTRD.	0.033	0.116	0.048	0.024	0.008
AVG	0.145	0.148	0.122	0.129	0.109

Table 6
Risk-return ratios for different lookback windows (long-short). The numbers in the column titles refer to the lookback windows in trading days.

	1 d	2 d	3 d	4 d	5 d
BAOVIET HOLDINGS	0.24	0.62	0.86	0.74	0.36
FLC GROUP	0.23	0.99	0.84	1.08	0.58
FPT	0.58	1.11	0.86	0.62	0.54
GEMADEPT	0.66	0.60	0.55	0.80	0.14
HAGL	1.51	1.02	0.79	0.72	1.00
HOA PHAT GROUP	0.87	0.70	0.31	1.03	0.83
HOA SEN GROUP	0.77	0.38	0.92	0.59	0.71
HOCHIMINH CITY INFR.INV.	−0.58	−0.27	0.08	0.74	0.09
HOCHIMINH CTY.SECS.	1.20	1.43	0.40	−0.08	0.25
JST.CMLBK.FOR FRGN.TRD. OF VTM.	0.01	1.11	0.54	0.45	0.33
KINH DO	1.59	0.76	0.58	0.60	−0.05
KINHBAC CTDEV.SHAREHLDG.	−0.08	0.67	0.03	0.06	−0.32
MASAN GROUP	1.16	0.02	−0.11	0.03	−0.57
MILITARY COML.JST.BANK	−0.32	0.02	0.14	0.04	0.78
PETROVIETNAM DRILLING	1.32	1.07	0.57	0.57	1.14
PETROVIETNAM FCM.	0.45	0.96	0.34	0.33	−0.41
PETROVIETNAM GAS	1.08	1.04	0.76	1.11	0.62
PETROVIETNAM PWR.NHON TRACH 2	−0.69	−0.22	−0.52	−0.33	0.01
PHA LAI THERMAL PWR.	0.19	0.02	0.12	−0.18	−0.29
REFRIG.ELECT.ENGR.CORP.	0.70	0.09	0.32	0.03	−0.05
SAI GTT.COML.JST.BK.	0.34	−0.45	−0.37	−0.46	−0.09
SAIGON SECURITIES	0.67	0.39	0.56	0.73	0.33
TAN TAO INV.IND.	−0.05	−0.05	0.51	0.67	0.32
THANH THANH CONG TAY NINH	0.97	−0.19	−0.17	0.02	0.02
VIETNAM DAIRY PRODUCTS	0.60	0.76	0.45	0.40	0.28
VINCOM	1.22	0.47	0.05	0.42	0.45
VN30 INDEX	0.71	2.07	1.18	1.07	1.24
VTM.JST.CMLBK.FOR INTRD.	−0.08	0.46	0.02	−0.14	−0.23
AVG	1.47	1.47	1.03	1.13	0.76

Table 7
Annualized returns for different lookback windows (long-short). The numbers in the column titles refer to the lookback windows in trading days.

	1 d	2 d	3 d	4 d	5 d
BAOVIET HOLDINGS	0.087	0.233	0.327	0.282	0.136
FLC GROUP	0.102	0.458	0.394	0.503	0.273
FPT	0.133	0.266	0.206	0.148	0.130
GEMADEPT	0.207	0.194	0.176	0.258	0.045
HAGL	0.539	0.382	0.298	0.272	0.378
HOA PHAT GROUP	0.268	0.222	0.101	0.331	0.266
HOA SEN GROUP	0.282	0.144	0.345	0.221	0.266
HOCHIMINH CITY INFR.INV.	−0.182	−0.091	0.026	0.245	0.030
HOCHIMINH CTY.SECS.	0.434	0.537	0.150	−0.029	0.095
JST.CMLBK.FOR FRGN.TRD. OF VTM.	0.003	0.348	0.171	0.141	0.104
KINH DO	0.445	0.224	0.173	0.180	−0.014
KINHBAC CTDEV.SHAREHLDG.	−0.026	0.245	0.013	0.022	−0.121
MASAN GROUP	0.326	0.006	−0.034	0.008	−0.168
MILITARY COML.JST.BANK	−0.080	0.006	0.038	0.012	0.204
PETROVIETNAM DRILLING	0.509	0.425	0.230	0.229	0.459
PETROVIETNAM FCM.	0.103	0.232	0.082	0.080	−0.099
PETROVIETNAM GAS	0.372	0.371	0.271	0.400	0.222
PETROVIETNAM PWR.NHON TRACH 2	−0.254	−0.089	−0.210	−0.134	0.003
PHA LAI THERMAL PWR.	0.058	0.006	0.039	−0.059	−0.095
REFRIG.ELECT.ENGR. CORP.	0.177	0.024	0.084	0.008	−0.013
SAI GTT.COML.JST.BK.	0.112	−0.155	−0.128	−0.161	−0.031
SAIGON SECURITIES	0.198	0.123	0.180	0.234	0.105
TAN TAO INV.IND.	−0.018	−0.020	0.195	0.260	0.124
THANH THANH CONG TAY NINH	0.315	−0.062	−0.057	0.007	0.006
VIETNAM DAIRY PRODUCTS	0.123	0.165	0.100	0.090	0.063
VINCOM	0.317	0.128	0.014	0.114	0.123
VN30 INDEX	0.115	0.332	0.190	0.173	0.200
VTM.JST.CMLBK.FOR INTRD.	−0.023	0.142	0.007	−0.044	−0.072
AVG	0.166	0.171	0.121	0.135	0.094

considered as curve fitting and the results are, typically, only good with the benefit of hindsight.

Surprisingly, applying moving average rules on the benchmark index VN30 itself also leads to very attractive risk-return ratios, albeit that they are subject to range within a larger band, between 1.10 and 2.33. Since there are no exchange traded funds in Vietnam, an outright index trade is thus not possible.[5] It would still be necessary to trade the individual stocks in a market-cap weighted portfolio. This would offer only little advantage of just applying the moving average rules individually. A recently introduced index futures contract might make the index trading more interesting. However, at the time of writing this paper, the history on the index futures is still too short and market liquidity is still too low as to consider this market a viable alternative. In the following years, if a designated market maker system would be introduced, futures trading would certainly be an option in this trading strategy. As of now, it remains to be seen whether the index future also exhibits short-term momentum compared to the theoretical index construct.

Looking at individual stocks reveals a remarkably mixed bag of performances. There is only one case where a single stock consistently shows risk-return ratios larger than one (HOA PHAT GROUP). In all other cases, results vary and sometimes wildly. Selecting individual stocks based on these results seems hazardous, especially as the selection would be based on hindsight results. It is therefore a first suggestion, to trade portfolios of stocks or apply a similar strategy to the index (traded through the respective index components).

Furthermore, Tables 6 and 7 show risk-return ratios and annualized returns for different lookback windows of long-short strategies respectively. For these strategies, it is allowed to short

[5] Index trading is mostly performed by exchange traded funds (ETFs). These funds are based on an index with the aim to reflect the index's performance to the investors by investing in the securities on its base index in proportion to their weight in the index. Thereby, investing in ETF rather than purchasing the equities of the index separately would yield to the same outcome.

individual stocks or the index. Shorting stocks on the Vietnamese stock market can be considered impossible for most intents and purposes. Some brokers will offer unofficial ways of shorting stocks based on individual agreements with clients. Almost all stocks should be considered hard-to-borrow and the lending costs are prohibitively high on average. The presented results do not take any of these additional shorting costs into account and are therefore an inflated view of what could have been realized with a (difficult to implement) long-short strategy. The general expectation of a strategy that is not practically implementable would be, that the results are excellent, as the strategy is not actually executable. However, for the present sample, the results are remarkably average. risk-return ratios for the AVG and the VN30 index portfolios are rather worse and less consistent than in the long-only case. Annualized returns tend to improve slightly, though. Equally, a more detailed analysis of individual stocks in the long-short strategy does not show a compelling advantage neither. In addition, results for individual stocks remain overall less robust than the portfolio results.

From a practical point of view, there is no point in choosing to test a long-short strategy, because the current state of the Vietnamese market is such that a long-short strategy couldn't be implemented in a cost-efficient way, if it is even tradeable. The current legislation also leaves a somewhat gray area as to whether short-selling is allowed or not and, generally, short positions are not popular in Vietnam nor are they encouraged. Analyzing the long-short strategy (as opposed to the long-only strategy) is, therefore,

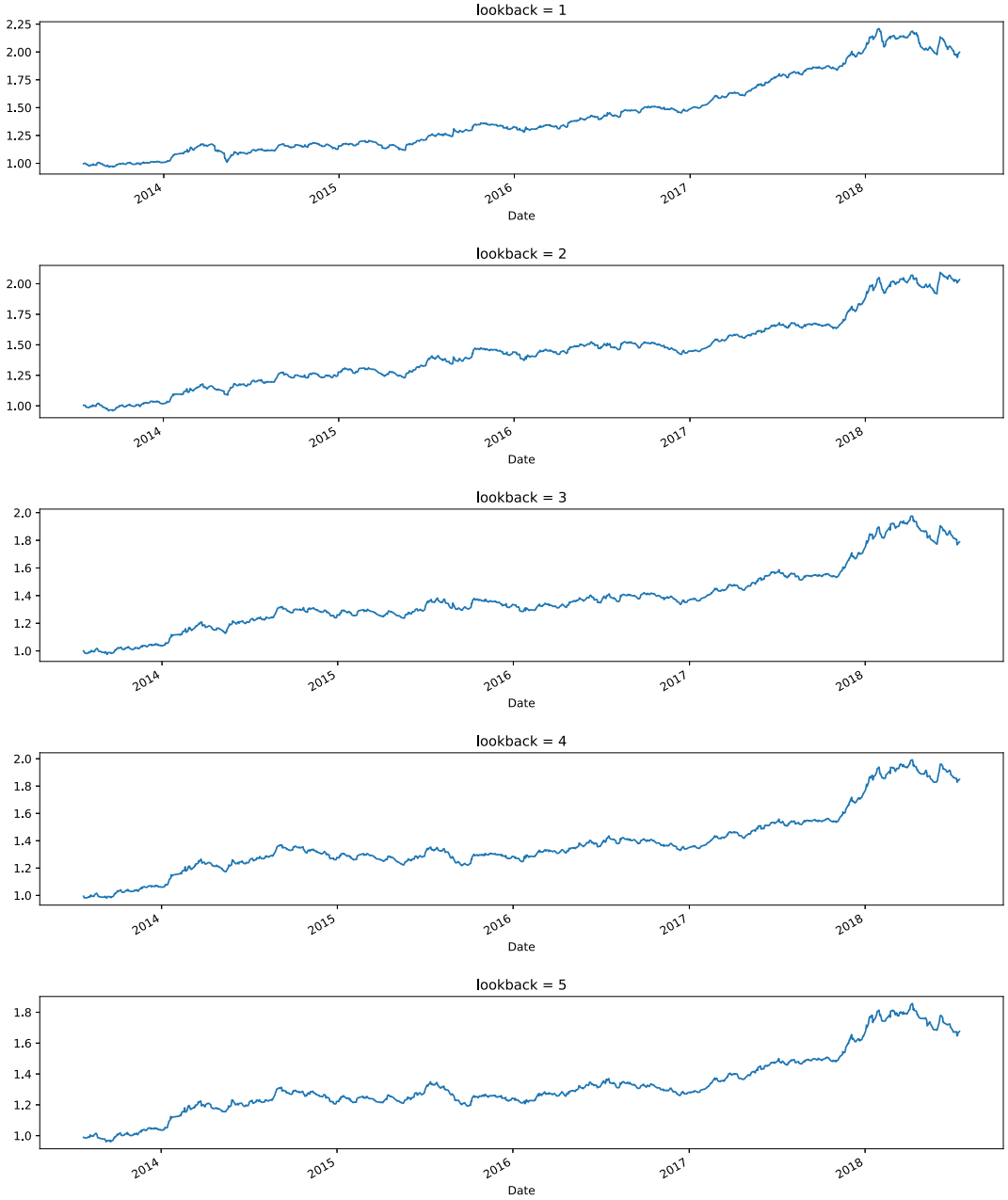

Fig. 3. Equity curve for long-only portfolios with different lookback windows varying from 1 to 5 days.

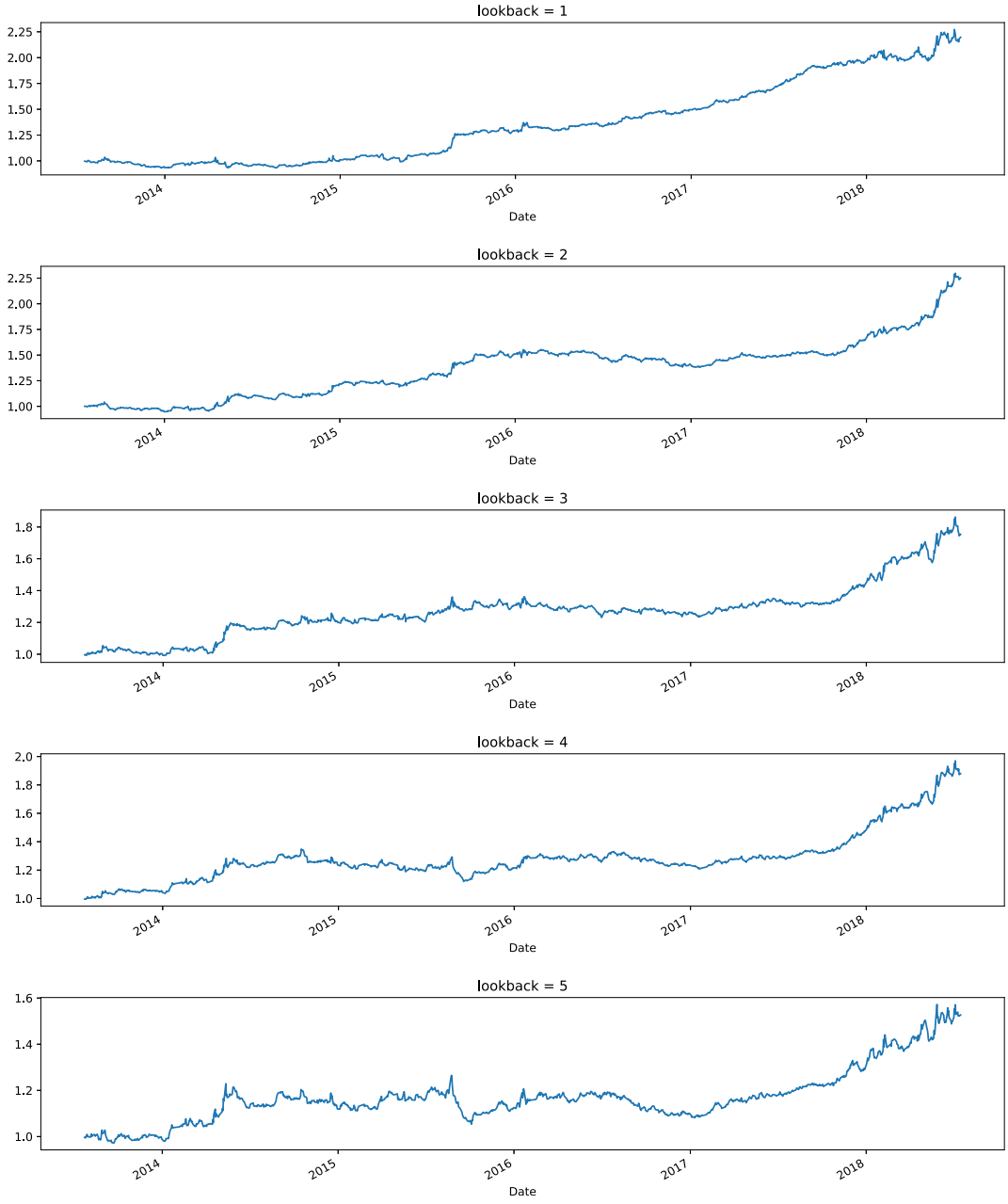

Fig. 4. Equity curve for long-short portfolios with different lookback windows varying from 1 to 5 days.

mostly an academic exercise that the authors assumed to unearth unattainable profits. Strategies that are, virtually, impossible to trade tend to show profits that are "too good to be true" (and indeed they are, as they are not implementable). However, remarkably, the unrealistic long-short strategy performs worse than the long-only strategy.

A comparison of the long-only equity curves on Fig. 3 and long-short equity curves on Fig. 4 visually document the advantage of the (rather theoretical) long-short strategy. As the reader will recall from Fig. 1, the year 2018 has seen a strong correction on the Vietnamese stock market. Naturally, in this environment, a long-only strategy will struggle as Fig. 3 shows, even if the strategy selects individual stocks. On the other hand, the long-short strategy in Fig. 4 should be able to catch some return on the short side. However, the improved equity curve over the course of the year 2018 for the long-short strategy does not translate into better risk-adjusted returns over the whole sample.

Overall, our trading expert system based on short-term moving averages yields robust and attractive risk-return ratios when using an equally-weighted portfolio or the benchmark index on a realistic long-only strategy. However, momentum is markedly less successful and robust in selecting individual stocks. Also, there would have been no especially successful stock to trade. Surprisingly, applying similar rules to an unrealistic long-short strategy does not lead to better (theoretical) results neither. Rather, results of a long-short strategy are less stable.

5. Concluding remarks

Our paper focuses on the weak-form efficiency property of the emerging Vietnamese stock market. We show that the Vietnamese market does not exhibit glaring inefficiencies, overall. However, we can demonstrate that for some stocks and especially stock portfolios, a comparatively simple expert system using a trend following model yields attractive risk-adjusted returns.

Specifically, we analyze how the Vietnamese stocks with highest liquidity can be traded conditioned upon past short-term returns. Overall, we find that the past one to five day returns offer a good indication of next trading day's expected return sign. Short-term momentum, overall, works reasonably well on these liquid Vietnamese stocks, even after accounting for conservative transaction costs. Interestingly, long-short strategies do not seem to robustly improve risk-adjusted returns, despite being almost impossible to implement, leading us to conclude that the advantage of short-selling in a daily context does not seem compelling in the Vietnamese stock market, at least in our sample period.

Still, a critical assessment of the feasibility of these trading strategies should take into account the comparatively overall low liquidity in the Vietnamese stock market. Large transactions of, for example, more than $1 million equivalent would (sometimes severely) impact the market. This is in contrast to the top liquid stocks in more developed or even emerging markets' trading venues where such amounts would have negligible effects when traded with advanced order execution methods. This has to be taken into account when implementing our strategies on portfolios through carefully adjusting the order sizes to be submitted.

Another consideration is rather of importance for non-Vietnamese investors who might want to achieve returns in currencies other than the Vietnamese Dong. The Vietnamese Dong has been subject to significant volatility over the past five years. While, overall, for this time frame a very slight appreciation has been recorded, the general long-term tendency has been towards devaluation. This means that the comparatively high returns would have been partly compensated by a depreciation in the local currency, depending on the exact time of starting a potential trading strategy. Nevertheless, the Dong could be used to provide diversification for international investors. Moreover, the currency risk could be hedged with derivatives in over-the-counter markets if the aim is to achieve successful returns in another currency than the Dong.

Future research should include more sophisticated expert systems. Especially, good quality intraday data has been available for the Vietnamese stock market in the last few years and designing expert systems has not been exploited much in scientific publications from a high-frequency perspective. In today's developed financial markets, algorithmic (especially high-frequency) trading activities dominate the trading venues. For example, the estimated percentage of the algorithmic trading volume in the total volume in US stocks was 85% in 2012, where the big part of this value was attributed to high-frequency traders (Glantz & Kissell, 2013). With the installation of improved financial technologies and the inclusion of a broader investor base, Vietnamese financial markets are expected to develop significantly in the near future. In this course, with more algorithmic approaches to trading picking up among informed domestic and foreign investors, high-frequency expert system designs should be of interest to refine our approach.

Declaration of Competing Interest:

Authors do not have any conflict of interest with other people or organizations that could inappropriately influence their work.

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