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# The profitability of MACD and RSI trading rules in the Australian stock market


## Abstract

This study investigates the profitability of two popular technical trading rules − the Moving Average Convergence Divergence (MACD) and the Relative Strength Index (RSI) − in the Australian stock market. Utilizing relatively recent data from 1996 to 2014 on the Australian All Ordinaries Index, the authors find that the MACD generally performs poorly, although the RSI shows some profit potentials. Overall, the results suggest that the Australian stock market is not weak form efficient. Implication of this finding is that participants in the Australian stock market can use technical trading rules to earn abnormal returns on a consistent basis.


**Keywords:** technical analysis, Moving Average Convergence Divergence, Relative Strength Index, Australian stock market, market efficiency.
**JEL Classification:** G11, G14, G17.

## Introduction

Technical analysis is perhaps the oldest form of investment appraisal technique and has been utilized since the Babylonian age. It refers to the use of historical market patterns to forecast future returns or trends by signalling appropriate buy and sell points. Although the strategy is widely used in practice for making short-term trading decisions (Taylor and Allen, 1992; Wong et al., 2003), it is in stark contrast to the weak-form efficient market hypothesis as postulated by Fama (1970)[1]. Briefly stated, if technical trading rules allow investors to yield greater returns and outperform the naive buy-and-hold policy, market efficiency (in that stock market) is said to be invalid. The profitability of technical analysis is therefore controversial as it has significant implications for both investment practice and theory.

A large number of studies have explored the profitability of technical trading rules. Fama and Blume (1966) discover that even before costs, filter rules generally underperform the naive buy-and-hold rule in the US. Dryden (1970) observes the opposite in the UK market. Brock et al. (1992) document profitability of simple moving average and trading range rules in the US. Their finding is corroborated by Bessembinder and Chan (1995) for emerging Asian markets (even after costs), although the more developed Asian markets are weak-form efficient. Using moving average rules, Gunasekarage and Power (2001) and Lai et al. (2007) observe predictive ability of technical analysis in South Asian and Malaysian stock markets, respectively. Yu et al. (2013) also document that simple technical rules possess superior forecasting ability (before costs) in the emerging Asian markets.

Although the Moving Average Convergence Divergence (MACD) and the Relative Strength Index (RSI) oscillators are quite popular among real-life traders, little attention has been paid to the performance of these trading rules. This argument is also supported by the recent study of Chong et al. (2014). Wong et al. (2003) document benefits of RSI in the Singapore Stock Exchange. Chong and Ng (2008) find that MACD and RSI generally outperform the buy-and-hold strategy for the London Stock Exchange FT30 Index. Chong et al. (2014) observe that these rules are not robust to different market conditions. A weakness of these studies, however, is that they overlook historical developments of the two oscillators. Specifically, both MACD and RSI were developed in the late 1970s, while these studies explore these two oscillators using data dating back to when they were not yet developed − thus opening up the possibility of look-ahead bias[2]. Accordingly, this paper seeks to investigate the profitability of these two oscillators using data for the Australian stock market and attempts to mitigate the potential look-ahead bias. Further, it considers the performance of the above technical rules during four major episodes of the Australian stock exchange. These four episodes are explained in the next section.

## 1. Data and technical trading rules

**1.1. Data.** This study uses the Australian All Ordinaries Index (XOA) data from 1st January 1996 to 30th June 2014. During this 23 year period there were a total of 4,685 daily observations. The sample is further divided into four non-overlapping subperiods of equal size (with the exception of the most recent subperiod): (I) 1/1/1996-31/12/2000,

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[1] The efficient market hypothesis argues that since stock prices instantly and rapidly reflect historical information, trading on the basis of technical analysis will not be able to produce abnormal returns when the stock market is (at least) efficient in the weak-form.

[2] For example, Chong and Ng (2008) explore the profitability of these trading rules for a sample period that begins in the year 1935 (to 1994), even though the RSI was only introduced by Wilder (1978) 40 years later. Therefore, it would not have been possible for traders to use the strategies in their decisions.

(II) 1/1/2001-31/12/2005, (III) 1/1/2006-31/12/2010 and (IV) 1/1/2011-30/06/2014. These subperiods include some major episodes in the Australian market. The first subsample covers the phase where the clearing house electronic settlement system (CHESS) in the ASX became fully automated. The second subperiod includes the abolishment of stamp duty for marketable securities. The third subsample covers the global financial crisis period, while the final subsample reflects its recovery phase. Daily closing index values are obtained from Yahoo Finance (http://finance.yahoo.com) website.

**1.2. Trading rules.** In this paper we examine the performance of two oscillators as investigated by Chong and Ng (2008) and Chong et al. (2014), the MACD and the RSI. We focus on the more established signal generators, where trades for both oscillators are executed based on their signal lines. The trading rules can be described as follows. The MACD, a trend-following indicator developed by Gerald Appel, is formed on the differences between the long and short exponential moving average (EMA). The EMA can be mathematically presented as:

$$EMA_t = \left[\frac{2}{n} \times (P_t - EMA_{t-1})\right] + EMA_{t-1}, \qquad (1)$$

where $EMA_t$ indicates the exponential moving average at time $t$, $P_t$ denotes the index value at time $t$, while $n$ shows the number of periods for the EMA (Chong and Ng, 2008). The MACD can therefore be formulated as:

$$MACD = \sum_{i=1}^{n} EMA_k - \sum_{i=1}^{n} EMA_d, \qquad (2)$$

where $k$ = 12 and $d$ = 26 reflect the number of days in EMA. These values are consistent with those widely used by real-life traders, as argued by Murphy (1999). We also construct a signal line on the basis of the 9-day EMA of the MACD. Consequently, a buy (sell) signal is generated when the MACD penetrates over (under) the signal line.

The RSI indicator, invented by Wilder (1978), measures the magnitudes of recent gains and losses to establish whether the stock is overbought or oversold. The oscillator ranges from 0 to 100 and can be defined as:

$$RSI = 100 - \left[\frac{100}{1 + RS}\right], \qquad (3)$$

where $RS$ = average up index value / average down index value over the $n$ period. Following Wilder (1978), we use $n$ = 14 days. In order for the RSI to emit buy and sell signals, its value is compared with the signal lines that represent overbought (70) and oversold (30) thresholds. More specifically, whenever RSI > 70 (< 30), it suggests a security is overvalued (undervalued). Accordingly, a buy signal is produced when RSI crosses over 30, whereas a sell signal is generated when RSI crosses below 70.

In this article, the buy (sell) trade for both MACD and RSI is executed at the next day ($t_1$) index value, following the trading signals generated at $t_0$. This is to ensure a realistic trading environment and therefore mitigate any possibility of look-ahead bias[1]. Consistent with prior studies (e.g. Brock et al., 1992; Chong and Ng, 2008; Chong et al., 2014), we examine the 10-day holding period returns following a trading signal, computed as follows:

$$r_t^{10} = \log(P_{t+10}) - \log(P_t). \qquad (4)$$

All other signals that are produced within this 10-day period are ignored. Positive (negative) returns for the buy (sell) signals indicate positive profits. In order to test for statistical significance, we follow the approaches utilized in Brock et al. (1992). The t-statistic for buy (sell) returns is calculated as:

$$t_r = \frac{\mu_r - \mu}{\sqrt{\frac{\sigma^2}{N_r} + \frac{\sigma^2}{N}}}, \qquad (5)$$

where $\mu_r$ and $N_r$ indicate the mean return and number of trades (signals) for the trading rules, $\sigma^2$ is the estimated variance for the sample, while $\mu$ and $N$ denote the unconditional mean and the number of observations. In testing the long-short (buy-sell) strategies, we compute the t-statistic as follows:

$$t_{buy-sell} = \frac{\mu_b - \mu_s}{\sqrt{\frac{\sigma^2}{N_b} + \frac{\sigma^2}{N_s}}}, \qquad (6)$$

where $\mu_b$ ($\mu_s$) and $N_b$ ($N_s$) indicate the mean return and number of signals for the buys (sells). In line with the existing literature, we assume homogeneity of the variances of returns. This allows for comparability with other documented findings in this area.

## 2. Empirical results

Table 1 describes the summary statistics for the 10-day returns and the four subperiods for the Australian All Ordinaries Index. The unconditional (buy-and-hold) mean 10-day return for the entire period is about

[1] Note that Chong and Ng (2008) and Chong et al. (2014) do not reveal whether their trades are executed at the next trading day, although this might be the case. Executing trades at day $t$ (the same day when the signal is emitted) nonetheless would have meant that traders react on non-available information, and the study would therefore suffer from look-ahead bias.

0.104%, or 2.593% annually[1]. It can be seen that the returns are most volatile (having a high standard deviation) during the third subsample period, which coincides with the global financial crisis. The distribution of returns is leptokurtic in the early subsample. Overall, it has a slightly higher peak than that is expected in a Gaussian distribution. In all periods, the returns exhibit longer left tails. With the exception of the third subsample, a reduction in skewness and kurtosis can be observed during the periods.

Table 1. Descriptive statistics for the 10-day returns

| | Min | Max | Mean | SD | Skewness | Kurtosis |
|---|---|---|---|---|---|---|
| Whole period | -0.0636 | 0.0401 | 0.001037 | 0.0121593 | -0.916 | 3.543 |
| Subperiod | | | | | | |
| 1996-2000 | -0.0636 | 0.0224 | 0.001115 | 0.0123425 | -1.367 | 5.460 |
| 2001-2005 | -0.0325 | 0.0242 | 0.001398 | 0.0090662 | -0.680 | 1.172 |
| 2006-2010 | -0.0630 | 0.0401 | 0.001290 | 0.0150370 | -0.844 | 2.704 |
| 2011-2014 | -0.0287 | 0.0248 | 0.000040 | 0.0112857 | -0.288 | 0.029 |

Notes: Table shows the unconditional (buy-and-hold) 10-day returns for the period of 1st January 1996 to 30th June 2014 including the four subperiods. All subperiods are equally sized, except for the most recent subperiod.

For illustration purposes only, we provide the graphical depiction of the trading signals generated by the MACD, along with the historical index value, for the period of 1 January 2012 to 30 April 2012 (Figure 1). In short, the buy signal is emitted when the MACD (green line) crosses over the signal (dotted red line), and vice versa. The trade is then executed the next day ($t$ + 1).

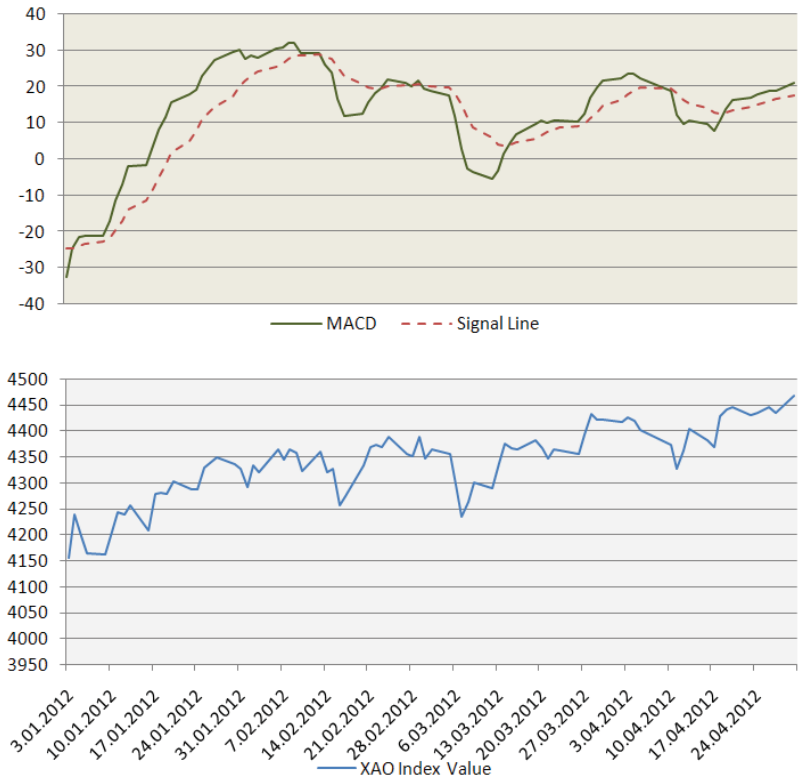


**Fig. 1. Australian All Ordinaries Index (XAO) index value, MACD and the signal line (9-day exponential moving average of the MACD) for the period of 1 January 2012 to 30 April 2012**

Table 2 reports the returns from trading using the MACD. On the whole, the number of buy signals "N(Buy)" exceeds the number of sell signals "N(Sell)". There are 8.595 (8.108) buy (sell) signals on average generated per annum[2]. The fractions of profitable signals for both long and short strategies are only slightly higher than half of the total trades. Long trades generate profits only during the first two subperiods, with mean 10-day returns of 0.123% and 0.052%, respectively. Interestingly for the whole sample, trading on the buy signals leads to an average 10-day loss of 0.005%, or about 0.043% per annum[3].

[1] This paper assumes that the average annual number of trading days in the Australian stock market is 250.

[2] This study investigates a total of 18.5 year of data from 1996 to mid-2014. Therefore, in the case of the MACD, the average number of buy trading signals is 159/18.5 = 8.595 per annum.

[3] We annualize the mean 10-day returns on the conditional trading strategies by multiplying the mean returns with the average number of signals per year. Therefore, mean return is 0.005%* 8.595 = 0.043% per annum.

The null hypothesis for the equality of returns between the MACD buy signals and the buy-and-hold trading rule cannot be rejected.

Using MACD for short selling yields positive returns overall (annualized profit of 0.641%) and outperforms the buy-and-hold for the first and fourth subperiods, although a statistically different result is obtained only for the period of 1996-2000. Traders can profit from the long-short trading rule, but the result is statistically significant (at 10% level) only for the first subperiod. It appears that for both buy and sell signals, the MACD performs worst during the third (global financial crisis) subperiod.

Table 2. The returns of the MACD rule

| | N(Buy) | N (Sell) | Buy | Sell | Buy > 0 | Sell > 0 | Buy-Sell |
|---|---|---|---|---|---|---|---|
| Whole period | 159 | 150 | -0.00005 (-0.915) | -0.00079 (-1.611) | 0.572 | 0.560 | 0.00074 (0.509) |
| Subperiod | | | | | | | |
| 1996-2000 | 47 | 43 | 0.00123 (0.056) | -0.00268* (-1.793) | 0.574 | 0.605 | 0.00391* (1.709) |
| 2001-2005 | 42 | 39 | 0.00052 (-0.525) | -0.00029 (-1.054) | 0.595 | 0.538 | 0.00081 (0.418) |
| 2006-2010 | 38 | 35 | -0.00146 (-0.910) | 0.00190 (0.209) | 0.526 | 0.514 | -0.00336 (0.826) |
| 2011-2014 | 30 | 31 | -0.00067 (-0.258) | -0.00169 (-0.715) | 0.600 | 0.548 | 0.00101 (0.276) |

Notes: The table shows the returns for the long and short MACD strategies for the period of 1st January 1996 to 30th June 2014 including the four subperiods. N(Buy) and N(Sell) indicate the number of buy and sell signals generated by the trading rule. Buy and Sell denote the average 10-day returns from the long and short strategies. Buy > 0 and Sell > 0 show the fractions of profitable trades. Buy-Sell indicates the differences between the long and short strategies. The numbers inside the brackets indicate the t-statistics for the mean MACD Buy and Sell from the unconditional 10-day returns, as well as the Buy-Sell from zero. * denotes statistical significance at the 10% level.

Figure 2 exhibits the index value for XOA, the RSI, as well as overbought and oversold signal lines for the period of 1 June 2011 to 30 September 2012. The buy signal is emitted when the RSI (aqua line) crosses over the oversold threshold (red line), while the sell signal is generated when the RSI penetrates below the overbought threshold (green line). The trade is then executed at $t + 1$.

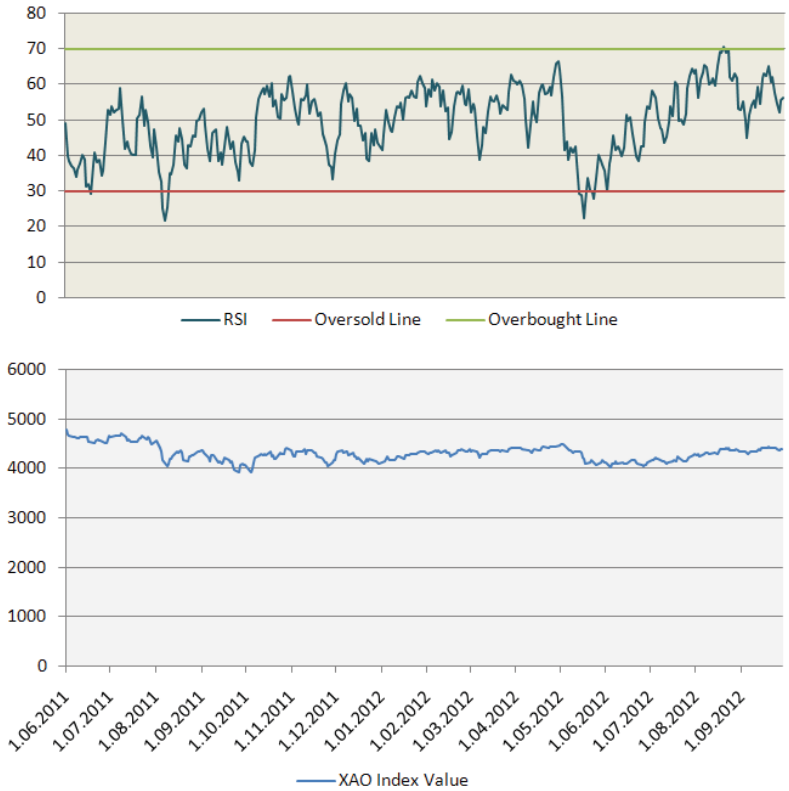


**Fig. 2. Australian All Ordinaries Index (XAO) index value, RSI, overbought and oversold signal lines for the period of 1 June 2011 to 30 September 2012**

Table 3 shows the returns from the RSI trading rule. On average, the RSI buy (sell) produces 1.838 (3.568) signals per year. The number of sell signals "N(Sell)" generally exceeds the number of buy signals "N(Buy)". The RSI (buy) seems to provide a good degree of predictability, where almost two thirds of its trading signals yield profits. For the whole period, the buy (sell) rule appears to perform quite well where it yields positive (negative) returns, although the results are not statistically significant. In other words, traders following the buy (sell) signals can earn a profit of 0.630% (0.225%) per year.

Table 3. The returns of the RSI rule

| | N(Buy) | N (Sell) | Buy | Sell | Buy > 0 | Sell > 0 | Buy-Sell |
|---|---|---|---|---|---|---|---|
| Whole period | 34 | 66 | 0.00343 (1.047) | -0.00063 (-1.063) | 0.647 | 0.530 | 0.00406 (1.390) |
| Subperiod | | | | | | | |
| 1996-2000 | 8 | 20 | 0.00897* (1.754) | 0.00081 (-0.108) | 0.875 | 0.400 | 0.00817** (2.181) |
| 2001-2005 | 9 | 20 | 0.00380 (0.719) | -0.00026 (-0.772) | 0.556 | 0.550 | 0.00406 (0.946) |
| 2006-2010 | 10 | 17 | -0.00511 (-1.173) | -0.00355 (-1.251) | 0.500 | 0.706 | -0.00156 (-0.187) |
| 2011-2014 | 7 | 7 | 0.00882* (1.980) | -0.00058 (-0.142) | 0.714 | 0.571 | 0.00940* (1.794) |

Notes: The table shows the returns for the long and short RSI strategies for the period of 1st January 1996 to 30th June 2014 including the four subperiods. N(Buy) and N(Sell) indicate the number of buy and sell signals generated by the trading rule. Buy and Sell denote the average 10-day returns from the long and short strategies. Buy > 0 and Sell > 0 show the fractions of profitable trades. Buy-Sell indicates the differences between the long and short strategies. The numbers inside the brackets indicate the t-statistics for the mean RSI buy and sell from the unconditional 10-day returns, as well as the buy-sell from zero. * and ** denote statistical significance at the 10% and 5% levels, respectively.

The RSI (buy) trading rule outperforms the buy-and-hold rule in all periods, except for the third subperiod. It offers significant returns at the 10% level for the first (0.897% vs. buy-and-hold's 0.112%) and the last (0.882% vs. buy-and-hold's 0.004%) subperiods. In a similar vein, the paired long-short trading rule dominates the buy-and-hold for the whole period and each of the subperiods, with the exception of the third subperiod. More specifically, the return from the long-short RSI strategy for the year 1996 to 2000 is statistically significant at the 5% level (with a mean 10-day return of 0.391%) and at the 10% level (average 10-day return of 0.101%) for the period of 2011-2014.

## Conclusions

In this study, we investigated whether the MACD and RSI trading rules can generate profitable trades in the Australian stock market. The results reveal that in general, buy signals from trading using the MACD underperforms the naive buy-and-hold strategy, although there is some support for it for short selling. Nonetheless, the profits from the latter are too small and generally insignificant, and can be eliminated in the presence of trading costs. In any event, short selling restrictions mean that such strategy might not be able to fully capitalize on any inefficiency in processing historical market data. Overall, the poor results from MACD are consistent with Chong et al. (2014) for the developed markets such as Germany, Japan and USA.

The evidence from this study appears to support the profit potential of the RSI. The buy signals generally outperform the unconditional mean returns, and the effect is stronger for the long-short strategy. The long and long-short trading rules are also capable of producing significant profits in the most recent subperiod. While the annualized returns for RSI are smaller than those from the naive buy-and-hold strategy (due to the small number of average RSI trades per year). Its greater mean returns indicate greater profit potential. This can be achieved by exposing more capital per trade for each RSI signals through the use of proper money management techniques. The use of RSI only during the non-trending period (as opposed to all periods inclusive) may also offer an even superior trading performance, as argued by Wong et al. (2003).[1]

To conclude, our results suggest that the Australian stock market is not efficient in the weak-form. Nonetheless, since the strategies work well in some periods (but perform poorly in others), the findings of this research support the idea of constantly revising existing trading strategies and optimizing the parameters of the trading rules in order to exploit market inefficiency. Future studies can explore these possibilities on different equity markets. Further, future studies can incorporate practical constraints, such as trading costs and short-selling restrictions to see the robustness of the results.

[1] It is argued that the RSI works well in a non-trending market phase.

## References


1. Bessembinder, H. & Chan, K. (1995). The profitability of technical trading rules in the Asian stock markets, *Pacific-Basin Finance Journal*, 3 (2-3), pp. 257-284.
2. Brock, W., Lakonishok, J. & LeBaron, B. (1992). Simple technical trading rules and the stochastic properties of stock returns, *Journal of Finance*, 47 (5), pp. 1731-1764.
3. Chong, T.T.L. & Ng, W.K. (2008). Technical analysis and the London stock exchange: testing the MACD and RSI rules using the FT30, *Applied Economics Letters*, 15 (14), pp. 1111-1114.
4. Chong, T.T.L., Ng, W.K. & Liew, V.K.S (2014). Revisiting the performance of MACD and RSI oscillators, *Journal of Risk and Financial Management*, 7 (1), pp. 1-12.
5. Dryden, M.M. (1970). Filter tests of U.K. share prices, *Applied Economics*, 1 (4), pp. 261-275.
6. Fama, E.F. (1970). Efficient capital markets: a review of theory and empirical work, *Journal of Finance*, 25 (2), pp. 383-417.
7. Fama, E.F. & Blume, M.E. (1966). Filter rules and stock-market trading, *Journal of Business*, 39 (1), pp. 226-241.
8. Gunasekarage, A. & Power, D.M. (2001). The profitability of moving average trading rules in South Asian stock markets, *Emerging Markets Review*, 2 (1), pp. 17-33.
9. Lai, M.M., Balachandher, K.G. & Nor, F.M. (2007). An examination of the random walk model and technical trading rules in the Malaysian stock market, *Malaysian Accounting Review*, 6 (2), pp. 99-121.
10. Wilder, J.W. (1978). *New concepts in technical trading systems*, Greensboro, NC: Trend Research.
11. Wong, W.K., Manzur, M. & Chew, B.K. (2003). How rewarding is technical analysis? Evidence from Singapore stock market, *Applied Financial Economics*, 13 (7), pp. 543-551.
12. Taylor, M.P. & Allen, H. (1992). The use of technical analysis in the foreign exchange market, *Journal of International Money and Finance*, 11 (3), pp. 304-314.
13. Yu, H., Nartea, G.V., Gan, C. & Yao, L.J. (2013). Predictive ability and profitability of simple technical trading rules: recent evidence from Southeast Asian stock markets, *International Review of Economics and Finance*, 25, pp. 356-371.