THE PREDICTIVE POWER AND ECONOMIC EFFECTIVENESS OF TRADING RULES STRATEGIES: APPLICATION OF VMA (P, Q, R) AND TRB (P, R, D) CONDITIONAL MODELS TO CANADIAN EQUITY MARKET

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Abstract

The Predictive Power and Economic Effectiveness of Trading Rules Strategies: Application of VMA (p, q, r) and TRB (p, r, d) Conditional Models to Canadian Equity Market

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This study evaluates the predictive power and economic effectiveness of ten variable-length moving average (VMA) and six trading range break-out (TRB) rules applied to S&P/TSX Composite Index. It is found that VMA rules do not generate random buy and sell signals, which is consistent with trading rules having predictive power. By capturing negative risk premia, the rules reduce risk and yield significant excess returns over a simple buy-and-hold-strategy. The effect of trading costs on profitability is nontrivial; break-even two-way transaction costs suggest the rules are effective only in a low-cost trading environment. The performance of the rules is consistent; the best and the worst performing rules in-sample remain so out-of-sample.

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Table of Contents

List of Tables and Figures

I. Introduction

Brock, Lakonishok and LeBaron (1992)[1] provide evidence that moving average and trading range break-out rules[2] can yield significant returns over a simple buy-and-hold strategy. Their findings are noteworthy, because every one of the rules demonstrates predictive power on the Dow Jones Industrial Average index (DJIA) over a period of 90 years. Moreover, their bootstrap results suggest that none of the employed null models, namely random walk, autoregressive, GARCH-M, and Exponential GARCH, is consistent with the observed conditional returns. Findings such as these have prompted revisits that attempt to challenge the statistical significance of the results through the use of various bootstrap simulations and novel methodologies. Evidence from White's Reality Check (Sullivan, Timmermann and White, 1999), a test that accounts for the bias inherent in a researcher's choice of trading rules to apply, suggests that moving average and trading range break-out rules are robust to data snooping. The predictive ability of trading rules is also supported by genetic algorithms that, in the same vein as the Reality Check, attempt to overcome problems related to the possible biased selection of trading rules and their parameters. Instead of adopting *ad hoc* specifications and then controlling for data snooping biases, genetic algorithms generate new optimal rules *ex-ante* by simultaneously searching for optimal structures and parameters in estimation samples and then applying them to out-of-sample forecast periods. Allen and Karjalainen (1999), who pioneered the genetic approach with financial data series, conclude that with 0.25%

[1] Where convenient Brock, Lakonishok and LeBaron (1992) will be referred to as BLL.
[2] A moving average rule is defined as "buying (or selling) when the short-period moving average rises above (or falls below) the long-period moving average", page 1735; under a trading range break-out rule "signals are generated as stock prices hit new highs and lows", page 1733.

transaction costs most of the genetically generated rules "are effectively similar to a 250-day moving average rule"[3]. This, along with evidence that trading rules yield excess returns in a number of emerging and developed equity markets (Bessembinder and Chan, 1995 and Ito, 1999, among others), incite further examination.

This study evaluates the performance of Variable-length Moving Average (VMA) and Trading Range Break-out (TRB) rules on the Toronto Stock Exchange S&P/TSX Composite Index (TSX). Previously, Ito (1999, 2002) replicate BLL rules employing Canadian equity data. The first evaluates trading rules profitability in Pacific-Basin equities (Datastream Indices, 1980-1996) in the context of asset pricing models; the second investigates whether two non-linear models can explain the statistically significant returns produced by VMA rules on the TSE 300 from 1977 to 1995. Both studies have weaknesses, however. The first adopts the double-or-out trading strategy on the assumption that some governments restrict short sales, but this is not the case in Canada and is therefore inappropriate. The second overstates the economic significance of conditional returns by annualising buy and sell signal mean daily return differences, rather than simply the total return divided by the number of days in the sample. Unconditional mean returns are overstated as well because the calculation of the mean does not exclude the first 200 observations that were used for estimating parameters.

Ito's (2002) original sample from 1977 to 1995 is employed for a number of analyses in, what will be referred to as, the in-sample. Eight more years of data, from 1996 to 2003, were collected and are used as out-of-sample period. Trading rule

[3] Page 262

predictive power is investigated by testing the buy and sell signals for randomness where standard and distribution-free tests are employed. Their effectiveness is then studied in the framework of Jensen's (1978) definition of the Efficient Market Hypothesis where both price and total returns are adjusted for risk and transaction costs. Trading rule returns are compared to unconditional returns from the buy-and-hold strategy on a risk-adjusted basis using Sharpe and Jensen measures. The wealth depletion effect of transaction costs is measured and break-even levels are estimated. Next, Consistency Check is performed, that is, the robustness of the results is examined by comparing the rank order of trading rules risk-adjusted performance in-sample and out-of-sample, providing evidence of forecast reliability; in other words, it is tested whether rules differ and whether the identified best and worst performing rules remain so when applied to hold-out data. And finally, the relationship between excess returns and market volatility is explored.

This study reveals that VMA trading rules do not generate random signals and they yield excess returns over buy-and-hold. The risk associated with conditional returns is lower where the best performing models have negative betas. The results are largely consistent over the various comparison criteria, and are robust to transaction costs of 25 basis points. Increasing transaction costs to 150 basis points, however, quickly erodes their profitability; the break-even is about 75 and 50 points for price and total returns, respectively. Out-of-sample results suggest that TRB rules produce random signals and their excess profitability is negative after transaction costs. The rank order test of trading rules risk-adjusted performance lends support to a degree of forecast reliability. The two best and worst VMA rules in-sample remain so out-of-sample. The same test on TRB rules shows no significant difference among them, consistently, in-sample and out-of-sample. There is a positive and significant relationship between conditional returns and unconditional variance.

The remainder of the paper is organised as follows. Section 2 reviews the literature. Section 3 discusses the trading rules. The methodology is explained in Section 4, and the Data samples in Section 5. Section 6 presents the results. Section 7 discusses the main findings, and Section 8 concludes.

II. Literature Review

Brock, Lakonishok and LeBaron (1992) apply two of the most popular *ad-hoc* trading rules, namely, the moving average and the trading range break-out, to DJIA index daily data from 1897 to 1986. All of the rules considered, which include ten variable- and ten fixed-length moving averages, and six trading range break-outs, are shown to yield excess returns and in which serial correlation accounts for less than 10%. The authors also use a bootstrap to compare actual trading rule returns to returns simulated from a number of generating processes, and find that trading rule returns are not consistent with a random walk, autoregressive, GARCH-M, or Exponential GARCH process. They find that buy signals consistently produce higher returns than sell signals and that returns following buy signals are less volatile than those following sells.

The asymmetry of buy and sell signal returns suggests non-linearity. Employing a single layer feed-forward network regression as a non-linear conditional mean estimator and the previous buy and sell signals from two moving average rules, Gencay (1998) addresses this issue and documents non-linear predictability in stock market returns. His specification forecasts better than linear AR and GARCH-M models, which supports the BLL finding that linear conditional mean estimators fail to characterise the temporal dynamics of equity returns. More generally across samples, moving averages provide at least a 10% forecast improvement in more volatile years. Performance is considerably better in "trendy years" and moderate during periods without clear price tendencies.

Results for a number of developed and less-developed or emerging equity markets support the predictive power of trading rules. Hudson, Dempsey and Keasey (1996) and Mills (1997) largely replicate BLL on the UK equity market (FT30) and obtain results remarkably similar to BLL. Isakov and Hollistein (2002) provide evidence from the Swiss market (SBC General Index, 1969-1997). Bessembinder and Chan (1995) find that trading rules are more profitable on less-developed than on developed markets. Ito (1999), Parisi and Vasquez (2000), Ahmed, Beck and Goldreyer (2000), Gunasekarage and Power (2001), and Chang, Lima and Tabak (2004) all support the hypothesis that emerging markets are less efficient. Ratner and Leal (1999) is the one exception.

Although BLL do not find that trading rules performance differs across sub-periods, replications of their work suggest weakening profits in the latest periods. Sullivan, Timmermann, and White (1999), for instance, document that the best rule from 1897 to 1986 does not repeat its superior performance in the out-of-sample experiment from 1987 to 1996. In fact, none of the rules is able to maintain its profitability. The authors outline three possible explanations: the out-of-sample is not representative, the trading rules are not representative, and the markets have become more efficient. The first is an acknowledgement that, depending on the way performance is evaluated, one out-of-sample period really yields only one observation, and thus is insufficient to draw convincing conclusions about forecast reliability. The second addresses the possibility that the employed 7846 rules are not representative of the whole universe. They ultimately favour the third, citing low-cost computing power, lower transaction costs, and increased liquidity as making markets more efficient. Ready (2002) has similar findings and speculates that arbitrage activities on Wall Street have minimised trading rules return opportunities. Employing data from 1962 to 1996 for NYSE and from 1973 to 1996 for NASDAQ, Kwon and Kish (2002) find weakening profits from trading rules and suggest that markets are becoming more efficient in disseminating information to a wider range of investors. Bessembinder and Chan (1998) find that the break-even two-way transaction costs decline rapidly after 1975 (DJIA Index, 1926-1991) and conclude that excess trading rule returns are consistent with this improvement in operational efficiency.

Excess returns from trading rules cannot as yet be explained by measurement error. Bessembinder and Chan (1998), for example, conclude that the heightened returns cannot be attributed solely to errors arising from non-synchronous trading. Further, they argue that the omission of dividend yields introduces bias in sell signal returns and estimate that the additional return from dividends is 0.016% per day, which compares to sell signal mean return of 0.027%. Ready (2002) controls for such possible measurement error by using total index returns and finds that four moving average trading rules perform worse than buy-and-hold from 1987 to 2000. However, both studies apply short position constraints assuming respectively, double-or-out and long-bond-instead-of-short-stock trading strategies, which limits the representativeness of their results.

Trading rules are economically effective in a low-cost trading environment. Isakov and Hollistein (2002) find that only investors who face two-way transaction costs of less than 0.66% can benefit on Swiss market and conclude that for a large fraction of participants the weak form of market efficiency cannot be rejected. Two separate studies employing large samples, from 1935 to 1994 for FT30 (Hudson, Dempsey and Keasey, 1996) and from 1926 to 1991 for DJIA (Bessembinder and Chan, 1998), estimate identical average break-even two-way transaction costs of 0.8% and 0.78%, respectively. In contrast, Ito (1999) reports an average of 1.58% in Canada from 1980 to 1996.

III. Conceptual Foundation of the Trading Rules

1. Variable-length Moving Average Rules

The moving average oscillator is one of the oldest and most popular tools used by technical analysis. It smoothes data, ostensibly removing noise to reveal underlying trends. At time t, a moving average is calculated as:

$$ma_t(p) = \frac{1}{p}\sum_{i=0}^{n-1} x_{t-i}, \qquad (1)$$

where p is the smoothing parameter (number of observations) and x_t is the closing price at time t.

Murphy (1999) and Schwager (1996) describe the double crossover moving average strategy as two moving averages, one with a short and the other a long smoothing parameter. A moving average trading rule generates a buy signal when the short moving average crosses above the long moving average, and a sell signal when the short moving average crosses below the long moving average (see Figure I). It is given formally as:

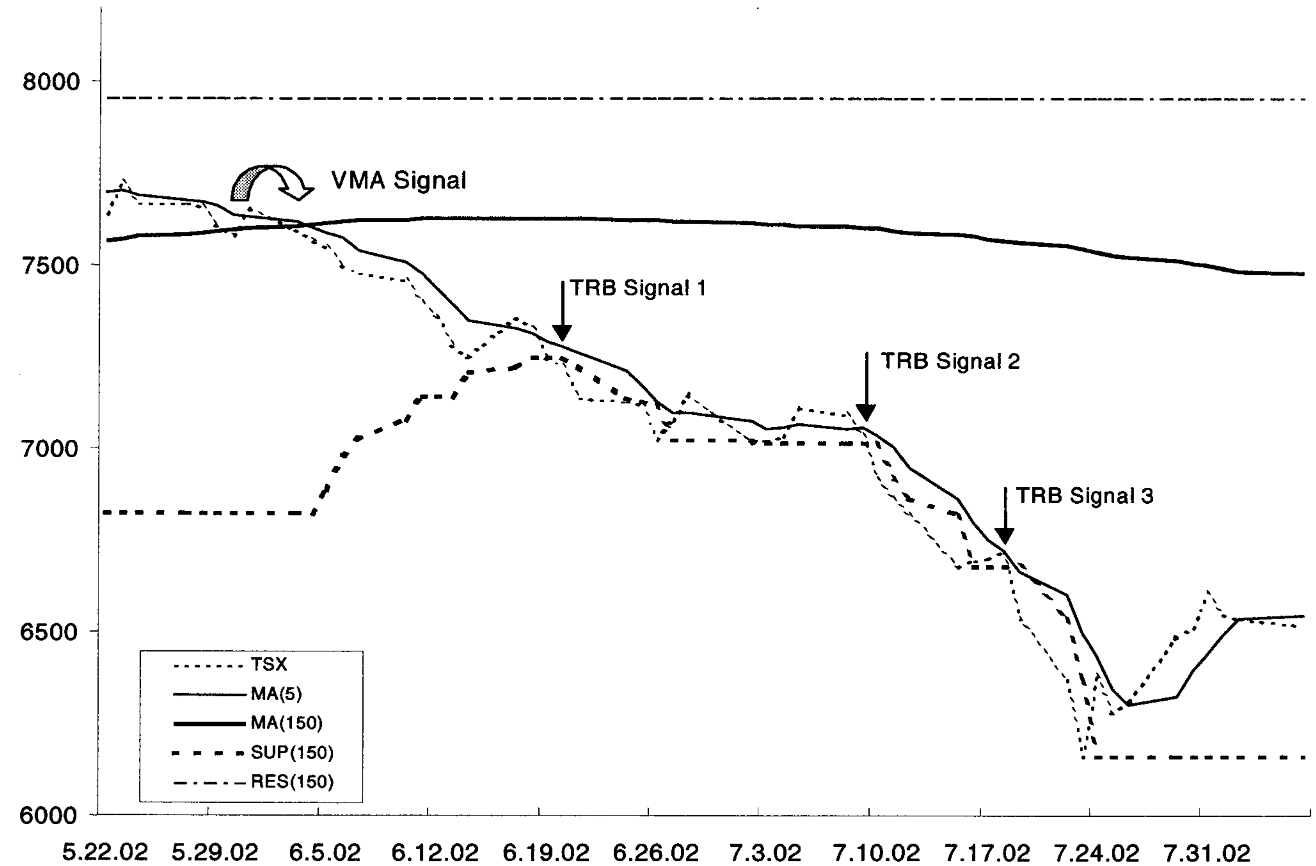
$$if, \frac{1}{p}\sum_{i=0}^{n-1} x_{t-i} > \frac{1}{q}\sum_{i=0}^{n-1} x_{t-i}, \; then\ Buy, \qquad (2)$$

$$if, \frac{1}{p}\sum_{i=0}^{n-1} x_{t-i} < \frac{1}{q}\sum_{i=0}^{n-1} x_{t-i}, \; then\ Sell, \qquad (3)$$

where p is the smoothing parameter of the short moving average, q is the smoothing parameter of the long moving average and x_t is the closing price at time t.

Figure I
Trading Signals

VMA (5, 150, 0) sell signal is generated as the short moving average with smoothing constant of 5 days crosses below the long moving average with smoothing constant of 150 days. Three TRB (150, 0, 10) model sell signals are generated as the closing index price declines below the 150 trading days minimum.



The crossing of the two moving averages is indicative of reversal in price direction and a possible opportunity to exploit well-known low-order serial correlation (Allen and Karjalainen, 1999). Smaller smoothing parameters suggest more sensitive to price moving averages and thus, more frequent crossovers. If the smoothing parameter of the short moving average p is equal to one, then the average is effectively equal to the price, and the rule is known as single crossover moving average strategy.

This study examines Variable-length Moving Average rules (VMA), which include the double crossover moving average with and without a trading filter band. The purpose of this band is to filter out weak signals by validating each signal with respect to whether the short moving average is outside a fixed percentage band around the long moving average:

$$if, \frac{1}{p}\sum_{i=0}^{n-1} x_{t-i} > \left(1+\frac{r}{100}\right)\frac{1}{q}\sum_{i=0}^{n-1} x_{t-i}\text{, } then\ Buy, \tag{4}$$

$$if, \frac{1}{p}\sum_{i=0}^{n-1} x_{t-i} < \left(1-\frac{r}{100}\right)\frac{1}{q}\sum_{i=0}^{n-1} x_{t-i}\text{, } then\ Sell, \tag{5}$$

where p is the smoothing parameter of the short moving average, q is the smoothing parameter of the long moving average, r is the size of the filter band and x_t is the closing price at time t.

The notation of moving average trading rules is given by VMA (p, q, r) model, where p is the short smoothing parameter, q is the long smoothing parameter, and r is the size of the filter band. The parameters used are the same as BLL, namely, (1, 50, 0), (1, 50, 0.01), (1, 150, 0), (1, 150, 0.01), (5, 150, 0), (5, 150, 0.01), (1, 200, 0), (1, 200, 0.01), (2, 200, 0) and (2, 200, 0.01).

2. Trading Range Break-out Rules

Schwager (1996) defines the trading range as a horizontal corridor that contains price fluctuations for a specific period of time. The upper and the lower boundaries of this corridor define local maximum, called resistance, and local minimum, called support, which can be represented as follows:

$$resistance_t\,(p) = \max(x_{t-1},\ldots,x_{t-p}), \tag{6}$$

$$support_t\,(p) = \min(x_{t-1},\ldots,x_{t-p}), \tag{7}$$

where p is the time parameter (number of observations) and x_t is the closing price at time t.

A simple trading range break-out rule generates a buy signal when the closing price exceeds the prior local maximum, and a sell signal, when the closing price declines below the local minimum (see Figure I):

$$if,\ x_t > resistance_t\,(p),\ then\ Buy, \tag{8}$$

$$if,\ x_t < support_t\,(p),\ then\ Sell, \tag{9}$$

where p is the time parameter and x_t is the closing price at time t.

The ability of the price to move to a new high or low indicates a potential for a new trend in the direction of the break-out (Schwager, 1996). Thus, the penetration of a previous high is viewed as a buy signal, and the penetration of previous low as a sell signal. Shorter time periods imply more frequent signals.

Following BLL, this study employs Trading Range Break-out rules (TRB) with and without trading filter bands:

$$if, x_t > \left(1+\frac{r}{100}\right)\text{resistance}_t\,(p), then\ Buy\ and\ hold\ for\ (d)\ periods, \tag{10}$$

$$if, x_t < \left(1-\frac{r}{100}\right)\text{support}_t\,(p), then\ Sell\ and\ hold\ for\ (d)\ periods, \tag{11}$$

where p is the time parameter, r is the size of the filter band, d is the holding period and x_t is the closing price at time t.

The notation of the rules is given by TRB (p, r, d) model, where p is the time parameter, r is the size of the filter band and d is the holding period. The parameter specifications are (50, 0, 10), (50, 0.01, 10), (150, 0, 10), (150, 0.01, 10), (200, 0, 10) and (200, 0.01, 10).

3. Trading Strategy

VMAs and TRBs are lagging indicators because they generate trading signals after a price trend has ostensibly changed. In this respect, the buy-and-hold will yield higher returns in any given period of consecutive positive market returns, while rules can compensate for the lagging effect during negative drifts. This consideration brings to the important issue regarding the way short selling is implemented. Ratner and Leal (1999), Ahmed, Beck and Goldreyer (2000) and Ready (2002) constraint short positions by replacing sell days with neutral days, under which sell signal returns are equal to risk free rate. This approach is biased, because it assumes equality between negative risk premia and risk free rate. Moreover, there is no difference between sell signal returns as implied by the definition of the trading rules and neutral signal returns.

Another type of short position constraint found in previous studies (Bessembinder and Chan, 1998, Ito, 1999, among others) is the double-or-out trading strategy. Under this strategy, the neutral signal return is taken to be equal to the buy-and-hold return and the sell signal return is taken to be equal to the risk free rate. The buy signal is associated with borrowing of additional funds at risk free rate and opening a long position, which is doubled. The implications for comparative performance of this double-or-out strategy are unclear because of the effects of leverage and the assumption that funds can be borrowed or lent at the same rate.

IV. Methodology

1. Return Series

Since the omission of dividends may lead to overstated performance of trading rules, the VMA and TRB rules are examined for both daily price returns, which are based solely on change in security prices, and daily total returns, which are based on prices and distributions (stocks, dividends, etc.). The returns are calculated as the difference between natural logarithms of closing prices:

$$R_t^h = \ln(x_{t+h}) - \ln(x_t), \tag{12}$$

where h is the holding period (daily return series are generated as h=1) and R is the return for the period.

Returns conditional on buy, sell and neutral signals are given by:

$$R_{C_t} = \eta_{t-1}\left[\ln(x_{t+1}) - \ln(x_t)\right], \tag{13}$$

where η is a signal indicator and R_C is the conditional return.

The buy signal (η = 1) prescribes a long position whose return is equal to the buy-and-hold. The sell signal (η = -1) prescribes a short position whose return is the negative of the buy-and-hold for price return series; when total return data is used it is net of dividend yield and of the risk-free rate to represent the cost of borrowing. For a neutral position (η = 1), the return is equal to the risk-free rate.

2. Evaluation of Trading Rules

2.1. Randomness of Buy and Sell Signals

Let buy and sell signal returns be binary variables with two possible outcomes – positive or negative, and θ denotes the proportion of positive returns to all outcomes. The process of generating buy and sell signal return series is equivalent to a sampling procedure with VMA (p, q, r) and TRB (p, r, d) models as the sample selection methods, and unconditional return series as the underlying population. As long as the selection methods are random, buy and sell sampling distributions will approximate the population distribution. More specifically, buy and sell signal point estimators of the population proportion of positive returns will be equal. This is consistent with trading rules generating random signals, and tested employing a distribution-free chi-square test of null hypothesis of equality of k proportions H_0: $\theta_1 = \theta_2 = \ldots = \theta_k$ with test statistics[4]:

$$Q = \frac{1}{\theta_0(1-\theta_0)} \sum_{i=1}^{k} \frac{x_i^2}{n_i} - \frac{N\theta_0}{1-\theta_0}, \tag{14}$$

where n_i, N and x_i are the number of trials, observations and positive returns, respectively.

Randomness of trading signals also implies equal buy and sell signal point estimators of population mean. Three null hypotheses of equality between two independent means are tested using a standard Gossett t-test[5]:

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[4] One-tail rejection region: $Q \geq \chi^2_{k-1,\,\alpha}$; Gibbons and Chakraborti (2003) explain the test in detail, page 390.
[5] Two-tail rejection region: $|t^*| > t(1-\alpha/2;\ n_1 + n_2 - 2)$

(H1) Null hypothesis of equality between conditional on buy signal mean return and unconditional mean return H_0: $R_{C\text{-}BUY} - R_{UC} = 0$, with test statistics:

$$t^* = \frac{\mu_b - \mu}{\sqrt{\frac{\sigma_b^2}{N_b} + \frac{\sigma^2}{N}}}, \tag{15}$$

where μ_b , σ_b^2 and N_b are the buy signal mean return, variance and number of buy days, and μ, σ^2 and N are the mean return, variance and number of observations under buy-and-hold.

(H2) Null hypothesis of equality between conditional on sell signal mean return and unconditional mean return H_0: $R_{C\text{-}SELL} - R_{UC} = 0$, with test statistics:

$$t^* = \frac{\mu_s - \mu}{\sqrt{\frac{\sigma_s^2}{N_s} + \frac{\sigma^2}{N}}}, \tag{16}$$

where μ_s , σ_s^2 and N_s are the sell signal mean return, variance and number of sell days, and μ, σ^2 and N are the mean return, variance and number of observations under buy-and-hold.

(H3) Null hypothesis of equality between conditional on buy signal mean return and conditional on sell signal mean return H_0: $R_{C\text{-}BUY} - R_{C\text{-}SELL} = 0$, with test statistics:

$$t^* = \frac{\mu_b - \mu_s}{\sqrt{\frac{\sigma_b^2}{N_b} + \frac{\sigma_s^2}{N_s}}}, \tag{17}$$

where μ_b , σ_b^2 and N_b are the buy signal mean return, variance and number of buy days, and μ_s , σ_s^2 and N_s are the sell signal mean return, variance and number of sell days.

The power of the t-test for difference between means of two independent large samples with estimated standard deviation depends on the assumption that both populations are approximately normally distributed, which however, is not the case with stock market returns. BLL address this issue by generating a bootstrap distribution that is used to make inferences about the original distribution. None of their null models, or those used by others in later studies, could generate a bootstrap distribution for which trading rule returns are persistently higher than those generated with the actual series. In the Canadian context, Ito (1999, 2002) applied the bootstrap methodology to the VMA (p, q, r) and TRB (p, r, d) models from 1980 to 1996 and again to the VMA (p, q, r) from 1977 to 1995. None of his null models are consistent with the actual trading rule return distributions at the 5% level of significance.

To address the issue of distribution form, this paper employs distribution-free tests based on another measure of central tendency, the median, which distribution does not depend on that of the population and thus, assumptions about underlying population are not necessary. The hypotheses *H1* and *H2* are adjusted for differences between median returns, that is, H_0: $M_{C\text{-}BUY} = M_{UC}$ and H_0: $M_{C\text{-}SELL} = M_{UC}$, and Mood's median test[6] is applied with asymptotic[7] *z* test statistics[8]:

$$z^* = \frac{U - n_1 t / N}{\sqrt{n_1 n_2 t (N - t) / N^3}}, \qquad (18)$$

[6] Gibbons and Chakraborti (2003) explain the test in detail, page 247.
[7] For large N the hypergeometric distribution approaches the binomial one and the asymptotic distribution is approximately standard normal.
[8] Two-tail rejection region: $|z^*| > z_{\alpha/2}$

where N is the total number of observations, n_1 and n_2 are the number of observations in the two samples, U is the number of observations less than the grand median, and t is equal to $N/2$, if N is even, or $(N-1)/2$, if N is odd.

The null hypothesis that trading rules generate random signals implies identical distributions of buy signal and sell signal returns. To test this, Wilcoxon rank-sum test[9] is employed, and the hypothesis *H3* is adjusted for equality between any two corresponding locations, that is, H_0: $\theta = 0$. The test statistic[10] is:

$$W_N = \sum_{i=1}^{N} iZ_i, \tag{19}$$

where i is the simple weights and Z_i is the indicator random variable and rank-order statistics of the combined samples.

2.2. Adjustment for Risk

The notion of risk-adjusted returns is fundamental for the precise evaluation of trading strategies, because it demands comparison of returns at equal level of risk. Neely (2001) argues that a number of studies on the topic leave unclear implications for the Efficient

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[9] Gibbons and Chakraborti (2003) explain the test in detail, page 298.

[10] Two-tail rejection region: $W_N = \dfrac{n_1(N+1)}{2} \pm \left(\dfrac{1}{2} + z_{\alpha/2}\sqrt{\dfrac{n_1 n_2 (N+1)}{12}}\right)$,

where the p-value is the smaller of:

$$\Phi\left(\frac{\omega_0 + \dfrac{1 - n_1(N+1)}{2}}{\sqrt{\dfrac{n_1 n_2 (N+1)}{12}}}\right) \quad \text{or} \quad 1 - \Phi\left(\frac{\omega_0 - \dfrac{1 + n_1(N+1)}{2}}{\sqrt{\dfrac{n_1 n_2 (N+1)}{12}}}\right)$$

Market Hypothesis (EMH), because the simple comparison of mean returns is not sufficient to evaluate the usefulness of the models. Brown, Goetzmann and Kumar (1998) emphasise the importance of risk adjustment by pointing a study by Alfred Cowles, which led to the development of EMH and which apparently was flawed, because the difference in the relative risk had not been taken into account.

This study controls for risk using the Sharpe ratio (Sharpe, 1966) and Jensen measure (Jensen, 1968). Both require the calculation of excess returns, which are defined as conditional or unconditional returns minus the risk-free interest rate:

$$ER_t^h = E(R_t^h \mid C, UC) = R_t^h - \sum_t^h \frac{\ln(1 + r_{f_t})}{252}, \tag{20}$$

where *ER* is the excess return over risk free rate, C and UC are the conditional and unconditional return and r_f is the annualised risk free rate at the end of the previous period.

Considered as a standard return-risk measure (Schwager, 1996), the Sharpe ratio is a reward-to-variability proportion that measures excess return per unit of risk. The familiar ratio is written as:

$$SR = \frac{\mu_{ER}}{\sigma_{ER}}, \tag{21}$$

where μ_{ER} is the conditional or unconditional mean daily excess returns and σ_{ER} is the standard deviation of returns.

Jensen measure is derived from a CAPM model specification where α is the legitimate risk-adjusted measure of performance and β is the risk parameter (Jensen, 1968):

$$ER_{C_t} = \alpha + \beta \ ER_{UC_t} + \varepsilon_t, \tag{22}$$

where ER_C and ER_{UC} are the conditional and unconditional excess return series.

In the context of this study, α is the average incremental risk-adjusted return due to predictive power of trading rules. It is employed for comparison across trading rules and against the buy-and-hold strategy where the positive and significant intercepts are indicative for superior performance of trading rules. The risk parameter β is a measure of tendency of conditional excess returns to move in line with the market risk premia.

2.3. Adjustment for Transaction Costs

The wealth depletion effect of transaction costs borne by institutional and individual investors is incorporated by adjusting conditional returns with 25 and 150 basis points for every two-way transaction. One-way transaction costs apply only for trading rules with filter bands when there is a shift from a neutral to a long or short position or *vice versa*. Transaction costs, TC, are subtracted from the trading rule returns on the day they are incurred:

$$R_{C-TC_t} = E(R_{C_t} | TC, TC/2) = R_{C_t} - \ln(1 + TC) \tag{23}$$

The analysis also includes an estimation of the break-even two-way transaction cost across all trading rules. For a given number of trades, the break-even is the level of transaction costs at which mean trading rule returns are equal to mean buy-and-hold returns:

$$TC^0 = \frac{R_C - R_{UC}}{N}, \tag{24}$$

where N is the number of two-way transactions.

3. Consistency Check

One gauge of forecast reliability is to see whether the best and worst performing trading rules in the in-sample keep their performance ranking in the out-of-sample. Assume that trading rules are not significantly different one from another. In this case, the probability of a trading rule changing rank from best to worst or *vice versa* in a later period is equal across all trading rules, and so combining all trading rules and using a weighted signal is as good as any. If, on the other hand, trading rules differ significantly in performance, then an optimal strategy will involve separating the best from the worst. To do this, the trading rules are first ranked according to their Sharpe ratios. Then a median exact test[11] with Monte Carlo significance for differences across k independent samples is conducted. The probability distribution for this test is a multivariate extension of the hypergeometric distribution used in (18), and the associated test statistic[12] has approximately a chi-square distribution under the null hypothesis that all trading rules are equally effective:

[11] Gibbons and Chakraborti (2003) explain the test in detail, page 355.
[12] One-tail rejection region: $Q(N-1)/N \geq \chi^2_{k-1,\,\alpha}$

$$Q = \frac{N^2}{t(N-t)} \sum_{i=1}^{k} \frac{(u_i - n_i t / N)^2}{n_i} \qquad (25)$$

where N is the total number of observations, n_i is the number of observations in the i^{th} sample, u_i is the number of observations in the i^{th} sample less than the grand median, and t is equal to $N/2$, if N is even, or $(N-1)/2$, if N is odd.

The Monte Carlo simulation is performed on 10,000 sample tables in order to estimate 99% confidence intervals for the exact significance. If H_0 is rejected, this is, trading rules are not equally effective, then the best and the worst are excluded, and the procedure is repeated on the remaining rules until all are tested.

4. Returns and Market Volatility

Previous research provides evidence that trading rules are more effective when applied to less developed markets (Bessembinder and Chan, 1995 and Ito, 1999, among others). Since emerging markets are, in general, more volatile than developed markets, it can be inferred that there is a relationship between the performance of trading rules and the volatility of the market. This is examined by regressing excess monthly returns on the monthly variance of returns:

$$R_{C_t} - R_{UC_t} = \alpha + \beta \sigma_{M_t}^{2} + \varepsilon_t \qquad (26)$$

Brock, Lakonishok and LeBaron (1992) find that trading rules tend to generate long positions when returns are high and volatility is low and vice versa for the sell signals. Allen and Karjalainen (1999) confirm the above patterns and hypothesize that when volatility is low, expected returns decrease and the corresponding upward revision of prices is picked up by the trading rules. This suggests the presence of a systematic relationship between trading rule signal returns and volatility, which is investigated in this study by employing the following two models:

$$R_{C-BUY\,t} = \alpha + \beta R_{M\,t} + \gamma \sigma_{M\,t}^{2} + \varepsilon_{t},$$

$$R_{C-SELL\,t} = \alpha + \beta R_{M\,t} + \gamma \sigma_{M\,t}^{2} + \varepsilon_{t}, \qquad (27)$$

where $R_{C\text{-}BUY\ or\ SELL}$ is the buy or sell signal monthly return, R_M is the unconditional monthly return, and σ_M^2 is the monthly variance.

V. Data Samples

The data set consists of three daily time series: the Toronto Stock Exchange S&P/TSX Composite Price Index, which is based on closing prices; the Toronto Stock Exchange S&P/TSX Composite Total Return Index, which is based on prices adjusted for dividends; and the average yield on 91-day Government of Canada T-bills, which is based on weekly auctions and corresponds to Statistics Canada CANSIM series B14007. The sample runs from the first trading day of 1977, January 3rd, to the last trading day of 2003, December 31st, for a total of 6,803 observations. The first 200 observations are set aside for calculation of the first observation of the trading rules. The in-sample matches Ito's (2002), January 3rd, 1977 to December 29th, 1995, for 4,788 observations, including the initial 200. The out-of-sample runs from January 2nd, 1996 to December 31st, 2003 for 2,015 observations. All data were obtained from the Toronto Stock Exchange – Canadian Financial Markets Research Center Summary Information Database (TSX-CFMRC), a product of the TSX Group.

Table I
Summary Statistics

In-sample and out-of-sample price and total returns are employed. Estimation periods are excluded. Returns are calculated as ln differences (applying formulas 12 and 13). Kolmogorov-Smirnov statistics are used to test whether returns are normally distributed where p-value corresponds to Prob > D. ρ (1), ρ (2) and ρ (5) are estimated autocorrelations. For each Pearson's lagged correlation coefficients p-values (Prob > |r|) under null hypothesis H_0: Rho=0 are presented.

	In-Sample 1977-1995		Out-of-Sample 1996-2003	
	Price Returns	Total Returns	Price Returns	Total Returns
N Observations	4588	4588	2015	2015
Total Return	1.56248	2.22211	0.55624	0.68977
Mean Return	0.0003406	0.0004843	0.0002761	0.0003423
Median Return	0.000561	0.000693	0.000823	0.000877
Minimum Return	-0.120086	-0.119645	-0.084652	-0.084652
Maximum Return	0.086459	0.086460	0.046835	0.046842
Standard Deviation	0.0076831	0.0076782	0.0106938	0.0106889
Skewness	-1.276870	-1.271984	-0.6733076	-0.6771215
Kurtosis	23.963403	23.857263	5.5195858	5.5372957
Kolmogorov-Smirnov	0.077316	0.077443	0.065414	0.064102
p-value	<.0100	<.0100	<.0100	<.0100
ρ (1)	0.23503	0.23583	0.08557	0.08503
p-value	<.0001	<.0001	0.0001	0.0001
ρ (2)	0.02480	0.02573	-0.02661	-0.02658
p-value	0.0931	0.0814	0.2327	0.2333
ρ (5)	0.05604	0.05500	0.00463	0.00459
p-value	0.0001	0.0002	0.8358	0.8371

VI. Empirical Results

1. Summary statistics

Table I contains descriptive statistics and autocorrelation estimates for the returns. The in-sample mean daily and total daily returns are approximately 0.0341% and 0.0484%; the out-of-sample means are 0.0276% and 0.0342%. The in-sample returns appear to be less volatile than the out-of-sample returns. All returns are skewed left and are leptokurtic, and Kolmogorov-Smirnov tests reject the null hypothesis that the series are normally distributed. There is significant positive autocorrelation between one-day lagged in-sample returns, which however, is smaller in the out-of-sample. The autocorrelations with two- and five-day lags are weak.

2. Trading Signals

A description of the trading signals is presented in Table II with the in-sample in Panel A and the out-of-sample in Panel B. Results for the in-sample and out-of sample are similar, so most of the observations here will refer to Panel A. Columns *Buy*, *Sell* and *Neutral* are the number of days that correspond to long, short and out-of-market positions, respectively. *Time Long*, *Time Short* and *Time Out* approximate these periods relative to the sample's duration.

Table II
Trading Signals
Panel A: In-Sample 1977-1995

S&P/TSX Composite Price Index signals generated by VMA (p, q, r) and TRB (p, r, d) models. *Buy*, *Sell* and *Neutral* correspond to number of days holding long, short and out-of-market position, respectively (1-11). Given in percentages, *Time Buy*, *Sell* and *Neutral* present the number of days relative to the total number of days. *N Trades* is the number of two-way transactions. *Days/Trade* is the average number of days of holding a position.

Conditional Model	Buy	Time Long	Sell	Time Short	Neutral	Time Out	N Trades	Days/Trade
VMA (1, 50, 0)	2794	60.9%	1794	39.1%	-	-	267	17.2
VMA (1, 50, 0.01)	2215	48.3%	1285	28.0%	1088	23.7%	214	21.4
VMA (1, 150, 0)	3037	66.2%	1551	33.8%	-	-	103	44.5
VMA (1, 150, 0.01)	2821	61.5%	1301	28.4%	466	10.2%	123	37.3
VMA (5, 150, 0)	3032	66.1%	1556	33.9%	-	-	63	72.8
VMA (5, 150, 0.01)	2804	61.1%	1292	28.2%	492	10.7%	64	71.7
VMA (1, 200, 0)	3147	68.6%	1441	31.4%	-	-	89	51.6
VMA (1, 200, 0.01)	2925	63.8%	1274	27.8%	389	8.5%	99	46.3
VMA (2, 200, 0)	3144	68.5%	1444	31.5%	-	-	71	64.6
VMA (2, 200, 0.01)	2936	64.0%	1268	27.6%	384	8.4%	79	58.1
Average	*2885.5*	*62.9%*	*1420.6*	*31.0%*	*563.8*	*12.3%*	*117.2*	*48.6*
TRB (50, 0, 10)	1520	33.1%	630	13.7%	2438	53.1%	160.5	28.6
TRB (50, 0.01, 10)	360	7.8%	310	6.8%	3918	85.4%	63	72.8
TRB (150, 0, 10)	1090	23.8%	300	6.5%	3198	69.7%	101	45.4
TRB (150, 0.01, 10)	250	5.4%	160	3.5%	4178	91.1%	40	114.7
TRB (200, 0, 10)	1010	22.0%	250	5.4%	3328	72.5%	92	49.9
TRB (200, 0.01, 10)	230	5.0%	150	3.3%	4208	91.7%	37	124.0
Average	*743.3*	*16.2%*	*300.0*	*6.5%*	*3544.7*	*77.3%*	*82.3*	*72.6*

Moving average trading rules result in a long position being held roughly two-thirds of the time and a short position the remain third with remarkable inter-sample consistency. Increasing the length of the averaging period greatly reduces the number of two-way transactions or, equivalently, increases the length of time a position is held. A 50-day moving average, for example, results in 267 two-way transactions in the in-sample (see column *N Trades*) or a position being held for two to three weeks (column *Days/Trade*), whereas only 71 two-way transactions occur under a 200-day rule or a position being held for an average of about two months. The effect of filter bands is to increase the time out of the market to about 10% without a change in the relative duration of the long and short positions. Double crossover moving averages greatly reduce the number of transactions, whereas filter bands almost always increase them slightly. To see this, consider the simple VMA (1, 150, 0) model. It generates 103 two-way transactions. Lengthening the short smoothing parameter to five days, that is, VMA (5, 150, 0), reduces the number of trades by 40% to 63, but adding a one percent filter band increases the number of trades to 123. More importantly, trade-generating frequency is constant in-sample and out-of sample; it is 48.6 and 49.8 days, respectively.

As expected, trading range breakouts result in far fewer two-way transactions than moving averages and more time spent out of the market. Depending on the length of the period used to capture local minima and maxima, roughly three-quarters of the time is spent out of the market, and when a position is held, the duration of long positions is about three to four times that of short positions. In contrast to moving average rules, trading range breakouts are much more sensitive to filter bands, and the result is to dramatically reduce the number of trades and the time spent in the market.

Table II
Trading Signals
Panel B: Out-of-Sample 1996-2003

S&P/TSX Composite Price Index signals generated by VMA (p, q, r) and TRB (p, r, d) models. *Buy*, *Sell* and *Neutral* correspond to number of days holding long, short and out-of-market position, respectively (1-11). Given in percentages, *Time Buy*, *Sell* and *Neutral* present the number of days relative to the total number of days. *N Trades* is the number of two-way transactions. *Days/Trade* is the average number of days of holding a position.

Conditional Model	Buy	Time Long	Sell	Time Short	Neutral	Time Out	N Trades	Days/Trade
VMA (1, 50, 0)	1227	60.9%	788	39.1%	-	-	96	21.0
VMA (1, 50, 0.01)	1084	53.8%	633	31.4%	298	14.8%	97	20.8
VMA (1, 150, 0)	1352	67.1%	663	32.9%	-	-	50	40.3
VMA (1, 150, 0.01)	1268	62.9%	582	28.9%	165	8.2%	57	35.4
VMA (5, 150, 0)	1356	67.3%	659	32.7%	-	-	24	84.0
VMA (5, 150, 0.01)	1274	63.2%	579	28.7%	162	8.0%	26	77.5
VMA (1, 200, 0)	1328	65.9%	687	34.1%	-	-	42	48.0
VMA (1, 200, 0.01)	1270	63.0%	638	31.7%	107	5.3%	40	50.4
VMA (2, 200, 0)	1336	66.3%	679	33.7%	-	-	34	59.3
VMA (2, 200, 0.01)	1265	62.8%	634	31.5%	116	5.8%	33	61.1
Average	*1276.0*	*63.3%*	*654.2*	*32.5%*	*169.6*	*8.4%*	*49.9*	*49.8*
TRB (50, 0, 10)	699	34.7%	390	19.4%	926	46.0%	81	24.9
TRB (50, 0.01, 10)	288	14.3%	240	11.9%	1487	73.8%	46.5	43.3
TRB (150, 0, 10)	549	27.2%	160	7.9%	1306	64.8%	53	38
TRB (150, 0.01, 10)	218	10.8%	120	6.0%	1677	83.2%	29.5	68.3
TRB (200, 0, 10)	519	25.8%	110	5.5%	1386	68.8%	45	44.8
TRB (200, 0.01, 10)	218	10.8%	90	4.5%	1707	84.7%	26.5	76
Average	*415.2*	*20.6%*	*185.0*	*9.2%*	*1414.8*	*70.2%*	*46.9*	*50.8*

Table III
Buy and Sell Proportions

In-sample and out-of-sample daily returns are employed. *Buy>0* contains the proportion of buy signal returns greater than zero to all buy days. *Sell>0* contains the proportion of sell signal returns greater than zero to all sell days. *Difference* presents the nominal difference between *Buy>0* and *Sell>0* proportions. The last columns contain p-values of distribution-free chi-square test statistics $Q \geq \chi^2_{k-1,\alpha}$, (14) for null hypothesis H_0: $\theta_1 = \theta_2 = \ldots = \theta_k$ of equality for k proportions.

	In Sample 1977-1995				Out of Sample 1996-2003			
Conditional Model	Buy>0	Sell>0	Difference	p-value	Buy>0	Sell>0	Difference	p-value
VMA (1, 50, 0)	0.568719	0.501115	0.067604	<.0001	0.566422	0.488579	0.077843	0.0006
VMA (1, 50, 0.01)	0.582844	0.490698	0.092146	<.0001	0.571956	0.486572	0.085384	0.0006
VMA (1, 150, 0)	0.562726	0.502257	0.060469	0.0001	0.552515	0.502262	0.050253	0.0337
VMA (1, 150, 0.01)	0.566466	0.501153	0.065313	<.0001	0.550473	0.500000	0.050473	0.0434
VMA (5, 150, 0)	0.556398	0.514781	0.041617	0.0075	0.545723	0.515933	0.029790	0.2088
VMA (5, 150, 0.01)	0.559558	0.507740	0.051818	0.0020	0.546311	0.511226	0.035085	0.1609
VMA (1, 200, 0)	0.561487	0.500347	0.061140	0.0001	0.551205	0.506550	0.044655	0.0569
VMA (1, 200, 0.01)	0.561368	0.494505	0.066863	<.0001	0.553543	0.504702	0.048841	0.0437
VMA (2, 200, 0)	0.559160	0.505540	0.053620	0.0007	0.548653	0.511046	0.037607	0.1099
VMA (2, 200, 0.01)	0.559605	0.496845	0.062760	0.0002	0.553360	0.511041	0.042319	0.0813
Average	*0.563833*	*0.501498*	*0.062335*		*0.554016*	*0.503791*	*0.050225*	
TRB (50, 0, 10)	0.560526	0.473016	0.087510	0.0002	0.552217	0.505128	0.047089	0.1354
TRB (50, 0.01, 10)	0.613889	0.477419	0.136470	0.0004	0.520833	0.483333	0.037500	0.3905
TRB (150, 0, 10)	0.553211	0.410000	0.143211	<.0001	0.555556	0.518750	0.036806	0.4117
TRB (150, 0.01, 10)	0.588000	0.462500	0.125500	0.0125	0.536697	0.516667	0.020030	0.7242
TRB (200, 0, 10)	0.556436	0.404000	0.152436	<.0001	0.560694	0.518182	0.042512	0.4171
TRB (200, 0.01, 10)	0.573913	0.473333	0.100580	0.0540	0.536697	0.522222	0.014475	0.8170
Average	*0.574329*	*0.450045*	*0.124285*		*0.543782*	*0.510714*	*0.033069*	
Average across models	*0.567769*	*0.482203*	*0.085566*		*0.550178*	*0.506387*	*0.043791*	
Buy-and-Hold	0.542284				0.536476			

3. Randomness of Buy and Sell Signals

Table III presents the in-sample and out-of-sample results of distribution-free chi-square tests for equal proportions. Column *Buy>0* contains the proportions of buy signal returns greater than zero, and column *Sell>0* proportions of sell signal returns greater than zero. The difference between the two is about 8 percentage points in-sample and 4 out-of-sample, the latter attributable to a narrowing for trading range breakouts. Moving average proportion differences decrease from 6.2335% to 5.0225%, while TRBs from 12.4285% to 3.3069%, respectively. From 1977 to 1995 all trading rules generate significant differences between buy and sell proportions. All tests associated with moving average rules reject the null hypothesis with risk of less than 1%. This result is consistent with BLL and Mills (1997), among others. Out-of-sample, the differences are highly significant for single crossover moving averages, and not significant for any of the trading range breakouts.

Panel A of Table IV contains in-sample mean price returns where columns μ *(Buy)* and μ *(Sell)* correspond respectively to buy signal mean return and sell signal mean return. All buy signal mean returns are positive with an average daily return of 0.0854%. Applying continuous compounding for an average of 252 trading days, this is approximately 24.01% at an annual rate. This compares with the buy-and-hold average of 0.0341% or about 8.97% per year. Models with lower smoothing parameters and filter bands tend to yield higher buy signal mean returns.

Table IV
Buy and Sell Returns
Panel A: In-Sample 1977-1995

Price returns from buy-and-hold, VMA (p, q, r) and TRB (p, r, d) models are employed. Columns *μ (Buy)*, *μ (Sell)* and *μ (Buy)-μ (Sell)* contain respectively buy signal mean return, sell signal mean return, and the nominal difference between buy and sell signal mean returns. Columns *p-value G*, *p-value M* and *p-value W* correspond to the p-values of test-statistics associated with Gossett standard t-test (15-17), Mood median test (18) and Wilcoxon rank-sum test (19).

Conditional Model	μ(Buy)	p-value G	p-value M	μ (Sell)	p-value G	p-value M	μ (Buy)-μ (Sell)	p-value G	p-value W
VMA (1, 50, 0)	0.000769	0.0113	0.0171	-0.000327	0.0058	0.0019	0.001096	<.0001	<.0001
VMA (1, 50, 0.01)	0.000942	0.0011	0.0018	-0.000525	0.0042	0.0012	0.001467	<.0001	<.0001
VMA (1, 150, 0)	0.000623	0.0906	0.0510	-0.000211	0.0343	0.0027	0.000834	0.0016	<.0001
VMA (1, 150, 0.01)	0.000666	0.0559	0.0287	-0.000252	0.0421	0.0049	0.000918	0.0020	<.0001
VMA (5, 150, 0)	0.000517	0.2942	0.1687	-0.000002	0.1834	0.0379	0.000519	0.0480	0.0047
VMA (5, 150, 0.01)	0.000523	0.2914	0.0992	-0.000155	0.0861	0.0355	0.000678	0.0219	0.0030
VMA (1, 200, 0)	0.000570	0.1669	0.0808	-0.000160	0.0645	0.0065	0.000730	0.0077	0.0001
VMA (1, 200, 0.01)	0.000570	0.1764	0.0670	-0.000256	0.0427	0.0044	0.000826	0.0058	0.0001
VMA (2, 200, 0)	0.000541	0.2268	0.1153	-0.000096	0.1060	0.0148	0.000637	0.0198	0.0008
VMA (2, 200, 0.01)	0.000534	0.2563	0.0887	-0.000261	0.0394	0.0052	0.000795	0.0076	0.0002
Average	*0.000626*			*-0.000225*			*0.000850*		
TRB (50, 0, 10)	0.000588	0.2535	0.1928	-0.000584	0.0407	0.0058	0.001172	0.0135	0.0006
TRB (50, 0.01, 10)	0.002046	0.0001	0.0010	-0.000896	0.1401	0.2253	0.002942	0.0016	0.0007
TRB (150, 0, 10)	0.000554	0.3942	0.4187	-0.002024	0.0044	0.0001	0.002578	0.0025	<.0001
TRB (150, 0.01, 10)	0.001888	0.0039	0.0511	-0.001696	0.1648	0.2270	0.003584	0.0210	0.0045
TRB (200, 0, 10)	0.000548	0.4169	0.2970	-0.001680	0.0145	0.0001	0.002228	0.0088	<.0001
TRB (200, 0.01, 10)	0.001792	0.0059	0.1763	-0.000568	0.4749	0.3192	0.002360	0.0844	0.0117
Average	*0.001236*			*-0.001241*			*0.002477*		
Average across models	*0.000854*			*-0.000606*			*0.001460*		
Buy-and-Hold	*0.000341*								

Employing standard t-test, the null hypothesis that buy signal mean returns and buy-and-hold mean returns are equal is rejected at the 1% significance level for four of the rules, and at 5%, and 10% for two others (see *p-value G*). The probabilities associated with Mood's distribution-free test statistic presented in column *p-value M* indicate overall higher statistical significance; ten tests suggest rejection of the equality at less than 10%, eight of which are based on moving average trading rules.

All sell signal mean returns in column μ *(Sell)* are negative, which means that sell signals generate positive returns in periods of negative market returns. On average trading rules yield 16.50% at an annual rate. Filter bands improve performance of all VMA pairs and one of the TRB rules. It does not appear that lower smoothing parameters influence explanatory power. Interestingly, test statistics results presented in the next two columns are stronger for sell signal returns. Nine t-tests, six of which are based on the moving average rules, reject the null hypotheses at 5% or less, and five rules are marginally significant. The risk of Type I Error is substantially reduced employing distribution free test statistics; ten tests reject the equality of mean daily returns at less than 1% significance level; three trading range break-out rules are marginally significant.

The differences between buy and sell signal mean returns are presented in column μ *(Buy)*-μ *(Sell)*. This study does not consider these differences economically, but literally, that is, as evidence of the inequality between buy signal and sell signal returns. In general, the differences is smaller for the moving average rules than trading range breakouts; the introduction of a filter band increases the differences; and an

Table IV
Buy and Sell Returns
Panel B: Out-of-Sample 1996-2003

Price returns from buy-and-hold, VMA (p, q, r) and TRB (p, r, d) models are employed. Columns *μ (Buy)*, *μ (Sell)* and *μ (Buy)-μ (Sell)* contain respectively buy signal mean return, sell signal mean return, and the nominal difference between buy and sell signal mean returns. Columns *p-value G*, *p-value M* and *p-value W* correspond to the p-values of test-statistics associated with Gossett standard t-test (15-17), Mood median test (18) and Wilcoxon rank-sum test (19).

Conditional Model	μ(Buy)	p-value G	p-value M	μ (Sell)	p-value G	p-value M	μ (Buy)-μ (Sell)	p-value G	p-value W
VMA (1, 50, 0)	0.000722	0.1887	0.2594	-0.000432	0.1853	0.0547	0.001154	0.0314	0.0104
VMA (1, 50, 0.01)	0.000846	0.1050	0.1633	-0.000462	0.2180	0.0617	0.001309	0.0314	0.0117
VMA (1, 150, 0)	0.000540	0.4493	0.5041	-0.000280	0.3176	0.2725	0.000820	0.1458	0.0995
VMA (1, 150, 0.01)	0.000475	0.5757	0.5717	-0.000407	0.2603	0.3520	0.000882	0.1531	0.1338
VMA (5, 150, 0)	0.000488	0.5439	0.6992	-0.000178	0.4153	0.5009	0.000666	0.2384	0.3191
VMA (5, 150, 0.01)	0.000439	0.6466	0.6937	-0.000376	0.2814	0.6450	0.000816	0.1859	0.2576
VMA (1, 200, 0)	0.000577	0.3912	0.5478	-0.000322	0.2731	0.3535	0.000898	0.1049	0.0836
VMA (1, 200, 0.01)	0.000582	0.3911	0.4517	-0.000443	0.2069	0.3229	0.001025	0.0781	0.0565
VMA (2, 200, 0)	0.000542	0.4475	0.6263	-0.000264	0.3263	0.4118	0.000805	0.1488	0.1584
VMA (2, 200, 0.01)	0.000572	0.4078	0.4645	-0.000276	0.3329	0.4186	0.000847	0.1454	0.1161
Average	*0.000578*			*-0.000344*			*0.000922*		
TRB (50, 0, 10)	0.000735	0.2523	0.7835	0.000302	0.9745	0.6646	0.000433	0.6058	0.5422
TRB (50, 0.01, 10)	0.000147	0.8365	0.6587	-0.000145	0.7047	0.4166	0.000292	0.8127	0.8098
TRB (150, 0, 10)	0.000779	0.2454	0.6772	-0.000202	0.7327	0.8743	0.000981	0.4914	0.5054
TRB (150, 0.01, 10)	0.000272	0.9955	0.8303	-0.000972	0.4495	0.8551	0.001244	0.4810	0.5977
TRB (200, 0, 10)	0.000827	0.2167	0.6152	-0.000354	0.7245	0.8408	0.001181	0.5145	0.5813
TRB (200, 0.01, 10)	0.000272	0.9955	0.8303	-0.000745	0.6137	0.8258	0.001017	0.6311	0.6800
Average	*0.000505*			*-0.000353*			*0.000858*		
Average across models	*0.000551*			*-0.000347*			*0.000898*		
Buy-and-Hold	*0.000276*								

increase in the smoothing parameter decreases differences for moving averages, but increases them for trading range breakouts. The last two columns, *p-value G* and *p-value W*, contain t-test and Wilcoxon rank-sum test statistics. The test for equality of means is rejected for all trading rules, with the non-parametric tests providing stronger results.

The out-of-sample results are presented in Panel B. VMA rules generate buy signal returns of 15.68% per year, which compares to in-sample 17.09%. In contrast, TRB rules have much weaker predictive power with an average daily return of 0.0505%. None of the standard t-tests reject the null hypothesis that conditional and unconditional mean returns are equal; distribution free tests have similar probability levels. TRB (50, 0, 10) model has a positive sell signal mean return; in all other cases the returns are negative. Trading rules yield on average 9.14% at an annual basis. The differences between buy and sell signal mean returns are all positive. TRB rules are unable to sustain the spread, which decreases from 0.2477% to 0.0858%. In contrast, VMA rules demonstrate remarkable consistency in their ability to produce positive and statistically significant differences. Overall, three standard tests and five non-parametric tests reject the null hypothesis of identical buy and sell signal return distributions.

4. Adjustment for Risk

Descriptive results regarding the risk associated with the various strategies are presented in Table V. Risk is measured by the standard deviation of the returns and also decomposed into buy, sell and neutral signals. It appears that returns accumulated during

Table V
Variability of Returns

In-sample and out-of-sample conditional and unconditional returns are employed. *σ (Buy)*, *σ (Sell)* and *σ (Neutral)* contain standard deviations of buy, sell and neutral signal price returns. *σ (Model)* is the standard deviation of conditional returns. *σ (Buy-and-Hold)* is the standard deviation of buy-and-hold strategy.

	In-Sample 1977-1995				Out-of-Sample 1996-2003			
Conditional Model	σ (Buy)	σ (Sell)	σ (Neutral)	σ (Model)	σ (Buy)	σ (Sell)	σ (Neutral)	σ (Model)
VMA (1, 50, 0)	0.006633	0.009043	-	0.007667	0.008446	0.013440	-	0.010677
VMA (1, 50, 0.01)	0.006841	0.010042	0.000162	0.007133	0.008520	0.013832	0.000058	0.009955
VMA (1, 150, 0)	0.006734	0.009244	-	0.007675	0.009386	0.012946	-	0.010685
VMA (1, 150, 0.01)	0.006756	0.009681	0.000111	0.007393	0.009430	0.013454	0.000040	0.010398
VMA (5, 150, 0)	0.006822	0.009125	-	0.007683	0.009415	0.012928	-	0.010687
VMA (5, 150, 0.01)	0.006899	0.009546	0.000115	0.007399	0.009462	0.013392	0.000040	0.010393
VMA (1, 200, 0)	0.006792	0.009324	-	0.007678	0.009369	0.012858	-	0.010683
VMA (1, 200, 0.01)	0.006853	0.009683	0.000101	0.007481	0.009466	0.013074	0.000032	0.010511
VMA (2, 200, 0)	0.006801	0.009308	-	0.007680	0.009363	0.012908	-	0.010685
VMA (2, 200, 0.01)	0.006868	0.009584	0.000100	0.007454	0.009462	0.013031	0.000034	0.010466
Average	*0.006800*	*0.009458*	*0.000118*	*0.007524*	*0.009232*	*0.013186*	*0.000041*	*0.010514*
TRB (50, 0, 10)	0.007178	0.010976	0.000204	0.005796	0.008518	0.015291	0.000081	0.008391
TRB (50, 0.01, 10)	0.007997	0.014611	0.000166	0.004428	0.009853	0.016826	0.000076	0.006884
TRB (150, 0, 10)	0.007377	0.014247	0.000198	0.005130	0.008471	0.017446	0.000080	0.006603
TRB (150, 0.01, 10)	0.008275	0.018486	0.000153	0.003968	0.009896	0.017885	0.000069	0.005426
TRB (200, 0, 10)	0.007255	0.012940	0.000195	0.004557	0.008588	0.018588	0.000080	0.006142
TRB (200, 0.01, 10)	0.007806	0.015518	0.000151	0.003313	0.009896	0.019048	0.000067	0.005153
Average	*0.007648*	*0.014463*	*0.000178*	*0.004532*	*0.009204*	*0.017514*	*0.000076*	*0.006433*
Average across models	*0.007118*	*0.011335*	*0.000151*	*0.006402*	*0.009221*	*0.014809*	*0.000060*	*0.008984*
σ (Buy-and-Hold)				0.007683				0.010694

buy days are less volatile than those from sell days, and overall, none of the trading rules is riskier than buy-and-hold. VMA and TRB rules have an average standard deviation of 0.68% and 0.7648%, which compares to 0.7683% of the passive buy-and-hold approach. The introduction of a filter band increases long and short returns variability across all pairs. The out-of-sample results presented in the second section of the table are remarkably similar to the in-sample results.

In-sample and out-of-sample price and total risk-adjusted returns are presented in Table VI. *Sharpe* presents the Sharpe ratio of conditional and unconditional returns. *Jensen* α and β are the intercept and β coefficient of the regression model (22) with their respective p-values. From 1977 to 1995 the average price excess returns across all trading rules is 0.0111% or 2.87% at an annual rate (see column *Excess*). This compares to a negative buy-and-hold risk premia of 0.0032% or 0.80% per year. All trading rules outperform the buy-and-hold strategy per unit of risk where the average Sharpe ratio is 1.897%, compared to –0.4134% for the passive approach. Fifteen *Jensen* α are positive, but the intercept is highly significant only for two of the moving average models, VMA (1, 50, 0) and VMA (1, 50, 0.01), and half of the trading range break-out models: TRB (50, 0.01, 10), TRB (150, 0, 10) and TRB (150, 0.01, 10). Rules yielding significant intercepts are these with the highest Sharpe ratios. On a risk-adjusted incremental basis moving average rules outperform buy-and-hold strategy with 0.0106% or 2.71%; TRB rules yield excess return of 0.0119% or 3.04% per year. The introduction of dividend yield leads to a marginal improvement in the average conditional excess returns and a substantial increase in the unconditional series. The Sharpe ratio of buy-and-hold

Table VI
Sharpe Ratio and Jensen Measure
Panel A: In-Sample 1977-1995

Price and total returns from buy-and-hold, VMA (p, q, r) and TRB (p, r, d) models are employed. *Excess* contains total mean excess return (20). *Sharpe* presents the Sharpe ratio of conditional and unconditional return (21). *Jensen* α and β are the intercept and β coefficient of the regression model (22). Columns *p-value* α and *p-value* β correspond respectively to the p-values of the intercept and β coefficient of the regression model (22).

	Price Returns						Total Returns					
Conditional Model	Excess	Sharpe	Jensen α	p-value α	β	p-value β	Excess	Sharpe	Jensen α	p-value α	β	p-value β
VMA (1, 50, 0)	0.000224	0.029213	0.000221	0.0501	-0.08552	<.0001	0.000254	0.033098	0.000263	0.0198	-0.08489	<.0001
VMA (1, 50, 0.01)	0.000314	0.044030	0.000311	0.0030	-0.09319	<.0001	0.000343	0.048077	0.000353	0.0008	-0.09248	<.0001
VMA (1, 150, 0)	0.000111	0.014512	0.000112	0.3222	0.02079	0.1586	0.000157	0.020436	0.000155	0.1739	0.02042	0.1677
VMA (1, 150, 0.01)	0.000144	0.019458	0.000145	0.1848	0.02703	0.0569	0.000191	0.025820	0.000188	0.0852	0.02670	0.0603
VMA (5, 150, 0)	-0.000030	-0.003912	-0.000029	0.8026	0.04417	0.0027	0.000015	0.001897	0.000010	0.9283	0.04329	0.0034
VMA (5, 150, 0.01)	0.000028	0.003814	0.000030	0.7825	0.05942	<.0001	0.000074	0.009964	0.000067	0.5381	0.05872	<.0001
VMA (1, 200, 0)	0.000069	0.008955	0.000071	0.5287	0.07493	<.0001	0.000120	0.015622	0.000112	0.3222	0.07405	<.0001
VMA (1, 200, 0.01)	0.000091	0.012200	0.000093	0.3967	0.06736	<.0001	0.000140	0.018764	0.000133	0.2277	0.06654	<.0001
VMA (2, 200, 0)	0.000029	0.003749	0.000031	0.7795	0.07651	<.0001	0.000080	0.010396	0.000071	0.5287	0.07572	<.0001
VMA (2, 200, 0.01)	0.000070	0.009377	0.000073	0.5058	0.08248	<.0001	0.000119	0.016021	0.000111	0.3447	0.08157	<.0001
Average	*0.000105*	*0.014140*	*0.000106*		*0.02740*		*0.000149*	*0.020010*	*0.000146*		*0.02696*	
TRB (50, 0, 10)	0.000100	0.017243	0.000100	0.2421	0.00929	0.4066	0.000127	0.021873	0.000126	0.1416	0.00977	0.3789
TRB (50, 0.01, 10)	0.000161	0.036322	0.000156	0.0133	-0.15569	<.0001	0.000162	0.036533	0.000179	0.0044	-0.15449	<.0001
TRB (150, 0, 10)	0.000152	0.029719	0.000152	0.0445	-0.00928	0.3473	0.000174	0.033972	0.000175	0.0209	-0.00871	0.3789
TRB (150, 0.01, 10)	0.000126	0.031777	0.000122	0.0312	-0.13699	<.0001	0.000127	0.031994	0.000142	0.0119	-0.13600	<.0001
TRB (200, 0, 10)	0.000112	0.024516	0.000113	0.0930	0.03986	<.0001	0.000132	0.028939	0.000127	0.0575	0.04003	<.0001
TRB (200, 0.01, 10)	0.000075	0.022554	0.000072	0.1332	-0.07924	<.0001	0.000075	0.022721	0.000084	0.0805	-0.07862	<.0001
Average	*0.000121*	*0.027022*	*0.000119*		*-0.05534*		*0.000133*	*0.029339*	*0.000139*		*-0.05467*	
Average across models	*0.000111*	*0.018970*	*0.000111*		*-0.00363*		*0.000143*	*0.023508*	*0.000144*		*-0.00365*	
Buy-and-Hold	-0.000032	-0.004134					0.000112	0.014579				

Table VI
Sharpe Ratio and Jensen Measure
Panel B: Out-of-Sample 1996-2003

Price and total returns from buy-and-hold, VMA (p, q, r) and TRB (p, r, d) models are employed. *Excess* contains total mean excess return (20). *Sharpe* presents the Sharpe ratio of conditional and unconditional return (21). *Jensen* α and β are the intercept and β coefficient of the regression model (22). Columns *p-value* α and *p-value* β correspond respectively to the p-values of the intercept and β coefficient of the regression model (22).

	Price Returns						Total Returns					
Conditional Model	Excess	Sharpe	Jensen α	p-value α	β	p-value β	Excess	Sharpe	Jensen α	p-value α	β	p-value β
VMA (1, 50, 0)	0.000453	0.042469	0.000482	0.0367	-0.23708	<.0001	0.000467	0.043802	0.000512	0.0272	-0.23660	<.0001
VMA (1, 50, 0.01)	0.000469	0.047071	0.000491	0.0242	-0.18278	<.0001	0.000483	0.048557	0.000517	0.0175	-0.18249	<.0001
VMA (1, 150, 0)	0.000300	0.028036	0.000295	0.2151	0.03503	0.1165	0.000320	0.029977	0.000314	0.1870	0.03538	0.1119
VMA (1, 150, 0.01)	0.000273	0.026270	0.000269	0.2451	0.03202	0.1395	0.000294	0.028309	0.000288	0.2134	0.03236	0.1353
VMA (5, 150, 0)	0.000232	0.021669	0.000226	0.3422	0.04406	0.0478	0.000253	0.023713	0.000245	0.3031	0.04440	0.0456
VMA (5, 150, 0.01)	0.000242	0.023313	0.000237	0.3059	0.04428	0.0409	0.000264	0.025364	0.000255	0.2700	0.04454	0.0397
VMA (1, 200, 0)	0.000335	0.031325	0.000333	0.1617	0.01338	0.5485	0.000353	0.033094	0.000351	0.1417	0.01354	0.5419
VMA (1, 200, 0.01)	0.000359	0.034195	0.000357	0.1287	0.02076	0.3446	0.000378	0.035957	0.000374	0.1104	0.02090	0.3399
VMA (2, 200, 0)	0.000293	0.027417	0.000291	0.2226	0.01767	0.4296	0.000313	0.029281	0.000309	0.1937	0.01776	0.4238
VMA (2, 200, 0.01)	0.000299	0.028526	0.000296	0.2051	0.02474	0.2566	0.000317	0.030281	0.000312	0.1807	0.02493	0.2530
Average	*0.000326*	*0.031029*	*0.000328*		*-0.01879*		*0.000344*	*0.032834*	*0.000348*		*-0.01853*	
TRB (50, 0, 10)	0.000112	0.013297	0.000133	0.4655	-0.17464	<.0001	0.000121	0.014400	0.000153	0.4010	-0.17448	<.0001
TRB (50, 0.01, 10)	-0.000005	-0.000692	0.000016	0.9128	-0.17322	<.0001	-0.000004	-0.000622	0.000028	0.8490	-0.17311	<.0001
TRB (150, 0, 10)	0.000173	0.026139	0.000177	0.2264	-0.03903	0.0045	0.000184	0.027906	0.000191	0.1937	-0.03871	0.0048
TRB (150, 0.01, 10)	0.000060	0.011101	0.000069	0.5631	-0.07394	<.0001	0.000062	0.011461	0.000076	0.5253	-0.07376	<.0001
TRB (200, 0, 10)	0.000183	0.029874	0.000183	0.1804	0.00274	0.8337	0.000196	0.031872	0.000195	0.1529	0.00284	0.8259
TRB (200, 0.01, 10)	0.000038	0.007390	0.000044	0.7005	-0.04856	<.0001	0.000041	0.007925	0.000050	0.6623	-0.04843	<.0001
Average	*0.000094*	*0.014518*	*0.000104*		*-0.08444*		*0.000100*	*0.015490*	*0.000116*		*-0.08428*	
Average across models	*0.000239*	*0.024838*	*0.000244*		*-0.04341*		*0.000253*	*0.026330*	*0.000261*		*-0.04318*	
Buy-and-Hold	0.000121	0.011309					0.000187	0.017514				

improves to 1.4579%, outperforming VMA (5, 150, 0), VMA (5, 150, 0.01) and VMA (2, 200, 0) models. The average Sharpe ratio across all rules is 2.3508%. Interestingly, dividend yield increases intercepts and reduces the risk of Type I error. Noteworthy is the result that six models have negative and highly significant betas.

The out-of-sample average daily excess returns across all trading rules is 0.0239% or 6.208% at an annual rate, where the improvement is due entirely to the moving average rules. The employment of total returns leads to an increase in trading rule excess returns to nearly double the returns from buy-and-hold. All of the moving average rules outperform buy-and-hold with an average Sharpe ratio of 3.1029%; none of the trading range breakout rules with a filter band has a better reading than that of the passive strategy. The Jensen measure suggests that all trading rules outperform the benchmark since they have positive intercepts with both daily and total daily returns. However, only VMA (1, 50, 0) and VMA (1, 50, 0.01), have highly significant α's. The average betas are negative where six models have both negative and highly significant risk measures.

5. Adjustment for Transaction Costs

Table VII outlines the effect of transaction costs on in-sample and out-of-sample price and total returns. The *25 BPS* and *150 BPS* columns contain total mean returns with two-way transaction costs of 25 and 150 basis points. Column *>B&H* presents the annualised continuously compounded differences between trading rule and buy-and-hold returns. *Break-even* is the level of transaction costs measured in basis points at which trading rule

Table VII
Transaction Costs
Panel A: In-Sample 1977-1995

Price and total returns from buy-and-hold, VMA (p, q, r) and TRB (p, r, d) conditional models are employed. *Return* is the conditional mean return before transaction costs. *25 BPS* and *150 BPS* contain conditional mean return with two-way transaction costs of 25 and 150 basis points (23). *>B&H* is the difference between conditional and unconditional returns on annualised continuously compounded basis. *B-E* is the break-even two-way transaction cost in basis points (24)

	Price Returns							Total Returns						
Conditional Model	Return	>B&H	25 BPS	>B&H	150 BPS	>B&H	B-E	Return	>B&H	25 BPS	>B&H	150 BPS	>B&H	B-E
VMA (1, 50, 0)	0.000596	7.23%	0.000451	3.06%	-0.000273	-15.62%	43.9	0.000626	4.12%	0.000481	-0.09%	-0.000244	-18.94%	24.4
VMA (1, 50, 0.01)	0.000686	9.90%	0.000570	6.47%	-0.000011	-9.25%	74.1	0.000715	6.77%	0.000599	3.32%	0.000018	-12.52%	49.5
VMA (1, 150, 0)	0.000484	4.00%	0.000428	2.42%	0.000148	-5.17%	63.8	0.000529	1.29%	0.000473	-0.31%	0.000194	-7.96%	20.0
VMA (1, 150, 0.01)	0.000516	4.91%	0.000449	3.01%	0.000116	-6.01%	65.5	0.000563	2.27%	0.000496	0.34%	0.000163	-8.78%	29.4
VMA (5, 150, 0)	0.000342	0.03%	0.000308	-0.90%	0.000137	-5.46%	1.3	0.000387	-2.73%	0.000353	-3.67%	0.000182	-8.28%	-70.9
VMA (5, 150, 0.01)	0.000401	1.66%	0.000366	0.69%	0.000192	-4.02%	43.0	0.000446	-1.08%	0.000411	-2.06%	0.000238	-6.79%	-27.4
VMA (1, 200, 0)	0.000441	2.78%	0.000393	1.44%	0.000151	-5.09%	51.8	0.000492	0.23%	0.000444	-1.13%	0.000202	-7.75%	4.1
VMA (1, 200, 0.01)	0.000464	3.43%	0.000410	1.91%	0.000141	-5.36%	57.0	0.000513	0.83%	0.000459	-0.71%	0.000190	-8.07%	13.1
VMA (2, 200, 0)	0.000401	1.66%	0.000362	0.58%	0.000170	-4.60%	39.1	0.000452	-0.91%	0.000414	-1.98%	0.000221	-7.24%	-20.8
VMA (2, 200, 0.01)	0.000442	2.81%	0.000399	1.60%	0.000185	-4.20%	59.0	0.000492	0.23%	0.000449	-0.99%	0.000234	-6.90%	4.3
Average	*0.000477*	3.84%	*0.000414*	2.03%	*0.000096*	-6.48%	*49.85*	*0.000522*	1.10%	*0.000458*	-0.73%	*0.000140*	-9.32%	*2.57*
TRB (50, 0, 10)	0.000472	3.66%	0.000385	1.22%	-0.000051	-10.25%	37.6	0.000499	0.43%	0.000412	-2.03%	-0.000024	-13.57%	4.2
TRB (50, 0.01, 10)	0.000533	5.40%	0.000499	4.43%	0.000328	-0.36%	140.2	0.000534	1.43%	0.000500	0.46%	0.000329	-4.33%	36.2
TRB (150, 0, 10)	0.000525	5.17%	0.000470	3.60%	0.000196	-3.91%	83.7	0.000546	1.78%	0.000491	0.20%	0.000217	-7.35%	28.2
TRB (150, 0.01, 10)	0.000498	4.40%	0.000477	3.80%	0.000368	0.74%	181.0	0.000499	0.43%	0.000477	-0.20%	0.000369	-3.23%	16.9
TRB (200, 0, 10)	0.000484	4.00%	0.000434	2.58%	0.000184	-4.23%	71.5	0.000504	0.57%	0.000454	-0.85%	0.000204	-7.70%	9.8
TRB (200, 0.01, 10)	0.000447	2.95%	0.000427	2.39%	0.000326	-0.41%	131.9	0.000448	-1.02%	0.000427	-1.61%	0.000327	-4.38%	-45.7
Average	*0.000493*	4.26%	*0.000449*	3.00%	*0.000225*	-3.07%	*107.65*	*0.000505*	0.60%	*0.000460*	-0.67%	*0.000237*	-6.76%	*8.27*
Average across models	*0.000483*	4.00%	*0.000427*	2.39%	*0.000144*	-5.20%	*71.53*	*0.000515*	0.91%	*0.000459*	-0.71%	*0.000176*	-8.36%	*4.71*
Buy-and-Hold	0.000341							0.000484						

and buy-and-hold returns are equal. Before transaction costs all trading rules yield higher mean daily price return than buy-and-hold from 1977 to 1995. The highest mean return of 0.0686% is produced by VMA (1, 50, 0.01) model. At an annual rate it is approximately 18.87% or nearly 9.90% higher than buy-and-hold. VMA (5, 150, 0), which has the lowest mean return, outperforms buy-and-hold by 0.03% per year. Across all trading rules, the buy-and-hold approach is outperformed by 0.0142% per day or 4.00% at an annual rate. Overall, it appears that trading rules with lower smoothing parameters tend to yield higher returns. The introduction of filters bands improves the performance in six of the eight trading rule pairs by at least 0.0023% per day.

Adjusting for transaction costs of 25 basis points only VMA (5, 150, 0) model is unable to outperform buy-and-hold strategy. The best performing model is VMA (1, 50, 0.01), which delivers approximately 6.47% above unconditional return per year. On average trading rules beat buy-and hold by 2.39%. The wealth depletion effect under transaction costs of 150 basis points is enormous, as only TRB (150, 0.01, 10) model generates positive return. Moving average trading rules require an average two-way transaction cost of less than 49.85 basis points in order to be profitable. This break-even for trading range break-out rules is about 107.65 basis points. The introduction of trading filter bands increases the break-even points for all pairs.

Dividend yield has a substantial impact on excess returns, as trading rules outperform buy-and-hold strategy with less than 1%. Adjustment for transaction costs of 25 basis points puts the overwhelming majority of trading rules in loosing position with

Table VII
Transaction Costs
Panel B: Out-of-Sample 1996-2003

Price and total returns from buy-and-hold, VMA (p, q, r) and TRB (p, r, d) conditional models are employed. *Return* is the conditional mean return before transaction costs. *25 BPS* and *150 BPS* contain conditional mean return with two-way transaction costs of 25 and 150 basis points (23). *>B&H* is the difference between conditional and unconditional returns on annualised continuously compounded basis. *B-E* is the break-even two-way transaction cost in basis points (24)

	Price Returns							Total Returns						
Conditional Model	Return	>B&H	25 BPS	>B&H	150 BPS	>B&H	B-E	Return	>B&H	25 BPS	>B&H	150 BPS	>B&H	B-E
VMA (1, 50, 0)	0.000609	9.38%	0.000489	5.91%	-0.000103	-9.76%	69.8	0.000623	8.00%	0.000504	4.54%	-0.000089	-11.22%	58.8
VMA (1, 50, 0.01)	0.000624	9.83%	0.000503	6.31%	-0.000096	-9.59%	72.2	0.000638	8.44%	0.000518	4.94%	-0.000081	-11.02%	61.5
VMA (1, 150, 0)	0.000455	4.95%	0.000393	3.21%	0.000084	-5.06%	72.0	0.000475	3.72%	0.000413	1.97%	0.000104	-6.35%	53.6
VMA (1, 150, 0.01)	0.000428	4.19%	0.000358	2.24%	0.000006	-7.05%	53.8	0.000449	2.98%	0.000379	1.02%	0.000027	-8.32%	37.8
VMA (5, 150, 0)	0.000387	3.04%	0.000357	2.21%	0.000209	-1.79%	92.9	0.000408	1.83%	0.000379	1.02%	0.000230	-3.03%	55.5
VMA (5, 150, 0.01)	0.000397	3.32%	0.000365	2.43%	0.000205	-1.90%	94.0	0.000419	2.14%	0.000386	1.22%	0.000226	-3.14%	59.1
VMA (1, 200, 0)	0.000490	5.94%	0.000438	4.47%	0.000178	-2.62%	102.5	0.000508	4.66%	0.000456	3.18%	0.000197	-3.91%	79.7
VMA (1, 200, 0.01)	0.000515	6.66%	0.000465	5.23%	0.000218	-1.56%	120.1	0.000533	5.37%	0.000483	3.94%	0.000236	-2.87%	96.0
VMA (2, 200, 0)	0.000448	4.75%	0.000406	3.57%	0.000196	-2.14%	101.9	0.000468	3.52%	0.000426	2.33%	0.000216	-3.41%	74.4
VMA (2, 200, 0.01)	0.000454	4.92%	0.000413	3.77%	0.000209	-1.79%	108.4	0.000472	3.63%	0.000431	2.47%	0.000227	-3.11%	79.1
Average	*0.000481*	5.70%	*0.000419*	3.93%	*0.000111*	-4.33%	*88.76*	*0.000499*	4.43%	*0.000438*	2.66%	*0.000129*	-5.64%	*65.55*
TRB (50, 0, 10)	0.000267	-0.24%	0.000166	-2.93%	-0.000334	-15.28%	-2.3	0.000276	-1.80%	0.000175	-4.49%	-0.000325	-16.86%	-16.5
TRB (50, 0.01, 10)	0.000150	-3.35%	0.000093	-4.83%	-0.000195	-12.00%	-54.5	0.000151	-5.12%	0.000093	-6.63%	-0.000194	-13.77%	-83.0
TRB (150, 0, 10)	0.000328	1.41%	0.000262	-0.38%	-0.000065	-8.83%	19.6	0.000339	-0.08%	0.000274	-1.85%	-0.000054	-10.35%	-1.2
TRB (150, 0.01, 10)	0.000215	-1.64%	0.000179	-2.59%	-0.000003	-7.28%	-41.5	0.000217	-3.38%	0.000181	-4.33%	-0.000002	-9.05%	-85.4
TRB (200, 0, 10)	0.000339	1.72%	0.000283	0.19%	0.000005	-7.08%	28.0	0.000351	0.25%	0.000295	-1.28%	0.000017	-8.57%	3.8
TRB (200, 0.01, 10)	0.000193	-2.22%	0.000160	-3.09%	-0.000003	-7.28%	-63.0	0.000196	-3.94%	0.000163	-4.81%	-0.000001	-9.03%	-111.3
Average	*0.000249*	-0.72%	*0.000191*	-2.27%	*-0.000099*	-9.62%	*-18.95*	*0.000255*	-2.35%	*0.000197*	-3.90%	*-0.000093*	-11.27%	*-48.93*
Average across models	*0.000394*	3.29%	*0.000333*	1.61%	*0.000032*	-6.31%	*48.37*	*0.000408*	1.89%	*0.000347*	0.20%	*0.000046*	-7.75%	*22.62*
Buy-and-Hold	0.000276							0.000342						

an average negative performance of 0.71%. Among the four models that remain profitable, VMA (1, 50, 0.01) yields the highest annual return of 3.32% above the buy-and-hold strategy. The employment of 150 basis points extends the average loss down to –8.36%, and none of the trading rules is able to yield profits above buy-and-hold strategy. The break-even averages are reduced to economically insignificant 2.57 and 8.27 basis points. However, four of the trading rules are able to outperform the buy-and-hold strategy assuming transaction costs between 28.2 and 45.9 basis points.

The out-of-sample results are presented in Panel B. Before transaction costs moving average mean returns are similar in-sample and out-of sample. More importantly, the best performing model, VMA (1, 50, 0.01), persistently generates before transaction costs excess return of about 10% per year; with 25 basis points the excess returns are about 6.4%. Overall, it appears that VMA rules improve their performance after transaction costs from 1996 to 2003. This is implied by the weaker wealth depletion effect where price and total return average break-even increase from 49.85 to 88.76 and from 2.57 to 65.55 basis points in-sample and out-of sample, respectively. In contrast, trading range breakouts perform less consistently; average performance is halved between samples. Four of the rules yield negative excess returns before transaction costs. The worst performing model is TRB (50, 0,01, 10) with daily returns of 0.015% or 3.85% at an annual rate. For TRB rules, the relationship between smoothing parameters and returns is reversed, and the introduction of a filter band does not improve performance; for VMA rules the results are consistent.

7. Consistency Check

The result of the evaluation of forecast reliability is presented in Table VIII. Column *Sharpe Ranking* shows the trading rules ranked according to their Sharpe ratios. *N Obs* is the number of observations in each group. Column $\mu(H)$ - $\mu(L)$ presents the difference in mean excess returns between the rule with the highest Sharpe ratio and the rule with the lowest Sharpe ratio within each rank. *Chi-Sq.* is the test statistics from (25), and *p-value* is the p-value of the test for difference among all rules within the rank. Columns *Lower B* and *Upper B* are the lower and upper band of the 99% confidence interval calculated with Monte Carlo simulations based on 10,000 sample tables of the corresponding *p-value*. *Best Model* and *Worst Model* show the trading rules that yield the highest and the lowest mean returns within the groups.

The in-sample test results indicate that at a 1% level of significance the null hypothesis of equality among moving average rules is rejected as long as the two best and the two worst performing trading rules are present. There is virtually no significant difference among trading rules ranked from three to eight. The out-of-sample test results are similar. Most important is that the two best and two worst performing trading rules are the same for both samples (marked with '*' in the last two columns). Moreover, they do not change their ranks. In order of their performance, these models are VMA (1, 50, 0,01), VMA (1, 50, 0), VMA (5, 150, 0,01) and VMA (5, 150, 0). With respect to trading range breakout rules, the test results suggest that there is no significant difference among them, again, consistently in-sample and out-of sample.

Table VIII
Consistency Check

In-sample and out-of-sample returns from VMA (p, q, r) and TRB (p, r, d) conditional models are employed. *Sharpe Ranking* contains ranked in ascending order trading rules according to their Sharpe ratios. *N Obs* is the number of observations in each group. μ(H) - μ(L) presents the nominal mean excess return differences between the rule with highest Sharpe ratio and the rule with lowest Sharpe ratio within groups. *Chi-Sq.* is the test statistics (25). *p-value, Lower B and Upper B* correspond to the p-value and its 99% confidence interval (lower and upper band limits) of the median exact test with Monte Carlo simulation based on 10 000 sample tables. *Best Model* and *Worst Model* contain the exact conditional models that yield the highest and the lowest mean returns. Conditional Models that do not change their ranks are marked with '*'.

Sharpe Ranking	N Obs.	μ(H) - μ(L)	Chi-Sq.	Monte Carlo Exact p-value	Monte Carlo Exact Lower B	Monte Carlo Exact Upper B	Best Model	Worst Model
				In-Sample 1977-1995				
VMA Ranked 1-10	45880	0.000344	24.940	0.003	0.001	0.004	VMA (1, 50, 0.01)*	VMA (5, 150, 0)*
VMA Ranked 2-9	36704	0.000195	20.222	0.005	0.003	0.007	VMA (1, 50, 0)*	VMA (5, 150, 0.01)*
VMA Ranked 3-8	27528	0.000115	12.888	0.024	0.020	0.028	VMA (1, 150, 0.01)	VMA (2, 200, 0)
VMA Ranked 4-7	18352	0.000043	10.894	0.013	0.010	0.016	VMA (1, 150, 0)	VMA (1, 200, 0)
VMA Ranked 5-6	9176	0.000022	0.021	0.898	0.890	0.906	VMA (1, 200, 0.01)	VMA (2, 200, 0.01)
TRB Ranked 1-6	27528	0.000086	3.056	0.692	0.681	0.704	TRB (50, 0.01, 10)	TRB (50, 0, 10)
TRB Ranked 2-5	18352	0.000053	1.764	0.626	0.613	0.638	TRB (150, 0.01, 10)	TRB (150, 0, 10)
TRB Ranked 3-4	9176	0.000014	0.002	0.984	0.980	0.987	TRB (150, 0, 10)	TRB (200, 0, 10)
				Out-of-Sample 1996-2003				
VMA Ranked 1-10	20150	0.000237	41.701	0.000	0.000	0.000	VMA (1, 50, 0.01)*	VMA (5, 150, 0)*
VMA Ranked 2-9	16120	0.000212	26.299	0.000	0.000	0.000	VMA (1, 50, 0)*	VMA (5, 150, 0.01)*
VMA Ranked 3-8	12090	0.000087	12.712	0.028	0.023	0.032	VMA (1, 200, 0.01)	VMA (1, 150, 0.01)
VMA Ranked 4-7	8060	0.000042	5.056	0.169	0.159	0.179	VMA (1, 200, 0)	VMA (2, 200, 0)
VMA Ranked 5-6	4030	0.000001	4.066	0.049	0.043	0.054	VMA (2, 200, 0.01)	VMA (1, 150, 0)
TRB Ranked 1-6	12090	0.000189	6.445	0.261	0.250	0.272	TRB (200, 0, 10)	TRB (150, 0.01, 10)
TRB Ranked 2-5	8060	0.000135	2.053	0.556	0.543	0.569	TRB (150, 0, 10)	TRB (200, 0.01, 10)
TRB Ranked 3-4	4030	0.000052	1.669	0.209	0.198	0.219	TRB (50, 0, 10)	TRB (50, 0.01, 10)

8. Return and Market Volatility

Table IX presents the full-sample results of the regression model defined in (27). *Alpha* and *Beta* are the intercept and the slope. Columns *p-value* α and *p-value* β correspond respectively to the p-values of the intercept and of the slope. *R-square* is the coefficient of determination of the fitted regression models. All regression models are highly significant with p-values of the F-tests less than 0.0001 (the p-values are not shown in the table). For all trading rules the intercept is negative, implying that without variability, trading rule returns would be less than buy-and-hold returns. Without any exception the intercepts are highly significant. The positive and highly significant betas suggest that an increase in market volatility is associated with better performance of the trading rules. It appears that an increase in smoothing parameters dampens this relationship, while the introduction of a filter band does not have significant effect. The coefficients of determination vary between 11.08% and 27.9%.

Full-sample results for the long and short returns modelling as given in (29) are presented in Table X. *Alpha, Beta* and *Gamma* are the intercept and the regression coefficients of predictor variables. Columns *p-value* α, *p-value* β and *p-value* γ correspond respectively to their p-values. *R-square* is the coefficient of determination. All regression models are highly significant with p-values of the F-tests less than 0.0001 (the p-values are not shown in the table). *Ceteris paribus*, positive buy-and-hold returns lead to higher return from long positions and lower return from short positions and *vice*

Table IX
Predictive Power and Volatility

Full-sample 1977-2003 (6603 observations) returns from VMA (p, q, r) and TRB (p, r, d) conditional models are employed. *Alpha* and *Beta* are the intercept and the slope of the regression model (26). Columns *p-value* α and *p-value* β correspond respectively to the p-values of intercepts and slopes. All regression models are highly significant with p-value of the F-test less than 0.0001 (not shown). *R-square* is the coefficient of determination of fitted regression models (26).

Conditional Model	Alpha	p-value α	Beta	p-value β	R-square
VMA (1, 50, 0)	-0.00057359	0,0018	11.74539	<.0001	0.2308
VMA (1, 50, 0.01)	-0.00050872	0,0035	11.71250	<.0001	0.2482
VMA (1, 150, 0)	-0.00052195	0,0064	9.36756	<.0001	0.1489
VMA (1, 150, 0.01)	-0.00050565	0,0076	9.36949	<.0001	0.1518
VMA (5, 150, 0)	-0.00062394	0,0014	9.15497	<.0001	0.1376
VMA (5, 150, 0.01)	-0.00057363	0,0026	8.99595	<.0001	0.1399
VMA (1, 200, 0)	-0.00047878	0,0132	8.50623	<.0001	0.1242
VMA (1, 200, 0.01)	-0.00046392	0,0147	8.64208	<.0001	0.1310
VMA (2, 200, 0)	-0.00048716	0,0124	8.05747	<.0001	0.1108
VMA (2, 200, 0.01)	-0.00049271	0,0093	8.57566	<.0001	0.1300
TRB (50, 0, 10)	-0.00058882	0,0006	9.28802	<.0001	0.1758
TRB (50, 0.01, 10)	-0.00077725	<.0001	11.93648	<.0001	0.2790
TRB (150, 0, 10)	-0.00060599	0,0002	10.28302	<.0001	0.2318
TRB (150, 0.01, 10)	-0.00067956	<.0001	10.56142	<.0001	0.2547
TRB (200, 0, 10)	-0.00041087	0,0083	7.33812	<.0001	0.1398
TRB (200, 0.01, 10)	-0.00050011	0,0011	7.59108	<.0001	0.1525

Table X
Buy and Sell Signal Returns Modelling

Full-sample 1977-2003 (6603 observations) returns from VMA (p, q, r) and TRB (p, r, d) conditional models are employed. *Alpha, Beta* and *Gamma* are the intercept and the regression coefficients of predictor variables in (27). Columns *p-value* β and *p-value* γ correspond respectively to the p-values of the regression coefficients. All regression models are highly significant with p-value of the F-test less than 0.0001 (not shown). *R-square* is the coefficient of determination.

	Buy Signal Returns						Sell Signal Returns					
Conditional Model	Alpha	Beta	p-value β	Gamma	p-value γ	R-sq.	Alpha	Beta	p-value β	Gamma	p-value γ	R-sq.
VMA (1, 50, 0)	0.00012742	0.52702	<.0001	2.24421	<.0001	0.5628	-0.00012691	0.47281	<.0001	-2.24641	<.0001	0.6138
VMA (1, 50, 0.01)	0.00014204	0.47040	<.0001	2.24507	<.0001	0.5221	-0.00007793	0.38664	<.0001	-2.55432	<.0001	0.5394
VMA (1, 150, 0)	0.00013423	0.54875	<.0001	1.22198	0,0232	0.5396	-0.00013371	0.45108	<.0001	-1.22418	0,0226	0.5023
VMA (1, 150, 0.01)	0.00011924	0.51458	<.0001	1.28884	0,0173	0.5013	-0.00013084	0.41146	<.0001	-1.22547	0,0245	0.4534
VMA (5, 150, 0)	0.00008715	0.54427	<.0001	1.08134	0,0512	0.5219	-0.00008663	0.45556	<.0001	-1.08355	0,0512	0.4865
VMA (5, 150, 0.01)	0.00007977	0.51666	<.0001	0.88138	0,1261	0.4805	-0.00010564	0.41936	<.0001	-1.21682	0,0209	0.4791
VMA (1, 200, 0)	0.00015020	0.55516	<.0001	0.84050	0,1261	0.5407	-0.00014968	0.44467	<.0001	-0.84270	0,1261	0.4719
VMA (1, 200, 0.01)	0.00013023	0.53095	<.0001	0.92435	0,0930	0.5153	-0.00016210	0.42245	<.0001	-0.90390	0,0930	0.4621
VMA (2, 200, 0)	0.00014749	0.55347	<.0001	0.60315	0,2802	0.5361	-0.00014697	0.44636	<.0001	-0.60535	0,2802	0.4588
VMA (2, 200, 0.01)	0.00012004	0.53615	<.0001	0.79058	0,1586	0.5156	-0.00014592	0.43046	<.0001	-0.95141	0,0735	0.4776
TRB (50, 0, 10)	-0.00000541	0.30476	<.0001	1.63140	0,0003	0.3206	-0.00009335	0.27054	<.0001	-0.39010	0,4413	0.2767
TRB (50, 0.01, 10)	0.00003760	0.11353	<.0001	0.60183	0,0293	0.1488	0.00015775	0.16792	<.0001	-3.45672	<.0001	0.3842
TRB (150, 0, 10)	-0.00001567	0.23901	<.0001	1.28981	0,0025	0.2433	-0.00002992	0.19765	<.0001	-1.74377	<.0001	0.3216
TRB (150, 0.01, 10)	0.00002576	0.07953	<.0001	0.40720	0,0819	0.1064	0.00007906	0.12029	<.0001	-2.33643	<.0001	0.3547
TRB (200, 0, 10)	0.00001062	0.21177	<.0001	0.94761	0,0226	0.2147	-0.00019223	0.17253	<.0001	0.89539	0,0155	0.1834
TRB (200, 0.01, 10)	0.00002832	0.07014	<.0001	0.28729	0,2150	0.0891	-0.00010182	0.11616	<.0001	0.57725	0,0404	0.1505

versa. Unconditional returns have greater impact on buy returns than on sell returns. The introduction of a filter band consistently reduces this impact and increases the importance of volatility. Both buy and sell signal returns are positively correlated to market risk. Interestingly, it appears that market volatility has similar effects on both buy and sell returns. The coefficient of determination implies that around half of the variation of the conditional returns resulting from moving average rules can be explained by the simple modelling employed in this paper. This figure is considerably lower for trading range breakouts.

VII. Discussion

Considering the large qualitative differences between the in-sample and out-of-sample unconditional return distributions, the VMA rules demonstrate remarkable consistency. Not only is their signal-generating frequency similar, 48.6 and 49.8 days, but also their long and short positions duration is stable, 2/3 and 1/3 of the time, respectively. This is not an accidental coincidence, as the standard and distribution-free tests provide sufficient evidence to reject the null hypothesis that conditional models generate random signals. The striking fact is that the accumulated returns following sell signals are all positive and higher that risk-free rate, which indicates successful identification of negative risk premia. This is reflected in the conditional variances where trading rule returns are consistently less volatile than buy-and-hold returns. Noteworthy are the negative betas associated with the best performing models, which are typical for strategies designed to counter the market, such as those employed by hedge funds. In-sample and out-of-sample VMA returns are effectively equal and the difference in returns between the rule generating the highest returns and buy-and-hold strategy is consistently around 10% at an annual rate. In many aspects, TRB rules have similar characteristics, but less consistently so. First moment conditional returns are relatively small, which implies that possible measurement errors cannot explain excess returns (see Appendix B).

Employing Datastream dividend-adjusted index for Canada, Ito (1999) finds that VMA and TRB rules can be profitable under transaction costs of 1.88% and 1.09%, respectively. In contrast, the break-even levels estimated in this study are 0.0257% and

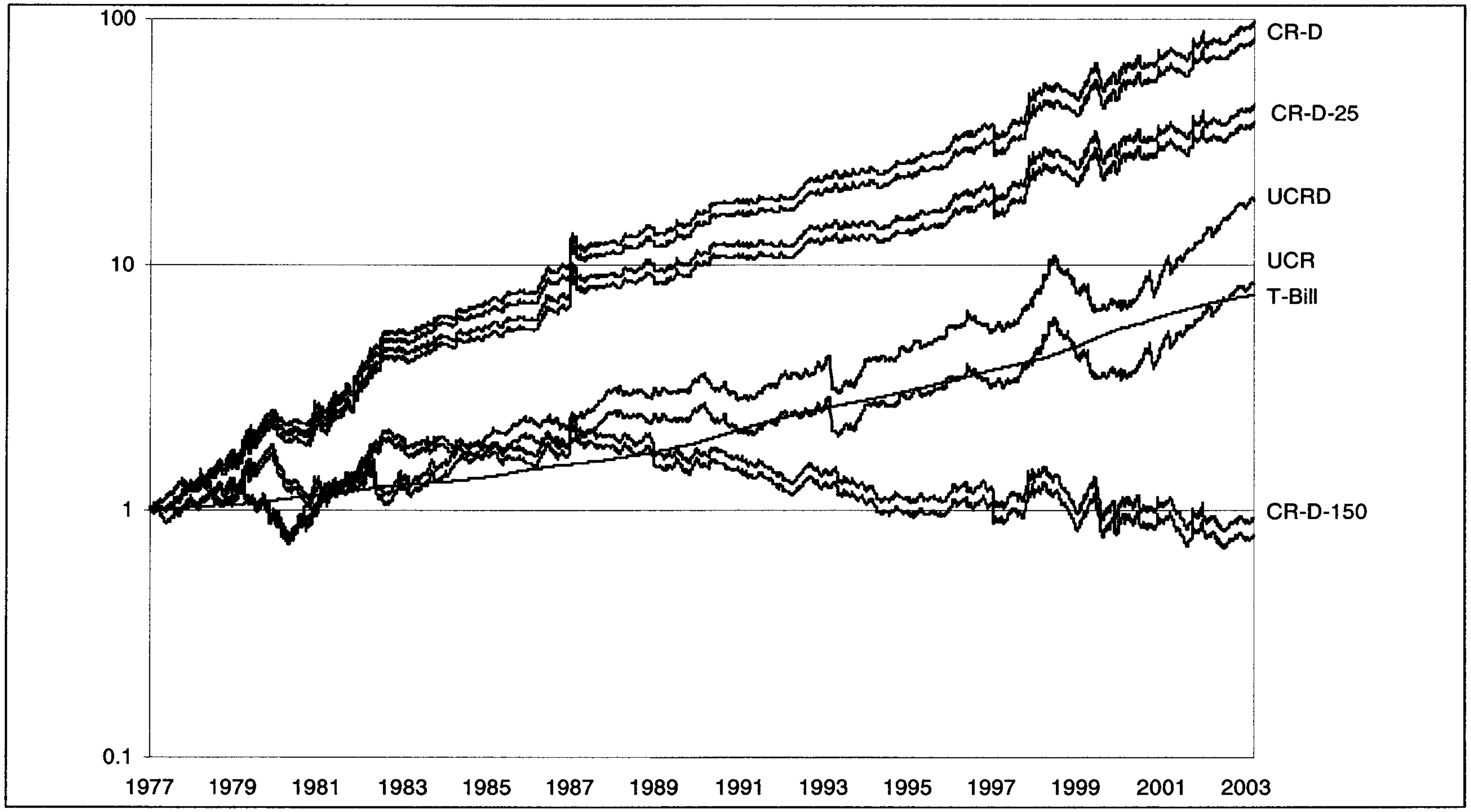
Table XI
Summary Performance of VMA (1, 50, 0.01) and VMA (5, 150, 0)

Results from tables II to VII are employed. Differences are calculated for returns, standard deviations and Sharpe ratios. *B&H* is the buy-and-hold strategy.

	In-Sample 1977-1995		Out-of-Sample 1996-2003	
	VMA (1, 50, 0.01)	VMA (5, 150, 0)	VMA (1, 50, 0.01)	VMA (5, 150, 0)
Total Time Holding Long Position	48.30%	66.10%	53.80%	67.30%
Total Time Short Position	28.00%	33.90%	31.40%	32.70%
Total Time Out of the Market	23.70%	-	14.80%	-
Number of Days Between Trades	21.4	72.8	20.8	84
Random Signals p-value	<.0001	0.0047	0.0117	0.3191
p-value W (Table 4)	<.0001	<.0001	0.0002	0.0215
σ (Model) - σ (B&H)	-0.000550	0	-0.000740	-0.000007
Price Returns				
Sharpe (Model) - Sharpe (B&H)	0.048164	0.000222	0.035762	0.010360
Jensen α	0.000311	-0.000029	0.000491	0.000226
p-value of α	0.0030	0.8026	0.0242	0.3422
Annual Model - B&H	9.90%	0.03%	9.83%	3.04%
Annual Model - B&H with TC = 25 BPS	6.47%	-0.90%	6.31%	2.21%
Annual Model - B&H with TC = 150 BPS	-9.25%	-5.46%	-9.59%	-1.79%
Break-even Two-way Transaction Costs (TC)	74.1	1.3	72.2	92.9
Total Returns				
Sharpe (Model) - Sharpe (B&H)	0.033498	-0.01268	0.031043	0.006199
Jensen α	0.000353	0.00001	0.000517	0.000245
p-value of α	0.0008	0.9283	0.0175	0.3031
Annual Model - B&H	6.77%	-2.73%	8.44%	1.83%
Annual Model - B&H with TC = 25 BPS	3.32%	-3.67%	4.94%	1.02%
Annual Model - B&H with TC = 150 BPS	-12.52%	-8.28%	-11.02%	-3.03%
Break-even Two-way Transaction Costs (TC)	49.5	-70.9	61.5	55.5

Figure II
Evolution of Wealth

VMA (1, 50, 0.01) cumulative dollar returns are employed. *CR (-D)* present the conditional price (upper line) and total (lower line) returns. *25* and *150* are costs in basis points per a two-way transaction. *UDC (-D)* present the unconditional price and total returns. *T-Bill* is the T-Bill yield employed as risk-free rate.



0.0827% for roughly the same period, using TSX data. The differences resulting from data samples and trading strategies cannot explain the gap. Presumably, Ito (1999) fails to distinguish between buy-sell difference and actual return. Out-of-sample break-even transaction costs are higher, which provides evidence that VMA rules improve their performance. This is a contradictory finding with respect to the hypothesis that trading rules experience a weakening predictive power. TRB rules results may support this hypothesis, but their overall out-of-sample significance is marginal. Because there is a positive and significant relationship between conditional returns and market volatility, the improved VMA performance is partially explained by the higher unconditional variance out-of-sample.

The best and worst performing rules in-sample remain so out-of-sample. Table XI contains selected measures related to the performance of VMA (1, 50, 0.01) and VMA (5, 150, 0), which respectively yield the highest and the lowest risk-adjusted mean return among the rules that significantly differ from one another. Employing VMA (1, 50, 0.01) with transaction costs of 25 basis points, the buy-and-hold strategy is outperformed by 6.47 percentage points in-sample, and 6.31 percentage points out-of-sample. Use of total returns brings these numbers down to 3.32% and 4.94%, still nontrivial. At the same time, risk is reduced, significantly improving the overall performance. Assuming transaction costs of 150 basis points, the best performing rule on a risk-adjusted basis yields negative returns. Figure II depicts the evolution of dollar returns produced by VMA (1, 50, 0.01), buy-and-hold, and T-Bills, indicating the effect that use of total returns data and transactions costs has on performance.

VIII. Conclusion

The results of this study are consistent with trading rules having predictive power. Accumulating positive sell signal returns and reducing risk, VMA rules demonstrate a degree of forecasting reliability, which cannot be attributed to chance. Evidence from the consistency check method, a contribution of this paper, reveals that the best performing conditional models remain so when applied to out-of-sample data. In a low-cost trading environment, they yield economically significant excess returns over the buy-and-hold strategy; for market participants facing high transaction costs, however, the notion of market efficiency is valid.

It is worthwhile to investigate the predictive power of VMA rules. An interesting alternative would be to test with individual equities and to create zero-cost portfolios by matching buy and sell signals for different stocks. Future research may also focus on experimenting with lower smoothing parameters or examining the effects of filter bands.

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Appendix A. Full-sample 1977-2003 Results

Table I
Summary Statistics

Full-sample price and total returns are employed. Estimation periods are excluded. Returns are calculated as log differences (applying formulas 12 and 13). Kolmogorov-Smirnov statistics are used to test whether returns are normally distributed where p-value corresponds to Prob > D. ρ (1), ρ (2) and ρ (5) are estimated autocorrelations. For each Pearson's lagged correlation coefficients p-values (Prob > |r|) under null hypothesis H_0: Rho=0 are presented.

	Price Return	Total Return
N Observations	6603	6603
Total Return	2.118717	2.91188
Mean Return	0.00032087	0.00044099
Median Return	0.000628	0.000733
Minimum Return	-0.120086	-0.119645
Maximum Return	0.086459	0.086460
Std Deviation	0.00871205	0.00870741
Skewness	-0.9914339	-0.9952852
Kurtosis	14.2196746	14.1877191
Kolmogorov-Smirnov	0.078213	0.079063
p-value	<0.0100	<0.0100
ρ (1)	0.16643	0.16664
p-value	<.0001	<.0001
ρ (2)	0.00187	0.00131
p-value	0.8793	0.9154
ρ (5)	0.03262	0.03209
p-value	0.0080	0.0091

Table II
Trading Signals

Full-sample S&P/TSX Composite Price Index signals generated by VMA (p, q, r) and TRB (p, r, d) models. *Buy*, *Sell* and *Neutral* correspond to number of days holding long, short and out-of-market position, respectively (1-11). Given in percentages, *Time Buy*, *Sell* and *Neutral* present the number of days relative to the total number of days. *N Trades* is the number of two-way transactions. *Days/Trade* is the average number of days of holding a position.

Conditional Model	Buy	Time Long	Sell	Time Short	Neutral	Time Out	N Trades	Days/Trade
VMA (1, 50, 0)	4021	60.9%	2582	39.1%	-	-	363	18.2
VMA (1, 50, 0.01)	3299	50.0%	1918	29.0%	1386	21.0%	311	21.2
VMA (1, 150, 0)	4389	66.5%	2214	33.5%	-	-	153	43.2
VMA (1, 150, 0.01)	4089	61.9%	1883	28.5%	631	9.6%	180	36.7
VMA (5, 150, 0)	4388	66.5%	2215	33.5%	-	-	87	75.9
VMA (5, 150, 0.01)	4078	61.8%	1871	28.3%	654	9.9%	90	73.4
VMA (1, 200, 0)	4475	67.8%	2128	32.2%	-	-	131	50.4
VMA (1, 200, 0.01)	4195	63.5%	1912	29.0%	496	7.5%	139	47.5
VMA (2, 200, 0)	4480	67.8%	2123	32.2%	-	-	105	62.9
VMA (2, 200, 0.01)	4201	63.6%	1902	28.8%	500	7.6%	112	59.0
Average	*4161.5*	*63.0%*	*2074.8*	*31.4%*	*733.4*	*11.1%*	*167.1*	*48.8*
TRB (50, 0, 10)	2219	33.6%	1020	15.4%	3364	50.9%	242	27.3
TRB (50, 0.01, 10)	648	9.8%	550	8.3%	5405	81.9%	109.5	60.3
TRB (150, 0, 10)	1639	24.8%	460	7.0%	4504	68.2%	154.5	42.7
TRB (150, 0.01, 10)	468	7.1%	280	4.2%	5855	88.7%	69.5	95.0
TRB (200, 0, 10)	1529	23.2%	360	5.5%	4714	71.4%	137.5	48.0
TRB (200, 0.01, 10)	448	6.8%	240	3.6%	5915	89.6%	63.5	104.0
Average	*1158.5*	*17.5%*	*485.0*	*7.3%*	*4959.5*	*75.1%*	*129.4*	*62.9*

Table III
Buy and Sell Proportions

Full-sample daily returns are employed. *Buy>0* contains the proportion of buy signal returns greater than zero to all buy days. *Sell>0* contains the proportion of sell signal returns greater than zero to all sell days. *Difference* presents the nominal difference between *Buy>0* and *Sell>0* proportions. The last columns contain p-values of distribution-free chi-square test statistics $Q \geq \chi^2_{k-1,\alpha}$, (14) for null hypothesis H_0: $\theta_1 = \theta_2 = \ldots = \theta_k$ of equality for k proportions.

Conditional Model	Buy>0	Sell>0	Difference	p-value
VMA (1, 50, 0)	0.568267	0.501936	0.066330	<.0001
VMA (1, 50, 0.01)	0.579570	0.509906	0.069663	<.0001
VMA (1, 150, 0)	0.559809	0.497290	0.062519	<.0001
VMA (1, 150, 0.01)	0.561751	0.498672	0.063079	<.0001
VMA (5, 150, 0)	0.553327	0.484424	0.068903	<.0001
VMA (5, 150, 0.01)	0.555665	0.490647	0.065018	<.0001
VMA (1, 200, 0)	0.558659	0.497180	0.061479	<.0001
VMA (1, 200, 0.01)	0.559237	0.501569	0.057668	<.0001
VMA (2, 200, 0)	0.556250	0.492228	0.064022	<.0001
VMA (2, 200, 0.01)	0.557962	0.497897	0.060065	<.0001
Average	*0.561050*	*0.497175*	*0.063875*	
TRB (50, 0, 10)	0.557909	0.513725	0.044183	0.0192
TRB (50, 0.01, 10)	0.572531	0.518182	0.054349	0.0595
TRB (150, 0, 10)	0.553996	0.550000	0.003996	0.8790
TRB (150, 0.01, 10)	0.564103	0.510714	0.053388	0.1563
TRB (200, 0, 10)	0.557881	0.561111	-0.003230	0.9115
TRB (200, 0.01, 10)	0.555804	0.508333	0.047470	0.2343
Average	*0.560371*	*0.527011*	*0.033360*	
Average across models	*0.560795*	*0.508364*	*0.052431*	
Buy-and-Hold	0.540512			

Table IV
Buy and Sell Returns

Full-sample price returns from buy-and-hold, VMA (p, q, r) and TRB (p, r, d) models are employed. Columns *μ (Buy)*, *μ (Sell)* and *μ (Buy)-μ (Sell)* contain respectively buy signal mean return, sell signal mean return, and the nominal difference between buy and sell signal mean returns. Columns *p-value G*, *p-value M* and *p-value W* correspond to the p-values of test-statistics associated with Gossett t-test (15-17), Mood median test (18) and Wilcoxon rank-sum test (19).

Conditional Model	μ(Buy)	p-value G	p-value M	μ (Sell)	p-value G	p-value M	μ (Buy)-μ (Sell)	p-value G	p-value W
VMA (1, 50, 0)	0.000758	0.0053	0.0061	-0.000359	0.0037	0.0002	0.001117	<.0001	<.0001
VMA (1, 50, 0.01)	0.000914	0.0004	0.0005	-0.000504	0.0035	0.0003	0.001419	<.0001	<.0001
VMA (1, 150, 0)	0.000600	0.0766	0.0519	-0.000232	0.0255	0.0016	0.000832	0.0009	<.0001
VMA (1, 150, 0.01)	0.000610	0.0726	0.0332	-0.000300	0.0240	0.0041	0.000910	0.0012	<.0001
VMA (5, 150, 0)	0.000511	0.2309	0.1827	-0.000054	0.1265	0.0352	0.000565	0.0238	0.0042
VMA (5, 150, 0.01)	0.000500	0.2712	0.1281	-0.000224	0.0465	0.0438	0.000723	0.0097	0.0024
VMA (1, 200, 0)	0.000574	0.1057	0.0693	-0.000212	0.0355	0.0031	0.000786	0.0022	<.0001
VMA (1, 200, 0.01)	0.000577	0.1110	0.0554	-0.000318	0.0188	0.0031	0.000895	0.0012	<.0001
VMA (2, 200, 0)	0.000544	0.1547	0.1196	-0.000150	0.0637	0.0111	0.000694	0.0069	0.0004
VMA (2, 200, 0.01)	0.000548	0.1573	0.0700	-0.000266	0.0303	0.0061	0.000814	0.0032	0.0001
Average	*0.000614*			*-0.000262*			*0.000876*		
TRB (50, 0, 10)	0.000634	0.1069	0.2563	-0.000245	0.1723	0.0095	0.000879	0.0419	0.0027
TRB (50, 0.01, 10)	0.001202	0.0161	0.0289	-0.000568	0.1872	0.1459	0.001770	0.0186	0.0129
TRB (150, 0, 10)	0.000629	0.1600	0.4045	-0.001390	0.0188	0.0008	0.002020	0.0067	0.0001
TRB (150, 0.01, 10)	0.001135	0.0604	0.1139	-0.001386	0.1185	0.2986	0.002521	0.0307	0.0198
TRB (200, 0, 10)	0.000642	0.1529	0.2310	-0.001275	0.0438	0.0017	0.001917	0.0178	0.0001
TRB (200, 0.01, 10)	0.001052	0.0921	0.2609	-0.000635	0.3832	0.4316	0.001687	0.1489	0.0436
Average	*0.000882*			*-0.000917*			*0.001799*		
Average across models	*0.000714*			*-0.000507*			*0.001222*		
Buy-and-Hold	*0.000321*								

Table V
Variability of Returns

Full-sample conditional and unconditional returns are employed. *σ(Buy)*, *σ (Sell)* and *σ (Neutral)* contain standard deviations of buy, sell and neutral signal price returns. *σ (Model)* is the standard deviation of conditional returns. *σ (Buy-and-Hold)* is the standard deviation of buy-and-hold strategy.

Conditional Model	σ (Buy)	σ (Sell)	σ (Neutral)	σ (Model)
VMA (1, 50, 0)	0.007235	0.010578	-	0.008697
VMA (1, 50, 0.01)	0.007434	0.011429	0.000141	0.008099
VMA (1, 150, 0)	0.007649	0.010487	-	0.008705
VMA (1, 150, 0.01)	0.007685	0.010983	0.000095	0.008425
VMA (5, 150, 0)	0.007717	0.010400	-	0.008711
VMA (5, 150, 0.01)	0.007790	0.010879	0.000099	0.008427
VMA (1, 200, 0)	0.007647	0.010592	-	0.008706
VMA (1, 200, 0.01)	0.007737	0.010929	0.000087	0.008521
VMA (2, 200, 0)	0.007655	0.010590	-	0.008708
VMA (2, 200, 0.01)	0.007741	0.010852	0.000086	0.008487
Average	*0.007629*	*0.010772*	*0.000102*	*0.008549*
TRB (50, 0, 10)	0.007623	0.012799	0.000186	0.006696
TRB (50, 0.01, 10)	0.008911	0.015606	0.000171	0.005302
TRB (150, 0, 10)	0.007758	0.015440	0.000187	0.005621
TRB (150, 0.01, 10)	0.009090	0.018202	0.000164	0.004465
TRB (200, 0, 10)	0.007731	0.014880	0.000185	0.005093
TRB (200, 0.01, 10)	0.008905	0.016889	0.000163	0.003967
Average	*0.008336*	*0.015636*	*0.000176*	*0.005191*
Average across models	*0.007894*	*0.012596*	*0.000142*	*0.007289*
σ (Buy-and-Hold)				0.008712

Table VI
Sharpe Ratio and Jensen Measure

Full-sample price and total returns from buy-and-hold, VMA (p, q, r) and TRB (p, r, d) models are employed. *Excess* contains total mean excess return (20). *Sharpe* presents the Sharpe ratio of conditional and unconditional return (21). *Jensen* α and β are the intercept and β coefficient of the regression model (22). Columns *p-value* α and *p-value* β correspond respectively to the p-values of the intercept and β coefficient of the regression model (22).

	Price Returns						Total Returns					
Conditional Model	Excess	Sharpe	Jensen α	p-value α	β	p-value β	Excess	Sharpe	Jensen α	p-value α	β	p-value β
VMA (1, 50, 0)	0.000296	0.034002	0.000298	0.0048	-0.15478	<.0001	0.000321	0.036881	0.000341	0.0012	-0.15431	<.0001
VMA (1, 50, 0.01)	0.000363	0.044810	0.000365	0.0002	-0.13402	<.0001	0.000387	0.047846	0.000405	<.0001	-0.13355	<.0001
VMA (1, 150, 0)	0.000171	0.019590	0.000170	0.1119	0.02766	0.0245	0.000208	0.023947	0.000204	0.0562	0.02758	0.0251
VMA (1, 150, 0.01)	0.000185	0.021964	0.000185	0.0749	0.02963	0.0127	0.000224	0.026612	0.000220	0.0337	0.02957	0.0130
VMA (5, 150, 0)	0.000052	0.005914	0.000051	0.6384	0.04449	0.0003	0.000089	0.010237	0.000083	0.4413	0.04410	0.0003
VMA (5, 150, 0.01)	0.000095	0.011307	0.000094	0.3615	0.05281	<.0001	0.000133	0.015830	0.000126	0.2227	0.05250	<.0001
VMA (1, 200, 0)	0.000152	0.017416	0.000151	0.1586	0.04702	0.0001	0.000193	0.022162	0.000186	0.0819	0.04654	0.0002
VMA (1, 200, 0.01)	0.000175	0.020516	0.000174	0.0965	0.04630	0.0001	0.000215	0.025183	0.000208	0.0467	0.04588	0.0001
VMA (2, 200, 0)	0.000111	0.012762	0.000110	0.3030	0.04984	<.0001	0.000153	0.017532	0.000146	0.1739	0.04939	0.0001
VMA (2, 200, 0.01)	0.000141	0.016659	0.000141	0.1777	0.05630	<.0001	0.000181	0.021374	0.000174	0.0955	0.05584	<.0001
Average	*0.000174*	*0.020494*	*0.000174*		*0.00653*		*0.000210*	*0.024760*	*0.000209*		*0.00635*	
TRB (50, 0, 10)	0.000104	0.015463	0.000105	0.2006	-0.07519	<.0001	0.000125	0.018672	0.000135	0.0990	-0.07489	<.0001
TRB (50, 0.01, 10)	0.000110	0.020802	0.000113	0.0729	-0.16380	<.0001	0.000111	0.020957	0.000133	0.0342	-0.16306	<.0001
TRB (150, 0, 10)	0.000159	0.028225	0.000159	0.0215	-0.02293	0.0039	0.000177	0.031556	0.000180	0.0091	-0.02249	0.0045
TRB (150, 0.01, 10)	0.000106	0.023741	0.000108	0.0452	-0.10805	<.0001	0.000107	0.024007	0.000122	0.0235	-0.10742	<.0001
TRB (200, 0, 10)	0.000134	0.026242	0.000133	0.0332	0.02284	0.0015	0.000151	0.029727	0.000148	0.0178	0.02296	0.0014
TRB (200, 0.01, 10)	0.000063	0.016016	0.000064	0.1819	-0.06516	<.0001	0.000065	0.016327	0.000073	0.1283	-0.06476	<.0001
Average	*0.000113*	*0.021748*	*0.000114*		*-0.06872*		*0.000123*	*0.023541*	*0.000132*		*-0.06828*	
Average across models	*0.000151*	*0.020964*	*0.000151*		*-0.02169*		*0.000178*	*0.024303*	*0.000180*		*-0.02163*	
Buy-and-Hold	0.000015	0.001702					0.000135	0.015494				

Table VII
Transaction Costs

Full-sample price and total returns from buy-and-hold, VMA (p, q, r) and TRB (p, r, d) conditional models are employed. *Return* is the conditional mean return before transaction costs. *25 BPS* and *150 BPS* contain conditional mean return with two-way transaction costs of 25 and 150 basis points (23). *>B&H* is the difference between conditional and unconditional returns on annualised continuously compounded basis. *B-E* is the break-even two-way transaction cost in basis points (24).

	Price Returns							Total Returns						
Conditional Model	Return	>B&H	25 BPS	>B&H	150 BPS	>B&H	B-E	Return	>B&H	25 BPS	>B&H	150 BPS	>B&H	B-E
VMA (1, 50, 0)	0.000602	7.96%	0.000464	3.98%	-0.000220	-13.82%	51.1	0.000627	5.36%	0.000489	1.36%	-0.000195	-16.55%	33.8
VMA (1, 50, 0.01)	0.000669	9.94%	0.000551	6.47%	-0.000035	-9.30%	73.9	0.000693	7.33%	0.000576	3.87%	-0.000010	-12.01%	53.6
VMA (1, 150, 0)	0.000477	4.35%	0.000419	2.71%	0.000130	-5.10%	67.2	0.000514	2.07%	0.000457	0.45%	0.000168	-7.43%	31.7
VMA (1, 150, 0.01)	0.000491	4.75%	0.000423	2.82%	0.000084	-6.29%	62.4	0.000530	2.53%	0.000462	0.59%	0.000123	-8.61%	32.7
VMA (5, 150, 0)	0.000358	1.02%	0.000325	0.11%	0.000161	-4.28%	27.9	0.000395	-1.29%	0.000362	-2.20%	0.000198	-6.64%	-34.7
VMA (5, 150, 0.01)	0.000401	2.21%	0.000367	1.26%	0.000198	-3.31%	59.0	0.000439	-0.06%	0.000405	-1.01%	0.000236	-5.63%	-1.2
VMA (1, 200, 0)	0.000458	3.81%	0.000408	2.40%	0.000161	-4.28%	69.0	0.000499	1.65%	0.000449	0.23%	0.000202	-6.53%	29.2
VMA (1, 200, 0.01)	0.000481	4.46%	0.000428	2.96%	0.000166	-4.15%	76.0	0.000521	2.28%	0.000468	0.76%	0.000206	-6.43%	37.8
VMA (2, 200, 0)	0.000417	2.66%	0.000377	1.54%	0.000180	-3.78%	60.6	0.000459	0.51%	0.000419	-0.62%	0.000221	-6.03%	11.1
VMA (2, 200, 0.01)	0.000447	3.50%	0.000405	2.32%	0.000194	-3.42%	74.6	0.000487	1.30%	0.000445	0.11%	0.000234	-5.68%	27.4
Average	*0.000480*	4.46%	*0.000417*	2.66%	*0.000102*	-5.77%	*62.17*	*0.000516*	2.17%	*0.000453*	0.34%	*0.000138*	-8.15%	*22.14*
TRB (50, 0, 10)	0.000410	2.46%	0.000318	-0.08%	-0.000138	-11.84%	24.2	0.000431	-0.28%	0.000339	-2.84%	-0.000117	-14.66%	-2.7
TRB (50, 0.01, 10)	0.000416	2.63%	0.000375	1.49%	0.000168	-4.10%	57.5	0.000417	-0.67%	0.000376	-1.82%	0.000169	-7.40%	-14.4
TRB (150, 0, 10)	0.000465	4.01%	0.000406	2.35%	0.000115	-5.48%	61.4	0.000483	1.19%	0.000425	-0.45%	0.000134	-8.32%	18.0
TRB (150, 0.01, 10)	0.000412	2.52%	0.000386	1.79%	0.000255	-1.79%	86.5	0.000413	-0.79%	0.000387	-1.51%	0.000256	-5.09%	-26.5
TRB (200, 0, 10)	0.000440	3.30%	0.000388	1.85%	0.000128	-5.15%	57.0	0.000457	0.45%	0.000405	-1.01%	0.000146	-8.01%	7.8
TRB (200, 0.01, 10)	0.000370	1.35%	0.000345	0.66%	0.000226	-2.56%	50.6	0.000371	-1.95%	0.000347	-2.62%	0.000227	-5.87%	-73.1
Average	*0.000419*	2.71%	*0.000370*	1.34%	*0.000126*	-5.15%	*56.20*	*0.000429*	-0.34%	*0.000380*	-1.70%	*0.000136*	-8.22%	*-15.15*
Average across models	*0.000457*	3.81%	*0.000399*	2.16%	*0.000111*	-5.54%	*59.93*	*0.000484*	1.23%	*0.000426*	-0.42%	*0.000137*	-8.18%	*8.16*
Buy-and-Hold	0.000321							0.000441						

Appendix B. One-day Trade Lag

In-sample, out-of-sample and full-sample price returns from VMA (p, q, r) and TRB (p, r, d) conditional models are employed. Trading signals are implemented with one-day lag. Columns *p-value Q* and *p-value W* correspond to the p-values of the test-statistics associated with distribution-free chi-square test statistics $Q \geq \chi^2_{k-1,\alpha}$, (14) for null hypothesis H_0: $\theta_1 = \theta_2 = \ldots = \theta_k$ of equality for k proportions, and the Wilcoxon rank-sum test (19) for identity between buy and sell signal return distributions. *Δ Return* is the difference between conditional mean return with and without one-day lag. *B-E* is the break-even two-way transaction cost in basis points (24) in case of one-day trade lag.

	In-Sample 1977-1995				Out-of-Sample 1996-2003				Full-Sample 1977-2003			
Conditional Model	p-value Q	p-value W	Δ Return	B-E	p-value Q	p-value W	Δ Return	B-E	p-value Q	p-value W	Δ Return	B-E
VMA (1, 50, 0)	0.0050	0.0140	-0.000232	4.1	0.0032	0.0730	-0.000103	48.3	0.0001	0.0024	-0.000191	16.4
VMA (1, 50, 0.01)	0.0000	0.0000	-0.000212	28.5	0.0002	0.0480	-0.000131	45.1	0.0000	0.0000	-0.000186	34.4
VMA (1, 150, 0)	0.0026	0.0315	-0.000117	11.6	0.1931	0.2509	-0.000126	21.3	0.0011	0.0176	-0.000119	16.2
VMA (1, 150, 0.01)	0.0000	0.0042	-0.000105	26.2	0.0944	0.2071	-0.000104	16.9	0.0000	0.0030	-0.000103	24.5
VMA (5, 150, 0)	0.0096	0.0386	-0.000006	-3.2	0.2710	0.2350	-0.000028	70.0	0.0052	0.0192	-0.000011	19.6
VMA (5, 150, 0.01)	0.0007	0.0328	-0.000029	22.4	0.1503	0.2100	-0.000057	49.7	0.0003	0.0150	-0.000035	32.8
VMA (1, 200, 0)	0.0010	0.0203	-0.000061	20.2	0.2237	0.2497	-0.000098	55.5	0.0006	0.0127	-0.000071	33.2
VMA (1, 200, 0.01)	0.0003	0.0099	-0.000072	23.8	0.0852	0.1296	-0.000098	70.8	0.0001	0.0034	-0.000078	38.9
VMA (2, 200, 0)	0.0060	0.0569	-0.000062	-0.9	0.1788	0.1846	-0.000033	82.2	0.0021	0.0205	-0.000051	28.1
VMA (2, 200, 0.01)	0.0003	0.0224	-0.000054	27.5	0.0764	0.1586	-0.000024	94.3	0.0001	0.0082	-0.000043	49.1
Average			-0.000095	16.02			-0.000080	55.41			-0.000089	29.32
TRB (50, 0, 10)	0.0036	0.0889	-0.000093	11.0	0.3988	0.6926	-0.000028	-9.2	0.0050	0.1524	-0.000074	4.2
TRB (50, 0.01, 10)	0.0216	0.0339	-0.000091	73.9	0.6099	0.8491	-0.000087	-92.4	0.0406	0.1808	-0.000090	3.3
TRB (150, 0, 10)	0.0001	0.0153	-0.000115	31.6	0.8099	0.6036	-0.000080	-10.8	0.0012	0.0379	-0.000104	17.0
TRB (150, 0.01, 10)	0.1869	0.2484	-0.000085	83.4	0.8951	0.7176	-0.000046	-73.4	0.2800	0.2959	-0.000073	16.9
TRB (200, 0, 10)	0.0001	0.0040	-0.000060	41.7	0.7075	0.8399	-0.000100	-16.5	0.0005	0.0267	-0.000072	22.5
TRB (200, 0.01, 10)	0.3933	0.1461	-0.000020	107.5	0.8349	0.9369	-0.000060	-108.5	0.4120	0.3349	-0.000032	17.3
Average			-0.000077	58.18			-0.000067	-51.80			-0.000074	13.53

Appendix C. Filter Effects

Full-sample price returns from VMA (p, q, r) and TRB (p, r, d) conditional models are employed. *Return Structure* contains differences between mean returns with and without filter band, per neutral day. *Buy* and *Sell* represent the mean added return following the introduction of the filter. *RFR* is the neutral signal return (the mean risk-free rate for the corresponding days. *Total* is the return spread (the sum of *Buy*, *Sell* and *FRF*). *Transaction Cost Savings* contains the effect of filter on mean return under 25 and 150 basis points. *Success* and *Failure* represent the number of neutral days, for which the introduction of filter leads to positive return differences. *Buy* and *Sell* indicate alternative positions in case filter is not applied.

	Return Structure				Transaction Cost Savings		Success		Failure	
Conditional Model	Buy	Sell	RFR	Total	25 BPS	150 BPS	Buy	Sell	Buy	Sell
VMA (1, 50, r)	-0.000022	0.000065	0.000313	0.000356	0.000094	0.000563	373	318	349	345
VMA (1, 150, r)	-0.000220	0.000142	0.000291	0.000213	-0.000107	-0.000642	160	162	140	169
VMA (5, 150, r)	-0.000310	0.001654	0.000297	0.001641	-0.000011	-0.000069	162	155	148	189
VMA (1, 200, r)	-0.000305	0.000566	0.000297	0.000558	-0.000040	-0.000242	154	99	126	117
VMA (2, 200, r)	-0.000271	0.000843	0.000293	0.000865	-0.000035	-0.000210	148	98	131	123
Average	-0.000226	0.000654	0.000298	0.000726	-0.000020	-0.000120	199.4	166.4	178.8	188.6
TRB (50, r, 10)	-0.000116	0.000284	0.000113	0.000280	0.000061	0.000368	940	315	777	307
TRB (150, r, 10)	-0.000085	-0.001809	0.000069	-0.001825	0.000036	0.000218	702	154	585	114
TRB (200, r, 10)	-0.000086	-0.002415	0.000060	-0.002441	0.000031	0.000188	654	118	527	78
Average	-0.000096	-0.001313	0.000081	-0.001329	0.000043	0.000258	765.3	195.7	629.7	166.3

Appendix D. After Costs Risk-adjusted Returns

Full-sample price and total returns from buy-and-hold, VMA (p, q, r) and TRB (p, r, d) models are employed; conditional returns are deducted with 25 basis points for every two-way transaction. *Jensen* α and β are the intercept and β coefficient of the regression model (22). Columns *p-value* α and *p-value* β are respectively the p-values of the intercept and β coefficient of the regression model (22). *>B&H* is the annualised on continuously compounded basis *Jensen* α.

	Price Returns					Total Returns				
Conditional Model	Jensen α	>B&H	p-value α	β	p-value β	Jensen α	>B&H	p-value α	β	p-value β
VMA (1, 50, 0)	0.000369	9.73%	0.1170	-0.236041	0.0000	0.000398	10.56%	0.0904	-0.235550	0.0000
VMA (1, 50, 0.01)	0.000376	9.94%	0.0873	-0.181399	0.0000	0.000403	10.68%	0.0671	-0.181099	0.0000
VMA (1, 150, 0)	0.000239	6.20%	0.3196	0.036534	0.1036	0.000257	6.69%	0.2841	0.036894	0.1003
VMA (1, 150, 0.01)	0.000204	5.28%	0.3813	0.033712	0.1221	0.000223	5.78%	0.3388	0.034060	0.1183
VMA (5, 150, 0)	0.000202	5.23%	0.3967	0.044270	0.0473	0.000221	5.72%	0.3543	0.044605	0.0457
VMA (5, 150, 0.01)	0.000210	5.44%	0.3645	0.045063	0.0378	0.000228	5.93%	0.3244	0.045327	0.0367
VMA (1, 200, 0)	0.000287	7.49%	0.2320	0.014056	0.5307	0.000304	7.97%	0.2042	0.014217	0.5260
VMA (1, 200, 0.01)	0.000313	8.20%	0.1836	0.022216	0.3125	0.000330	8.66%	0.1609	0.022421	0.3081
VMA (2, 200, 0)	0.000254	6.62%	0.2874	0.017685	0.4289	0.000273	7.12%	0.2534	0.017780	0.4265
VMA (2, 200, 0.01)	0.000260	6.78%	0.2658	0.025963	0.2351	0.000277	7.22%	0.2366	0.026152	0.2317
Average	0.000271	7.09%		-0.017794		0.000291	7.63%		-0.017519	
TRB (50, 0, 10)	0.000032	0.80%	0.8625	-0.174061	0.0000	0.000052	1.33%	0.7745	-0.173900	0.0000
TRB (50, 0.01, 10)	-0.000041	-1.04%	0.7791	-0.173067	0.0000	-0.000030	-0.74%	0.8416	-0.172953	0.0000
TRB (150, 0, 10)	0.000111	2.84%	0.4505	-0.039640	0.0040	0.000125	3.21%	0.3949	-0.039315	0.0044
TRB (150, 0.01, 10)	0.000033	0.83%	0.7850	-0.074192	0.0000	0.000039	1.00%	0.7415	-0.074009	0.0000
TRB (200, 0, 10)	0.000127	3.25%	0.3550	0.002073	0.8716	0.000139	3.56%	0.3110	0.002172	0.8656
TRB (200, 0.01, 10)	0.000011	0.28%	0.9222	-0.048911	0.0000	0.000017	0.43%	0.8809	-0.048769	0.0000
Average	0.000045	1.16%		-0.084633		0.000057	1.46%		-0.084462	
Average across models	0.000187	4.87%		-0.042859		0.000204	5.32%		-0.042623	