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DIPLOMARBEIT

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Forecasting Financial Returns
Using Recursive Market Timing Strategies

Verfasser

Christian Holzmann

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Contents

1 Introduction

Prediction is very difficult, especially about the future.

Niels Bohr

The ambition to forecast market returns is a vision with roots long before the first stock exchange opened its doors in the late 13th century[1]. The realization of this desire was usually supposed to be an illusion. Under the absence of risk, an investor should not be able to outperform the market by using public information. The efficient market hypothesis excludes arbitrage opportunities since all of the relevant information should be contained in the current stock prices. However several studies show evidence for the predictability of stock returns. During the last decades, the research of this topic established a wide spectrum of different forecasting techniques.

The existing literature and models for stock market forecasting can be classified into two different groups: Micro- and macro-forecasting. The first group is also known as "security analysis" and forecasts price movements of individual stocks relative to stocks generally. The approach of microforecasting often involves the implementation of the "capital asset pricing model" (CAPM) developed by Sharpe (1964), Lintner (1965) and Mossin (1966), which refers to the equilibrium relationships among security prices when these securities are selected on the basis of the expected rate of return and the expected variance. Merton (1973) arranged one step ahead forecasts for various individual stock options and then determined if they are "under-" or "over-valued". So investment managers could buy these under-valued stocks and outperform the market portfolio. Fama & French (1988) argued that a slowly mean-reverting[2] component of stock prices tends to induce negative autocorrelation in returns. In particular the autocorrelation is strong for long-horizon returns but not for daily and weekly holding periods.

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[1] VAN ANTWERP, W.C., (1913)

[2] The theory of mean reverting suggests that price changes tend to reverse over time by a predictable change into the other direction.

Campbell and Shiller (1988) used the earnings-price ratio; Schwert, French, and Stambaugh (1987), Ghysels, Santa-Clara, and Valkanov (2005), and Guo (2006) used stock market volatility for forecasting stock market returns. In fact there are hundreds of empirical investigations relating to this field of study. However some of these security analysis methods have a poor performance and are only effective in the absence of taxes or transaction costs.

The second type I mentioned above is, macroforecasting, also known as "market-timing". It forecasts price movements of the general stock market relative to fixed income securities. Especially government bonds with AAA[3] ratings are usually supposed to be risk free assets. So it is common practice to use these assets as basic investment alternatives. Of course the assumption of risk neutrality does not apply to a representative investor in general, however it can often be found in financial papers. Pesaran and Timmermann (1995) analyzed the excess return predictability of US stock indices over short term treasury bills using a recursive modelling strategy. In the model they used, a representative agent supposes some specific variables to be correlated with future returns. Since ex ante, the investor does not know the true model, the excess rate of the index returns were regressed on all combinations of this base set of variables in each period. The optimal model was selected on the basis of model selection criteria such as the Akaike information criterion (AIC) or the Schwarz information criterion (SIC).

Kenneth J. Edwards (2000) used this approach to outperform the Canadian Toronto Stock Exchange Index (TSE 300). He used seven financial variables to gather information on the US and Canadian stock and bond markets. His data set began January 3, 1989 and ended May 28, 1999. Edwards implemented various model selection criteria: adjusted R^2 (RBS), Bayesian information criterion (BIC), Akaike information criterion (AIC) and Hannan-Quinn criterion. The predictive failure test of Pesaran and Timmermann (1992) was applied to test the ability of the recursive modelling strategy to predict the sign of the one day ahead excess return on the TSE 300. By using this recursive forecasting technique, Edwards showed that it was possible to improve the performance of the TSE 300 Index for trading costs up to 0,25 %.

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[3]Standard & Poors

In our thesis, we investigate the performance of recursive market timing strategies for the Canadian S&P/TSX Venture Composite Index. Therefore we apply our optimal forecasts to a predefined investment strategy and simulate the path of capital accumulation that results from Canadian bond and stock markets. In March 15, 1999 the Vancouver and Alberta stock exchange merged to the CDNX, the Canadian Venture Exchange, which had also captured some junior Toronto and Montreal Exchange companies. Later, in 2002, the CDNX was changed to the TSX Venture Composite Index. This index lists a series of junior and venture companies, most of which are in the mining and energy sector. For the analysis we use daily data of the S&P/TSX Venture Composite Index and a data set of eight explanatory variables including the crude oil price West Texas Intermediate (WTI). This variable reflects economical relevance of crude oil for these regions.

The remainder of the thesis is organized the following way. Chapter 2 provides some basic concepts of financial time series analysis that are relevant to our analysis. We proceed with a detailed description on the investment strategies and the path of capital accumulation. The data set is introduced in chapter 4, where we also will define the variables, establish the criteria of model selection and give the summary statistics for all explanatory variables. Chapter 5 focuses on the variable inclusion rates, tests the power of the forecasts and derives the performance for different transaction costs. In the end of this study we present the conclusion.

2 Financial Time Series Modelling

2.1 Some Basic Concepts

2.1.1 Stationarity

In econometric time series analysis many tests and procedures are based on the assumption of weak or covariance stationarity. This term refers to the constancy of the first and second moments of the underlying distribution and a stationary series x_t is therefore defined as a series satisfying the following conditions:

$$E[x_t] = \mu \qquad Var[x_t] = \sigma^2 < \infty \qquad Cov[x_t, x_{t+h}] = Cov[x_{t+s}, x_{t+h+s}] \qquad \forall_{t,s,h}$$

In other words, a covariance stationary process has a constant mean and a constant finite variance and a covariance of x_t and x_{t+h} depending solely on h, but not on time t. A random walk type of process is an example of a non-stationary process. A common practice to convert a non-stationary process into a stationary one is to take the first difference of the series. Such a process is called integrated of order one $I(1)$. More generally speaking, a time series is called integrated of order d if the series is stationary after taking the dth difference. A time series is called trend stationary if the elimination of a deterministic trend is sufficient to achieve stationarity.

2.1.2 Unit Root Test

At this point we describe the Augmented Dickey-Fuller Test (ADF-Test) to test for unit roots in a time series. This test potentially detects non-stationarity and helps to avoid the problem of spurious regression. Whereas the DF-Test ignores the possibility of short-term dependencies, the augmented version also captures the structural effects (autocorrelation) of the series. The ADF testing procedure is based on the following model:

$$\Delta x_t = \alpha + \beta t + (\phi - 1)x_{t-1} + \delta_1 \Delta x_{t-1} + ... + \delta_p \Delta x_{t-p} + \epsilon_t$$

The parameters α, β of this general model represent a constant and a linear time trend. By introducing a certain number of lags p we are able to account for serial correlation. The residuals are white noise. The test hypotheses and the test statistic of the Augmented Dickey Fuller test are:

$$H_0 : \phi = 1 \qquad\qquad DF_0 = \frac{\widehat{\phi}}{\sqrt{Var\widehat{\phi}}}$$
$$H_A : \phi \neq 1$$

Since the value of the ADF test statistic is usually negative, it follows that the more negative it is, the stronger the rejection of the null hypotheses becomes, which states that there is a unit root.

2.1.3 Regression

In order to forecast excess returns we use one of the most commonly used method of estimating parameters in econometrics, which is the method of ordinary least squares (OLS). More precisely, our calculations are based on linear regressions on sets of variables that were modified at each point in time. This will be explained in the next step. The multiple linear regression models have the following form:

$$
\begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix} = \begin{bmatrix} 1 & x_{12} & \cdots & x_{1k} \\ 1 & x_{22} & \cdots & x_{2k} \\ \vdots & \vdots & \cdots & \vdots \\ 1 & x_{n2} & \cdots & x_{nk} \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta_2 \\ \vdots \\ \beta_k \end{bmatrix} + \begin{bmatrix} u_1 \\ u_2 \\ \vdots \\ u_k \end{bmatrix}
$$

The equation can be simplified to the compact notation: $\vec{y} = X\vec{\beta} + \vec{u}$

OLS calculates the best fit between the model and the underlying data. The parameters are estimated by minimizing the sum of the squared residuals. Hence the OLS minimizing problem can be specified with the following expression:

$$
\sum_{t=1}^{n} (y_t - \beta_1 - \beta_2 x_{t2} - ... - \beta_k x_{tk})^2 \rightarrow min!
$$

In contrast to a lower dimensional regression model, formulas for the OLS estimates of the multiple models are difficult to obtain algebraically without matrix notations. Of course, the OLS estimates can easily be obtained with statistical software packages like R.

3 Methodology

3.1 Investment Strategy in the Absence of Transaction Costs

By simulating the actions of a rational investor we attempt to outperform the Canadian S&P/TSX Venture Composite Index. Thereby we deal with the general problem of portfolio management, the conflict between the achievement of a higher return on the one hand and a lower volatility on the other. To meet the requirements we have to sidestep during a bear market and switch the portfolio into a risk free asset. Subsequently, when the market has turned we should hold stocks again. To find such a procedure we use a market timing strategy that is based on econometric calculations. For this task we just use publicly available information that we expect to contain information on the financial markets. More precisely, the methodology that is applied in this paper works with daily data, with which we generate forecasts for the excess rate of index return over a risk free asset.

Of course, an investor cannot know a priori the best forecasting model based on a given set of potential determinants of future returns. For this reason we first have to look for a suitable model. We do that by running a series of linear regressions that cover all possible combinations of the independent variables. At each point in time, the final model used for forecasting is selected from the vast number of fitted models and chosen with the help of model selection criteria like AIC, BIC and FPEsub[1]. The estimated coefficients of the selected model are used to forecast the return of the next day.

As mentioned above we focus on the excess returns of the S&P/TSX Venture Composite Index over a risk free asset, for which we use Canadian Treasury bills. Based on the forecasts we decide whether to invest in the index or in the 30-day Treasury bills. If the estimated excess return is positive, we invest in the index, if it is negative, we invest in the 30-day Canadian Treasury bills.

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[1]Subset version of the Final Prediction Error, Reschenhofer E., (2004)

3.2 Allowing for Transaction Costs

A serious shortcoming of the approach described in 3.1 is the disregard of transaction costs. In the absence of these costs, an investor has the flexibility to change his portfolio in the light of any new information. In practice, transaction costs will always have an effect on investment decisions, since an investor has to ponder whether the expected gains from switching outweigh the costs. Under risk neutrality a rational agent only realizes an asset switch if the expected net return is positive.

In this investment strategy a rational agent holding treasury will only move into stocks if the expected gain outweighs the costs that will arise from the trade. On the other hand, when an investor expects the returns to be smaller than the resulting transaction costs, the agent will stay in bonds. The same argument can be used in order to explain the effect of negative signs of the forecast. The agent will switch from the S&P/TSX Venture Index into bonds only if the expected loss is smaller than the transaction costs. For this reason, the number of trades will decrease as the transaction costs increase.

In fact there is no fixed fee or rate that holds for any trade. For instance, an institutional investor like a fund manager has very low transaction costs. Due to former research, Ang and Chua (1991) found evidence that floor traders even pay only 0,1 % per trade. Retail investors on the other hand can trade via online stock broking companies and may then have average transaction costs of about 0.25 % per trade. Moreover, since regulations and taxes for trading are usually different from country to country, we take only the direct transaction costs into account and ignore any taxes on capital gains and other costs.

For simplicity, we only consider transaction costs once, which capture the costs for both selling an asset and buying another asset. This means that we have to multiply the rates above by two. The total transaction costs of one switch are represented by the variable c.

3.3 Capital Accumulation

Given the investment strategy and all the explanatory variables, the evolution of wealth can be simulated and compared to an alternative like a simple buy and hold strategy. The capital accumulation of the switching strategy can be expressed in the following formulas, where:

W_t = the value of the portfolio at time t

c = the transaction costs as a percentage of the portfolio value

r_t = the current daily rate of return on the S&P/TSX Venture Index at time t

r_t^f = the current daily rate of return on 30-day Canadian treasury bills

If at the current period the portfolio is in the S&P/TSX Venture Index and the forecast of the excess return of the next day is smaller than c, the investor will stay in stocks and the value of the portfolio at time $t+1$ becomes:

$$W_{t+1} = W_t(1 + r_{t+1})$$

If at time t the portfolio is invested in the index and is switched to Treasury bills at the end of period t, the portfolio is worth at time $t+1$:

$$W_{t+1} = W_t(1 - c)(1 + r_{t+1}^f)$$

When the portfolio is and remains in Treasury bills, the value of the portfolio at time $t+1$ will become:

$$W_{t+1} = W_t(1 + r_{t+1}^f)$$

Finally, in the case where the portfolio is switched from Treasury bills into the S&P/TSX Venture Index at the end of period t, the value of the portfolio at time t+1 will become:

$$W_{t+1} = W_t(1 - c)(1 + r_{t+1})$$

4 Data

4.1 Data Sources

In our study we used daily data from 10 December 2001 to 30 October 2009, whereas the data until the end of January 2002 was only used for model selection. The base set contains eight macroeconomic and financial variables from Canada and the United States and was obtained from various sources. We collected the Index data for the S&P 500 from Yahoo finance and the S&P/TSX Venture Composite data from the TSX Venture Exchange database. The West Texas Intermediate spot oil price was collected from the United States Energy Information Administration. The remaining series were obtained from the Datastream International database.

As a consequence of the use of daily data from different countries we have to adjust them because of differences in the holidays. Holidays such as Canada Day, Victoria Day, Boxing Day, Remembrance Day or Civic Holiday are only celebrated in Canada, whereas Independence Day, Presidents Day, Veterans Day and some other holidays are only celebrated in the US but not in Canada. The data set was corrected for every day the TSX Venture Exchange was closed. Since trading takes place in Canada while the United States celebrate holiday we have no new information from the American market, so we take the values of the previous day as a proxy for these missing observations.

4.2 Variable Selection

In order to make predictions on the TSX Venture Index we have to determine which variables might be useful. Of course there is a wide spectrum of variables that are suitable, however we selected financial and macroeconomic independent variables that should have the highest explanatory power. The one step ahead excess return of the TSX Venture Index ρ_{t+1} is the variable we regularly needs to forecast for our investment strategy. The excess return is determined as the difference between the daily rate of return of the stock market index r_t and the daily 30-day Treasury bill rate r_t^f.

$$\rho_t = r_t - r_t^f$$

As mentioned before, data from Canada as well as from the United States were used, thus we account for the high linkage of these markets. By international standards Canada has a very open economy and the closest business relationships to the United States. In 2007, 76 % of Canada's exports went to the U.S and 65 % of Canada's imports came from there[1]. For this reason, movements in the United States economy, which are reflected by the S&P 500 Composite index, should have a significant positive effect on the Canadian TSX Venture Composite Index.

The Canadian-US exchange rate should be taken into account, since it directly affects the competitiveness of companies in the two countries. An appreciation of the Canadian dollar relative to the US dollar should affect the TSX Venture Composite Index negatively, since Canadian goods will become more expensive for American consumers and thus have a negative impact on the Canadian export industry. On the other hand a depreciation of the Canadian dollar relative to the US dollar leads to a stimulation of the Canadian export industry. The data on the Canadian-US exchange rate is on the base of direct quotation, which is defined as the ratio of the Canadian dollar to the US dollar.

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[1]US Department of State

As a proxy for the monetary policy of the US Federal Reserve and the Bank of Canada we use the 90-day Treasury bill rate. Most central banks focus on short-term interest rates in order to control the economy. For instance, by raising the short term-interest rates the central bank might cool down the economy and contain inflation. The influence of higher short term interest rates is manifold. First, the costs of borrowing increase, which will lead to higher debt costs for firms, reduces profits and slows down the economy.

Since the value of a representative company is determined through the net present value of all future profits, its reduction lowers the market value of the firm and leads to a lower share price. Moreover, higher short-term interest rates increase the costs of credit for consumers, so they will reduce expenditures for durable goods. Both effects will set pressure on the stock index. Another explanation is based on the opportunity cost of money that rises with higher interest rates. This is because of the fact that higher interest rates bonds yield a higher rate of return and hence become more attractive. Rational agents adjust their portfolios and invest into bonds which impos pressure on the stock prices. Therefore the Canadian 90-day Treasury bill rate and the TSX Venture index return should have an inverse relationship.

The same holds for the 90-day treasury bill rate. With a contractionary monetary policy of the Federal Reserve due to higher interest rates, the economy of the United States slows down and reduces the demand for Canadian goods. Another argument comes through competition for international capital. With higher US interest rates, it becomes more attractive to invest in the US since higher returns will be earned in that market. In order to prevent capital outflows, the Bank of Canada does also have to increase the interest rates. Indeed, it can be observed that both interest rates are always tied together and monetary policy of the Federal Reserve is partially reflected in the Canadian interest rates. For that reason, the 90-day US Treasury bill should also be negatively correlated to the Canadian stock market index.

As an indicator for future real economic activity we use the spread between government bonds and short-term treasury bills. These assets are equal in all respects except for their term to maturity, the difference between them is known as maturity-premium or term-premium. Because of its forecasting power for future economic growth[2], the spread between the yields on the Canadian one year government bond and the 30-day Treasury bill rate should have explanatory power for the TSX Venture Composite index.

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[2]Bonser-Neal C. and Morley T.R., (1997)

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The composition of this index exhibits a large fraction of companies dealing with the energy or mining sector. In 2007, from the entire number of the 500 companies 47 % are listed in the mining sector and further 13 % in the oil and gas sector.[3] Therefore we add a variable that captures the movements of the West Texas Intermediate spot oil price. On the one hand, higher oil prices directly result in higher earnings for companies in the oil and gas sector. On the other hand, it increases the costs for the remaining economy. Since the second effect should outweigh the first, we assume the WTI spot oil price to be negatively related to the TSX Venture Composite Index.

The following variables will establish the constant base set of regressors, which is used for the calculation of the optimal model at each point in time.

$$X_t = \{\rho_t,\ XSP_t,\ dCNTB_t,\ dUSTB_t,\ CNSP_t,\ USSP_t,\ dXR_t,\ dWTI_t\}$$

ρ_t ....   current excess return on the TSX Venture Composite Index

XSP_t ...   current excess return on the US S&P 500 Composite Index over the 30-day US treasury bill rate

$dCNTB_t$ first difference of the log of the Canadian 90-day treasury bill rate

$dUSTB_t$ first difference of the log of the US 90-day treasury bill rate

$CNSP_t$.   spread between the 12-month Canadian government bond rate and the 30-day Canadian treasury bill rate

$USSP_t$ ..   spread between the 12-month US government bond rate and the 30-day US treasury bill rate

dXR_t ...   first difference of the logged Canada-US exchange rate

$dWTI_t$ ..   first difference of the logged West Texas Intermediate spot oil price

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[3]http://www.goldworld.com/articles/tsx-venture-exchange/124

4.3 Model Selection

With respect to the investment strategy, we are looking for the model with the best forecast of the one period ahead excess return. Therefore we do not include all variables of the constant base set, but rather look for an optimal subset. For this decision making process we rely on several information criteria which search across all possible combinations of explanatory variables and indicate the best possible subset at each point in time. For instance the model m_i is given by:

$$Y_t = \alpha_i + \beta_i X_{it-1} + e_{it}$$

α_i is the parameter for the constant of model i

β_i denotes a regression coefficient of model i

X_{it-1} denotes a variable subset in the model m_i

e_{it} denotes a random error for this model

Since the base set includes eight independent variables, the model m_i is determined through a 8 x 1 vector of binary code k_i. When the jth element of the model i is one, the variable j is included, if it is zero, variable j is not included. All possible combinations of the models are then calculated for each point in time, so there are 256 (2^8) competing models to forecast the excess return on the S&P/TSX Venture Composite Index. The best model is selected by one of three different information criteria. These model selection criteria are: Akaike Information Criteria (AIC), Schwarz Information Criteria (BIC), and a subset version, FPEsub, of the Final Prediction Error (FPE) criterion (Reschenhofer E., 2004). These criteria try to find the optimal trade off between a large log-likelihood function (or a small sum of squared errors, respectively) and a term that punishes the inclusion of any additional variable. They select the model by solving the trade-off between parsimony and fit.

The log-likelihood function has the following form:

$$\widehat{L}_{t,l} = \frac{-t}{2}\left[1 + \log(\frac{2\pi}{t}\sum_{t=0}^{t-1}(\rho_{t+1} - X'_{t,l}\widehat{\beta}_{t,l})^2)\right]$$

In addition to the log-likelihood function the model selection criteria include a term that accounts for parsimony which is given through the number of independently adjusted coefficients k. Both information criteria (AIC and BIC) can also be calculated by using the sum of squared errors (SSE) and a penalty term.

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The Akaike Information Criterion (AIC) that was developed by Akaike H., (1974) is one of the most often used model selection criteria in econometric studies and it is given by the following equation:

$$AIC_{t,l} = -2\ln(\widehat{L}_{t,l}) + 2k$$

The Bayesian Information Criterion (BIC) or Schwarz Criterion (SBC), developed by Schwarz G.E., (1978), punishes over-specification more and tends to choose models with fewer explanatory variables compared to the AIC. BIC is given by:

$$BIC_{t,l} = -2\ln(\widehat{L}_{t,l}) + k\ln(n)$$

The third selection criterion, FPEsub, differs from AIC in the fact that it punishes the inclusion of the first variables more, but subsequently is milder to the next variables to be included.

$$FPEsub = SSE * \frac{n+1+\varsigma_{jk}}{n-1-\varsigma_{jk}}$$

Table 4.3.1: Approximate Values of ς_{jk}:

0.9996	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.6368	1.9998	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.1000	2.8040	2.9968	0.0000	0.0000	0.0000	0.0000	0.0000
2.4723	3.4724	3.8816	4.0024	0.0000	0.0000	0.0000	0.0000
2.7749	4.0310	4.6473	4.9189	5.0021	0.0000	0.0000	0.0000
3.0352	4.5171	5.3249	5.7501	5.9443	6.0052	0.0000	0.0000
3.2586	4.9396	5.9213	6.4951	6.8089	6.9556	7.0021	0.0000
3.4553	5.3149	6.4575	7.1726	7.6059	7.8480	7.9629	7.9997

Index j determines the number of variables in the base set, which is fixed by eight explanatory variables. k on the other hand is the number of included independent variables at each point in time. For each j, we generated one million random samples of size j from a chi-square distribution with one degree of freedom in order to determine the values of $\varsigma_{jk}, \quad k = 1, ..., j$.

4.4 Summary Statistics

In this section we will take a closer look on the underlying financial and macro-economic data. Table 4.4.1 depicts selected descriptive statistics as well as the Augmented Dickey Fuller statistic for the excess return on the S&P/TSX Venture Composite Index and the independent variables. As described in section 2.1.2 the ADF-test is used to avoid the problem of spurious regression. It determines whether the variable has a unit root $\phi = 1$, which is an indication of non-stationary. For the whole observation period the null hypothesis of non-stationarity was rejected at the 5 % level for all variables. The ADF-test statistic includes five lags to account for serial correlation in the error term that covers the whole week.

Table 4.4.1: Summary Statistics

Variable	Mean	Max	Min	ADF
S&P/TSX V.C. Index Total Return	0.000131	0.077740	-0.136700	
S&P/TSX V.C. Index Excess Return	0.000059	0.077730	-0.136700	-15.65
Canadian 1 Month T Bill	0.000102	0.000171	0.000003	
Canadian Yield Spread	0.000015	0.000065	-0.000014	-4.29
Change in Can 3 M T Bill	-0.001129	1.171000	-1.154000	-20.66
S&P 500 Excess Return	-0.000137	0.104200	-0.094700	-19.87
US Yield Spread	0.000015	0.000070	-0.000019	-5.68
Change in US 3 M T Bill	-0.001782	2.037000	-3.332000	-21.15
Growth Rate ($CAN/$US)	-0.000193	0.038070	-0.050720	-17.92
WTI Growth Rate	0.000725	0.275600	-0.191500	-20.59

The following graphs depict the daily spot price of the S&P/TSX Venture Composite Index, the daily return of the Canadian 30-day Treasury bill rate, and the daily excess returns over the 30-day Treasury bills. Additional plots for all explanatory variables can be found in the Appendix A.

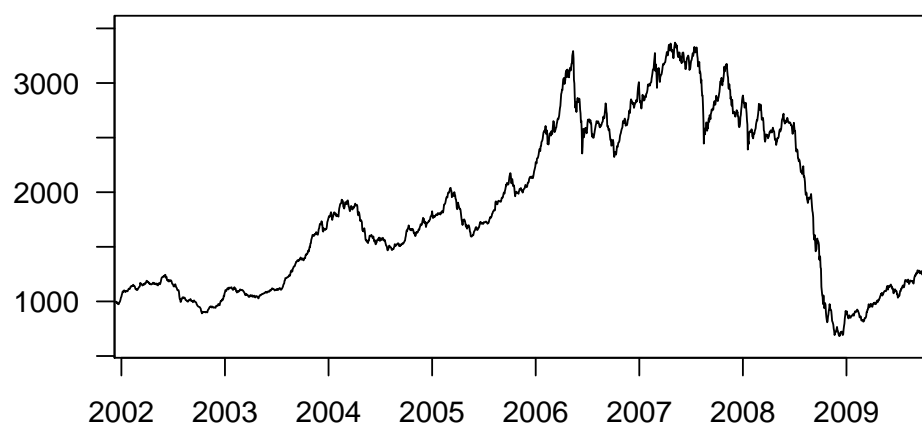Figure 4.4.1: S&P/TSX Venture Composite Index

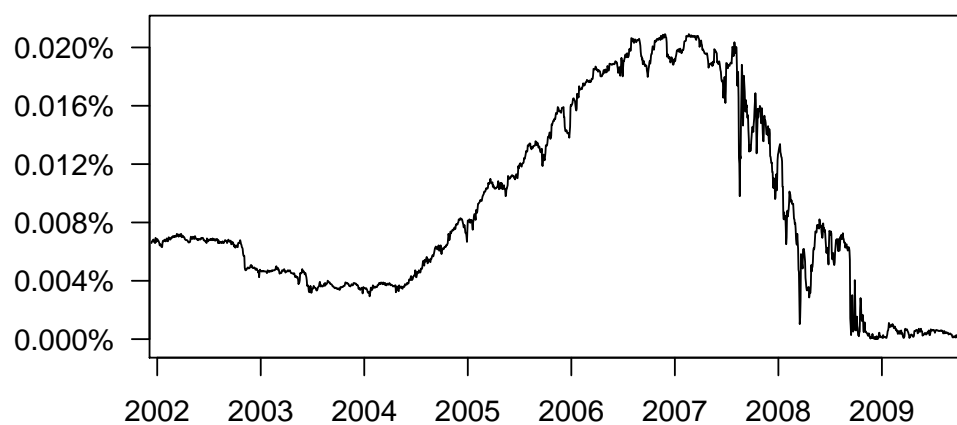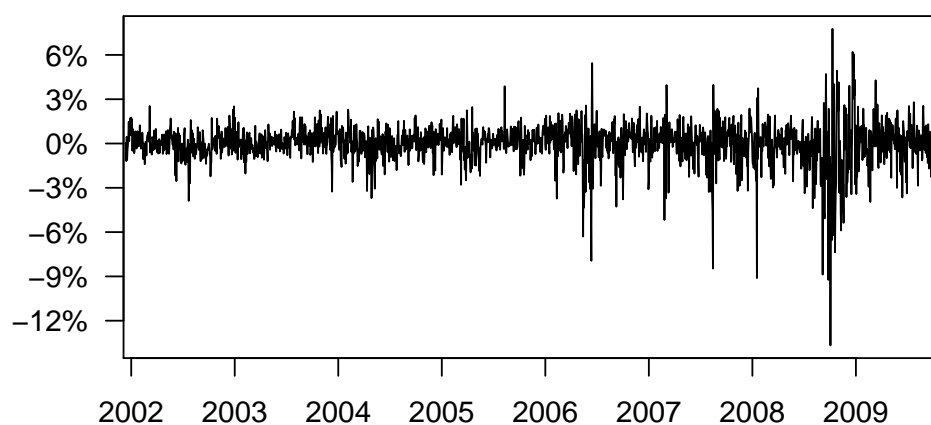Figure 4.4.2: Canadian 30-Day Treasury Bill Rate - Daily Returns

Figure 4.4.3: S&P/TSX Venture Composite Index - Daily Excess Returns

5 Results

5.1 Variable Inclusion Rates

According to the model selection process described in section 4.3, the optimal subset of variables was chosen with the Akaike Information Criterion, the Schwarz Information Criterion, and the subset version of the Final Prediction Error criterion, respectively. All selections were based on all 256 possible combinations of the base set at each point in time. Table 5.1.1 lists the aggregated variable inclusion rates.

Table 5.1.1: Variable Inclusion Rates

		AIC	**BIC**	**FPEsub**
Inclusion rate of:	ρ_{t-1}	98.56	98.00	97.84
Inclusion rate of:	XSP_{t-1}	98.72	95.53	97.79
Inclusion rate of:	$dCNTB_{t-1}$	29.50	5.76	70.40
Inclusion rate of:	$dUSTB_{t-1}$	53.44	38.39	70.55
Inclusion rate of:	$CNSP_{t-1}$	0.26	0.00	54.01
Inclusion rate of:	$USSP_{t-1}$	48.41	11.25	71.48
Inclusion rate of:	dXR_{t-1}	38.13	9.76	71.22
Inclusion rate of:	$dWTI_{t-1}$	4.11	0.00	59.61

All three criteria selected the first two variables, the current excess return of the S&P/TSX Venture Index and current excess return of the US S&P 500 Composite Index almost always. In contrast, the spread between the 12-month Canadian government bond rate and the 30-day Canadian Treasury bill rate and the first difference of the log West Texas Intermediate spot oil price were hardly ever selected by the AIC and the BIC. Not surprisingly, the BIC generally selected smaller models than the AIC. The subset version of the FPE criterion selected the largest models. This is due to the fact, that on the one hand some important variables were almost always included and on the other hand this criterion is milder to less important variables, once a number of important variables already have been included.

5.2 Predictive Failure Test

The predictive failure test is used to analyze the predictive ability of the selected models on the one step ahead excess return of the S&P/TSX Venture Composite Index. It was established by Pesaran and Timmermann (1992) and examines the predictive power of the forecasts obtained by the recursive modelling strategy. More precisely, this test tests the accuracy of the sign of the forecast rather than on its exact magnitude and simply analyzes the frequency that the sign is predicted correctly. The predictive failure test examines the correlation between the actual and the forecasted values of the excess return and determines its statistical significance. In the following, the actual values are denoted by y_t and the estimated values by x_t.

N is the length of the sample.

$\widehat{P}_y$ denotes the estimated probability that the sign of the Index is positive.

$\widehat{P}_x$ denotes the estimated probability that the sign of the forecast is positive.

$\widehat{P}$ denotes the estimated probability that the sign of the forecast is correct.

Under the null hypothesis, the test statistic:

$$T_N = \frac{\widehat{P} - P_0}{\left\{ \widehat{V}(\widehat{P}) - \widehat{V}(\widehat{P_0}) \right\}^{1/2}},$$

where

$\widehat{V}(\widehat{P}) = N^{-1}\widehat{P}_0(1 - \widehat{P}_0),$

$\widehat{V}(\widehat{P_0}) = N^{-1}(2\widehat{P}_y - 1)^2\widehat{P}_x(1 - \widehat{P}_x) + N^{-1}(2\widehat{P}_x - 1)^2\widehat{P}_y(1 - \widehat{P}_y) + 4N^{-1}\widehat{P}_y\widehat{P}_x(1 - \widehat{P}_y)(1 - \widehat{P}_x),$

$\widehat{P}_0 = \widehat{P}_y\widehat{P}_x + (1 - \widehat{P}_y)(1 - \widehat{P}_x),$

of the predictive failure test is normally distributed $N(0, 1)$.

The test is based on the proportion of times that the direction of change in is correctly predicted in the sample. In the long run the underlying a sufficiently long time period the performance of most stock markets is positive.

For this reason an agent who always predicts the market returns to be positive will be right in more than 50 % of the cases, notwithstanding the test of Pesaran and Timmermann would be equal to zero. The null-hypothesis of the predictive failure test states that the forecast technique has no power to forecast the sign of the one step ahead excess return of the S&P/TSX Venture Composite Index, whereas the alternative hypothesis states that the forecasting technique does have predictive power.

In the period from the 1 February 2002 to 30 October 2009 there were 1946 returns on the S&P/TSX Venture Composite Index. 1091 (56.6 %) returns were positive and 855 (43.94 %) negative. As a consequence of the transformation process of the data, the length of the time series is reduced to 1945 observations. Given the Akaike Information Criterion the forecast of the excess return was estimated as positive 1186 times or 60.98 percent and negative 759 times or 39.02 percent. The AIC forecasted 60.98 % positive signs. Overall, 58.87 % of the forecasted signs were correct. The respective percentages were 62.21 % and 58.15 % for the BIC and 61.49 % and 59.69 % for the subset version of FPE.

Figure 5.2.1: Actual and Predicted Signs with AIC

	Forecast Positive	Forecast Negative
Actual Positive	732	346
Actual negative	454	413

Figure 5.2.2: Actual and Predicted Signs with BIC

	Forecast Positive	Forecast Negative
Actual Positive	737	341
Actual negative	473	394

Figure 5.2.3: Actual and Predicted Signs with FPEsub

	Forecast Positive	Forecast Negative
Actual Positive	745	333
Actual negative	451	416

These results indicate that the recursive modelling forecasts do have predictive ability and outperform a naïve forecast strategy. Since the excess return of the S&P/TSX Venture Composite Index was positive in 1083 cases or in 55.65 percent of times, an agent who always predicts a positive sign would forecast accurately in 55.65 % of the time. Thus, there is only evidence that the recursive modelling strategy is reasonable if the excess returns are correctly predicted in more than 55.65 % of times.

Table 5.2.4: Test Statistics of the Predictive Failure Test

Selection Criteria	Test Statistic
AIC	6.98
BIC	6.25
FPEsub	7.70

Table 5.2.4 shows the test statistic for the different model selection criteria. The test statistic is normally distributed and all values are therefore statistically significant. Hence the recursive forecasting technique can be used with all three criteria for predicting the sign of the one day ahead excess return of the index.

5.3 Forecasting Performance under Zero Transaction Costs

This section discusses the result of the investment strategy under the various model selection criteria and shows the performance for an initial capital stock of 1000 USD. The investment horizon is from 1 February 2002 until 30 October 2009.

We start with the simplest "buy and hold" investment strategy. If on 1 February 2002 an investor placed 1000 USD in the S&P/TSX Venture Composite Index and sold it on 30 October 2009, the initial capital would have grown to 1140.26 USD, which corresponds to 1.72 % annually. On the other hand if this agent invests in 30-day Canadian Treasury bills the capital would be equal to 1221.96 USD at the end of this period. This corresponds to an average rate of return of 2.64 percent.

Table 5.3.1: Portfolio Summary Statistics - Zero Transaction Costs

Transaction costs: 0.0 %	AIC	BIC	FPEsub	Buy and Hold
Final Capital:	15494.51	15167.14	19105.44	1140.26
Average Annual Return:	42.70 %	42.31 %	46.63 %	1.72 %
Average Daily Return:	0.14093 %	0.13983 %	0.15171 %	0.00675 %
Std. Deviation of Returns:	0.00889	0.00886	0.00904	0.01394
Proportion in Stocks:	61.00 %	62.23 %	61.51 %	100 %
Number of Switches:	758	792	744	0

Following the investment strategy under the Akaike Information Criterion the portfolio was switched between the index and the Treasury bills 758 times, so that the portfolio was adjusted on average every 2.57 days. During this investment horizon the initial capital grew to 15494.51 USD, or 42.70 percent annually. Of course this return is too good to be true. The problem is that we ignored transaction cost. We will account for them in the next section. Figure 5.3.2 depicts the recursive investment strategy and its alternatives under the AIC model selection criterion for zero transaction costs.

With the Bayesian Information Criterion the variable inclusion rates drop essentially and less explanatory variables contribute to forecast the one day ahead excess return. Under this criterion the portfolio was changed 792 times or on average every 2.46 days. The annual growth rate of capital was 42.31 percent which resulted in a final capital stock of 15167.14 USD which is slightly less compared to AIC.

The FPEsub criterion had inclusion rates of the explanatory variables between 97.84 and 54.01 %. The portfolio was switched 744 times or every 2.61 days. With the FPEsub criterion the sign of the one day ahead excess return was correctly forecasted in 59.66 percent of times, which is higher compared to AIC and BIC. The portfolio grew to 19105.44 USD, or 46.63 percent annually.

Figure 5.3.1: Capital Accumulation - Zero Transaction Costs (AIC)
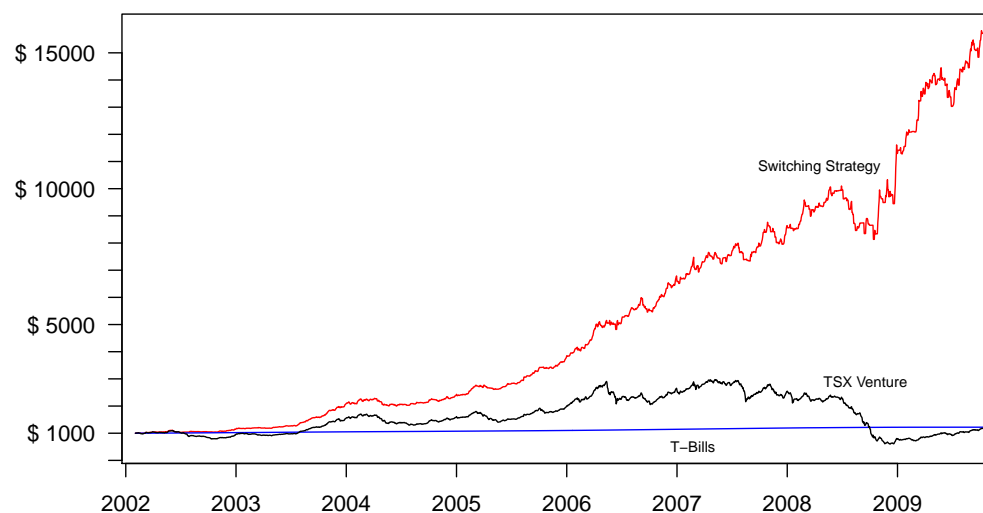
5.4 Implementation of Transaction Costs

Of course, the returns are negatively affected by transaction costs. Furthermore, a trader will only switch into another asset if the expected gains are high enough to justify a change of the portfolio. In fact this effect will reduce the number of trades and also affect the returns. The following tables present the findings when we account for different levels of transaction costs:

Table 5.4.1: Portfolio Summary Statistics - 0.1 % Transaction Costs

Transaction costs: 0.1 %	AIC	BIC	FPEsub	Buy and Hold
Final Capital:	12968.96	12718.19	12184.55	1140.26
Average Annual Return:	39.45 %	39.09 %	38.32 %	1.72 %
Average Daily Return:	0.13177 %	0.13077 %	0.12856 %	0.00675 %
Std. Deviation of Returns:	0.00887	0.00892	0.00882	0.01394
Proportion in Stocks:	64.59 %	68.14 %	64.90 %	100 %
Number of Switches:	510	520	514	0

Table 5.4.2: Portfolio Summary Statistics - 0.25 % Transaction Costs

Transaction costs: 0.25 %	AIC	BIC	FPEsub	Buy and Hold
Final Capital:	8871.99	8611.09	8918.16	1140.26
Average Annual Return:	32.74 %	32.22 %	32.83 %	1.72 %
Average Daily Return:	0.11224 %	0.11070 %	0.11250 %	0.00675 %
Std. Deviation of Returns:	0.00929	0.00939	0.00937	0.01394
Proportion in Stocks:	67.73 %	71.58 %	69.22 %	100 %
Number of Switches:	290	298	290	0

Table 5.4.3: Portfolio Summary Statistics - 0.5 % Transaction Costs

Transaction costs: 0.5 %	AIC	BIC	FPEsub	Buy and Hold
Final Capital:	3214.17	4532.72	3431.54	1140.26
Average Annual Return:	16.36 %	21.66 %	17.35 %	1.72 %
Average Daily Return:	0.06002 %	0.07769 %	0.06338 %	0.00675 %
Std. Deviation of Returns:	0.00880	0.00870	0.00903	0.01394
Proportion in Stocks:	54.73 %	56.47 %	57.19 %	100 %
Number of Switches:	126	120	122	0

Table 5.4.4: Portfolio Summary Statistics - 1.0 % Transaction Costs

Transaction costs: 1 %	AIC	BIC	FPEsub	Buy and Hold
Final Capital:	588.50	992.57	1152.08	1140.26
Average Annual Return:	-6.65 %	-0.10 %	1.85 %	1.72 %
Average Daily Return:	-0.02724 %	-0.00038 %	0.00727 %	0.00675 %
Std. Deviation of Returns:	0.00931	0.00866	0.01116%	0.01394
Proportion in Stocks:	36.84 %	34.64 %	72.35 %	100 %
Number of Switches:	24	26	25	0

These results show in the case of low transaction costs (less than 1 %) for all model selection criteria, the switching strategy outperformed the buy and hold strategy during the sample period. From table 5.4.1 to 5.4.4 it can be seen that with 0.1 % transaction costs the average annual return is about 39 percent. When transaction costs increase to 0.25 % the return is 32.5 percent and for 0.5 % transaction costs the average annual return would be about 18 percent. Transaction costs of 1 % practically erase all profits. In Figures 5.4.1 to 5.4.4 the switching strategy is shown only for the AIC.

Figure 5.4.1: Capital Accumulation - 0.1 % Transaction Costs[1] (AIC)
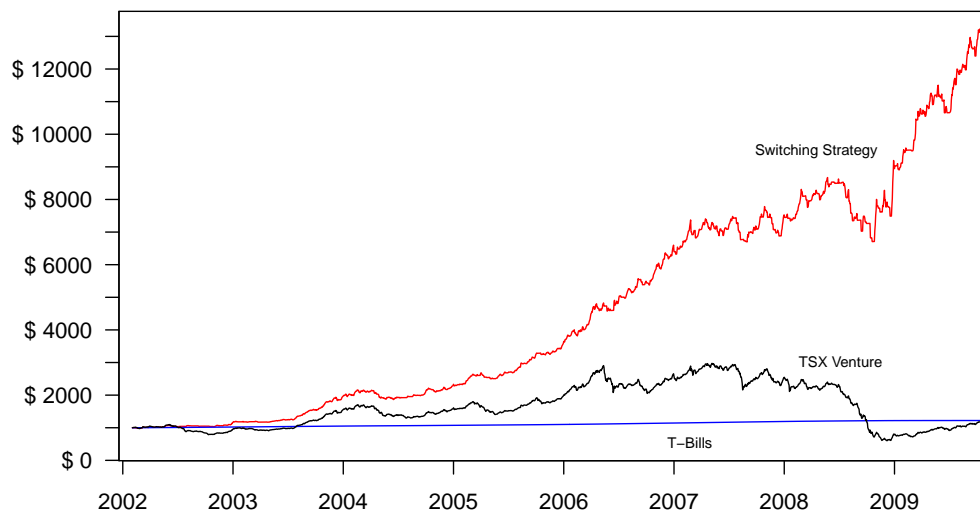
[1] All Transaction costs include the costs of selling an asset and buying a new asset.

Figure 5.4.1 depicts the path of capital accumulation when 1000 USD were invested in 1 February 2002. Until 30 October 2009 the performance with all three information criteria was about 39 % per year. Many times the switching strategy was able to forecast and thereby avoid downward trends but was flexible enough to reinvest in the stock market later.

Figure 5.4.2: Capital Accumulation - 0.25 % Transaction Costs (AIC)
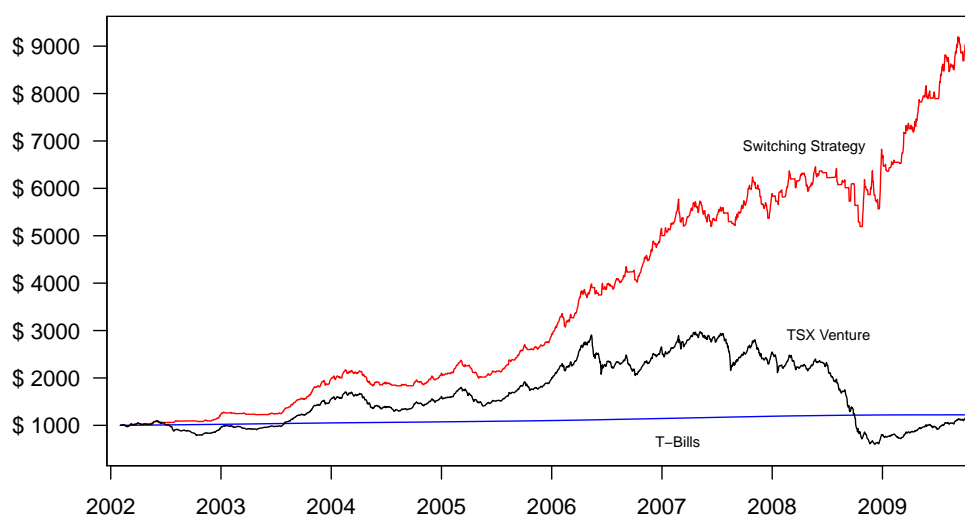
With transaction costs of 0.25 % the average annual returns decreased to about 8800 USD or 32.5 percent annually. The number of changes in the portfolio declined to about 290 and the proportion of investments in stocks was 70 percent. Just like with transaction of 0.1 percent the switching strategy outperforms the "buy and hold" alternative from the early sample period.

Figure 5.4.3: Capital Accumulation - 0.5 % Transaction Costs (AIC)
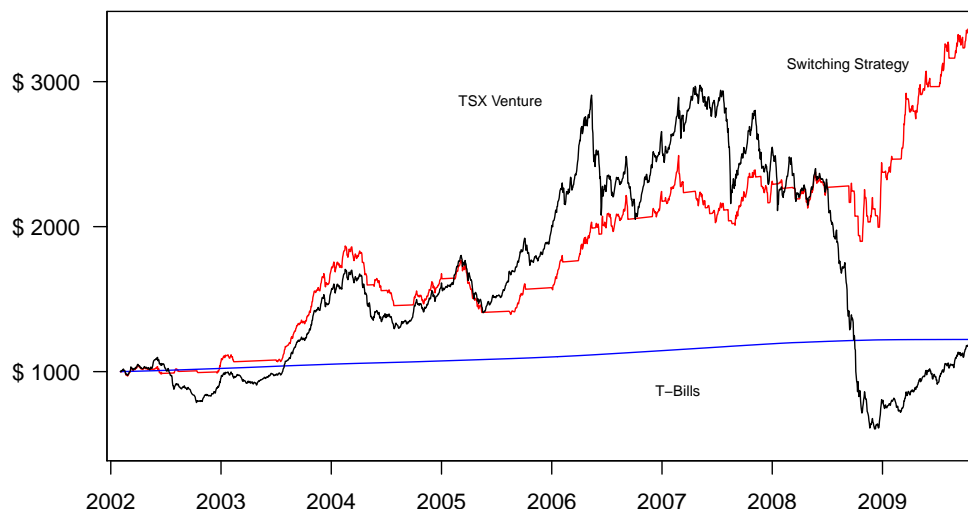
The results with transaction costs of 0.5 % are especially interesting since our findings on transaction costs for individuals trading via online stock broking companies are about 0.46 percent[2]. Figure 5.4.3 shows that, with transaction costs of 0.5 %, the switching strategy outperformed the buy and hold strategy only because of the huge drop of the stock market in 2008. To be more precisely between 2 July 2008 and 31 December 2008 the S&P/TSX Venture Composite Index fell from 2651.89 points to 797.02 and lost about 73 % of its value. During this time the switching strategy with the AIC as model selection criterion was invested in Canadian 30-day Treasury bills in 66 % of the times. From 2 January 2009 to the 30 October 2009 the stock market rebound and climbed to the mark of 1291.41 points, which corresponds to a raise of 62.03 %. Most of the time the portfolio captured this upward trend, which resulted in a rapid increase until the end of the investment horizon.

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[2]including all charges and fees

For the sake of completeness, Figure 5.4.4 presents the results for 1 % transaction costs, although they are unrealistically high for most investors. For both AIC and BIC the proportion in stocks was about 35 % and yields a negative performance. With the model selection criterion FPEsub the portfolio was invested 72.35 % of the times in stocks, however the result was only slightly better with an average annual return of 1.85 %.

Figure 5.4.4: Capital Accumulation - 1.0 % Transaction Costs (AIC)
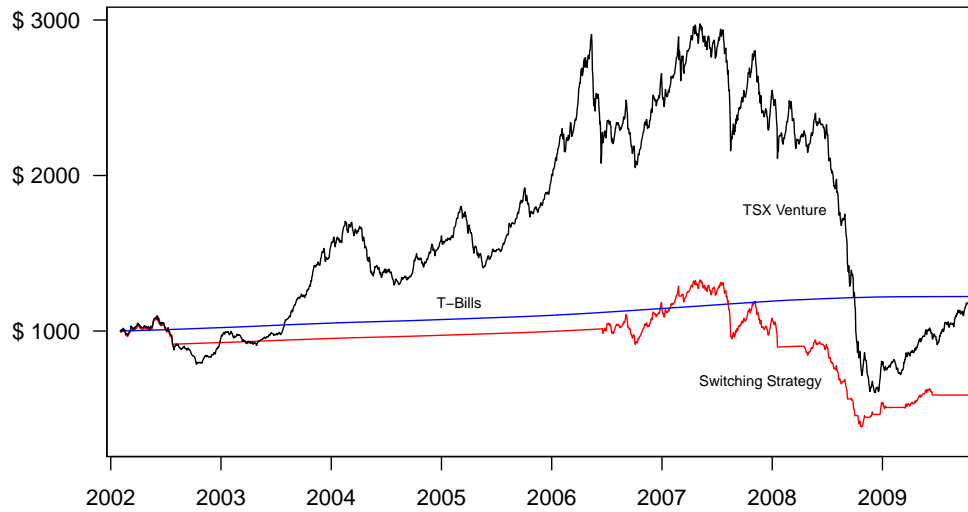
We also arranged two fixed scheme settings. For the first we only used one explanatory variable ρ_t, for the second we always included the whole base set of variables to forecast the one day ahead excess return of the S&P/TSX Venture Composite Index ρ_{t+1}. The results indicate that the switching strategy for transaction costs up to 0.25 % was better in the mixed setting for all three model selection criteria compared to both of the fixed scheme settings. However, for large transaction costs the fixed settings achieved a higher final capital stock. This was because the portfolio remained in the Canadian 30-day Treasury bills until the early 2009. Then the portfolio was shifted into the stock market where its value grew rapidly. Still it seems that there will be a need for further research in order to compare fixed scheme settings with recursive modelling techniques.

6 Concluding Remarks

In our thesis we used a recursive forecasting technique to predict the excess returns of the Canadian S&P/TSX Venture Composite Index over the Canadian 30-day Treasury bills. Thereby eight financial and macroeconomic variables establish the constant base set from which optimal subsets of variables were selected with different model selection criteria at each time. Forecasts of the sign of the excess return deliver information if a rational investor should hold Canadian Treasury bills or rather invest in the stock market.

Our results indicate that one day ahead excess returns of the Canadian S&P/TSX Venture Composite Index are forecastable. Since transaction costs should be taken into account we ran simulations of the switching strategy that covers different levels of transaction costs. The findings show that even with transaction costs of 0.5 %, it was possible to outperform the stock index. However, this is mainly a result of the crash in 2008 where the strategy switched to Treasury bills. For 0.25 % transaction costs the recursive trading technique was effective during the sample period.

With transaction costs of 0.5 % the portfolio changed about 120 times. Certainly in the case of frequent trading and transaction costs higher than zero, switches into short term treasury bills will almost always end up with negative returns. Therefore we modified the methodology, used cash as the risk free asset and made forecasts on the returns instead of the excess returns. Even though the costs could be reduced, the overall improvement on the performance was only marginal.

We also applied our calculations to the Canadian TSE 300 Index in order to approve of the results of K.J. Edwards in 2000. Thereby we run our simulations not only to that time period but also on the following years until October 30, 2009. These results can be found in the Appendix B. Our findings indicate the efficiency of the Canadian stock market remain unchanged since the pattern of capital accumulation under different transaction costs exhibit a similar structure.

7 Appendix A

7.1 Plots of all Variables

This section depicts the plots of all the explanatory variables that are contained in the base set. As explained in 4.2 some of the variables where transformed in order to account for stationarity. This requirement holds for all variables.

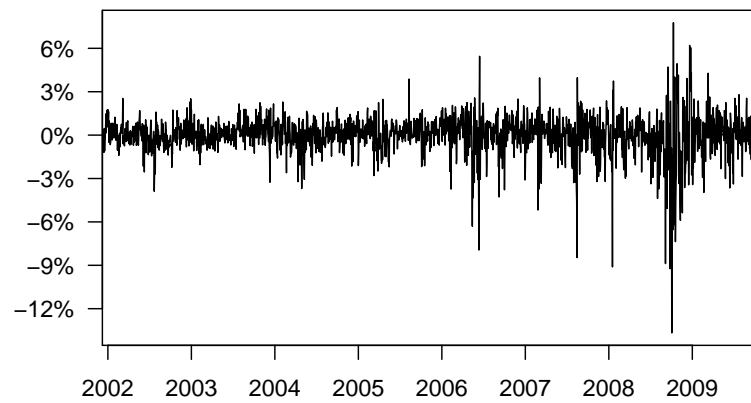Figure 7.1.1: S&P/TSX Venture Composite Index - Daily Excess Returns

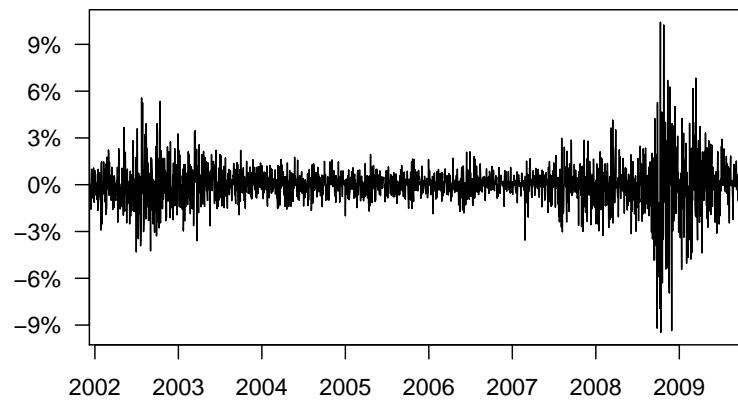Figure 7.1.2: S&P 500 Composite Index - Daily Excess Returns
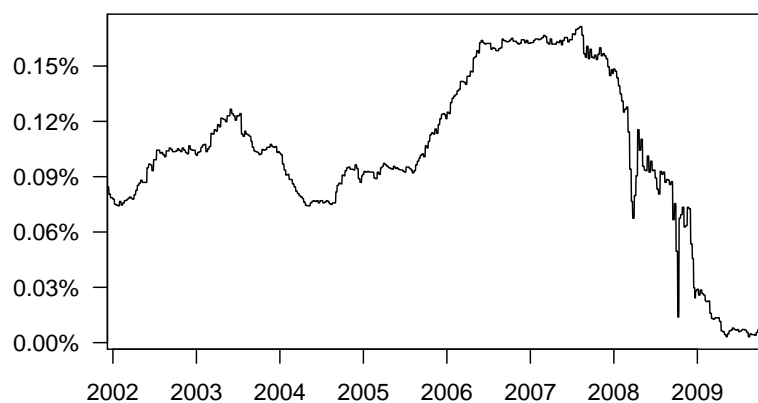
Figure 7.1.3: 30-Day Canadian Treasury Bills - Daily Returns

Figure 7.1.4: 30-Day US Treasury Bills - Daily Returns
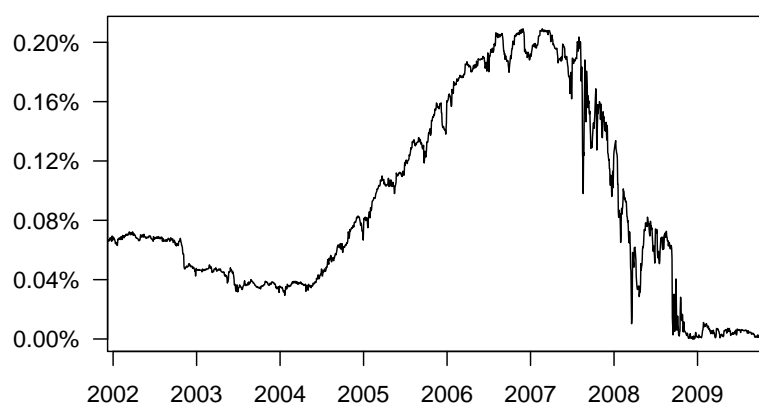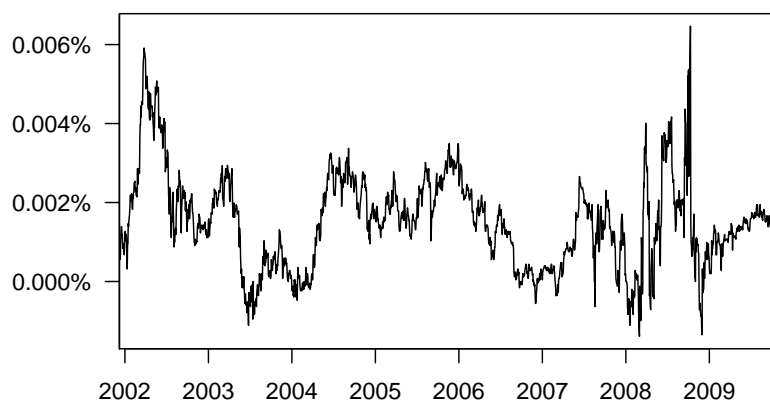

Figure 7.1.5: Canadian Yield Spread

Figure 7.1.6: US Yield Spread
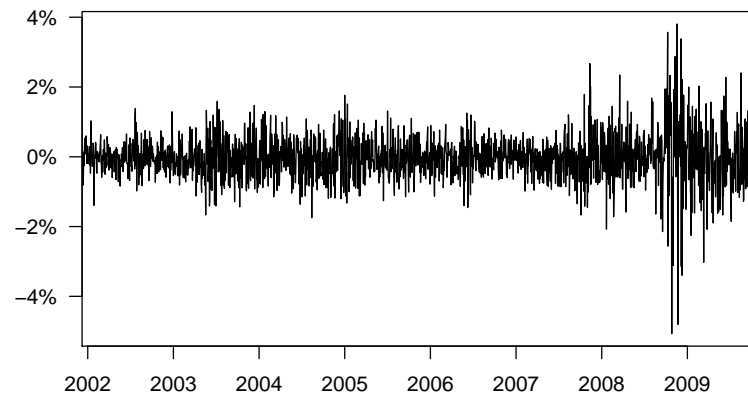

Figure 7.1.7: Exchange Rate ($CAN/$US)
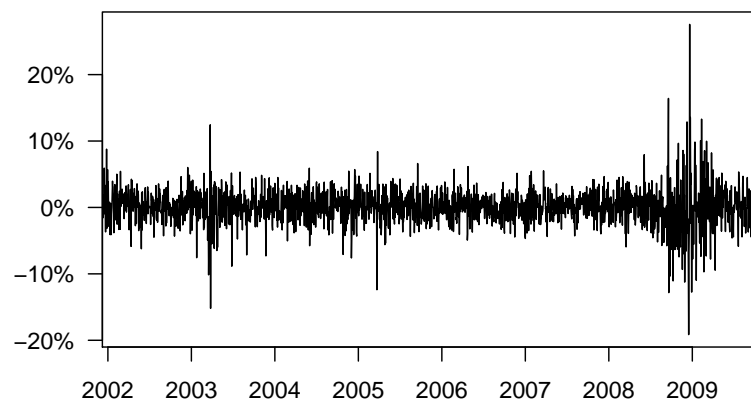

Figure 7.1.8: Growth Rate of WTI Spot Oil Price

8 Appendix B

8.1 TSE 300 Composite Index

The following pages show the results obtained by applying the recursive forecasting strategy to the Canadian TSE 300 index. We did not include the West Texas Intermediate spot oil price to make our results comparable to those obtained by K.J. Edwards (2000). Since the data for the US 30-day treasury bill rate was not available before the end of July 2001 we used the US 90-day treasury bill rate instead.

8.2 Performance Jan. 3, 1989 to May 28, 1999

Table 8.2.1: Average Annual Return of the TSX 300 Index[1]

	AIC	BIC	FPEsub
Transaction costs: 0.0 %	26.00 %	26.49 %	26.00 %
Transaction costs: 0.1 %	17.52 %	15.68 %	17.52 %
Transaction costs: 0.25 %	8.66 %	10.33 %	8.66 %
Transaction costs: 0.5 %	-0.46 %	2.22 %	-0.46 %

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[1]During this period the TSE 300 Index yield average annual returns of 6.22 percent.

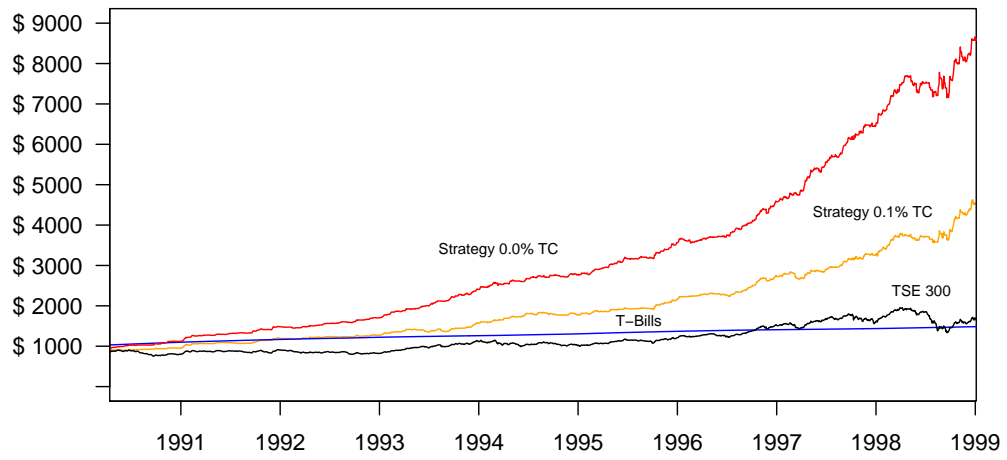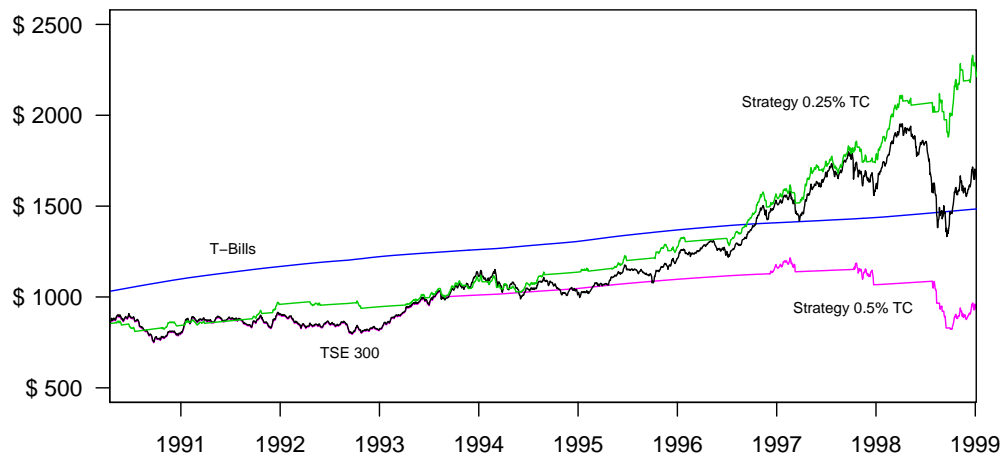Figure 8.2.1: Capital Accumulation - 0.0 % & 0.1 % Transaction Costs (AIC)

Figure 8.2.2: Capital Accumulation - 0.25 % & 0.5 % Transaction Costs (AIC)
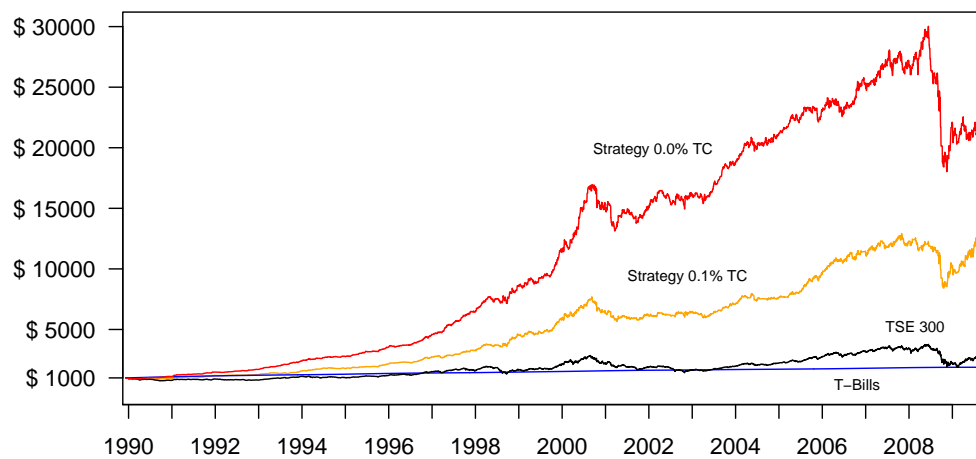
8.3 Performance Jan. 3, 1989 to Oct. 30, 2009

Table 8.3.1: Average Annual Return of the TSX 300 Index[2]

	AIC	**BIC**	**FPEsub**
Transaction costs: 0.0 %	17.60 %	17.48 %	17.56 %
Transaction costs: 0.1 %	14.23 %	12.73 %	14.25 %
Transaction costs: 0.25 %	10.03 %	7.70 %	9.92 %
Transaction costs: 0.5 %	2.52 %	4.04 %	2.52 %

Figure 8.3.1: Capital Accumulation - 0.0 % & 0.1 % Transaction Costs (AIC)

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[2]During this period the TSE 300 Index yield average annual returns of 4.60 percent.

Figure 8.3.2: Capital Accumulation - 0.25 % & 0.5 % Transaction Costs (AIC)
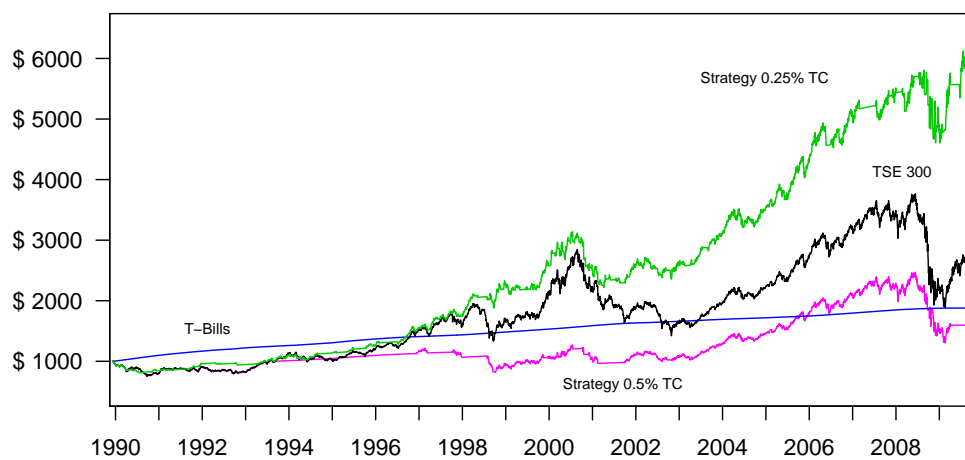
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SHARPE, W.F., (1964): *Capital asset prices: A theory of market equilibrium under conditions of risk*, Journal of Finance, Vol.19(3), pp. 425-442.

VAN ANTWERP, W.C., (1913): *The Stock Exchange from within.* Doubleday, Page & company Garden City, N.Y

Abstract

Daily financial and macroeconomic variables are used to forecast one day ahead excess returns on the S&P/TSX Venture Composite Index using a recursive forecasting technique. Out of this base set of variables, different model selection criteria are used to chose an optimal subset that is used to run the forecasts at each point in time. On this basis, a rational agent decides to invest either in the stock index or in 30-day Canadian Treasury bills, depending on which asset is predicted to have a higher return. Simulations show the performance of an initial capital stock for the time horizon between 1 February 2002 and 30 October 2009, thereby considering different levels of transaction costs. The results indicate that even for 0.25 percent transaction costs the switching strategy outperforms the buy and hold strategy for the sample time period.

Zusammenfassung

Diese Arbeit prognostiziert mit Hilfe von finanziellen und makroökonomischen Variablen den Mehrertrag des Kanadischen S&P/TSX Venture Composite Index über 30-tägige Staatsanleihen. Anhand von Informationskriterien wird in jeder Zeitperiode das optimale Subset aus einem konstanten Basisset erklärender Variablen gewählt und für eine Schätzung verwendet. Diese Schätzung stellt die Entscheidungsgrundlage dar, aufgrund dessen das Portfolio entweder in Aktien oder Staatsanleihen gehalten wird. Durch Simulationen wird die daraus resultierende Kapitalentwicklung über den Zeitraum vom 1. Februar 2002 bis zum 30. Oktober 2009 berechnet. Dabei werden unterschiedlichste Transaktionskosten berücksichtigt. Die Resultate zeigen, dass eine rekursive Wechselstrategie in der zugrunde liegenden Zeitperiode auch bei Transaktionskosten von 0,25 Prozent eine „buy and hold" Strategie übertrifft.

Lebenslauf

Persönliche Daten:

Vorname/ Nachname:	Christian Holzmann
Adresse:	Geblergasse 54/11
Email:	christian.holzmann@oeh.univie.ac.at
Geburtsdaten:	12.12.1980, Bregenz
Staatsbürgerschaft:	Österreich / Schweiz

Ausbildung:

10/2006	dato	Studium der Statistik
		Universität Wien
10/2005	05/2010	Studium der Volkswirtschaftslehre
		Universität Wien
08/2007	02/2008	Auslandsaufenthalt
		Universität Zürich
09/2001	01/2005	Abendmatura
		Volkshochschule Bregenz
09/1996	02/2000	Lehre als Werkzeugmacher
		Ausbildungsstelle: Alpla-Werke, Hard

Berufserfahrung:

09/2001	11/2004	CNC-Fräser / CNC-Dreher
		Firma Steiger, Rheineck, Schweiz
03/2000	06/2001	CNC-Fräser / Programmierer für Pilot-Formenbau
		Alpla-Werke, Hard, Österreich

Sonstige Erfahrung:

01/2006	12/2009	Studienrichtungsvertretung Volkswirtschaftslehre
		Mitarbeit bei der StudentInnenzeitung, Teilnahme an
		Fakultätskonferenzen, Institutskonferenz, interne Seminare, etc.
10/2006	01/2007	Tutor für erstsemestrige Studierende
02/2005	09/2005	Reisen in diverse nordafrikanische und asiatische Länder

Wien, Mai 2010