

TABLES

TABLE 1: FINANCIAL MARKET FORECASTING STUDIES: DESIGN DIFFERENCES

Study	Modeling subject	Market	Forecasting horizon	Prediction Method		Dynamic simulation	Technical indicators	Subject of prediction			Result discussed re EMH
				SVM	ANN			Change direction	Price change	Trading Strategy	
Ornoneit and Neuneier (1996)	Index	German	Hourly		X						
Steiner and Wittkempfer (1997)	Stock	German	Daily		X	YES				X	YES
Kuo et al. (2001)	Index	Taiwan	Daily		X		YES				X
Chen et al. (2003)	Index	Taiwan	Monthly		X		YES				X
Mittermayr (2004)	Stock	U.S.	Hourly	X							X
Zhang et al. (2004)	Index	China	Daily		X		YES				X
Vanstone et al. (2005)	Stock	Australia	Daily		X		YES				X
Pan et al. (2005)	Index	Australia	Daily		X		YES	X (80%)			
Huang et al. (2005)	Index	Japan	Weekly	X				X (75%)			
Armano et al. (2005)	Index	U.S.	Daily		X		YES				X
Chen and Ho (2005)	Index	Taiwan	Daily	X			YES		X		
Doeksen et al. (2005)	Stock	U.S.	Daily		X		YES				X
Bodyanskiy and Popov (2006)	Index	U.S.	Daily		X			X (72%)	X		
Qian and Rasheed	Index	U.S.	Daily		X	YES	YES	X (65%)			

(2007)									
Hassan et al. (2007)	Stock	U.S. stocks	Daily		X		YES		X
Tseng et al. (2008)	Index	Taiwan	Daily		X		YES		X
Huang et al. (2008)	Index	Taiwan, Korea	Daily	X	X		YES	X (80%)	
Schumaker and Chen (2009)	Index	U.S.	Daily	X					X
Zhang and Wu (2009)	Index	U.S.	Daily		X		YES		X
Chang et al. (2009)	Stock	Taiwan	Daily		X		YES		X
Lee (2009)	Index	U.S.	Daily	X			YES	X (87%)	
Tsai and Hsiao (2010)	Stock	Taiwan	Season		X	YES		X (78%)	
Hadavandi et al. (2010)	Stock	U.S.	Daily		X				X
Huck (2010)	Stock	U.S.	Weekly		X		YES		X
Bollen et al. (2011)	Index	U.S.	Daily		X				X
Kara et al. (2011)	Index	Turkey index	Daily	X	X		YES	X (75%)	
Dai et al. (2012)	Index	Taiwan, Hong Kong, Japan	Daily	X			YES		X
de Oliveira et al. (2013)	Index	Brazil index	Monthly		X		YES	X (86%)	
Ballings et al. (2015)	Stock	Europe	Year	X	X		YES	X (70%)	
Patel et al. (2015)	Index	India	Daily	X	X		YES	X (90%)	

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\* Ormoneit and Neuneier (1996) predict hourly volatility.

TABLE 2: SUMMARY OF THE EXPERIMENTAL SETUP

Experimental factor	Factor Hypotheses	levels
Market maturity	High income level vs. middle income level	H1a,b
Model simulation methodology	Sliding-window cross-validation vs. a static evaluation	H2a,b
Covariate composition	Simple price covariates vs. simple price covariates combined with technical indicators	H3a,b
Forecast horizon	Daily vs. hourly	H4a,b
Prediction method	SVM vs ANN	H5a,b
	SVM vs AR	H6a,b

TABLE 3: SUMMARY OF THE FINANCIAL MARKET DATA SET

No.	Economy	Region	Income Level	Index	Code	Start Date	End Date
1	US	America	High	S&P 500 SP TSX	SP	1/2/2008	19/2/2014
2	Canada	America	High	Composite Index	TS	1/2/2008	19/2/2014
3	Japan	Asia & Pacific	High	Nikkei 225	NE	1/2/2008	19/2/2014
4	Korea	Asia & Pacific	High	KOSPI 200 Index	KM	1/2/2008	19/2/2014
5	Hong Kong	Asia & Pacific	High	Hang Seng Index	HI	1/2/2008	19/2/2014
6	Singapore	Asia & Pacific	High	Straits Times Index	ST	1/2/2008	19/2/2014
7	China	Asia & Pacific	Middle	ShangHai SE Composite Index	SH	1/2/2008	19/2/2014
8	Malaysia	Asia & Pacific	Middle	FTSE Bursa Malaysia KLCI Index	KL	1/2/2008	19/2/2014
9	Thailand	Asia & Pacific	Middle	Thai Stock Exchange MAI Securities Index	TH	1/2/2008	19/2/2014
10	Indonesia	Asia & Pacific	Middle	Jakarta Composite Index	JC	1/2/2008	19/2/2014
11	France	Europe	High	CAC 40	CF	1/2/2008	19/2/2014
12	UK	Europe	High	FTSE 100	FT	1/2/2008	19/2/2014
13	Italy	Europe	High	FTSE MIB Index	II	1/2/2008	19/2/2014
14	Germany	Europe	High	DAX	DA	1/2/2008	19/2/2014
15	Hungary	Europe	Middle	BUX	BU	1/2/2008	19/2/2014
16	South Africa	Africa	Middle	FTSE/JSE Africa Top40	TO	1/2/2008	19/2/2014
17	Turkey	Middle East	Middle	ISE-100	TU	1/2/2008	19/2/2014
18	Switzerland	Europe	High	Swiss Market Index	SW	1/2/2008	19/2/2014
19	Spain	Europe	High	IBEX 35	IB	1/2/2008	19/2/2014
20	Netherland	Europe	High	AEX	AE	1/2/2008	19/2/2014
21	Belgium	Europe	High	BEL20	BE	1/2/2008	19/2/2014
22	Portugal	Europe	High	PSI-20	PP	1/2/2008	19/2/2014
23	Sweden	Europe	High	OMX ALL- SHARE Stockholm Index	SM	1/2/2008	19/2/2014
24	Norway	Europe	High	OSE All Share Index	OL	1/2/2008	19/2/2014
25	Denmark	Europe	High	OMX Copenhagen Index	KA	1/2/2008	19/2/2014

26	Finland	Europe	High	OMXH25	HE	1/2/2008	19/2/2014
27	Austria	Europe	High	ATX	AT	1/2/2008	19/2/2014
28	Czech	Europe	High	Prague Stock Exchange Index	PS	1/2/2008	19/2/2014
29	Lithuania	Europe	High	OMX Vilnius Index	VI	1/2/2008	19/2/2014
30	Estonia	Europe	High	OMX Tallinn Index	TA	1/2/2008	19/2/2014
31	Latvia	Europe	High	OMX Riga Index	RI	1/2/2008	19/2/2014
32	US	America	High	Dow Jones Industrial Average	DJ	1/2/2008	19/2/2014
33	US	America	High	NASDAQ- 100	ND	1/2/2008	19/2/2014
34	Brazil	America	Middle	Brazilian Bovespa Futures	BR	06/01/2010	19/2/2014

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TABLE 4: COVARIATES EMPLOYED IN THE FINANCIAL TIME SERIES FORECASTING MODELS

	Covariate	Definition	Papers where covariate employed
Price-based covariates	<b>Opening price in period <math>t</math>.</b>	$OI_t$	
	<b>Highest price in period <math>t</math></b>	$HI_t$	
	<b>Lowest price in period <math>t</math></b>	$LI_t$	
	<b>Closing price in period <math>t</math></b>	$CI_t$	
Indicators from the field of technical analysis	<b>Simple Moving Average (SMA)</b> SMA is the average closing price in a fixed length moving window. We calculate SMA for 5, 10 and 20 periods.	$SMA_{t,n} = \frac{\sum_{i=0}^{n-1} CI_{t-i}}{n}$	Hassan et al. (2007), Hadavandi et al. (2010), Huck (2010), Bollen et al. (2011)
	<b>Moving Average Convergence / Divergence (MACD)</b> MACD is the difference between a longer and a shorter exponentially weighted moving average (EMA). In general, a buy/sell signal is triggered when the MACD line crosses the zero line, which is usually a nine-day EMA. Our models use MACD and a nine-day EMA as covariates	$EMA_{t,n} = EMA_{t-1,n} + \frac{2(CI_t - EMA_{t-1,n})}{n+1}$ $MACD_{t,n} = EMA_{t,12} - EMA_{t,26}$	Hassan et al. (2007), Bollen et al. (2011)
	<b>Relative Strength Index (RSI)</b> The RSI indicates whether a market is overbought. We calculate RSI for 6, 9 and 14 periods.	$RSI_{t,n} = \frac{\sum_{i=0}^{n-1} (CI_{t-i} - CI_{t-i-1}) \times I\{CI_{t-i} - CI_{t-i-1}\}}{\sum_{i=0}^{n-1}  CI_{t-i} - CI_{t-i-1} } \times 100$	Huck (2010), Bollen et al. (2011)
	<b>Williams %R</b> Williams %R represents the relative position of the current share value in the past n periods. We use n=5 and n=10 periods.	$WilliamsR_{t,n} = \frac{HHI_{t,n} - CI_t}{HHI_{t,n} - LLI_{t,n}} \times -100,$	Hassan et al. (2007), Hadavandi et al. (2010), Bollen et al. (2011)
	<b>Accumulation/Distribution Oscillator (ADO)</b> Given some financial time series, the ADO measures the strength of an upward/downward trend.	$ADO_t = \frac{(HI_t - OI_t) + (CI_t - LI_t)}{2 \times (HI_t - LI_t)} \times 100,$	Hadavandi et al. (2010)

**Stochastic Oscillator (SO)**

SO compares the current share price to the values in the past 10 days. We include the %K and %D variables in our models.

$$StochasticK_t = \frac{CI_t - LLI_{t,10}}{HHI_{t,10} - LLI_{t,10}}$$

$$StochasticD_t = \frac{\sum_{i=0}^2 StochasticK_{t-i}}{3}$$

Hassan et al. (2007),  
Hadavandi et al. (2010)

**Bollinger Bands (BB)**

BB consist of a middle, upper, and lower line. Advocates of BB believe that the trend is likely to revert when share prices approach the upper or lower line. To accommodate BB, we consider three covariates: mid, upper and lower values.

$$BollingerMid_t = SMA_{t,20}$$

$$BollingerUp_t = BollingerMid_t + 2 \times \sigma_{t,20}$$

$$BollingerLow_t = BollingerMid_t - 2 \times \sigma_{t,20}$$

Bollen et al. (2011)

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\* Our notation is as follows:  $CI_t$  is the closing price of a share/index in period  $t$ .  $OI_t$ ,  $HI_t$ , and  $LI_t$  denote, respectively, the opening, highest, and lowest price in period  $t$ . We use  $n$  to denote the length of the window of a moving average.  $I\{x\}$  is an indicator function, which is one if  $x$  is true and zero otherwise.  $HHI_{t,n}$  is the highest share price observed in period  $t-n$  to  $t$ . Similarly,  $LLI_{t,n}$  is the lowest price observed in period  $t-n$  to  $t$ . Last,  $\sigma_{t,20}$  is the standard deviation of  $CI_t$  calculated over the period  $t-20$  to  $t$ . The literature column lists the studies which adopt the indicator.

TABLE 5: CANDIDATE VALUES FOR SVM AND ANN META-PARAMETERS

ANN	Hidden layer neurons	6, 18, 48
	$\lambda$	1, 100, 0, 0.01
SVM	$\lambda$	$2^{-10}, 2^{-8}, 2^{-6}, 2^{-4}, 2^{-2}, 1, 2^2, 2^4, 2^6, 2^8,$ $2^{10}$
	$\gamma$	$2^{-10}, 2^{-8}, 2^{-6}, 2^{-4}, 2^{-2}, 1, 2^2, 2^4, 2^6, 2^8,$ $2^{10}$



TABLE 6: REGRESSION ANALYSIS OF PREDICTIVE ACCURACY – ML TECHNIQUES

Predictive accuracy	Estimated Coefficient	Std. Error	t value	p value	Cohen's d	partial $\eta^2$
(Intercept)*	0.5081	0.0023	221.4	$< 10^{-16}$		
Market maturity (MI)	-0.0103	0.0023	-4.389	$< 10^{-4}$	0.4016	0.0346
Model simulation methodology (ST)	0.0086	0.002	4.319	$< 10^{-4}$	0.3350	0.0335
Covariate composition (T)	-0.0001	0.002	-0.037	0.971	0.0028	0.0000
Forecast horizon (D)	0.0174	0.002	8.748	$< 10^{-16}$	0.7105	0.1245
Prediction method (SVM)	0.0106	0.002	5.315	$< 10^{-6}$	0.4154	0.0499
Residual standard error	0.02323	df	538			
R <sup>2</sup>	0.2096	Adjusted R <sup>2</sup>	0.2023			
F-statistic	28.54	(on 5 and 538 DF)				
p-value	$< 2.2^{-16}$					

\* Base model indicated by values of experimental factors given in brackets: MI: Middle income markets; ST: Static simulation methodology; T: Technical indicators included amongst the covariates; D: Forecast horizon of one day; SVM: Prediction method employed is SVM

TABLE 7: REGRESSION ANALYSIS OF ROI – ML TECHNIQUES

ROI	Estimated Coefficient	Std. Error	t value	p value	Cohen's d	partial $\eta^2$
(Intercept)*	1.1764	0.02228	52.8	< $10^{-16}$		
Market maturity (MI)	-0.1496	0.02280	-6.564	< $10^{-8}$	0.6264	0.0741
Model simulation methodology (ST)	0.1021	0.01934	6.015	< $10^{-6}$	0.4220	0.0492
Covariate composition (T)	-0.0168	0.01934	-0.867	0.3864	0.0679	0.0014
Forecast horizon (D)	-0.0442	0.01934	-2.285	<b>0.0227</b>	0.1795	0.0096
Prediction method (SVM)	0.1163	0.01934	5.277	< $10^{-8}$	0.4842	0.0630
Residual standard error	0.2255	df	538			
R <sup>2</sup>	0.1737	Adjusted R <sup>2</sup>	0.166			
F-statistic	22.62	(on 5 and 538 DF)				
p-value	< $2.2^{-16}$					

\* Base model indicated by values of experimental factors given in brackets: MI: Middle income markets; ST: Static simulation methodology; T: Technical indicators included amongst the covariates; D: Forecast horizon of one day; SVM: Prediction method employed is SVM

TABLE 8: REGRESSION ANALYSIS OF PREDICTIVE ACCURACY – SVM vs. AR

Predictive accuracy	Estimated Coefficient	Std. Error	t value	p value	Cohen's d	partial $\eta^2$
(Intercept)*	0.5067	0.0026	192.11	$< 10^{-16}$		
Market maturity (MI)	-0.0094	0.0027	-3.4973	<b>0.0005</b>	0.3680	0.0295
Model simulation methodology (ST)	0.0055	0.0023	2.4191	<b>0.016</b>	0.2146	0.0143
Covariate composition (T)	-0.0003	0.0028	-0.1049	0.9165	0.2394	0.00002
Forecast horizon (D)	0.0183	0.0023	7.9853	$< 10^{-13}$	0.7528	0.1369
Prediction method (SVM)	0.0129	0.0028	4.6147	$< 10^{-5}$	0.5068	0.0503
Residual standard error	0.0231	df	403			
R <sup>2</sup>	0.2142	Adjusted R <sup>2</sup>	0.2045			
F-statistic	21.92	(on 4 and 403 DF)				
p-value	$< 10^{-16}$					

\*Base model indicated by values of experimental factors given in brackets: MI: Middle income markets; ST: Static simulation methodology; T: Technical indicators included amongst the covariates; D: Forecast horizon of one day; SVM: Prediction method employed is SVM

TABLE 9: REGRESSION ANALYSIS OF ROI – SVM vs. AR

ROI	Estimated Coefficient	Std. Error	t value	p value	Cohen's d	partial $\eta^2$
(Intercept)*	1.1576	0.0242	47.832	$< 10^{-16}$		
Market maturity (MI)	-0.186	0.0248	-7.5092	$< 10^{-12}$	0.8183	0.1230
Model simulation methodology (ST)	0.0718	0.021	3.4181	<b>0.0007</b>	0.3018	0.0282
Covariate composition (T)	-0.0245	0.0257	-0.9515	0.3419	0.2402	0.0022
Forecast horizon (D)	-0.0466	0.021	-2.2188	<b>0.0271</b>	0.1946	0.0121
Prediction method (SVM)	0.1638	0.0257	6.3665	$< 10^{-9}$	0.6598	0.0916
Residual standard error	0.2122	df	403			
R <sup>2</sup>	0.2301	Adjusted R <sup>2</sup>	0.2206			
F-statistic	29.82	(on 4 and 403 DF)				
p-value	$< 10^{-16}$					

\*Base model indicated by values of experimental factors given in brackets: MI: Middle income markets; ST: Static simulation methodology; T: Technical indicators included amongst the covariates; D: Forecast horizon of one day; SVM: Prediction method employed is SVM

Table 10: REGRESSION ANALYSIS OF SLIDING WINDOW SIZE

	Predictive accuracy				ROI			
	Estimated Coefficient	Std. Error	t value	p value	Estimated Coefficient	Std. Error	t value	p value
(Intercept)*	0.5148	0.0019	273.52	<math>10^{-16}</math>	1.2286	0.0176	69.678	<math>10^{-16}</math>
Market maturity (MI)	-0.0086	0.0016	-5.265	<math>10^{-6}</math>	-0.1328	0.0154	-8.636	<math>10^{-16}</math>
Sliding Window Size 25 (SW25)	-0.0114	0.0020	-5.769	<math>10^{-7}</math>	-0.1224	0.0184	-6.632	<math>10^{-8}</math>
Sliding Window Size 50 (SW50)	-0.0086	0.0020	-4.369	<b>0.0001</b>	-0.1021	0.0184	-5.532	<math>10^{-7}</math>
Sliding Window Size 100 (SW100)	-0.0083	0.0020	-4.201	<math>10^{-4}</math>	-0.1029	0.0184	-5.578	<math>10^{-7}</math>
Covariate composition (T)	-0.0006	0.0014	-0.422	<b>0.673</b>	-0.0072	0.0130	-0.548	<b>0.5837</b>
Forecast horizon (D)	0.0145	0.0014	10.403	<math>10^{-16}</math>	-0.0405	0.0130	-3.101	<b>0.0020</b>
Prediction method (SVM)	0.0170	0.0014	12.225	<math>10^{-16}</math>	0.1948	0.0130	14.930	<math>10^{-16}</math>
Residual standard error	0.0230	df	1080		0.2151	df	1080	
R <sup>2</sup>	0.2301				0.2507			
Adjusted R <sup>2</sup>	0.2251				0.2459			
F-statistic	46.11	(on 7 and 1080 DF)			51.63	(on 7 and 1080 DF)		
p-value	<math>10^{-16}</math>				<math>10^{-16}</math>			

\* Base model indicated by values of experimental factors given in brackets: MI: Middle income markets;

SW 25,50,100: Sliding window size 25,50 and 100, respectively; T: Technical indicators included amongst the covariates; D: Forecast horizon of one day; SVM: Prediction method employed is SVM

Table 11: WORLD BANK, IMF and MSCI MARKET CLASSIFICATIONS

World Bank		IMF		MSCI	
High Income	Middle Income	Advanced	Emerging	Advanced	Emerging or Frontier
US, Canada,	Brazil, ,	US, Canada,	Brazil, China,	US, Canada,	Brazil, China,
Japan, Korea,	China,	Japan, Korea,	Malaysia,	Japan, Hong	Korea,
Hong Kong,	Malaysia,	Hong Kong,	Thailand,	Kong,	Malaysia,
Singapore,	Thailand,	Singapore,	Indonesia,	Singapore,	Thailand,
France, UK, Italy,	Indonesia,	France, UK,	Hungary, South	France, UK,	Indonesia,
Germany,	Hungary,	Italy,	Africa, Turkey,	Italy, Germany,	Hungary, South
Switzerland,	South Africa,	Germany,	Lithuania, Latvia	Switzerland,	Africa, Turkey,
Spain,	Turkey	Switzerland,		Spain,	Czech,
Netherland,		Spain,		Netherland,	Lithuania,
Belgium,		Netherland,		Belgium,	Estonia
Portugal,		Belgium,		Portugal,	
Sweden, Norway,		Portugal,		Sweden,	
Denmark,		Sweden,		Norway,	
Finland, Austria,		Norway,		Denmark,	
Czech, Lithuania,		Denmark,		Finland,	
Estonia, Latvia		Finland,		Austria	
		Austria,			
		Czech, Estonia			

Table 12: REGRESSION ANALYSIS OF PREDICTIVE ACCURACY WITH IMF AND MSCI MARKET CLASSIFICATIONS

Predictive accuracy	Eq. (14)				Eq. (16)			
	Estimated Coefficient	Std. Error	t value	p value	Estimated Coefficient	Std. Error	t value	p value
(Intercept)	0.5088	0.0023	220.69	$<10^{-16}$	0.5118	0.0023	226.20	$<10^{-16}$
IMF (IMFE)	-0.0109	0.0022	-5.023	$<10^{-6}$				
MSCI (MSCIE)					-0.0163	0.002	-8.284	$<10^{-15}$
Model simulation methodology (ST)	0.0086	0.002	4.342	$<10^{-4}$	0.0086	0.002	4.506	$<10^{-5}$
Covariate composition (T)	-0.00007	0.002	-0.037	0.97	-0.00007	0.002	-0.039	0.969
Forecast horizon (D)	0.0174	0.002	8.795	$<2^{-16}$	0.0174	0.002	9.128	$<10^{-16}$
Prediction method (SVM)	0.0106	0.002	5.344	$<10^{-6}$	0.0106	0.002	5.546	$<10^{-7}$
Residual standard error	0.02311				0.02227			
R <sup>2</sup>	0.218				0.274			
Adjusted R <sup>2</sup>	0.2108				0.2672			
F-statistic	30	(on 5 and 538 DF)			40.6	(on 5 and 538 DF)		
p-value	$<10^{-15}$				$<10^{-15}$			

\* Base model indicated by values of experimental factors given in brackets: IMFE: Emerging market as classified by IMF classification; MSCIE: Emerging market as classified by MSCI; ST; Static simulation methodology; T: Technical indicators included amongst the covariates; D: Forecast horizon of one day; SVM: Prediction method employed is SVM

Table 13: REGRESSION ANALYSIS OF ROI WITH IMF AND MSCI MARKET CLASSIFICATIONS

ROI	Eq. (15)				Eq. (17)			
	Estimated Coefficient	Std. Error	t value	p value	Estimated Coefficient	Std. Error	t value	p value
(Intercept)*	1.1749	0.0228	51.543	<math>10^{-16}</math>	1.1965	0.0227	52.685	<math>10^{-16}</math>
IMF Emerging (IMFE)	-0.1146	0.0215	-5.331	<math>10^{-6}</math>				
MSCI Emerging Frontier (MSCIE)					-0.1448	0.0197	-7.342	<math>10^{-12}</math>
Model simulation methodology (ST)	0.1021	0.0196	5.210	<math>10^{-6}</math>	0.1021	0.0192	5.326	<math>10^{-6}</math>
Covariate composition (T)	-0.0168	0.0196	-0.856	0.3925	-0.0168	0.0192	-0.875	0.3820
Forecast horizon (D)	-0.0442	0.0196	-2.256	<b>0.0245</b>	-0.0442	0.0192	-2.306	<b>0.0215</b>
Prediction method (SVM)	0.1163	0.0196	5.939	<math>10^{-8}</math>	0.1163	0.0192	6.071	<math>10^{-8}</math>
Residual standard error	0.2284				0.2235			
R <sup>2</sup>	0.1523				0.1888			
Adjusted R <sup>2</sup>	0.1444				0.1813			
F-statistic	19.33	(on 5 and 538 DF)			25.04	(on 5 and 538 DF)		
p-value	<math>10^{-15}</math>				<math>10^{-15}</math>			

\* Base model indicated by values of experimental factors given in brackets: IMFE: Emerging market as classified by IMF classification; MSCIE: Emerging market as classified by MSCI; ST; Static simulation methodology; T: Technical indicators included amongst the covariates; D: Forecast horizon of one day; SVM: Prediction method employed is SVM