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Abstract

The study investigates the profitability of 1024 moving average and momentum models and their components in the yen/dollar market. It turns out that all models would have been profitable between 1976 and 2007. The pattern of profitability is as follows. The models produce more single losses than single profits. At the same time, the size of the single profits is on average much higher than the size of single losses because profitable positions last two to six times longer than unprofitable positions. Hence, the profitability of technical currency trading is exclusively due to the exploitation of persistent exchange rate trends. These results hold also when technical trading is examined over subperiods. The models which perform best over the most recent subperiod are in most cases significantly profitable also ex ante. However, the profitability of technical currency trading based on daily data has declined since the mid 1990s, and it has disappeared since 2000.

Keywords: Exchange rate; Technical trading; Speculation

JEL classification: F31; G14; G15

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Profitability of Technical Currency Speculation: The Case of Yen/Dollar Trading 1976 - 2007*

1. Introduction

According to survey studies technical analysis is the most widely used trading technique in foreign exchange markets. Over the 1990s the importance of technical analysis has stronger increased than other trading practices like the orientation on fundamentals or on customer orders. Nowadays between 30% and 40% of professional currency traders use technical systems as their most important trading technique (for recent survey studies see Cheung-Chinn-Marsh, 2004; Cheung-Wong, 2000; Cheung-Chinn, 2001; Oberlechner, 2001; Gehrig-Menkhoff; 2004, 2005A and 2005B). However, professionals do not blindly follow technical trading signals but use this information together with other kinds of information like news about fundamentals or customer order flows (as documented by Gehrig-Menkhoff, 2005B). Hence, professional traders try to extract that information from technical analysis which might improve their overall trading performance.

Studies testing the performance of technical analysis (have to) assume that traders follow blindly a certain rule. The difference between this assumption and the actual practice might explain the following contradiction. On the one hand, surveys of professional currency traders indicate a rising importance of technical analysis, on the other hand, profitability studies indicate that the profitability from blindly following a trading rule has declined over the past 15 years (for profitability studies see Schulmeister, 1988; Levich-Thomas, 1993; Menkhoff-Schlumberger, 1995; Neely-Weller-Dittmar, 1997; Gencay-Stengos, 1998; Chang-Osler, 1999; Neely-Weller, 1999; Gencay, 1999; LeBaron, 1999; Osler, 2000; Maillet-Michel, 2000; Neely-Weller, 2003; Olson, 2004; an excellent survey of the use of the use of technical analysis in currency markets is Menkhoff-Taylor, 2007).

As a first step towards a thorough examination of this puzzle one has to sort out the profitable and unprofitable informational content of technical trading systems. Hence, one has to

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answer questions like the following: What is the relation between the number of profitable and unprofitable positions produced by technical models? Is the average return per day during profitable positions greater than during unprofitable positions? Do profitable positions last significantly longer than unprofitable positions? Does the structure of profitability of technical models differ between in-sample and out-of-sample simulations?

These issues were already investigated for the DM/dollar market on the basis of the performance of 1024 moving average and momentum models (Schulmeister, 2008A). The main scope of the present study is threefold. First, it shall analyze the profitability components of the same technical models in the second most active foreign exchange market, the yen/$ market based on daily data.[1]) Second, the study shall compare the results for yen/dollar trading to the results already obtained for DM/dollar trading. Hence, this study applies the same methods as the DM/dollar study.[2]) Third, this study shall present a cluster analysis of the performance of technical models in both markets, the DM/dollar as well as the yen/dollar market.

The main results are as follows:

- Over the entire sample period 1976/2007, the 1024 technical models would have produced a gross return of 6.9% per year in the yen/dollar market, slightly less than in the DM/dollar market between 1973 and 1999 (7.9%).
- This difference is due to the unprofitability of technical currency trading in recent years. Between 1976 and 1999 the 1024 models would have returned 9.1% per year in yen/dollar trading, a little more than in DM/dollar trading.
- The overall profitability of technical currency trading is exclusively due to the exploitation of persistent exchange rate trends. This is reflected by profitable positions lasting 2 to 6 times longer than unprofitable positions in either market.
- The 25 best performing models in each in-sample period examined were profitable also out of sample in most cases.
- The profitability of technical trading has been declining since the late 1980s, in the yen/dollar market even stronger than in the DM/dollar market.

[1]) The exchange rates used are mid rates at noon in New York as published by the Federal Reserve Bank of New York (http://www.federalreserve.gov/releases/H10/hist).

[2]) The main difference concerns the sample period. The DM/dollar study covers the period 1973/99, this study comprises the period 1976/2007. The first subperiod of the DM/dollar study (1973/75) was left out in the present study because over this period the Bank of Japan frequently stabilized the yen/dollar exchange at a constant level (i. e., the yen exchange rates did not freely float over the entire period 1973/76).

2. The rationale of moving average models and momentum models

Technical analysis tries to exploit price trends which "technicians" consider the most typical feature of asset price dynamics ("the trend is your friend"). Hence, this trading technique derives buy and sell signals from the pattern of the most recent price movements which (purportedly) indicate the continuation of a trend or its reversal (trend-following or contrarian models). Technical traders believe that the phenomenon of trending occurs across different time scales, hence, they apply their models to different data frequencies (for an introduction into technical analysis see Neely, 1997; for a comprehensive treatment see Kaufman, 1987; Murphy, 1986).

The quantitative approaches try to identify trends using statistical transformations of past prices. These models produce clearly defined buy and sell signals. Since one cannot know precisely which models are actually used in practice, one should restrict an analysis of the performance of technical analysis to the most popular and most simple types of models. A review of the literature on technical analysis as well a survey of technical trading software reveals that moving average models and momentum models meet both criteria.

The basic version of the first type of model consists of a short-term moving average (MAS) and a long-term moving average (MAL) of past prices. The trading rule is as follows: Buy (go long) when the short-term (faster) moving average crosses the long-term (slower) moving average from below and sell (go short) when the converse occurs.

The momentum model operates with the difference between the current price and that i days ago ($M(i) = P_t - P_{t-i}$). The trading rule is as follows: Buy (go long) when the momentum M(i) turns from negative into positive and sell (go short) in the opposite case.

There exist many modifications of moving average and momentum models (see, e.g., Kaufman, 1987, chapters 5 and 6). This study, however, considers only the basic version.

Price oscillations often cause technical models to produce "wrong" signals. In order to filter them out the signal execution can be delayed by n days, i. e., a signal is executed only if it remains valid over n consecutive days. In this study only the shortest possible lag of signal execution is tested (1 day).

3. The overall performance of technical trading systems in the yen/dollar market

The simulations comprise the same models as in two studies on technical trading in the DM/dollar market (Schulmeister, 2006; 2008A): In the case of moving average models all combinations of a short-term moving average (MAS) between 1 and 15 days and a long-term moving average (MAL) between 5 and 40 days are tested (474 models). In the case of momentum models the time span i runs from 3 to 40 days (38 models). Each model is

simulated with and without a lag of signal execution by one day (delay filter). Hence, a total of 1024 different technical trading models is analyzed.

Table 1 shows the performance of three moving average and three momentum models over the entire sample period (these are the same models as in table 1 in Schulmeister, 2008). The fastest (momentum) model operating a time span of 9 days displays an average duration of profitable positions of 18.8 days, hence, it focuses on short-term trends. Most of the selected models display a duration of profitable positions between 30.7 and 65.6 days, hence, they specialize on the exploitation of medium- term and long-term exchange rate trends.

Table 1: Pattern of yen/dollar-trading 1976/2007

	Moving average models			Momentum models		
Length i of MAS	1	3	11			
Length i of MAL	16	30	30			
Time span i				9	23	9
Lag of signal execution						1
Gross rate of return per year	6.94	6.99	7.67	5.97	7.96	7.27
Sum of profits per year	21.57	16.82	14.65	22.31	18.00	20.07
Profitable positions						
Number per year	8.31	4.44	3.84	12.56	7.75	7.78
Average return						
Per position	2.60	3.79	3.81	1.78	2.32	2.58
Per day	0.085	0.067	0.058	0.095	0.069	0.083
Average duration in days	30.69	57.02	65.58	18.79	33.60	31.17
Sum of losses per year	-14.62	-9.83	-6.99	-16.34	-10.04	-12.80
Unprofitable positions						
Number per year	21.30	9.03	4.69	22.77	12.71	12.52
Average return						
Per position	-0.69	-1.09	-1.49	-0.72	-0.79	-1.02
Per day	-0.133	-0.088	-0.062	-0.127	-0.096	-0.104
Average duration in days	5.16	12.42	24.13	5.67	8.24	9.79
Distribution of the single rates of return						
Mean	0.235	0.519	0.899	0.169	0.389	0.358
t-statistic	3.160	3.266	3.863	2.900	3.821	3.462
Median	-0.363	-0.484	-0.320	-0.220	-0.227	-0.313
Standard deviation	2.284	3.297	3.838	1.960	2.604	2.634
Skewness	3.751	2.462	1.758	3.111	3.189	2.512
Excess kurtosis	19.899	7.061	3.902	14.119	13.204	9.886
Sample size	948	431	273	1131	655	650

All of the selected models are profitable, their gross rates of return amounts to roughly 7% per year. The annual rates of return represent also the excess returns from technical currency speculation because the benchmark for excessive profitability is a return of zero (given the assumption that traders do not invest own capital).

Transaction costs are put at 0.02% per trade which implies a bid-ask spread of 4 basis points (this assumption is in line with estimates of transaction costs in the yen/dollar market in Hartmann, 1999). Hence, the net rate of return is by less than 1% smaller than the gross rate in most cases.

For any open position interest is earned from the long position and paid for the short position. If one calculates the overall interest effect using the information on the duration of the long and the short dollar positions and on the interest differential it turns out that this effect was close to zero during the sample period (this holds true for yen/dollar trading as well as for DM/dollar trading; see Schulmeister, 2000, p. 74f). A similar result is reported by LeBaron (1999).

The gross rate of return (GRR) of any technical trading model can be split into six components, the number of profitable/unprofitable positions (NPP/NPL), the average return per day during profitable/unprofitable positions (DRP/DRL), and the average duration of profitable/unprofitable positions (DPP/DPL). The following relationship holds:

GRR = NPP*DRP*DPP – NPL*DRL*DPL

The selected models have the following trading pattern in common (table 1):

- The number of profitable trades is lower than the number of unprofitable trades.
- The average return per day during profitable positions is smaller (in absolute terms) than during unprofitable positions.
- Profitable positions last on average 3 to 6 times longer than unprofitable positions.

The overall profitability of the models is therefore due to the exploitation of persistent exchange rate trends. Smaller fluctuations often cause technical models to produce losses, which, however, are small, precisely because the fluctuations are small.

The distribution of the single rates of return reflects these properties of technical trading systems:

- The median is negative.
- The standard deviation is several times higher than the mean.
- The distribution is skewed to the right and leptokurtotic.

The Probability of making an overall loss by blindly following a technical trading model is estimated by testing the mean of the single rates of return against zero (only if it is negative does the trading rule produce an overall loss). Since the t-statistic of almost every model

shown in table 1 exceeds 2.9 one can conclude that the probability of making an overall loss by following these models over the entire sample period was less than 0.1%.

Figure 1: Distribution of trading systems by the gross rate of return
Yen/dollar trading 1976 - 2007

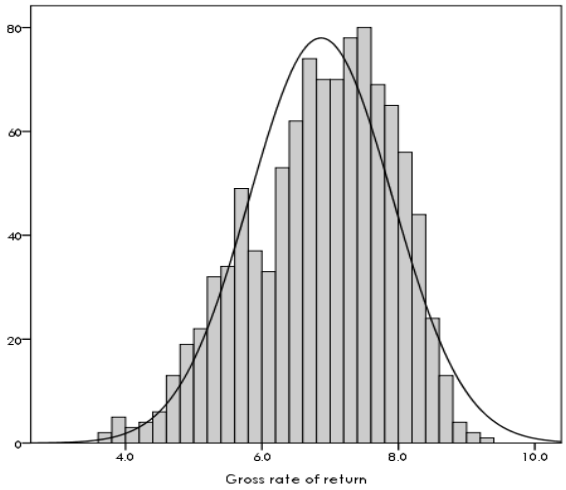
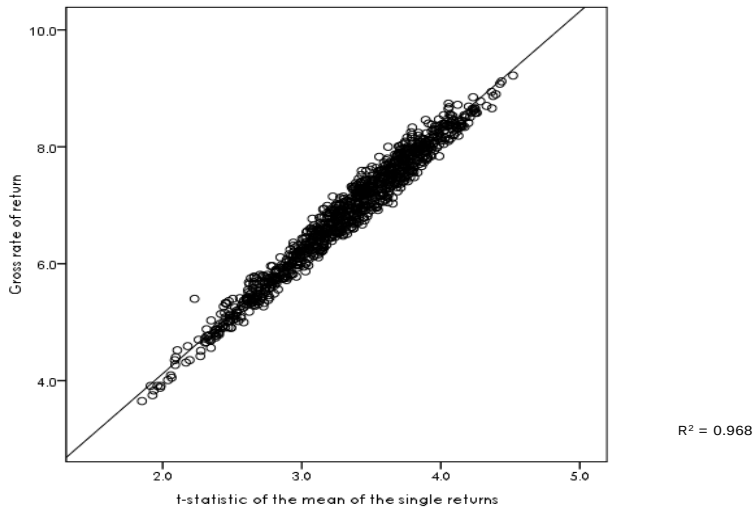


Figure 1 shows the distribution of all 1024 trading systems by their annual gross rates of return. On average they produce a mean return of 6.9% per year with a standard deviation of 1.05. The best performing models produce an annual return of roughly 9%, the worst models roughly 4%.

Figure 2: Profitability and riskiness of 1024 technical trading systems
Yen/dollar trading 1976 - 2007



The t-statistic of the mean of the single rates of return exceeds 2.5 in almost all cases (figure 2) which implies a probability of making an overall loss by blindly following these rules of less than 0.5%.

4. Components of the profitability of technical models

Table 2 classifies all models according to their performance as measured by the t-statistic into four groups and quantifies the components of profitability for each of them. A t-statistic greater than 4.0 is achieved by 7.7% of all models, the average rate of return per year (GRR) over these models amounts to 8.5%. The t-statistic of 32.8% of all models lies between 3.5 and 4.0 (GRR: 7.7%), 34.5% generate a t-statistic between 3.0 and 3.5% (GRR: 6.8%). The worst performing models, (t-statistic<3) still produce an average return of 5.4% per year.

Table 2: Components of the profitability of trading systems by types of models
Moving average and momentum models
Yen/dollar-trading 1976 - 2007

	Number of models									
	Abolute	Share in %	Gross rate of return	t-statistic	Profitable positions			Unprofitable positions		
					Number per year	Return per day	Duration in days	Number per year	Return per day	Duration in days
t-statistic of the mean of the single returns										
<3.0	256	25.0	5.4	2.648	6.89	0.071	51.03	10.89	-0.094	16.42
3.0-<3.5	353	34.5	6.8	3.267	6.31	0.070	49.17	9.72	-0.092	14.95
3.5-<4.0	336	32.8	7.7	3.723	5.41	0.067	51.34	7.42	-0.083	16.80
>4.0	79	7.7	8.5	4.142	5.01	0.065	53.76	6.00	-0.075	19.17
All models	1024	100.0	6.9	3.329	6.06	0.069	50.70	8.97	-0.088	16.25
Moving average models	948	92.6	6.9	3.353	5.94	0.069	51.50	8.66	-0.087	16.66
Momentum models	76	7.4	6.3	3.038	7.61	0.072	40.69	12.85	-0.099	11.09
Models with lag = 0	512	50.0	7.0	3.386	6.56	0.071	48.64	10.28	-0.092	14.72
Models with lag = 1	512	50.0	6.7	3.273	5.57	0.067	52.76	7.66	-0.084	17.78

The pattern of profitability is the same for each class of models (table 2). The number of single losses exceeds the number of single profits, the average return per day (in absolute terms) is higher during unprofitable positions than during profitable positions, hence, the overall profitability is only due to profitable positions lasting three to four times longer than unprofitable positions. A comparison of table 2 to table 2 in Schulmeister (2008A) shows that the profitability pattern of yen/dollar trading is almost identical to the pattern observed in DM/dollar trading.

Figure 3: Frequency of profitable and unprofitable positions
Yen/dollar trading 1976 - 2007

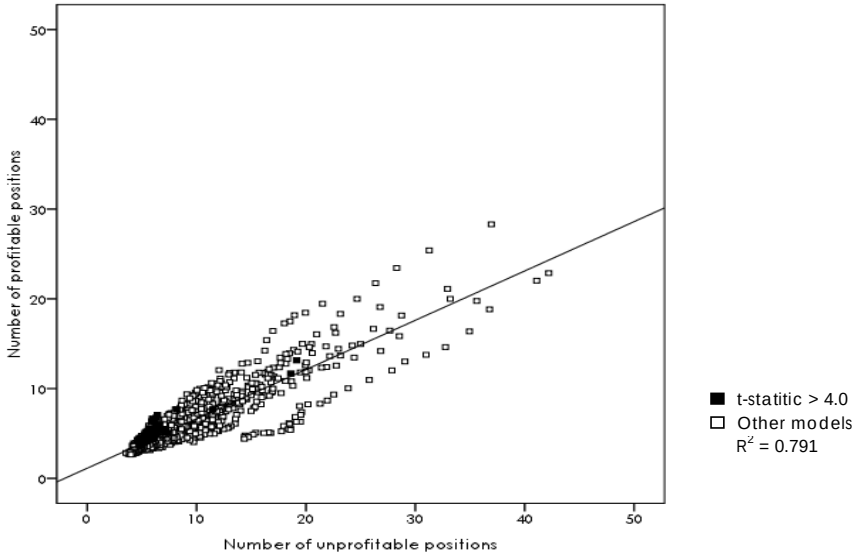
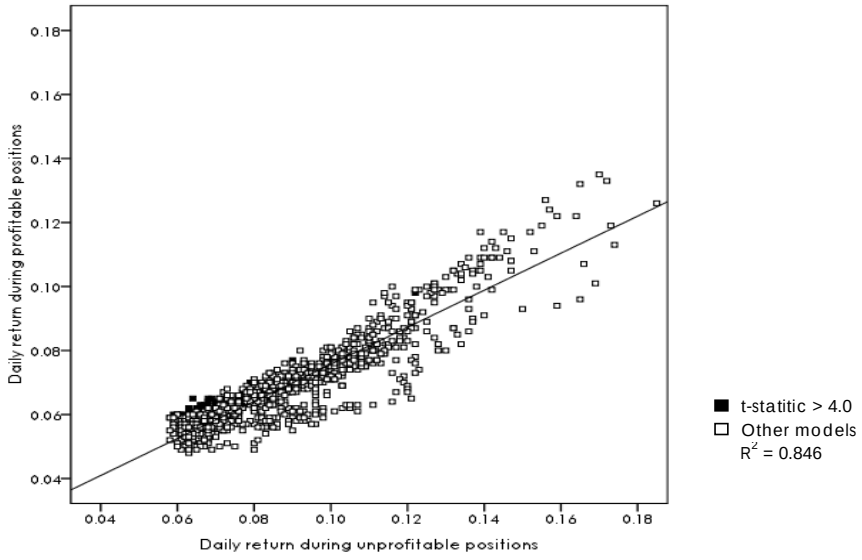


Figure 4: Average daily return during profitable and unprofitable positions
Yen/dollar trading 1976 - 2007

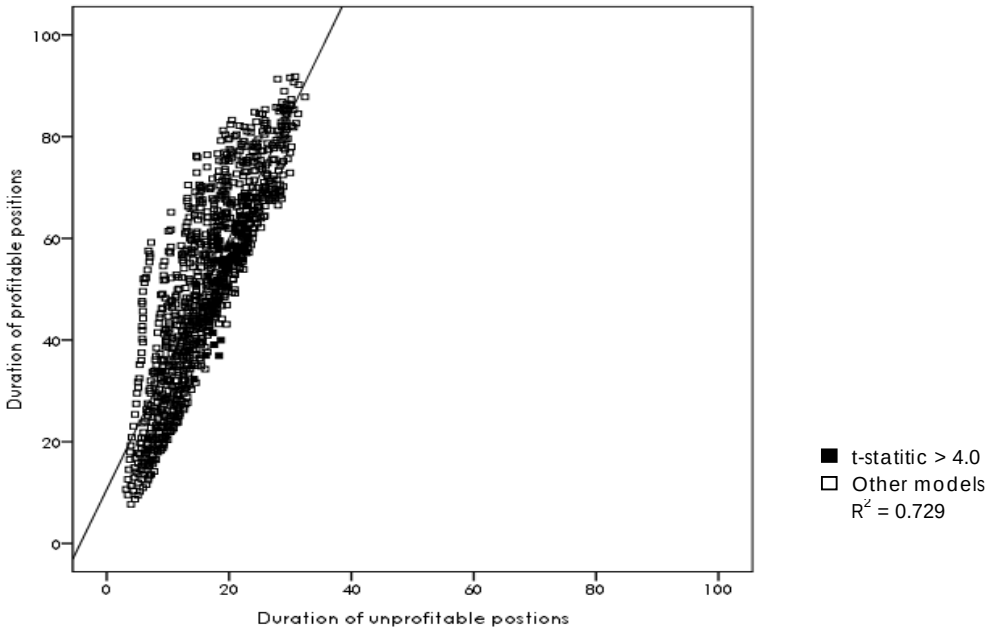


Figures 3 to 5 show the number, the daily return and the duration of profitable positions relative to the unprofitable positions for each of the 1024 models. The models signal in almost

all cases less profitable positions than unprofitable positions (the slope of the regression in figure 3 line is much smaller than 45^0).

The average return per day during profitable positions is always lower than during unprofitable positions (figure 4). What accounts for the overall profitability of technical currency trading is the fact that profitable positions last several times longer than unprofitable positions (figure 5). This is the most typical property of the performance of technical trading systems in general, even if they produce an overall loss (Schulmeister 2008A; 2008B). That the duration of profitable positions is several times longer than the duration of unprofitable positions reflects the phenomenon of "trending" in asset markets, which technical models try to exploit ("the trend is your friend").

Figure 5: Average duration of profitable and unprofitable positions
Yen/dollar trading 1976 - 2007



5. Clusters of technical models

In order to detect similarities in the trading behavior of certain groups of technical models, statistical clustering techniques are used. These methods classify all models into similar groups in the following way. All models characterized by a certain number of variables (profitability components in our case) are assigned to different clusters under the condition that the differences between the models are minimized within each cluster and maximized across clusters. For this (descriptive) exercise the simple approach called K-Means Cluster Analysis was adopted (provided by the SPSS software package). In this case the number of clusters

has to be predetermined (here three clusters are sufficient to illustrate characteristic differences in the trading behavior of technical models).

Table 3 shows the results of the cluster analysis. When trading the yen/dollar exchange rate the 253 models of cluster 1 produce the highest number of open positions (26.7 per year on average), mainly for that reason the duration of profitable positions is relatively short (24.6 days on average). Cluster 1 comprises therefore those (fast) models which are most sensitive to price changes. The 415 models of cluster 2 signal 13.4 open positions per year, the profitable positions last 48.3 days on average. Cluster 3 comprises 356 (slow) models which produce only 8.6 open positions per year, their profitable positions last 71.8 days on average.

Table 3: Cluster of technical trading systems according to profit components
Yen/dollar trading 1976 - 2007

	Number of models	Gross rate of return	Profitable positions			Unprofitable positions		
			Number per year	Return per day	Duration in days	Number per year	Return per day	Duration in days
Cluster 1	253	6.5	10.79	0.089	24.57	15.93	-0.119	8.72
2	415	7.4	5.34	0.067	48.53	8.08	-0.087	15.00
3	356	6.6	3.55	0.057	71.79	5.07	-0.068	23.05
Total	1024	6.9	6.06	0.069	50.70	8.97	-0.088	16.25

From these results one can conclude the following. First, the models of cluster 1 exploit primarily short-term exchange rate trends, those of cluster 2 specialize on medium-term trends, whereas the models of cluster 3 exploit mainly long-term trends. Second, the daily returns during profitable and unprofitable positions differ significantly across the three clusters, they are the higher the shorter last the duration of the profitable and unprofitable positions (the slope of "underlying" exchange rate trends is on average the smaller the longer the trends last – see Schulmeister, 2008C).

A comparison of the results of the cluster analysis between yen/dollar trading and DM/dollar trading confirms that the profitability structure of technical models is almost identical in both markets. The only difference concerns the relative profitability across clusters. In the yen/dollar market the most profitable models belong to cluster 2, these models exploit medium-term exchange rate trends (figure 6 and table 2). In the DM/dollar market, by contrast, the most profitable models specialize on comparatively shorter trends, and, hence, belong to clusters 1 and 2.

Figure 6: Three clusters of technical trading systems according to profit components
Yen/dollar trading 1976 – 2007

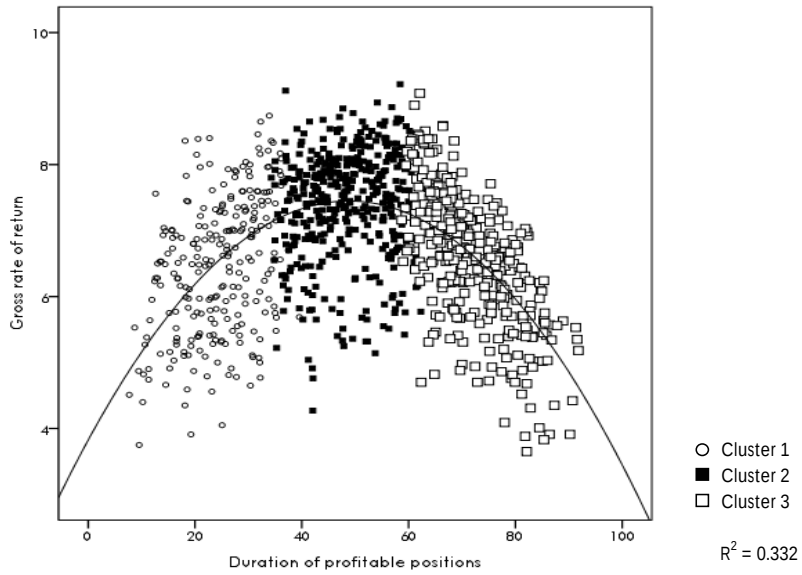
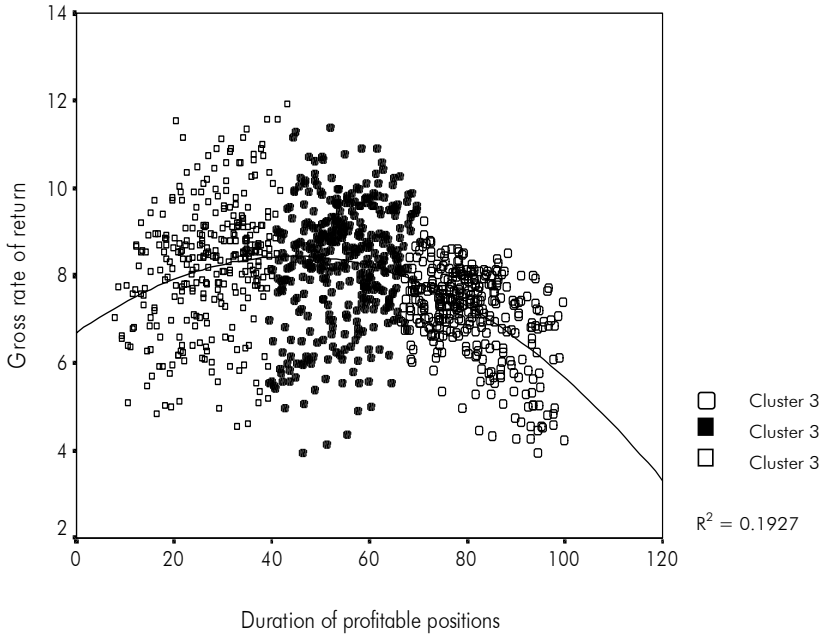


Figure 7: Three clusters of technical trading systems according to profit components
DM/dollar trading 1973 – 1999



6. The performance of technical trading systems over subperiods

The study divides the overall sample period of 24 years into 8 subperiods each lasting 4 years and investigates the performance of the 1024 models in each of them in sample (ex post) and out of sample (ex ante).

Table 4 displays the performance of the models over these subperiods. The ex-post-performance of the 1024 models over the subperiods can be summarized as follows. First, these models would have made losses in only 1287 out of 8192 cases (1024 models over 8 subperiods). Second, whereas the average profitability of technical currency trading remained roughly the same between 1976 and 1987 it has been declining thereafter (as already reported by Olson, 2004, and Neely – Weller – Ulrich, 2007):

- Over the subperiod 1996/99 the models achieve a gross rate of return of only 3.2% on average, 17.7% of the models would have produced losses (the extraordinary yen volatility in 1998 might have contributed to this result – see Cai et al, 2001).
- Over the subsequent two subperiods the performance of the models has further declined. Their average gross return amounts to only -0.2% (2000/03) and 0.5% (2004/07), respectively, roughly half of the models would have produced losses (in euro/dollar trading the GRR of the same models would have been 3.8% - Schulmeister, 2008A).

The decline in the profitability of technical trading as reported by Neely-Weller-Ulrich (2007), Olson (2004) and Schulmeister (2008A) for currency trading and by Schulmeister (2008B) for stock trading could be explained in four different ways:

- In the first case, the profitability of trading rules as reported in several studies was merely the result of "data mining" and, hence, could not be reproduced out of sample. In a recent study Neely – Weller – Ulrich (2007) reject this hypothesis for most studies they evaluated.
- In the second case, markets become gradually more efficient in an evolutionary process as expected by the Adaptive Market Hypothesis (AMH). This theoretical concept was proposed by Lo (2004) as an alternative to the too rigid Efficient Market Hypothesis (EMH). By learning to exploit profit opportunities market participants will gradually erode these opportunities. According to Neely – Weller – Ulrich (2007) the results of their out-of-sample-tests support the AMH.
- In the third case, the continuous rise in the "speed" of transactions causes technical traders to use increasingly intraday data instead of daily data.[3]) This development could

[3]) Such a shift to using data of higher frequencies than daily data when applying (automated) trading systems has most probably contributed to the tremendous increase in transaction volume in financial markets in general and in foreign exchange markets in particular (as documented in Schulmeister – Schratzenstaller – Picek, 2008). E. g., between 1986 and 2007 currency transactions in spot and derivatives markets rose by 15.0% per year.

have caused intraday exchange rate movements to become more persistent and, hence, exploitable by technical models. As a consequence, exchange rate changes based on daily data have become bigger and more erratic which in turn causes technical trading on the basis of daily data to become less profitable.[4])

- In the fourth case, technical traders use increasingly more complex trading models instead of traditional rules like moving average or momentum rules. Such a shift will in turn change the trending pattern of exchange rates and, hence, cause traditional models to become unprofitable (for the feed-back of the aggregate trading behavior of technical models on exchange rate and stock price movements see Schulmeister, 2006; 2007). Such a shift to more complex trading rules will be strengthened by the shift to intraday data since the latter call for more sophisticated techniques to filter out short-term trends (exchange rate volatility rises with data frequency – see Schulmeister, 2008C).

Also the AMH expects that new and more sophisticated trading strategies will emerge once the "old" and simpler rules have become unprofitable. The main difference between the AMH and the hypotheses 3 and 4 sketched above is as follows. The AMH assumes that any originally profitable trading rule will become gradually less profitable because more and more people use them (i.e., through the classical arbitrage mechanism). As a consequence, smart traders seek for and finally discover new profitable rules.

By contrast, the hypotheses 3 and 4 assume that the causality runs from the use of new and more complex rules based on an ever increasing data frequency to the erosion of the profitability of the older and simpler rules. This effect is mainly due to the change in the trending pattern of asset prices caused by the gradually increasing use of the new trading strategies. More specifically, the phenomenon of trending will shift from daily to intraday data in tandem with the increase in the speed of trading and, hence, with the increasing use of intraday data by technical models (there operates a self-reinforcing interaction between the transitory features of asset price trends and the data frequencies as well as the specific rules used in technical trading – Schulmeister, 2006, 2007, deals with some aspects of this interaction).

[4]) Studies on the profitability of technical currency trading based on intraday data arrive at mixed results. Osler (2000), Dempster-Jones (2002) and Gencay et al. (2003) find this type of trading to be profitable, Curcio et al. (1997) and Neely-Weller (2003) arrive at the opposite conclusion. As regards stock trading, Schulmeister (2008B) reports that the profitability of technical models in the stock index futures market has been declining over the 1990s when based on daily data but has remained roughly the same when based on 30-minute-data. However, since 2001 the profitability of technical stock trading based on 30-minute-data has been declining (it might have shifted to even higher data frequencies and/or the use of more complex rules).

Table 4: Performance of technical trading systems by subperiods
In sample and out of sample
Yen/dollar-trading 1976 - 2007

		All models	25 best models In sample	25 best models Out of sample
1976-1979	Gross rate of return	13.95	18.55	
	t-statistic	2.341	2.826	
	DPP	63.19	47.53	
	Share of profitable positions	100.0	100.0	
1980-1983	Gross rate of return	9.79	17.85	12.64
	t-statistic	1.595	2.637	1.891
	DPP	48.19	21.03	35.87
	Share of profitable positions	100.0	100.0	100.0
1984-1987	Gross rate of return	14.96	21.37	17.72
	t-statistic	2.031	2.788	2.476
	DPP	53.43	50.97	20.24
	Share of profitable positions	100.0	100.0	100.0
1988-1991	Gross rate of return	5.59	11.35	4.04
	t-statistic	0.951	1.893	0.664
	DPP	46.90	49.42	41.27
	Share of profitable positions	97.6	100.0	100.0
1992-1995	Gross rate of return	7.51	15.79	10.22
	t-statistic	1.045	2.091	1.422
	DPP	50.01	46.67	52.11
	Share of profitable positions	93.7	100.0	100.0
1996-1999	Gross rate of return	3.16	9.33	-0.05
	t-statistic	0.490	1.429	0.013
	DPP	47.49	53.26	45.61
	Share of profitable positions	82.3	100.0	52.0
2000-2003	Gross rate of return	-0.21	5.66	-0.54
	t-statistic	-0.046	1.183	-0.115
	DPP	46.22	26.19	52.39
	Share of profitable positions	44.9	100.0	32.0
2004-2007	Gross rate of return	0.47	7.02	1.05
	t-statistic	0.082	1.689	0.337
	DPP	45.24	26.51	27.92
	Share of profitable positions	57.8	100.0	60.0

To summarize: There are two alternative explanations for why technical trading systems tend to become gradually less profitable and finally become unprofitable. The Adaptive Market Hypothesis focuses on the arbitrage mechanism as the main force causing profits from technical trading to disappear, the hypothesis sketched above focuses on the self-reinforcing interaction between the type of model and the data frequency used by technical traders and the specific features of asset price trends. An empirical evaluation of these two hypotheses represents a complex task. Hence, it has to be left to future research.

7. The performance of technical trading in sample and out of sample

The fact that persistent exchange rate trends of varying lengths occur "abnormally" frequently does not ensure the profitability of technical trading ex ante. If, e. g., a trader selects a model that would have performed best over the most recent past for trading over a subsequent period, then he might become a victim of his own "model mining" for the following reason.

The ex-post profitability of the best models consists of two components. The first stems from the "normal" non-randomness of exchange rate dynamics, namely, the occurrence of persistent price trends. The second component stems from the selection or overfitting bias since a part of the ex-post profits of the best models would have been produced only by chance (Sullivan-Timmerman-White, 1999). Now, if the "optimal" profitability of a selected model is mainly the result of this "model mining" then this model will perform much worse over the subsequent period. However, if the in-sample profitability stems mainly from the exploitation of "usual" exchange rate trends then it might be reproduced out of sample.

In order to investigate this matter, the following exercise was carried out. In a first step the 25 best models are identified on the basis of their ex-post performance (measured by the net rate of return) over the most recent subperiod. Then the performance of the selected models is simulated over the subsequent subperiod.

Table 4 shows that the out-of-sample-performance of the 25 best models is similar to the average in-sample-performance. If one had selected the 25 best performing models for trading in the subsequent period one would have made significant profits between 1980 and 1995. However, over the past 12 years this trading strategy would have been no longer profitable.

Table 5 summarizes the means over the gross rates of returns and over the three ratios of the profitability components of all models as well as of the 25 best models in sample and out of sample. In addition, t-statistics are calculated which test for the significance of the difference between the means of the best models and the means of all models. In order to facilitate a comparison between technical trading in the yen/dollar market and the DM/dollar market, the last two subperiods are left out in table 5 (these periods are not covered by the DM/dollar study – see Schulmeister, 2008A).

Table 5: Distribution of trading systems by the gross rate of return and by the ratio of profit components over subperiods

	Yen/dollar-trading 1980 - 1999		DM/dollar-trading 1976 - 1999	
Variable	Mean	t-statistic	Mean	t-statistic
		All models		
	N = 5120		N = 6144	
Gross rate of return	8.20		5.99	
NPP/NPL	0.744		0.760	
DRP/DRL	0.840		0.751	
DPP/DPL	3.365		3.412	
		The 25 most profitable models: In sample		
	N = 125		N = 150	
Gross rate of return	15.14	17.262	12.88	18.234
NPP/NPL	0.949	8.931	0.920	5.584
DRP/DRL	1.102	8.758	0.844	4.049
DPP/DPL	3.142	– 2.438	4.001	4.410
		The 25 most profitable models: Out of sample		
Gross rate of return	8.91	1.187	6.61	1.217
NPP/NPL	0.666	– 5.476	0.623	– 10.097
DRP/DRL	0.893	2.095	0.700	– 2.987
DPP/DPL	3.226	– 1.636	4.168	5.613

NPP (NPL) . . . Number of profitable (unprofitable) positions per year.
DRP (DRL) . . . Return per day during profitable (unprofitable) positions.
DPP (DPL) . . . Average duration of profitable (unprofitable) positions.

The t-statistic tests for the significance of the difference between the mean of the four variables over the 125 (150) cases of the best models (in and out of sample) and the respective mean over the 5120 (6144) cases of all models.

In the yen/dollar market the mean annual rate of return of the best models (15.1%) is almost twice as high as the mean over all models (8.2%). This result holds also true for the DM/dollar market. This high profitability is due to the means of all three ratios of the profit components being significantly higher in the case of the 25 best models in sample than in the case of all models.

This profitability pattern of the best models cannot be reproduced out of sample. The mean ratio between the number of profitable and unprofitable positions is significantly lower in the case of the best models out of sample as compared to the average ratios over all models. This observation holds true for yen/$ trading as well as for DM/$ trading. The results are mixed for the mean ratio between the daily return during profitable and unprofitable positions, it is higher (yen/$) or lower (DM/$) out of sample than on average over all cases. Since the high values of these two ratios observed in sample can not be reproduced out of sample they should be considered as a result of "model mining".

However, the ratio between the duration of profitable and unprofitable positions of the best models out of sample is even slightly higher than in sample. Moreover, this ratio is significantly

higher than in the case of all models (DM/dollar) or only insignificantly lower (yen/dollar). Hence, that property of technical currency trading which in general accounts for its profitability, i.e., the longer duration of profitable positions relative to unprofitable positions, is reproduced out of sample (even though to a lesser extent in yen/dollar trading as compared to DM/dollar trading). Finally, it should be mentioned that these results hold true for the 1980s and 1990s – they would be less clear-cut for the most recent years as the results in table 4 show.

8. Summary

The main results of this study can be summarized as follows:

- Over the entire sample period 1976/2007, the 1024 technical models would have produced a gross return of 6.9% per year in the yen/dollar market, slightly less than in the DM/dollar market between 1973 and 1999 (7.9%).
- This difference is due to the unprofitability of technical currency trading in recent years. Between 1976 and 1999 yen/dollar trading would have returned 9.1% per year, and, hence, would have been more profitable than DM/dollar trading.
- The probability of making an overall loss when strictly following one of these models was close to zero in the yen/dollar market as well as in the DM/dollar market.
- The profitability of technical currency trading is exclusively due to the exploitation of persistent exchange rate trends. This is reflected by profitable positions lasting 2 to 6 times longer than unprofitable positions.
- These results do not change substantially when technical currency is simulated over subperiods. In only 1287 out of 8192 cases did the technical models produce losses in the yen/dollar market (the results are similar for the DM/dollar market).
- The ex-ante profitability of those models which performed best over the most recent subperiod was slightly higher than the average in-sample profitability of all models. However, this result holds true for yen/dollar trading only between 1976 and 1995.
- The profitability of technical trading has been declining since the mid 1990s, in the yen/dollar market even stronger than in the DM/dollar market. Between 2000 and 2007 the 1024 models would have generated an average gross return of only 0.1% per year in yen/dollar trading (in euro/dollar trading between 2000 and 2004 the same models would have returned 3.8% per year).

It is an important challenge for future research to find out whether the decline in the profitability of technical trading based on daily data is due to asset markets becoming more efficient or due to technical trading becoming "faster" and more sophisticated, i.e., being increasingly based on intraday data as well as on more complex trading rules.

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