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 **WORKING PAPERS**

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263/2005

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WIFO Working Papers, No. 263
December 2005

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Abstract

This paper investigates the sources of the profitability of 1024 moving average and momentum models when trading in the German mark (euro)/U.S. dollar market based on daily data. The main results are as follows. First, each of these models would have been profitable over the entire sample period. Second, this profitability is exclusively due to the exploitation of persistent exchange rate trends. Third, these results do not change substantially when trading is examined within subperiods. Fourth, the 25 best performing models in each in-sample period examined were profitable also out of sample in most cases. Fifth, the profitability of technical trading the German mark (euro)/U. S. dollar exchange rate has been significantly lower since the late 1980s as compared to the first 15 years of the floating rate period.

Keywords: Exchange rate; Technical trading.

JEL classification: F31; G14 ; G15

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Components of the Profitability of Technical Currency Trading *

1. Introduction

Technical analysis is widely used in the currency markets. Surveys conducted among market participants over the past 20 years document the following. First, roughly 90% of market participants base their trading at least in part on technical analysis. Second, between 30% and 40% of professionals use technical analysis as their most important trading technique. Third, the importance of technical analysis has increased more strongly over the 1990s than other trading practices like the orientation on fundamentals or on customer orders.¹⁾

These results cast doubt on the conventional assumptions about trading behavior in the foreign exchange market. Hence, many researchers investigated if trading rules were actually profitable in this market (see, e.g., Sweeny, 1986; Schulmeister, 1988; Levich-Thomas, 1993; Menkhoff-Schlumberger, 1995; Neely-Weller-Dittmar, 1997; Curcio-Goodhart-Guillaume-Payne, 1997; Gencay-Stengos, 1998; Chang-Osler, 1999; Neely-Weller, 1999; Gencay, 1999; LeBaron, 1999; Osler, 2000; Maillat-Michel, 2000; Neely-Weller, 2003; Ohlson, 2004).

All of these studies have found technical trading systems to be profitable when tested in sample based on daily exchange rates. However, their performance out of sample was in most cases found to be significantly worse. Some authors also found that the profitability of trading rules has declined over time (Marsh, 2000; LeBaron, 2002; Ohlson, 2004). Studies on the performance of technical currency trading based on intraday data arrive at mixed results. Dempster-Jones (2002) and Gencay-Dacarogna-Olsen-Pictet (2003) find this type of trading to be profitable, Curcio-Goodhart-Guillaume-Payne (1997) and Neely-Weller (2003) arrive at the opposite result (for an excellent survey of all types of studies on technical analysis in different asset markets see Park-Irwin, 2004).

* The author appreciates valuable comments from William Brock, Ramo Gencay, Michael Goldberg, Chris Neely and Carol Osler. Special thanks go to Eva Sokoll for statistical assistance and to Markus Fulmek for writing the program for testing technical trading systems. Financial assistance from the Anniversary Fund of the Österreichische Nationalbank (Austrian National Bank) is gratefully acknowledged (Project 7966).

¹⁾ For survey studies see Group of Thirty, 1985; Taylor-Allen, 1992; Menkhoff, 1997 and 1998; Wolgast, 1997; Lui-Mole, 1998; Cheung-Chinn-Marsh, 2004; Cheung-Wong, 2000; Cheung-Chinn, 2001; Oberlechner, 2001; Gehrig-Menkhoff; 2004, 2005A and 2005B.

At first glance, the results of the surveys and of the profitability studies seem puzzling. If the out-of-sample profitability of technical models is low and declining over time why does a large and rising share of professionals use these techniques?

An explanation of this puzzle could be as follows. Professional dealers and fund managers do not blindly follow technical models (as assumed by the profitability studies), but use technical signals together with other information like news about fundamentals or customer order flows in order to improve their overall trading performance (Cheung-Chinn-Marsh, 2004; Cheung-Wong, 2000; Gehrig-Menkhoff, 2005B). If market practitioners find ways to extract the profitable information provided by technical models, then one might observe an increasing use of technical models in practice and a declining profitability of blindly following technical models according to simulation studies.

Consider the following simple example: If a trader holds a long dollar position due to his technical model and a piece of news hit the market that indicates an imminent dollar depreciation then he will change his position immediately. The same might be true if the trader were confronted with a sudden increase of customer sell orders. In both cases, he would not wait until his model signals a short position. If market practitioners learn to extract the useful (profitable) information provided by technical models and combine this with other information, then one might observe an increasing use of technical models in practice and a declining profitability of blindly following technical models according to simulation studies.

As a first step towards gaining insights into how traders might use rules less mechanically this study sorts out the profitable and unprofitable informational content of technical trading systems. More specifically, I focus on the profitability components of a great number of models actually used in practice (1024 moving average and momentum models). The analysis is based on daily exchange rates in the single most active foreign exchange market, the DM/\$ market between 1973 and 1999. An out-of-sample test of the performance of all 1024 models between 2000 and 2004 (euro/US dollar) completes the study. The main results are as follows:

- Each of these models would have been profitable over the entire sample period, 91.7% would have remained profitable between 2000 and 2004.
- The number of profitable trades is lower than the number of unprofitable trades.
- The average return per day during profitable positions is smaller than the average loss per day during unprofitable positions.
- Profitable positions last 3 to 5 times longer than unprofitable positions. Hence, the overall profitability of technical currency trading is exclusively due to the exploitation of persistent exchange rate trends.
- 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 significantly lower since the late 1980s as compared to the first 15 years of the floating rate period.

I hope that this paper might help to fill the gap between the actual expectations formation and transaction behavior of technical traders and the (oversimplifying) assumptions made in theoretical models which take feed-back traders into account. For example, it is often assumed that these actors forecast by extrapolating the most recent price movements and that they continuously buy (sell) during an upward (downward) trend. Both assumptions miss the essence of trading behavior implied by technical analysis as shall later be shown.

2. How moving average models and momentum models work

Technical analysis tries to derive profitable buy and sell signals by isolating upward and downward price trends from oscillations around a stable level, called "whipsaws" in the traders' jargon (for an introduction into technical analysis see Neely, 1997; for a comprehensive treatment see Kaufman, 1987; Murphy, 1986).

The qualitative approaches rely on the interpretation of some (purportedly) typical price configurations and contain therefore an important subjective element (note, however, that computer software can provide the basis for a more objective identification of chart configurations – see Chang-Osler, 1999; Osler, 2000; Lo-Mamaysky-Wang, 2000).

The quantitative approaches try to isolate price runs from non-directional movements using statistical transformations of past prices. These models produce clearly defined buy and sell signals. The most common trading systems are moving average models and momentum models.

The first type of model consists of a (unweighted) short-term moving average (MAS) and an long-term moving average (MAL) of past prices. The length of MAS usually varies between 1 day (the original price series) and 8 days, that of MAL between 10 and 30 days.

The trading rule of the basic version of moving average models 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 second type of model works with the difference between the current price and that i days ago:

$$M(i) = P_t - P_{t-i}$$

The trading rule of the basic version of momentum models 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.

Short-term price oscillations often cause technical models to produce "wrong" signals. In order to filter them out the signal execution is often delayed by n days according to the following rule: Execute a signal 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 profitability of technical trading systems and its components over the entire sample period

The simulations comprise the following models. 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).²⁾

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 are analyzed.

3.1 Overview of the performance of 1024 trading systems

Table 1 shows the performance of three moving average and three momentum models which are very different with respect to their price sensitivity (1973/99).³⁾ The fastest models operating with relatively short moving averages or time spans display an average duration of profitable positions between 20 and 30 days (they focus on short-term trends like the moving average model 1/16 or the momentum model 9). Most of the selected models display an duration of profitable positions between 30 and 60 days, only the moving average model 11/30 specializes on the exploitation of long-term exchange rate trends.

All of the selected models are profitable, their gross rates of return center around 10% 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).

The profitability of technical trading is calculated as follows. The trader always holds an open position of 1\$. The single (rate of) return from any open position i (r_i) is then the difference

²⁾ These parameter ranges were chosen to cover those models that are used in practice. Even though dealers revealed in interviews that moving average models with MAS longer than 10 days and MAL longer than 30 days as well as momentum models with a time span of more than 30 days are rarely used, a wider parameter range was chosen in order to analyze also the behavior of slower models. However, models with moving averages of 150 or even 200 days (as simulated by Brock-Lakonishok-LeBaron, 1992) have not been tested because those extremely slow models are not used in practice (in the DM/dollar market the MA rules 1/150, 5/150, 1/200 and 2/200 would have signaled only 7.2, 3.6, 6.8 and 4.5 open positions per year between 1973 and 1999).

³⁾ 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>). For 1999 the hypothetical DM/\$ exchange rate was derived from the daily euro/\$ rate and the DM/euro conversion rate.

between the sell price and the buy price (in DM), converted into dollars at the prevailing exchange rate. The overall gross rate of return per year (GRR) is calculated as sum over all single returns, annualized according to the length of the trading period in days (D):

$$GRR = (365/D) * \sum r_i$$

Table 1: Pattern of DM/dollar-trading 1973/1999

	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	0	0	0	0	0	1
Gross rate of return per	11.12	10.10	8.33	11.53	10.66	9.20
Sum of profits per year	23.13	18.05	14.75	24.82	18.72	20.88
Profitable positions						
Number per year	9.07	4.81	3.41	12.70	7.77	7.55
Average return						
Per position	2.55	3.75	4.33	1.95	2.41	2.76
Per day	0.086	0.063	0.057	0.096	0.066	0.083
Average duration in days	29.68	59.49	75.49	20.38	36.28	33.42
Sum of losses per year	-12.01	-7.95	-6.42	-13.29	-8.06	-11.68
Unprofitable positions						
Number per year	19.62	7.22	4.11	18.96	9.59	10.92
Average return						
Per position	-0.61	-1.10	-1.56	-0.70	-0.84	-1.07
Per day	-0.125	-0.101	-0.059	-0.125	-0.097	-0.104
Average duration in days	4.88	10.90	26.25	5.60	8.65	10.31
Single rates of return						
Mean	0.388	0.840	1.108	0.364	0.614	0.498
t-statistic	4.867	4.310	3.857	5.035	4.591	4.090
Median	-0.293	-0.334	-0.265	-0.167	-0.105	-0.268
Standard deviation	2.215	3.507	4.084	2.114	2.892	2.717
Skewness	16.122	2.118	1.295	3.171	2.801	2.093
Excess kurtosis	3.274	5.326	1.790	17.253	10.072	7.527
Sample size	775	325	203	855	469	499

Transaction costs are put at 0.02% per trade which implies a bid-ask spread of 4 basis points (according to Cheung-Chinn-Marsh, 2004; Cheung-Wong, 2000; Cheung-Chinn, 2001, the spread was only 3 basis points in the DM/\$ market). Hence, the net rate of return is by less than 1% smaller than the gross rate. Even for the fastest model (momentum 9/0 involving roughly 63 transactions per year) annual transaction costs would have amounted to only 1.27%.⁴⁾

⁴⁾ The number of transactions is always twice the number of open positions. Since for more than 80% of all 1024 models transaction costs are below 1% per year the profitability analysis is based on gross returns. This procedure has the additional advantage that the profitability components of the models depend only on the model parameters and the pattern of exchange rate movements (if the analysis was based on net returns the average return per day during profitable/unprofitable positions would also be influenced by transaction costs).

For any open position interest is earned from the long position and paid for the short position. Thus, the overall interest effect can be calculated using the information on the duration of the long and the short dollar positions and the interest differential. It turns out that during the sample period interest earnings and interest costs almost exactly (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:

$$\text{GRR} = \text{NPP} * \text{DRL} * \text{DPP} - \text{NPL} * \text{DRL} * \text{DPL}$$

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 than during unprofitable positions (measured in absolute terms, i.e., unsigned).
- 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.⁵⁾ The 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 reflect 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 profitability of making an overall loss when blindly following a technical trading model is estimated by testing the mean of the single rates of return against zero (only if this mean is negative does the trading rule produce an overall loss).⁶⁾ Since the t-statistic of almost every model shown in table 1 exceeds 4.0 one can conclude that the probability of making an

⁵⁾ The phenomenon of short-run exchange rate trends is investigated by Dewachter (2001) and Neely-Dueker (2005), their accumulation to long-run trends is modeled by Engel-Hamilton (1990).

⁶⁾ The t-statistic is more appropriate for measuring the return-risk relationship of technical trading systems than the Sharpe ratio since the latter does not take the number of single returns (open positions) into account, which varies across different models. If, e.g., two trading rules produce the same ratio between the average of single returns and their standard deviation (the Sharpe ratio) but a different number of trades, then the profitability of making an overall loss would be lower in the case of that model which trades more frequently. This fact is reflected by the t-statistic but not by the Sharpe ratio (for the same sample size both risk-return measures are just scalar multiples of each other).

overall loss by following the trading signals of these models over the entire sample period was less than 0.05%.

Figure 1: Distribution of 1024 trading systems by the gross rate of return DM/dollar trading 1973 - 1999

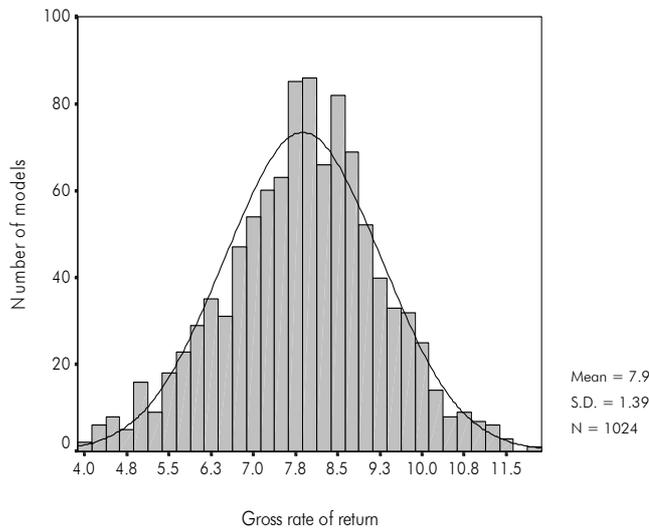
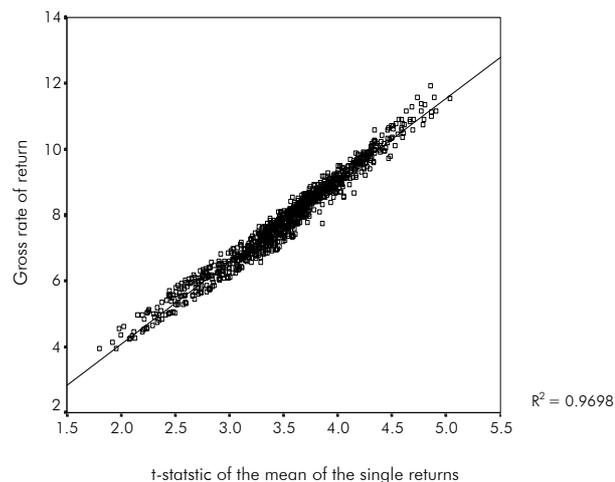


Figure 1 shows the distribution of all 1024 trading systems by their annual gross rates of return. On average they produce a mean return of 7.9% per year with a standard deviation of 1.39. The best performing models produce an annual return of roughly 12%, the worst models roughly 4%.

Figure 2: Profitability and riskiness of 1024 technical trading systems DM/dollar trading 1973 - 1999



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%. There prevails a very close linear relationship between the gross rates of return and the t-statistic: the more profitable a model is the smaller is the probability of making an overall loss.

3.2 The pattern of profitability of technical trading 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 18.2% of all models, the average rate of return per year (GRR) over these models amounts to 9.8%. The t-statistic of 38.7% of all models lies between 3.5 and 4.0 (GRR: 8.3%), 27.1% generate a t-statistic between 3.0 and 3.5 (GRR: 7.2%). The worst performing models, (t-statistic<3) with a share of 16.0%, still produce an average return of 5.7% per year.

Table 2: Components of the profitability of trading systems by types of models
Moving average and momentum models
DM/dollar-trading 1973-1999

t-statistic of the Mean of the single returns	Number of models		Gross rate of return	t-statistic	Mean for each class of models					
	Absolute	Share in %			Profitable positions			Unprofitable positions		
					Number per year	Return per day	Duration in days	Number per year	Return per day	Duration in days
< 3.0	164	16.0	5.69	2.616	5.82	0.065	56.91	7.26	-0.088	20.71
3.0 - < 3.5	278	27.1	7.21	3.296	5.23	0.063	63.26	6.73	-0.083	20.58
3.5 - < 4.0	396	38.7	8.34	3.717	5.99	0.069	53.83	7.84	-0.092	15.89
> 4.0	186	18.2	9.83	4.289	7.16	0.075	43.54	11.19	-0.106	10.05
All models	1,024	100.0	7.88	3.530	5.97	0.068	55.01	8.05	-0.091	16.87
MA models	948	92.6	7.85	3.517	5.84	0.068	55.82	7.80	-0.091	17.32
Momentum models	76	7.4	8.23	3.697	7.51	0.070	44.94	11.27	-0.101	11.24
Models with lag = 0	512	50.0	8.31	3.711	6.48	0.070	52.87	9.13	-0.095	15.38
Models with lag = 1 2000-2004 ¹⁾	512	50.0	7.45	3.349	5.45	0.066	57.16	6.98	-0.088	18.36
All models out-of-sample	1024	100.0	3.82	0.775	6.00	0.069	50.66	10.12	-0.116	13.24

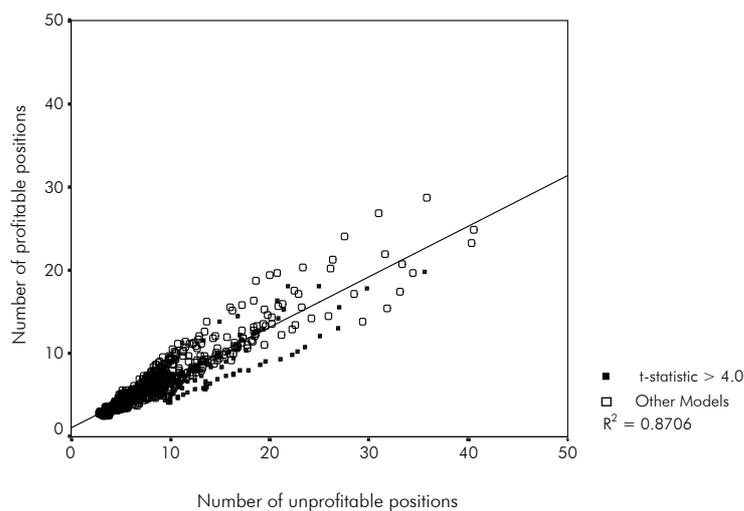
¹⁾ Euro/dollar trading.

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, so that the overall profitability is only due to profitable positions lasting three to four times longer than unprofitable positions. The best performing models signal the shortest open positions, this is particularly pronounced with respect to the unprofitable positions (they last only 10,1 days compared to 16.9 days in the case of all models). Hence, the best performing models optimize the duration of profitable positions relative to the duration of unprofitable positions.

Momentum models perform slightly better than moving average models (table 2). As expected, models operating with a lag of signal execution by one day produce significantly less trades than in the case of instantaneous execution. However, the average profitability of the models is slightly reduced by this delay filter (from 8.3% to 7.5% per year), mainly because it increases on average the duration of unprofitable positions to a greater extent than the duration of profitable positions.

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°). This is particularly true for the best performing models (t-statistic > 4.0).

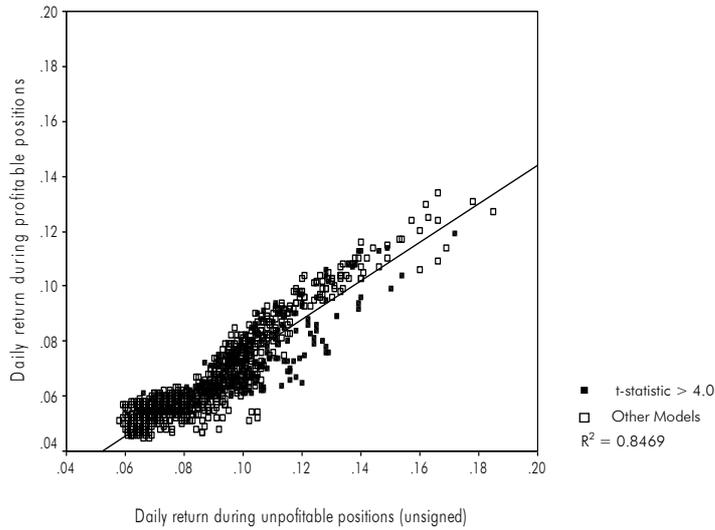
Figure 3: Frequency of profitable and unprofitable positions DM/dollar trading 1973 - 1999



The average return per day during profitable positions is always lower than during unprofitable positions (figure 4). However, profitable positions last several times longer than

unprofitable positions. This typical property of technical trading systems is particularly pronounced in the case of the best performing models (Figure 5).

Figure 4: Average daily return during profitable and unprofitable positions DM/dollar trading 1973 - 1999



Two conclusions can be drawn from these observations. First, the profitability of technical currency trading stems from the successful exploitation of persistent exchange rate trends. Second, the best performing models minimize the duration of unprofitable positions.

Figure 5: Average duration of profitable and unprofitable positions DM/dollar trading 1973 - 1999

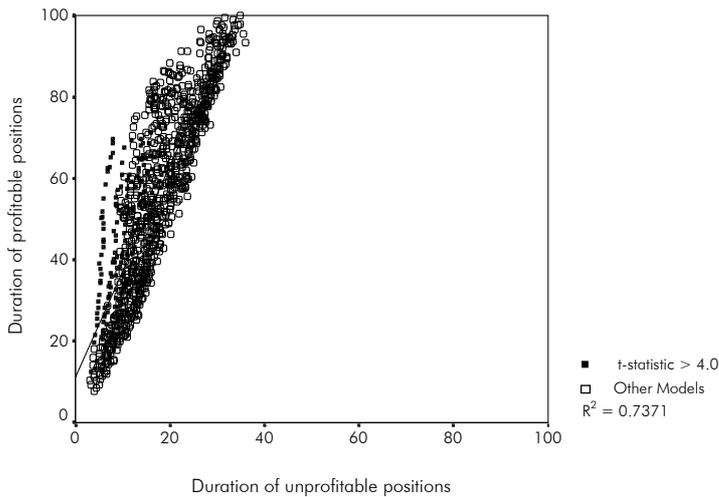


Figure 6: Distribution of 1024 trading systems by the ratio between the number of profitable and unprofitable positions
DM/dollar trading 1973 - 1999

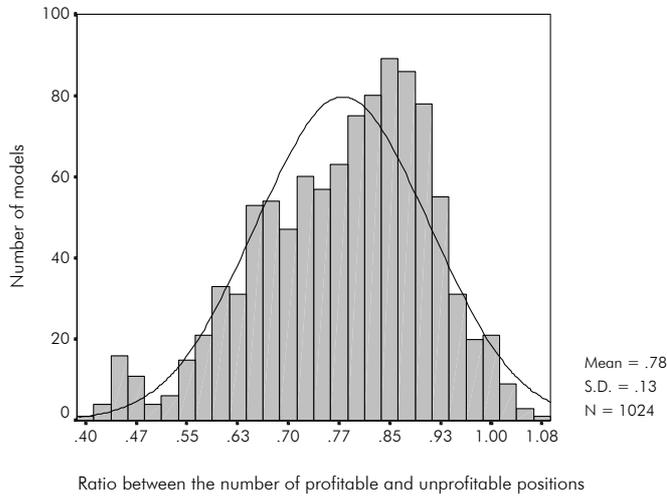


Figure 7: Distribution of 1024 trading systems by the ratio between the daily return during profitable and unprofitable positions
DM/dollar trading 1973 - 1999

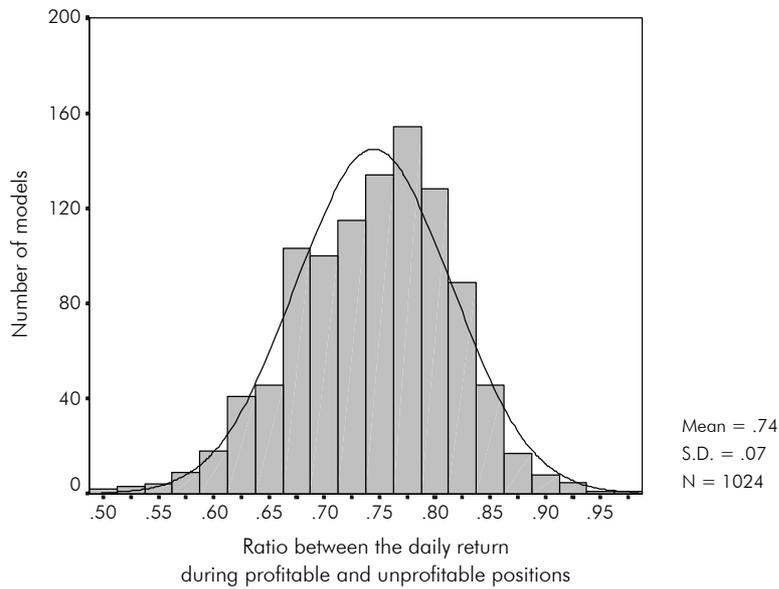
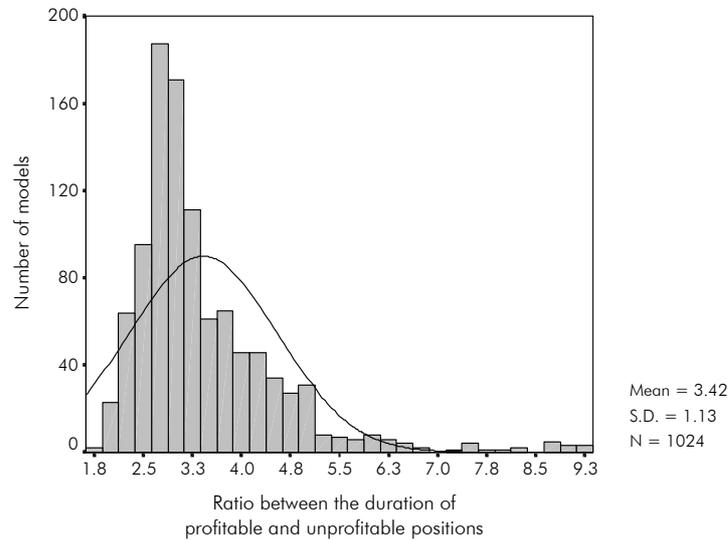


Figure 8: Distribution of 1024 trading systems by the ratio between the duration of profitable and unprofitable positions
DM/dollar trading 1973 - 1999



The figures 6 to 8 display the distribution of the 1024 trading systems by the ratios between the number of profitable and unprofitable positions, between the daily return during profitable and unprofitable positions, and between the duration of profitable and unprofitable positions. All three distributions are not symmetric. The mean of the ratio between the number of profitable and unprofitable positions (0.78) as well as the mean of the ratio between the daily return during profitable and unprofitable positions (0.74) are significantly lower than 1 and also lower than the mode and the median (very small values occur more frequently than implied by the normal distribution).

Profitable positions last on average 3.42 times longer than unprofitable positions (figure 8). At the same time the distribution of their ratio is extremely skewed to the right since very high ratios occur abnormally frequently. Hence, the high profitability of the best performing models might be the result of extraordinary high ratios between the duration of profitable and unprofitable positions which could have occurred only by chance.

Table 3 summarizes the results of splitting the overall profitability of technical currency trading into the ratios of its components. Only 2.1% of all models produce a greater number of single profits than single losses. The daily return during profitable positions is in most cases (52.0%) by 20% to 30% lower than during unprofitable positions. For 65.7% of all models the average duration of profitable positions is between 2.5 and 4.0 times longer than the duration of unprofitable positions.

Table 3: Distribution of technical trading systems by the ratio of the profit components
 Moving average and momentum models
 DM/dollar-trading 1973-1999

t-statistic of the mean of the single returns	NPP/NPL			DRP/DRL			DPP/DPL		
	<0.8	0.8 - 1.0	>1.0	<0.7	0.7 - 0.8	>0.8	<2.5	2.5 - 4.0	>4.0
< 3.0	32.9	67.2	-	17.7	72.0	10.4	34.8	61.0	4.3
3.0 - < 3.5	36.0	62.9	1.1	16.5	50.4	33.1	7.6	84.2	8.3
3.5 - < 4.0	51.0	44.7	4.3	27.5	49.2	23.2	11.1	68.2	20.7
> 4.0	82.3	16.7	1.1	46.2	42.5	11.3	5.4	37.1	57.5
Total	49.7	48.1	2.1	26.4	52.0	21.7	12.9	65.7	21.4

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 ratios are calculated in absolute terms, i.e., the negative sign of returns of unprofitable positions is neglected.

At first glance paradoxically, the performance of technical models is better the greater is the number of unprofitable positions relative to profitable positions. However, this effect is more than compensated by the average duration of profitable positions relative to the unprofitable positions. This ratio rises even stronger with the profitability of the models. Such a pattern reflects the general property of technical trading models: The profits from the exploitation of relatively few persistent price trends exceed the losses from many but small price fluctuations ("cut losses short and let profits run").

3.3 Parameters of technical models and their trading behavior

A clear relationship prevails between the size of the parameters of technical models and their sensitivity to price changes ("speed") and, hence, their "specialization" on the exploitation of price trends by their duration.

In the case of moving average models (figure 9), the duration of the profitable positions increases with the difference between the length of the short-term and the long-term moving averages (the smaller this difference is the more crossovers occur between both moving averages). The average duration of profitable positions produced by momentum models increases almost monotonically with the size of the time span i .

The relationship between the length of the long-term moving average and the profitability of moving average models is displayed in figure 11 taking the models with $MAS=1$ and instantaneous signal execution as examples. In this case the most profitable models are those which use a long-term moving average between 15 and 35 days. The close relationship displayed in figure 11 can hardly be reconciled with a near random behavior of the exchange rate. This does not imply that one can easily select profitable models ex ante.

However, finding such relationships as in figure 11 when searching for optimal models will attract more and more traders to use technical analysis at least as an additional source of information.

Figure 9: Duration of profitable positions and the parameter of trading systems
Moving average models with lag = 0
DM/dollar trading 1973 - 1999

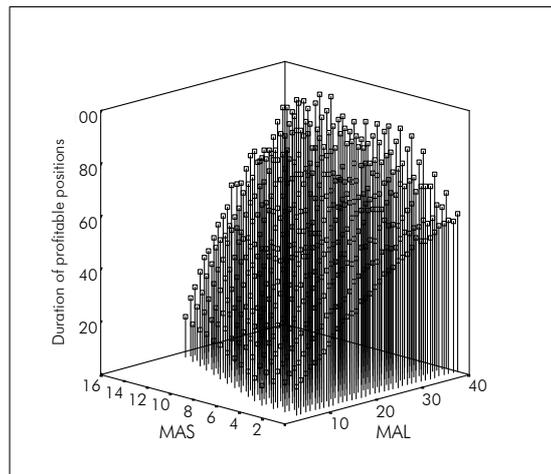


Figure 10: Duration of profitable positions and the parameters of trading systems
Momentum models with lag = 0
DM/dollar trading 1973 - 1999

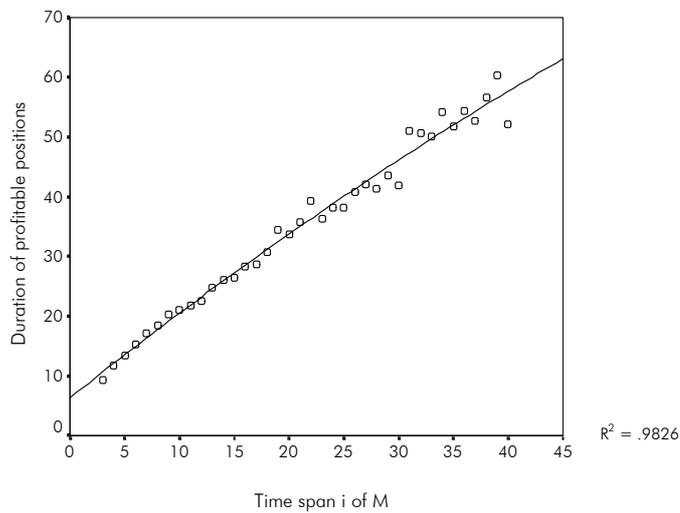


Figure 11: Profitability and parameter of trading systems
Moving average models with MAS = 1 and lag = 0
DM/dollar trading 1973 - 1999

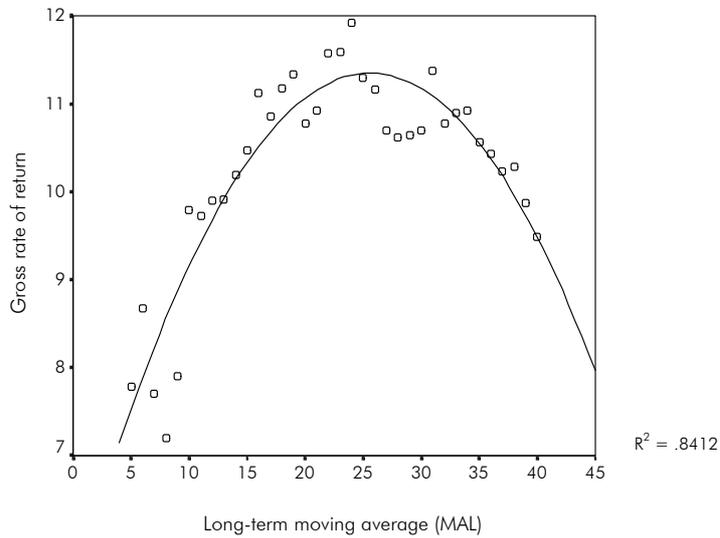
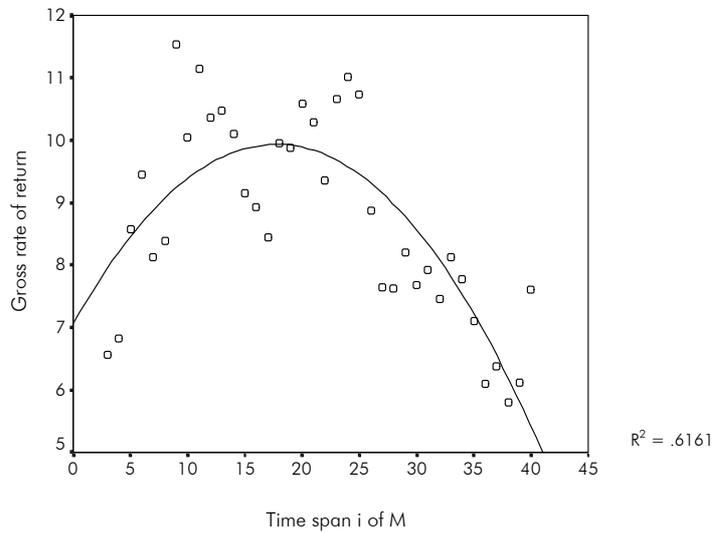


Figure 12: Profitability and parameter of trading systems
Momentum models with lag = 0
DM/dollar trading 1973 - 1999



In the case of momentum models the highest profitability is achieved by those models which use a time span i between 10 and 25 days. However, the relationship between the performance of technical models and the size of their parameters is less close in the case of the momentum models as compared to the moving average models (figures 11 and 12).

4. The performance of technical trading systems over subperiods

4.1 Performance of all models

The study divides the overall sample period 1973/99 into 7 subperiods each lasting 4 years except for the first subperiod which lasts for 3 years. Table 4 shows the performance of the 1024 technical models over these subperiods plus the out-of-sample period 2000-2004.

*Table 4: Performance of technical trading systems by subperiods
In sample and out of sample
DM/dollar-trading 1973-1999*

	All models	25 best models	
		In Sample	Out of sample
1973 - 1975			
Gross rate of return	23.61	29.78	
t-statistic	2.570	2.939	
Duration of profitable positions	62.6	48.47	
Share of profitable models in %	100.0	100.0	
1976 - 1979			
Gross rate of return	8.35	12.69	9.13
t-statistic	2.184	3.670	2.485
Duration of profitable positions	56.68	31.57	38.99
Share of profitable models	100.0	100.0	100.0
1980 - 1983			
Gross rate of return	9.52	16.97	9.35
t-statistic	1.663	2.983	1.609
Duration of profitable positions	55.61	22.77	35.18
Share of profitable models in %	99.6	100.0	100.0
1984 - 1987			
Gross rate of return	9.71	19.43	13.20
t-statistic	1.357	2.707	1.976
Duration of profitable positions	59.77	32.88	21.56
Share of profitable models	100.0	100.0	100.0
1988 - 1991			
Gross rate of return	7.03	13.29	8.93
t-statistic	1.086	2.027	1.423
Duration of profitable positions	50.35	47.93	33.52
Share of profitable models	97.9	100.0	96.0
1992 - 1995			
Gross rate of return	-1.24	7.62	-3.96
t-statistic	-0.223	1.333	-0.707
Duration of profitable positions	47.73	35.28	43.45
Share of profitable models	37.8	100.0	0.0
1996 - 1999			
Gross rate of return	2.58	7.26	2.98
t-statistic	0.595	1.580	0.679
Duration of profitable positions	51.54	55.16	38.13
Share of profitable models	90.6	100.0	76.0
2000-2004 ¹⁾			
Gross rate of return	3.82	9.80	0.48
t-statistic	0.775	1.990	0.098
Duration of profitable positions	50.66	57.22	47.73
Share of profitable models	91.7	100.0	52.0

¹⁾ Euro/dollar trading.

The (ex-post) performance of the 1024 models over all subperiods can be summarized as follows (table 4). First, these models would have made losses in only 840 out of 8192 cases (1024 models over 8 subperiods). Second, by far most of these losses (637) occurred over the subperiod 1992-1995, when also the average return over all models was slightly negative (-1.24%).⁷⁾ Third, the profitability of technical currency trading was higher over the period 1973/1987 as compared to the period 1988/2004. However, there is no clear trend of declining returns within the latter period.

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 consist 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.

4.2 Performance of the best models in sample and 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 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.

⁷⁾ An inspection of exchange rate movements points to two main reasons for the poor performance of technical models between 1992 and 1995. First, exchange rate trends were steeper and shorter over this subperiod (as well as over the last subperiod 1996/99) when compared to the preceding 18 years. Second, the size of countermovements during exchange rate trends as well as the size of short-term fluctuations ("whipsaws") were unusually large, causing technical models to produce relatively big single losses. The fact that long-term models performed comparatively better between 1992 and 1995 lends support to this explanation.

Table 5: Distribution of trading systems by the gross rate of return and by the ratio of profit Components over six subperiods
DM/dollar-trading 1976-1999

Variable	Mean	S.D.	t-statistic
All models (N = 6144)			
Gross rate of return	5.99	5.05	
NPP/NPL	0.760	0.237	
DRP/DRL	0.751	0.229	
DPP/DPL	3.412	1.253	
The 25 most profitable models (N = 150)			
In sample			
Gross rate of return	12.88	4.56	18.234
NPP/NPL	0.920	0.349	5.584
DRP/DRL	0.844	0.279	4.049
DPP/DPL	4.001	1.624	4.410
Out of sample (N = 150)			
Gross rate of return	6.61	6.19	1.217
NPP/NPL	0.623	0.162	-10.097
DRP/DRL	0.700	0.206	-2.987
DPP/DPL	4.168	1.638	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 150 cases of the best models (in and out of sample) and the respective mean over the 6144 cases of all models.

As expected, the means of all three ratios of the profit components are significantly higher in the case of the 25 best models in sample than in the case of all models. Consequently, the mean annual rate of return of the best models (12.9%) is more than twice as high than the mean over all models (6.0%).

The profitability pattern of the best models out of sample is very different from the profitability pattern of all models and of the best models in sample. The mean ratio between the number of profitable and unprofitable positions as well as the mean ratio between the daily return during profitable and unprofitable positions are significantly lower in the case of the best models out of sample as compared to the average ratios over all models. Hence, these differences are even greater between the best models out of sample and in sample. 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 and consequently significantly higher than in the case of all models. 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.

4. Summary and concluding remarks

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

- Each of the 1024 moving average and momentum models investigated would have produced a positive overall return in the DM/dollar market between 1973 and 1999. The risk of making an overall loss when strictly following one of these models would have been close to zero.
- In the out-of-sample period between 2000 and 2004, 91.7% of the models would have remained profitable.
- The profitability of technical currency trading is exclusively due to the exploitation of persistent exchange rate trends since profitable positions last on average several times longer than unprofitable positions. At the same time, unprofitable positions occur more frequently than profitable positions and the average loss per day during unprofitable positions is higher than the average profit during profitable positions.
- These results do not change substantially when technical currency trading is examined over subperiods. With 1024 models and 8 subperiods, we have 8192 cases. In only 840 of these did the technical models produce losses.
- The out-of-sample profitability of those models which performed best in sample is slightly higher than the average in-sample profitability of all models. However, the ex-post best models perform worse out of sample than in sample.
- The profitability of technical trading has been significantly lower since the late 1980s as compared to the first 15 years of the floating rate period. However, there is no clear trend of declining returns within the period since the late 1980s.

These results do certainly not prove that one can easily make money through technical currency trading. They do, however, demonstrate that the profitability of many popular models is sufficiently high to cause an increasing number of practitioners to use them at least as an additional informational basis for their trading decisions.

When noise traders are specified in theoretical models it is often assumed that they just follow the most recent price movement, e.g., they buy whenever the price is rising.⁸⁾ Such an assumption does not hold true for technical analysis as the most popular form of non-fundamental trading. This is so because any technical model produces only one signal per

⁸⁾ For theoretical treatments of noise traders see De Long-Shleifer-Summers-Waldmann, 1990A and 1990B; Frankel-Froot, 1990; Cutler-Poterba-Summers, 1991; Hong-Stein, 1999; Daniel-Titman, 2000.

(expected) trend, namely, in its early stage. If a (noise) trader – as assumed in theoretical models - would continuously buy (sell) during an upward (downward) trend he will systematically lose on all trades made in the late stage of a trend.

Also, technical trading does not imply a simple forecast through extrapolation as is mostly assumed in theoretical models. The expectation implied by following a technical trading signal consists of three different elements. First, in most cases a trader will incur losses when following the signal. Second, in some cases a price trend will take off in line with the signal (it is not specified when this will happen). Third, if a trend develops no forecast is implied as to how long it will last or what price level will be reached by its end. Hence, technical trading signals do not represent forecasts in any conventional sense. The main "forecast" implied by the use of technical analysis concerns the pattern of asset price dynamics as a whole. It is implicitly assumed that persistent price movements occur sufficiently often so as to more than compensate a technical trader for the more frequent losses caused by minor fluctuations. This type of expectations formation reduces the complexity of making trading decisions to the minimum required for earning profits in "trending" asset markets.

This type of expectations formation can also explain why most currency trading is done on an intraday basis even if traders consider intraday exchange rate movements unpredictable (as surveys reveal). This is so because technical models based on high frequency data enable one to trade intraday without having to make exchange rate predictions.⁹⁾

The general property of technical analysis – that of reducing the complexity of decision making to the minimum required for making profits in "trending" asset markets - has certainly contributed to its increasing popularity among professionals (this popularity can even be interpreted as a result of the professionals' learning from their extremely poor forecasting performance – see Bofinger-Schmidt, 2004; Menkhoff-Rebitzky-Schröder, 2005). The widespread use of technical models based on different data frequencies - fostered by technical trading software and the internet – might also explain to a great part the level and growth of trading volume in currency markets. News alone does not emerge frequently enough to account for this volume.

The expectation formation and (potential) profitability implied by technical models are only based on a qualitative pattern in asset price dynamics, unrelated to any kind of fundamental equilibrium. Hence, Milton Friedman's argument that speculators necessarily wipe out profit opportunities by exploiting them and that they push the price to its fundamental value by doing so, does not apply for technical trading. If (more) traders attempt to exploit profit opportunities (allegedly) provided by technical models and start using these models, then the trending behavior of the respective asset price and, hence, the source of the profitability of technical analysis would rather be strengthened than weakened.

⁹⁾ An open question is the extent to which intraday currency speculation is practiced by banks also as compared to customers like hedge funds – on this issue see Lyons, 1998; Yao, 1998; Mende-Menkhoff, 2005).

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