Forex Trading System Based On Macroeconomic Announcements

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1 Abstract

This paper presents research on Forex market trading models which are designed to explore market inefficiencies occurring directly after macroeconomic announcements. The proposed trading system is based on the observation that the value of the difference between the actual announcement and its forecast, if sufficiently distant from zero, causes a strong and predictable market reaction. The exemplary closing position algorithms are presented and next for chosen macroeconomic indicators the optimization process and tests are performed. The results of the calculations confirm the existence of exploitable trading patterns which validates the presented approach to event-driven trading and results in the possibility of performing succesfull optimization. The effective closing position patterns can be simple and effectively implemented.

Keywords: foreign exchange market, macroeconomic announcements, event-driven trading, strategies, optimization.
Article Classification: Research Paper.

2 Introduction

Macroeconomic announcements are often a cause of rapid and significant price change of numerous financial instruments, and among them currency pairs. A violent market reaction occurs in most cases when the actual announcement differs significantly from the market expectations quantified in the forecast. This reaction usually covers first few minutes after the publication and is caused by unequal access to information (investors receive and process incoming data in different time). Event-driven trading as we define it is an attempt to exploit the above described market inefficiencies. This can be done either by discovering the inefficiencies by observing market reaction or by technology advantage (faster processing of incoming data). In this paper we focus on possible exploitation of macroeconomic announcement causing market inefficiencies. The investment decision of the presented system is taken based on the value of the difference between the actual announcement and its forecast (which can be interpreted as the unknown compoment of the announcement and is shortly denoted by Delta in this paper). Although there is a strong dependance between the Delta and the

corresponding market reaction, there is no visible pattern for predicting price change scale. The crucial elements of the presented market behaviour research are:

- identifying which announcements cause the significant price reaction for the related instruments,
- establishing the border values of Delta, above which there is big probability of rapid and significant market reaction,
- finding closing position signals.

This paper analyses 8 chosen macroeconomic indicators, proposes the algorithm of finding proper Delta values and three closing mechanisms which are based on a moving price indicator. The parameters optimization is performed and the resulted parameters are tested out of sample in order to examine the validity of the presented approach. The data used in this research consists of two major components: macroeconomic data received thanks to Robotero - an event-driven trading platform (macroeconomic data include both macroeconomic indicators and their forecasts) and tick-by-tick historical price data collected by the authors).

3 Glossary

For further clearance, please find below notation and the definitions of terms used in this paper.

- Actual - the value of the released indicator,
- Forecast - the value of the published market forecast for the indicator
- Delta = Actual - Forecast
- Ask prize- the price at which an investor can buy one unit of the given currency
- Bid prize - the price at which an investor can sell one unit of the given currency
- Spread
- 1 point (1 pts) - price change of currency pair valued 0.00001
- 1 tick - a single available quotation which includes information on Ask price, Bid price and the exact time (with the milliseconds accuracy),

4 Trading system scheme and data

The general scheme of the analysed trading system is presented below.

Trading system scheme.

0 **Before the announcement**.

(a) Choose the corresponding instrument

(b) Fix proper values of: $D_1 > 0$ and $D_2 < 0$

(c) Choose a closing position algorithm and the appropriate parameters, including stop loss parameter S_2 and time parameter T.

1. **Entry rule.**

   (a) As soon as the information is available calculate:

   $$Delta = Actual - Forecast.$$

   (b) If the following condition is satisfied:

   $$\text{Delta} > D_1 \text{ or Delta} < D_2 \tag{1}$$

   open a position immediately. The sign of Delta determines the expected direction of the price change and thus it determines whether short or long position is taken.

2. **Exit rule.** Close the position when one of the following conditions is satisfied:

   (a) the closing algorithm found the closing position signal

   (b) the price of the instrument crossed the stop loss level

   (c) the time of length T has passed since the announcement

Columns of Table 1 present information on data used for system optimization and tests:

- the analysed macroeconomic indicators,
- corresponding currency pairs - EUR, USD, GBP, AUD are considered as major currencies in Forex market while NOK is an example of a rather "exotic" Forex currency which has rather low liquidity and relatively big spreads
- the expected direction of price change - the arrows express this direction depending on the sign of Delta. For example, positive value of Delta for Nonfarm Payroll indicator expresses that the US economy is strengthenning and thus the price of EURUSD is expected to decrease.
- after announcement time intervals T which were used for further calculations. Recall that T parameter is the maximal time before position closing - the crucial thing is that the value of T is big enough to exploit the indicator potential. For Nonfarm Payroll, the most influencial indicator, the proposed time T is big enough to guarantee that the position is closed at the end of the trading week (Friday 17 PM (time UTC-5)) if closing signals are not found earlier.
- time periods covering data sets. The time period cannot be to long as the market reactivity patterns change in time. For American announcements a smaller data sample has been used because of the change of the American market behaviour pattern which took place in the second half of 2012.

- density on data used in the analysis - fifth column presents the mean number of ticks which occurs during first minute after macroeconomic release (the greatest investors'activity occours directly after the announcement) which is a measure of the data density.

Table 1: Announcements

Indicator	Symbol	Inf.	Time	Period	Ticks
US Nonfarm Payrolls	EURUSD	$+ \searrow$ $- \nearrow$	8.5 h	09.2012-04.2015	366
US ADP Nonfarm Payrolls	EURUSD	$+ \searrow$ $- \nearrow$	1.75 h	08.2012-05.2015	278
Unemployment Claims (USA)	EURUSD	$+ \nearrow$ $- \searrow$	0.5 h	07.2012-04.2015	281
US Core Retail Sales	EURUSD	$+ \searrow$ $- \nearrow$	2.5 h	08.2012-05.2015	289
Retail Sales ex auto (NOR)	EURNOK	$+ \searrow$ $- \nearrow$	0.5 h	01.2011-05.2015	139
Employment Change (AUS)	AUDUSD	$+ \nearrow$ $- \searrow$	0.5 h	01.2011-05.2015	297
Ifo Business Climate Index	EURUSD	$+ \nearrow$ $- \searrow$	0.5 h	01.2011-05.2015	223
Manufacturing Production (UK)	EURGBP	$+ \searrow$ $- \nearrow$	0.5 h	01.2011-05.2015	188

5 Position openning

A short position is taken if the price is expected to decreaseand a long position is taken in the opposite case. Based on the assumption that desirable (i.e. strong and predictable) market reaction occur when Delta is sufficiently distant from zero the simple openning condition (1) is proposed. A general criterion for choosing the right values of constants $D1$ and $D2$ does not exit. A general rule is: the more restrictive Delta condition the less risk but also the lower number of transactions. The basic difficulty in finding proper values of $D1$ and $D2$ is small amount of data: the announcements are relatively rare and at the same time the analyzed time period cannot be too long as the market reactivity patterns change in time. The procedure used in this paper was simple and and it was applied to in sample part of data. The resulted values $D1$ and $D2$ were used forout of sample tests.

6 Position closing

For significant values of Delta the market reaction is usually rapid. However, there is no visible correlation between this value and the scale of price change. Therefore, finding an optimal position closing is a challenging issue. This section describes precisely proposed closing position algorithms. Roughly speaking, the position closing signal is found when the current price value crosses an appropriate indicator function. A simpler approach to the analyzed problem could be to close the position right after the market currency exchange rate crosses

some satisfactory level S ("Take Profit" algorithm). However such approach is far from optimal - after crossing the level S the currency value dynamics can be still profitable and the appropriate closing mechanism could increase the final profit. The closing postion algorithms are combined with the stop loss mechanism and authomatic closing after time T. They work on tick-by-tick data and depend on four parameters (including stop loss parameter and time parameter). The following three parameters are common for all the exit rules analysed here:

- stop loss parameter $S_2 > 0$ - the algorithm closes the position automatically if the current profit is negative (the loss) and the value of the loss is greater than S_2,
- time parameter $T > 0$ - if the position is not closed before time T since the announcement then the position is closed automatically,
- parameter $S \geq 0$ - if the market reaction reaches the level S then the "closing mechanism" of the strategy is started automatically - the algorithm starts to wait for closing position signal which is determined by fourth parameter (the details are given below).

Roughly speaking, the fourth parameter determines the closing mechanism sensitivity towards changes in the prize behaviour. The detailed description will use the following notation (recall that algorithms work on tick by tick data):

- Ask(n) - the Ask price of the currency pair at the n-th after the announcement tick,
- Bid(n) - the Bid price of the currency pair at the n-th tick after the announcement tick,
- P_n - the profit from the transaction which is opened immediately after the announcement and closed at the n-tick after the announcement. Depending on the sign of Delta, we have

$$P_n = Ask(n) - Bid(1) \text{ or } P_n = Bid(n) - Ask(1).$$

The formulas below are presented under the assumption that the currency prize is expected to decrease - the short position is taken at the beginning and final profit P is given by the formula $P = Ask(T_S) - Bid(1)$, when T_S is the closing moment. In the opposite case (the increase of the exchange rate) the strategies mechanisms are analogous - in particular, the inequalities in the formulas are opposite and the algorithms analyze the behaviour of the Bid values instead of Ask values as the final profit is given by $P = Bid(T_S) - Ask(1)$.

Af first define the moment T_1 which starts the closing mechanism according to the equation:

$$T_1 = \min\{n \in \mathbb{N} \colon Ask(n) \leq Ask(1) - S\}.$$

Next the closing moment is determined by one of the following rules:

1. **TSL method.** The closing moment T_2 based on TSL method uses parameter $S_1 \geq 0$ and is given by the formula:

$$T_2 = \min\{n > T_1 \colon \min_{i=1,\ldots,n} Ask(i) + S_1 \leq Ask(n) \}.$$

2. **Median method.** The closing moment T_2 based on moving median uses parameter $m \in \{2, 3, 4, \dots\}$ and is given by the formula:

$$T_2 = \min\{n > T_1 : \ median(Ask(n-m+1), \dots, Ask(n)) \leq Ask(n) \ \},$$

where function $median()$ denotes the median of the sequence.

3. **Mean method.** The closing moment T_2 based on moving mean uses parameter $m \in \{2, 3, 4, \dots\}$ and is given by the formula:

$$T_2 = \min\{n > T_1 : \ median(Ask(n-m+1), \dots, Ask(n)) \leq Ask(n) \ \},$$

where function $mean()$ denotes the mean of the sequence.

The closing moment T_2 based on TSL method determines the first tick after the moment $T1$ at which: 1) the value of Ask is greater than the smallest (the best) value observed so far and 2) the difference between those two values crossed the level S_1 - a suggestion that the profitable dynamics of the currency has changed. Small values of S_1 can lead to premature closing of the position while the big values of this parameter delay the closing of the position. The proper values of S_1 are strongly dependent on the scale of the after announcement currency volatility. The below pictures illustrate exemplary behaviour of the TSL strategy. The currency is EURUSD which responds to the announcement of German Ifo Business Climate Index from day 22.03.2013. The green points represent the moment T_1 and the brown points represent the closing moment T_2. The red line represents the TSL function which is given by the formula

$$TSL(n) = \min_{i=1,\dots,n} Ask(i) + S_1.$$

Picture 1 shows how small values of S and S_1 lead to premature closing moment and the loss. On the picture 2 greater value of S_1 closes the position at proffitable moment.

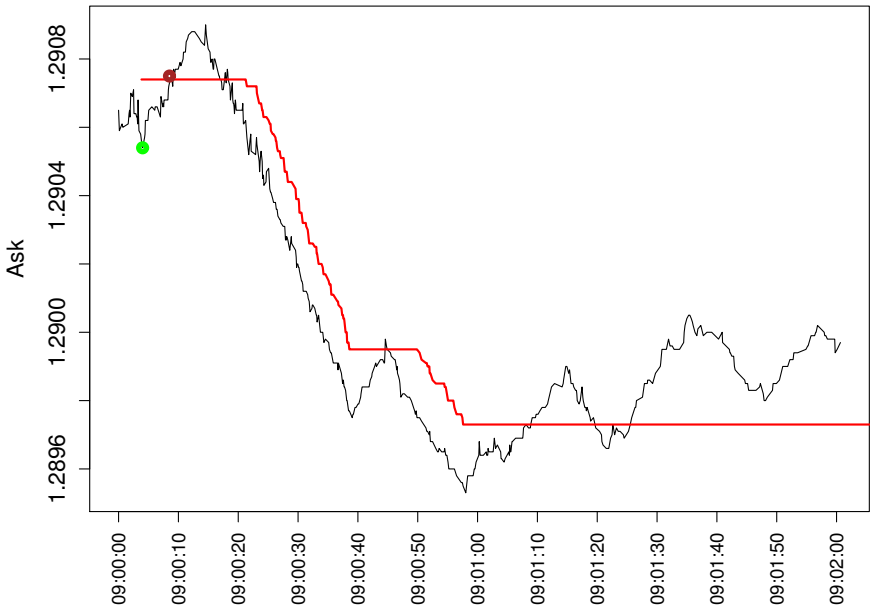

Figure 1: Exemplary behavior of TSL strategy for S=10, S1=20

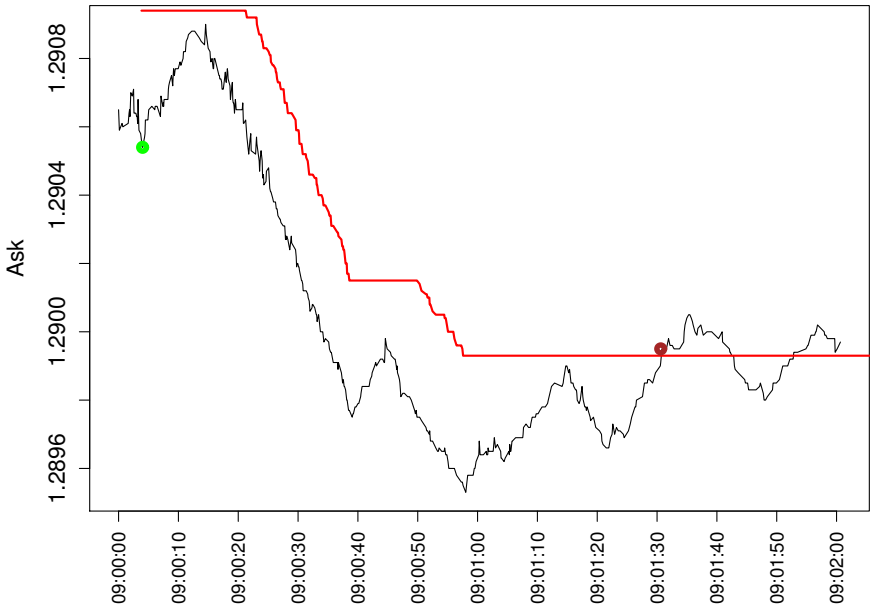

Figure 2: Exemplary behavior of TSL strategy for S=10, S1=40

Regarding Median/Mean closing method, the T_2 is the first moment after T_1 at which the value of Ask is greater that the median/mean of the m previous Ask values. A small value of m may lead to premature closing of the position while big values of m delay the closing of the position. Contrary to the properties of the S_1 parameter of TSL strategy the proper values of m are strongly dependent on the frequency of available tick data and are not dependent on the scale of the market reaction towards to macroeconomic announcement.

Pictures 3 and 4 present behavior of Median strategy. The currency is EURUSD which responds to the macroeconomic indicator German Ifo Business Climate Index from day 24.08.2011. The green points represent the moment of opening the strategy(T_1) and the brown points represent the moment of strategy (and position) close T_2. Blue lines represent the value of a median of m last ticks. Picture 3 shows how too small values of m lead to premature closing moments. On the picture 4 greater value of m increases the final profit.

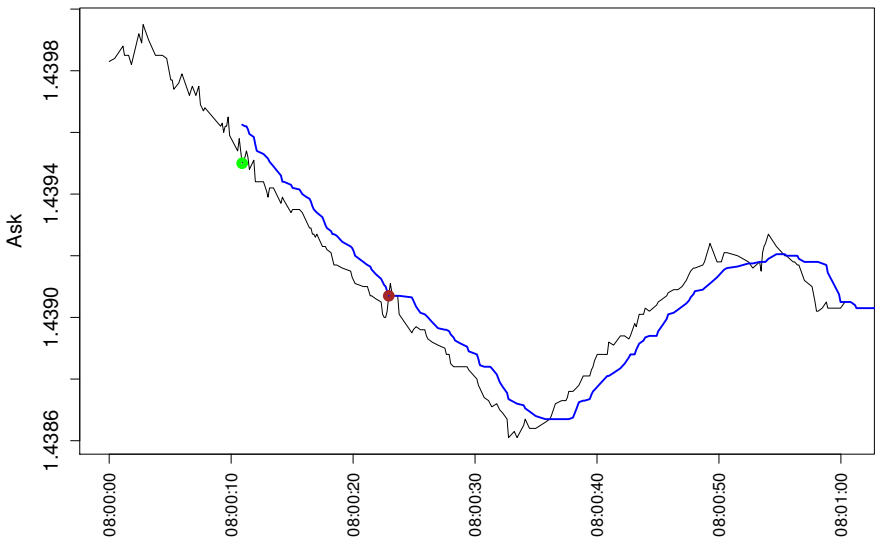

Figure 3: Exemplary behavior of Mediana strategy with parameters S=30, m=15

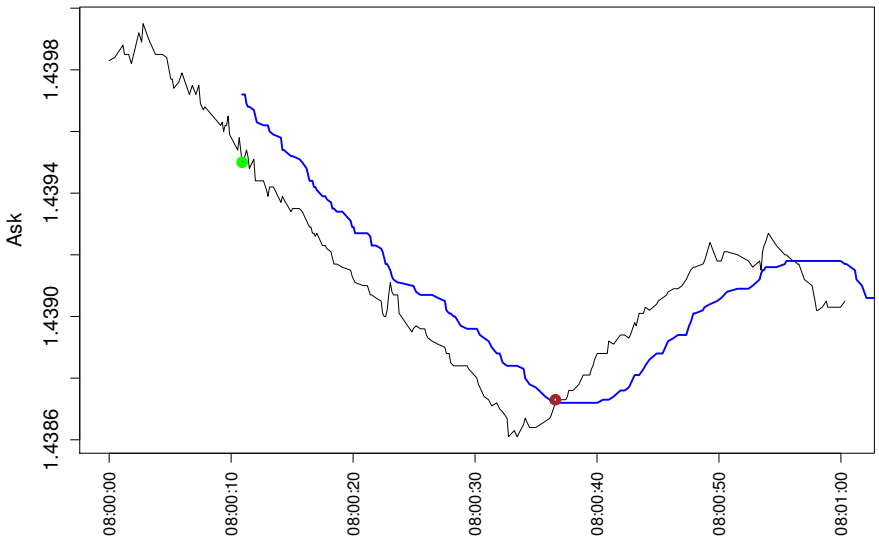

Figure 4: Exemplary behavior of Mediana strategy with parameters S=30, m=30

Recal that all the three above closing position methods are combined with the stop loss an the authomatic closing after time T. Thus the final entry rule is to close the position in moment $T_S = \min\{T_2, T_3, T_4\}$, where T_2 is the closing moment detected by TSL/Median/Mean method, T_3 is the moment defined by the stop loss S_2 and T_4 is defined by the time parameter.

7 Optimization and tests. Methodology.

This section describes the methodology behind the optimization process and further tests. At first all data are divided into historical data (in sample data) and test data (out of sample data) in chronological order according to the proportion 80-20 approximately. Next, based on historical data, the values of D_1 and D_2 are calculated according to the methodology described in Section 5. Macroeconomic publications which do not satisfy condiction (1) do not cause position openning and thus they are removed from further optimization process. The remaining historical data is used to calculate the optimal parameters for each indicator and a closing position strategy. The performed optimization is simple - for each currency pair, closing position algorithms and corresponding collection of admissible parameters: S, $S2$ and $S1/m$, the total profit is calculated. The parameters with the greatest final return are chosen as optimal. Next the trading system is tested out of sample: the optimal parameters are

used to calculate strategies's profits on test data. The optimization validatity is examined with use of the following indicators :

1. **mean profit** - mean profit from all the transactions (in points)
2. **win ratio**- the proportion of the profitable publications to all the transactions
3. **standard deviation** - the standard deviation of all strategy profits (in points)
4. **total efficiency** - the proportion of the total profit (the sum of all single profits from the strategy) to the total maximal profit (the total maximal profit is the sum of maximal possible profits for all non-rejected publications; maximal possible profit from a single publication equals to the value of $\max_{n=1,2,\ldots,n_T} P_n$, where n_T is the last observed within time interval determined by the time parameter T).

The above mentioned indicators of the strategy are calculated on historical and test data separately for optimal parameters.

8 Optimization and tests. Empirical results.

Coluymns of Table 2 present further information on historical data:

- first two columns present the results of Delta calculations, i.e. the border values D1 and D2. In case of US Initial Unemployment Claims indicator cases it was noticed that negative values of Delta cause different market behaviour pattern than positive values and because of that cases $Delta > D1$ and $Delta < Delta2$ were analysed and optimised separately.
- the ratio of transactions denote the proportion of annoncements for which Delta value caused the position opening (see condition (1)) to all the considered announcements.
- mean maximum possible profit is the average of maximal possible profits which are given by

$$Max = \max\{P_n : \ time(n) \leq T\} \tag{2}$$

  (recall that the P_n is the profit from the transaction which is closed at the n-th tick accessible after the announcement)

- mean maximal possible loss is the average of maximal possible losses which are given by:

$$MaxL = \min\{P_n : \ time(n) \leq T\} \tag{3}$$

- mean initial spread is the average spread at the moment of position openning

Table 2: Delta values and basic statistics

Indicator	D1	D2	Ratio of trans.	Mean max. profit	Mean max. lost	M. in. spread
US Nonfarm Payrolls	-10	10	25:32	812	146	32
US ADP Nonfarm Payrolls	-10	10	31:35	299	208	11
Unemployment Claims (USA) negative Delta	-11	X	42:81	167	166	14
Unemployment Claims (USA) positive Delta	X	11	26:71	147	184	16
US Core Retail Sales	-0.1	0.1	31:34	558	161	19
Retail Sales ex auto (NOR)	-0.6	0.6	24:42	1791	952	542
Employment Change (AUS)	-500	500	52:53	469	117	56
Ifo Business Climate Index	-0.1	0.1	52:53	188	114	14
Manufacturing Production (UK)	-0.5	0.5	25:53	147	59	28

The values of last three columns are expressed in points of variable currency which is echanged for one unit of fixed currency - for an illustration assume that an investors echange one Euro with Dolars after the release of US Nonfarm Payrolls (i.e. opens a long position on EURUSD currency by bying one Euro). The mean maximal profit of this investor equals to $0,00812$ Dolars.

Pictures 5 and 6 illustrate the market reactivity. For every release from the analysed time period the maximal possible profits Max are represented by red dots and the maximal possible losses (3) are represented by blue dots (the x-axis presents the values of Delta and the values on y-axis are expressed in points). As one can notice, for the most powerful indicator US Nonfarm Payroll there is the most visible advantage of the maximum possible profits over the maximum possible loss if we do not take into account the releases with the values of Delta close to zero. Naturally, the reaction scale depends on a currency pair.

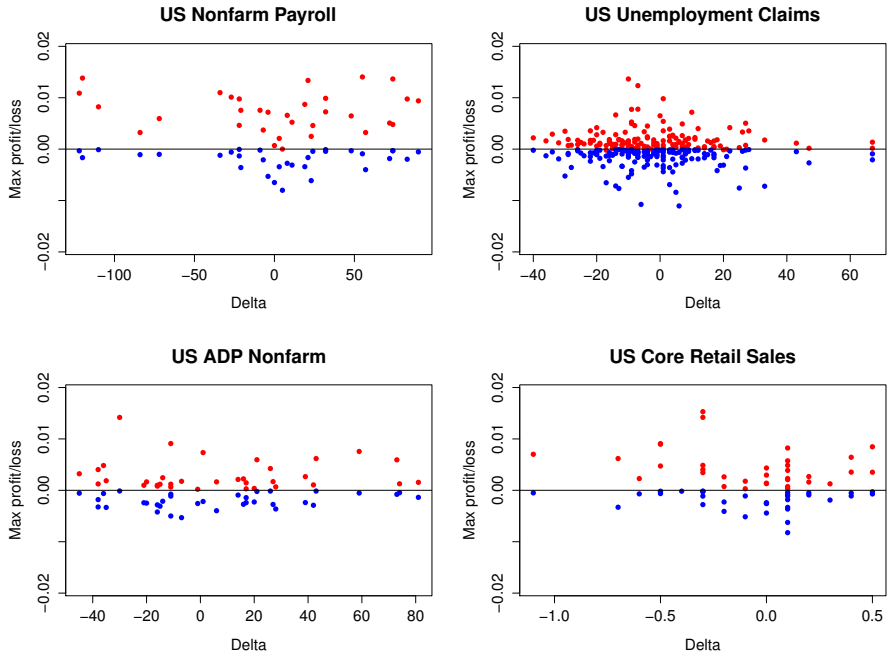

Figure 5:

Figure 6:

Table 3 presents the results of optimization. Column "Parameters" contains the values of optimal parameters in the following order: (S, S_1, S_2) for TSL, and (S, m, S_2) for median/mean. The last three columns present: win ratio, standard deviation and total efficiency (expressed in points) for optimal parameters (one must remember that points from different currencies are different measures of profitability).

Table 3: Optimization results (historical data)

Indicator	Mean profit	Parameters	Win ratio	S.d.	Total eff.
US Nonfarm Payrolls	TSL: 470	(850; 100; 450)	16:20	422	0.638
	Mean: 469	(825; 5; 450)	16:20	400	0.637
	Median: 469	(825; 10; 450)	16:20	400	0.637
US ADP Nonfarm Payrolls	TSL: 71	(120; 8; 35)	16:25	96	0.256
	Mean: 74	(120; 60; 35)	16:25	101	0.268
	Median: 74	(40; 185; 245)	24:25	110	0.269
Unemployment Claims (USA) negative delta	TSL: 80	(96; 12; 140)	31:34	72	0.47
	Mean: 82	(96; 28; 140)	31:34	75	0.48
	Median: 82	(96; 28; 140)	31:34	75	0.48
Unemployment Claims (USA) positive delta	TSL: 39	(114; 28; 40)	9:21	103	0.34
	Mean: 37	(120; 40; 40)	6:21	93	0.32
	Median: 37	(120; 32; 40)	9:21	95	0.32
US Core Retail Sales	TSL: 200	(980; 136; 280)	14:21	509	0.45
	Mean: 162	(860; 90; 280)	14:21	373	0.364
	Median: 161	(860; 120; 280)	14:21	373	0.363
Retail Sales ex auto (NOR)	TSL: 835	(2450; 280; 2200)	16:24	1445	0.517
	Mean: 846	(2450; 190; 2200)	16:24	1385	0.521
	Median: 837	(975; 204; 1800)	19:24	1090	0.518
Employment Change (AUS)	TSL: 333	(0; 172; 250)	39:42	241	0.682
	Mean: 321	(0; 216; 250)	39:42	229	0.656
	Median: 321	(510; 34; 300)	37:42	262	0.656
Ifo Business Climate Index (GER)	TSL: 95	(22; 28; 120)	39:42	79	0.477
	Mean: 97	(22; 186; 120)	37:42	87	0.488
	Median: 99	(22; 178; 120)	37:42	89	0.493
Manufacturing Production (UK)	TSL: 77	(69; 72; 100)	15:20	130	0.556
	Mean: 70	(66; 294; 100)	18:20	88	0.504
	Median: 69	(66; 240; 100)	18:20	88	0.497

Table 4 presents the results of tests - the optimal parameters were used to calculate the profits on test data (out of sample data).

Table 4: Test of optimal parameters (test data)

Indicator	Mean profit	Win ratio	S.d.	Total eff.
US Nonfarm Payrolls	TSL: 634	4:5	512	0.568
	Mean: 554	4:5	469	0.496
	Median: 553	4:5	469	0.496
US ADP Nonfarm Payrolls	TSL: 61	3:6	127	0.15
	Mean: 72	3:6	142	0.177
	Median: 90	6:6	142	0.22
Unemployment Claims (USA) negative delta	TSL: 54	7:8	89	0.35
	Mean: 55	7:8	90	0.36
	Median: 56	7:8	90	0.36
Unemployment Claims (USA) positive delta	TSL: 8	2:5	78	0.026
	Mean: 10	2:5	79	0.035
	Median: 12	2:5	81	0.04
US Core Retail Sales	TSL: 580	4:5	575	0.56
	Mean: 522	4:5	512	0.505
	Median: 520	4:5	511	0.503
Retail Sales ex auto (NOR)	TSL: 143	3:5	1090	0.054
	Mean: 1270	4:5	1420	0.481
	Median: 822	4:5	1879	0.311
Employment Change (AUS)	TSL: 138	7:10	238	0.333
	Mean: 258	9:10	240	0.625
	Median: 186	6:10	319	0.45
Ifo Business Climate Index (GER)	TSL: 31	7:10	47	0.21
	Mean: 56	8:10	52	0.378
	Median: 52	8:10	45	0.355
Manufacturing Production (UK)	TSL: 111	4:5	156	0.612
	Mean: 100	4:5	130	0.551
	Median: 101	4:5	126	0.559

Not surprisingly, the total efficiency on test data is in general smaller than on historical data. The mean profit from the strategies is still positive and considerably big for the majority of announcements. For some indicators (i.e. US Nonfarm Payrolls and US Core Retail Sales) there are even improvements of the final result - this is related to the time-changeable maximal profitability of the announcements (the total efficiency indicator is resistant to the profitability change). Among above announcements only the optimization of Initial Unemployment Claims with positive Delta gives rather poor results - win ratio below 50% on both test and historical data.

Picture 7 present an exemplary plot of mean profit as a function of parameters S and S_1 (for TSL strategy). Majority of remaining plots are also rather smooth which means that some inaccuracy in estimation of parameters should not cause large fall of profit.

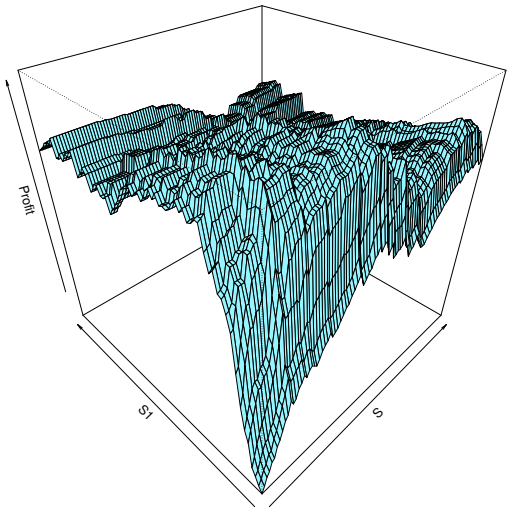

Figure 7: TSL strategy (with $S_2 = 120$) profit plot for German Ifo Business Climate Index

9 Summary, Conclusions

This paper analysed an exemplary trading system based on event-driven phenomenon. For the chosen macroeconomic indicators the system opens a position immediately after the announcement under the condition that the difference between the actual value and the forecast (Delta) is sufficiently distant from zero. The algorithms of closing a position are based on the technical analysis of the price behaviour. The process of optimizing the parameters is performed and next, the optimization effectiveness is verified by backtesting methods. The main goal of the research is to provide some insight into the investing potential of this approach and to verify the possibility of finding exploitable trading patterns which in fact mean the possibility of valid optimization.

The results of the analysis confirmed that some macroeconomic announcements cause such market reaction that the presented simple trading algorithms could generate significant profit. Among the chosen indicators only the US Initial Unemployment Claims with positive Delta did not display an exploitable trading pattern. The research did not take into account the slippage in the transaction realization (delays in order execution depend on factors like computer network load and broker trading system; the results of further analysis which take into account the practical delays would be of great practical importance) but still the final results indicate big investing potential of this phenomenon. The win ratio on test data indicate that the risk of long series of loss is small. One announcement for which win ratio falls below 50% is unpredictable US Initial Unemployment Claims with positive delta. The comparison of optimization results and test results suggest the existence of exploitable trading

patterns which leads to the possibility of creating efficient trading systems based on mechanisms which open position automatically after the announcement.

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