THE ROLE OF "NOISE TRADING"
IN MODELING OF STOCK MARKET
RETURNS

by

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Abstract

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Fisher Black in his paper “Noise” (1986) introduces the concept of “noise traders” who trade on stock market based on the restricted information. Such traders take some observable indicator as a reference point in decision-making process. Timo Terasvirta (1993, 1996, 2004) uses smooth transition regression (STR) modeling to explain the processes when the players’ behavior changes due to changes in indicator (so-called transition) variable. Based on the papers of Black and Terasvirta, David MacMillan in his paper “Non-Linear Predictability of UK Stock Market Returns” (2003) estimates changes in UK stock market return due to existence of “noise trading”. The idea of my thesis is to check for the existence of “noise trading” on the Ukrainian stock market (PFTS). First, I use the STAR model of MacMillan (2003). Secondly, I use a more general specification of STR where any explanatory variable can be the transition variable. The STAR model shows an insignificant influence of macroeconomic variables on stock returns. The test for non-linearity supports the STAR specification of the model but I have not found evidence of “noise trading” on the Ukrainian stock market.

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GLOSSARY

Noise traders – part of stock market players who have imperfect information about "fundamental" value of the stocks, and use observable information as a macroeconomic indicator or stock market history to make decision.

Smooth transition regression (STR) – the type of non-linear model where the influence of explanatory variables changes due to smooth moving of transition variable from one regime to another.

Smooth transition autoregressive model (STAR) – the special case of STR with lagged value of dependent variable as a transition variable.

Chapter 1

INTRODUCTION

The Main Ukrainian stock exchange index (PFTS) has shown a very interesting dynamics in the last couple of years. Before the 2008 crisis it increased by 1200 points over a period of 10 years (Landa, 2008). After the crisis it declined sharply and lost 90% in one year. (Gerasimova, 2009). Now it increases again. The recent surge is also very substantial, and rather unexpected. It is not supported by foreign investment in Ukraine and at first sight, seems inconsistent with the general economic situation in Ukraine. To shed light on this issue, this thesis attempts to understand how macroeconomic variables affect the stock market.

There is some intuition behind the causal influence of macroeconomic variables on the behavior of the stock market. The stock price should depend on the information about the enterprise which issues it. The state of enterprises depends on investments, consumers, inflation policy etc.

Balvers, Cosimano and McDonald (1990) derive the causal dependence of stock returns which are relative changes in stock prices from the lagged values of aggregated output. From their point of view this relationship can be captured by the neoclassical growth model. They solve the utility maximization problem of representative consumer. The consumer tries to smooth consumption over periods. He divides the income between the consumption and buying of stocks. The solving of the problem shows that the optimal level of stock return should equalize additional unit of consumption today and unit of the consumption tomorrow which would be received from investment in the stock market.

The consumption changes due to changes in output. The changes in consumption lead to changes in demanded stock return to maintain equality. Thus, the stock return depends on the output.

I start from the assumption that the macroeconomic variables define the "true value" of the stocks. However, market price deviates from the "true value" due to non-perfect market information. This is the essence of "noise" which was introduced by Black (1986).

Black (1986) defines two classes of the traders which are "noise traders" and "information traders". He assumes that there is non-perfect and asymmetric information on the stock market. "Information traders" have better information about "true value" of the stocks than "noise traders", although nobody has perfect information. "Noise traders" on average drive stock prices away from the "true value". "Information traders" can gain from this. They become the counterparts of "noise traders" in the market deals. This process turns market prices back to the "true values". The further "noise traders" push stock prices away from "true value" the more "information traders" have incentives to intervene. Generally, the market is not in the static equilibrium. According to Black (1986) there is a dynamic equilibrium which includes influence of "noise" as a natural part.

Without perfect information about the market "noise traders" can orient on some observable indicator which gives opportunity to predict stock prices from their point of view. This is the usual practice of technical traders. They try to find cycles in market prices. If one knows what this indicator is one can understand how the behavior of "noise traders" will change.

Black (1986) does not introduce a formal model which includes the changing of market players' behavior.

A formal model which can capture behavioral changes is the smooth transition regression. Several recent papers developing this model have been written by Terasvirta (1994, 1998, 2004). The most typical specifications of this model cover two types of behavior change strategies. The behavior changes if either the size of the indicator's value changes or the sign of it changes.

This thesis investigates whether there exists "noise trading" in the Ukrainian stock market. If "noise trading" exists it changes the influence of macroeconomic variables on the stock market, and creates the dynamic equilibrium mentioned above.

There are some papers which either investigate effects of macroeconomic variables on the stock market in Ukraine or can be useful for the discussion about the relationship between the macroeconomic variables and the stock market here.

These papers do not look at non-linearities, however.

Pelykh (2008) has shown the effect of the news about a company on its stock in Ukraine. This leads to the assumption that macroeconomic changes which influence a lot of companies could influence the whole stock market.

Moskalenko (2005) demonstrates the effect of positive political and economical news on excess stock return, and, in fact, supports the assumption.

Gamolya (2006) analyzing the interaction of macroeconomic variables such as banking capitalization, and GDP with the stock market in Ukraine, find a significant effect of banking capitalization on the value of the stock market.

All these papers focus on the linear effect of macroeconomic variables on Ukrainian stock market. In contrast, I am interested in non-linear influence of macroeconomic variables on stock market which appears due to "noise trading".

In Ukraine, firms are substantially less transparent meaning that the true information is much harder to discover – hence the importance of "noise" is likely to be substantial. If the market players "know" that macroeconomic changes affect companies, and company news affects stock return, they will orient on the changes in these macroeconomic variables. They can not be sure about receiving true company news in time. Therefore, they should look at the macroeconomic reference point.

To investigate "noise" I use smooth transition regression. As a benchmark I take McMillan (2003) who uses it to incorporate "noise trading" into the modeling of stock returns with macroeconomic variables. McMillan (2003) uses the models with both types of strategies, and shows that such models fit the data and predict stock prices much better than a simple linear model with macroeconomic variables for the UK stock market. He uses logistic and exponential transition threshold models and finds the best result is given by the exponential model. The difference between this thesis and McMillan (2003) is that McMillan (2003) uses, so-called, smooth transition autoregression model. It is special case of smooth transition regression which assumes that the reference point to change the strategy, called transition variable, can be just one of the lagged values of dependent variable. In stock market case it means that the transition variable for "noise traders" is one of the lagged values of stock return. General case of smooth transition regression does not put such restriction. Terasvirta (2004) mentions that if the transition variable does not come strictly from theory it is usually chosen from independent variables in the model. Black (1986) does not specify the lagged stock return as an only indicator for "noise traders". The argumentation of the best choice is given in the Methodology of the thesis.

The estimation of the model is done with JMulTi software. JMulTi's smooth transition modeling completely follows Terasvirta's methodology. He uses this software in the recent researches (Terasvirta 2004). Terasvirta is also one of the popularizers of JMulTi.

The thesis has the following structure. Chapter 2 gives brief literature review of the role of macro variables on stock returns and the discussion about traders' behavior differences. It shows the non-linear models which can take into account the behavior influence in macro modeling. Chapter 3 is Methodology and Data. It explains the smooth transition regression specifications used in the thesis, the argumentation of the variables, data descriptive statistics, and data stationarity testing results. Chapter 4 shows empirical estimation of the models. Chapter 5 presents conclusions of the research.

C h a p t e r 2

LITERATURE REVIEW

I want to estimate non-linear influence of macroeconomic variables on stock market caused by “noise trading”. This forms the structure of my literature review. At the beginning of the chapter I review the literature about the relationships between “real” sector and financial sector. I am interested in the evidences and possible explanations of the influence of macroeconomic variables on the stock returns. In particular, I am interested in the previous researches about Ukrainian stock market. At the second stage I look at the concept of “noise trading ”. Existence of “noise” leads to the fluctuations in the influence of macroeconomic variables on the stock return which can not be captured by linear models. These fluctuations are not random. They have the rules and form dynamic equilibrium of the stock market. Thus, at the end of the chapter, I view the literature about non-linear model which can be used for this purpose.

The investigation of relationship between stock market and macroeconomic variables has a long history. It is a part of more general problem of causal relations between “real” and financial variables. Since Kydland and Prescott (1982) there has been a continuous discussion about the connections between the financial and the “real” cycles. Real business cycle theory rejects the influence of financial variables on “real” ones. Later studies take real business cycle theory as a benchmark. They try either to support it or to reject. Therefore they are looking for influence of financial sector on the real one and not vice versa. Sinai (1992) even uses the term “financial business cycle” for real cycle followed by changes in financial variables. The same idea we can find in Iacoviello (2010) and Bernanke, Gertler, and Gilchrist (1998).

But there is evidence about the reverse causality. A very popular methodology to analyze the interaction of real and financial variables is VAR. To study the direction of causality researchers have used the VAR methodology. The results of these studies, however, are not uniform. Blanco (2009) supports a one-sided direction: financial variables influencing real variables for Latin America. Esso (2009) find two-sided causality for some of the ECOWAS countries (Africa). Calderon and Liu (2002) analyzed a large cross-country dataset and found strong influence of financial sector on real one. When they split sample into developing and developed countries they find two-side causality between financial and real sector for 87 developing countries and 22 developed countries. Levine (2005) finds one-sided causality (financial sector influences real sector) based on a comprehensive sample of countries for the period 1960-1989. Rousseau and Wachtel (2007) repeat Levine's investigation based on the sample for 1960-1989 and 1990-2003 and confirm Levine's result for sample 1960-1989 but show the insignificance of most of Levine's financial variables for the sample period 1990-2003.

Rousseau and Wachtel (1998) emphasize the sample specific features of this type of research. They show a strong one-sided causality for the period before the Great Depression. They conclude that the strong one-sided relation is possible for economies with highly developed intermediaries such as the banks and weak financial markets. These are developing countries where most part of the financial sector is banking. Developed countries with strong financial markets could have two-side causality or even breakdown of financial-real relationship. Mukhopadhyay and Pradhan (2010) also pointed out an ambiguous effect for Asian developing financial markets. But Binswanger (2004) shows a decreasing effect of the shocks in real sector on the financial one during the 80-ies and 90ies. He explains his finding by referring to"financial bubbles".

In contrast to the empirical papers, Balvers, Cosimano, McDonald (1990) derive theoretically the influence of "real" output on stock market. Their hypothesis is that people try to smooth consumption over life. Therefore, fluctuations in "real" output cause fluctuations in the consumption, and in the marginal utility of investments in stock market. This leads to changes in the return which investors would demand from stocks. They even come to conclusion that stock market returns are not random walk, and can be predicted based on the aggregate output fluctuations.

There are also investigations for the Ukrainian stock market. Gamolya (2006) analyzes the relationships among the stock market, banking capitalization, and GDP using a VAR model. He doesn't find substantial influence of GDP on stock market, and argumentation of reverse causality. But he finds that banking capitalization influences the stock market. This means that macroeconomic variables have influence on stock market in Ukraine. At least the banking sector has.

Moskalenko (2005) investigates "economic and political news" effects. He uses VAR model including such variables as index of industrial production, money supply, spreads between nominal short-term interest rate on deposits and credits, consumer price index, exchange rate. APT is a basis for the model. Moskalenko finds significant effect of exchange rate on stock market return, and the effect of positive news (economic or non-economic) on stock excess returns.

Effect of news was also investigated by Pelykh (2008). He concentrates on the news about a company and its owners. He finds significant effect. "News effects" significance implies asymmetric information. Some traders have possibility to know about some news before other and can use this to their advantage.

In this thesis I start from the assumption that macroeconomic variables can influence stock market returns in Ukraine. They form "fundamental value" of stock market. The question which I am interested in the thesis is deviations from "fundamental value" due to "noise".

Black (1986) says that imperfect information leads to "noise trading" which means trading on the prices different from the "true value" of a stock. Existence "noise" creates difference in the expectations of traders and, generally, possibility to trade. Following Black (1986), He and Modest (1995) explain that "information traders" trade actively only in case of arbitrage opportunity. They take opposite positions and therefore lead market back to "fundamental values" of stocks. De Long, Shleifer, Summers, and Waldmann (1990) support the idea that "noise traders" could significantly drive away asset prices from "fundamental values". But they come to conclusion that "smart" traders could take the same position as "noise traders" and drive market even further away from the true values if there is a very strong pressure of "noise traders" on the market.

According to Black (1986) the presence of the "noise" forms dynamic stock market equilibrium. If it is true, the inclusion of "noise" into the stock return modeling is necessary. The "noise" is omitted part in the linear macroeconomic models which can not capture dynamic market properties.

Macmillan (2003) shows models for the U.K. stock market which allows taking "noise" into account in a macro model. He uses smooth transition models. Terasvirta (1994, 1998) explains that smooth transition regressions can capture differences in a behavior due to changes in a variable-indicator. This is the case of "noise trading".

Macmillan (2003) estimates two models, one with logistic function and another with exponential function as the smooth transition function. The logistic function gives opportunity to segregate behavior of traders on the basis of changes of the sign of return (positive or negative). The exponential function does the same thing but focusing on the size of return. Macmillan (2003) finds that smooth transition regression models give better results for the U.K. stock market both in terms of fitting of the data and forecasting.

I take smooth transition regression modeling as a basis of my research. The model has two terms on the right-hand side of equation: vector of macroeconomic variables and product of this vector by smooth transition function. The second term shows the non-linearity in the effect of macroeconomic variables which appears due to players' reaction on stock return movements. Macmillan (2003) uses delayed value of return as an argument of the smooth transition function, transition variable. This partial case of smooth transition regression model is called smooth transition autoregressive model (STAR). In general case, the transition variable could be not just lagged dependent variable but any other variable.

I use smooth transition regression with macroeconomic variables to check "noise trading" on Ukrainian stock market. This is done for the first time. I use two specification of the model. First one is STAR similar to Macmillan (2003). Second one is general case of smooth transition regression. It does not come from the theory that just the lagged values of stock return can be transition variable. I check the general case where any explanatory variable can be the transition variable. There is a procedure to choose the most appropriate one.

Chapter 3

METHODOLOGY

The smooth transition regression (STR) function is a generalization of the switching (threshold) regression models. Most simple threshold models use two regimes with one threshold and the regression coefficients change if the transition variable takes a value higher than the threshold. STR assumes that there is not one threshold but a lot of them. The coefficients hence could change at any time period.

STR was developed by Chang and Tong (1986), Granger and Terasvirta(1993), Terasvirta (1994), Terasvirta (1998). The main line of the methodology which I use is summarized in Terasvirta (2004). All equations in this chapter, except equation 6, are taken from that paper. Equation 6 is based on Draper and Smith (1981).

The general form of the model is

$$y_t = \varphi' z_t + \theta' z_t G(\gamma, c, s_t) + u_t = \{\varphi + \theta G(\gamma, c, s_t)\}' z_t + u_t, t = 1,..., T \quad (1)$$

where, z is the vector of independent variables including lags of y, G is smooth transition function (STF). In our case z is the vector of macroeconomic variables, their lagged values, and the stock return's lagged values. s_t is the transition variable, γ is a slope parameter, and c is a vector of location parameters. The transition variable is our reference point for the behavioral changes.

We can use logistic function as a STF:

$$G(\gamma, c, s_t) = (1 + \exp\{-\gamma \prod_{k=1}^{K} (s_t - c_k)\})^{-1}, \gamma > 0 \tag{2}$$

(eq.1) and (eq.2) define logistic STR model.

This is a non-linear model which can be interpreted as a 'linear model with stochastic time-varying coefficients' (Terasvirta, 2004).

Slope parameter, γ shows how smooth is the regime changes. For example, if γ is a very high the logistic function changes regime very quickly when the threshold is crossed.

To understand the sense of location parameters, c, it is better to turn to other explanation of STR. There are different types of logistic STR functions depending on values which K (look at the product in eq.2) can take. Two cases of logit model are used usually in practice: K equals 1 or 2. Suppose K=1. The equation 2 transforms to the following one:

$$G(\gamma, c, s_t) = (1 + \exp\{-\gamma (s_t - c)\})^{-1}, \gamma > 0 \tag{3}$$

Such type of logistic function can explain situations where transition variable has two regimes. This is the usual logit-function. It can take values in a range between zero and one depending of transition variable. It shows the probability to reach the regime labeled with 1. "Parameter c can be interpreted as the threshold between two regimes, in a sense that the logistic function changes monotonically from 0 to 1 as st increases, and G(c,γ,c)=.5" (Dijk, Terasvirta and Franses, 2000).

The type of logistic function with K=2 characterizes other two-regime situation. The changes of regime happens if the absolute value of st deviates from some range. In this case the coefficients of STR change symmetrically around the value (c1 + c2)/2. Alternative version of the model is exponential STR with transition function:

$$G_E(\gamma, c, s_t) = 1 - \exp\{-\gamma(s_t - c_1^*)^2\}, \gamma > 0 \tag{4}$$

Macmillan (2003) used logistic function with K=1 and exponential STR. The exponential function, however, has some drawbacks. When γ=0 or goes to infinity the function becomes just a number. Jansen and Terasvirta (1996) shows that logistic function with K=2 do not have these drawbacks and can be used to define the same situation as the exponential function.

The most important question when estimating this function is the choice of transition variable.

The transition variable could come from the theory or be chosen from the set of dependent variables, the vector z. If the theory does not tell anything about appropriate transition variable I should take every variable from z, repeat the modeling process for each one.

Choosing the right transition variable is determined by a linearity test.

One should choose the variable which rejects linearity and gives minimum p-value in this test comparing to other transition variables which reject linearity also.

In this thesis I will investigate both logistic models. The estimation will be done with the JMulTi software which gives an opportunity to estimate the logistic STR with K=1 and K=2.

It is possible that linear model would be the best choice comparing with nonlinear ones. In this case I would be able to say that influence of macro indicators on the stock returns is stable in long run. No influence of "noise" on the macro model would be found.

Smooth transition regressions are used to capture smooth shift in behavior. Therefore, "noise" is the best theoretical explanation of possible non-linearity in my model. The model says that the influence of macroeconomic variables on stock return changes following changes in a transition variable. Thus, it is naturally to look for the source of these fluctuations inside of stock market. This is the traders' behavior.

I expect the logistic STR K=1 to produce the best result. This hypothesis is based on the results of Moskalenko (2005) who showed that there is a reaction of stock index just in case of positive news in the economy.

Constructing a logistic STR (LSTR) involves three stages: specification, estimation, and evaluation. The main steps of the procedure are common for estimation of nonlinear functions. Methods of estimation of nonlinear functions are described, for instance, by Draper and Smith (1981). Explaining the constructing of the model I will follow Terasvirta (1994, 2004) and Draper and Smith (1981).

STR function is specified as an alternative to linear function. I choose nonlinear functional form if I can reject linear one.

One can linearize the logistic STR (LSTR) with K=1 using a third-order Taylor approximation around γ=0.

$$y_t = \beta_0^{'} z_t + \sum_{j=1}^{3} \beta_j^{'} \hat{z}_t s_t^j + u_t^* \tag{5}$$

where $z_t = (1, \hat{z}'_t)'$, $u_t^* = u_t + R_3(\gamma, c, s_t)\theta' z_t$, R3 is the remainder

This approximation is linear in parameters. The null hypothesis is linearity: $\beta_1 = \beta_2 = \beta_3 = 0$.

To check linearity F-statistics is used with 3m and T-4m-1 degrees of freedom, where m is number of variables in z.

The second step of the specification is the choosing between LSTR models with K=1 and K=2. If I reject linear model than I choose LSTR against which the linear one is rejected. If it is rejected against both I should choose one with stronger rejection. The indicator is p-value.

Next step of the procedure is estimation of the model parameters. Conditional maximum likelihood is used for this purpose. I will do empirical estimation with JMulti software which implements ML numerically through an iteration process.

The starting point (γ,c) is found by grid search. For arbitrary point (γ,c) the program calculates φ and θ. The procedure repeats until

$$\left| \{ p_{i(j+1)} - p_{ij} \} / \, p_{ij} \right| < \delta \qquad (6)$$

where p are parameters φ and θ: pi= φ if i=1 and pi= θ if i=2,

j is number of iterations, δ is prespecified precision level, for example, 0.0000001

The idea is to choose the slope and location parameters which minimize residual sum of squares of STR error terms. To do slope parameter scale-free JMulTi's procedure divides it by standard deviation of transition variable in the power K.

When the starting point is found JMulTi estimates STR with Newton-Raphson method. The goal is to maximize conditional maximum likelihood function.

Chapter 4

DATA DESCRIPTION

Asset Pricing Theory (APT) which is the basis for the modeling of macroeconomic variables influence on stock market prices doesn't mention the list of variables one should include. Macmillan (2003) uses dividend yields, consumer price index, unemployment, production, consumption, treasury bills and bonds, and M1. I slightly change the specification as explained below.

Fama and French (1988) show a statistical significance of dividend yield in prediction of stock market return. But one should take into account the argumentation about dividend yields in the APT models. Stock price is a discounted future cash flows stream. Dividends are future cash flows. Thus, they influence prices. Ukrainian companies pay very small dividends. Those companies which are included into the PFTS basket indeed pay dividend amounts that are very small compared to the changes in the stock prices. Receiving of the dividends hence can not be the goal of holding stocks in Ukraine.

It is also unlikely that the dividends could be a good candidate to be the transition variable. Brealey and Myers (2008) describe the game between a company managers and investors. In particular, the managers could increase dividends to show a good performance. In short horizon the managers are able to give wrong "signals" to the market by increasing of dividends. But in the long run they could not do it because it will cause a lack of resources. Investors know this and can take dividends as a signal of performance. In Ukraine where dividends are very low (less than 1% of profit) dividends are unlikely to be used as a signal.

In addition, there is a lack of the data. Ukrainian companies usually pay dividends on the annual basis. MacMillan (2003) however uses quarterly data in his modeling. He can include dividends because the British companies usually pay dividends on the quarterly basis.

Instead of consumption and CPI I use just CPI. There are two reasons. First of all, the Ukrainian Statistical Committee changed the data report structure in 2009. There is just quarterly data of consumption for 2009-2010. A second reason is the strong correlation between CPI and consumption. The correlation for 2003-2008. is 0,93.

The argumentation for the inclusion of the consumer price index is the C-CAPM (Grossman, Shiller, 1981) model. C-CAPM is one of the CAPM modifications which captures the influence of investor's opportunity to consume on stock market returns.

Like MacMillan (2003), we include the production based on the production CAPM theory and the paper of Cochrane (1991) which assumes that production influences stock market due to increasing of cash flows.

Unemployment is included as it gives stock market the signals about future interest rates and companies' profits. Boyd, Jagannathan, and Hu (2001) investigate the influence of unemployment effect on stock market. They indeed conclude that unemployment news has effect on the stock market.

The treasury bills and bonds rates used by Macmillan (2003) have intuitively simple explanation. Treasury bills and bonds are an alternative to the investments in stock market. Changes in bonds return will have negative influence on stock market with very high probability.

Data about Ukrainian bonds can not be used. There is no type of government bonds which has been issued on a monthly basis in the period 2003-2010. I use the credit interest rate on the Ukrainian inter-banks market as a substitute for bond rates. The average short term rate on the credits among banks is reasonable approximation of a low-risk investments.

The money aggregate (M1) also should be included into the model. The changes in M1 have influence on the economy's opportunity to growth. They can have a substantial effect on stock market. Beltratti and Morana (2006) show that M1 changes are one of the main sources that can explain U.S. stock market volatility in the period 1970-2001.

Note, there is a strong correlation between M1 and CPI (0,9) but not between differences of M1 and CPI (coefficient of correlation is 0,18).

The dependent variable is the difference in logarithms of PFTS stock index. It is leading Ukrainian stock market index. Taking a difference in PFTS logarithm I find the changes in stock prices, hence the stock returns.

The sources of the data are macroeconomic dataset of National Bank of Ukraine (NBU) and the data of State Committee of Statistics of Ukraine.

The data presents monthly observations for 2001-2010 years (120 months). Note that MacMillan (2003) uses quarterly data for 1970-1995 years. This is 104 observations.

Daily data of PFTS is transformed in monthly data with a simple average procedure.

Consumer Price Index (CPI) is calculated to January, 2003 basis. Index of production output is calculated to January, 2001 basis.

All independent variables should be taken in difference. This will show how the stock returns react on their changes. This approach agrees with Moskalenko

(2005) conclusions that stock market reacts on the news. Table 1 consist descriptive statistics for variables in differences.

Table 1. Descriptive statistics for variables in differences

Name of variable	Number of observations	Mean	Standard deviation	Min	Max
ΔMoney supply, M1	119	2417.79	4097.51	-8215.7	13520
ΔLogarithm of PFTS	119	.0234	.1161	-.4046	.3628
ΔConsumer Price Index	119	0.0137	.0174	-.0181	.0715
ΔIndex of Production Output	119	0.0040	.0947	-0.2532	0.2158
ΔUnemployment	119	-0.0185	0.1467	-0.3000	0.7000
ΔInterest rate	119	-0.0235	3.3733	-13.77	14.71

Table 2 consist correlation between variables in the model. There is no strong correlation. Therefore, I will not have the problems with multicollinearity

Table 2. Correlation matrix

	Δ M1	ΔLog_PFTS	ΔCPI	ΔProd	ΔUnempl	ΔInterest rate
Δ M1	1	-0,07	0,18	0,26	-0,04	-0,02
ΔLog_ PFTS	-0,07	1	-0,2	0,01	-0,01	-0,02
ΔCPI	0,18	-0,2	1	0,08	0,05	0,00
ΔProd	0,26	0,01	0,08	1	-0,3	0,12
ΔUnempl	-0,04	-0,01	0,05	-0,3	1	0,02
ΔInterest rate	-0,02	-0,02	0,00	0,12	0,02	1

.

The data is checked for stationarity with Dickey-Fuller test. The results are presented in Table 3. Plots of the data are put into Appendix.

Here I want to mention the abbreviations which I use for differenced variables.

m1_d1 – first difference of M1 money aggregate,

cpi_d1 - first difference of CPI,

prod_d1 - first difference of index of production output,

unempl_d1 - first difference of unemployment level,

int_rate_d1 - first difference of inter-bank credit interest rate,

pfts_log_d1 - first difference of logarithm of PFTS stock index.

Table 3. Dickey-Fuller test

Name of variable	Test statistic	1% critical value
m1_d1	-7.5243	-2.56
prod_d1	-11.368	-2.56
cpi_d1	-4.533	-2.56
unempl_d1	-4.8490	-2.56
int_rate_d1	-16.3340	-2.56
pfts_log_d1	-6.03272	-2.56

The general conclusion of data testing is all differenced variables are stationary.

Chapter 5

EMPIRICAL RESULTS

The algorithm of STR model estimation with JMulTi is given in Chapter3 (methodology part). This chapter contains the outputs given by JMulTi for each step of the model estimation.

In the first part of the chapter I use smooth transition autoregressive (STAR) specification of the model. I replicate Macmillan (2003). STAR assumes that just the lagged value of the dependent variable could be the transition variable.

In the second part of this chapter I go one step further and estimate STR in general form. This means that I assume that any explanatory variable from the linear part of the model can be transition variable.

One can wonder whether it is possible to have more then one transition variable. One can assume that "noise trader" orients on either two or three indicators. But if these indicators move differently the decision of "noise trader" becomes very complex. I am not aware of any papers that allow such complex specification of the model. The JMulTi software also does not give opportunity to estimate models with more than one transition variable. A more model should include the subjective "noise traders' " ranking of transition variables or even estimate their utility function with transition variables as arguments. I do not try to do so complex analysis here. Instead, I use model with just one transition variable.

The specification of STR model includes testing STR against linear model and choice of appropriate LSTR model type (K=1 or K=2).

I included one-lagged values of all independent variables and dependent variable in the model. Macmillan (2003) uses two lags. But increasing number of lags can lead to non-robust estimation. There is not a lot of observations.

The JMulTi rejects hypothesis about linear type of model in STAR specification. It suggests logistic STR with K=2.

The next step is grid search of appropriate starting values. The results are $\gamma=1.9151$, $c1=-0.4046$, $c2= -0.2194$.

As I have starting point I can estimate the model. The results are given in tables 4 and 5.

Table 4. Estimation outputs of STAR specification (linear part)

variable	start	estimate	t-stat	p-value
const	-2.916	-45.56	-0.1943	0.8464
pfts_log_d1(t-1)	277.47	4290.98	0.3049	0.7612
CPI_d1(t)	2550.73	43189.24	0.2893	0.7730
prod_d1(t)	262.79	4619.076	0.2964	0.7676
int_rate_d1(t)	8.018	113.89	0.3349	0.7384
m1_d1(t)	-0.016	0.263	0.292	0.7707
unempl_d1(t)	119.04	1995.66	0.3113	0.7563
CPI_d1(t-1)	2347.52	34861.73	0.3210	0.7489
int_rate_d1(t-1)	-14.31	-239.13	0.2941	0.7694
m1_d1(t-1)	0.005	0.086	0.275	0.7843
prod_d1(t-1)	747.39	11484.74	0.3137	0.7545
unempl_d1(t-1)	24.95	457.55	0.1415	0.8878

Table 5 Estimation outputs of STAR specification (non-linear part)

variable	start	estimate	t-stat	p-value
const	2.95	45.59	0.194	0.8463
pfts_log_d1(t-1)	-276.86	-4290.36	0.3048	0.7612
CPI_d1(t)	-2551.57	-43190.11	-0.2893	0.7730
int_rate_d1(t)	-8.02	-113.9	-0.3350	0.7384
m1_d1(t)	0.016	0.263	0.292	0.7707
prod_d1(t)	-262.82	-4619.10	-0.3064	0.7676
unempl_d1(t)	-119.01	-1995.64	-0.3113	0.7563
CPI_d1(t-1)	-2348.07	-34862.36	-0.3211	0.7489
int_rate_d1(t-1)	14.31	239.12	0.2941	0.7694
m1_d1(t-1)	-0.00489	-0.08640	-0.2745	0.7843
prod_d1(t-1)	-747.42	-11484.76	-0.3137	0.7545
unempl_d1(t-1)	-24.87	-457.46	-0.1415	0.8878
Gamma	1.92	1.12	0.4667	0.6418
C1	-0.40	-0.43	-1.32	0.19
C2	-0.22	-0.40	-1.05	0.30

All coefficients are insignificant. Thus, I can not state neither significant influence of macroeconomic variables on stock returns, nor existence of "noise trading". One can be confused with huge estimates of coefficients. But in most cases linear and non-linear parts have opposite signs. They thus cancel each other out.

Next step is to check other explanatory variables to be the transition variable. This is not the usual way but it does not contradict to the theory. Following Terasvirta (2004) I check the best candidate based on the minimization of residual sum of squares of error term in the model.

Table 6 contains checking for best choice of transition variable among all explanatory variables.

The best choice is labeled with asterisk. This is changes in lagged value of stock return with logistic STR with K=2. The best candidate is the STAR model which has already been estimated.

Table 6 Testing the linearity hypothesis in STR model

transition variable	suggested model
pfts_log_d1(t-1) *	LSTR2
CPI_d1(t)	Linear
int_rate_d1(t)	LSTR1
m1_d1(t)	Linear
prod_d1(t)	Linear
unempl_d1(t)	LSTR1
CPI_d1(t-1)	Linear
int_rate_d1(t-1)	Linear
m1_d1(t-1)	Linear
prod_d1(t-1)	Linear
unempl_d1(t-1)	Linear
TREND	Linear

Thus, the using of general STR specification and standard procedure of checking the transition variable supports choosing of STAR model. The results also mean that in case of STAR the linear type of model is rejected.

C h a p t e r 6

CONCLUSION

The hypothesis which is tested in this thesis is whether “noise trading” is present on the Ukrainian stock market. To test the hypothesis a smooth transition regression modeling was used. Empirical estimation was done with the JMulTi statistical software.

Following the benchmark paper of MacMillan(2003). I estimate a smooth transition autoregressive model (STAR). The test rejects the linear specification of the model. It suggests using of non-linear model logistic STR with K=2. Estimation of the model shows that all coefficients are insignificant.

I use general case of STR model assuming that any explanatory variable can be the transition variable. According to Terasvirta (2004) I looked for the best choice of the transition variable based on the rejection of linear type of model. The procedure supports the choice of STAR model.

Therefore, my conclusion is that there is little evidence for the existence of “noise trading” in the Ukrainian stock market. At the same time, I find no clear evidence that macro variables in general influence the stock market which one could interpret as saying that there is only “noise trading”. An alternative interpretation would be that the data series considered here are not those that should be considered here. Further research could try to find such alternative explanatory variables.

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APPENDIX. PLOTS OF THE DATA

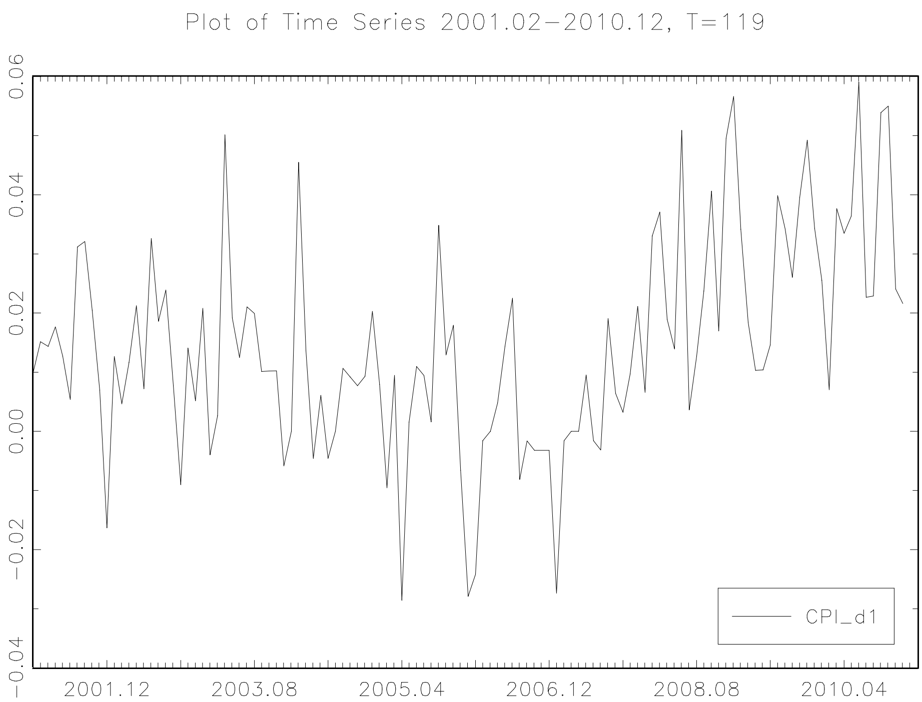

Figure 1. Plot of the first differences of Consumer Price Index

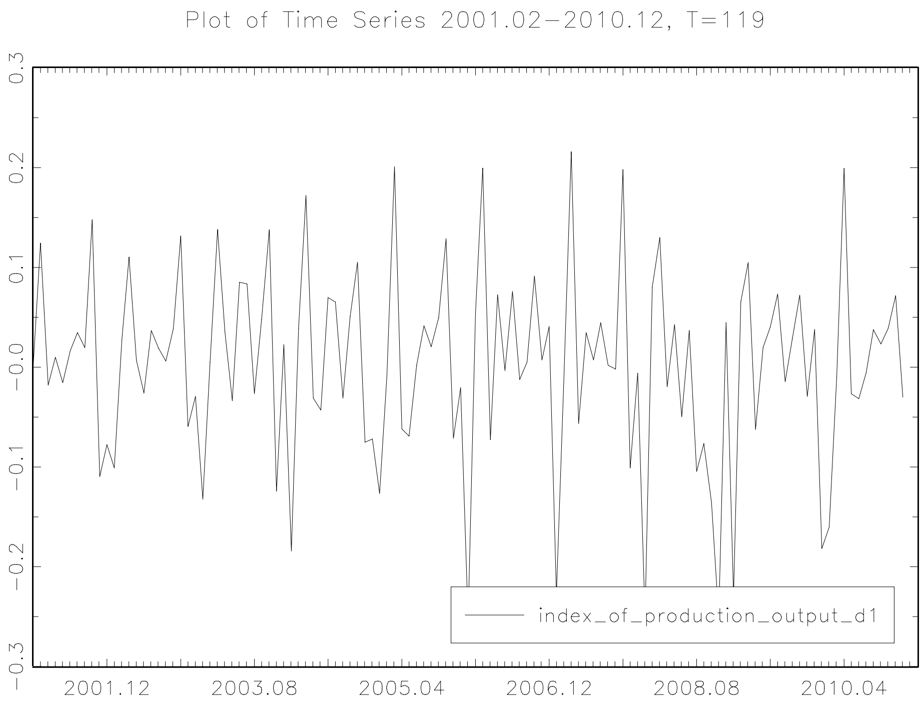

Figure 2. Plot of the first differences of Index of Production Output

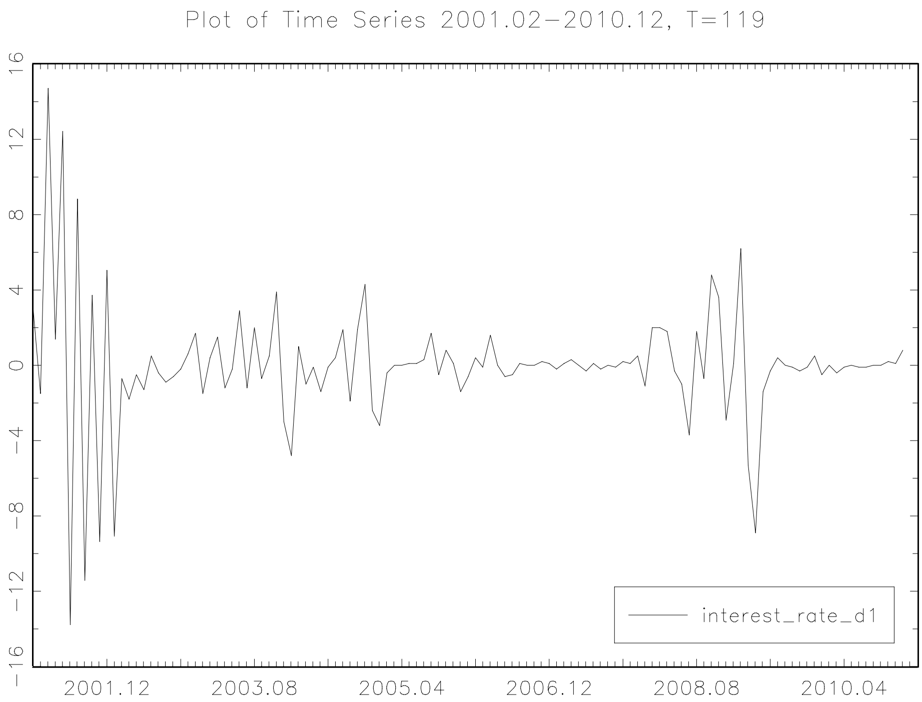

Figure 3. Plot of the first differences of Interest Rate

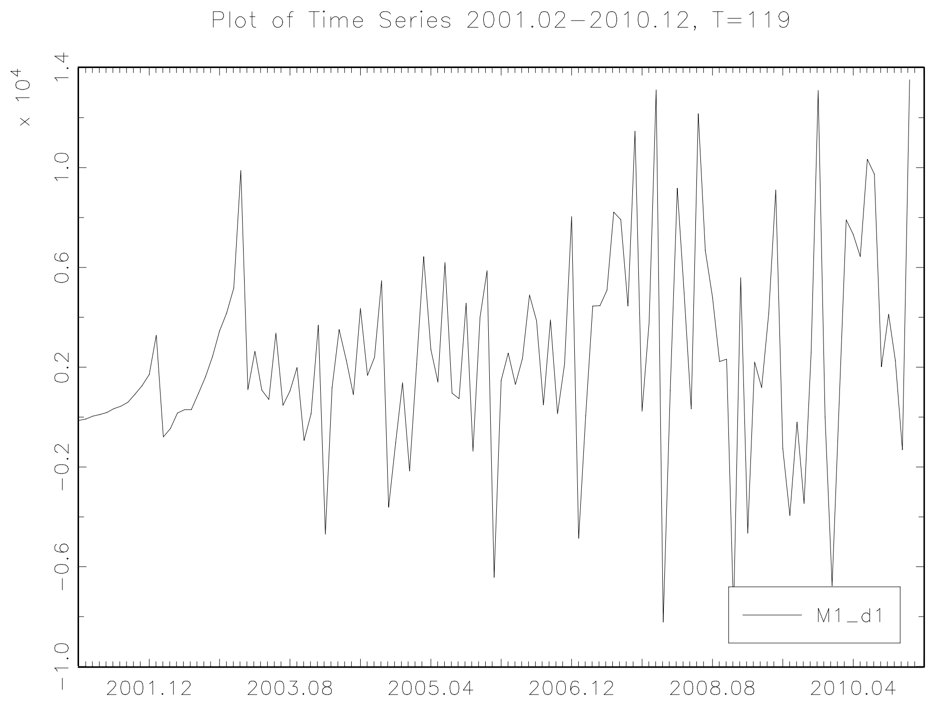

Figure 4. Plot of the first differences of M1

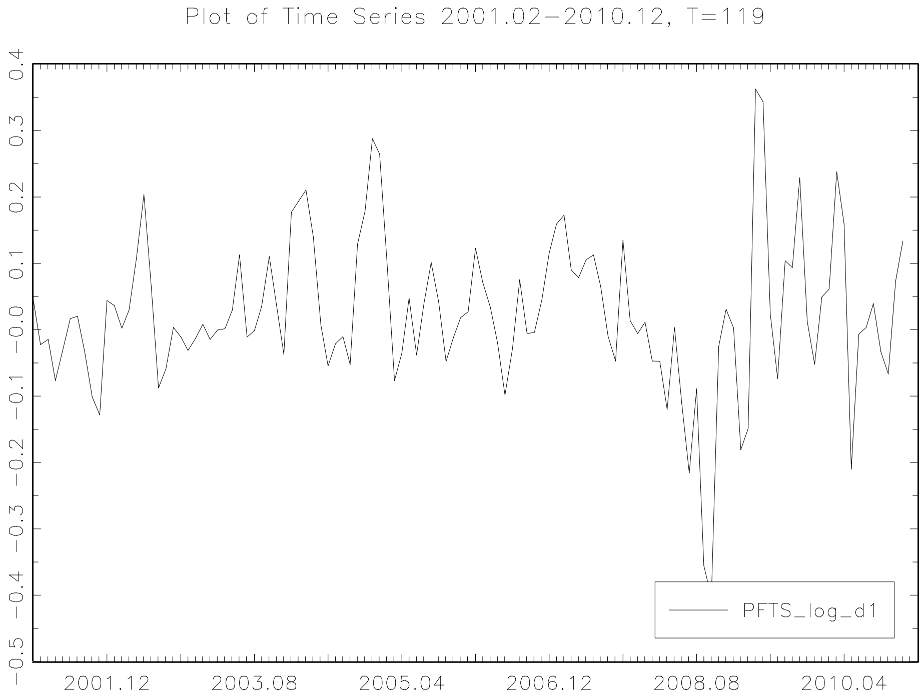

Figure 5. Plot of the first differences of logarithm of PFTS stock index

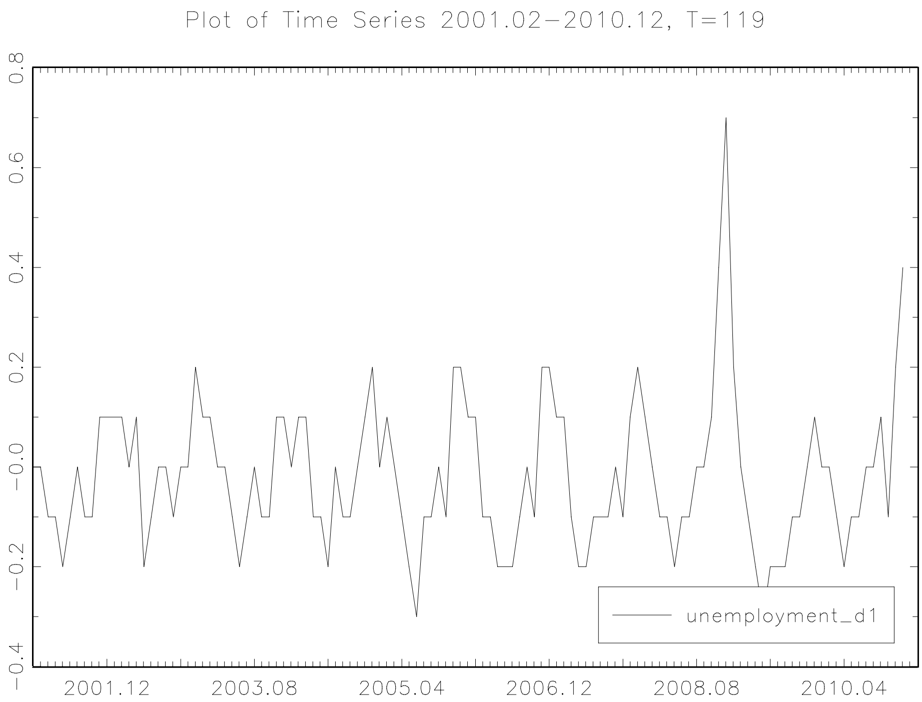

Figure 6. Plot of the first differences of unemployment