A VAR analysis of

Nordic electronic market linkages

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Abstract

This paper firstly examined the data properties of the electronic priceS of 7 Nordic regions with daily data from May 1st 2007 to April 30th 2008. Based on the seasonal changing price finding, the Granger causality relations between these regions are revealed and a multivariate VAR model is constructed and evaluated to further explain on the data structure of the electronic price pattern. As a conclusion, the Oslo market is of the most importance among all the Nordic electronic markets. It has influence on all the Nordic markets except for the Danmarkwest. On the other hand, The Danmarkwest market is also very influential, especially to those electronic markets outside Norway. Both of these two market are under high influence of the other markets, however, the correlation between them are weak.

Key words: Nord Pool Electronic Price VAR model Granger Causality

Contents

1. Introduction:

As the Europe largest and most liquid marketplace for physical and financial power contract, the Nord Pool contains much information of the Nordic countries. Up till now, many researches has been done with the modeling work of some major single markets*, however, contemporaneous causal relationship among these markets is also of great interest. As 7 major regions in the Nordic electronic price market, Danmarkeast, Danmarkwest, Sweden, Finland, Oslo, Thodheim and Tromso have different power structure; therefore the price in each of these markets might be different. Facilitated by the established power grid transmission system, the electronic power can be transmitted from one place to another. The linkages of the market price between these regions are formed. In order to reveal the price linkages of these 7 markets, a VAR model is employed to analyze on the whole year data from May 1st 2007 to April 30th 2008. Data analysis shows that the whole year data can be split into two sub periods ----- May 1st 2007 to September 20th 2007 as warm season and the October 1st 2007 to April 30th 2008 as cold season. Based on this break points assumption, a two period VAR model is constructed. Granger causality test is then conducted and shows that Oslo market has the most powerful affect among the seven regions. Except for those Norway regions, both Finland and Sweden are highly influenced by it. On the other hand, Denmark power market seems comparatively independent and its two sub markets ------ Danmarkeast and Danmarkwest tend to be inter-dependent. Compared with Danmarkeast, Danmarkwest market has higher influence on the other countries.

2. The Nordic power market:

As the Europe largest and most liquid marketplace for physical and financial power contract, the Nord pool started to function in 1993 in Oslo, Norway. Its service circle mainly covers Nordic countries such as Finland, Sweden, Denmark and Norway. Now, it has more than 420 members in total. The Nord Pool services can be divided into four different areas: The physical market, the financial market, clearing and consulting, which, respectively are represented by the Nord Pool Spot AS, the Nord Pool ASA, the Nord Pool clearing ASA and the Nord Pool consulting AS. Among these, the physical market is of the most importance and is the basis for the financial market. The physical market includes Elspot and Elbase markets and Elspot is the common Nordic market for trading physical electricity contracts with next-day supply. The market system is based on a day-ahead market, where participants can buy and sale power contracts of 1 hour duration covering the 24h of the following day. (Niels Haldrup, Morten Orregaard Nielsen 2006) During resent several years, the Nord Pool Spot AS has undergone remarkable changes toward liberization (nord pool report 2006) and

Norway, Finland, Sweden and Danmark have cooperated to serve electronic power and at the same time have their own separate price areas. These separate prices may coexist depending on regional supply and demand.

Norway, Finland, Sweden and Danmark have different electronic power structure. For Norway, its electronic power almost all comes from hydropower. The major electronic resource for Danmark is thermal plants and combined heating and power facilities. Sweden and Finland mainly use nuclear plants, fossil-fuel powered plants and hydropower for electronic generation. Each of these markets has its own capacity barrier. When the demand and supply for one market cannot clear up in a separate market, the price of it will influence the price of neighboring regions.

3. Data description:

The data employed in this study is daily observations of following 7 regions: Danmarkeast, Danmarkwest, Finland, Sweden, Oslo, Trondheim and Thomso [1]. The data covers from 2007-05-01 to 2008-04-30. For each individual time series, it includes 366 observations. Because of the weather influence, according to experience, the fluctuation of daily electronic price for each year can be divided into two

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[1] * we use eruo as unit to compute the daily electronic price. Since Kristiansand and Kristiansund in Norway do not have euro based price, we don’t put them into consideration in the VAR model. And because Bergen has exactly same price as Oslo, we omit it as well.

periods. The first period, which we usually called warm season, starts from May 1st to September 30th. The second one, which usually called as cold season spans from the October 1st to the April 30th of the next year. For the sake of space saving, I would only use the data of Sweden to explain on the difference between these two periods. Data description tables of the rest of 6 regions are put as part of appendix.

From table one, we can see that in Sweden, the mean price of cold season is 41.51, and it is 59% higher than the average price in warm season. This could be explained by the difference of the day time between these two periods. In the cold season, the day time is very short and electricity is in higher demand for lighting. When summer time came, day light will be available for more than 18 hours and electricity demand falls down significantly.

Table 1: the descriptive statistics of Sweden for the daily price and related time series (20070501-20080430)

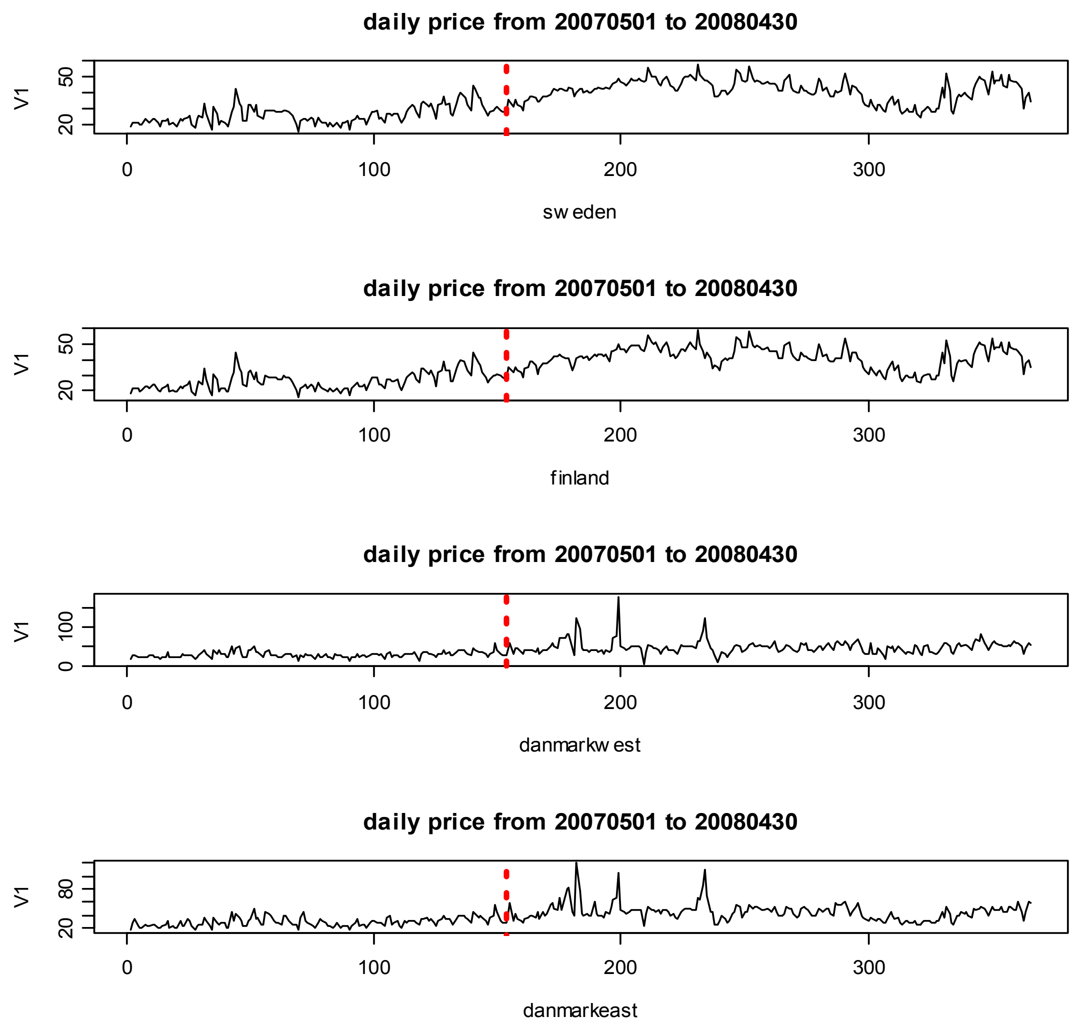
Series	number of observation	Mean	Median	Minimum	Maximum	Stand Deviation	1st quarter	3rd quarter
Panel A all seasons (20070501-200870430)								
Pt	366	35.04	35.15	15.54	58.52	10.01	26.98	43.12
Pt-Pt-1	365	0.05	-0.21	-12.42	15.38	4.06	-1.95	1.73
Log(Pt)	366	3.51	3.56	2.74	4.07	0.30	3.30	3.76
Log(Pt)-log(Pt-1)	365	0.00	0.00	-0.35	0.62	0.13	-0.06	0.05
Panel B Warm season (20070501-20070930)								
Pt	154	26.01	25.03	15.54	44.43	5.65	21.65	29.07
Pt-Pt-1	153	0.06	-0.16	-9.16	15.38	4.05	-2.13	1.85
Log(Pt)	154	3.24	3.22	2.74	3.79	0.21	3.07	3.37
Log(Pt)-log(Pt-1)	153	0.00	0.00	-0.33	0.62	0.15	-0.09	0.06

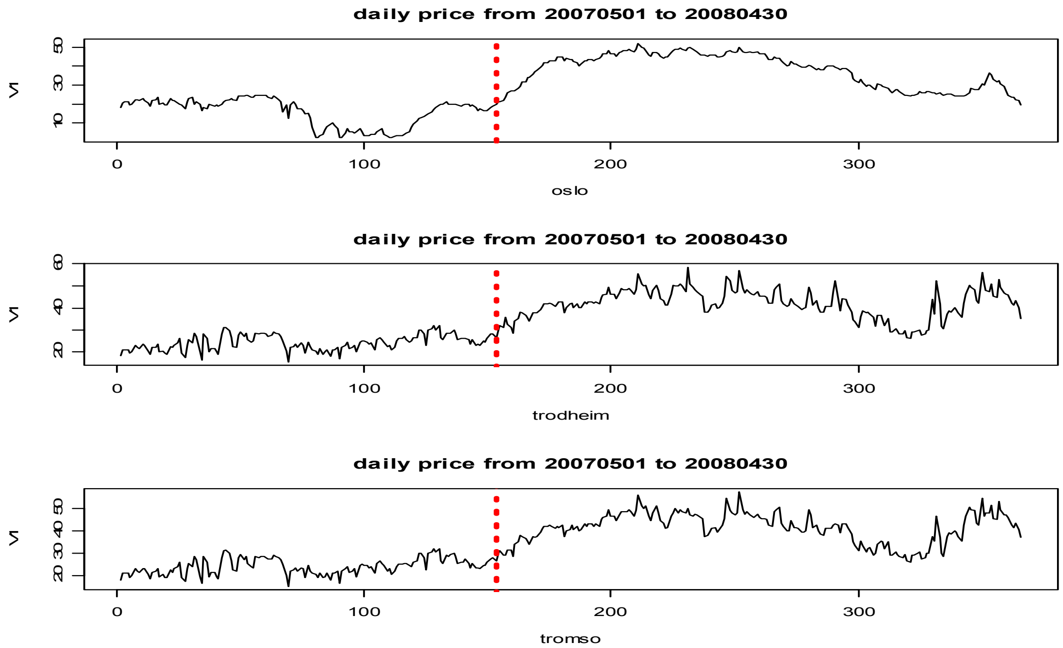
	Panel C	cold season	(20071001-20080430)					
Pt	202	41.52	41.96	24.75	58.52	6.97	37.60	46.85
Pt-Pt-1	201	0.00	-0.24	-12.42	15.19	4.05	-1.86	1.65
Log(Pt)	202	3.71	3.74	3.21	4.07	0.18	3.63	3.85
Log(Pt)-log(Pt-1)	201	0.00	0.00	-0.35	0.38	0.10	-0.05	0.04

Note: pt represents for the level data, Pt-Pt-1 represents for the first difference of the level data, log(Pt) represents for the natural logarithm of the level data and Log(Pt)-Log(Pt-1) represents for the first difference of the natural log of the level data.

From the following graph 1, we can get a direct impression that after the red dashes that represents the date of September 30 of 2007, electronic price started to grow and reach to a higher average level than the warm season's price.

Figure1: full year daily price plot of the 7 markets:





4. VAR model introduction:

The model we are using in the essay is a multivariate VAR (p) model with consideration of one seasonal break. Let Y_t denotes a vector as (k × 1) dimension, our VAR (p) model can be defined as :

$$\begin{cases} y_{1t} = V_1 + A_{1,1} y_{1,t-1} + ... + A_{1,p_1} y_{1,t-p_1} + u_{1,t} & t \le T_0 \\ y_{2t} = V_2 + A_{2,1} y_{1,t-1} + ... + A_{2,p_2} y_{2,t-p_2} + u_{2,t} & t > T_0 \\ y_t \ = V + A_1 y_{t-1} + ... + A_p y_{1,t-p} + u_t & t = 1, 2, ..., T \end{cases} \quad (1)$$

$y_t = (y_{1t,} ...... y_{Kt})'$ is a $(K \times 1)$ random vector and the same for y_{1t} and y_{2t}. A_i, A_{1i}, A_{2i} are fixed $(K \times K)$ coefficient matrix. v, v_1, v_2 are $(K \times 1)$ vectors of intercept term allowing for the possibility of a nonzero mean $E(y_t)$. $u_t, u_{1,t}, u_{2,t}$ are all K-dimensional white noise. To be specific: $u_t = (u_{1t}, ... u_{Kt})'$

In the following practical analysis, a 7 dimension VAR system is taken into consideration. This means in function (1), K=7. In order to determine the optimal lag order of the VAR model, common criterion such as the Schwarz's SC (1978), Hannan and Quinn (1979) HQ information criteria, Akaike information criteria AIC are exploited. Both the AIC and FPE criteria suggest the optimal lag as 7. Then in the subsequent analysis, we define the lag length p=7.

Since unstationary process will lead to arbitrary result when doing Granger causality analysis, therefore we need to check for the stationary property before we start to estimate the model and do Granger causality analysis. Commonly, we use augment Dicky-Fuller test (ADF) to test for the existence of the unit root. But the inefficiency of ADF test is obvious. First, its test critical value (or p-value) for different small sample size has to be approximated asymptotically computed by simulation methods. And its test power is comparatively weak such that it is more likely to accept the null hypothesis H0 of a unit root and reject the alternate Hypothesis H1 of no unit root. Therefore we also use pp test to test for the existence of unit root. Constant term and trend are both under consideration.

Table2 ADF and PP test on level data:

Region	without trend ADF value and p-value	without trend PP value	with trend ADF value and p-value	with trend PP value
Danmarkeast	-6.85(0.01)*	-7.73*	-7.72(0.01)*	-9.07*
Danmarkwest	-3.33(0.02)*	-9.21*	-10.73(0.01)*	-11.09*
Finland	-2.55(0.1)	-3.52*	-3.34 (0.06)	-4.92*
Sweden	-2.41(0.1)	-3.30*	-2.85(0.1)	-4.53*
Oslo	-1.14(0.1)	-1.13	-0.77(0.1)	-0.63

Trodheim	-1.98(0.1)	-2.59	-2.11(0.1)	-3.35
Tromso	-1.99(0.1)	-2.38	-2.46(0.1)	-3.15

Note: (1) the 5% critical value of the pp test without trend and with trend respectively are -2.87 and -3.42 (2) * means the test value fells in the reject region.

According to table 2, we can see that under both conditions of with and without trend, ADF test shows that only Danmarkeast and Danmarkwest are stationary series and PP test shows that the three Norway regions: Oslo, Trodheim and Tromso are non-stationary series. This means that some data transformation is in need. As denoted in table, transformation such as Log(Pt), (Pt-Pt-1), (log(Pt)-log(Pt-1)) are being considered. Similar to above procedure, we can find that there is no unit root in their first differences (Pt-Pt-1) and difference log value (log(Pt)-log(Pt-1)) at the 5% significance level. We are going to use the first difference data in the estimation VAR model and for the examination of causality relation.

5. Granger causality test:

Ever since Granger(1969) defined a concept of causality test, it has become a preliminary analysis method to analyze the short-run dynamic linkage. Its basic idea is easy to understand ------ a cause cannot come after the effect. If element A correlates with element B, then A must be helpful to improve the prediction of B, therefore the original granger causality is defined with the forecast MSE. (Lutkepohl, 2005) But the most commonly used Granger causality test statistics is F type statistics and its mathematical explanation comes as follows:

We still consider with the VAR(p) model as defined in function (1).

Suppose the vector of endogenous variables y_t is split into two subvectors: y_{1t}, and y_{2t} with dimensions ($k_1 \times 1$) and ($k_2 \times 1$). k = $k_1 + k_2$ Then, we can rewrite the VAR(p) function as :

$$[y_{1t}, y_{2t}] = \sum_{i=1}^{p} [\alpha'_{11,i}\ \alpha'_{12,i} \mid \alpha'_{21,i}\ \alpha'_{22,i}][y_{1,t-i}, y_{2,t-i}] + [\mu_{1t}, u_{2t}] \quad (2)$$

The null hypothesis of granger causality test with function (2) that the subvector y_{1t}, does not Granger-cause y_{2t} is defined as $\alpha'_{21,i}$ = 0 for i = 1, 2, ... p. The alternative is: $\exists\, \alpha'_{21,i} \neq 0$ for i = 1, 2, . . . , p. The total number of parameters in the above VAR(p)

In this essay, we only conduct a bivariate granger causality test to examine the causal relation between each two of these 7 countries. The result comes in table 3 as follows:

Table 3 : bivariate Granger causality test result:

Target variable: **Danmarkeast**						
	Influential variables					
	Danmarkwest	Finland	Sweden	Oslo	Trodheim	Tromso
F statistics and p value	1.35 (0.12) *	1.86 (0.08)**	1.3 (0,25)	1.55 (0.14)*	1.07 (0.38)	1.27 (0.29)
Target variable: **Danmarkwest**						
	Influential variables					
	Danmarkeast	Finland	Sweden	Oslo	Trodheim	Tromso
F statistics and p value	4.32 (0.00)***	3.13 (0.00)***	2.29 (0.03)***	1.33 (0.24)	1.76 (0.09)**	2.06 (0.05) ***
Target variable: **Finland**						
	Influential variables					
	Danmarkeast	Danmarkwest	Sweden	Oslo	Trodheim	Tromso
F statistics and p value	1.49 (0.17)	1.64 (0.12)*	1.42 (0.2)	2.83 (0.00)***	1.08 (0.37)	1.88 (0.07)**
Target variable: **Sweden**						

	Influential variables Danmarkeast	Danmarkwest	Finland	Oslo	Trodheim	Tromso
F statistics and p value	0.77 (0.61)	0.95 (0.46)	1.26 (0.26)	3.33 (0.00)***	1.23 (0.29)	2.25 (0.03)***
Target variable: **Oslo**						
	Influential variables Danmarkeast	Danmarkwest	Finland	Sweden	Trodheim	Tromso
F statistics and p value	1.74 (0.10)**	1.59 (0.14)*	1.98 (0.06)**	1.67 (0.12)*	1.91 (0.07)**	2.67 (0.01)***
Target variable: **Trodheim**						
	Influential variables Danmarkeast	Danmarkwest	Finland	Sweden	Olso	Tromso
F statistics and p value	1.16 (0.32)	1.23 (0.29)	0.49 (0.84)	0.94 (0.48)	2.63 (0.01)***	3.88 (0.00)***
Target variable: **Tromso**						
	Influential variables Danmarkeast	Danmarkwest	Finland	Sweden	Olso	Thodheim
F statistics and p value	0.63 (0.73)	0.87 (0.53)	0.45 (0.87)	0.71 (0.67)	2.55 (0.01)***	1.32 (0.24)

Notes: *means significant under 15% level, **means significant under 10% level and ***means significant under 5% level

According to the table, we can see that, at the 15% significance level, Finland and Oslo may influence the Danmarkeast market; all markets except Oslo may influence Danmarkwest markets; Danmarkwest, Oslo and Tormso may influence Finland market; Oslo and Tromso may influence Sweden market; Oslo market is under the influence of every market in the Nordic market; Trodheim markets is influenced only by the other two Norway market ---- Oslo and Tromso and Tromso is solely influenced by the Oslo market. Therefore, this result clearly suggest that under the 15% significance level, the Oslo market has a dorminant effect on the other markets in the system and it is also closely correlated with other markets at the same time. At the

10% level, only Finland market has influence on the Danmarkeast market, but the casual correlation of Danmarkwest, Sweden, Trodheim and Tromso is still significant. The influence of Danmarkwest and Sweden market on Oslo is insignificant this time. The links between Oslo and Tromso is very strong and it is even significant under the 5% level. So does the linkage of Sweden and Finland market to Oslo market. Compared with the 15% level result, under the 5% level, the influence of Oslo market on these Nordic markets is still eminent but become weak in the Danmarkeast market. The Danmarkwest market, from the beginning to the end, has never been influence by the powerful Oslo market. This is of great interesting and need our further study.

6. Empirical application:

6.1 Whole data estimation:

Though we have assumed that the whole period data consist of two sub periods ---- the warm season and the cold season, VAR model built on the whole data span still contain important information and worth our attention. By OLS regression, we get the whole data VAR(7). Because the VAR(7) estimation result contains too many estimated coefficients, I put them into a separate file. (see “result .txt“ file)From the result, we can see that, the price fluctuation of Danmarkeast market is significantly explained by the price variance of Finland, Sweden and influence coming from Trodheim and Tromso tend to affect the Danmarkeast market after longer period. The Danmarkeast market is influence mainly by three markets: Danmarkwest, Finland and Sweden and Finland price has longer term influence as well. Sweden and Finland has the same price pattern --- they are highly inter-correlated and influenced by Danmarkwest. Compared with Finland, Sweden market is more self dependent. Oslo market is a self dependent one. The price pattern of Trodheim and Tromso are similar ---- they are all highly influenced by Sweden and Finland.

6.2 Sub-sample VAR model: warm season

For the sub period as warm season, we can construct a sub sample VAR model to investigate the fluctuation condition during this period. Also see the estimation result in the “result.txt” file.

From the result we can see that the Danmarkeast price are mainly self dependent and price influence coming from two Norway regions of Throdheim and Tromso have longer term effect of its price fluctuation. So it is the case of Danmarkwest market. For Finland market, price fluctuation mainly comes from the Danmarkwest and Trodheim market. Sweden market is shortly self determined and in the long run, it closed related with those Norway markets and also Danmarkwest. Except for the short term self influence, the Danmarkeat is the only market that can influence Oslo’s longer term price.

6.3 Sub sample VAR model: cold season

In cold season, average electronic price are higher than warm season. According to the difference price graph before, we can see that there is no sight of trend in this period either. So, we construct a short period VAR model wih only constant term. See the model estimation result in file “result.txt”. During the warm season, Finland and Sweden have continuous influence on the price of Danmarkeast. Price of Danmarkwest is under several influence coming form both itself and market such as Danmarkeast, Finland and Sweden. The effect from Danmarkeast decreases after several days. Compared with the cold season, Finland now is mostly influenced by Sweden market and those Norway markets still have influence on it. For Oslo, the Danmarkeast market influence now disappeared and it is mainly influenced by markets inside Norway.

6.4 Model evaluation:

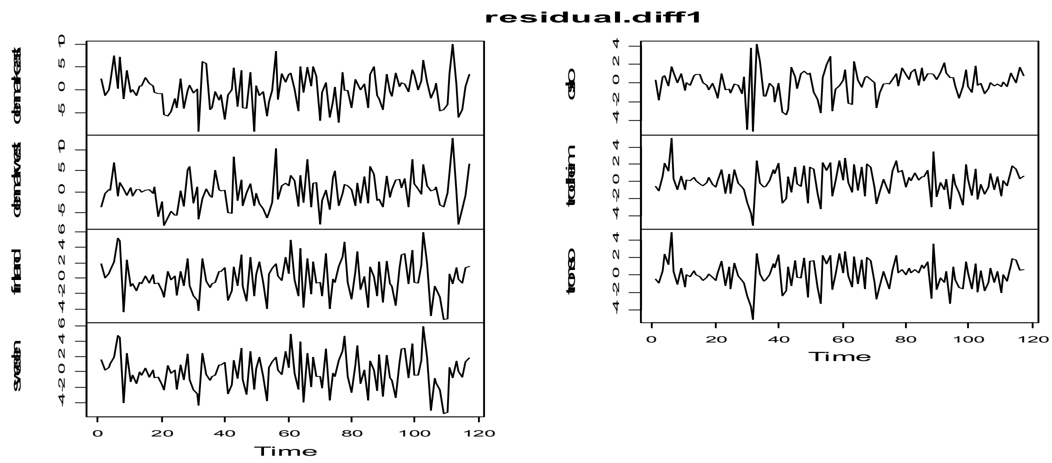
The prior model selection criterion for this model is Portmanteau Test statistics, which is mainly used to examine whether residual correlation exists in each of the model. The test results come as table 4.

Table 4. Adjusted Portmanteau test result with p=20

Period / p-value	Whole Period	Warm season	Cold Season
Chi-square value And P- value	694.97 (0.06)	795.66 (0.01)	695.78 (0.052)

Under the 5% significance level, except for the warm season, the p values fell into the accept region which means the null hypothesis can be accepted that there is no sign of autocorrelation in this VAR model. Though the warm season did not pass the Portmanteau Test, its residual plot looks good. Generally, we can say that the model fits to the data well.

Figure 2: Residual plot of the warm season:



7. Conclusion:

This paper examines the linkages of daily electronic price among 7 Nordic electronic markets during May 1st 2007 to April 20th 2008. The granger causality test result demonstrates the strong influence of the Oslo market-----on both markets in Norway and on the whole Nordic markets. This might because the main power supply of Oslo is hydropower and it is comparatively cheaper than the thermal power that dominates the power resource in the south part of the Nordic power market. Sweden, Finland have the same linkage pattern, and both of them are highly influenced by the Oslo market. This might because their similarity on the resource supply ---- both of these two regions depend on nuclear power, fossil fuel and hydropower. And the dependency of Sweden market on Oslo market can be explained by its power structure, in which 30% of its resource relies on hydropower. However, the Danmarkwest market and the Oslo market seems to be two isolated markets. The Danmarkwest market is well influenced by all the markets except for the Oslo and its influence on Oslo market is also comparatively weak than other markets. This might because the big difference of the power structure between these two regions. For Denmark, almost 90% of its electricity supply is generated by thermal plants and it is comparatively a separate price area since it joined in the Nord Pool. (Erik Hjalmarsson 2000)

However, we should also notice that the Granger causality has its inborn deficiency and therefore sometimes will lead to arbitrary conclusion. (Sims, 1972) For example, the instantaneous correlations between market innovations are not been taken into consideration. As we can see, practically, the Sweden market and Finland market has strong linkages, but the granger causality did not test out this point. Now, a new method named directed acyclic graph (DAG) becomes popular in analyzing the correlations between several markets. (Jian Yang 2006). I have used this method to analyze the same problem in another paper. It seems that the DAG is a better method than Granger causality test in analyzing the electronic market correlations.

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Appendix:

A. Table A.1: the descriptive statistics of Danmarkeast for the daily price and related time series (20070501-20080430)

Series	number of observation	Mean	Median	Minimum	Maximum	Stand Deviation	1st quarter	3rd quarter
Panel A all seasons (20070501-200870430)								
Pt	366	38.16	36.80	15.99	120.38	13.68	28.37	45.57
Pt-Pt-1	365	0.10	-0.61	-59.37	82.5	10.54	-4.07	3.88
Log(Pt)	366	3.59	3.60	2.77	4.79	0.33	3.34	3.82
Log(Pt)-log(Pt-1)	365	0.00	0.01	-0.83	1.16	0.24	-0.12	0.12
Panel B Warm season (20070501-20070930)								
Pt	153	29.02	28.33	15.99	55.20	7.27	23.28	32.95
Pt-Pt-1	152	0.06	-1.14	-17.69	26.36	7.32	-4.23	3.76
Log(Pt)	153	3.34	3.34	2.77	4.01	0.25	3.15	3.50
Log(Pt)-log(Pt-1)	152	0.00	-0.04	-0.50	0.87	0.25	-0.15	0.14
Panel C cold season (20071001-20080430)								
Pt	213	44.73	44.12	23.31	120.4	13.43	37.21	49.36
Pt-Pt-1	212	0.06	-0.23	-59.37	82.5	12.33	--3.79	3.86
Log(Pt)	213	3.76	3.79	3.15	4.79	0.27	3.62	3.90
Log(Pt)-log(Pt-1)	212	0.001	-0.00	0.83	1.16	0.22	-0.09	0.1

Note: pt represents for the level data, Pt-Pt-1 represents for the first difference of the level data, log(Pt) represents for the natural logarithm of the level data and Log(Pt)-Log(Pt-1) represents for the first difference of the natural log of the level data.

Table A.2 the descriptive statistics of Danmarkwest for the daily price and related time series (20070501-20080430)

Series	number of observation	Mean	Median	Minimum	Maximum	Stand Deviation	1st quarter	3rd quarter
Panel A all seasons (20070501-200870430)								
Pt	366	39.43	37.64	13.89	178.2	16.84	28.27	48.19
Pt-Pt-1	365	0.10	-0.60	-127.52	102.6	14.66	-5.27	5.06
Log(Pt)	366	3.60	3.63	1.36	5.18	0.40	3.34	3.88
Log(Pt)-log(Pt-1)	365	0.00	-0.02	-2.43	2.24	0.34	-0.14	0.14
Panel B Warm season (20070501-20070930)								
Pt	153	28.26	27.53	13.05	57.29	7.28	23.19	32.33
Pt-Pt-1	152	0.06	-0.60	-17.64	26.02	7.59	-4.10	3.72
Log(Pt)	153	3.31	3.32	2.57	4.05	0.25	3.14	3.48
Log(Pt)-log(Pt-1)	152	0.00	-0.03	-0.73	0.89	0.27	-0.16	0.14
Panel C cold season (20071001-20080430)								
Pt	213	47.45	45.75	3.89	178.2	17.18	38.28	53.96
Pt-Pt-1	212	0.05	-0.78	-127.5	102.6	18.11	-5.93	5.46
Log(Pt)	213	3.80	3.82	1.36	5.18	0.35	3.65	4.00
Log(Pt)-log(Pt-1)	212	0.00	-0.02	-2.43	2.24	0.38	-0.14	0.13

Note: pt represents for the level data, Pt-Pt-1 represents for the first difference of the level data, log(Pt) represents for the natural logarithm of the level data and Log(Pt)-Log(Pt-1) represents for the first difference of the natural log of the level data.

Table A.3 the descriptive statistics of Finland for the daily price and related time series (20070501-20080430)

Series	number of observation	Mean	Median	Minimum	Maximum	Stand Deviation	1st quarter	3rd quarter
Panel A all seasons (20070501-200870430)								
Pt	366	34.8	34.3	15.54	58.50	9.83	26.98	42.66
Pt-Pt-1	365	0.14	-0.60	-117.32	106.5	4.18	-5.14	6.60
Log(Pt)	366	3.51	3.54	2.74	4.07	0.30	3.30	3.75
Log(Pt)-log(Pt-1)	365	0.00	0.00	-0.35	0.62	0.13	-0.06	0.06
Panel B Warm season (20070501-20070930)								
Pt	153	26.04	25.03	15.45	44.43	5.67	21.82	29.07
Pt-Pt-1	152	0.06	-0.25	-10.38	15.38	4.07	-2.13	1.81
Log(Pt)	153	3.24	3.22	2.74	3.79	0.21	3.08	3.37
Log(Pt)-log(Pt-1)	152	0.00	-0.01	-0.32	0.62	0.15	-0.09	0.06
Panel C cold season (20071001-20080430)								
Pt	213	41.4	41.35	24.75	58.50	6.93	36.82	46.36
Pt-Pt-1	212	0.00	-0.21	-12.42	15.19	4.24	-2.12	2.05
Log(Pt)	213	3.70	3.72	3.21	4.07	0.18	3.60	3.84
Log(Pt)-log(Pt-1)	212	0.00	0.00	-0.35	0.38	0.10	-0.05	0.05

Note: pt represents for the level data, Pt-Pt-1 represents for the first difference of the level data, log(Pt) represents for the natural logarithm of the level data and Log(Pt)-Log(Pt-1) represents for the first difference of the natural log of the level data.

Table A.4 the descriptive statistics of Oslo for the daily price and related time series (20070501-20080430)

Series	number of observation	Mean	Median	Minimum	Maximum	Stand Deviation	1st quarter	3rd quarter
Panel A all seasons (20070501-200870430)								
Pt	366	28.61	25.89	2.07	52.24	13.27	19.69	42.63
Pt-Pt-1	365	0.00	0.03	-6.96	7.16	1.45	-0.80	0.81
Log(Pt)	366	3.17	3.25	0.73	3.96	0.71	2.98	3.75
Log(Pt)-log(Pt-1)	365	0.00	0.00	-1.12	0.80	0.14	-0.02	0.03
Panel B Warm season (20070501-20070930)								
Pt	153	15.79	19.08	2.07	24.98	7.28	8.75	21.16
Pt-Pt-1	152	0.01	0,17	-6.96	7.16	1.79	-0.78	0.95
Log(Pt)	153	2.57	2.95	0.73	3.22	0/72	2.17	3.05
Log(Pt)-log(Pt-1)	152	0.00	0.01	-1.20	0.80	0.21	-0.04	0.08
Panel C cold season (20071001-20080430)								
Pt	213	37.82	40.30	19.40	52.24	9.06	28.16	45.95
Pt-Pt-1	212	0	-0.03	-2.57	4.36	1.16	-0.80	-0.62
Log(Pt)	213	3.60	3.70	2.97	3.96	0.26	3.33	3.83
Log(Pt)-log(Pt-1)	212	0.00	0.00	-0.11	0.13	0.03	-0.02	0.02

Note: pt represents for the level data, Pt-Pt-1 represents for the first difference of the level data, log(Pt) represents for the natural logarithm of the level data and Log(Pt)-Log(Pt-1) represents for the first difference of the natural log of the level data.

Table A.5 the descriptive statistics of Trodheim for the daily price and related time series (20070501-20080430)

Series	number of observation	Mean	Median	Minimum	Maximum	Stand Deviation	1st quarter	3rd quarter
Panel A all seasons (20070501-200870430)								
Pt	366	34.56	34.25	15.54	58.52	10.36	25.38	43.13
Pt-Pt-1	365	0.05	-0.21	-10.54	15.14	3.34	-1.66	1.49
Log(Pt)	366	3.50	3.53	2.74	4.07	0.31	3.23	3.76
Log(Pt)-log(Pt-1)	365	0.00	0.00	-0.32	0.54	0.10	-0.05	0.05
Panel B Warm season (20070501-20070930)								
Pt	153	24.29	24.26	15.45	32.09	3.56	21.59	26.87
Pt-Pt-1	152	0.06	-0.06	-7.40	11.81	2.79	-1.55	1.30
Log(Pt)	153	3.18	3.19	2.74	3.47	0.15	3.07	3.29
Log(Pt)-log(Pt-1)	152	0.00	0.00	-0.32	0.54	0.12	-0.06	0.05
Panel C cold season (20071001-20080430)								
Pt	213	41.94	42.09	26.18	58.52	6.71	37.96	47.02
Pt-Pt-1	212	0.02	-0.31	-10.54	15.19	3.68	-1.76	1.53
Log(Pt)	213	3.72	3.74	3.27	4.07	0.17	3.64	3.85
Log(Pt)-log(Pt-1)	212	0.00	0.00	-0.29	0.38	0.09	-0.04	0.04

Note: pt represents for the level data, Pt-Pt-1 represents for the first difference of the level data, log(Pt) represents for the natural logarithm of the level data and Log(Pt)-Log(Pt-1) represents for the first difference of the natural log of the level data.

Table A.6 the descriptive statistics of Tromso for the daily price and related time series (20070501-20080430)

Series	number of observation	Mean	Median	Minimum	Maximum	Stand Deviation	1st quarter	3rd quarter
Panel A all seasons (20070501-200870430)								
Pt	366	34.16	32.06	15.54	57.20	10.08	25.21	42.60
Pt-Pt-1	365	0.05	-0.11	-9.06	11.81	3,00	-1.66	1.31
Log(Pt)	366	3.49	3.47	2.74	4.05	0.31	3.23	3.75
Log(Pt)-log(Pt-1)	365	0.00	0.00	-0.32	0.54	0.10	-0.05	0.05
Panel B Warm season (20070501-20070930)								
Pt	153	24.26	24.07	15.54	32.09	3.57	21.59	26.86
Pt-Pt-1	152	0.06	-0.06	-7.4	11.81	2.81	-1.60	1.28
Log(Pt)	153	3.18	3.18	2.47	3.47	0.15	3.07	3.29
Log(Pt)-log(Pt-1)	152	0.00	0.00	-0.32	0.54	0.12	-0.06	0.05
Panel C cold season (20071001-20080430)								
Pt	213	41.26	41.97	26.16	57.20	6.67	37.47	46.50
Pt-Pt-1	212	0.03	-0.21	-9.06	11.42	3.14	-1.67	1.33
Log(Pt)	213	3.71	3.73	3.26	4.05	0.17	3.62	3.84
Log(Pt)-log(Pt-1)	212	0.00	0.00	-0.22	0.26	0.08	-0.04	0.03

Note: pt represents for the level data, Pt-Pt-1 represents for the first difference of the level data, log(Pt) represents for the natural logarithm of the level data and Log(Pt)-Log(Pt-1) represents for the first difference of the natural log of the level data

B. plot graph of transformed data:

Figure B.1: plot graph of transformed data of Sweden

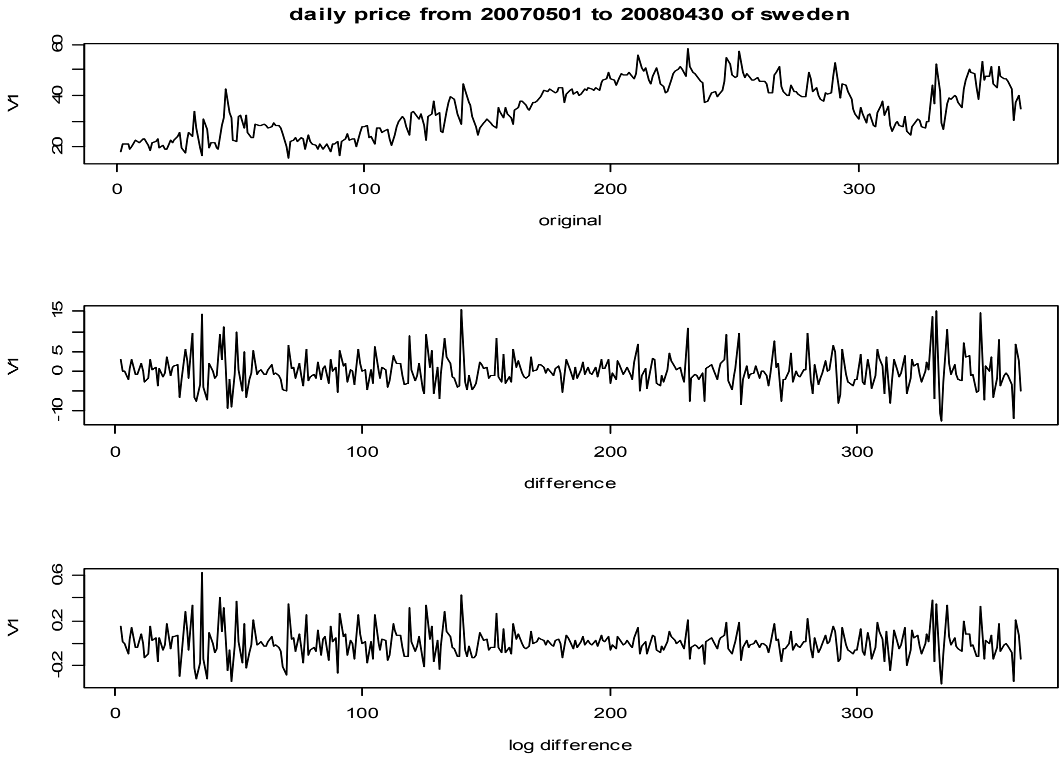

Figure B.2 plot graph of transformed data of Danmarkeast:

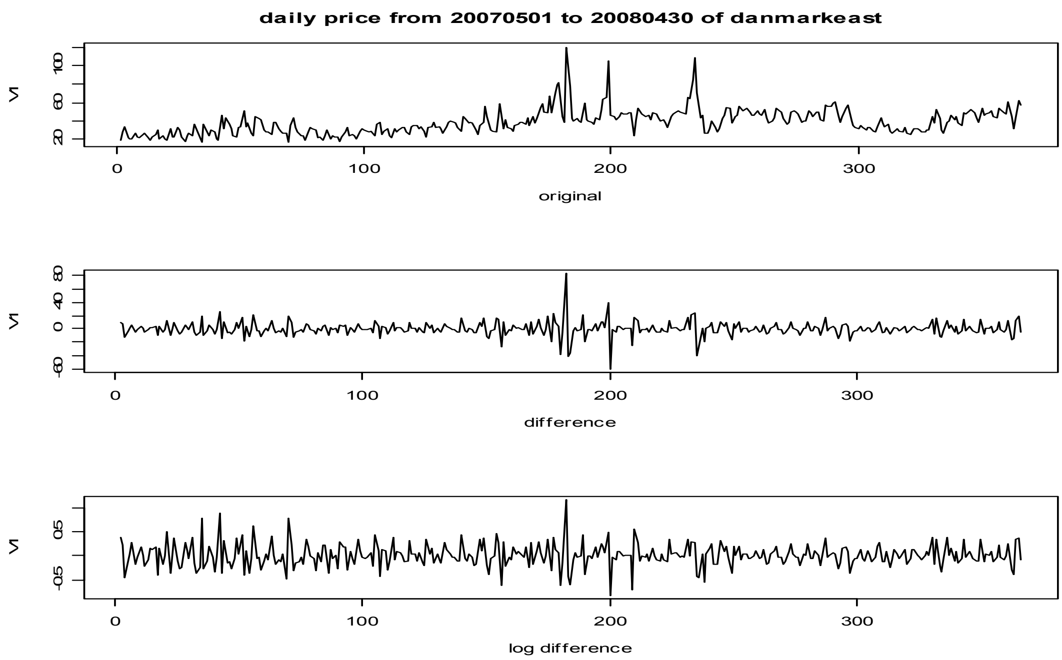

Figure B.3 plot graph of transformed data of Danmarkwest:

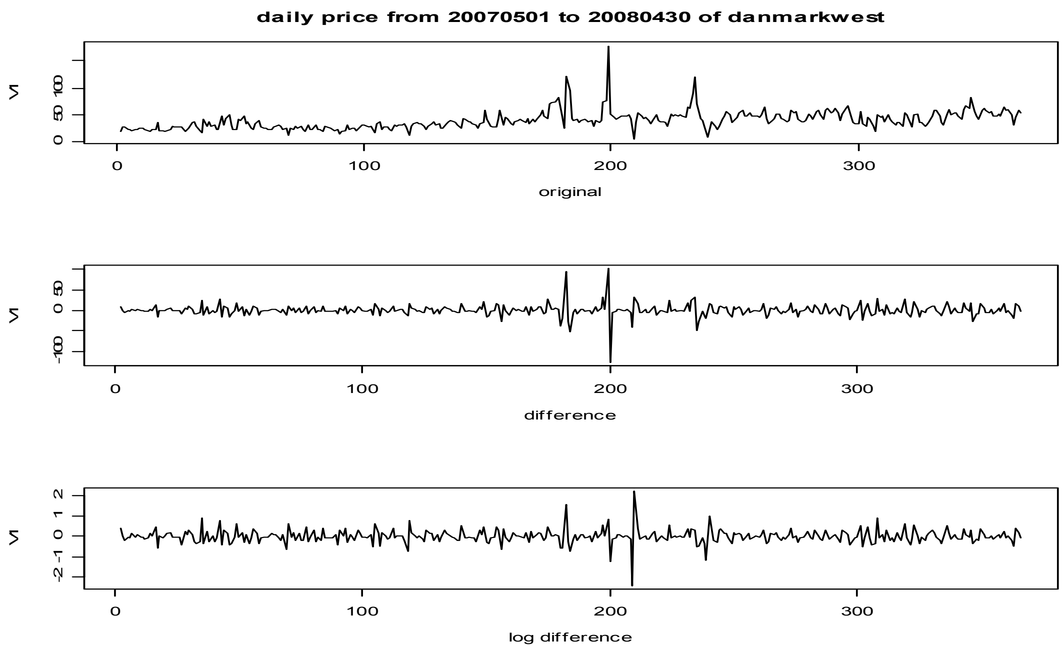

Figure B.4 plot graph of transformed data of Finland:

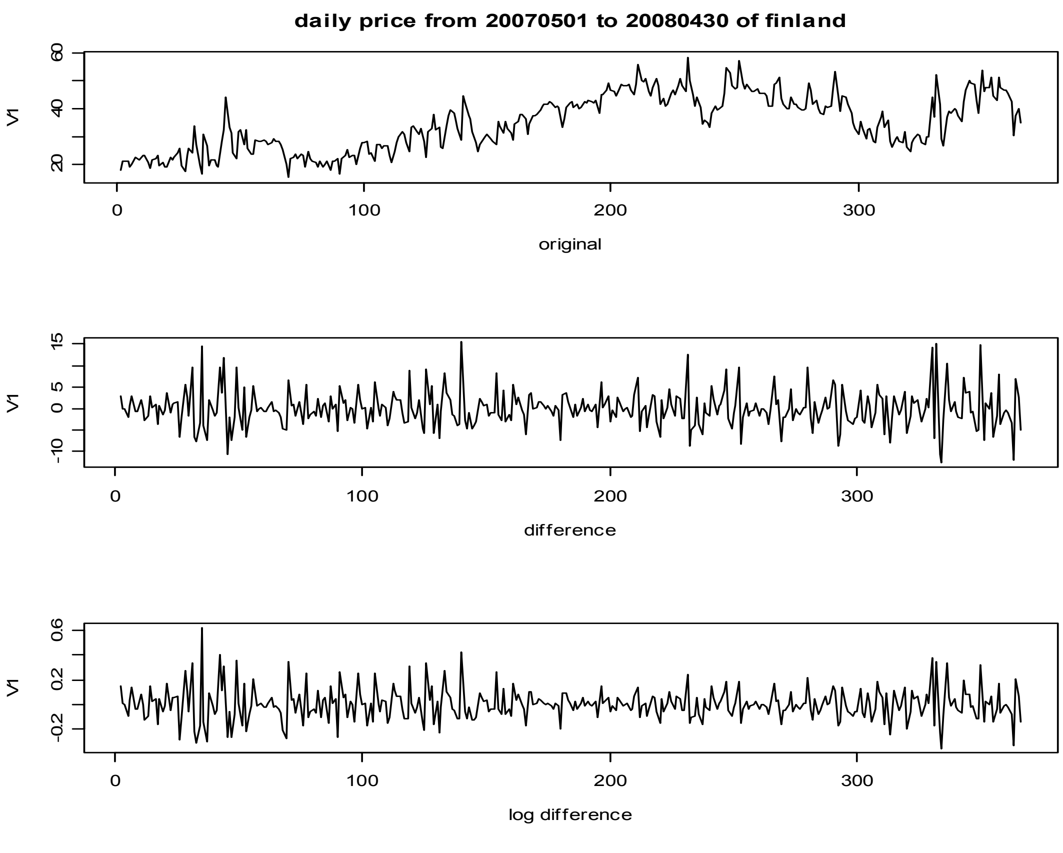

Figure B.5 plot graph of transformed data of Oslo:

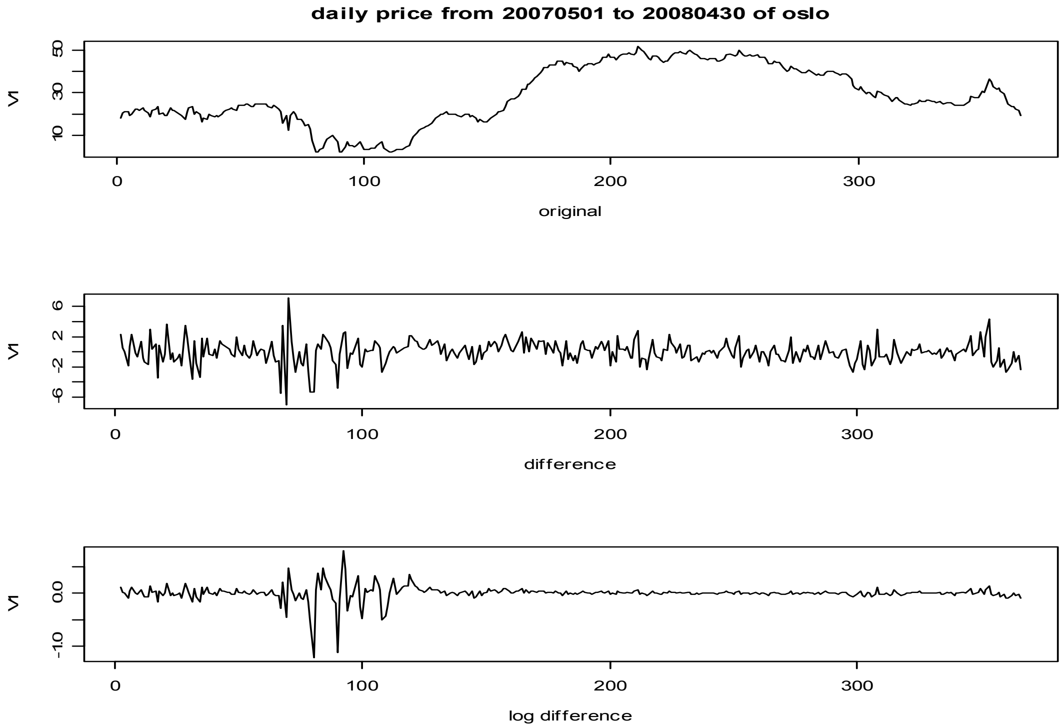

Figure B.6 plot graph of transformed data of trodheim:

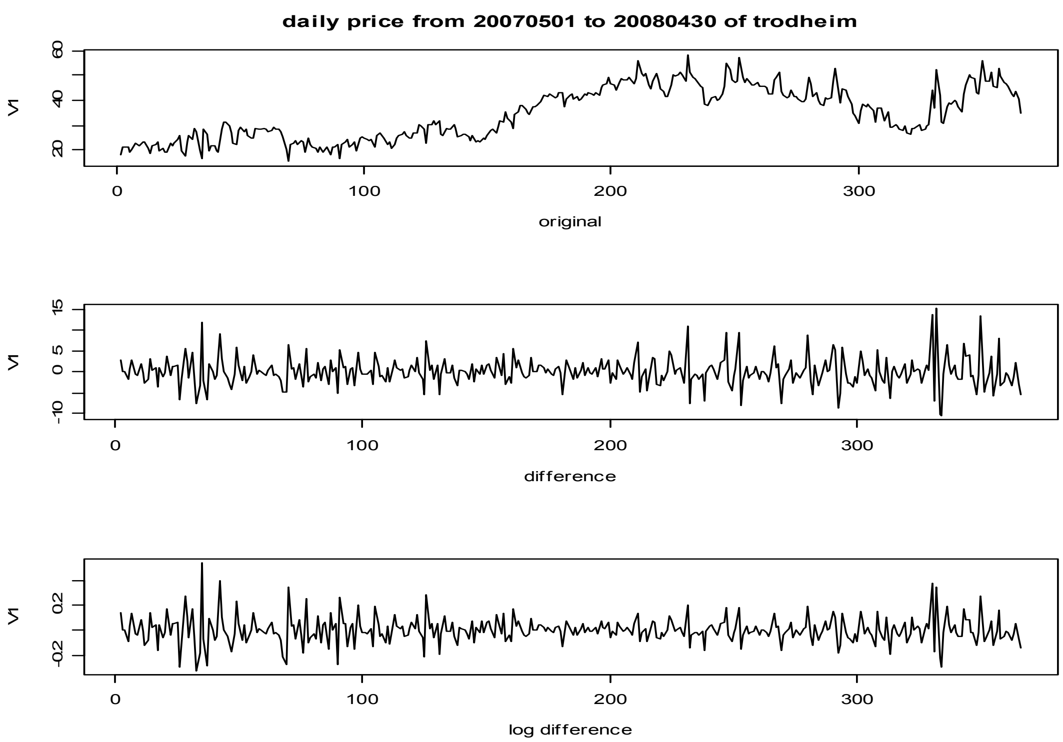

Figure B.7 plot graph of transformed data of Tromso: