MODELLING THE VOLATILITY OF ELECTRICITY SPOT PRICE IN BRAZIL

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Abstract: The Brazilian Electricity Sector faced two reforms in the last decade, in 1996 and 2004. These reforms introduced market mechanisms in the sector, among them a short-term Market. However, they also provoked an incrase in the complexity of princing behaviour. In particular, the volatility of the electricity spot price is the feature that best describes the current Brazilian market. the price of electricity in this market has experienced significant volatility. Thus, the aim of this study is to study the volatility of the electricity spot price in Brazil. We also explain why it is so volatile.

Keywords: Brazilian Electricity Sector – Spot Price - Volatility

JEL: D40 – Q41 – L94

1. INTRODUCTION

Market reforms had important consequences on the electricity sector worldwide. Among these we can mention: the impacts on the organization of the industry, on new forms of investment and transactions in the industry. In this sense, there is a need to develop an electricity spot market to meet some important goals: increase flexibility of transactions; allow adjustments between the contracted power and the energy generated and to be a reference to long-term contracts. Namely, a spot market is an important adjustment mechanism between demand and supply (Newbery, 1998).

As regards to the Brazilian electricity sector, there is a spot market that in fact fulfills some of the goals mentioned above. The spot market tends to adjust the differences between the electricity contracted and the one that was generated/consumed on the basis of the settlement price of the differences (PLD), which can be interpreted as a proxy for the spot price. In recent years, it has been observed a significant increase in the number of free consumers, partly spurred by short-term price, which until 2005 was at relatively low levels. However, from 2005, due to higher economic growth and the consequent strengthening of the relationship between demand and supply, the Price for Differences (PLD, which is the Brazilian spot price for electricity) has suffered significant volatility and unpredictability, making the short-term electricity market environment characterized by a high degree of uncertainty. In fact, the price of energy in various systems tends to demonstrate high degree of volatility in both thermal systems (Mount, 2001; Burger et al. 2004; Newbery, 1998; Silva, 2007) and in hydrothermal systems, which is the case of Brazil (Leite and Santana, 2006; Rodrigues, 2007).

In this sense, one of the biggest concerns of the Brazilian electricity sector agents, particularly those who operate in the free market (ACL), refers to the volatility, of the spot price, from now on PLD. These characteristics represent a significant tariff and financial risk for agents that act in the electric sector (Costa, 2012). Understanding the volatility of spot price is essential to calculate the portfolio risk and return.

So, in this paper I model the PLD in the Brazilian electricity sector. **To achieve this goal, this paper is divided into three parts, in addition to this introduction. The first section presents the theoretical foundations of the formation of spot price in electric power markets. The following section deals with the Brazilian electricity sector. The fourth section examines the PLD and the causes of its volatility. Finally, the conclusions of this work are presented.**

in other to achive the goal of the paper, we used weekly data from 2003 until 2015. The Electricity spot price in Brazil is on a weekly-basis, for the fours submarkets, which are South, Southeast, North and Northeast. We modeled the volatility using ARCH models. And then we did Granger to teste the relationship between prices in different submarkets.

We found that the PLD is a very volatile asset that is very difficult to predict, and this represents a significant risk for firms operating in the Brazilian market. We also found that (GRANGER results)

2. Background

The transition to competitive electricity market has raised new questions as to the most efficient way to ensure new investments in generation facilities. Mechanisms that were appropriate under public monopoly may not be efficient under a competitive industry. According to Muñoz & Bunn, 2007, electricity prices are more volatile than that other goods affected by extreme values. Electricity prices vary seasonally in association with demand, weather patterns, regulation patterns, monopoly power, and other reasons.

2.1 The Brazilian Electricity Industry (BEI)

The Brazilian Electricity Industry (BEI) is a large-scale hydro-thermal system characterized by the presence of large reservoirs, high capital intensity, large interconnections (Leite, 2012)

The main institutional feature of the BEI is the predominance of hierarchy as a governance structure. Until the 1990's, in Brazil, Eletrobras, the State owned holding, was on the top of the hierarchy. Eletrobras controled nearly 90% of supply and was responsible for planning and operating the whole system. This governance structure was created in the 1950's, based on state monopoly. The governance structure became more relevant in the 1970's, when efficiency gains from the interconnection of the system and economic growth resulted in a virtuous cycle, with decreasing short and long run marginal costs. And, the increase in demand was linked to the increase in supply. This was consequence of the centralized coordination of the operation and growth of the electric system (Santana e Oliveira, 1988 and 1999). From March 2004, generators sell energy to distributors only at the regulated contract environment (ACR). But, they can compete with distributors and retailers to sell electricity to free consumers. This is the free contract environment (ACL). The system is operated and coordinated by the National System Operator (ONS), which is a private institution. The shareholders are the generator, transmission, distribution and retail firms. ONS has five directors, and three of them are nominated by MME.

The BEI) has faced in the previous decades two important institutional reforms. In 1996, the BEI was restructured for the first time and the main purpose of this restructuring reform was to introduce competition and enhance investments in the industry. Nearly 80% of the distribution companies and 20% of the generation companies were privatized. Some companies remained state-owned and two (CEMIG and COPEL) were not unbundled. The 2001 supply crisis made clear that investments, both private and public, in electricity had decreased. After 2003, the government designed a new model for the BPS that strengthen the role of the State in the industry.

Though these reforms tried to introduce competition in generation, it is possible to say that the BEI is far from being a competitive market. As Araujo (2001) states, in a hydroelectrical system, like in Brazil, coordination is far more important than competition in energy markets.

The most important features of short-term Brazilian market are: existence of two market operators, with distinct functions. On one hand, the physical system operator, the National System Operator (ONS), is responsible for the coordination and control of the operation of installations for the generation and transmission of electric energy in the national interconnected System, under the supervision and regulation of the National Electric Energy Agency (ANEEL). On the other hand, the electric energy trading Chamber (CCEE) is responsible for transactions of purchase and sale of energy. Figure 1 shows the BPS institutional agents. It's important to notice the importance of the Government in the planning of the industry, and that also includes the methodology to determine prices.

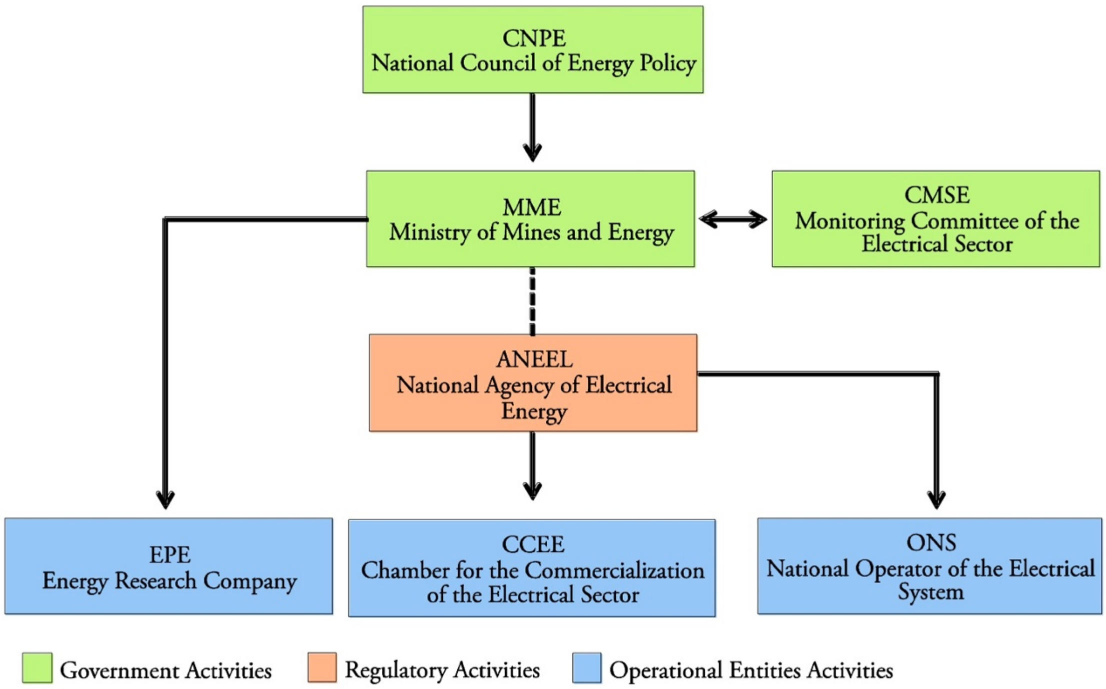


Fig 1. Brazilian Electricity Industry Institutional Agents

Source: (MME, 2013)

2.2 Spot market in Brazil

Unlike other countries, in Brazil there is no electricity market. The short-term electricity price in Brazil is known as Settlement Differences Prices (PLD) and it reflects the difference between what was contracted and what was really consumed . The PLD reflects, in instance, the opportunity costs for short-term electricity

i. For generator, that can sell non-contracted electricity
ii. For consumers, that can buy or sell the differences between what was contracted and what was effectively consumed.

The PLD is not determined by demand and supply, but by a computational program that takes into account the availability of water, for immediate use and for future use.. A balanced operation of the system involves a compromise between depleting (using water) and not depleting (using thermal plants) the reservoirs. The decision variable is the volume of water stored at the end of the operational period (Ferreira et al. 2015). This decision is associated with the Immediate Cost Function (ICF) and the Future Cost Function (FCF), in this case, the cost to use or to stock water in reservoirs.

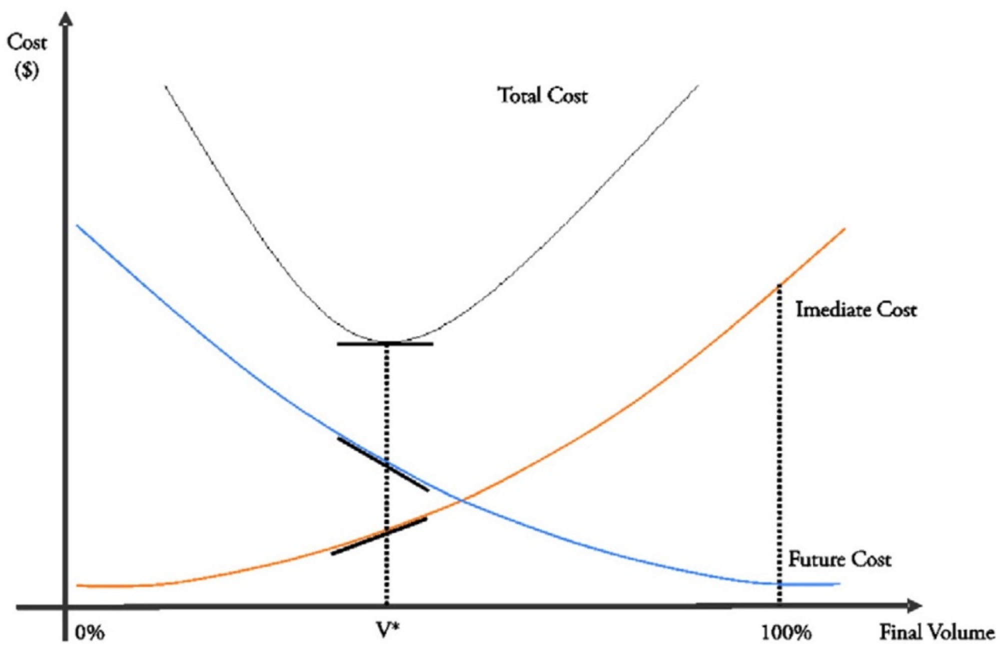


Fig 2 – Price determination in the brazilian electricity spot Market
Source: Silva (2001)

The PLD does not correct economic signal for decision-making of the agents. In periods of low rainfall, the price tends to reach very high levels, and in periods of high rainfall, the price is reduced significantly. The weather, more specifically, the hydrology is the main determinant of both the supply and energy prices in the short term.

The PLD is calculated *ex-ante* on a weekly-basis and it is based on the marginal price model system (PMS), as described in Silva (2001). To reduce computational overhead and to represent their hydrological interdependence, they are aggregated in reservoirs. Four subsystems are then represented by their corresponding shells equivalent, in which the main features are the generating capacity and the flow of energy. The whole market is divided in four submarkets: Southeast and Mid-West; South; Northeast and North.

The National Electric System Operator (ONS) uses two optimization models (Newave, for long run term and Decomp, for the short run term) to determine the minimum cost of operation dispatch (Mendes and Santana, 2003), as shown in figure 3. Also, a stochastic dual dynamic programming models is used to define the profile of generation units for each planning horizon to calculate the marginal cost of short-term operation (CMO) for the four sub-market. The information that are essential for optimal operation are: the prediction of water flows, load profile, network configuration, availability of resources and the generation and transmission planning (Maceira et al., 2001).

3. Methodology

To model the volatility of the PLD, I developed a GARCH model (General Autoregressive conditional heteroscedasticity model). A Garch Model is a useful generalization of the ARCH model developed by Engel (1982) and it was first introduced by Bollerslev (1986). This model is also a weighted average of past squared residuals, but it has declining weights that never go completely to zero. It gives parsimonious models that are easy to estimate and, even in its simplest form, has proven surprisingly successful in predicting conditional variances. It describes volatility clustering and excess kurtosis.

The most widely used GARCH specification asserts that the best predictor of the variance in the next period is a weighted average of the long-run average variance, the variance predicted for this period, and the new information in this period that is captured by the most recent squared residual. Such an updating rule is a simple description of adaptive or learning behavior and can be thought of as Bayesian updating (Engel, 2001)

4. Results and discussion

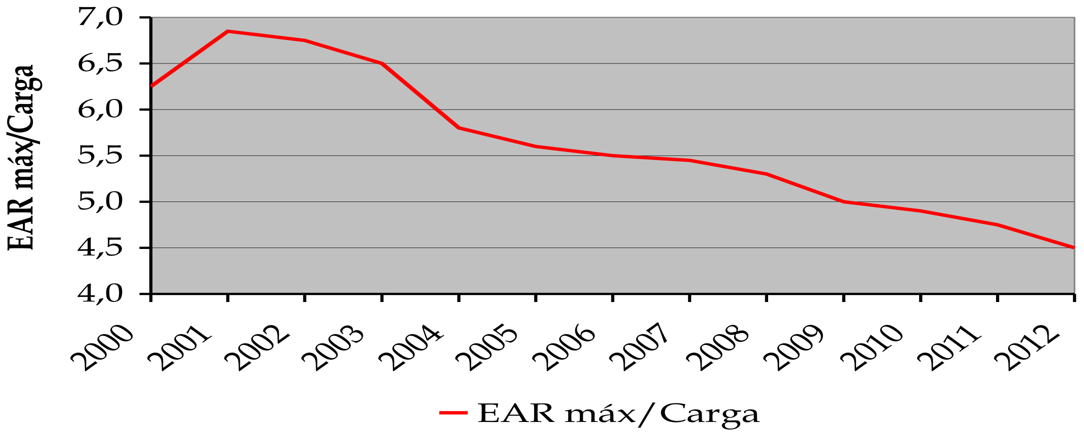
In the case of the Brazilian electricity sector, the price of electricity is a function of the characteristics of the industry, i.e., the availability of water in reservoirs and rain level, thermal transmission constraints, availability and cost of the deficit. In most systems, the hydroelectric energy prices tend to be somewhat volatile in the short term and more volatile in the medium term. This is because, in the short term, there's a transfer energy from low-load hours to the cutting edge by modulating the supply and reducing price volatility. While, in the medium term, the price of energy is more volatile because the hydraulic systems were designed to ensure the supply of electricity in adverse hydrological conditions.

The high volatility is related mainly with the dynamics of inflows. Another problem of the PLD is the fact that it does not take into account the reaction of demand, being just the hydrology-present and future-predicting the price forming. In short, it is a consensus among the various agents in the industry that there is significant volatility of PLD (Rodrigues, 2007; Leite and Santana, 2006).

There are 652 weekly prices. Data.

Figure 1 shows the evolution of the regularization of the reservoirs in Brazil, from 2000 to 2012. Note that when there is a significant decrease in this capacity, measured in terms of stored energy.

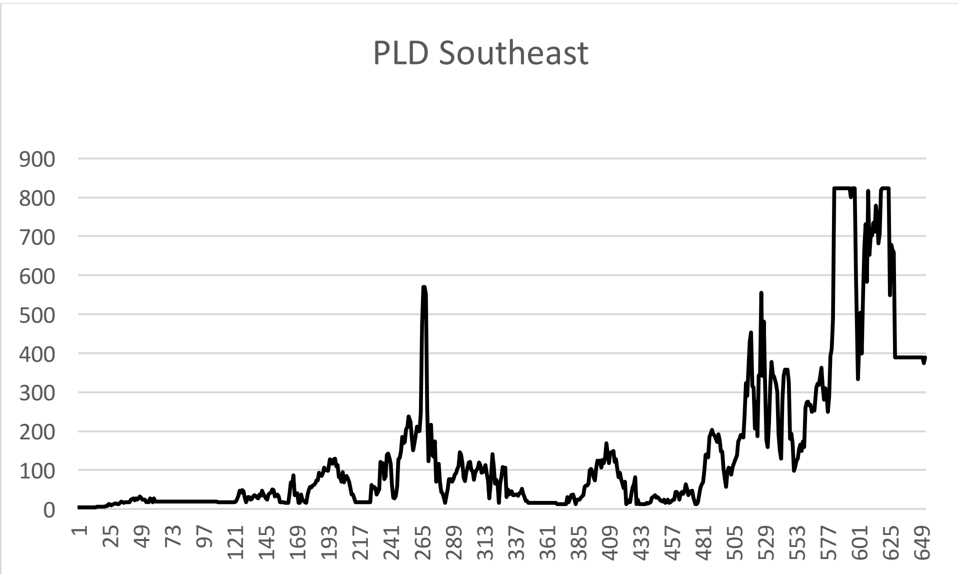
Figure 1 – Capacity of reservoirs regularization



Source: Chipp (2008)

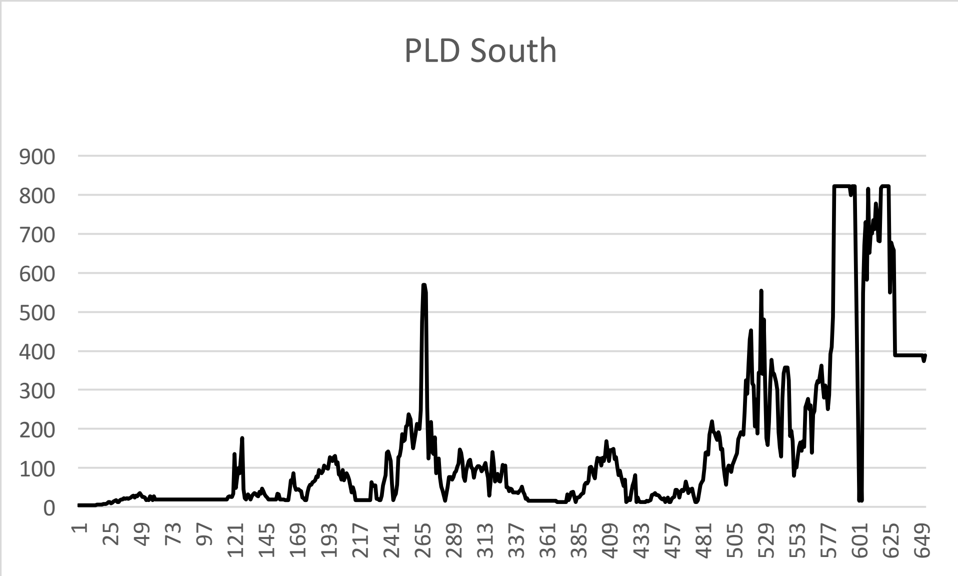
Figures 2, 3, 4 and 5 present, respectively, the historical series of the PLD from January to December 2012 for the four sub-markets. one can notice similar behavior. It is possible to notice that prices changed dramatically throughout the year.

Figure 2 – PLD in the Southeast & Mid West Market



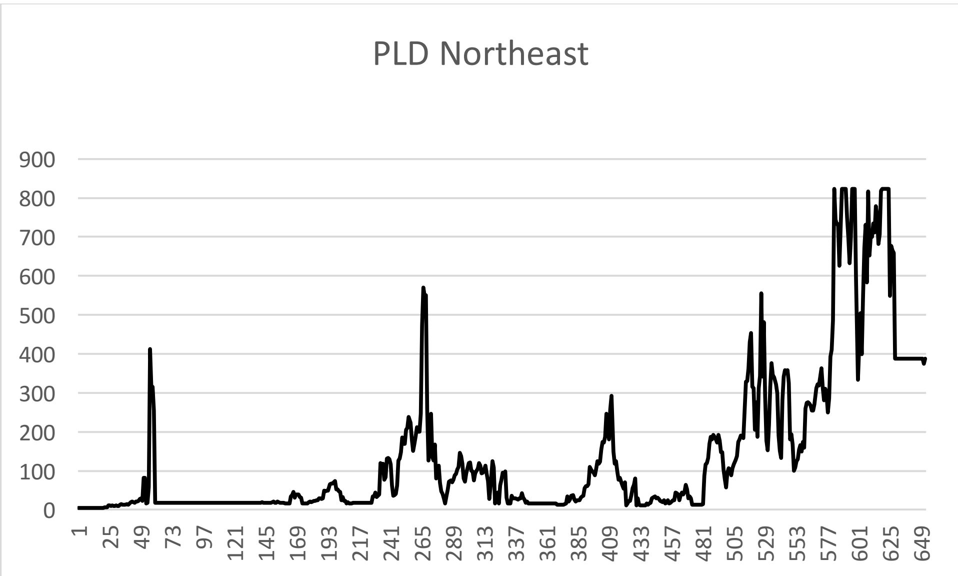
Source: CCEE (http://ccee.org.br)

Figure 2 – PLD in the South Market



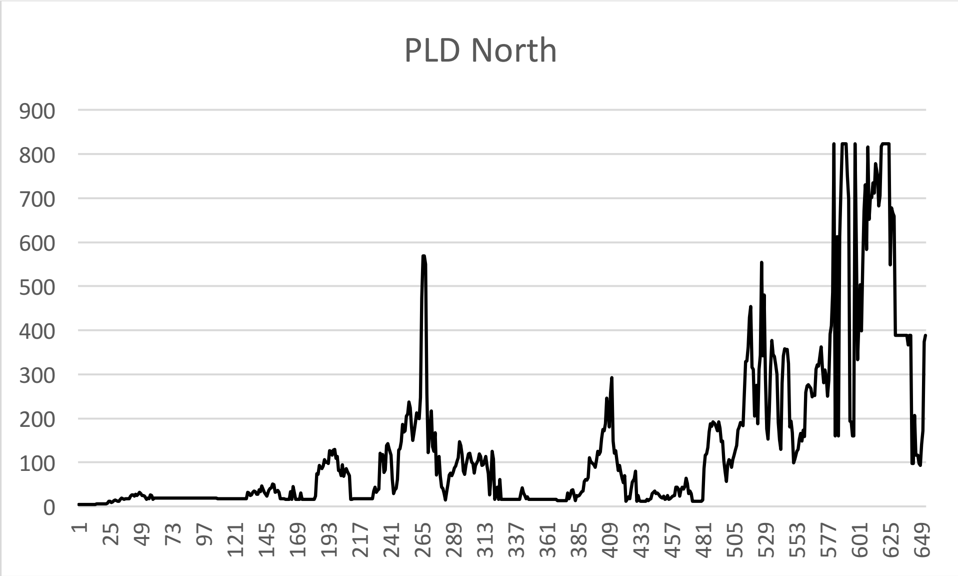
Source: CCEE (http://ccee.org.br)

Figure 3 – PLD in the Northeast Market



Source: CCEE (http://ccee.org.br)

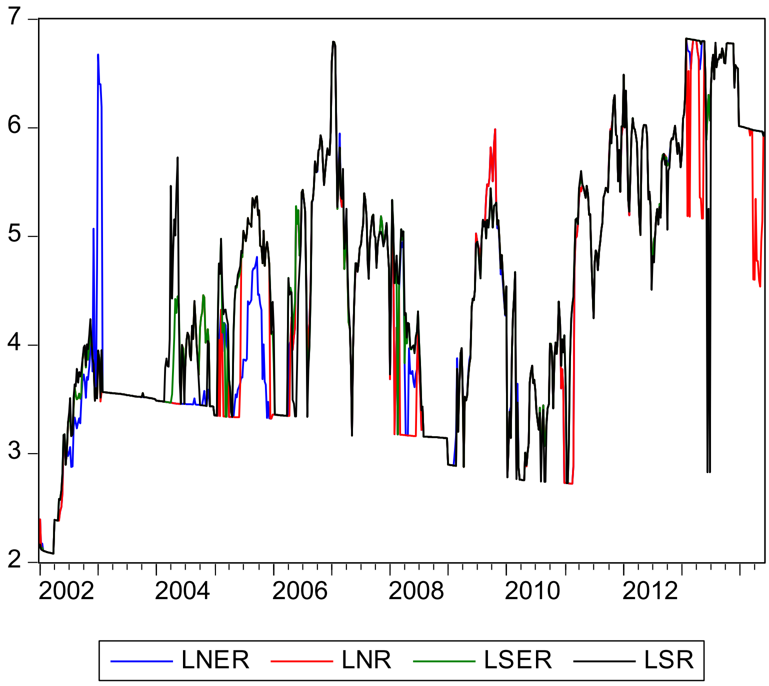
Figure 4 – PLD in the North Market



Source: CCEE (http://ccee.org.br)

Then, I did some correlation tests that found that prices in the four markets are highly correlated, according to table 1, in the appendix. Then I, first, deflationated prices and calculated the logarithm returns of the PLD in the four sub-markets, as its shown in figure 5.

Figure 5 – The PLD in the four sub-markets



Source: data from ons.org.br

The GARCH models showed some interesting results. For the Southeast sub-market the, model that fits the best is Garch (-1,-6). For the other three sub-markets, the best result was Garch (-1), These results are statistically significant and are shown in the appendix.

What they mean is that the PLD in week t is highly correlated with PLD in week t-1, that means that the only way to forecast the PLD is to do so by taking into account the previous week.

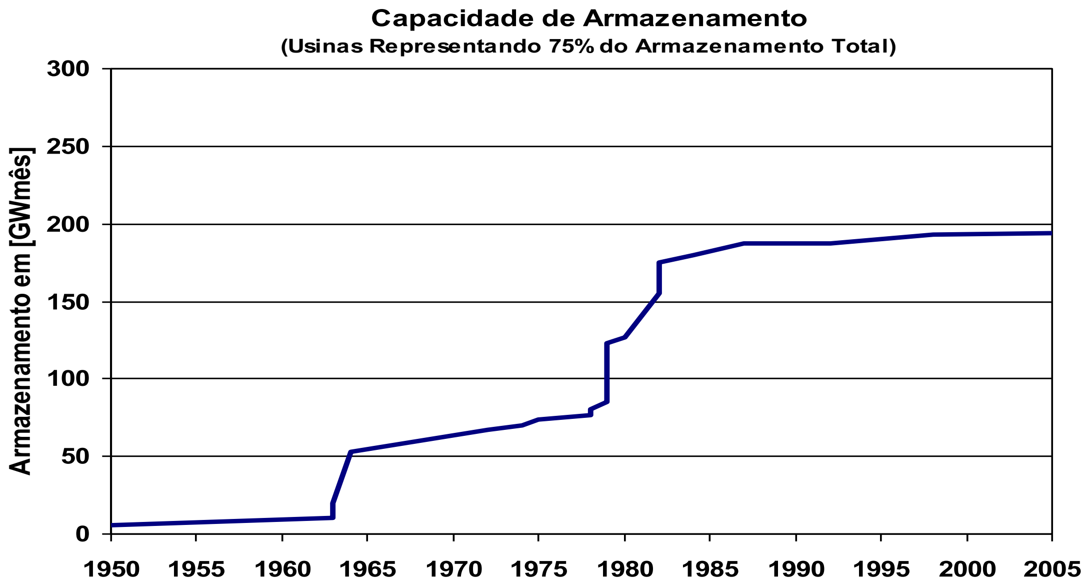
Essentially, there are three causes of such volatility. First, there was, in the period immediately after the energy rationing in 2001, a significant reduction of investments in the expansion of the system.

Another cause is related to the promulgation of the Federal Constitution in 1988, which brought to the fore a greater concern with environmental issues. These issues deal specifically with the consequences of flooding caused by the construction of large reservoirs, which entailed reducing the construction of new reservoirs of hydroelectric plants.

In fact, the hydropower plants built in the last two decades are of the run of the river type. The large reservoirs were used mainly to maintain the security of the system, and provide better control of the production of electricity in dry seasons. With the reduction of the volume of water stored in relation to demand, the volume of electricity generated from water source became more volatile, since it depends on more rainfall. And, this made the operator include more thermal plants in the calculation.

Figure 5 shows the historical series of storage capacity of the reservoirs of hydroelectric power plants in Brazil. Note that, although the industry's installed capacity increase storage capacity is constant, entrant power plants built have low load factor and little storage capacity, which implies greater volatility of the PLD and greater tendency to use thermal plants to generate power in dry seasons.

Figure 5 – Storage capacity of water reservoirs in Brazil



Source: Moreira, 2008

It is estimated that the hydraulic potential yet to be tapped in the country is approximately 126GW. Of this total, approximately 70 lies in the Amazon basin, where lowland rivers predominate and there are no conditions to build large reservoirs, so that the power plants to be auctioned will be the water line. Exclusive the remaining potential not individualized (28,000 MW), the potential in the basin is estimated at 77,058 MW spread over 13 sub-basins, and four of them (Tapajós, Xingu, Madeira and Trumpets) focus almost 90 of this potential. However, according to data from the PNE-2030 (EPE), only 38 of the potential can be classified as still viable without significant environmental constraints (milk, 2009).

The increased participation of the run-of-river hydro plants – wire without seasonal adjustment-will reduce the ability of strategic reserve system and will require greater operational flexibility of existing reservoirs. In addition to requiring increased installed capacity of back-up plants, i.e., flexible thermal, especially during periods of unfavourable hydrology.

Conclusions

This article analyzed the dynamics of the settlement price of the differences (PLD) in the Brazilian Electricity Sector in 2012, with emphasis on the causes and their volatility.

The PLD, corresponding to the spot price, has been very volatile and, by consequence, substantially unpredictable. These characteristics reduce the degree of certainty of the economic agents of the electricity sector to increase considerably the economic and financial risks.

The main cause of this volatility is related to the characteristics of the industry. Approximately, 90% of the energy generated in Brazil comes from hydro plants. The PLD is calculated in an ex-ante weekly basis through stochastic dynamic programming dual models that analyze the current flow and the flow rates in the short, medium and long term. Thus, the PLD is the result of computer models, and by failing to take into account the demand side, the PLD is inadequate and inconsistent signal to signal future investments and provide long-term contracts. In relation to the volatility of the PLD, examined mainly three factors: a shortage of investment in the period pós-racionamento, the end of the construction of new reservoirs and the order of the system operator. It was noted that these elements are interdependent, which implies that there is a trend increasingly explicit, the PLD will become an even more volatile variable, contributing to instability in the Brazilian electricity market.

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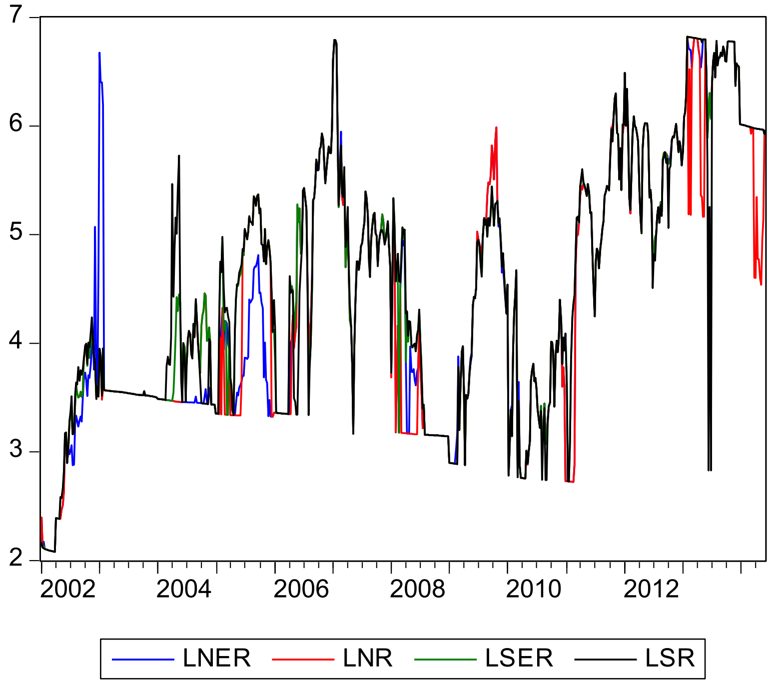
APPENDIX



Covariance Analysis: Ordinary

Table 1 – Correlation among sub-markets

Covariance Analysis: Ordinary
Date: 16/07/15 Time: 11:31
Sample: 28/12/2001 6/06/2014
Included observations: 650

Correlation Probability	LNER	LNR	LSER	LSR
LNER	1.000000 -----			
LNR	0.940957 0.0000	1.000000 -----		
LSER	0.947458 0.0000	0.954561 0.0000	1.000000 -----	
LSR	0.920401 0.0000	0.919891 0.0000	0.970687 0.0000	1.000000 -----

Pairwise Granger Causality Tests
Date: 20/07/15 Time: 15:02
Sample: 28/12/2001 12/06/2014
Lags: 6

Null Hypothesis:	Obs	F-Statistic	Prob.
LNR does not Granger Cause LNER	644	1.41670	0.2056
LNER does not Granger Cause LNR		1.71181	0.1157
LSER does not Granger Cause LNER	644	1.51132	0.1718
LNER does not Granger Cause LSER		1.22566	0.2910
LSR does not Granger Cause LNER	644	0.71946	0.6340
LNER does not Granger Cause LSR		**5.56641**	**1.E-05**
LSER does not Granger Cause LNR	**644**	**3.75030**	**0.0011**
LNR does not Granger Cause LSER		1.10643	0.3569
LSR does not Granger Cause LNR	644	1.58371	0.1493
LNR does not Granger Cause LSR		**6.32313**	**2.E-06**
LSR does not Granger Cause LSER	644	0.61930	0.7150
LSER does not Granger Cause LSR		**10.6559**	**3.E-11**

GARCH for SouthEast Sub-Market

Dependent Variable: LSER
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 20/07/17 Time: 17:00

Sample (adjusted): 8/02/2002 6/06/2014
Included observations: 644 after adjustments
Convergence achieved after 62 iterations
Bollerslev-Wooldridge robust standard errors & covariance
Presample variance: backcast (parameter = 0.7)
GARCH = C(4) + C(5)*RESID(-1)^2 + C(6)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.092202	0.042614	2.163675	0.0305
LSER(-1)	0.926372	0.033200	27.90286	0.0000
LSER(-6)	0.057826	0.031374	1.843113	0.0653
		Variance Equation		
C	0.003817	0.001515	2.519323	0.0118
RESID(-1)^2	0.227719	0.096448	2.361058	0.0182
GARCH(-1)	0.771620	0.072208	10.68608	0.0000

R-squared	0.939851	Mean dependent var	4.546729
Adjusted R-squared	0.939663	S.D. dependent var	1.155099
S.E. of regression	0.283734	Akaike info criterion	0.096178
Sum squared resid	51.60355	Schwarz criterion	0.137802
Log likelihood	-24.96928	Hannan-Quinn criter.	0.112330
F-statistic	2003.165	Durbin-Watson stat	2.043284
Prob(F-statistic)	0.000000		

Heteroskedasticity Test: ARCH

F-statistic	0.017684	Prob. F(1,641)	0.8943
Obs*R-squared	0.017738	Prob. Chi-Square(1)	0.8940

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 20/07/15 Time: 17:01
Sample (adjusted): 15/02/2002 6/06/2014
Included observations: 643 after adjustments
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.004657	0.153537	6.543432	0.0000
WGT_RESID^2(-1)	-0.005253	0.011924	-0.440483	0.6597

R-squared	0.000028	Mean dependent var	0.999405
Adjusted R-squared	-0.001532	S.D. dependent var	3.738483
S.E. of regression	3.741346	Akaike info criterion	5.479874
Sum squared resid	8972.507	Schwarz criterion	5.493765
Log likelihood	-1759.779	Hannan-Quinn criter.	5.485264
F-statistic	0.017684	Durbin-Watson stat	2.000197
Prob(F-statistic)	0.894251		

Dependent Variable: LNER
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 20/07/15 Time: 18:29
Sample (adjusted): 4/01/2002 6/06/2014

Included observations: 649 after adjustments
Convergence achieved after 69 iterations
Bollerslev-Wooldridge robust standard errors & covariance
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.050172	0.028920	1.734867	0.0828
LNER(-1)	0.990295	0.006512	152.0718	0.0000
		Variance Equation		
C	0.002999	0.001570	1.909541	0.0562
RESID(-1)^2	0.407785	0.113292	3.599410	0.0003
GARCH(-1)	0.719423	0.065202	11.03367	0.0000

R-squared	0.932006	Mean dependent var	4.425283
Adjusted R-squared	0.931901	S.D. dependent var	1.227170
S.E. of regression	0.320239	Akaike info criterion	0.103941
Sum squared resid	66.35174	Schwarz criterion	0.138420
Log likelihood	-28.72873	Hannan-Quinn criter.	0.117315
F-statistic	2217.151	Durbin-Watson stat	2.102158
Prob(F-statistic)	0.000000		

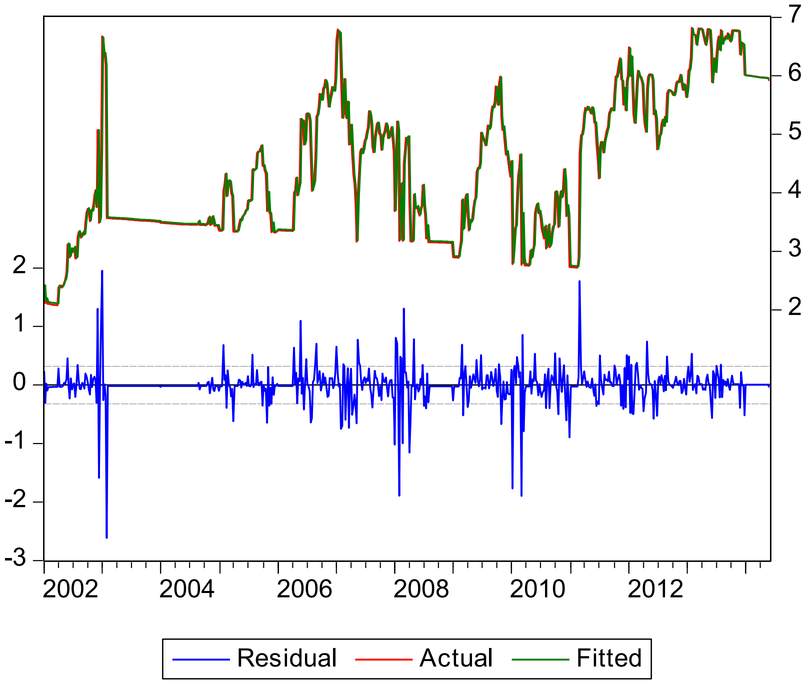
Heteroskedasticity Test: ARCH

F-statistic	0.060510	Prob. F(1,646)	0.8058
Obs*R-squared	0.060692	Prob. Chi-Square(1)	0.8054

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 20/07/15 Time: 18:30
Sample (adjusted): 11/01/2002 6/06/2014
Included observations: 648 after adjustments
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.008247	0.168162	5.995696	0.0000
WGT_RESID^2(-1)	-0.009678	0.011498	-0.841700	0.4003

R-squared	0.000094	Mean dependent var	0.998567
Adjusted R-squared	-0.001454	S.D. dependent var	4.176115
S.E. of regression	4.179151	Akaike info criterion	5.701175
Sum squared resid	11282.58	Schwarz criterion	5.714983
Log likelihood	-1845.181	Hannan-Quinn criter.	5.706531
F-statistic	0.060510	Durbin-Watson stat	2.000557
Prob(F-statistic)	0.805770		



Dependent Variable: LNR
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 20/07/15 Time: 17:15
Sample (adjusted): 4/01/2002 6/06/2014
Included observations: 649 after adjustments
Convergence achieved after 83 iterations
Bollerslev-Wooldridge robust standard errors & covariance
Presample variance: backcast (parameter = 0.7)
GARCH = C(4) + C(5)*RESID(-1)^2 + C(6)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.103194	0.048003	2.149744	0.0316
LNR(-1)	0.733046	0.093853	7.810598	0.0000
LSER(-1)	0.240593	0.093753	2.566246	0.0103
Variance Equation				
C	0.009371	0.004848	1.932996	0.0532
RESID(-1)^2	0.264499	0.082727	3.197235	0.0014
GARCH(-1)	0.705062	0.077644	9.080675	0.0000

R-squared	0.922143	Mean dependent var	4.413663
Adjusted R-squared	0.921902	S.D. dependent var	1.189187
S.E. of regression	0.332330	Akaike info criterion	0.414854
Sum squared resid	71.34640	Schwarz criterion	0.456229
Log likelihood	-128.6201	Hannan-Quinn criter.	0.430904
F-statistic	1530.256	Durbin-Watson stat	2.195965
Prob(F-statistic)	0.000000		

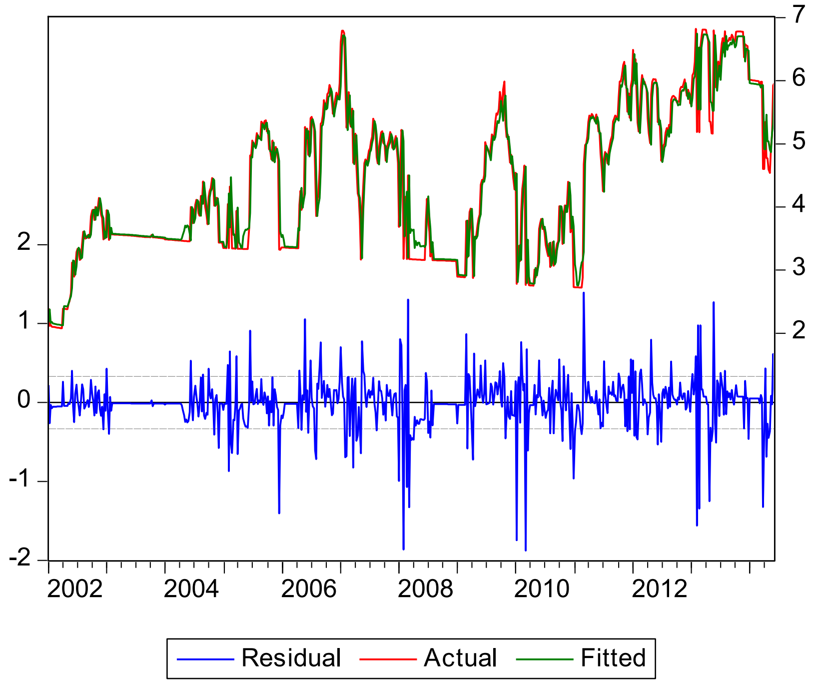
Heteroskedasticity Test: ARCH

F-statistic	0.057092	Prob. F(1,646)	0.8112
Obs*R-squared	0.057263	Prob. Chi-Square(1)	0.8109

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 20/07/15 Time: 17:16
Sample (adjusted): 11/01/2002 6/06/2014
Included observations: 648 after adjustments
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.008291	0.146388	6.887813	0.0000
WGT_RESID^2(-1)	-0.009401	0.013159	-0.714407	0.4752

R-squared	0.000088	Mean dependent var	0.998883
Adjusted R-squared	-0.001459	S.D. dependent var	3.590281
S.E. of regression	3.592900	Akaike info criterion	5.398878
Sum squared resid	8339.168	Schwarz criterion	5.412686
Log likelihood	-1747.236	Hannan-Quinn criter.	5.404235
F-statistic	0.057092	Durbin-Watson stat	2.000377
Prob(F-statistic)	0.811229		



Dependent Variable: LSR
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 20/07/15 Time: 17:34
Sample (adjusted): 4/01/2002 6/06/2014
Included observations: 649 after adjustments

Convergence achieved after 390 iterations
Bollerslev-Wooldridge robust standard errors & covariance
Presample variance: backcast (parameter = 0.7)
GARCH = C(4) + C(5)*RESID(-1)^2 + C(6)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.061870	0.037051	1.669863	0.0949
LSR(-1)	0.746182	0.057784	12.91328	0.0000
LSER(-1)	0.240884	0.058143	4.142968	0.0000
		Variance Equation		
C	0.017330	0.007190	2.410340	0.0159
RESID(-1)^2	0.581401	0.202209	2.875248	0.0040
GARCH(-1)	0.439229	0.113387	3.873706	0.0001

R-squared	0.909377	Mean dependent var	4.518407
Adjusted R-squared	0.909097	S.D. dependent var	1.170934
S.E. of regression	0.353038	Akaike info criterion	0.308867
Sum squared resid	80.51482	Schwarz criterion	0.350242
Log likelihood	-94.22728	Hannan-Quinn criter.	0.324916
F-statistic	1296.494	Durbin-Watson stat	2.338721
Prob(F-statistic)	0.000000		

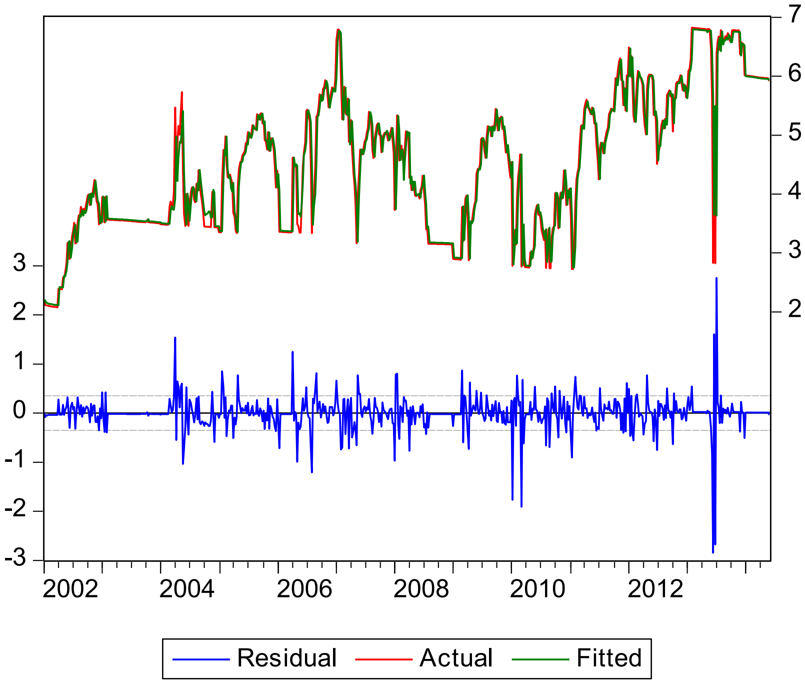
Heteroskedasticity Test: ARCH

F-statistic	0.028364	Prob. F(1,646)	0.8663
Obs*R-squared	0.028450	Prob. Chi-Square(1)	0.8661

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 20/07/15 Time: 17:49
Sample (adjusted): 11/01/2002 6/06/2014
Included observations: 648 after adjustments
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.008057	0.142305	7.083765	0.0000
WGT_RESID^2(-1)	-0.006626	0.019443	-0.340796	0.7334

R-squared	0.000044	Mean dependent var	1.001422
Adjusted R-squared	-0.001504	S.D. dependent var	3.525052
S.E. of regression	3.527702	Akaike info criterion	5.362252
Sum squared resid	8039.266	Schwarz criterion	5.376061
Log likelihood	-1735.370	Hannan-Quinn criter.	5.367609
F-statistic	0.028364	Durbin-Watson stat	2.000488
Prob(F-statistic)	0.866310		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2004
2006
2008
2010
2012
Residual
Actual
Fitted