II International Conference on Industrial Engineering and Industrial Management
XII Congreso de Ingeniería de Organización
September 3-5, 2008, Burgos, Spain

Evaluation of the Efficiency of the Iberian Power Futures Market

Álvaro Capitán Herráiz[1,2], Carlos Rodríguez Monroy[1]

[1] Energy Derivatives División. Spanish Energy Commission (CNE). C/ Alcalá 47, 28014 Madrid.
[2]Department of Industrial Organisation, Business Management, and Statistics. Institute of Technology of Industrial Engineering. Universidad Politécnica de Madrid. C/ José Gutiérrez Abascal, 2 28006 Madrid.
ach@cne.es; crmonroy@etsii.upm.es

Abstract

Market efficiency is analysed for the Iberian Power Futures Market and other European power markets, as well as other fuel markets through evaluation of ex-post Forward Risk Premium. The equilibrium price in OMIP compulsory auctions for distribution companies seems reasonable for remuneration purposes. In the period considered (August 2006 to April 2008), monthly future contracts behave similar as quarterly contracts. Average risk premia has been positive in power markets and negative in fuel markets. Different hypothesis are tested regarding increasing volatility with maturity and regarding Forward Risk Premium correlations (negative with variance and positive with skewness of spot prices). Enlarged data sets are recommended for stronger test results. Energy markets tend to show limited levels of market efficiency.

Key words: Iberian Power Futures Market, Market Efficiency, Forward Risk Premium.

1. Introduction

Since its beginning, on July 2006, the Iberian Power Futures Market managed by OMIP (Iberian Forward Market Operator), within the framework of the Iberian Electricity Market (MIBEL), has experienced a continuous development, in terms of number of participants and liquidity. At this moment, 28 market players participate in OMIP. Almost half of them (12) belongs to Iberian energy incumbents (vertically integrated energy groups with separated generation and distribution companies). Only a couple of members are pure financial agents, still too few. Additionally, only one market maker has been active and only in the period September 2007 – March 2008. The main amount of traded energy in OMIP is still driven by compulsory auctions according to national regulations aimed to foster the MIBEL. The Spanish Distribution Companies and the Portuguese Last Resort Supplier are obliged to purchase in those auctions, in order to partly cover their portfolios of end-user regulated supplies. Such an obligation comprises 5% of their regulated supplies, for the 2^{nd} half of year 2006, as agreed by MIBEL Council of Regulators in Évora Summit (November 2005), and published in the corresponding legislation (Order ITC/2129/2006), and 10% for year 2007 onwards, as agreed in Badajoz Summit (November 2006), and published in Orders ITC/3990/2006 and ITC/1865/2007 (Fernández et al., 2007).

In the second half of 2007 the amount of energy traded in the Continuous Market has gradually grown, with a record in November 2007, though it is still less than the auctioned amounts (since July 2006, the accumulated amount of energy traded in OMIP auctions is 6 times bigger than in the continuous market). Therefore, liquidity of this market is still reduced compared to other European Power Futures Markets.

An analysis of the Efficiency of the Iberian Power Futures Market is done to assess the status quo of this emerging market. In order to perform it, literature review regarding market efficiency is provided. Diverse tests are performed to assess if the price formation in OMIP auctions is satisfactory, and to compare OMIP settlement prices with other European Power Futures Markets and other Fuel Markets. In all these tests, the studied parameter is the ex-post Forward Risk Premium, consisting of the difference between the average settlement price of a future contract and the resulting average spot price during delivery (Furió et al., 2007). The Methodology employed in these tests and their Results are provided in different Sections. Finally, the Conclusions of this study summarise the findings of this research.

2. Literature Review about Market Efficiency

In this chapter, a short literature review of Market Efficiency is provided, focused on energy markets, and especially, in power markets compared to other commodities and financial markets. Market efficiency mainly refers in this context about how well the future price forecasts the spot price.

Cointegration tests as well as tests for measuring if the forward price is an unbiased forecast for cash price for commodity and power markets show that Futures Markets are efficient in the long-term, but not in the short-term, even if risk neutrality is neglected and a risk premium is assumed. In practice, the hypothesis claiming that forward price is an unbiased forecast of future cash price ("Efficient Market Hypothesis") is usually rejected (Engel, 1996).

According to statistics and econometric researchs, many commodity futures markets existing since the middle of the 19th Century are not efficient. Power Markets are considerably younger than Commodity Markets due to the deregulation trend in the 90's. Power Market differs from other markets since electricity storage is quite limited. There are many studies for the US and European Power Markets, analysing the behaviour and interactions of their different regional markets.

Regarding energy markets, Serletis (1992) examines the effects of maturity on future price volatility and trading volume for 129 energy futures contracts traded in NYMEX in the beginning of the 90's. The results provide support for the maturity effect hypothesis, that is, energy futures prices do become more volatile and trading volume increases as futures contracts approach maturity.

Regarding US Power markets, there are many studies comparing different regional markets. Arciniegas et al. (2003) detect that Pennsylvania/New Jersey/Maryland (PJM) Power Market and California Power Market are mored efficient that New York Power Market. Avsar et al. (2001) study market efficiency for PJM and California Power Markets and cannot reject the Efficient Market Hypothesis for the period July 1998-March 1999, but cannot accept it for the whole data period. They find remarkable learning effects from market agents. Additionally, market efficiency is linked to market maturity. In this sense, market players in Power Markets seem to learn faster than in oil markets, for instance, increasing its efficiency with time (Walls, 1999). Bessembinder and Lemmon (2002) consider that electricity cannot be economically stored and therefore, arbitrage-based methods are not applicable for pricing power derivative contracts. They build an equilibrium model implying that the forward power price is a downward biased predictor of the future spot price if expected power demand is low and demand risk is moderate. The equilibrium forward premium increases when either expected demand or demand variance is high, due to positive skewness induced in the spot power price distribution. Optimal forward positions for power producing and retailing firms depend on forecast power demand and on skewness of power prices. Premium in forward power prices is positively related to expected demand, and is large during summer.

Regarding European Power markets, the biggest number of studies exist for Nord Pool, the most developed in Europe since its foundation in 1993 (e.g. Byström, 2003). Byström concludes that traditional simple price hedging models are almost equally efficient as most advanced ones. Therefore, Hedging at Nord Pool (or whatever Power Futures Market) does not request more advanced models than from other financial markets though underlying product features differ noticeably from other financial or commodities products. The researchs regarding European markets are usually focused on the Regional Integration of the Power Markets (e.g., Armstrong and Galli, 2005, or Zachmann, 2005). Armstrong and Galli study European wholesale spot power prices and detect a price convergence between the price differences. Zachmann also finds a price convergence during period 2002-2004 between Dutch and German wholesale power prices but not between East Danish and German prices. He concludes that it is necessary to overcome the bottlenecks in the physical interconnection capacity in order to achieve an integration of the European Power Market.

Conclusions from existing studies measuring the efficiency of Futures Markets vary considerably. Reviewed literature shows no uniformity regarding the results provided by the existing measuring methods. The selected method can slightly bias the results. Additionally, the most advanced models may question previous results from older and simpler models. More advanced models tend to confirm market efficiency but older ones may be prone to reject it. In general, it seems that commodity, energy, and even power markets are not especially efficient (STEM, 2006).

3. Research Methodology

The present research is focused on the analysis of the Forward Risk Premium in the Iberian Power Futures Market comparing different Settlement Price criteria and comparing the magnitudes of such Risk Premium to other European Power Markets and even other Fuel Markets of interest. There are many studies regarding market efficiency based on the evaluation of Forward Risk Premium. Some of those studies are based on theoretical "ex-ante" analysis by modelling forecasted spot prices. Other studies use empirical data and evaluate "ex-post" the differences between the Future and Spot prices. This research represents an empirical analysis using the "ex-post" Forward Risk Premium.

The "ex-ante" Forward Risk Premium ("$\Delta_{ex\text{-}ante}$") can be matematically expressed as follows:

$$\Delta_{ex\text{-}ante} = F_{t,T} - E_t(S_T) \qquad (1)$$

Where $F_{t,T}$ refers to the Future power price observed on day "t" for delivery over period "T", and $E_t(S_T)$ refers to Expected Spot price on day "t" for delivery over period "T".

The "ex-post" Forward Risk Premium ("$\Delta_{ex\text{-}post}$") can be matematically expressed as follows:

$$\Delta_{ex\text{-}post} = F_{t,T} - \text{Average}(S_T) \qquad (2)$$

Where Average(S_T) refers to average spot price for delivery over period T.

In this research, the considered Future contracts are baseload and with monthly and quarterly maturity. Three European Power markets are considered, with all their prices in €/MWh: OMIP (Iberian Market), Powernext (French Market), and Nord Pool (Nordic Market). The fuel markets considered correspond to oil (Intercontinental Exchange (ICE) Brent Futures; only monthly futures are considered, expressed in US$/Bbl), natural gas (ICE Monthly Futures and over the counter (OTC) Quarterly Platts' Assessments, all related to the British National Balancing Point (NBP), and expressed in GB pence/therm), and coal (European Energy Exchange (EEX) Amsterdam-Rotterdam-Antwerp (ARA) Coal Futures, related to the the underlying Argus McCloskey weekly index, expressed in US$/t).

As different monetary units and energy units have been used (original units for each market), Forward Risk Premium expressed in percentage over the Future price is preferred when comparing all these markets. Such an expression is matematically written as follows (Furió et al., 2007):

$$\Delta_{ex\text{-}post\,\%} = [F_{t,T} - \text{Average}(S_T)] / F_{t,T} \qquad (3)$$

The selected period for the study corresponds to the current whole lifespan of OMIP market, which started on 3rd July 2006. Therefore, the monthly contracts span from August 2006 to April 2008, and the quarterly ones from Q4-06 to Q1-08.

3.1. Test 1: Assessment of OMIP Auction Equilibrium Prices

As mentioned in the Introduction, the Spanish Local Distribution Companies (and the Portuguese Last Resort Supplier) are obliged to purchase during the second half of year 2006 the 5% of their regulated power supplies (10% since year 2007). If they do not comply with such obligations, the different national regulations establish different penalties. Due to that fact, the distribution companies have been satisfactorily purchasing their required amounts in all the OMIP auctions. According to the legislation mentioned in the Introduction ("Orders ITC"), the cost of the energy purchased by the Spanish distribution companies in the OMIP auctions is recognised through the resulting equilibrium price of each auction.

Since the start of OMIP, all the Auction settled contracts has experienced positive Forward Risk Premia until October 2007 (Q4-07), when a trend change is appreciated and negative Risk Premia become dominant. Test 1 considers these two different periods in order to assess for each period the cost of the purchased energy by distribution companies, by distinguishing between different reference prices:

- Resulting Auction Equilibrium Price ("F_{eq}"): this is the price recognised to the distribution companies, as stated above.

- Average Future Price for all the quotation period ("F_{all}"): this is the average price of all the Daily Settlement Prices published by OMIP along the whole quotation period of the contract. The algorithm employed by OMIP, based on the traded prices and the bid-ask spread, is described in OMIP Operational Guide. Nonetheless, when OMIP does not rely on the resulting price due to low negotiation of the contract, OMIP consults a Price Committee and the daily price is obtained from representative quotations of the OTC market. Additionally, OMIP often employs the arbitrage criterion between a quarterly contract and their comprised monthly ones, to obtain the settlement prices by using weighted averages among those 4 contracts. This is due to the fact that as other forward market mechanisms coexist with OMIP auctions (Virtual Power Plant auctions, and Last Resort Supply auctions), the most traded contracts in OMIP are the prompt mont and quarterly ones (prompt and those quarterly ones coexisting in the other auctions), being the settlement prices of the least traded contracts obtained through this arbitrage criterion.

- Average Spot price: this is the average price resulting from the Spanish Power Pool day ahead prices. This Power Pool is managed by OMIE.

3.2. Test 2: Analysis of Basis Statistics of Future & Spot Prices

Basic statistics (Average, Median, Maximum, Minimum, Standard Deviation, Asymmetry Coefficient, and Curtosis) for the monthly and quarterly future contracts and their underlying average spot prices are provided in order to compare all the considered markets.

3.3. Test 3: Analysis of $\Delta_{ex\text{-}post\,\%}$ Magnitudes

Assessment of Risk Premium Existence

For all the considered markets, distinguishing between monthly and quarterly future contracts (F_{all}), a t Student Contrast is performed to detect, for each market, if the positive $\Delta_{ex\text{-}post\,\%}$ and the negative $\Delta_{ex\text{-}post\,\%}$ have the same average value (i.e. if the risk premium tends to 0, there would not be evidence of its existence).

Comparison of Futures Behaviour towards Maturity

For all the considered markets, distinguishing between monthly and quarterly future contracts, and per approach to maturity (all quotation period (F_{all}), 3rd last month of quotation (F_{M-3}), 2nd last month of quotation (F_{M-2}), and last month of quotation (F_{M-1})), different magnitudes are compared:

- Assessment of similar behaviour between Monthly and Quarterly Contracts
- Quantitative comparison of $\Delta_{ex\text{-}post\,\%}$ between Monthly and Quarterly Contracts
- Quantitative comparison of $\Delta_{ex\text{-}post\,\%}$ between Periods with positive or negative values
- Correlation between Future Series (F_{all}, F_{M-3}, F_{M-2}, F_{M-1})
- Serletis' hypothesis (1992): "Volatility increases as Futures contracts approach maturity"
- Increasing convergence to spot price (less $\Delta_{ex\text{-}post\,\%}$ in absolute value) with maturity

3.4. Test 4: Bessembinder's & Lemmon's hypothesis compliance

For each future contract type (monthly and quarterly, distinguishing between F_{all}, F_{M-3}, F_{M-2}, F_{M-1}) of the three considered European Power Markets, the following testable hypothesis from

Bessembinder & Lemmon (2002) is checked by using $\Delta_{ex\text{-}post}$: “The Forward Risk premium decreases in the variance of spot prices and increases in the skewness of wholesale prices”. In order to test the hypothesis, linear regression is applied according to:

$$\Delta_{ex\text{-}post} = \alpha + \beta * VAR(S_T) + \gamma * ASIM(S_T) + \varepsilon_T \qquad (4)$$

Where α is a constant, $VAR(S_T)$ reflects the variance of spot prices, $ASIM(S_T)$ represents the non-standardised Asymmetry Coefficient (“skewness”) of spot prices (it is the Asymmetry Coefficient multiplied by cubed Standard Deviation of Spot Prices), and ε_T is an error term.

Good compliance should render negative β , positive γ , and high R^2 values.

4. Results

4.1. Test 1: Assessment of OMIP Auction Equilibrium Prices

Figure 1 shows the evolution of $\Delta_{ex\text{-}post\ \%}$ according to the 3 reference prices stated in the Methodology and the two observed trend periods.

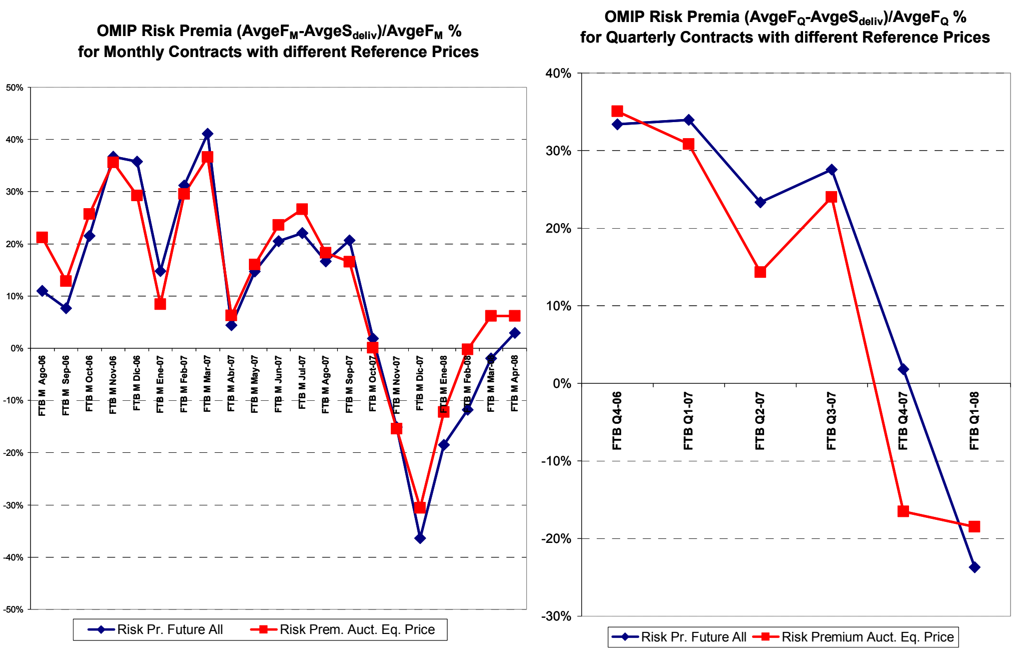

Figure 1. **OMIP Risk Premia in different quotation periods with different Referent Prices**

Table 1 shows the economic results for each period and the total according to the 3 reference prices.

Table 1. Cost assessment of Energy purchased in OMIP Auctions by Spanish Distribution Companies

Costs Assessement of energy purchased in OMIP Auctions by Spanish Distribution Companies				
Period	MWh	€ F_{all}	€ F_{eq}	€ Spot
Jul.06 to Sep.06 (Q4-06 to Q3-07)	9.515.107	**473.027.409**	464.983.170	359.715.922
Oct.07 to Apr.08 (Q4-07 to Q1-08)	8.417.376	**430.513.347**	435.677.742	477.976.766
Total	**17.932.483**	**903.540.757**	**900.660.912**	**837.692.688**

Source: OMIP, OMIE, CNE.

From the Figure 1 and the Table 1 it can be observed that F_{all} provides higher positive and negative values than the official recognised price (F_{eq}). Therefore, the total economic costs do not differ quite much as the extreme values of F_{all} offset the total amount. t-Student Contrasts, separately done for monthly and quarterly futures, show no evidence for assuming same average values for F_{all} and F_{eq}. From the results obtained, the following conclusions can be drawn:

- It seems reasonable to employ F_{eq} as official price for recognising cost to distribution companies, as the total cost is lesser than that of F_{all}.

- The Settlement Price published by OMIP maybe is not so accurate as desired, partly due to low liquidity levels in the continuous market and partly due to possible improvements in its calculation methodology.

- It can be reasonable to continue offering compulsory quantities via OMIP auctions to distribution companies until desired liquidity levels are reached in the continuos markets. At that stage, the Settlement Price published by OMIP should accurately reflect market prices and could be utilised for the calculation of last resort supply costs. Distribution companies would then be able to cover their forward energy needs through OMIP continuous market, not being necessary further compulsory OMIP auctions.

1.1. Test 2: Analysis of Basis Statistics of Future & Spot Prices

Table 2 and 3 show basic statistics for the monthly and quarterly futures prices respectively:

Table 2. Basic Statistics of F_{all} & Spot Prices of Monthly Future Contracts during period Aug.06-Apr.08

	Basic Statistics of Average Reference Prices of Monthly Contracts & Underlying Spot Prices. Period: Aug.06-Apr.08											
	OMIP (€/MWh)		Powernext (€/MWh)		Nord Pool (€/MWh)		NBP (GB p/therm)		Brent (US $/Bbl)		EEX ARA (US $/t)	
	Future	Spot	Future	Spot	Future	Spot	Future	Spot	Future	Spot	Future	Spot
Average	50,23	44,81	53,31	45,32	44,25	35,81	48,05	34,84	63,31	**75,44**	79,73	**92,23**
Median	51,43	38,48	52,69	36,74	46,18	33,43	43,94	30,93	62,60	**71,54**	69,40	**76,78**
Max	61,31	70,22	82,89	88,33	63,17	66,48	**80,08**	61,67	72,15	108,69	123,56	142,53
Min	38,35	29,68	27,87	27,02	23,77	16,53	26,48	16,24	**51,02**	53,91	**62,63**	65,70
Std.Dev.	7,59	11,73	16,40	18,20	13,11	14,39	**16,77**	13,68	4,93	16,18	18,70	28,68
Asymmetry	**-0,29**	0,92	0,20	0,86	**-0,20**	0,67	0,62	0,51	**-0,43**	0,60	1,32	0,74
Curtosis	-1,39	-0,15	-0,93	-0,38	-1,29	-0,33	-0,51	-1,03	1,13	-0,73	0,52	-1,25

Table 3. Basic Statistics of F_{all} & Spot Prices of Quarterly Future Contracts during period Q4.06-Q1.08

	Basic Stats. Avge. Ref. Prices Quarterly Contracts & Underlying Spot Prices. Period: Q4 06 - Q1-08									
	OMIP (€/MWh)		Powernext (€/MWh)		Nord Pool (€/MWh)		NBP (GB p/therm)		EEX ARA (US $/t)	
	Future	Spot	Future	Spot	Future	Spot	Future	Spot	Future	Spot
Average	52,31	43,69	55,83	44,78	40,10	32,42	50,93	33,82	70,70	**92,94**
Median	51,77	38,11	56,61	36,31	38,40	32,32	45,12	30,24	68,81	**79,89**
Max	58,57	65,86	70,06	72,71	**48,72**	44,60	**76,11**	52,94	79,84	137,86
Min	46,57	35,70	41,08	29,35	33,34	19,74	30,36	20,20	**66,14**	67,39
Std.Dev.	4,59	11,74	12,23	18,84	5,98	10,82	**17,93**	13,29	2,65	22,91
Asymmetry	0,22	1,80	**-0,10**	0,86	0,62	**-0,01**	0,57	0,66	1,46	0,89
Curtosis	-1,45	2,98	-2,31	-1,43	-1,25	-2,54	-1,41	-1,40	1,82	-1,35

From the information reflected in the tables, especially the highlighted values in bold letters, the following conclusions can be drawn:

- The same behaviour is detected for monthly and quarterly contracts, except for asymmetry coefficients

- The Average Risk Premia is positive in Power Markets, but negative in Fuel Markets

- Spot markets show bigger volatility and therefore more extreme values (except for gas markets, possibly due to the fact that the future values did not forecast high inventories of Liquefied Natural Gas (LNG) markets)

- Although not reflected in table, similar results (except for asymmetry) are obtained from OMIP F_{eq} as those shown for OMIP F_{all}.

1.2. Test 3: Analysis of $\Delta_{ex\text{-}post\ \%}$ Magnitudes

Assessment of Risk Premium Existence

t Student Contrasts performed for each market (except for EEX ARA Coal where all the risk premia are negative for every month in both monthly and quarterly contracts) render extremely low values rejecting the null hypothesis of no risk premium and therefore showing the existence of positive and negative risk premia.

Comparison of Futures Behaviour towards Maturity

Figure 2 shows the evolution of the Forward Risk Premia (in percentage) for both monthly and quarterly OMIP future contracts, considering the 4 series of future prices: F_{all}, $F_{M\text{-}3}$, $F_{M\text{-}2}$, and last month of quotation $F_{M\text{-}1}$. Figures 3-7 (cf. Annex) show the equivalent information for the rest of considered energy markets in this research.

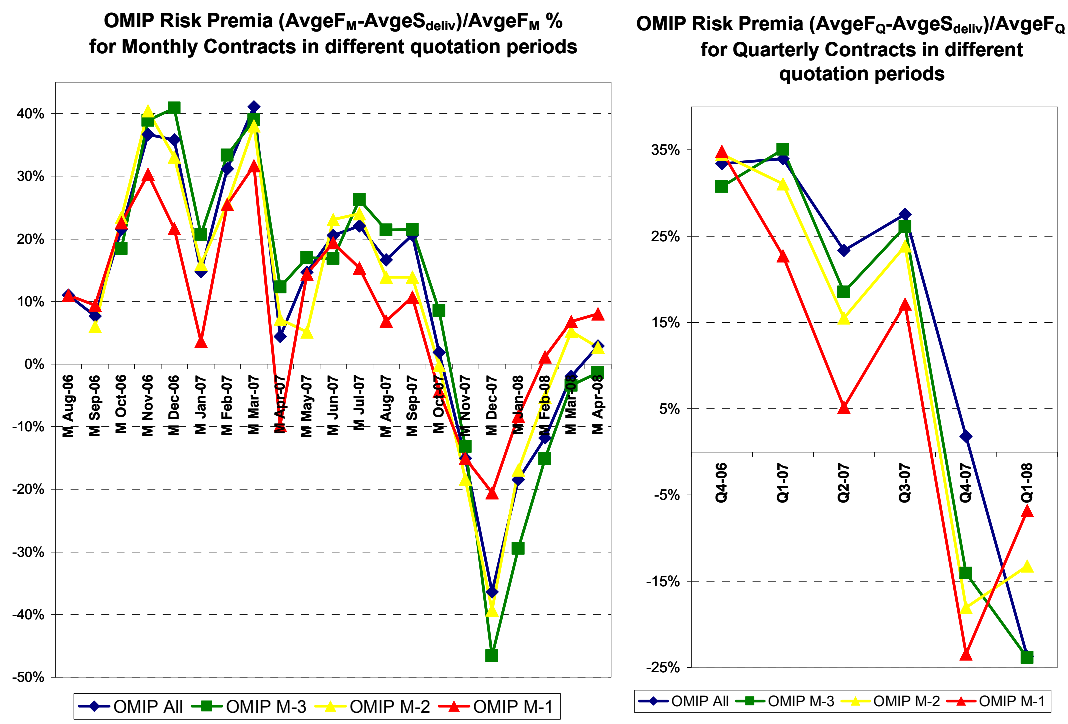

Figure 2. OMIP Risk Premia in different quotation periods with different Referent Prices

By analysing all these charts, various trends are detected. These trends are synthesised in Table 4 (cf. Annex). The following conclusions can be drawn from Table 4 and Figures 2-7:

- Monthly and Quarterly contracts have similar risk premium variation trends coinciding in alternance periods of positive $\Delta_{ex\text{-}post\ \%}$ or negative $\Delta_{ex\text{-}post\ \%}$. In the case of power markets, a trend change ("positive to negative") is produced in autum 2007.

- Variations of $\Delta_{ex\text{-}post\ \%}$ are similar for monthly and quarterly contracts, or slightly higher for monthly contracts. The smallest variations occur for OMIP (around 30%), and the biggest for NBP (around 70%).

- Whereas $\Delta_{ex\text{-}post\ \%.}$ positive is dominant in power markets, $\Delta_{ex\text{-}post\ \%.}$ negative is dominant in fuel markets, supposing inverse hedging strategies and enabling arbitrage opportunities in fossil fuel-fired generation.

- Correlation between Future Series (F_{all}, F_{M-3}, F_{M-2}, F_{M-1}) is not significant, only in Powernext and in EEX ARA Coal. In Power and Gas markets, correlation tends to diminish as futures contracts approach maturity.

- Serletis' maturity effect (increasing volatility) only noticeable in Powernext, EEX ARA Coal and Brent.

- Increasing convergence to spot price (less $\Delta_{ex\text{-}post\ \%}$ in absolute value) with maturity is fulfilled by all time series, as oldest quotation future prices might not be so accurate.

1.3. Test 4: Bessembinder's & Lemmon's hypothesis compliance

Table 5 (cf. Annex) summarises the results of applying multifactor linear regression. The following conclusions can be drawn from Table 5:

- In general, poor compliance for the 3 power markets. No significant differences are obtained between the 4 Futures series considered. In the case of OMIP, similar results are obtained by using F_{eq}. The low compliance may be caused by the limited data set as only 21 monthly contracts and 6 quarterly contracts are considered.

- OMIP is the least compliant market, as for both monthly and quarterly contract, coefficient signs are not right, R^2 results too low, and t tests (significant values for the coefficients) are not satisfactory.

- Powernext monthly contracts are the best compliant of all series, as coefficient signs are right, R^2 renders reasonable level, and t tests are partly satisfactory.

- Nord Pool quarterly contracts comply better than monthly ones, as R^2 is high for F_{all} and F_{M-1}, and t tests are partly satisfactory.

2. Conclusions

Market efficiency is analysed for the Iberian Power Futures Markets and other European power markets (Powernext and Nord Pool) and fuel markets (Brent, NBP and EEX ARA Coal) through evaluation of ex-post Forward Risk Premium. The equilibrium price in OMIP compulsory auctions for distribution companies seems reasonable for remuneration purposes as the purchasing costs for regulated supplies tend to be lower than those from OMIP settlement prices. Once OMIP has more liquidity, the settlement price would reflect more accurately the market prices and could be used for evaluating the cost of last supply resources.

In the period considered (August 2006 to April 2008), monthly future contracts behave similar as quarterly contracts and average risk premia has been positive in power markets (especially until Q4-07) but negative in fuel markets. The Forward Risk Premium for a future contract tends to diminish as it approaches maturity. The limited considered data for each market (21 monthly contracts and 6 quarterly contracts) show low compliance with testable hypothesis regarding increasing volatility with maturity, and regarding Forward Risk Premium correlations (negative with variance of spot prices, and positive with skewness of spot prices). Further research is proposed considering an enlarged data set to better test those hypotheses and draw additional conclusions. In general, it can be concluded that none of the considered markets present remarkable levels of market efficiency.

Acknoledgements

We are very grateful to Pablo Villaplana, Vice Director of the Energy Derivatives Division at the Spanish Energy Commission, who has provided us with very valuable insights for conducting this research.

References

Armstrong, M.; Galli, A. (2005). "Are day-ahead prices for electricity converging in Continental Europe? An exploratory data approach". *CERNA Working Paper*.

Avsar; Gulay, S.; Goss; Barry, A. (2001). "Forecast Errors and Efficiency in the US Electricity Futures Market". *Australian Economic Papers*, 40(4):479-499.

Bessembinder, H.; Lemmon, M.L. (2002). "Equilibrium Pricing and Optimal Hedging in Electricity Forward Markets". *The Journal of Finance*, LVII(3):1347-1382.

Byström, H. (2003). *Hedging perdormance of electricity futures on the Nordic Power Exchange*.

Engel, C. (1996). "The forward discount anomaly and the risk premium: A survey of recent evidence". *Journal of Empirical Finance*, 3(2):123-192.

Fernández, E.; Xiberta, J. (2007). "Restructuring and generation of electrical energy in the Iberian Peninsula". *Energy Policy*, 35:5117-5129.

Furió, D.; Meneu, V. (2007). "Analysis of the forward risk premium in the Spanish Electricity Market". *Valencia University Working Paper*.

Serletis, A. (1992). "Maturity Effects in Energy Futures". *Energy Economics*, 14(2):150-157.

STEM, Sveriges Energimyndigheten (2006). Finansiella elmarknaden. Bilaga 5 Översikt av den vetenskapliga litteraturen.

Walls, W. (1999). "Volatility, Volume and Maturity in Electricity Futures". *Applied Financial Economics*, 9(3):283-287.

Zachmann, G. (2005). "Convergence of Electricity Wholesale Prices in Europe? A Kalman Filter Approach". *DIW Discussion Paper 512*.