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Valuing interconnector transmission rights – do auction prices reflect option values?

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Valuing interconnector transmission rights – do auction prices reflect option values?

- Despite the ambitions of market coupling, Interconnector arrangements between separate markets remain commonplace
- Efficiency of Interconnector auction prices is often analysed as the arbitrage values across the two energy markets
- But Interconnector transmission rights convey the right to trade power between spot markets, and as such may represent spread options on the subsequent spot energy prices.
- Empirical data for power trading across the Moyle Interconnector between the separate markets of Ireland and Britain are analysed to test
 - if interconnector access prices exhibit arbitrage or option-like characteristics
 - if auction prices are undervalued vis-à-vis their option value
 - the impact of high wind penetration on access prices

Context

- EU legislation is driving European market integration
- Valuation of transmission rights has significant implications for market efficiency and price convergence in regional power markets
- High wind penetration has significant implications for valuation and use of transmission access rights
- Observations in this analysis:
 - Auction prices for transmission rights between Ireland and the GB appear to be undervalued
 - Significant power flows against price spread
 - Exports not correlated with high wind output in Ireland

Ireland / GB Interconnection

- Ireland is currently connected to Scotland via the Moyle inter-connector:
 - Import capacity of 450 MW in Winter and 400 MW in summer
 - Export capacity 295mw (since Feb 2011, previously 80 MW)
- A new 500 MW EWIC is being built by, Eirgrid and will run from Dublin to Liverpool to be completed in 2012
- Increased levels of wind penetration creates intermittency which will further increase price volatility and hence option value of transmission rights
- Irish electricity market is approximately 1/10 size of GB market with approx. 2GW wind installed

Related Research

- Universal agreement in literature on benefits of integration facilitated by increased level of interconnection, (Hobbs, 2005, Cornwall, 2008, Malaguzzi, 2009):
 - Increased competition
 - Lower prices
 - Lower reserve requirements
- Malaguzzi (2009) estimates prices were 40% lower in GB in 2005
- So, increased levels of interconnection should reduce prices for Irish consumers

Related Research

- The literature on valuing IC transmission rights is developing:
 - Bunn and Martoccia (2010), Bunn and Zachmann (2010), Kristiansen (2007)
 - Cartea and Gonzalez-Pedraz (2010) derive the value of a one year lease in five pairs of European markets using a *strip of European-style Bull-Call Spreads on the power price spread between the markets*. This is a similar methodology to Rosenberg et al (2010)
- The Cartea and Gonzalez-Pedraz (2010) approach is used to value the option to trade power on the Moyle IC

Overview of SEM and BETTA Markets

| | SEM | BETTA |
|--------------------------|---|---|
| Market Type | Mandatory pool (except for de-minimis generators of less than 10 MW) | Bilateral market OTC and exchange - only 2% of trades through Balancing Mechanism |
| Market payments | Energy + capacity payment | Energy only |
| Dispatch | By System Operator | Self-dispatch |
| Price Settlement | D+4 days | Majority of trade is bilateral. SSP and SBP prices published 15 minutes after settlement period |
| Price caps | Yes €1,000 / MWhr | No |
| Forward / futures market | Limited – Contract for Difference Auctions to reduce ESB market power auctioned quarterly No non-physical traders in market | Forward market On exchanges, standard forward contract is 50MW in four hour blocks. Traders add liquidity and exploit arbitrage opportunities |

Data

- The sample consists of 1,036 days of data from 1 Nov 2007 to 1 Sep, 2010. Prices are half hourly so the dataset consists of 49,728 data points.
- Data for Irish electricity prices and capacity payments come from the Single Electricity Market (SEM) Operator (SEMO) www.sem-o.com.
- Electricity prices for the British Electricity Transmission and Trading Arrangements (BETTA) are from DataStream (UKPX) and exchange rates are from DataStream.
- Auction prices for Moyle interconnector transmission rights come from the Northern Ireland Transmission System Operator (TSO) www.soni.ltd.uk.
- Data for physical power flows over the Moyle IC were provided by the SEMO Helpdesk.
- Transaction costs – various sources

Transmission Rights Auctions

- To trade on the Moyle IC, participants must first book capacity on IC and then trade their power in a separate transaction
- Capacity is currently auctioned monthly on yearly and monthly basis for 5 MW capacity tranches
 - No daily auctions for non-standard contracts
 - Auctions are generally undersubscribed
- Unsold capacity is available on the day in a bilateral trade with the Moyle IC itself but availability cannot be guaranteed

Transmission Access Costs in (£/MW month)

| Access Month | Auction Date | | Monthly Auction data | | | |
|--------------|--------------|------------|----------------------|---------|-------------|---------|
| | | | Export | | Import | |
| | | | £/ MW month | MW Sold | £/ MW month | MW Sold |
| Nov | 2007 | 25/10/2007 | £500 | 5 | £5,156 | 50 |
| Dec | 2007 | 23/11/2007 | £2,095 | 45 | £0 | 0 |
| Jan | 2008 | 19/12/2007 | £502 | 10 | £2,013 | 20 |
| Feb | 2008 | 25/01/2008 | £0 | 0 | £2,013 | 20 |
| Mar | 2008 | 22/02/2008 | £0 | 0 | £501 | 40 |
| Apr | 2008 | 26/03/2008 | £0 | 0 | £662 | 130 |
| May | 2008 | 25/04/2008 | £0 | 0 | £502 | 130 |
| June | 2008 | 23/05/2008 | £0 | 0 | £502 | 100 |
| Jul | 2008 | 25/06/2008 | £0 | 0 | £0 | 0 |
| Aug | 2008 | 25/07/2008 | £0 | 0 | £0 | 0 |
| Sep | 2008 | 26/08/2008 | £0 | 0 | £0 | 0 |
| Oct | 2008 | 25/09/2008 | £702 | 75 | £0 | 0 |
| Nov | 2008 | 24/10/2008 | £1,458 | 80 | £0 | 0 |
| Dec | 2008 | 24/11/2008 | £1,100 | 80 | £388 | 100 |
| Jan | 2009 | 22/12/2008 | £1,529 | 40 | £200 | 180 |
| Feb | 2009 | 26/01/2009 | £750 | 80 | £300 | 230 |
| Mar | 2009 | 23/02/2009 | £450 | 80 | £353 | 285 |
| Apr | 2009 | 25/03/2009 | £450 | 80 | £800 | 190 |
| May | 2009 | 24/04/2009 | £0 | 0 | £820 | 195 |
| June | 2009 | 22/05/2009 | £0 | 0 | £956 | 195 |
| Jul | 2009 | 24/06/2009 | £100 | 80 | £1,260 | 195 |
| Aug | 2009 | 24/07/2009 | £0 | 0 | £2,253 | 195 |
| Sep | 2009 | 24/08/2009 | £0 | 0 | £2,402 | 195 |
| Oct | 2009 | 24/09/2009 | £0 | 0 | £1,000 | 60 |
| Nov | 2009 | 23/10/2009 | £0 | 0 | £1,800 | 100 |
| Dec | 2009 | 24/11/2009 | £0 | 0 | £2,083 | 100 |
| Jan | 2010 | 21/12/2009 | -£744 | 80 | £2,300 | 100 |
| Feb | 2010 | 25/01/2010 | -£744 | 80 | £2,350 | 100 |
| Mar | 2010 | 22/02/2010 | -£744 | 80 | £2,449 | 100 |
| Apr | 2010 | 24/03/2010 | -£744 | 80 | £2,423 | 110 |
| May | 2010 | 23/04/2010 | £0 | 0 | £2,640 | 110 |
| June | 2010 | 24/05/2010 | -£756 | 80 | £2,985 | 110 |
| Jul | 2010 | 24/06/2010 | -£818 | 80 | £3,686 | 110 |
| Aug | 2010 | 23/07/2010 | -£818 | 80 | £3,455 | 110 |
| Sep | 2010 | 24/08/2010 | £0 | 0 | £3,333 | 110 |

Are arbitrage profits equal to zero?

- The monthly cost of import capacity is compared to the sum of the cumulative import spreads of Irish over GB prices for 1MW of power in 1,440 periods (30 trading days x 48 trading periods per day)
- The spread is truncated at zero as the holder of the option would not trade the spread if the spread were negative as this would result in a loss
- If IC prices correctly anticipate energy spreads, then the premium of cumulative monthly spreads over actual month's auction prices should be zero
- If the sum of spreads is greater than zero then there are "excess profits" to be made from trading the IC

Are arbitrage profits equal to zero?

- There is significant support for the hypothesis that IC auction prices undervalue the arbitrage profit potential in the energy spread for both import and export capacity
- *The premium of arbitrage profits less auction costs is positive for both imports and exports in each month with average monthly arbitrage profits spreads of €16,957 and €4,490 for import and export transmission rights respectively*
- We conclude that arbitrage profits exist from trading the interconnector and hence auctions for IC capacity are ***underpriced***

Do auction prices undervalued their option values?

Following Cartea and Gonzalez-Pedraz (2010), the spread option is based on the following formula:

$$V_M = \sum_{i=1}^N e^{-r(T_i-t)} \text{Max}(S^{UKIrl}(i) - K^{UKIrl}(i), 0)$$
$$V_X = \sum_{i=1}^N e^{-r(T_i-t)} \text{Max}(S^{IrlUK}(i) - K^{IrlUK}(i), 0)$$

Where:

V_M = the value of the import spread

V_X = the value of the export spread

$N = 1,440$ (based on days in month times half hourly trading periods, typically 48×30)

$T_i - t$ = time to i^{th} payoff

r = risk free rate of return

S^{UKIrl} = is the spread in the import direction UK to Ireland (truncated for positive spreads only)

S^{IrlUK} = is the spread in the export direction Ireland to UK (truncated for positive spreads only)

K^{UKIrl} = transaction costs for importing power to Ireland

K^{IrlUK} = transaction costs for exporting power to the UK

Regression of Option Value Explaining Auction Costs

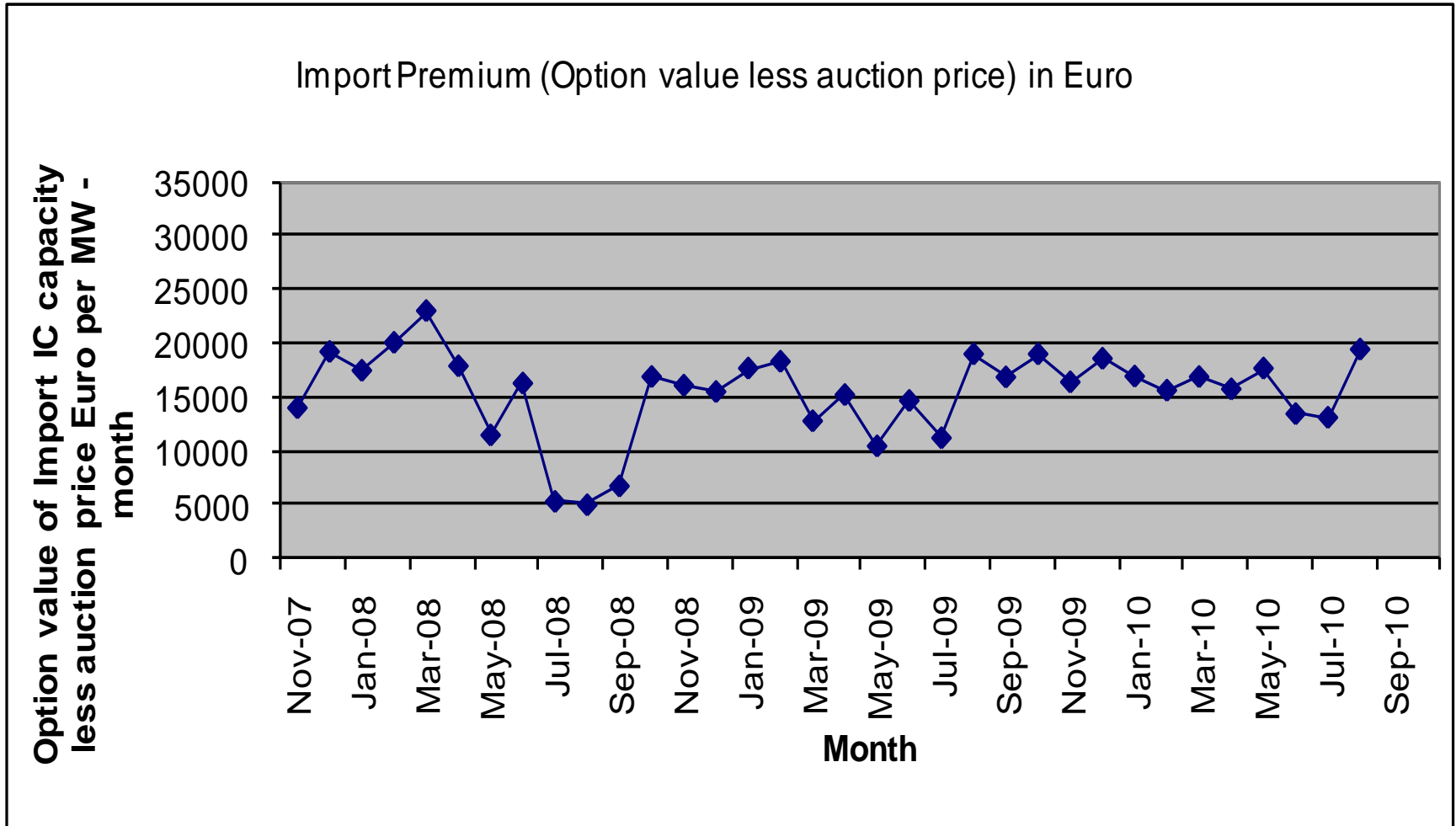
Imports

| Independent variables | R-squared | Coefficient | p-value |
|---|-----------|-------------|---------|
| <i>SMP+4 Prices (2007-2010) (Actual – month on month)</i> | 26.24% | .18352 | .001954 |
| <i>SMP+4 Prices (2007-2010) (Option values in t-12 (this month last year) predicting auction costs in time t)</i> | 13.53% | -.09317 | .09219 |
| <i>SMP+4 Prices (2007-2010) (Option values in t-1(previous month) predicting auction costs in time t)</i> | 14.09% | .1105 | .03136 |

Exports

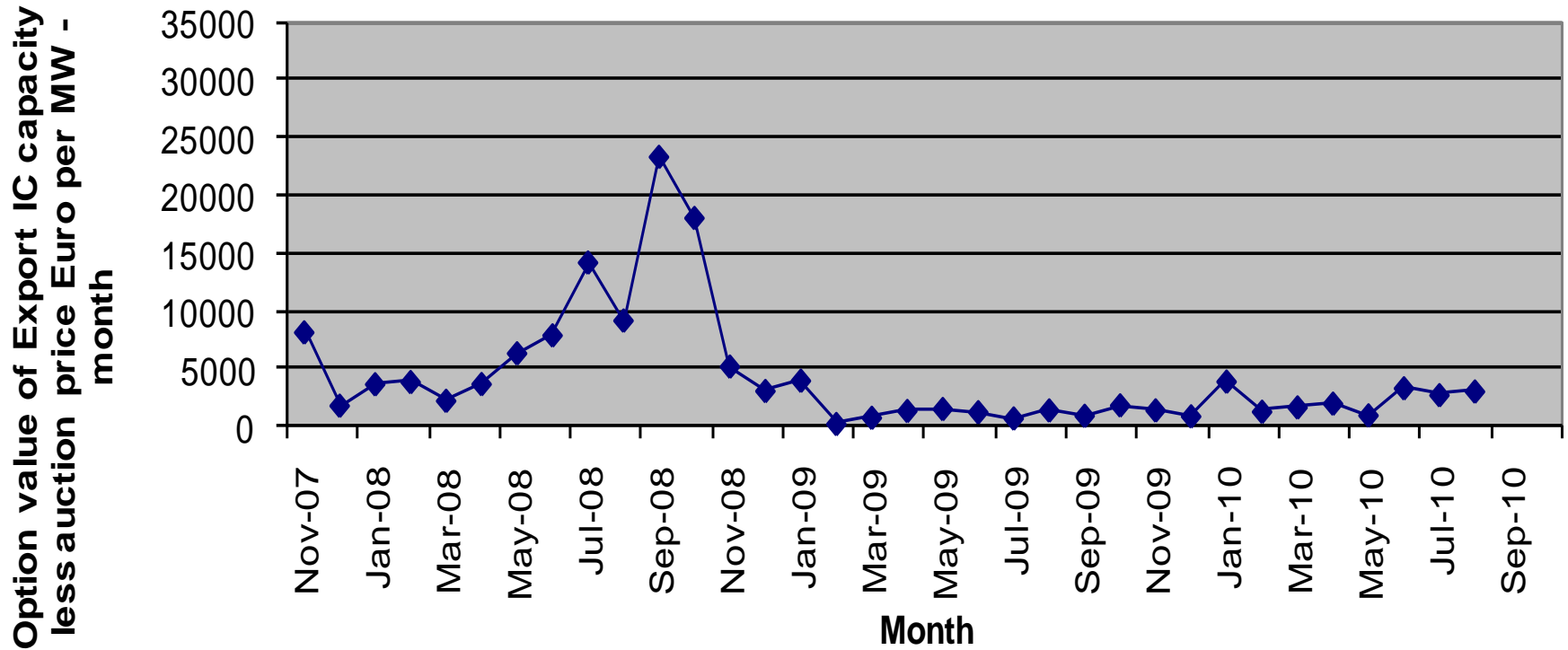
| Independent variables | R-squared | Coefficient | p-value |
|---|-----------|-------------|---------|
| <i>SMP+4 Prices (2007-2010) (Actual – month on month)</i> | 5.47% | .03764 | .18317 |
| <i>SMP+4 Prices (2007-2010) (Option values in t-12 (this month last year) predicting auction costs in time t)</i> | 4.92% | .03080 | .32104 |
| <i>SMP+4 Prices (2007-2010) (Option values in t-1(previous month) predicting auction costs in time t)</i> | 26.23% | .08216 | .002311 |

Premium of option value over auction prices



Premium of option value over auction prices

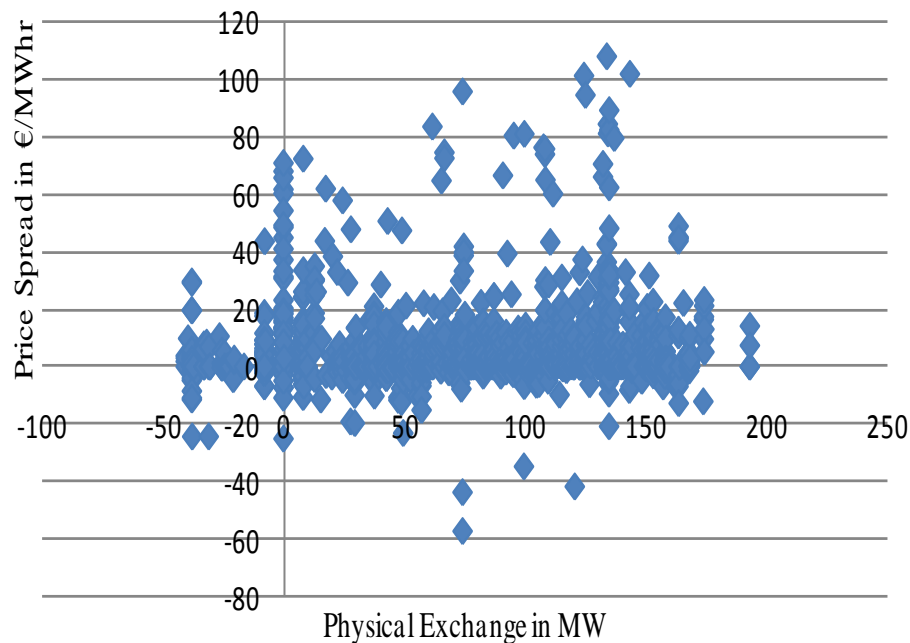
Export Premium (Option value less auction price) in Euro



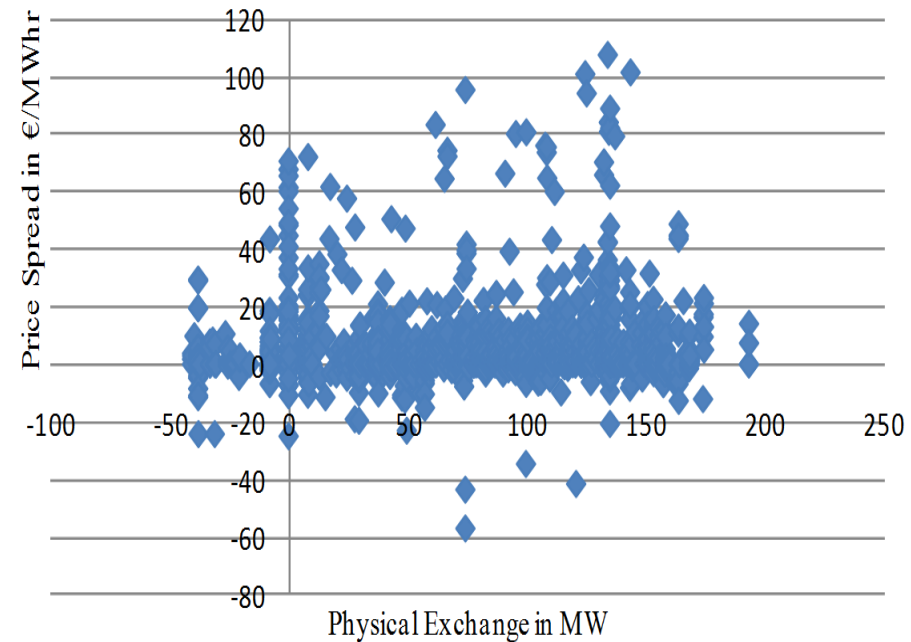
Power flows and price spreads

Weak correlation coefficients of 0.06 and 0.17 respectively in off-peak and peak hours

Physical Power Flows versus Price Spread in hour 3.00



Physical Power Flows versus Price Spread in hour 17.00



Maximum export capacity is 295 MW and maximum import capacity is 410 MW in summer and 450 MW in winter. The graphs shows that IC capacity is not being fully utilised even when there is a significant price spread.

Power flow and Efficiency

- The analysis of actual power flows showed:
 - Imports 84.38% of the time
 - Exports 12.17% of the time
 - No power flows 3.45% of the time
- An analysis of price spreads and transaction costs suggests that it would have been economic to:
 - Import 58.16% of the time
 - Export 20.15% of the time
 - 21.69% of the time it would have been uneconomic to trade the IC because transaction costs including physical losses were greater than the price spread.

Welfare Loss to Electricity Consumers

- To quantify the value loss to Irish consumers an “inefficiency indicator” is calculated as in Bunn and Zachmann (2010)
- This is calculated as the product of the price spread in the profitable direction times the difference between the total capacity and actual power flows in the profitable direction
- Based on this methodology, the total value of welfare loss for electricity consumers in the 34 months of this analysis is €195 million. Given the power flows are largely in the import direction the majority of these losses accrue to Irish electricity consumers

Market Integration Issues

1. Market misalignment between SEM and BETTA
 - Gate closure, lack of day ahead market in SEM
 - SEM pricing is ex post D+4
 - Aligning energy only and energy+ capacity markets
2. Availability and cost of IC capacity
 - Auctions for standard 5 MW monthly and yearly
 - No intra-day auctions for capacity (currently)
3. Charges / Physical losses
 - Triad charges have been historical barrier to IC trade
 - Generation TNUoS
 - TLAFs larger in export direction
 - Flow- based capacity payments may create deadband
4. Strategic Behaviour
 - Power flows against price spread by dominant players

Expert Surveys on these Results

- Based on these findings, a sample of experts was consulted.
- 18 surveys were distributed to attendees at “The East West Interconnector Access Rules Workshop” conference, hosted by Eirgrid in Dublin, Oct, 2010
- 6 surveys completed, a response of 33%. Follow up phone conversations with 5 of 6 respondents
- Objective of survey to answer following questions:
 - Why are transmission rights not fully utilised?
 - Why are auction values not represented by arbitrage / option value?
 - Why is power flowing against price spread?
 - Why are ex ante prices such poor predictors of ex post prices?
 - What is the impact of wind on transmission rights?

Expert Survey Results 1

- Ex post pricing in SEM and lack of hedging options makes exporting from SEM risky
- Increased use of Moyle in past year – increased comfort with operation of SEM
- High wind penetration makes it difficult to predict prices in SEM because wind can come up between ex ante price run and dispatch (weak empirical support for this view)
- High wind penetration in Ireland makes exports risky
 - $SMP = \text{shadow price} + \text{uplift}$, uplift = start up and no load costs for fast start plant to balance wind
 - Uplift is estimated at 5% of SMP is off peak but can be up to 50-60% during peak windy periods

Expert Survey Results 2

- Capacity payments based on flow versus availability may create deadband preventing exports
- Trading into Balancing Mechanism risky because of price spread between SBP and SSP
- Different time frames for investment:
 - Larger players hedging short positions for Irish supply business take long term view – may purchase power on long term contract in UK and import to Ireland against price spread
 - Arbitrageurs taking more opportunistic short term view to make money but high trading cost due to high levels of credit cover and settlement delays – working capital intense

Conclusions

- Auction prices for IC transmission capacity are undervalued vis-à-vis both arbitrage and option values
- Significant flows against the efficient price spreads
- Lack of market alignment between the Irish and UK power markets may prevent exploitation of arbitrage opportunities
- High start up costs for plant to balance wind may create barriers to export from Ireland in peak windy periods
- Charges and fixed costs may create a potential “deadband” that will prevent exports from Ireland
- This has implications for valuation of IC transmission rights and therefore investment in IC capacity
- Further implications for investment in Irish power assets if cheap power can be imported from the UK