ASSESSING THE QUALITY OF ELECTRICITY MARKETS

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Overview

ELECTRICITY MARKETS ARE DRIVING DECARBONIZATION

Source: https://reneweconomy.com.au/global-clean-energy-investment-hit-us1-77-trillion-in-2023-up-17/

Technological changes:

- Battery storage
- New interconnections
- Grid expansions
- Digitalization

Regulatory changes:

- Shorter dispatch intervals
- Pricing methodology
- Financial settlement periods
- Auction closure times

Overview

OBJECTIVE, CONTRIBUTIONS & DESIGN

Introduce Metrics to Assess the Quality of Electricity Markets

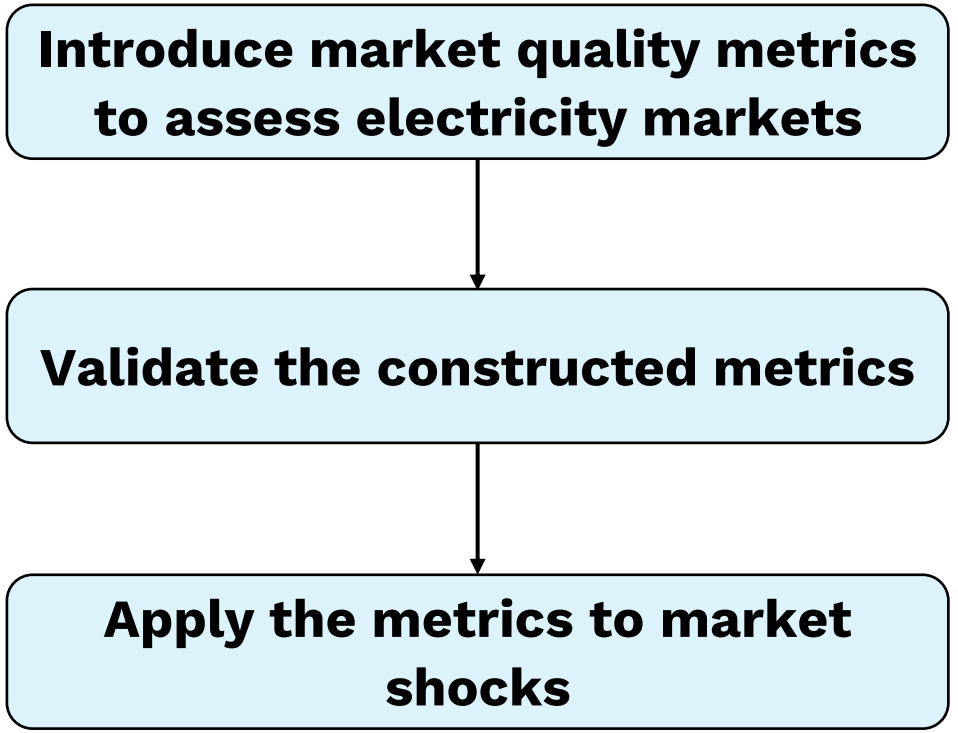
- Framework to assess price formation
- Built on participant bidding behaviour

General Contributions:

- Contributes to academic literature
  - ✓ Settlement price metrics

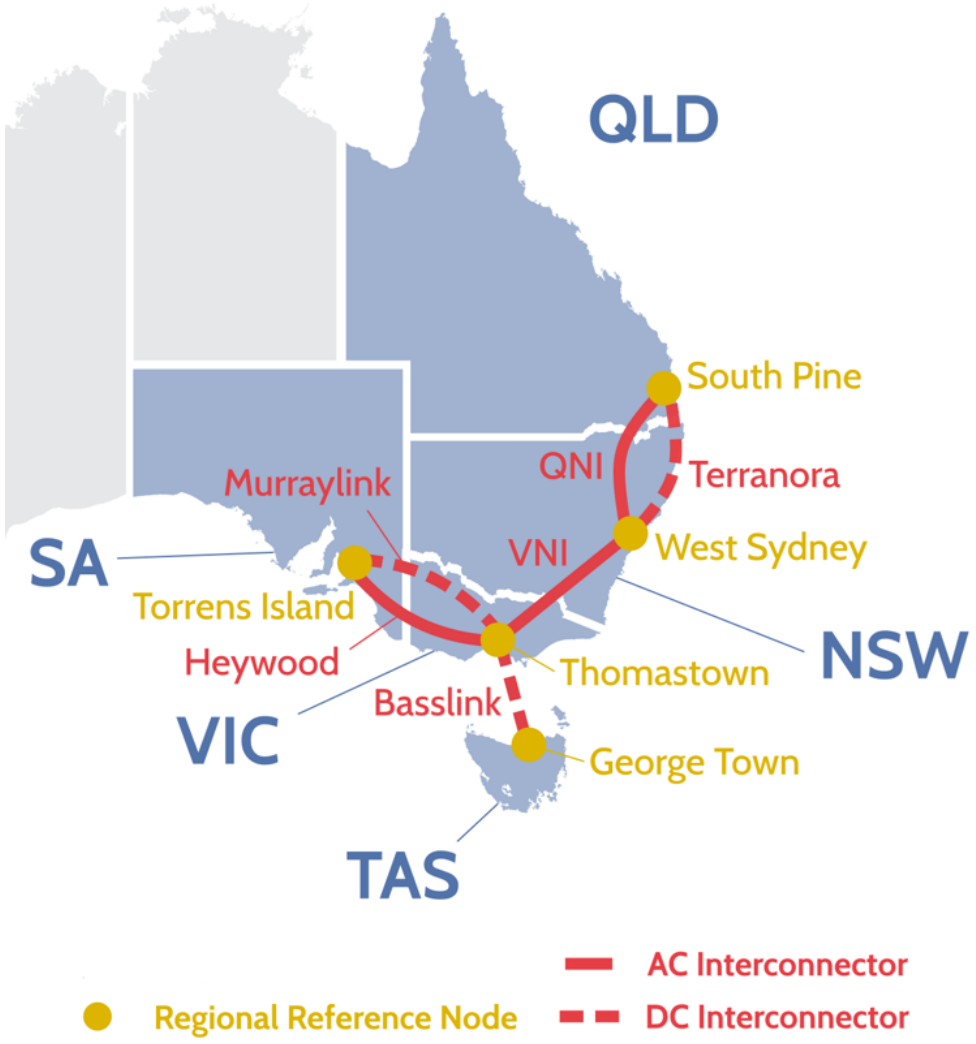
    (Li and Flynn, 2005, 2004a,b; Mayer and Trück, 2018)
  - ✓ Random walk tests

    (Arciniegas et al., 2003; Growitsch and Nepal, 2009; Higgs and Worthington, 2003)
- Practical implications for policymakers and regulators



Institutional Details

NATIONAL ELECTRICITY MARKET



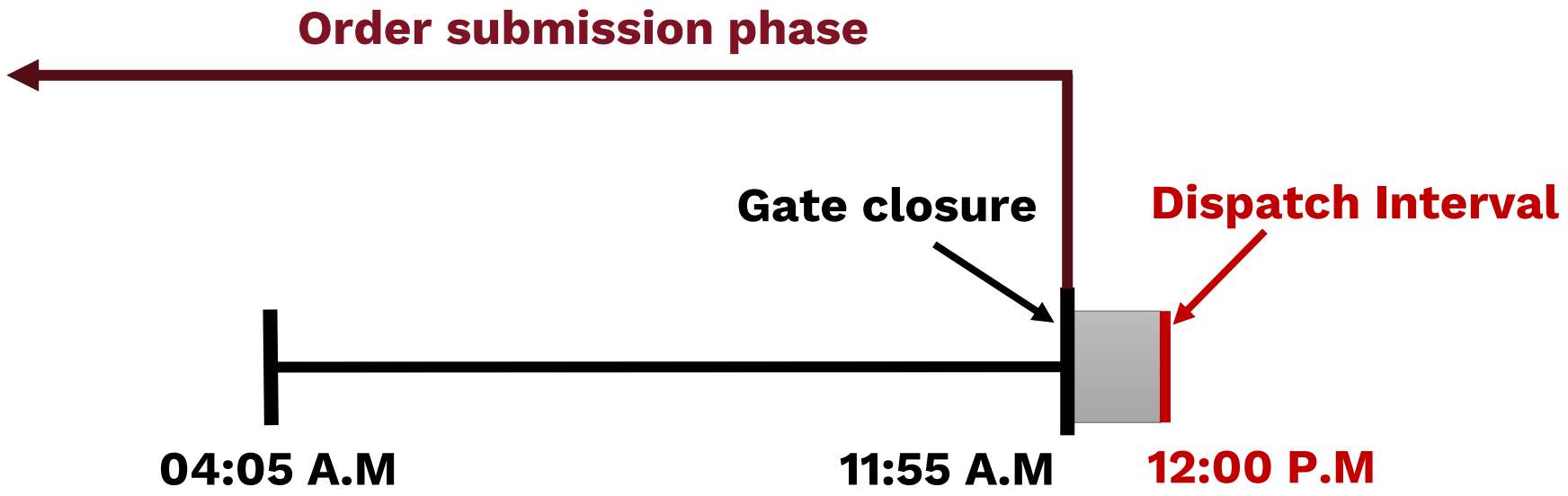
Network characteristics:

- Covers NSW, ACT, QLD, VIC, SA & TAS
- Interconnected system
- Cap price: $15,500 /MWh (FY 22-23)
- Floor price: -$1000/ MWh
- One-sided market

Source: https://wattclarity.com.au/articles/2022/12/how-common-are-islandings-and-transmission-tower-failures-in-the-nem/

Institutional Details

DISPATCH PROCESS



Network modelling:

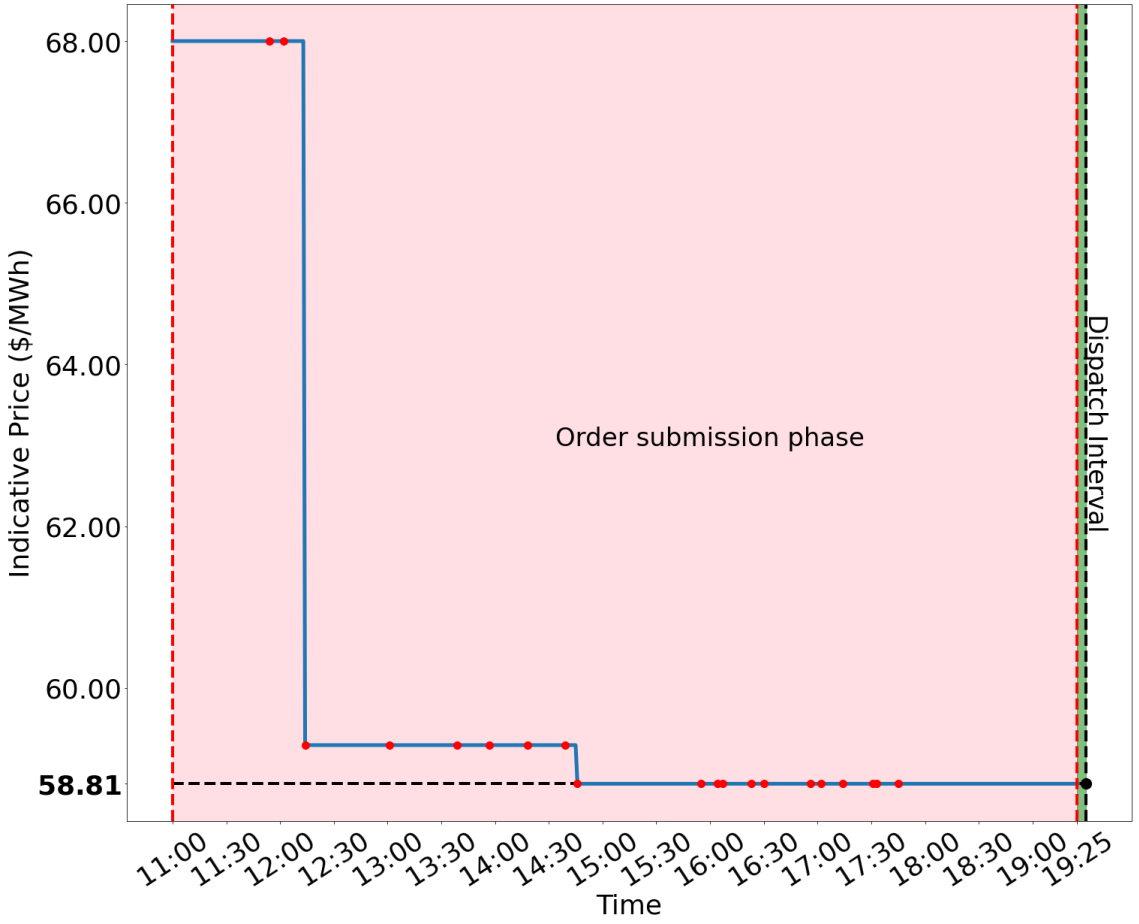
- Generator characteristics
- Interconnector constraints
- Generic constraints

→ **NEMPY- Python modelling package (Nick Gorman, Anna Bruce, Iain MacGill)**

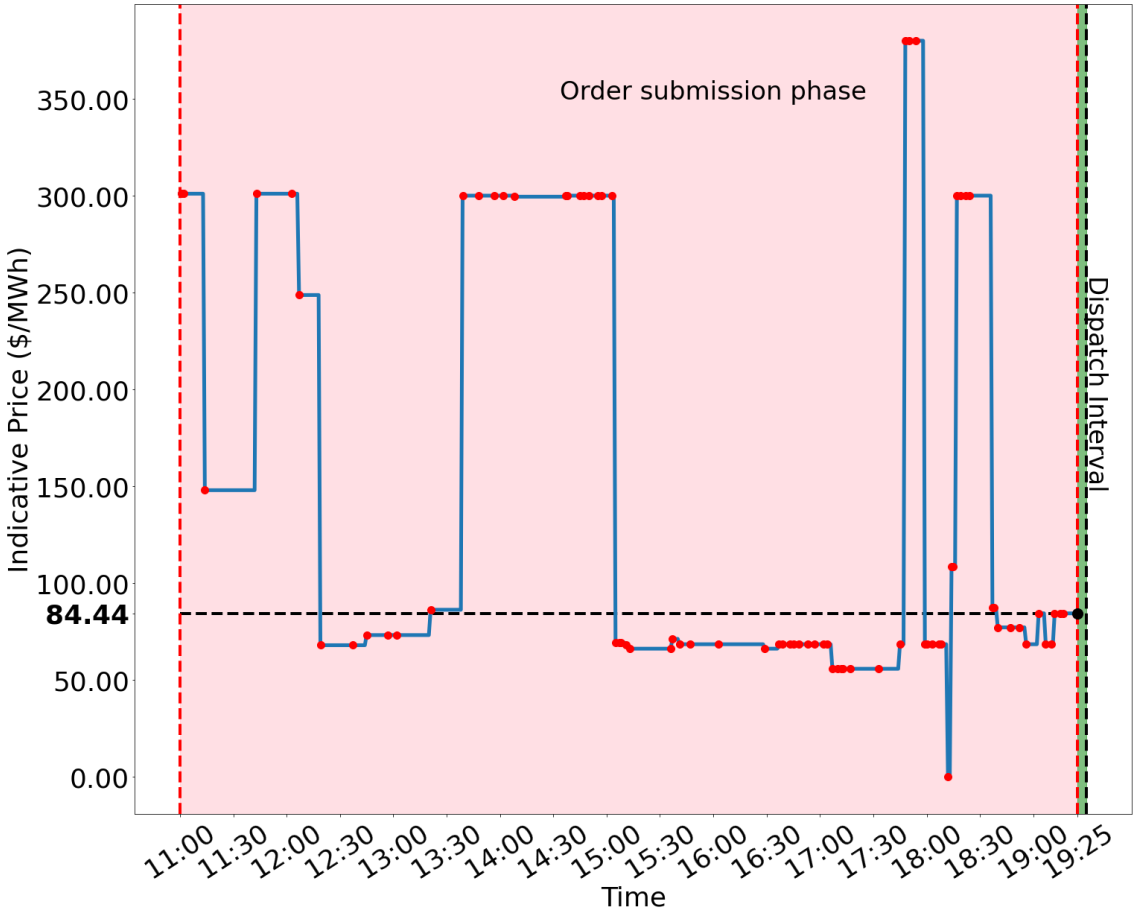
Methodology

INDICATIVE PRICE VOLATILITY

a) Stable price evolution



b) Volatile price evolution



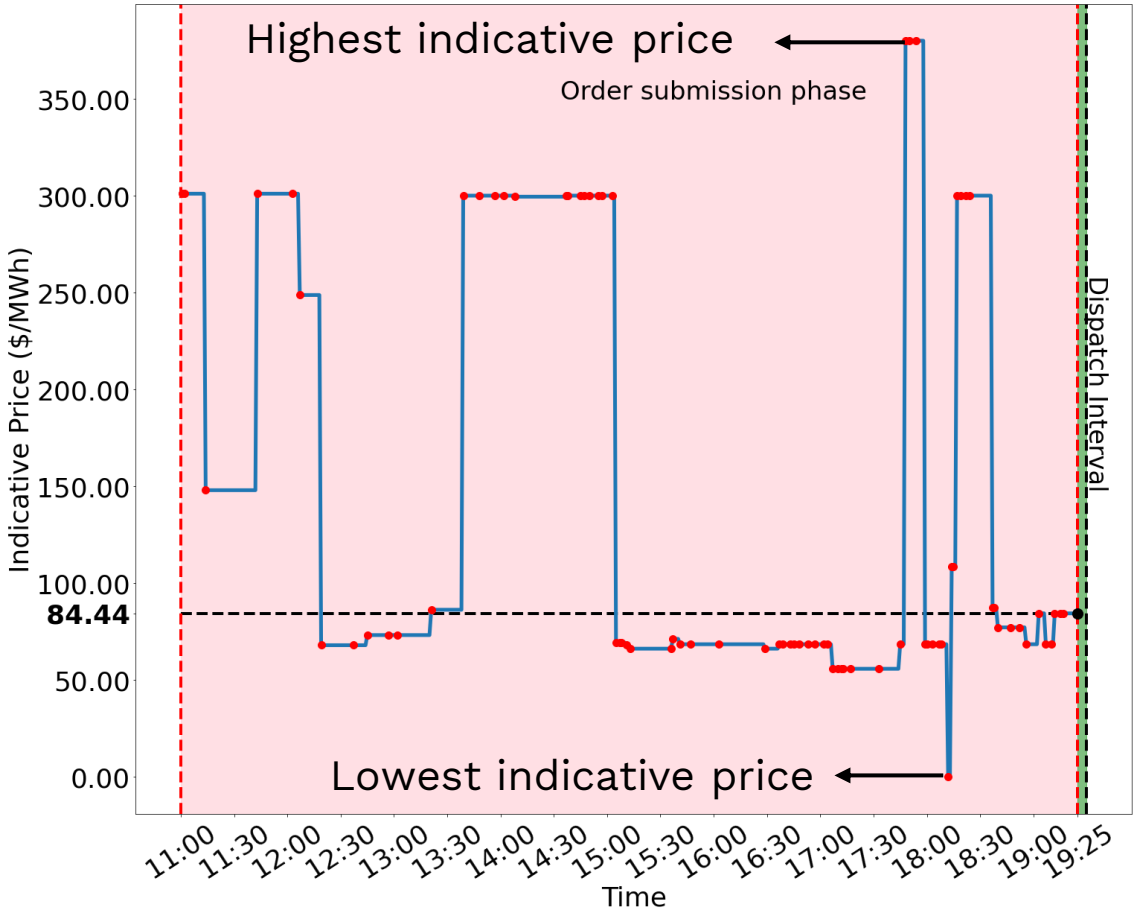
$$Indicative\ price\ volatility_{r,t} = \sqrt{\frac{\sum_{i=1}^{N_i}\left(IP_{i,r,t} - \overline{IP_{r,t}}\right)^2}{N_i - 1}}$$

Methodology

INDICATIVE PRICE RATIOS

$$\text{Lowest indicative price ratio}_{r,t} = \left| \frac{\min_{i=1}^{N_i} IP_{i,r,t}}{P_{r,t}} \right|$$

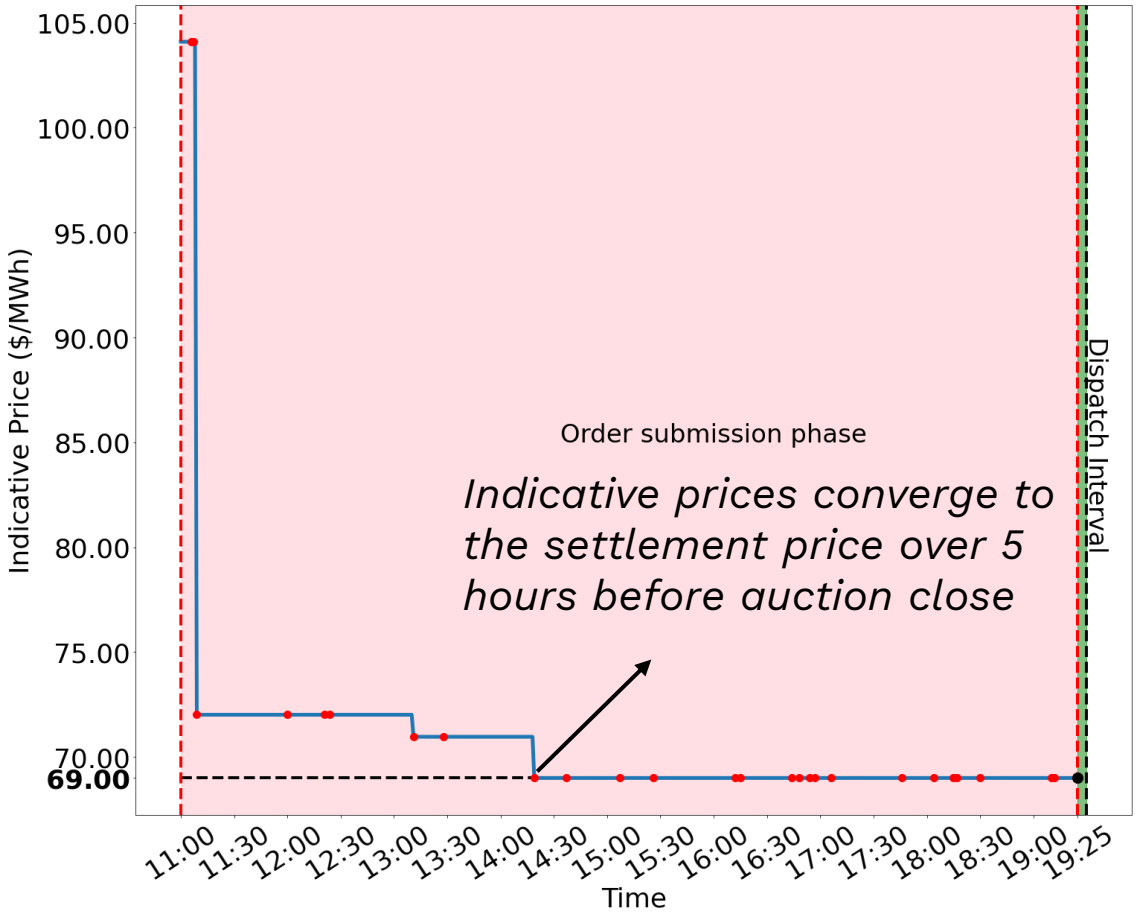
$$\text{Highest indicative price ratio}_{r,t} = \left| \frac{\max_{i=1}^{N_i} IP_{i,r,t}}{P_{r,t}} \right|$$



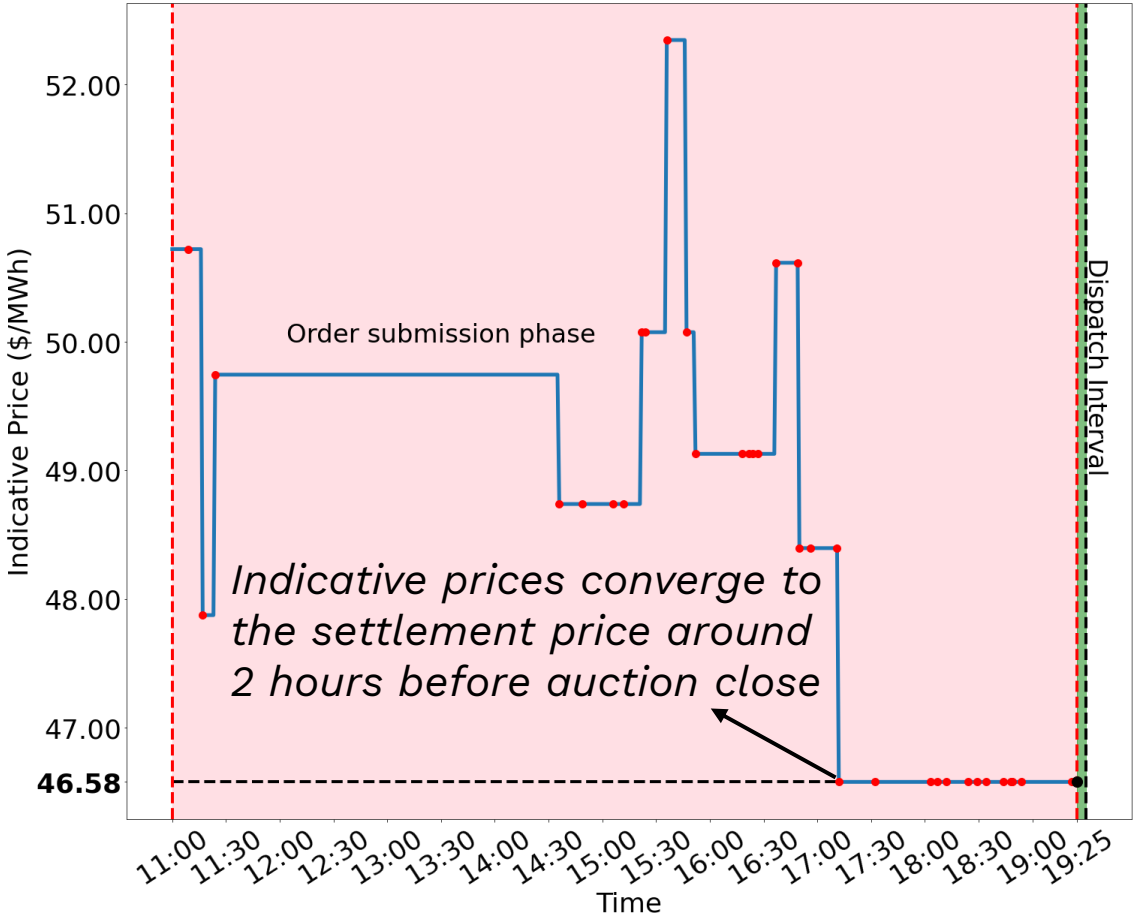
Methodology

INDICATIVE PRICE CONVERGENCE

a) Early price convergence



b) Delayed price convergence

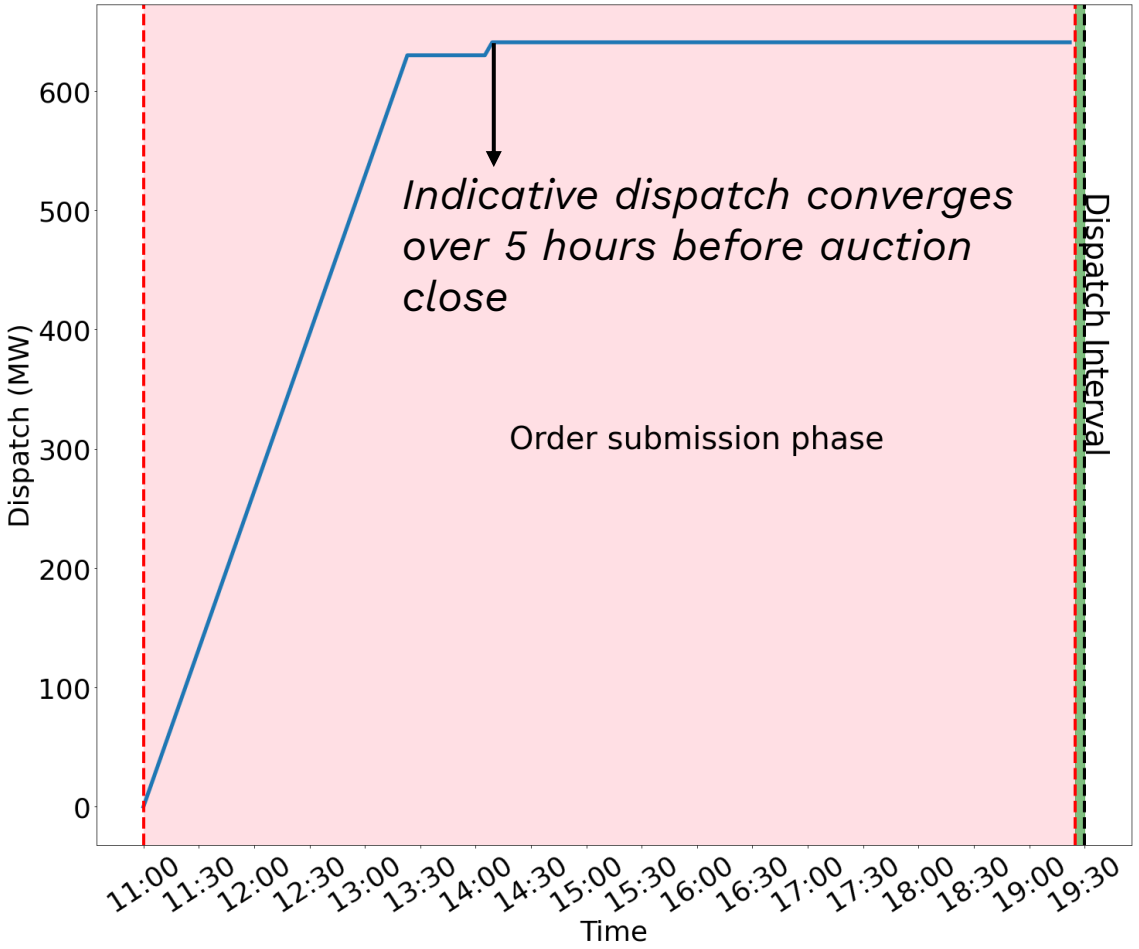


$$Indicative\ price\ convergence_{r,t} = max_{i=1}^{N_i} \left| \frac{IP_{i,r,t} - P_{r,t}}{t_{dispatch}} \right|$$

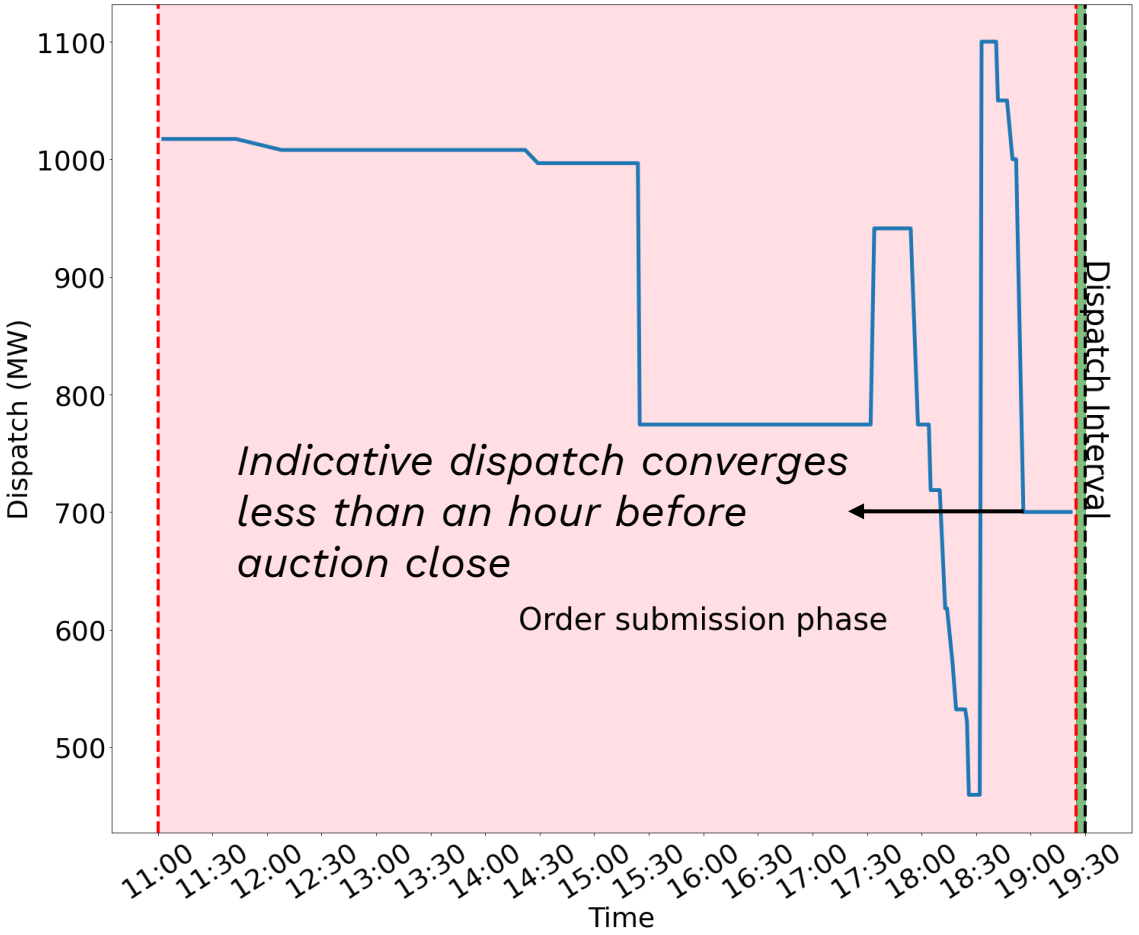
Methodology

INDICATIVE DISPATCH CONVERGENCE

a) Early dispatch convergence



b) Delayed dispatch convergence



$$\textit{Indicative dispatch convergence}_t = max_{i=1}^{N_i}\left(max_j^{N_j}\left|\frac{ID_{i,r,j,t} - D_{r,j,t}}{t_{dispatch}}\right|\right)$$

Methodology

MARKET EFFICIENCY METRICS

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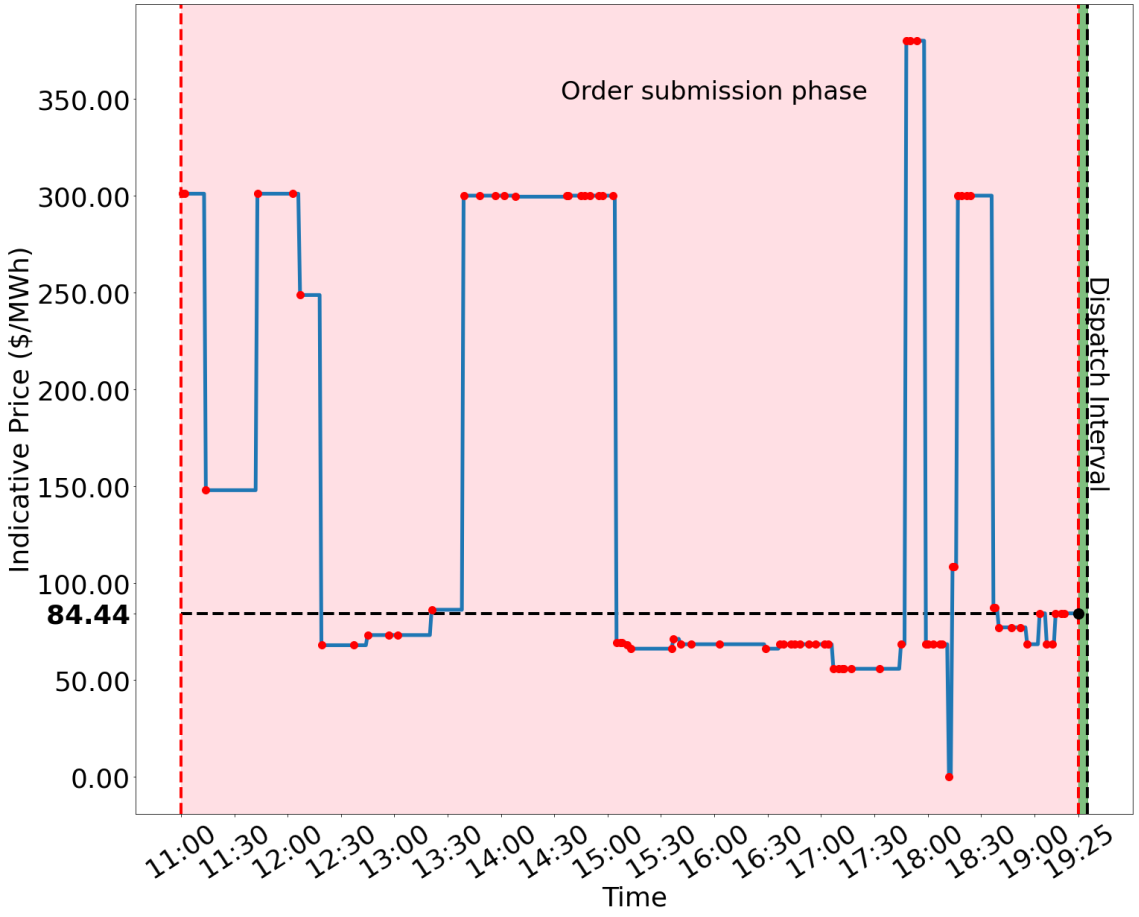
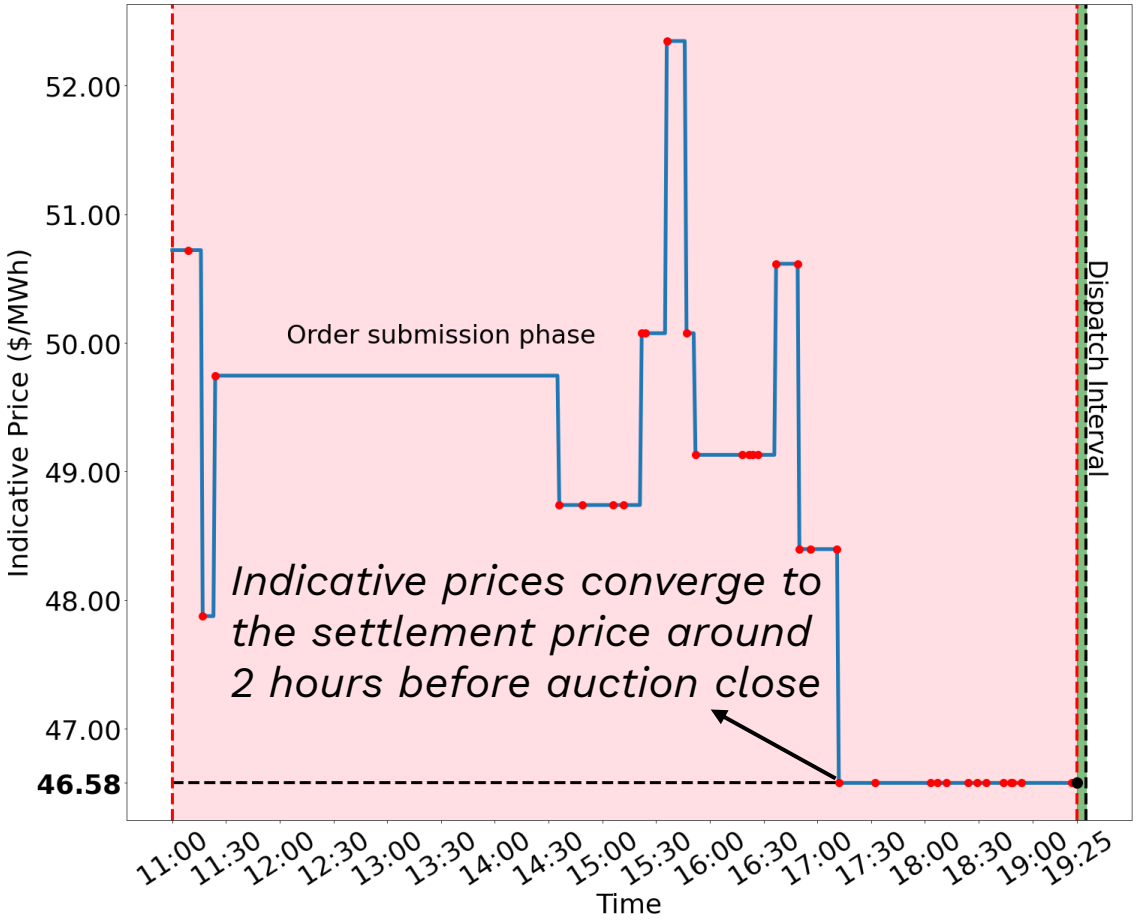
a) Volatile price evolution



b) Delayed price convergence

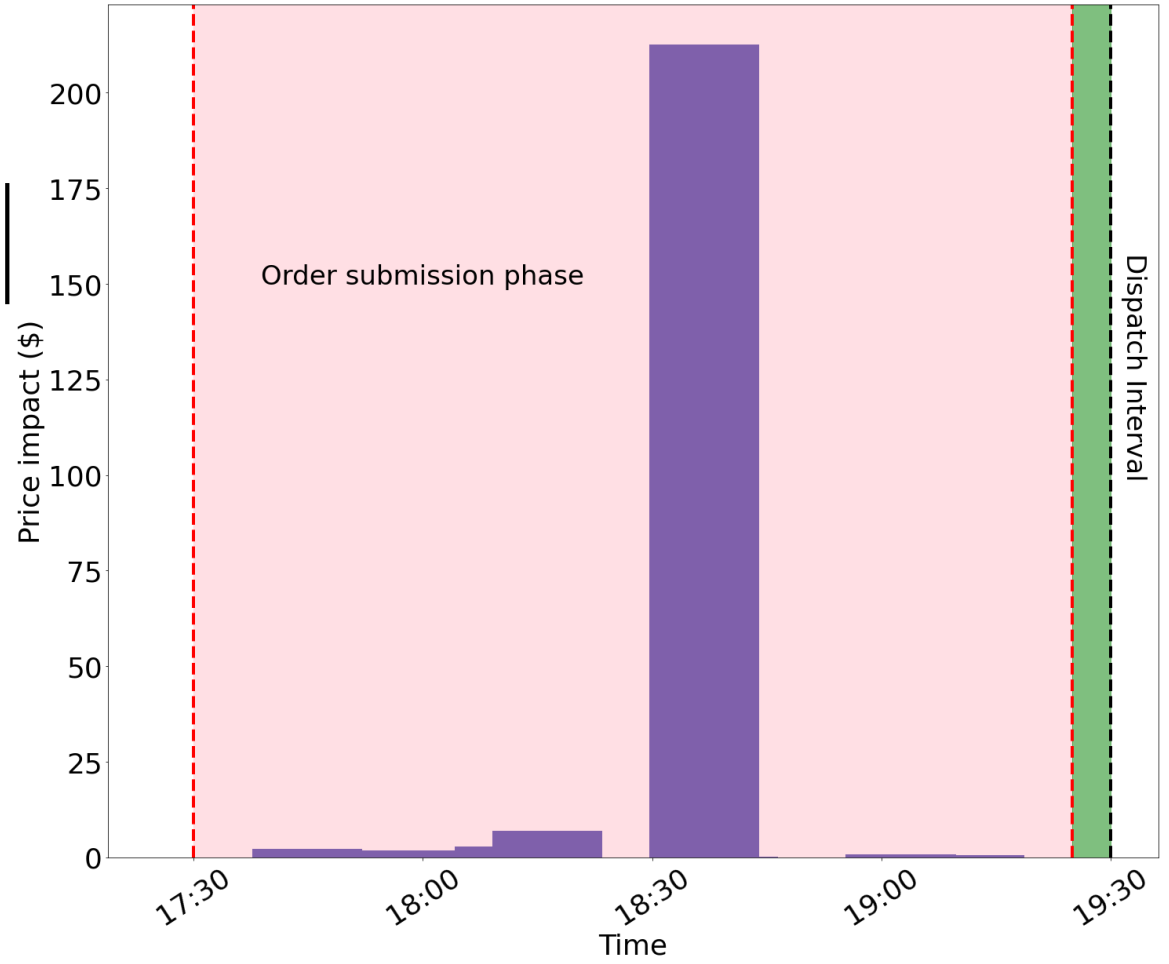


Methodology

REBID PRICE IMPACT

$$Rebid\ price\ impact_{r,t} = max \left| \frac{Change\ in\ indicative\ price}{Change\ in\ indicative\ dispatch\ of\ rebidder} \right|$$

Price response associated with a unit change in the volume of the rebidding participant



Validation phase

DO THE METRICS PREDICT PERIODS OF MARKET STRESS? (LOR 1 & 2)

$$ln\left(\frac{P(Y \leq J)}{1 - P(Y \leq J)}\right)_{r,t} = \alpha_j - \sum_{i=1}^{N} \beta_i \textbf{Metrics}_{i,r,t} + \epsilon_t$$

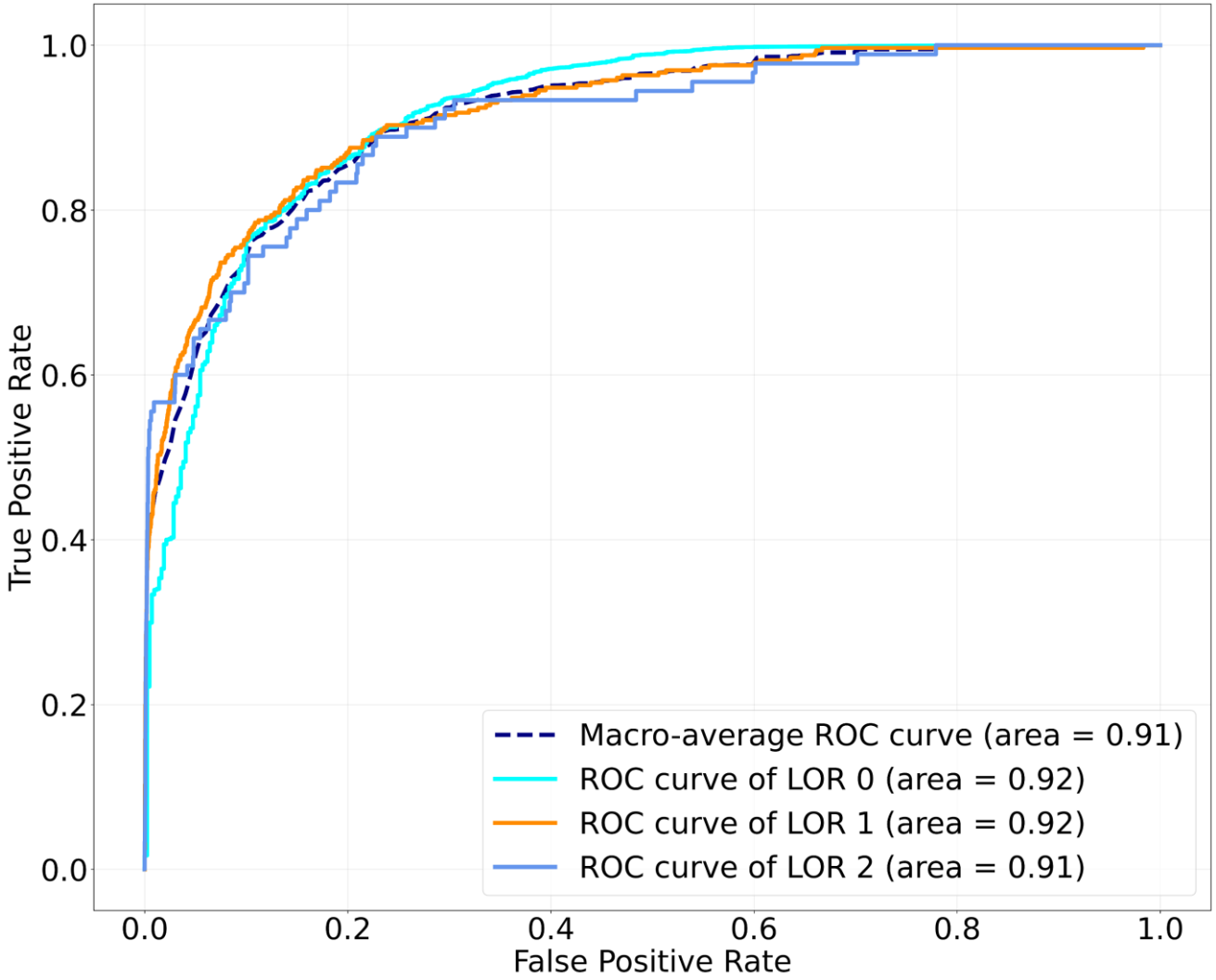
- Higher values across most metrics are associated with an increased likelihood of a Lack of Reserve (LOR) event
- Decrease in the lowest indicative price ratio is associated with an increased likelihood of market stress

	Dependent variable: Event
Indicative Price Volatility’	0.464***
	(0.044)
Indicative price convergence’	3.661***
	(0.454)
Indicative dispatch convergence’	1.537***
	(0.093)
Lowest indicative price ratio	-1.320***
	(0.097)
Highest indicative price ratio	0.038***
	(0.053)
Rebid price impact’	1.319***
	(0.069)
Observations	132,455
Normal market periods	131, 651
LOR 1 market periods	564
LOR 2 market periods	240

*p<0.1, **p<0.05, ***p<0.01
’Coefficients scaled by 1,000

Validation phase

CONSTRUCTING AN INDEX



- Plots the model's True Positive Rates against False Positive Rates at various probability thresholds

- Area Under the Curve (AUC) provides a single metric for assessing a model’s performance
  - AUC = 1: Perfect classifier
  - AUC = 0.5: Random guessing

Evaluation phase

USING METRICS TO EVALUATE THE MARKET DURING EVENTS

Events:

1. Interconnector outages in SA
2. Strategic rebidding in QLD
3. 5-minute settlement period change across NEM

$$y_{r,t} = \beta_0 + \beta_1 Event_{r,t} + \beta_2 FE + \epsilon_t$$

- $y_{r,t}$:market quality metric
- $Event_{r,t}$: indicator variable for interventions
- FE : hourly indicator variables

Evaluation phase

INTERCONNECTOR OUTAGES

Interconnectors:

- Inter-regional trade -> Improves liquidity
- Improved liquidity -> Improves efficiency (Chordia et al. 2008)

Theoretical predictions:

Outage would negatively impact market efficiency and liquidity

Interconnector outages heighten auction volatility, delay convergence to settlement conditions, and worsen market liquidity.

	Dependent variable: Event
Indicative price volatility	76.504***
	(7.417)
Lowest indicative price ratio	3.479***
	(0.144)
Highest indicative price ratio	0.872***
	(0.034)
Indicative price convergence	140.293***
	(29.700)
Indicative dispatch convergence	27.928***
	(2.200)
Rebid price impact	87.984***
	(4.911)

*p<0.1, **p<0.05, ***p<0.01

Evaluation phase

STRATEGIC REBIDDING

Strategic rebidding:

- Rebidding capacity from low to high prices before the close of a 30-minute settlement period
- Associated with price spikes (Clements et al., 2016)

Theoretical predictions:

Higher variations in the batching phase and bids would have a high price impact

Strategic rebidding heightens auction volatility, delays convergence to settlement conditions, and worsens market liquidity.

	Dependent variable: Event
Indicative price volatility	868.422***
	(44.475)
Lowest indicative price ratio	-0.132***
	(0.010)
Highest indicative price ratio	0.579***
	(0.039)
Indicative price convergence	2,963.744***
	(330.127)
Indicative dispatch convergence	33.064***
	(6.940)
Rebid price impact	202.730***
	(19.918)

*p<0.1, **p<0.05, ***p<0.01

Evaluation phase

5-MINUTE SETTLEMENT PERIOD CHANGE

Settlement period change:

- Implemented to eliminate strategic re-bidding (AEMC, 2017)

Theoretical predictions:

Lower variations in the batching phase and bids would have a lower price impact after rule change

Settlement period change reduced auction volatility, accelerated convergence to settlement conditions, and improved market liquidity.

	Dependent variable: Event
Indicative price volatility	-6.455***
	(1.390)
Lowest indicative price ratio	-0.933***
	(0.147)
Highest indicative price ratio	0.436*
	(0.252)
Indicative price convergence	-35.295***
	(5.291)
Indicative dispatch convergence	-2.347**
	(0.943)
Rebid price impact	-128.269***
	(5.443)

*p<0.1, **p<0.05, ***p<0.01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Appendix

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