Supply Curve Smoothing:
Moving Average Approach

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FMU/RPM Supply Curve Transparency MIC Subgroup Meeting
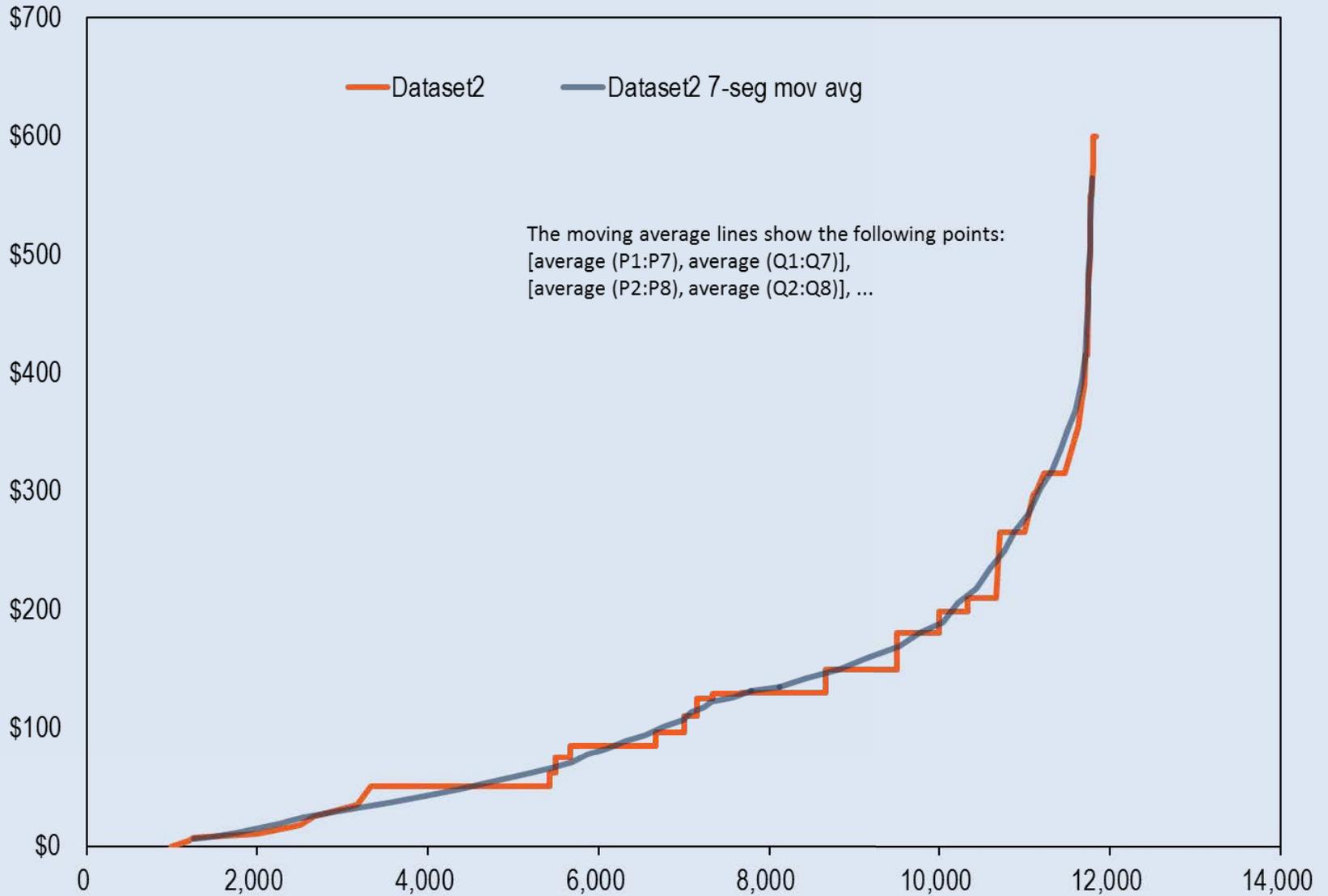
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Curve Smoothing Using Moving Averages

1. Simple and straightforward approach to smoothing

2. Widely used and easy to understand

3. Ensures the smoothed curve conceals but closely follows the data

4. Flexible approach – use moving average of fewer points for best fit, or use more points to better conceal underlying data

5. We suggest additional measures to ensure commercially sensitive bid data is not revealed under certain circumstances
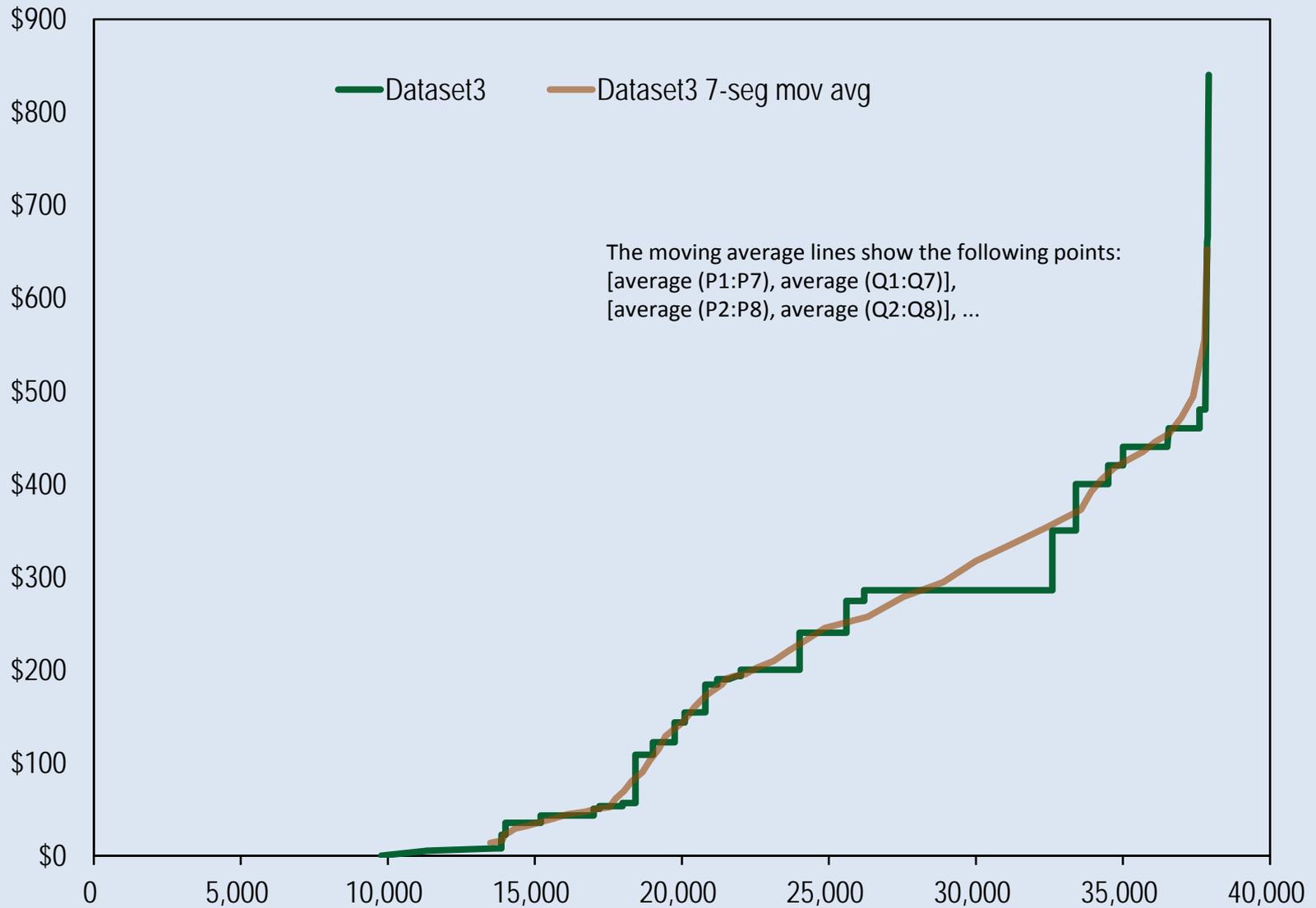
Suggested Approach: Seven Point Moving Average

1. Supply curve data set consists of N [P, Q] pairs, $P_1 \dots P_N$, $Q_1 \dots Q_N$ where the Ps are the prices and the Qs are the cumulative quantities at each price point.

2. To calculate a smoothed supply curve using a seven-point moving average (M=7):

    A. Replace P_i with average of $P_{i-3} \dots P_{i+3}$ (average of 7 surrounding prices) for i=4..N-3

    B. Replace Q_i with average of $Q_{i-3} \dots Q_{i+3}$ (average of 7 surrounding quantities) for i=4..N-3

3. To also pass through actual clearing point, add that point to the set.

4. Can be graphed as "step" curve or points can be directly connected.

"Dataset2" Sample Supply Curve Smoothed with 7-Point Moving Average

The moving average lines show the following points:
[average (P1:P7), average (Q1:Q7)],
[average (P2:P8), average (Q2:Q8)], ...

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"Dataset3" Sample Supply Curve Smoothed with 7-Point Moving Average

The moving average lines show the following points:
[average (P1:P7), average (Q1:Q7)],
[average (P2:P8), average (Q2:Q8)], ...

"Dataset1" Sample Supply Curve Smoothed with 7-Point Moving Average

The moving average lines show the following points:
[average (P1:P7), average (Q1:Q7)],
[average (P2:P8), average (Q2:Q8)], ...
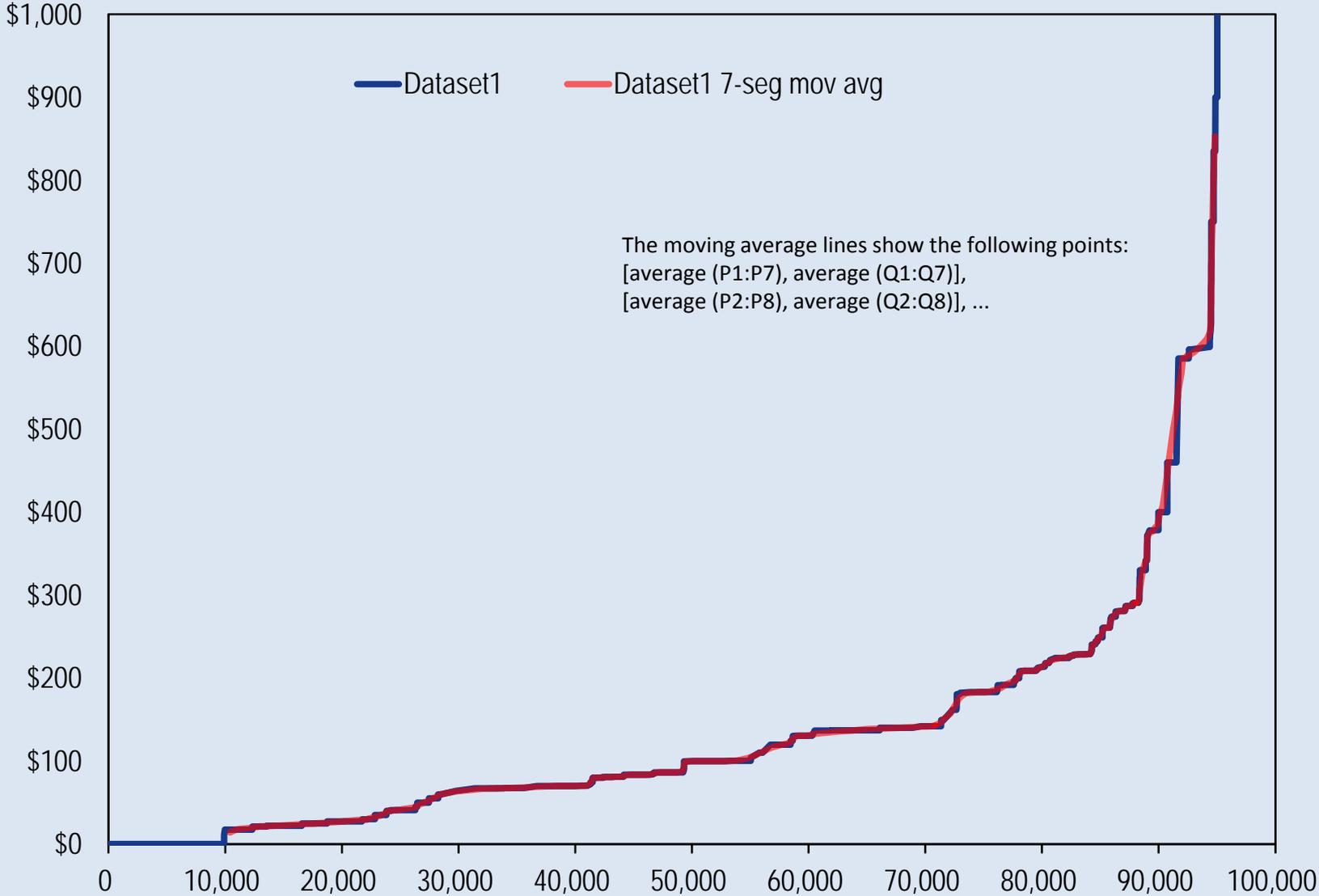
"Dataset1" Sample Supply Curve Smoothed with 7-Point Moving Average (detail)

The moving average lines show the following points:
[average (P1:P7), average (Q1:Q7)],
[average (P2:P8), average (Q2:Q8)], …
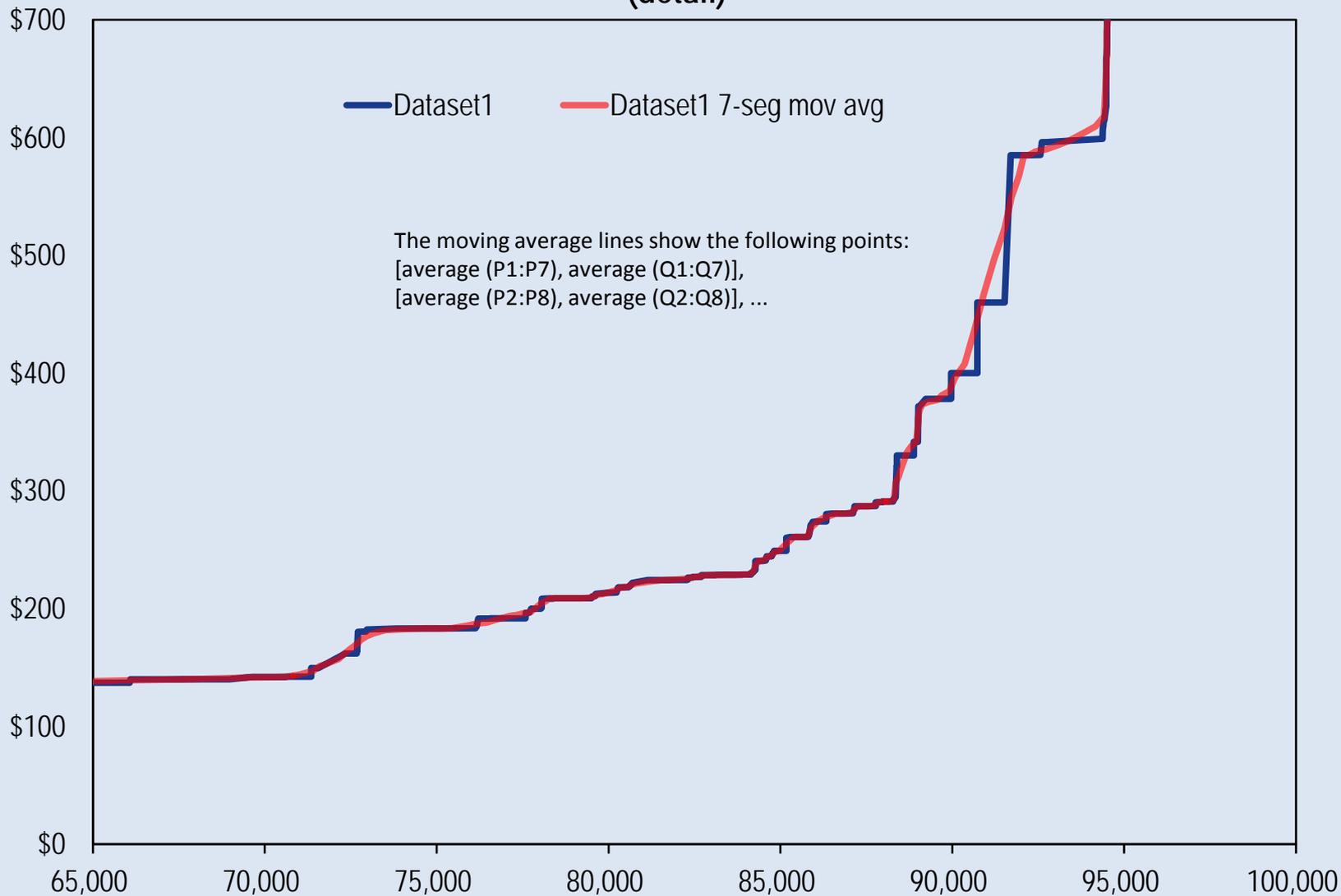
Dataset1 – Detail Around Price = $600

Dataset1 - Detail around P= $600					
Dataset1			Moving Average		
P	Q	Cum. Q	P	Q	Cum. Q
460.00	790	91,520	$ 466.92	259	90,911.4
585.10	180	91,700	$ 496.48	303	91,214.3
585.12	60	91,760	$ 522.93	307	91,521.4
585.12	330	92,090	$ 549.37	201	91,722.9
585.14	30	92,120	$ 567.25	213	91,935.7
585.14	20	92,140	$ 585.14	146	92,081.4
585.16	80	92,220	$ 585.15	123	92,204.3
585.18	320	92,540	$ 586.71	121	92,325.7
585.20	20	92,560	$ 588.27	90	92,415.7
596.02	50	92,610	$ 590.25	321	92,737.1
596.06	110	92,720	$ 593.37	320	93,057.1
599.00	1,650	94,370	$ 596.92	310	93,367.1
607.00	10	94,380	$ 600.90	266	93,632.9
610.00	10	94,390	$ 605.15	266	93,898.6
613.00	10	94,400	$ 609.58	267	94,165.7
615.00	20	94,420	$ 618.00	251	94,417.1
627.00	60	94,480	$ 627.71	16	94,432.9
655.00	0	94,480	$ 636.29	14	94,447.1
667.00	0	94,480	$ 644.86	14	94,461.4

Seven Point Moving Average: Fit Statistics

	Dataset1	Dataset2	Dataset3
R Squared	.9995	.9775	.9762
Mean Squared Error (prices)	55.87	86.96	498.70
Root Mean Squared Error ($)	$7.47	$9.33	$22.33

Approach: At regular quantity intervals, actual dataset prices were compared to the prices calculated under the moving average approach. Quantity intervals used: 1,000 MW, 100 MW, 500 MW for dataset1, dataset2, dataset3 respectively.

Ensuring Commercially-Sensitive Data Is Not Revealed

1. Criteria for publishing (not publishing) a supply curve:
   A. Minimum criteria for diversity of offered supply (e.g., no one supplier > 60%, no two suppliers > 80%, no three suppliers > 90%)
   B. Consider minimum LDA size (e.g., 5,000 MW minimum) below which there is a presumption there could be lack of diversity or too-large offers
   C. Publish supply curves without regard to whether LDA was binding
2. Possible criteria for special processing of large offers:
   A. Large offers (or clusters of similar-priced offers) could be broken up (pre-processed) so the moving average will better conceal them
   B. e.g., if 5% of the total offered supply is within 1% of the same price, break the total supply into five bundles, assign prices 0.90P, 0.95P, P, 1.05P, 1.10P
3. Final review by Market Monitor with authority to reject curve.

Other Proposed Details

1. Pass through clearing point: Yes, add clearing point to data set.

2. Indicate points where smoothed curve intersects real curve with markers.

3. Offers to include in supply curve: All Annual Resource offers, and offers from Limited and Extended Summer resources up to the total quantity allowed based on the applicable Limited and Subannual constraints (LDA, parent LDAs and RTO-level constraints).

Other Proposed Details (continued)

4. Full documentation of the approach in PJM manuals.

5. For each published curve, a footnote briefly describes approach and cites to the manual.

6. For LDAs for which a curve is not published, consider providing more detailed post-auction sensitivity analysis

   A. Standard practice has been to provide results for +/- 4% Annual Supply

   B. If no supply curve, consider providing +/- 2%, 4%, 8%

7. Also recommend publishing supply curves from past base residual auctions with the new approach.