Appendix: Pass-through from Fossil Fuel Market Prices to Procurement Costs of the U.S. Power Producers

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Appendix

This appendix contains a detailed analysis of coal pass through by basin. It also provides several tables and figures mentioned in the main text. Tables A1-A4 report tabular results from regressions documented in figures in the main text. Figures A3 and A4 compare the constructed counterfactual supply curves for year 2008 when fuel prices were at relatively high levels for CAISO and PJM. Figure A5 and A6 report dispatch algorithm comparisons in 2008. Finally, figures A7 and A8 report the cost differences between simulated dispatch curves that rely on wholesale and reported receipt price for CAISO and PJM in 2008.

1 Coal Pass-through across Basins

To verify that our results for coal are not driven by omitted coal attributes or geographic variation, we estimate the results for coal for each of three major deposits in the U.S., each with distinct characteristics: the Powder River Basin (PRB), the Illinois Basin and Central Appalachia (CAPP).

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Coal attributes like sulfur and heat content varies widely between these three types of coal.[1] Given the different characteristics of coal from each basin, spot prices for them are significantly different from each other. There is no clear difference in pass through patterns for any type of coal.

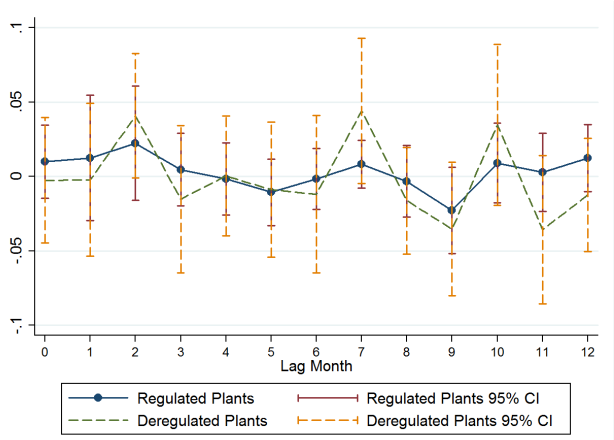
Finally, we focus on coal purchases only and categorize coal purchases from three major coal mining basins with coal production of significantly distinguishable characteristics. Since each type of coal is a (somewhat) differentiated product it is possible that pass-through behavior for each type could be different. At the same time, since each coal type is a substitute input, each price series could be co-integrated. As a result, this section relies on an identifying assumption that coal fired power plants don't substitute uniformly and rapidly across coal types in the spot market. We feel this is a reasonable assumption given that the vast majority of coal purchases occur via long term contract.

We first investigate pass-through patterns of the three types of coal between traditional regulated power plants and divested deregulated Independent Power Producers.[2] We estimate the using the same specification as the regulation status regressions above. Figure A1 plots the mean pass-through elasticity coefficients and corresponding 95% confidence intervals against the lag month terms (up to 12). One notable result is that the pass-through between spot prices and the receipt prices of power plants for PRB coal is almost zero over twelve months and there is no difference by regulatory status. For CAPP and Illinois Basin coal we see a similar pattern.

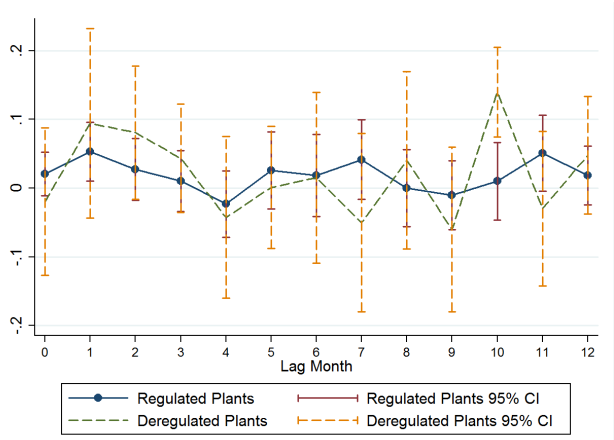
We also examine pass-through patterns of the 3 types of coal for commodity price increases versus decreases by estimating specification 4 in the main text by coal type. Table A3 shows the pass-through coefficients for negative shocks relative to positive ones. Figure A2 plots the estimated pass-through coefficients and corresponding 95% confidence intervals against the lag month terms. For PRB and Illinois Basin coal transactions, the pass-through patterns of an increase or a decrease in spot market price do not differ significantly from each other. Figure A2 suggests that there is some evidence that over the first year positive shocks are passed through more quickly than negative

[1] According to Busse and Keohane (2007), the median sulfur content of PRB coal is around 0.33% by weight, compared to much higher medians for Central Appalachia coal (0.90%) and Illinois Basin coal (2.7%); PRB coal also has much lower heat content than Central Appalachian and Illinois Basin Coal. The median heat content for PRB coal is 8674 British thermal units per pound, while heat contents are 12490 and 11309 for Central Appalachian and the Illinois Basin coal respectively.

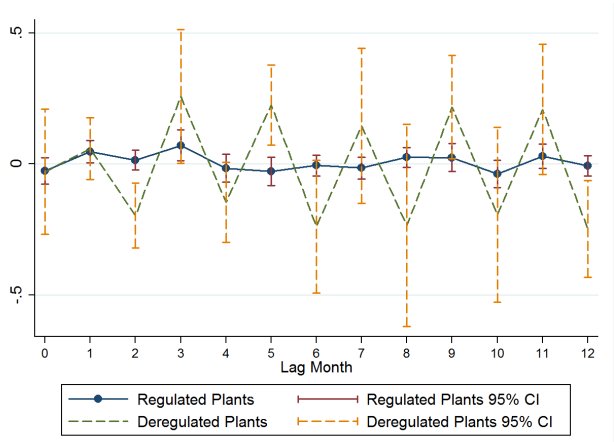
[2] Table A3 shows the deviation of pass-through elasticities for deregulated plants relative to the regulated counterparts.



(a) PRB Coal Transactions



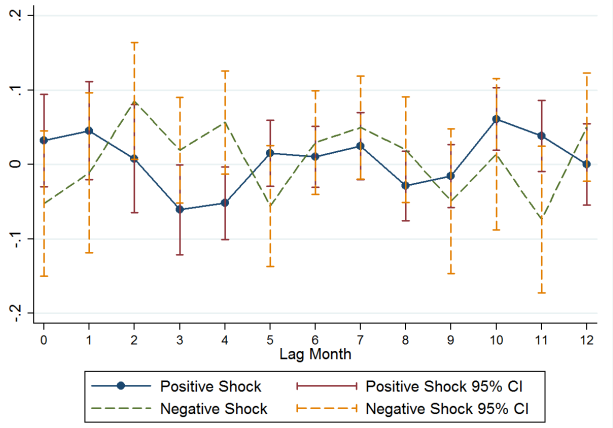
(b) CAPP Coal Transactions



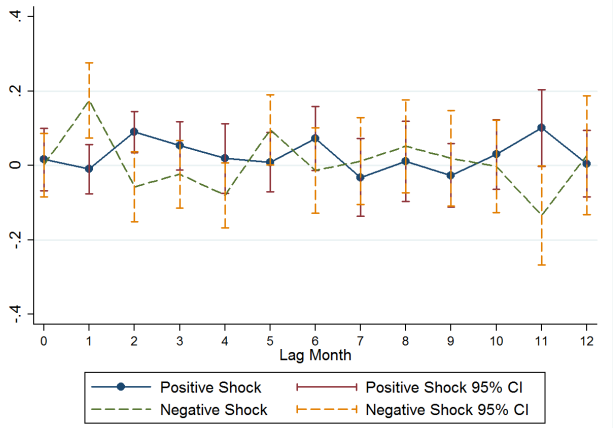
(c) IL Basin Coal Transactions

Figure A1: Pass-through Elasticity: Regulated vs. Deregulated

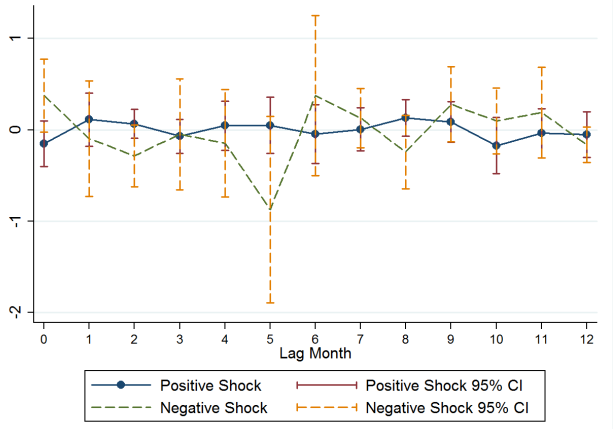
Note: deregulated plants are defined as divested ones of the independent power producers.



(a) PRB Coal Transactions



(b) CAPP Coal Transactions



(c) IL Basin Coal Transactions

Figure A2: Pass-through Elasticity: Positive vs. Negative Spot Price Changes

Note: Positive spot price changes in month k indicate increases in the spot price of coal month on month k months ago. Negative price changes are defined similarly.

shocks for CAPP coal. Based on the delta method, these differences are statistically significant at the 1% level, which is mostly likely due to the significant gap in the 11th lag.

2 Additional Tables and Figures

Table A1: Regression Results: Regulated versus Deregulated

	(1)	(2)	(3)
Coal × L0	0.0235***	0.0243***	0.0221**
Coal × Dereg × L0		-0.000961	0.000502
NG × L0	0.589***	0.501***	0.501***
NG × Dereg × L0		0.195***	0.195***
Coal × L1	0.0132	0.0170	0.0152
Coal × Dereg × L1		-0.0233	-0.0218
NG × L1	0.277***	0.326***	0.325***
NG × Dereg × L1		-0.100***	-0.0995***
Coal × L2	0.0174	0.0121	0.0109
Coal × Dereg × L2		0.0257	0.0268
NG × L2	-0.0424***	-0.0630***	-0.0637***
NG × Dereg × L2		0.0465***	0.0473***
Coal × L3	0.0375***	0.0411***	0.0401***
Coal × Dereg × L3		-0.0193	-0.0185
NG × L3	0.0122*	0.0114	0.0110
NG × Dereg × L3		-0.00861	-0.00794
Coal × L4	-0.00642	-0.00705	-0.00788
Coal × Dereg × L4		0.00607	0.00688
NG × L4	-0.00820	0.00925	0.00893
NG × Dereg × L4		-0.0399***	-0.0395***
Coal × L5	-0.00693	-0.00477	-0.00564
Coal × Dereg × L5		-0.0106	-0.00967
NG × L5	-0.0143**	-0.00121	-0.00148
NG × Dereg × L5		-0.0241*	-0.0238*
Coal × L6	-0.00463	-0.00201	-0.00265
Coal × Dereg × L6		-0.0162	-0.0156
NG × L6	0.0236***	0.00475	0.00434
NG × Dereg × L6		0.0420***	0.0423***
Observations	55756	55756	55756
Month FE	Yes	Yes	Yes
Owner FE	No	No	Yes
Adjusted R^2	0.218	0.225	0.221

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

Table A2: Regression Results: (+) versus (-) Shocks

	(1)	(2)	(3)
Coal × L0	0.0222**	0.0407*	0.0399*
Coal × Negative × L0		-0.0788**	-0.0760**
NG × L0	0.591***	0.580***	0.580***
NG × Negative × L0		0.0113	0.0108
Oil × L0	0.627***	0.551***	0.547***
Oil × Negative × L0		0.266*	0.277*
Coal × L1	0.0138	-0.00164	-0.00388
Coal × Negative × L1		0.0672	0.0706*
NG × L1	0.279***	0.242***	0.242***
NG × Negative × L1		0.0786***	0.0780**
Oil × L1	0.120***	0.342***	0.337***
Oil × Negative × L1		-0.459**	-0.448**
Coal × L2	0.0189*	0.0456**	0.0446*
Coal × Negative × L2		-0.0630*	-0.0627*
NG × L2	-0.0411***	-0.0687***	-0.0685***
NG × Negative × L2		0.0589**	0.0584*
Oil × L2	-0.0157	0.0422	0.0380
Oil × Negative × L2		-0.0785	-0.0718
Coal × L3	0.0353***	0.0144	0.0144
Coal × Negative × L3		0.0394	0.0391
NG × L3	0.0119	0.0930***	0.0935***
NG × Negative × L3		-0.155***	-0.156***
Oil × L3	0.0144	-0.135**	-0.139**
Oil × Negative × L3		0.212*	0.216*
Coal × L4	-0.00453	-0.0170	-0.0171
Coal × Negative × L4		0.0210	0.0212
NG × L4	-0.0122*	-0.0115	-0.0112
NG × Negative × L4		0.00872	0.00819
Oil × L4	0.0851**	0.0618	0.0557
Oil × Negative × L4		0.0277	0.0343
Coal × L5	-0.00915	-0.00274	-0.00368
Coal × Negative × L5		-0.0132	-0.0107
NG × L5	-0.0143**	-0.0240	-0.0235
NG × Negative × L5		0.0146	0.0134
Oil × L5	-0.0428	-0.167***	-0.171***
Oil × Negative × L5		0.162*	0.165*
Coal × L6	-0.00277	0.0271	0.0258
Coal × Negative × L6		-0.0261	-0.0249
NG × L6	0.0225***	0.0167	0.0171
NG × Negative × L6		0.00657	0.00527
Oil × L6	0.0170	-0.0972*	-0.102*
Oil × Negative × L6		0.188*	0.192*
Observations	61598	53091	53091
Month FE	Yes	Yes	Yes
Owner FE	No	No	Yes
Adjusted R^2	0.208	0.216	0.212

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

Table A3: Regression Results: Regulated versus Deregulated for Coal Purchases

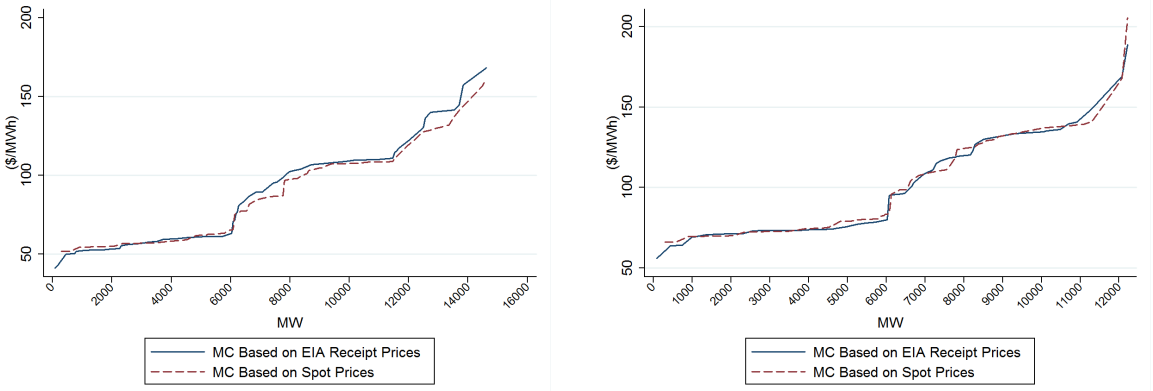
	(1)	(2)	(3)
PRB × L0	0.00692	0.00992	0.0101
PRB × Dereg × L0		-0.0140	-0.0127
CAPP × L0	0.0138	0.0209	0.0208
CAPP × Dereg × L0		-0.0404	-0.0406
IL × L0	-0.0274	-0.0251	-0.0261
IL × Dereg × L0		-0.00194	-0.00375
PRB × L1	0.00869	0.0124	0.0124
PRB × Dereg × L1		-0.0159	-0.0147
CAPP × L1	0.0612***	0.0536**	0.0532**
CAPP × Dereg × L1		0.0413	0.0411
IL × L1	0.0493**	0.0475**	0.0469**
IL × Dereg × L1		0.0146	0.0120
PRB × L2	0.0262	0.0224	0.0223
PRB × Dereg × L2		0.0174	0.0185
CAPP × L2	0.0364*	0.0275	0.0274
CAPP × Dereg × L2		0.0550	0.0536
IL × L2	0.00440	0.0146	0.0143
IL × Dereg × L2		-0.207***	-0.211***
PRB × L3	0.000360	0.00461	0.00450
PRB × Dereg × L3		-0.0209	-0.0198
CAPP × L3	0.0164	0.0106	0.0104
CAPP × Dereg × L3		0.0327	0.0330
IL × L3	0.0793***	0.0716**	0.0711**
IL × Dereg × L3		0.190	0.187
PRB × L4	-0.00160	-0.00156	-0.00163
PRB × Dereg × L4		0.000661	0.00199
CAPP × L4	-0.0256	-0.0229	-0.0232
CAPP × Dereg × L4		-0.0198	-0.0195
IL × L4	-0.0168	-0.0155	-0.0164
IL × Dereg × L4		-0.129	-0.130
PRB × L5	-0.0103	-0.0104	-0.0107
PRB × Dereg × L5		0.000531	0.00185
CAPP × L5	0.0203	0.0256	0.0257
CAPP × Dereg × L5		-0.0245	-0.0248
IL × L5	-0.0211	-0.0283	-0.0291
IL × Dereg × L5		0.255***	0.254***
PRB × L6	-0.00355	-0.00140	-0.00169
PRB × Dereg × L6		-0.0113	-0.0102
CAPP × L6	0.0176	0.0184	0.0186
CAPP × Dereg × L6		-0.00350	-0.00330
IL × L6	-0.0117	-0.00550	-0.00615
IL × Dereg × L6		-0.233*	-0.233*
Observations	22288	22288	22288
Month FE	Yes	Yes	Yes
Owner FE	No	No	Yes
Adjusted R^2	0.014	0.014	0.008

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

Table A4: Regression Results: (+) versus (-) Shocks for Coal Purchases

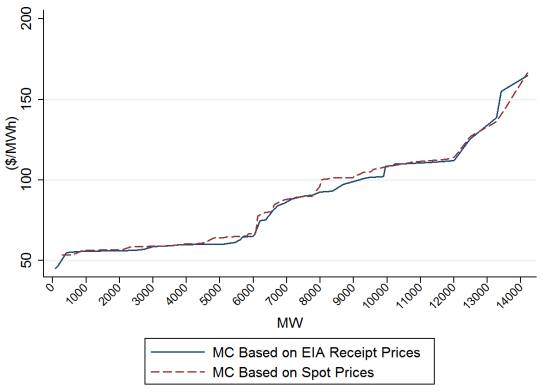
	(1)	(2)	(3)
PRB × L0	0.00692	0.0332	0.0321
PRB × Negative × L0		-0.0842	-0.0846
CAPP × L0	0.0138	0.00700	0.0160
CAPP × Negative × L0		-0.00664	-0.0146
IL × L0	-0.0274	-0.147	-0.151
IL × Negative × L0		0.544*	0.527*
PRB × L1	0.00869	0.0472	0.0453
PRB × Negative × L1		-0.0587	-0.0564
CAPP × L1	0.0612***	-0.0122	-0.00960
CAPP × Negative × L1		0.184***	0.185***
IL × L1	0.0493**	0.138	0.113
IL × Negative × L1		-0.246	-0.208
PRB × L2	0.0262	0.0102	0.00782
PRB × Negative × L2		0.0739	0.0777
CAPP × L2	0.0364*	0.0873***	0.0897***
CAPP × Negative × L2		-0.149**	-0.147**
IL × L2	0.00440	0.0640	0.0673
IL × Negative × L2		-0.314	-0.353
PRB × L3	0.000360	-0.0588*	-0.0608**
PRB × Negative × L3		0.0784	0.0800
CAPP × L3	0.0164	0.0506	0.0527
CAPP × Negative × L3		-0.0779	-0.0763
IL × L3	0.0793***	-0.0764	-0.0708
IL × Negative × L3		0.0825	0.0235
PRB × L4	-0.00160	-0.0499**	-0.0520**
PRB × Negative × L4		0.104**	0.109**
CAPP × L4	-0.0256	0.0197	0.0186
CAPP × Negative × L4		-0.101	-0.0985
IL × L4	-0.0168	0.0511	0.0457
IL × Negative × L4		-0.178	-0.192
PRB × L5	-0.0103	0.0164	0.0151
PRB × Negative × L5		-0.0720	-0.0708
CAPP × L5	0.0203	0.0103	0.00902
CAPP × Negative × L5		0.0828	0.0869
IL × L5	-0.0211	0.0495	0.0483
IL × Negative × L5		-0.946	-0.923
PRB × L6	-0.00355	0.0121	0.0102
PRB × Negative × L6		0.0152	0.0192
CAPP × L6	0.0176	0.0735*	0.0723*
CAPP × Negative × L6		-0.0834	-0.0857
IL × L6	-0.0117	-0.0640	-0.0478
IL × Negative × L6		0.482	0.424
Observations	22288	13781	13781
Month FE	Yes	Yes	Yes
Owner FE	No	No	Yes
Adjusted R^2	0.014	0.014	0.005

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

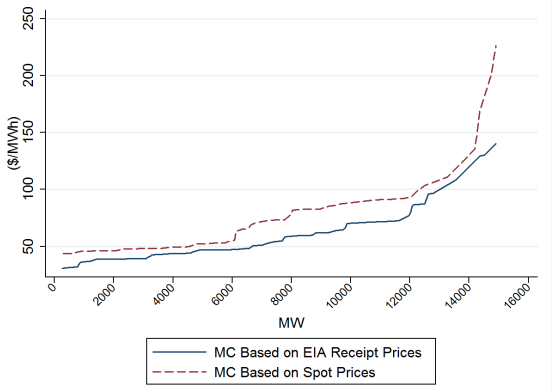


(a) January

(b) April

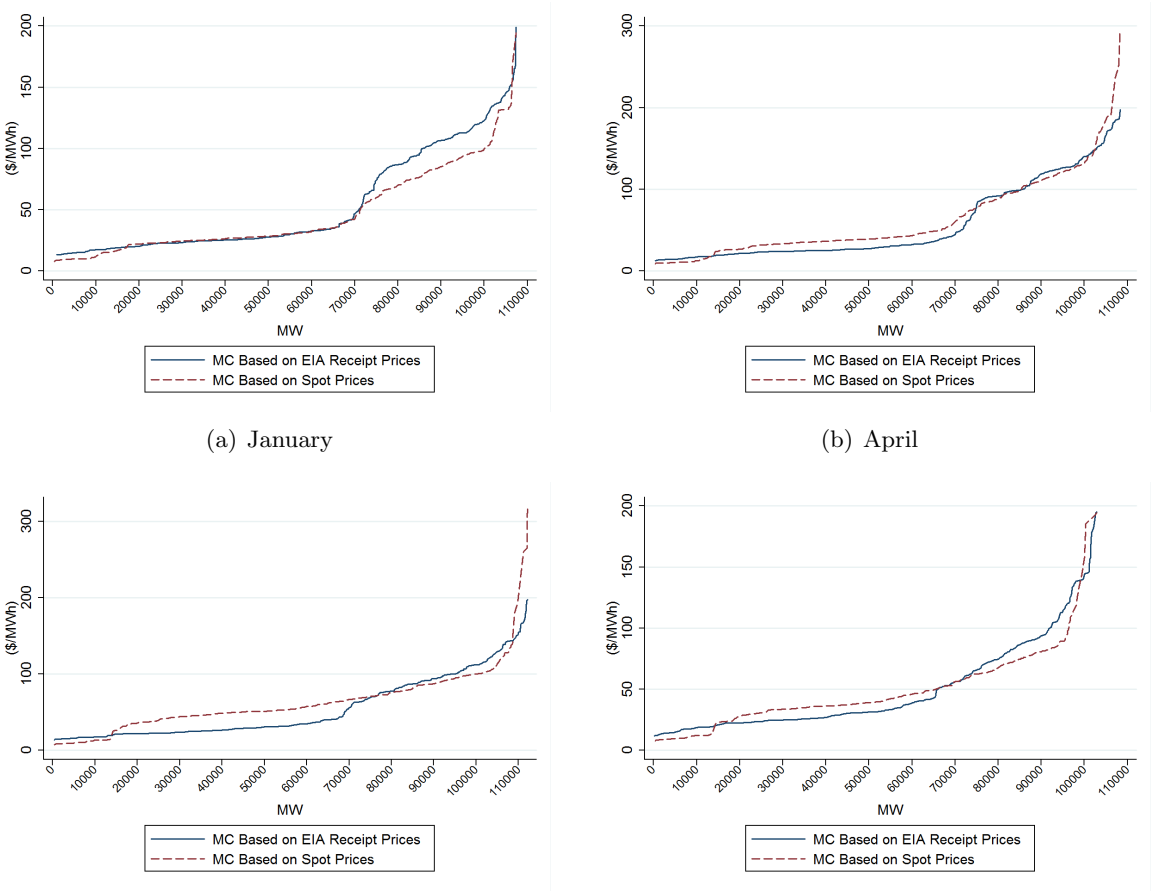


(c) August



(d) October

Figure A3: Constructed Counterfactual Supply Curves: CAISO 2008

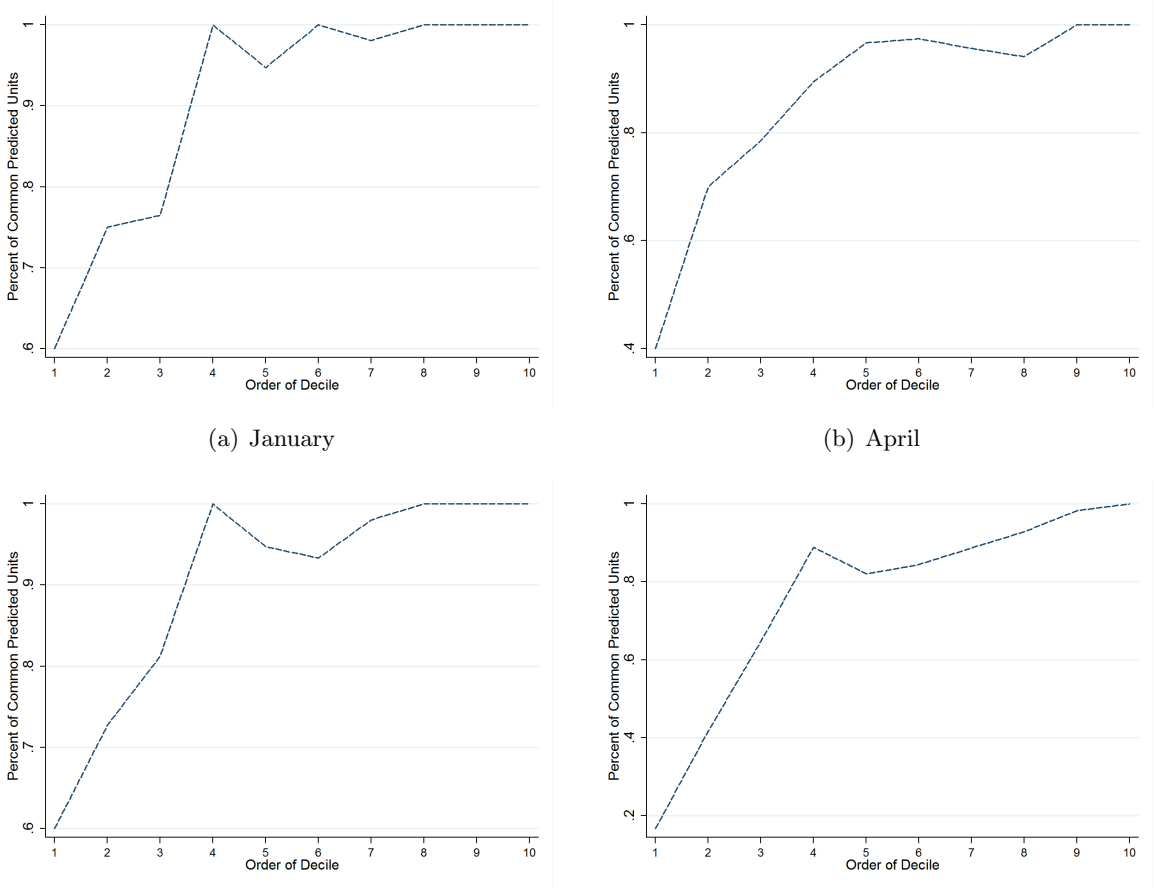


(a) January (b) April

(c) August (d) October

Figure A4: Constructed Counterfactual Supply Curves: PJM 2008

Note: units with abnormally high marginal costs (above 200 $/MWh) are excluded for better visualization.

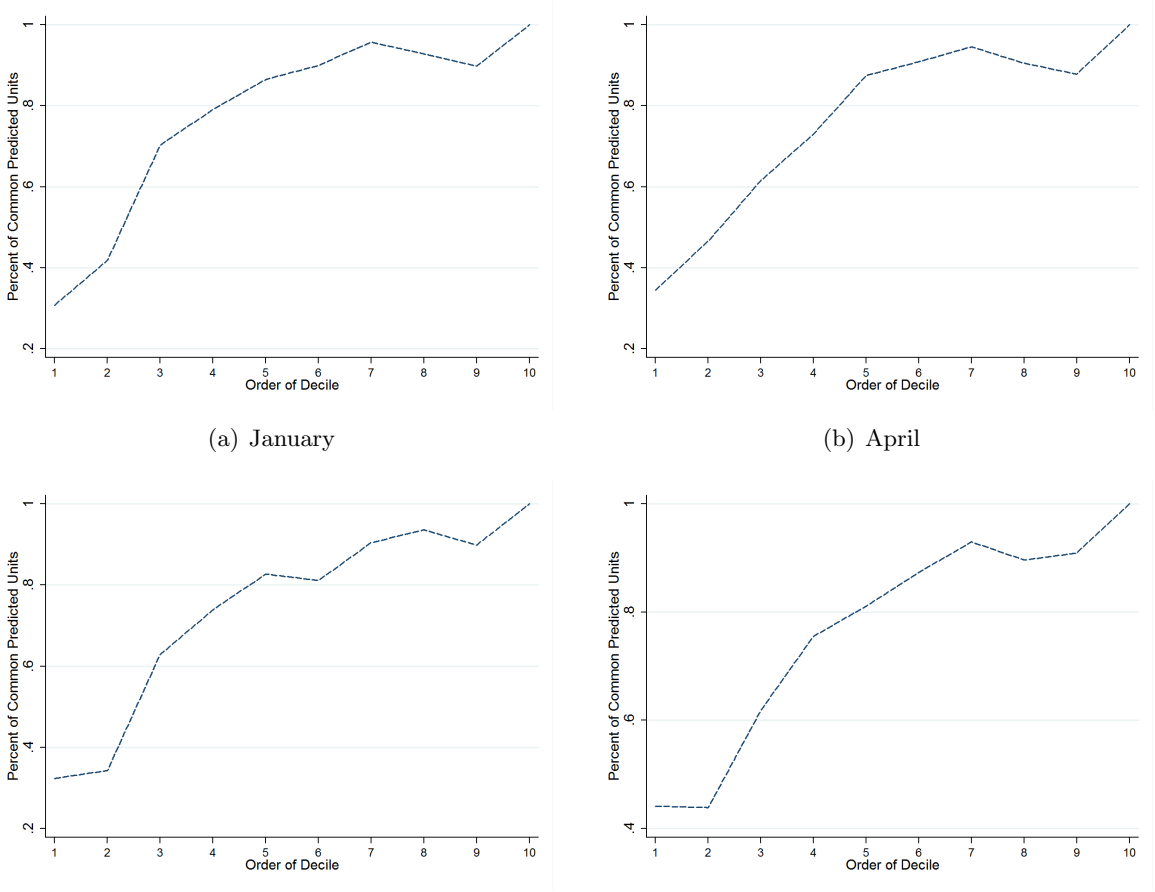


(a) January (b) April

(c) August (d) October

Figure A5: Dispatch Algorithm Comparison: CAISO 2008

Note: the graphs show the percent of commonly predicted units online under two models, weighted by the number under the spot-price model, at different demand levels (deciles of regional capacity levels) under two models in CAISO.



(a) January

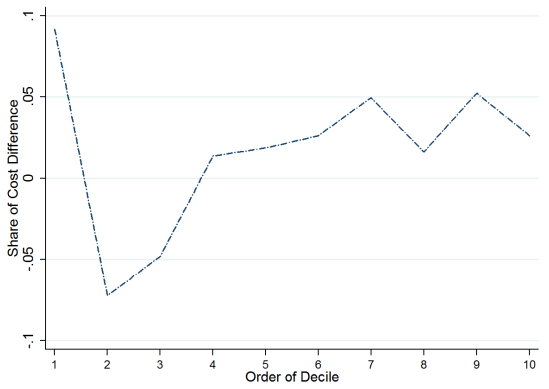
(b) April

(c) August

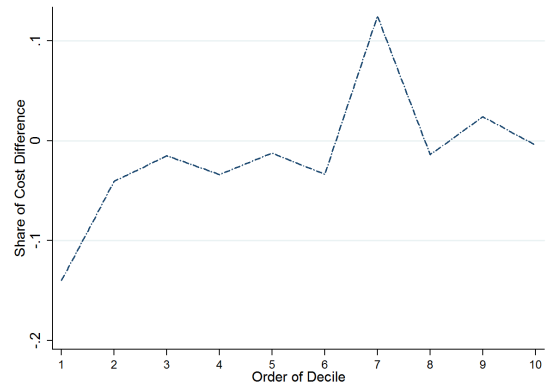
(d) October

Figure A6: Dispatch Algorithm Comparison: PJM 2008

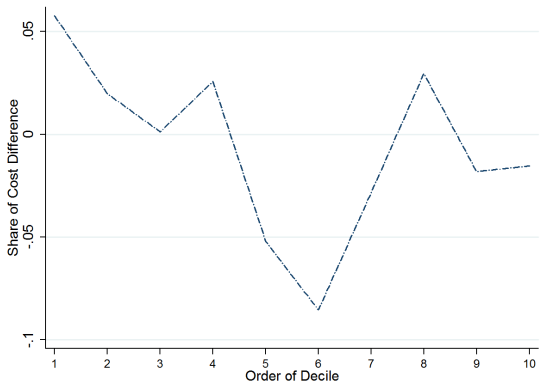
Note: the graphs show the percent of commonly predicted units online under two models, weighted by the number under the spot-price model, at different demand levels (deciles of regional capacity levels) in PJM.



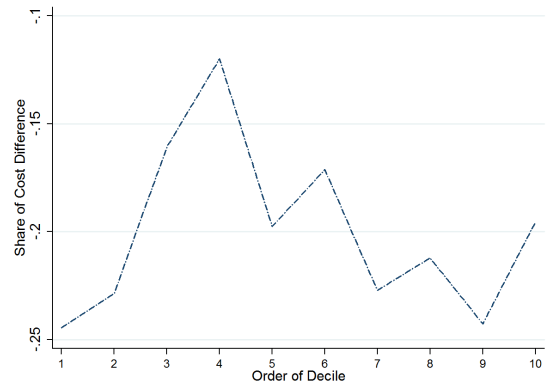
(a) January



(b) April

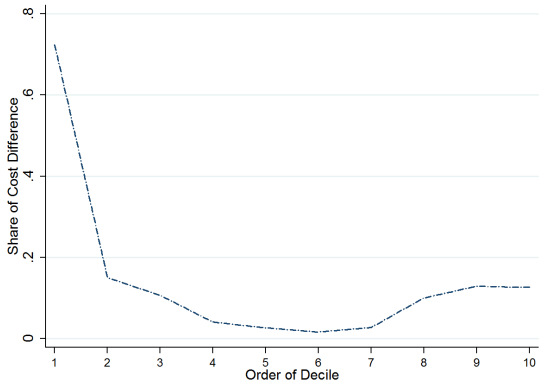


(c) August

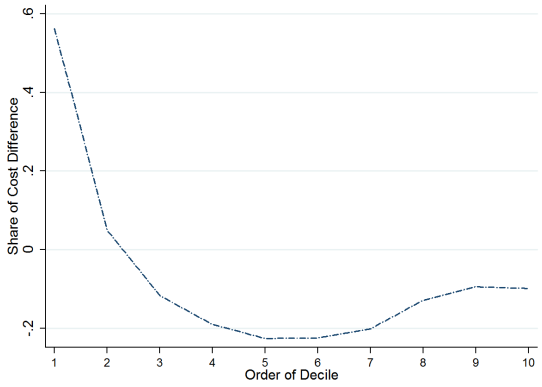


(d) October

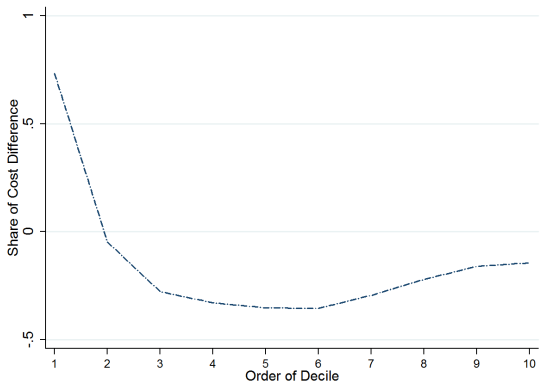
Figure A7: Total Cost Differences: CAISO 2008



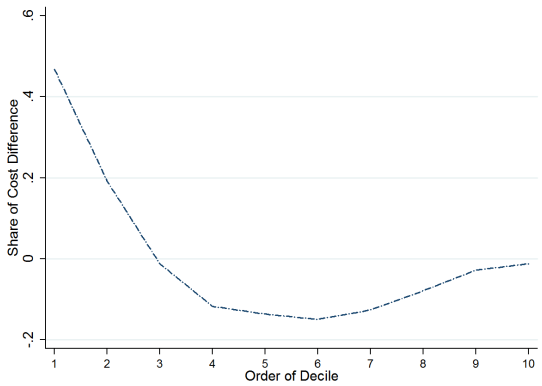
(a) January



(b) April



(c) August



(d) October

Figure A8: Total Cost Differences: PJM 2008