1. APPENDIX

1.1. Service Classification

This study included 131 specific services that are eligible for rewards incentives payments. We grouped these procedures into nine procedure categories—imaging procedures (CT scans, mammograms, MRIs, ultrasounds, and other imaging procedures) and invasive procedures (endoscopy, minor procedures, moderate procedures, and major procedures). The classification for each procedure is presented in Appendix Exhibit 1.

1.2. Distribution of 75th and 25th Price Percentiles

For each service grouping, we calculated the 75th and 25th price percentiles for each Metropolitan Statistical Area (MSA) in 2016. We used the combined intervention and comparison populations to calculate the price percentiles. Appendix Exhibit 2 presents the distribution of these ratios. The mean price ratios range from 1.77 for mammograms to 5.86 for non-classified imaging services. Across all procedures, the ratio is 3.48, which means that on average, the 75th percentile price is 2.48 times higher than the 25th percentile price for the same procedure in the same geographic market.

1.3. Unadjusted Price Trend Calculation

To calculate the unadjusted price trends, we calculated the monthly average price for each covered service in the intervention and comparison group. For both populations, we then weighted these average prices using the volume of services observed among the combined populations in 2016. Thus, the unadjusted price trends measure the change in service prices after holding utilization constant to 2016 levels.

1.4. Regression-Adjusted Trends

To measure regression-adjusted price trends, we estimated a difference-in-difference regression that included interaction terms between the intervention population indicator and each quarter. We used the fourth quarter of 2016, the quarter prior to implementation of the rewards program, as the reference group. This regression model thus provides the quarterly difference in prices between the intervention and comparison group. We assessed these price differences in the pre-implementation period to test for pre-implementation trends that may invalidate the necessary assumptions for our difference-in-differences model and in the post-implementation period to test for changes in the association with increasing exposure to the program.

We estimated the regression-adjusted price trend differences for each of the nine service groupings. For the secondary outcomes (choice of lower-priced provider and utilization), we pooled the services. We measured the use of rewards-eligible services at the year-level.

1.5. Multivariate Difference-in-Difference Analysis

To measure the impact of the rewards program on our three outcomes (price, choice of lower-priced provider, and utilization), we used a linear regression to estimate a difference-in-difference regression model of the following form:

$$y_{ijtk} = \alpha + \beta_1 post_t \times treatment_j + \beta_2 employer_j + \beta_3 time_t + \beta_4 X_{it} + \beta_5 CPT_k + \varepsilon_{ijtk} \quad (1)$$

In this equation, y_{ijtk} represents our outcomes of interest (i.e., service price, choice of lower-price provider, and utilization) for patient i who receives benefits from employer j in year t. The g and k terms index geographic market and service, respectively. The β_1 coefficient on the $post_t \times treatment_j$ interaction term of the post-rewards period (2017) and an indicator for the employers that have implemented the rewards program will provide our estimate of the effects of rewards. We do not include an independent

$post_t$ term because the model includes a time term for each year. Likewise, we do not include a main $treatment_j$ term because we include employer fixed effects.

X_{it} includes patient controls (age and gender). We also included fixed effects for each service's CPT code, which allows us to control for time-invariant differences in prices between services. We iteratively added fixed effects for Metropolitan Statistical Area (MSA). As sensitivity tests, we also included fixed effects that interact each CPT code and year to account for CPT code-specific time trends. As shown in Appendix Exhibit 3, adding additional controls does not meaningfully change the results. We were not able to include these interactions when using the annual utilization and spending dependent variables.

1.6. Changes in Provider Prices

One potential concern with our analysis is the possibility that providers lower prices for the intervention population due to the implementation of the rewards program. If these provider price changes do not also apply to the comparison population, then the price changes we estimate may not reflect evidence of price shopping. As a test of this scenario, we estimated a similar model as equation (1), but included provider fixed effects. The provider fixed effects allow us to estimate a *within-provider* change in price between the intervention and comparison population following the implementation of the rewards program.

As shown in Appendix Exhibit 6, we do not find that provider prices changed differentially for the intervention and comparison population. Regardless of the inclusion of controls, the difference-in-difference coefficients are small in magnitude and are not statistically significant.

Appendix Exhibit 1: Service Classification

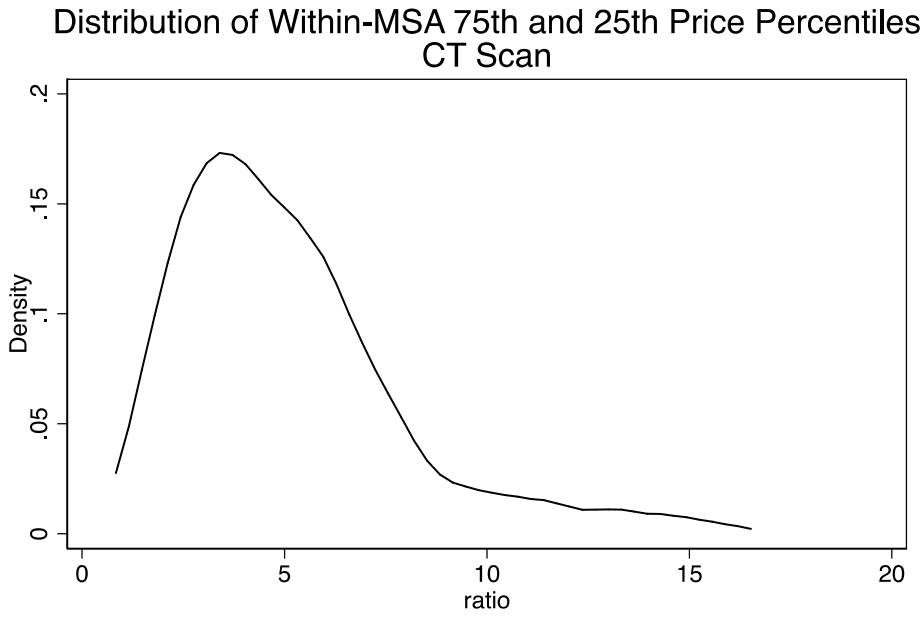
Service	Category
CT Abdomen & Pelvis w/ contrast	CT Scan
CT Scan Head/Brain w/o contrast	CT Scan
CT Abdomen & Pelvis w/o contrast	CT Scan
CT Scan Chest w/ contrast	CT Scan
CT Scan of Mouth, Jaw, and Neck w/o contrast	CT Scan
CT Scan Chest w/o contrast	CT Scan
CT Angiography Chest	CT Scan
CT Abdomen & Pelvis w/o & w/ contrast	CT Scan
CT Soft Tissue Neck w Dye	CT Scan
CT Scan of Lumbar Lower Spine w/o contrast	CT Scan
CT angiography neck w/ and w/o contrast	CT Scan
CT lower extremity w/o Contrast	CT Scan
CT Scan Abdomen w/ contrast	CT Scan
CT scan for needle biopsy	CT Scan
CT Scan Abdomen w/o & w/ contrast	CT Scan
CT Scan Chest w/o & w/ contrast	CT Scan
CT Scan Head/Brain w/o & w/ contrast	CT Scan
CT Scan of Lumbar Lower Spine w/ contrast	CT Scan
CT Scan Pelvis w/o contrast	CT Scan
CT Scan Abdomen w/o contrast	CT Scan
CT Angiography, Head w/o & w/ contrast	CT Scan
CT Scan of Mouth, Jaw, and Neck w/ contrast	CT Scan
CT Scan Pelvis w/contrast	CT Scan
CT Angiography, Abdomen and Pelvis w/o & w/ contrast	CT Scan
CT lower extremity w/ Contrast	CT Scan
CT Scan Head/Brain w/ contrast	CT Scan
CT Angiography, Abdomen w/o & w/ contrast	CT Scan
CT Scan Pelvis w/o & w/ contrast	CT Scan
CT Scan of Mouth, Jaw, and Neck w/o & w/ contrast	CT Scan
CT Scan of Lumbar Lower Spine w/o & w/ contrast	CT Scan
CT lower extremity w/ & w/o Contrast	CT Scan
Upper GI Endoscopy with Biopsy	Endoscopy
Screening Colonoscopy	Endoscopy
Colonoscopy with Biopsy	Endoscopy
Colonoscopy with Removal of Lesion(s) or polyp(s)	Endoscopy
Upper GI Endoscopy	Endoscopy
Sigmoidoscopy	Endoscopy
MRI Lower Limb with Joint w/o contrast	MRI
MRI Lumbar Spine w/o contrast	MRI
MRI Brain w/o & w/ contrast	MRI
MRI Neck Spine w/o contrast	MRI
MRI Brain w/o contrast	MRI
MRI Upper Limb Joint w/o contrast	MRI
MRI Abdomen w/o & w/ contrast	MRI
MRI Lower Limb w/o contrast	MRI
MR Angiography Head wo Dye	MRI
MRI Lumbar Spine w/o & w/ contrast	MRI
MRI Neck Spine w/o & w/ contrast	MRI
MRI Spine w/o contrast	MRI
MRI Pelvis w/o & w/ contrast	MRI
MRI Both Breasts	MRI
MRI Spine w/o & w/ contrast	MRI
MRI of Head (Orbit/Face/Neck) w/o & w/ contrast	MRI
MRI Upper Limb Joint w/ contrast	MRI
MRI Abdomen w/o contrast	MRI

MRI Pelvis w/o contrast	MRI
MRI Lower Limb w/o & w/ contrast	MRI
MRI Upper Limb (Other Than Joint) w/o contrast	MRI
MRI Lower Limb with Joint w/ contrast	MRI
MRI Lower Limb with Joint w/o & w/ contrast	MRI
MRI Upper Limb Joint w/o & w/ contrast	MRI
MRI Brain w/ contrast	MRI
MRI Upper Limb (Other Than Joint) w/o contrast & w/contrast	MRI
MRI of Head (Orbit/Face/Neck) w/o contrast	MRI
MRI Lumbar Spine w/ contrast	MRI
MRI Neck Spine w/ contrast	MRI
MRI Pelvis w/ contrast	MRI
MRI One Breast	MRI
MRI Lower Limb w/ contrast	MRI
MRI Spine w/ contrast	MRI
MRI Abdomen w/ contrast	MRI
MRI of Head (Orbit/Face/Neck) w/ contrast	MRI
Mammogram, Digital Screening of Two Breasts	Mammogram
Mammogram, Digital Diagnostic of One Breast	Mammogram
Mammogram, Digital Diagnostic of Two Breasts	Mammogram
Bone Density study of Spine or Pelvis	Other Imaging
PET Scan Image w/ CT from Skull base to Mid-Thigh	Other Imaging
Bone and Joint Scan of Whole Body	Other Imaging
PET Scan Image w/ CT of Whole Body	Other Imaging
Hip Replacement	Procedure - Major
Bariatric Surgery - Laparoscopic	Procedure - Major
Hysterectomy	Procedure - Major
Spinal Fusion (Posterior)	Procedure - Major
Cardiac Angioplasty - w/ Drug Eluting Stent	Procedure - Major
Spinal Fusion (Anterior)	Procedure - Major
Knee Replacement – Partial	Procedure - Major
Laminectomy - Inpatient	Procedure - Major
Bariatric Surgery (Lap Band)	Procedure - Major
Revision of Total Hip or Total Knee Replacement	Procedure - Major
Partial or Total Removal of Thyroid Gland	Procedure - Major
Urethra and Bladder Scope	Procedure - Minor
Breast Biopsy w/Imaging	Procedure - Minor
Tympanostomy and Myringotomy	Procedure - Minor
Bladder Scope with Stent	Procedure - Minor
Bronchoscopy	Procedure - Minor
Bladder Scope with Lithotripsy (Kidney Stone fragmentation)	Procedure - Minor
Cataract Removal	Procedure - Moderate
Knee Arthroscopy with Cartilage Repair	Procedure - Moderate
Laparoscopic Gall Bladder Removal	Procedure - Moderate
Nasal/Sinus - Endoscopy - Sinus Surgery	Procedure - Moderate
Hysteroscopy Uterine Tissue Sample (with Biopsy, with or without D&C)	Procedure - Moderate
Tonsillectomy and/or Adenoidectomy, Under Age 12	Procedure - Moderate
Nasal/Sinus - Corrective Surgery - Septoplasty	Procedure - Moderate
Nasal/Sinus - Submucous Resection Inferior Turbinate	Procedure - Moderate
Shoulder Arthroscopy	Procedure - Moderate
Tonsillectomy and Adenoidectomy, Over Age 12	Procedure - Moderate
Hysteroscopy with Removal of Lesion(s) or Uterine Lining (e.g. Endometrial)	Procedure - Moderate
Carpal Tunnel	Procedure - Moderate
Lithotripsy - Fragmenting of Kidney Stones	Procedure - Moderate
Laparoscopic Removal of Ovaries and/or Fallopian Tubes	Procedure - Moderate
Shoulder Arthroscopy with Rotator Cuff Repair	Procedure - Moderate
Bunionectomy	Procedure - Moderate

Hammertoe Correction	Procedure - Moderate
Breast Lumpectomy	Procedure - Moderate
Hernia Inguinal Repair (Age 5+, Non-Laparoscopic)	Procedure - Moderate
Repair of Umbilical Hernia (Age 5+)	Procedure - Moderate
Repair of Laparoscopic Inguinal Hernia	Procedure - Moderate
Bladder Repair For Incontinence (Sling)	Procedure - Moderate
Carpal Tunnel with Scope	Procedure - Moderate
Tympanoplasty (ear drum repair)	Procedure - Moderate
Total Thyroid Removal	Procedure - Moderate
Laparoscopic Tubal Block or Tubal Ligation	Procedure - Moderate
Rotator Cuff Repair (Surgical, Non-Arthroscopic)	Procedure - Moderate
Hysteroscopy and Sterilization (Tubal Ligation)	Procedure - Moderate
Ultrasound of Breast(s)	Ultrasound
Ultrasound of Abdomen	Ultrasound
Ultrasound Exam of Abdomen	Ultrasound
Ultrasound Exam Scrotum	Ultrasound
Ultrasound of Abdomen & Back	Ultrasound
Ultrasound of Head and Neck	Ultrasound
Ultrasound of Pelvis	Ultrasound

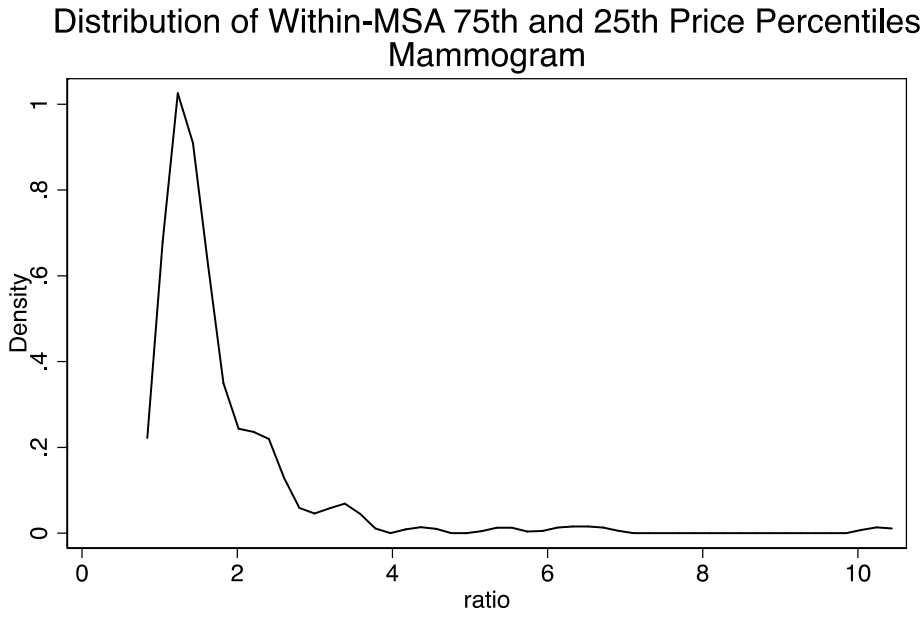
Appendix Exhibit 2: Distribution of Within-Market 75th and 25th Price Percentile Ratios

(a) CT Scan



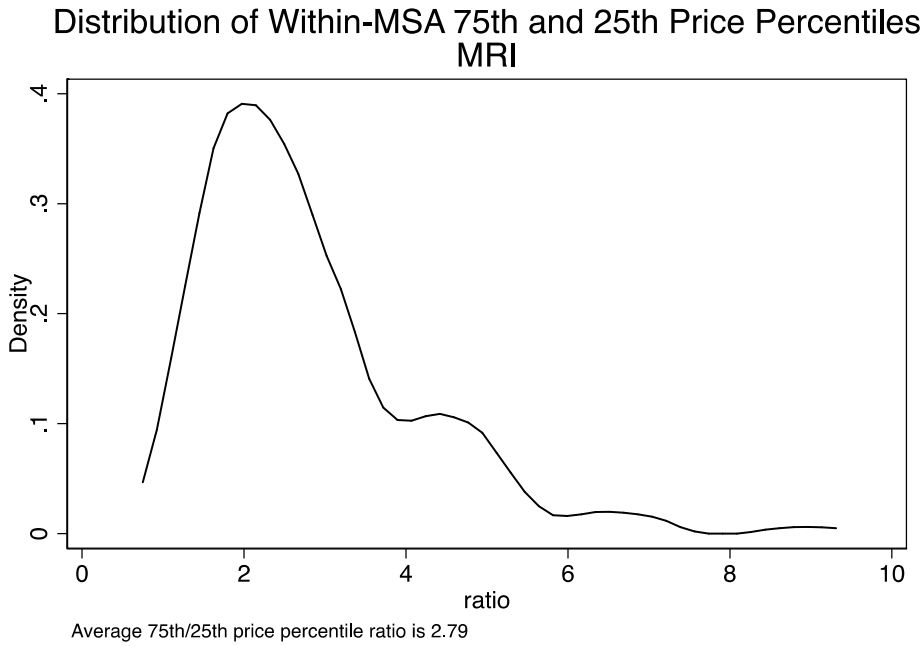
Average 75th/25th price percentile ratio is 5.11

(b) Mammogram

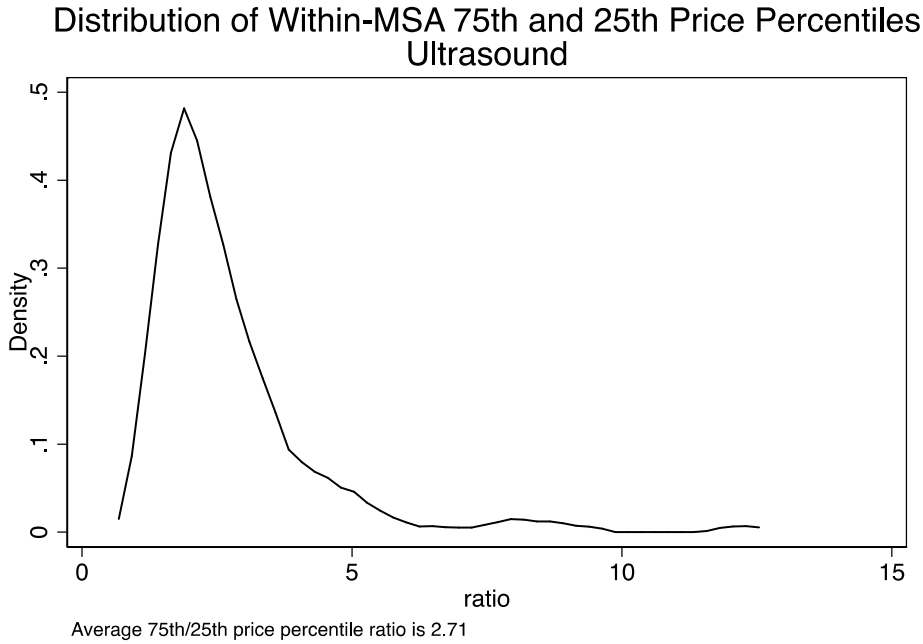


Average 75th/25th price percentile ratio is 1.77

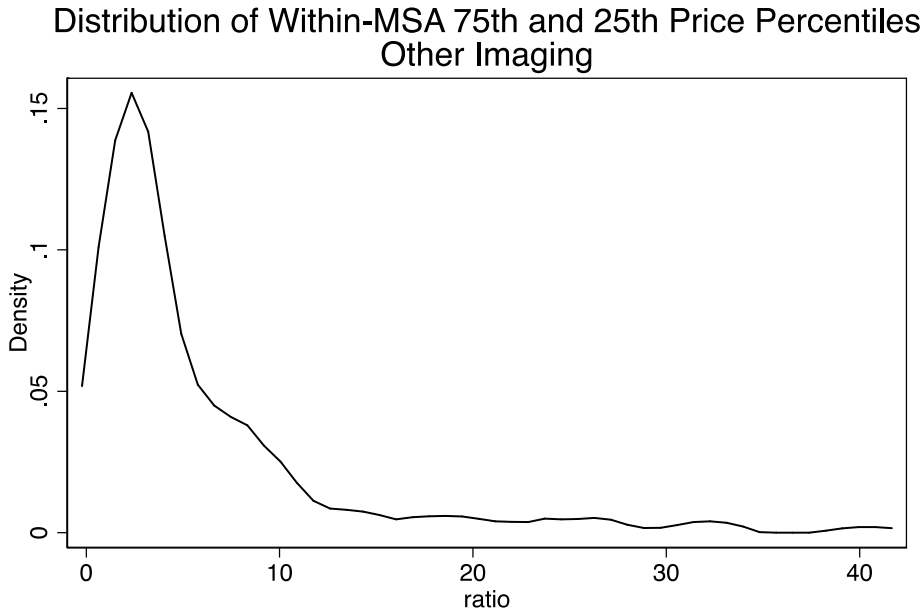
(c) MRI



(d) Ultrasound

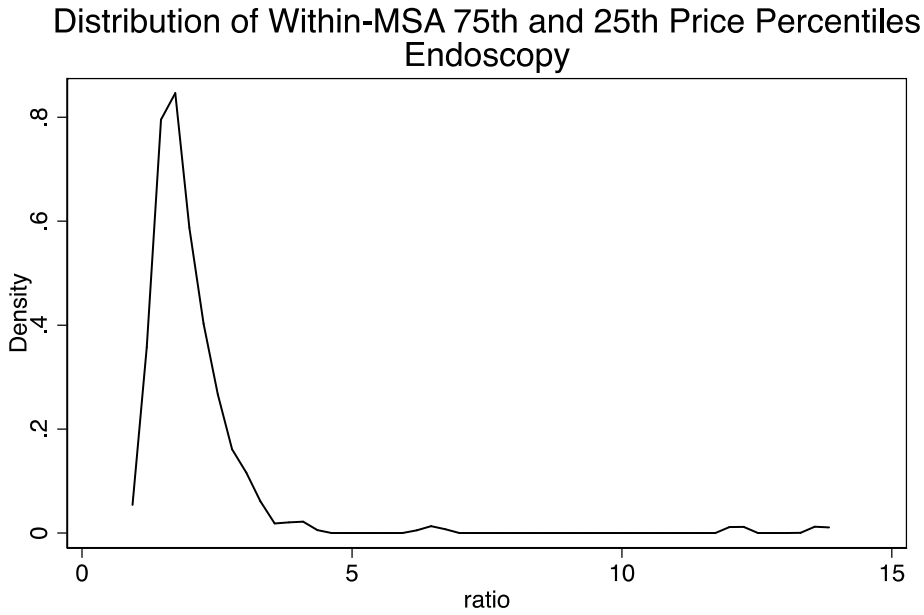


(e) Other Imaging



Average 75th/25th price percentile ratio is 5.88

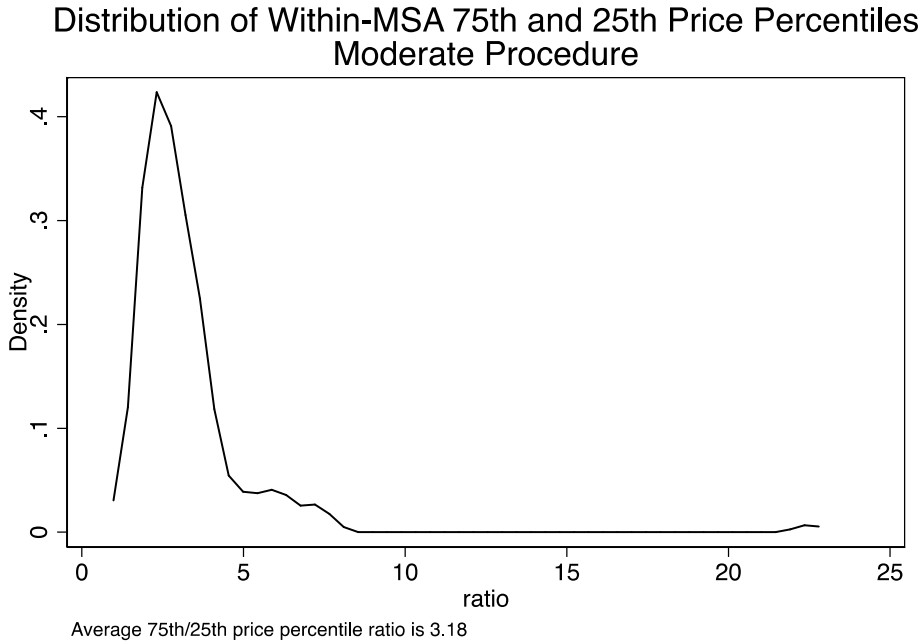
(f) Endoscopy



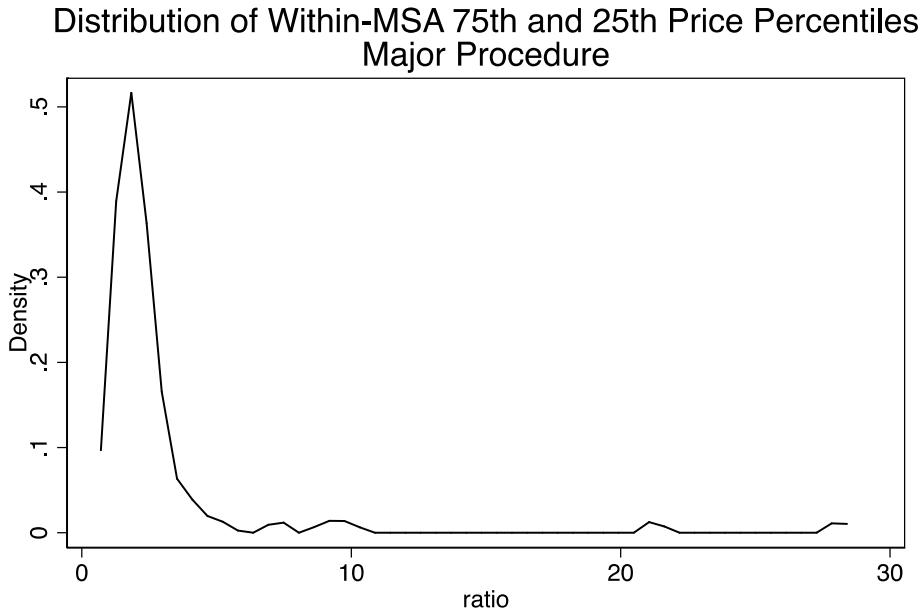
Average 75th/25th price percentile ratio is 2.08

(g) Minor Procedures

(h) Moderate Procedures



(i) Major Procedures



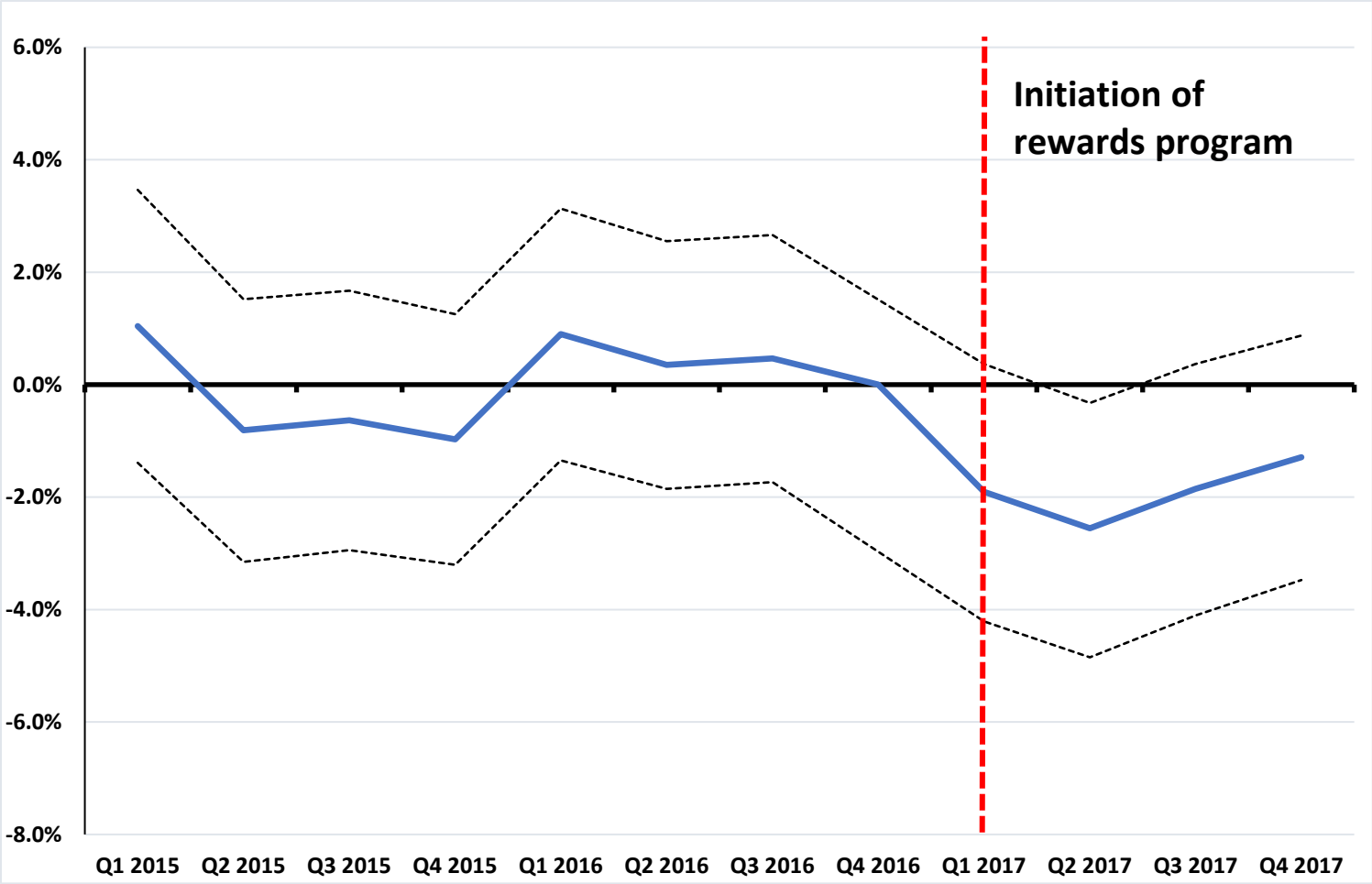
Average 75th/25th price percentile ratio is 2.84

Appendix Exhibit 3: Regression Sensitivity Test

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Log-transformed service price						
post X rewards	-0.026**	-0.022**	-0.021**	-0.023**	-0.020**	-0.024**
	(0.007)	(0.007)	(0.005)	(0.005)	(0.005)	(0.006)
R-squared	0.053	0.062	0.632	0.774	0.662	0.731
Observations	524,197	524,197	524,197	524,197	524,197	524,197
Panel B: Probability of choosing lower-priced provider						
post X rewards	0.014**	0.014**	0.013**	0.012**	0.013**	0.012***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.0034)
R-squared	0.001	0.01	0.17	0.45	0.36	
Observations	524,197	524,197	524,197	524,197	524,197	524,197
Panel C: Probability of having any rewards-eligible service in year						
post X rewards	-0.002	-0.003*	-0.003*	-0.006***	N.E.	N.E.
	(0.001)	(0.001)	(0.001)	(0.001)		
R-squared	0.10	0.11	0.11	0.17		
Observations	1,668,969	1,668,969	1,668,969	1,668,969		
Panel D: Log-transformed Annual Medical Spending						
post X rewards	-0.042*	-0.053**	-0.053**	-0.104**	N.E.	N.E.
	(0.020)	(0.020)	(0.020)	(0.020)		
R-squared	0.10	0.11	0.11	0.17		
Observations	1,668,969	1,668,969	1,668,969	1,668,969		
Regression Controls	demographics, year/month FE	+Plan FE	+CPT FE	+MSA FE	+Year X CPT FE	+Year X MSA FE

Note: * p < 0.05, ** p < 0.001. This table presents multivariate difference-in-difference regressions that iteratively add covariates. The results in column 1 include controls for patient demographic (age and gender), year fixed effects (FE), and month fixed effects. Column 2 adds plan fixed effects, column 3 adds CPT code fixed effects, column 4 adds Metropolitan Statistical Area (MSA) fixed effects. To control for CPT code- and state-specific time trends, columns 5 and 6 interact the year fixed effects with the CPT code and MSA fixed effects, respectively. Models using these interactions are non- estimable (N.E.) when using annual utilization and spending as the dependent variable, as we only have one observation per person-year. Panel A uses the log-transformed price as the dependent variable. These results can be interpreted in percentage terms by applying $\exp(\text{post X rewards}) - 1 \times 100$. Panel B uses the probability of receiving care from a lower-priced provider as the dependent variable, and Panel C estimates the probability of receiving at least one of the rewards-eligible services in each calendar year. Standard errors in parentheses.

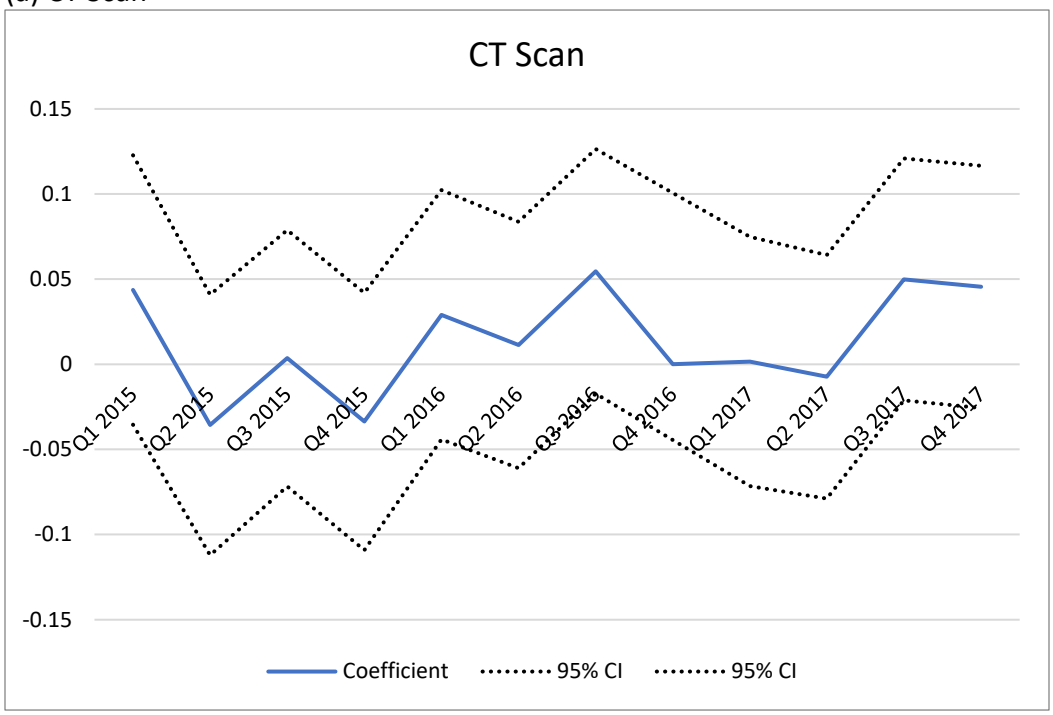
Appendix Exhibit 4: Estimated Impact of Reward Program on Relative Percent Change in Average Prices (95% CI)



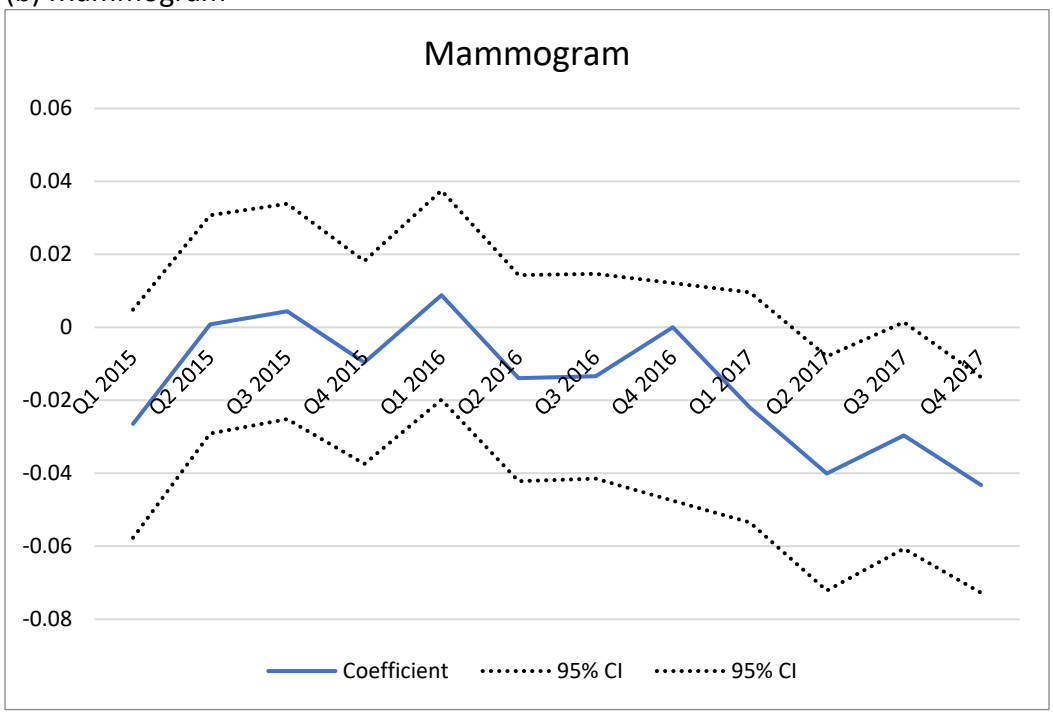
This figure shows the regression-adjusted differences in prices for all services between the intervention and comparison population during each quarter. The reference period is the last quarter of 2016. The vertical red line indicates the January 2017 implementation of the rewards program for the intervention population. The dashed horizontal lines indicate 95% confidence intervals.

Appendix Exhibit 5: Regression-Adjusted Quarterly Price Differences for Procedure-Specific Prices, Choice of Lower-Priced Provider, and Utilization Outcomes

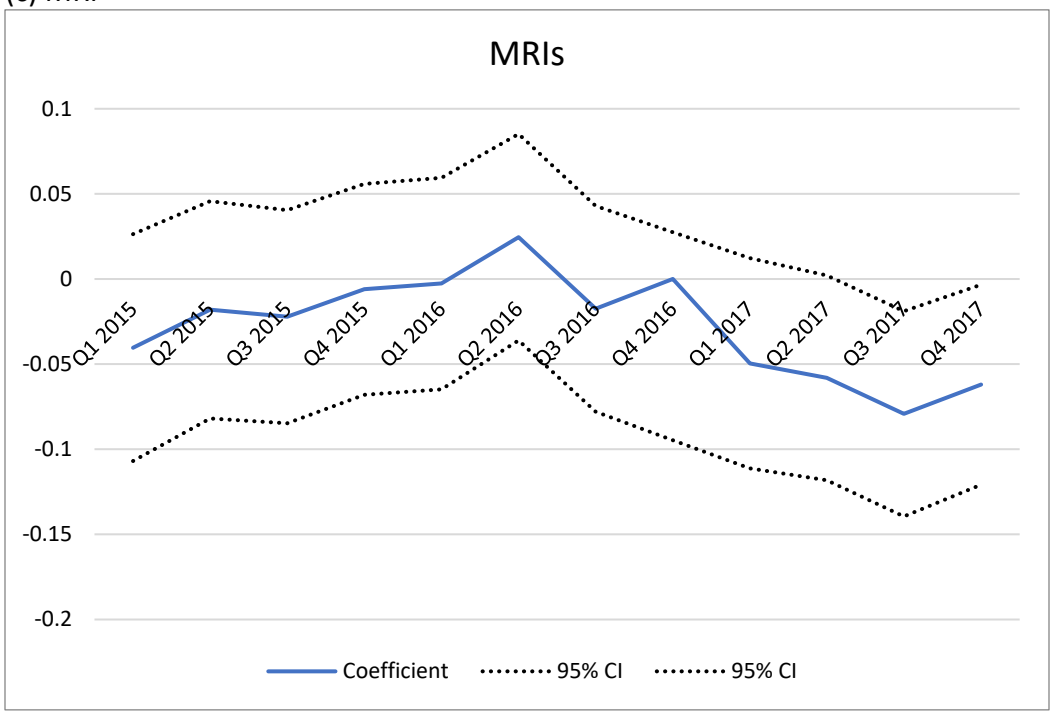
(a) CT Scan



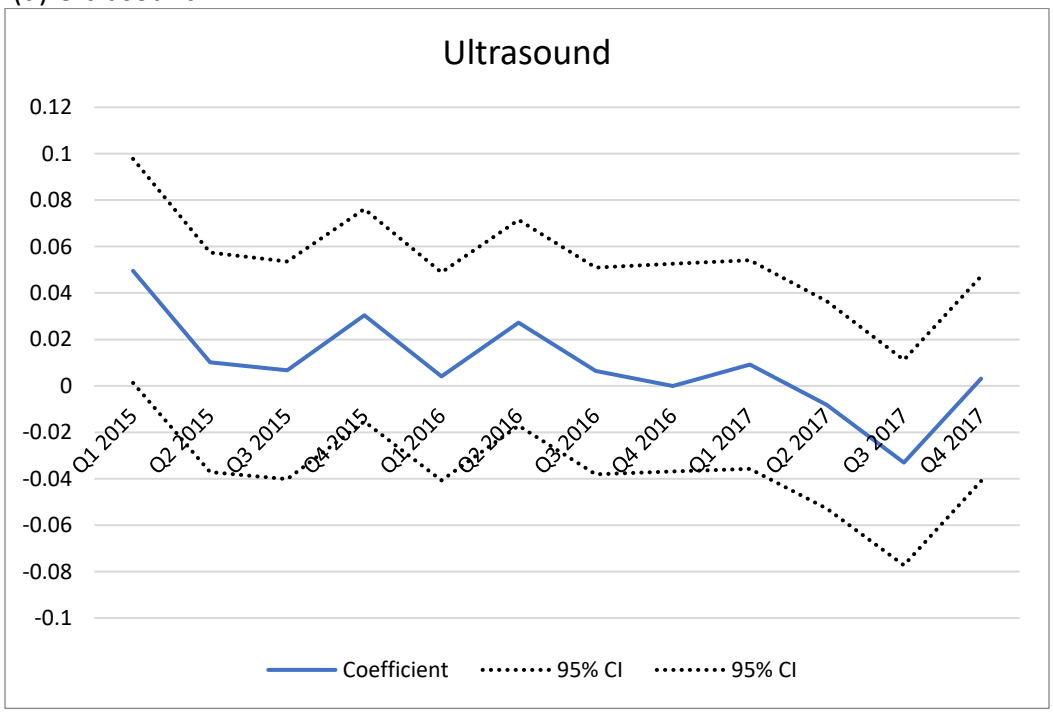
(b) Mammogram



(c) MRI

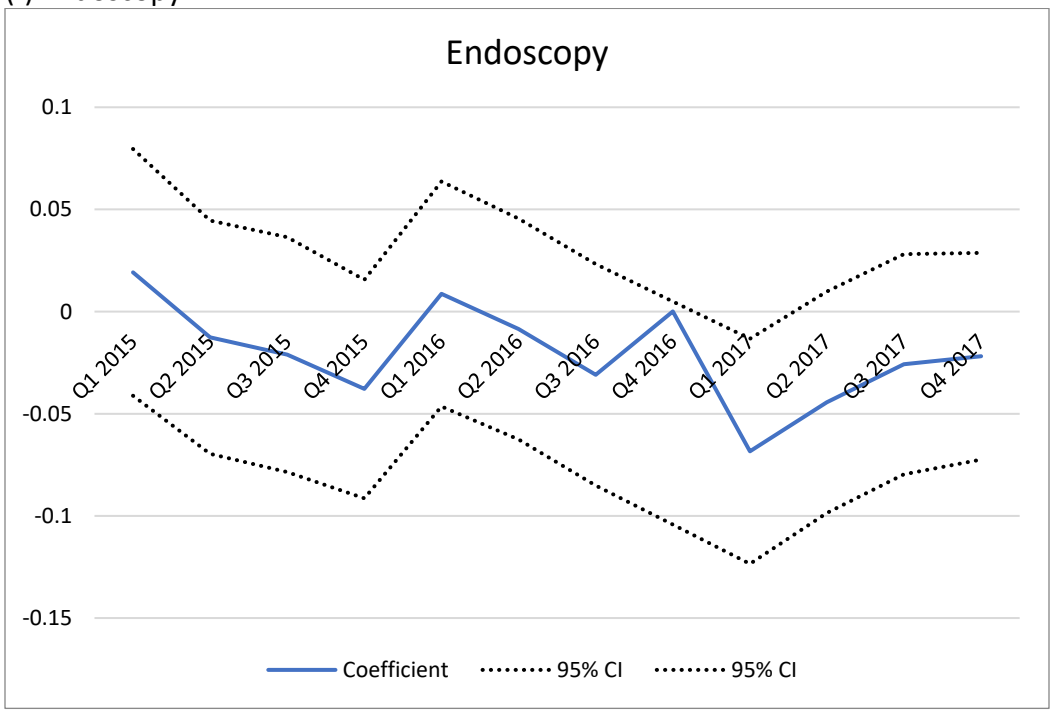


(d) Ultrasound

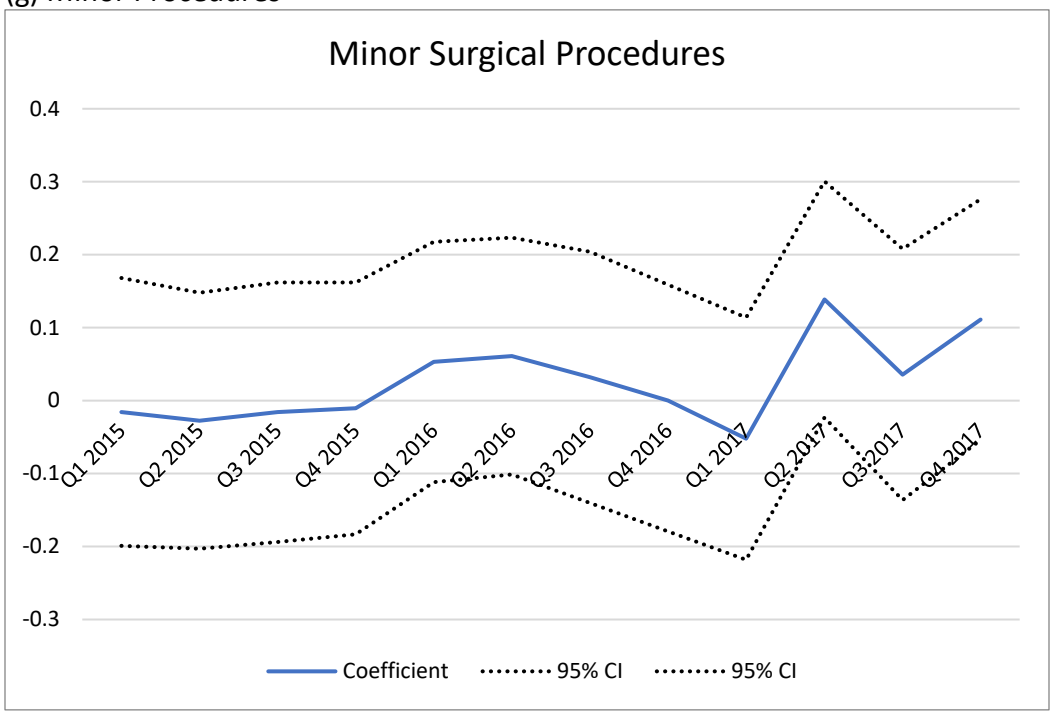


(e) Other Imaging

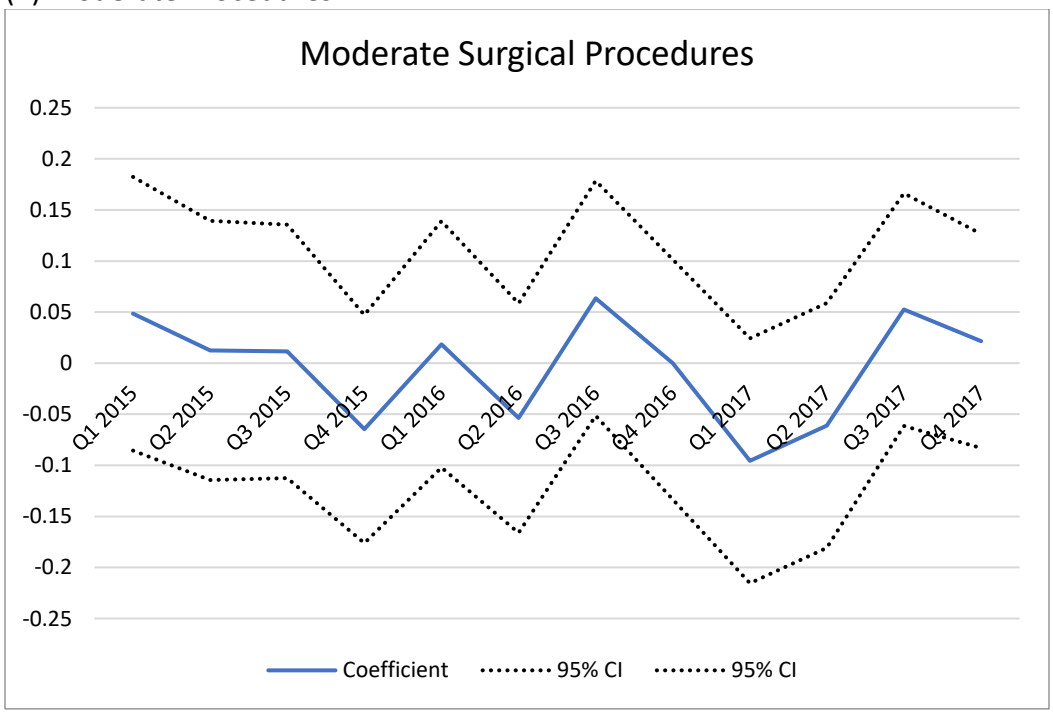
(f) Endoscopy



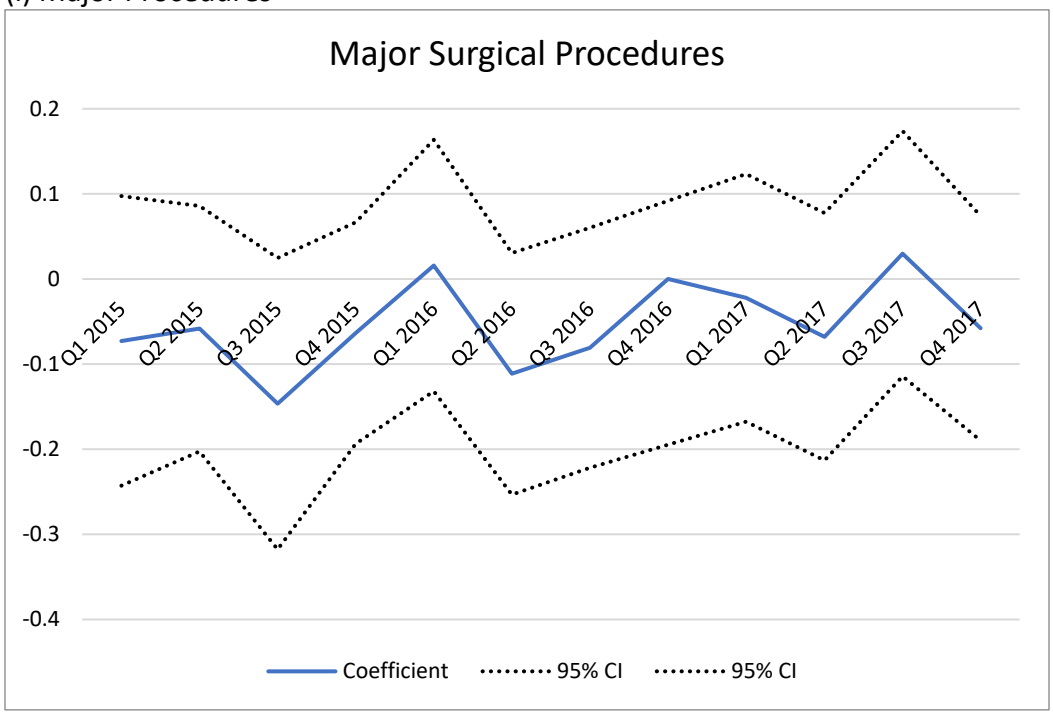
(g) Minor Procedures



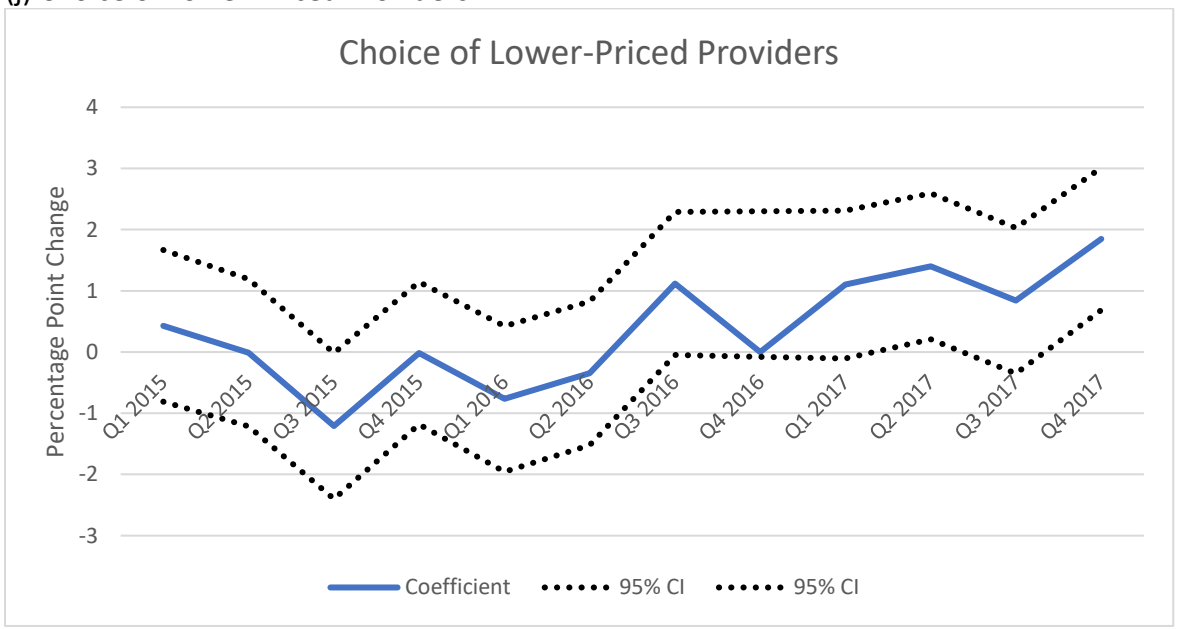
(h) Moderate Procedures



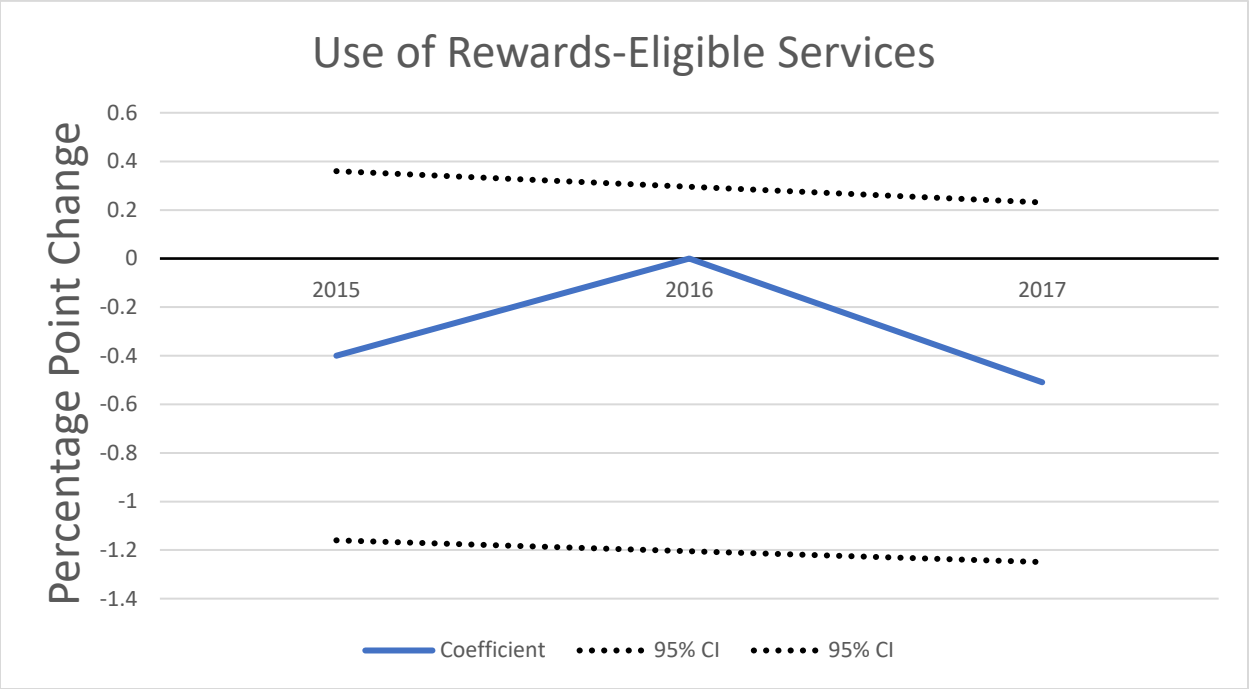
(i) Major Procedures



(j) Choice of Lower-Priced Providers



(k) Use of Rewards-Eligible Services



Appendix Exhibit 6: Test for Changes in Provider Prices

	(1)	(2)	(3)	(4)	(5)	(6)
post X rewards	-0.6% (-1.7% to 0.5%)	-0.3% (-1.6% to 1.1%)	0.1% (-0.5% to 0.7%)	0.3% (-0.3% to 0.9%)	-0.1% (-0.7% to 0.5%)	-0.1% (-0.7% to 0.5%)
R-squared	0.053	0.062	0.632	0.774	0.662	0.368
Observations	524,197	524,197	524,197	524,197	524,197	524,197
Provider FE	X	X	X	X	X	X
Regression Controls	demographics, year/month FE	+Plan FE	+CPT FE	+MSA FE	+Year X CPT FE	+Year X MSA FE

Note: * $p < 0.05$, ** $p < 0.001$. This table presents multivariate difference-in-difference regressions that include provider fixed effects to test for changes in provider prices between the intervention and comparison population. All columns include provider fixed effects. The results in column 1 include controls for patient demographic (age and gender), year fixed effects (FE), and month fixed effects. Column 2 adds plan fixed effects, column 3 adds CPT code fixed effects, column 4 adds Metropolitan Statistical Area (MSA) fixed effects. To control for CPT code- and state-specific time trends, columns 5 and 6 interact the year fixed effects with the CPT code and MSA fixed effects, respectively. The dependent variable is the log-transformed price, and results can be interpreted as percentage changes in prices. 95% confidence intervals in parentheses.

Appendix Exhibit 7: Savings Calculation

Total 2017 spending on rewards-eligible services among intervention population	$108,721,375
Average reduction in spending attributable to rewards program	2.1%
Implied spending on rewards-eligible services in the absence of rewards	$108,721,375 / (1-2.1%) = $111,053,498
Implied difference in spending due to rewards program	$111,053,498 - $108,721,375 = $2,283,149
Spending on rewards incentives	$204,700
Net savings attributable to rewards	$2,283,149 - $204,700 = $2,127,422
Number of individuals eligible for rewards program	269,875
Per-person savings	$2,127,422 / 269,875 = $7.88