*Econometrica Supplementary Material*

# SUPPLEMENT TO "ARE MEDICAL CARE PRICES STILL DECLINING? A RE-EXAMINATION BASED ON COST-EFFECTIVENESS STUDIES"

(*Econometrica*, Vol. 90, No. 2, March 2022, 859–886)

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## APPENDIX A.1: HEDONICS

HEDONIC REGRESSIONS are commonly applied to adjust prices for quality changes, especially for high-tech goods, and therefore offer another benchmark to compare to our preferred utility-based indexes. The theory used to justify hedonics relies on the assumption that consumers are responsive to prices, suggesting that hedonic regressions are not well-suited for health care where the full price is not paid for by the patient, although recent evidence suggests that patients are responsive to quality changes (Chandra, Finkelstein, Sacarny, and Syverson (2016)). We apply a first-difference hedonic model that takes the difference in price and QALY between the innovative and SOC treatments from the same study, which differences out common article-specific factors affecting price and QALYs. To address the skewness in the data, we estimate the first difference using the log functional form:

$$\log(S_{Ii}/S_{\mathrm{SOC}i}) = \alpha \log(H_{Ii}/H_{\mathrm{SOC}i}) + \beta X_i + \varepsilon_i,$$

where $\alpha$ reflects the change in price associated with the change in quality, and $X_i$ are covariates for other factors that may explain differences in price (e.g., publication year, type of intervention, or health condition).

The first column of Table AI shows the results of this hedonic regression. The $\alpha$ estimate of 0.817 implies that a 10 percent increase in quality yields an 8.2 percent increase in price. At the median SOC price of $20,321 and SOC QALY of 7.48 reported in Table I, this suggests an implicit cost of improving health by one QALY of $2032, which is implausibly low, and just 2 percent of our central utility value of $100,000.

As an alternative method to address skewness, the second column of Table AI shows the conditional median price of a QALY as estimated by a quantile regression and a linear functional form. The coefficient indicates the value of a QALY is $7536, again just a small fraction of estimates of the utility value of a QALY. Even when the quantile regression is applied to the upper quartile, shown in column (3), we find an implied value of a QALY of just $19,381. Regardless of the specification, we find the hedonic method places an

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https://doi.org/10.3982/ECTA17635

TABLE AI

HEDONIC REGRESSIONS.

| | (1) | (2) | (3) |
|---|---|---|---|
| | OLS Regression | Quantile Reg. (Median) | Quantile Reg. (Upper Quartile) |
| Dependent Variable | Log (Inn. Price)–Log (SOC Price) | Inn. Price–SOC Price | Inn. Price–SOC Price |
| Log(Innovator QALY)–Log(SOC QALY) | 0.817<br>(0.0610) | | |
| Innovator QALY–SOC QALY | | 7535.5<br>(494.7) | 19380.6<br>(1525.1) |
| Number of Observations | 10,639 | 10,639 | 10,639 |
| Adjusted R2 | 0.157 | | |

*Note*: Standard errors in parentheses. Standard errors are clustered by condition category for all estimates. The top and bottom 1 percent of outliers are removed based on PPQ index percentiles. The second and third columns apply quantile regressions that predict the conditional median (column 2) and the conditional 75th percentile (column 3). All regressions include controls for the condition category, the publication year, and the type of intervention (e.g., pharmaceutical or procedure).

extraordinarily low value on QALYs, which is consistent with Pakes (2004) who warned that hedonics tend to undervalue quality changes.[1] For purposes of comparison, we apply hedonic regressions to form adjusted price indexes using standard formulas applied in the literature.[2]

## APPENDIX A.2: COST-EFFECTIVENESS AND QUALITY-ADJUSTED PRICE INDEXES

Table AII shows the distribution of the average of the utility-based RP index and utility-based COLI index changes using a VSLY of $100k for different increments of the ICER. The top portion of the table shows the quality-adjusted price index based on different quadrants of the ICER ratio. A small number of innovations are strictly welfare reducing (NW quadrant). These innovations are associated with quality-adjusted price increases. In contrast, innovations with both decreasing prices and increasing quality (SE quadrant) are highly efficient and account for around 20 percent of the observations and are associated with steep quality-adjusted price declines. The bulk of the observations are the case of both higher cost and higher quality (NE quadrant), which are also generally associated with quality-adjusted prices declining. The magnitude of the decline in the NE quadrant depends on the ICER value, with low ICER values associated with steep price declines. The bottom of the table shows the quality-adjusted prices for different ICER values. The American College of Cardiology (ACC) and the American Heart Association (AHA) consider a cost-effectiveness ratio of $50,000 or less as highly effective, which is associated with quality-adjusted price declines of over 100 percent at the mean and large price declines at the median (Dubois (2016)). This table, then, suggests that standard thresholds for technology adoption are associated with steep quality-adjusted price declines.

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[1] We tested a variety of alternative functional forms and specifications and the results consistently show that hedonics produce low implicit valuations on QALYs.

[2] Taking the regression estimate $\hat{\alpha}(\text{Log}(\text{Inn. QALY}/\text{SOC QALY}))_i$, we can calculate the hypothetic price absent the quality improvement, where $\hat{s}^0_{1,i} = \exp(\log(S_{1,i}) - \hat{\alpha}(\text{Log}(\text{Inn. QALY}/\text{SOC QALY}))_i$. The index formula is then: Hedonic $= \frac{\hat{s}^0_1}{S_0}$, which is the change in price, holding the quality fixed to the level of the SOC treatment.

TABLE AII

AVERAGE UTILITY-BASED COLI AND RP INDEX PRICE CHANGES BY COST-EFFECTIVENESS TYPE BASED ON THE INCREMENTAL-COST-EFFECTIVENESS-RATIO (ICER).

| | Average Utility-Based Index ($100k VSLY) | | | | | |
|---|---|---|---|---|---|---|
| Technology Type by ICER Category | Obs | Mean | Median | p5 | p95 | sd |
| (NE) ↑ in Price & ↑ in QALY | 308 | 0.408 | 0.034 | −0.393 | 2.510 | 1.114 |
| (SE) ↓ in Price & ↑ in QALY | 1010 | 0.707 | 0.275 | 0.009 | 2.609 | 1.321 |
| (NW) ↑ in Price & ↓ in QALY | 2279 | −1.124 | −0.395 | −4.134 | −0.030 | 3.112 |
| (SW) ↓ in Price & ↓ in QALY | 7014 | −1.428 | −0.202 | −7.237 | 0.646 | 4.809 |
| Total | 10,611 | | | | | |
| *Average Quality-Adjusted Price Change: ↑ in Price & ↑ in QALY:* | | | | | | |
| ICER<$1000 & ICER ≥ 0 | 224 | −8.665 | −3.288 | −37.571 | −0.028 | 12.125 |
| ICER<$10,000 & ICER ≥ $1000 | 1278 | −4.002 | −1.086 | −17.181 | −0.061 | 7.561 |
| ICER<$50,000 & ICER ≥ $10,000 | 2651 | −1.280 | −0.476 | −4.884 | −0.021 | 2.983 |
| ICER<$100,000 & ICER ≥ $50,000 | 1107 | −0.361 | −0.089 | −0.976 | −0.001 | 1.727 |
| ICER<$200,000 & ICER ≥ $100,000 | 727 | 0.230 | 0.064 | 0.001 | 0.959 | 0.536 |
| ICER ≥ $200,000 | 1027 | 0.651 | 0.234 | 0.002 | 2.757 | 1.139 |
| Total | 7014 | | | | | |

*Note*: The table shows the average quality-adjusted price index by the characteristics of the technology. The technology is categorized into four quadrants of either increasing or decreasing quality and cost, as is typical in the cost-effectiveness literature. For the quadrant of increasing cost and increasing quality, we break out technologies by the incremental cost-effectiveness ratio.

## APPENDIX A.3: ALTERNATIVE QUALITY-ADJUSTED INDEXES

The quality-adjusted indexes rely on the diffusion rate of new technologies. The evidence of the diffusion rate is presented in Table AIII, Table AIV, and Table AV. Table AIII reports the diffusion rate for select technologies reported in the medical literature. Ta-

TABLE AIII

DIFFUSION RATES OF SPECIFIC TREATMENTS.

| | Time Period | Initial Percentage | Final Percentage | Total Percent Growth | Annual Rate |
|---|---|---|---|---|---|
| Disease: Rheumatoid arthritis (includes patients with poor reactions to standard treatments) | | | | | |
| Innovation: Enbrel diffusion rate | 2001–2006 | 0.035 | 0.217 | 0.182 | 0.036 |
| Any biologic disease-modifying antirheumatic drugs | 2001–2006 | 0.035 | 0.369 | 0.334 | 0.067 |
| Source: Krishnan, Lingala, Bruce, and Fries (2012) | | | | | |
| Disease: Prostate cancer<br>Innovation: Modulated radiation therapy<br>Source: Shahinian, Kaufman, Yan, Herrel, Borza, and Hollenbeck (2017) | 2007–2012 | 0.286 | 0.380 | 0.094 | 0.019 |
| Disease: Colon cancer<br>Innovation: Colon cancer screening<br>Source: https://progressreport.cancer.gov/detection/colorectal_cancer | 2000–2018 | 0.382 | 0.668 | 0.286 | 0.016 |
| Disease: HPV, cancer<br>Innovation: HPV Vaccine<br>Source: https://progressreport.cancer.gov/prevention/hpv_immunization | 2008–2018 | 0.37 | 0.70 | 0.33 | 0.033 |

*Note*: This table shows diffusion rates based on studies or reports specific to each condition. The selected diffusion rates were selected to correspond to the examples in Table IV in the text. We were able to find corresponding diffusion rates that correspond to the selected examples, except for diabetes management. The diffusion rate ranged from 1.6 percent per year to 6.7 percent per year.

TABLE AIV

NEW MOLECULE AND NEW CPT CODE SHARES.

| | New Molecule Spend | | | | | CPT Code Spend | |
|---|---|---|---|---|---|---|---|
| | Pill Count Share | Spending Share | Difference in Spending Share | Out-of-Pocket Spend Share | Difference in Spending Share | Spending Share | Difference in Spending Share |
| 2002 | 0.47% | 0.85% | 0.85% | 0.99% | 0.99% | 1.22% | 1.22% |
| 2003 | 1.57% | 3.34% | 2.48% | 3.20% | 2.21% | 2.99% | 1.78% |
| 2004 | 2.94% | 6.51% | 3.18% | 5.99% | 2.79% | 5.15% | 2.16% |
| 2005 | 3.67% | 8.71% | 2.19% | 8.04% | 2.04% | 7.36% | 2.21% |
| 2006 | 5.10% | 12.37% | 3.67% | 11.35% | 3.32% | 9.93% | 2.56% |
| 2007 | 6.29% | 16.10% | 3.73% | 14.44% | 3.08% | 12.15% | 2.23% |
| 2008 | 6.76% | 18.81% | 2.70% | 16.74% | 2.30% | 12.75% | 0.59% |
| 2009 | 7.00% | 20.79% | 1.98% | 18.15% | 1.41% | 14.78% | 2.03% |
| 2010 | 7.32% | 23.97% | 3.17% | 20.35% | 2.20% | 16.47% | 1.70% |
| 2011 | 7.72% | 27.86% | 3.89% | 22.57% | 2.22% | 19.77% | 3.30% |
| 2012 | 7.98% | 32.35% | 4.49% | 24.59% | 2.01% | 20.72% | 0.95% |
| 2013 | 8.07% | 36.22% | 3.86% | 26.04% | 1.45% | 23.56% | 2.84% |
| 2014 | 8.40% | 41.82% | 5.61% | 27.98% | 1.94% | 25.20% | 1.63% |
| 2015 | 9.34% | 47.86% | 6.04% | 32.26% | 4.28% | 26.89% | 1.69% |
| 2016 | 10.34% | 52.28% | 4.42% | 34.63% | 2.37% | 28.49% | 1.60% |
| 2017 | 11.71% | 56.30% | 4.01% | 36.81% | 2.18% | 30.22% | 1.73% |
| Average total change | | 3.519% | | 2.300% | | 1.889% | |

*Note*: The estimates from this table come from authors' calculation based on MarketScan claims data. The calculation is the share of spending on new molecules or new CPT codes, where a new molecule or CPT code is counted if it is not observed in the year 2000 or 2001. The population includes both the commercially insured population under 65, as well as retirees over 65 observed in the database.

ble AIV presents estimated proxies of technology diffusion rates for prescription drugs and CPT codes based on medical claims data. Table AV presents the proxy for technology diffusion based on hospital quality data.

In this appendix, we conduct several robustness checks of our results.

### *Alternative Functional Forms*

We apply alternative functional forms that are commonly used in the price index literature, including the Cobb–Douglas function and constant elasticity of substitution (CES) function. Based on economic theory, the arithmetic mean that we applied to our main estimates is very close to the price index corresponding to the Cobb–Douglas function, assuming each innovation has an equal chance of being adopted. For the Cobb–Douglas function, the associated price index functional form is a geometric mean. The Cobb–Douglas utility function produces conservative estimates, in the sense that the quality adjustments have a smaller effect, as it assumes that the cross-price elasticity is zero, implying no substitution among treatments, even as technologies improve. In addition to being simple to apply, the arithmetic mean is even more conservative than the geometric mean, as the arithmetic mean places relatively more weight on the larger price increases.

Denote each innovation by $i$ so that the price index formula constructed using the quality-adjusted price for innovation $i$ is $P_t^i$. The price index formula associated with the Cobb–Douglas function is the geometric mean, where $\alpha_i$ is a parameter that indicates the importance of the technology: $P_t^{\text{agg}} = \prod_{i=1}^{N}(P_t^i)^{\alpha_i}$.

TABLE AV

AVERAGE CHANGE IN PROCESS MEASURES OF QUALITY FROM HOSPITAL COMPARE DATABASE.

| | Percent of Patients Given the Following Recommended Treatment | | | |
|---|---|---|---|---|
| Process Measure for Patients Given: | 2004 | 2009 | % Increase | Level Change |
| *Condition: Heart Attack* | | | | |
| ACE Inhibitor or ARB for Left Ventricular Systolic Dysfunction | 82 | 96 | 16.8% | 13.8% |
| Aspirin at Arrival | 94 | 98 | 4.2% | 4.0% |
| Aspirin at Discharge | 94 | 98 | 4.2% | 4.0% |
| Beta Blocker at Discharge | 93 | 98 | 6.0% | 5.5% |
| Smoking Cessation Advice/Counseling | 87 | 99 | 14.9% | 12.9% |
| *Condition: Heart Failure* | | | | |
| ACE Inhibitor or ARB for Left Ventricular Systolic Dysfunction | 81 | 94 | 16.2% | 13.1% |
| Assessment of Left Ventricular Function | 87 | 98 | 11.7% | 10.2% |
| Discharge Instructions | 52 | 88 | 68.9% | 35.7% |
| Smoking Cessation Advice/Counseling | 74 | 98 | 33.5% | 24.7% |
| *Condition: Pneumonia* | | | | |
| Patients Assessed and Given Pneumococcal Vaccination | 52 | 93 | 78.0% | 40.6% |
| Initial Antibiotic(s) within 4 Hours After Arrival | 72 | 95 | 31.1% | 22.5% |
| Smoking Cessation Advice/Counseling | 70 | 97 | 38.5% | 27.0% |
| The Most Appropriate Initial Antibiotic(s) | 77 | 91 | 18.3% | 14.1% |
| Blood Culture Performed Prior to First Antibiotic Received in Hospital | 82 | 95 | 15.7% | 12.9% |
| *Surgical Infection Prevention* | | | | |
| Received Preventative Antibiotic(s) One Hour Before Incision | 77 | 96 | 24.7% | 19.1% |
| Preventative Antibiotic(s) are Stopped Within 24 hours After Surgery | 64 | 94 | 45.7% | 29.5% |
| Average Change Across Categories | | | | 18.1% |
| Average Annual Change Across Categories | | | | 3.62% |

*Note*: The estimates from this table come from authors' calculation from the Hospital Compare database archives from the Center for Medicare and Medicaid Services (https://data.medicare.gov/data/archives/hospital-compare). The estimates are based on a simple weighted average across all hospitals in the database where the weight is determined by the sample size at each hospital. Quality measures that were discontinued or continued in the middle of the sample range are not shown. The year reported in this table is based on the year the information was gathered from the hospital, which is typically lagged one year in the database. For instance, the process measures for 2004 are from the 2005 hospital compare database.

For each innovation $i$, we construct an index, $P_t^i = (1 - \Delta w)\cdot\frac{S_t}{S_{t-1}} + (\Delta w)\cdot\frac{S_{I,i} - \$\text{VSLY}\cdot(H_{I,i} - H_{\text{SOC},i})}{S_{\text{SOC},i}}$, using equation (7). Next, we assign each of the $N$ innovations equal weights, so $\alpha_i = 1/N$. Including these values, the price index from $t-1$ to $t$ is

$$P_t^{\text{agg}} = \prod_{i=1}^{N}\left((1 - \Delta w)\cdot\frac{S_t}{S_{t-1}} + (\Delta w)\cdot\frac{S_{I,i} - \$\text{VSLY}\cdot(H_{I,i} - H_{\text{SOC},i})}{S_{\text{SOC},i}}\right)^{(\frac{1}{N})}. \tag{A1}$$

As we will show, the estimates are quite close to those based on the arithmetic mean. In contrast to the Cobb–Douglas function, the CES function allows for positive cross-price elasticities among innovations, allowing for arguably more realistic substitution among alternatives. Relative to the Cobb–Douglas function, the CES will generate more substitution toward innovations that show larger declines in price, potentially generating larger quality adjustments and lower price indexes. We calculate the estimate based on a CES price index formula assuming elasticities of substitution of either 2 or 3.[3] The price index associated with the CES function is $P_t^{\text{agg,CES}} = \prod_{i=1}^{N} (\alpha_i (P_t^i)^{(1-\sigma)})^{\frac{1}{1-\sigma}}$.

The parameter $\sigma$ indicates the elasticity of substitution between products and $\alpha_i$ indicates the importance of the technology, which we assign equal weight, as in the Cobb–Douglas calculation. Substituting in equation (7) to the CES function (A1) and the assumption of equal weights, we get

$$P_t^{\text{agg,CES}} = \prod_{i=1}^{N} \left( \frac{1}{N} \left( (1 - \Delta w) \cdot \frac{S_t}{S_{t-1}} + (\Delta w) \frac{S_{I,i} - \$\text{VSLY} \cdot (H_{I,i} - H_{\text{SOC},i})}{S_{\text{SOC},i}} \right)^{(1-\sigma)} \right)^{\frac{1}{1-\sigma}}. \tag{A2}$$

For both the Cobb–Douglas and CES function, only positive values are allowed, so any extremely large price declines are dropped from the analysis. For the unweighted index, we apply this aggregation across all technologies. For the weighted index, we apply the indexes (A1) or (A2) at the condition category level and then aggregate based on the spending share of each condition category.

Table AVI reports these results, where we report estimates assuming a diffusion rate of 2.8 percent across scenarios, and based on different VSLY, as the assumption regarding the VSLY appeared to be more important than the different diffusion rates. Lines 1 and 2 repeat estimates from Tables VI and VII to compare as a baseline. Lines 3 and 4 repeat lines 1 and 2, but apply the index using the Cobb–Douglas functional form. The estimates are quite close to those using the arithmetic mean, as expected, although the arithmetic mean gives greater weight to price increases, relative to the geometric mean. Lines 5 and 6 repeat lines 1 and 2, but apply the CES functional form with $\sigma = 2$, which allows a small degree of substitution among innovations. Allowing for some substitution shows much larger quality-adjusted price declines for both the weighted and unweighted estimates, suggesting that the degree of substitution among technologies has an important effect on the price decline. Line 7 is identical to line 6, but allows for a higher elasticity of substitution, $\sigma = 3$. In this case, the quality-adjusted price index falls extremely fast, at a rate of 13 percent per year. As we obtain similar estimates for both the weighted and unweighted values, for the remainder of the robustness checks we only provide the preferrable weighted estimates.

### *Restricting Studies to Those From High-Income Countries*

One limitation is that some of these studies are from developing countries which are not necessarily applicable to the U.S., although it is arguable that countries such as China

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[3] The elasticity of substitution across many industries is estimated to be 3 or more based on a CES-type function (Feenstra (1994), Redding and Weinstein (2020), Aghion, Bergeaud, Boppart, Klenow, and Li (2019)).

TABLE AVI

ALTERNATIVE QUALITY-ADJUSTED PRICE INDEX AVERAGE ANNUAL GROWTH RATES FOR HEALTH CARE CONSUMPTION 2000–2017.

| Alternative Models With Diffusion Rate of 2.8 Percent | $VSLY | | | |
|---|---|---|---|---|
| | $50k | $100k | $150k | Obs |
| 1. Baseline, Unweighted (Table VI) | 0.77% | −1.23% | −3.13% | 10,611 |
| 2. Baseline, Weighted (Table VII) | 0.67% | −1.33% | −3.26% | 10,579 |
| 3. Cobb–Douglas, Unweighted | 0.52% | −1.39% | −2.95% | 10,562 |
| 4. Cobb–Douglas, Weighted | 0.44% | −1.70% | −3.03% | 10,532 |
| 5. CES Model—$\sigma = 2$, Unweighted | 0.14% | −4.27% | −7.60% | 10,562 |
| 6. CES Model—$\sigma = 2$, Weighted | 0.08% | −5.19% | −7.61% | 10,532 |
| 7. CES Model—$\sigma = 3$, Weighted | −0.50% | −13.03% | −17.62% | 10,532 |
| 8. Cobb–Douglas, Weighted, High-Income Countries | 0.89% | −0.69% | −2.23% | 9731 |
| 9. CES Model—$\sigma = 2$, Weighted, High-Income Countries | 0.69% | −1.73% | −4.67% | 9731 |
| 10. CES Model—$\sigma = 3$, Weighted, High-Income Countries | 0.39% | −7.18% | −13.13% | 9731 |
| 11. Cobb–Douglas, Weighted, High-Income Countries, Welfare Improving | −0.37% | −2.16% | −3.96% | 7387 |
| 12. CES model—$\sigma = 2$, Weigh., High-Inc. Cntry, Welfare Improving | −0.65% | −3.47% | −6.91% | 7387 |
| 13. CES model—$\sigma = 3$, Weigh., High-Inc. Cntry, Welfare Improving | −0.41% | −9.35% | −15.90% | 7387 |
| 14. Cobb–Douglas, Weigh., Drop 5% Largest Declines, Welfare Improving | 0.61% | −0.45% | −1.54% | 7241 |
| 15. CES model—$\sigma = 2$, Weigh., Drop 5% Largest Declines, Welf. Imp. | 0.59% | −0.51% | −1.69% | 7241 |
| 16. CES model—$\sigma = 3$, Weighted, Drop 5% Largest Declines, Welf. Imp. | 0.58% | −0.58% | −1.86% | 7241 |

*Note*: Each line corresponds to estimates of quality-adjusted price changes applied under alternative scenarios. We show the quality-adjusted price index based on alternative assumptions of the VSLY, which we found to be more important than the diffusion rate. Across scenarios, we assume the diffusion rate is equal to our central diffusion rate of 2.8 percent per year. The first two lines correspond to baseline estimates from Tables VI and VII where the Table VI estimate is unweighted and Table VII is weighted. The baseline models use simple arithmetic averaging, which places more weight on large price increases, leading to less of a quality adjustment. The estimates in rows 3 and 4 use a price index based on the Cobb–Douglas utility function, which applies a geometric mean, rather than an arithmetic mean, and the results are similar to the baseline estimates, but with slightly larger price declines. The Cobb–Douglas utility function allows for no cross-price substitution. A more realistic scenario is to allow for greater substitution among treatments, which is shown using CES models in rows 5 (unweighted) and 6 (weighted) where we assume an elasticity of substitution parameter of 2 (allowing for a small amount of substitution to better technologies), leading to much larger price declines relative to the estimates in rows 3 and 4. As we believe the weighted estimates are preferred, we focus on those for the remaining robustness checks. We also focus on estimates grounded in particular utility functions, such as CES or Cobb–Douglas, which are commonly used in the literature. Row 7 is the same as row 6, but the elasticity of substitution is set to 3, showing even sharper price declines. Rows 8, 9, and 10 are identical to rows 4, 6, and 7 but include only high-income countries. Rows 11, 12, and 13 are identical to rows 8, 9, and 10 but only include innovations that lead to quality-adjusted price declines. Finally, rows 14, 15, and 16 eliminate all innovations that show large changes by excluding innovations that are not welfare improving, but also excluding 5 percent of the observations that show the largest declines in quality-adjusted prices.

conduct cost-effectiveness studies that are relevant to the U.S.[4] In lines 8, 9, and 10 of Table AVI, we repeat the estimates from 4, 6, and 7, respectively, but only use studies from

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[4] For example, studies from China are often advanced comparable treatments to those in the U.S., such as Icotinib, a first-line treatment for lung cancer, Apatinib, a treatment for gastric cancer, and Yisaipu, a rheumatoid arthritis treatment.

TABLE AVII

Hypothetical adjustment to BLS multifactor productivity estimate for hospitals and nursing and residential care facilities (NAICS 622, 623).

| | BLS (Current) | | | | | Adjusted Price, Output, and Productivity | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Output Price Index | Real Output | Annual Output Price Index Growth | Real Combined Inputs | Multifactor Productivity Index (Real Output/Real Input) | Adj. Annual Output Price Index Growth | Adj. Output Price Index (Rebased) | Adj. Real Output | Adj. Productivity |
| 2000 | 72.38 | 62.60 | 4.4% | 61.34 | 1.02 | 2.6% | 89.54 | 50.60 | 0.82 |
| 2001 | 73.78 | 65.69 | 1.9% | 64.44 | 1.02 | 0.1% | 89.67 | 54.05 | 0.84 |
| 2002 | 75.73 | 70.15 | 2.6% | 68.79 | 1.02 | 0.8% | 90.43 | 58.75 | 0.85 |
| 2003 | 78.42 | 72.08 | 3.5% | 70.68 | 1.02 | 1.7% | 91.99 | 61.45 | 0.87 |
| 2004 | 81.47 | 73.61 | 3.9% | 71.44 | 1.03 | 2.1% | 93.88 | 63.88 | 0.89 |
| 2005 | 84.66 | 77.59 | 3.9% | 76.34 | 1.02 | 2.1% | 95.84 | 68.53 | 0.90 |
| 2006 | 87.65 | 79.96 | 3.5% | 78.70 | 1.02 | 1.7% | 97.49 | 71.89 | 0.91 |
| 2007 | 90.17 | 82.33 | 2.9% | 81.90 | 1.01 | 1.1% | 98.53 | 75.35 | 0.92 |
| 2008 | 93.05 | 85.17 | 3.2% | 83.25 | 1.02 | 1.4% | 99.89 | 79.34 | 0.95 |
| 2009 | 94.51 | 89.01 | 1.6% | 85.85 | 1.04 | −0.2% | 99.67 | 84.40 | 0.98 |
| 2010 | 96.25 | 92.59 | 1.8% | 90.97 | 1.02 | 0.0% | 99.72 | 89.37 | 0.98 |
| 2011 | 99.02 | 94.93 | 2.9% | 94.16 | 1.01 | 1.1% | 100.79 | 93.26 | 0.99 |
| 2012 | 100.00 | 100.00 | 1.0% | 100.00 | 1.00 | −0.8% | 100.00 | 100.00 | 1.00 |
| 2013 | 101.81 | 101.69 | 1.8% | 102.27 | 0.99 | 0.0% | 100.02 | 103.51 | 1.01 |
| 2014 | 103.88 | 103.83 | 2.0% | 104.74 | 0.99 | 0.2% | 100.26 | 107.58 | 1.03 |
| 2015 | 104.81 | 109.67 | 0.9% | 110.31 | 0.99 | −0.9% | 99.38 | 115.66 | 1.05 |
| 2016 | 106.03 | 114.82 | 1.2% | 116.02 | 0.99 | −0.6% | 98.77 | 123.26 | 1.06 |
| 2017 | 108.06 | 117.64 | 1.9% | 119.82 | 0.98 | 0.1% | 98.89 | 128.54 | 1.07 |
| Avg. Annual Rate | 2.39% | 3.78% | | 4.02% | −0.23% | | 0.59% | 5.64% | 1.56% |

*Note*: The BLS estimates of multifactor productivity taken from the table of productivity for the nonmanufacturing industries (https://www.bls.gov/mfp/mprdload.htm). The output price index, real output, real combined inputs, and multifactor productivity are from the table BLS 1987–2019 Combined Sector and Industry Multifactor Productivity. The annual output price index growth rate is adjusted by the amount of the bias of 1.79 percent per year, which is computed by taking the difference between the growth rate in the output price index of 0.46 per year and the quality-adjusted index of −1.33 percent per year. The adjusted price index affects output and productivity by the amount of this bias, so the multifactor productivity increases by 1.79 percent per year, increasing productivity from −0.23 percent to 1.56 percent.

high-income countries.[5] The estimates show less of a decline, but the quality-adjusted price decline is still substantial for the estimates using the CES functional form.

### *Only Including Innovations That Improve Welfare*

Another assumption is that the estimates assume that those technologies that reduce welfare (i.e., lead to a quality-adjusted price increase) are actually adopted. One reasonable restrictive assumption is that those less efficient technologies are never used. Lines 11, 12, and 13 of Table AVI repeat the estimates from lines 8, 9, and 10, respectively, but assume that only those technologies that lead to quality-adjusted price declines are adopted and diffused (i.e., only technologies that lead to lower quality-adjusted prices are

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[5] The grouping of high-income countries comes from a list maintained by the World Bank: https://datatopics.worldbank.org/world-development-indicators/the-world-by-income-and-region.html.

adopted). These estimates tend to lead to large quality-adjusted price declines for our central estimate when VSLY is set at $100k.

### *Removing Extreme Values*

A more general concern may be that the estimates could be affected by large negative or positive values. While we argue that some of those large quality-adjusted price changes are, in fact, very relevant, it is important to check the robustness of the estimates to their exclusion. For the last set of robustness checks, we exclude extreme values, including those technologies that are not welfare improving, but also the 5 percent of technologies that lead to the largest quality-adjusted price declines. Specifically, lines 14, 15, and 16 repeat the estimates from lines 4, 6, and 7, respectively, but removing the more extreme values. We find that across all three specifications, quality-adjusted prices are declining for our central estimate based on the VSLY of $100k, but the magnitude of the decline is smaller at around 0.5 percent per year.

## APPENDIX A.4: MULTIFACTOR PRODUCTIVITY

Table AVII reports the BLS multifactor productivity estimates for hospitals and nursing facilities (NAICS 622, 623), along with a hypothetical quality-adjusted multifactor productivity estimate. Unadjusted productivity falls by 0.23 percent per year, while the adjusted productivity measure increases by 1.56 percent per year.

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*Co-editor Charles I. Jones handled this manuscript.*

*Manuscript received 5 September, 2019; final version accepted 3 September, 2021; available online 27 September, 2021.*