APPENDIX B: Measures of Providers Private Prices and Medicare Reimbursements

Appendix B1: Inpatient Private-Payer Hospital Price Index: Our private-payer inpatient price index captures the combined amount paid by patients and insurers for patient case *i* in DRG *d* delivered in hospital *h,* and provided in year *t*. Following Gaynor and Vogt (2003) and Gowrisankaran, Nevo, and Town (2015), we regress hospital payments ($p_{i,h,d,t}$) on year-specific hospital fixed effects ($\alpha_{h,t}$), a vector of patient characteristics ($X_{i,h,d,t}$) comprised of indicators for patient age (measured in ten-year age bands), a dummy for the patient's sex, and a vector of DRG fixed effects (γ_d). The regression to produce our inpatient prices has the form:

$$p_{i,h,d,t} = \alpha_{h,t} + X_{i,h,d,t}\beta + \gamma_d + u_{i,h,d,t} \quad (4)$$

where $u_{i,h,d,t}$ is the stochastic error term. We recover the vector of hospital fixed effects $\alpha_{h,t}$ and calculate a hospital price index for each year at the sample means of the patient characteristics ($\bar{X}$) and the DRG indicators, $\bar{d}$ (i.e., the sample mean basket of DRGs).

$$\bar{p}_{h,t} = \alpha_{h,t} + \bar{X}\beta + \bar{\gamma}_d \quad (5)$$

This yields the hospital's price, adjusted for its mix of treatments and mix of patients (note the fixed effect $\alpha_{h,t}$ is the key output: $\bar{X}\beta + \bar{\gamma}_d$ is just a constant across all hospitals to match the mean in the data).

For robustness, we also created alternate price indexes using many different functional forms. For example, in Appendix Table XIII we show robustness of the estimates reported in Table IV in the paper to alternative approaches. Panel A has the baseline results which are the same as Panel A of Table IV, i.e. using $ln(\bar{p}_{h,t})$ as the dependent variable. Panel B constructs the risk-adjusted inpatient price by estimating Equation (4) but using $ln(p_{i,h,d,t})$ instead of $p_{i,h,d,t}$. We then implement the analog of Equation (5) to obtain an alternative *ln(price)* that we use as the dependent variable in Panel B. In Panel C of Appendix Table XIII, we use the level of price ($\bar{p}_{h,t}$) instead of the logarithm of price. In Panel D we include the Charlson Score of co-morbidities to the $X_{i,h,d,t}$ vector in Equation (4). In Panel E we include a full set of ICD9 dummies instead of DRG dummies.

In addition, we also looked at many other approaches. For example, we calculated regressions where DRG complexity was parameterized using CMS's MS-DRG weights as right hand side control variables, rather than as fixed-effects for each DRG. We also calculated a price index where we regressed the DRG price divided by the DRG weight against patient characteristics and hospital fixed effects. These price measures are all highly correlated with each other (correlation coefficients greater than 0.95), and using alternative price measures does not materially affect our baseline results.

Appendix B2: Procedure-Level Private-Payer Hospital Price Index:

In addition to creating an inpatient price index, we also create risk-adjusted prices for the specific procedures we study. We adjust prices for differences in patient characteristics, just as we did in the inpatient price index. These regressions take the form:

(6) $$p^{P}_{i,h,d,t} = \alpha^{P}_{h,d,t} + X_{i,h,d,t}\beta^{P}_{d} + \varepsilon^{P}_{i,h,d,t}$$

Superscript *P* indicates one of our seven procedures. We then recover our estimates of the hospital-year-procedure fixed effects as we did when we constructed our inpatient price index.

Appendix B3: Constructing Hospital-Insurer Contracts

Determining between Share of Charge and Prospective Payment contracts

Unfortunately we do not directly observe the contracts struck between insurers and hospitals. In order to classify cases into contracts we "reverse engineer" our data using an *ex post* algorithmic method from observations of prices, charges, and case characteristics. We did this after extensive discussions with insurers on a sensible way to back out contracts.

The first step is to search for repeated absolute prices and repeated price-to-charge ratios within a hospital for our narrowly defined procedures sample (or within DRGs in the inpatient sample). For each hospital and procedure, we look at all cases *i* over the two year period for which we observe hospital charge data (i.e. January 1st 2010 to December 31st 2011). Prices are considered repeated if for all cases *i* and *i'* (i) their prices match to the cent ($0.01) or (ii) their price-to-charge ratios match within 0.1 percent (0.001). Type (i) contracts are likely to be prospective (say tied to a DRG) whereas type (ii) will be share of charge contracts.

If there is only ever one charge for a procedure, we cannot distinguish whether a case falls into one of these two categories. For example, if cases *i* and *i'* have the same payment for a knee replacement (e.g. $1,000), then we will suspect them of being on prospectively paid contracts. But, if their charges are identical (e.g. $2,000), the price to charge is also at 50 percent for both. This is usually the case for lower limb MRIs, for example, which is why we cannot successfully implement our algorithm on this procedure. We can, however, identify the payment type if there exists a third hospital case *i''* which has the same price level but a different charge (or vice versa). For example if knee replacement case *i'' was also* $1,000, but had a charge of $4,000 we would classify all three cases as falling under a prospective pay contract as although its price was always $1,000, its price-to-charge ratio differed (i.e. was 25 percent for contract *i''* and 50 percent for *i* and *i'*).

There are, of course, a number of cases that cannot be classified in this manner, since they are singleton prices or singleton price-to-charge ratios. This may be because they are on a "hybrid" contract, which is prospective but with outlier payments. Or it may be that they are on one of the two standard contracts (share of charge or prospective payments) but there has only been one case over our period so we cannot distinguish the contract. We denote these "unclassified cases."

Repeated contracts

Repeated price-to-charges and repeated absolute prices define a "primitive contract," which we can then use to construct a more persistent set of payment agreements over time by observing whether the classifications hold sequentially over time. We define primitive contracts not only by their price, but also by the first and last date at which that agreement is executed. We calculate characteristics of these contracts, measuring the average monthly volume of patients who are paid under those agreements and measuring the plan characteristics of those contracts (percent of

patients on ASO or fully insured plans; the percent of patients by market segment: large group or small group; and the percent of patients by product type: health maintenance organization (HMO), preferred provider organization (PPO), point of service plan, exclusive provider organization, indemnity, and other). We use all of this information to find contracts that precede or follow each other in order to match primitive contracts over time. Matching contracts are those which begin/end within 45 days of the end/beginning of the candidate contract, and minimize the Euclidean distance of characteristics (patient volume and plan characteristics):

$$(7) \qquad d(x,y) = \sqrt{\sum_{i} \frac{(x_i - y_i)^2}{s_i^2}}$$

where x and y are vectors of contract characteristics, and s_i is the standard deviation of the i^{th} characteristic across contracts. We recognize "valid" matches to be two contracts that mutually minimize this distance for each other.

While we can determine the type of contract without this matching procedure, the fact that matches are well determined by plan characteristics gives us confidence that distinct contracts reflect distinct agreements across insurers at the same hospital. As we illustrate in Figure V in the paper, we are able to link primitive contracts over renegotiations. For example, we can link two primitive contracts if, before and after a price increase, both have 60 percent of cases where the beneficiary is on an ASO product and 80 percent are part of a PPO plan.

Illustrative Examples and Descriptive Statistics

To illustrate this, re-consider Figure VI in the paper for vaginal deliveries in one of the hospitals in our sample. This hospital had between 500 and 600 cases overall in 2010 and 2011.[8] We were able to identify that 59.5 percent of these fall under a share of charge contract (the circles) and 38.0 percent of these fall under a prospective pay contract (the triangles). The remaining 2.5 percent were unclassified. In one month in 2011, for example, we had 24 cases of which 10 were the same absolute price of $1000 and 14 were all on a 60 percent price-to-charge ratio. This means that for this hospital-month, 41.7 percent of cases were prospective payment contracts, 58.3 percent were price-to charge contracts and zero cases were unclassified.

Figure VII shows how the contracts are split by the inpatient sample and for each procedure (these are all in terms of fractions of cases). The fraction unclassified is related to the sparsity of the data. As we noted above, the unclassifieds are a mixture of truly hybrid contracts and those we cannot classify, due to the fact we may only observe one case under a particular contract so do not have any other cases we can "match prices" with. This is particularly an issue for the inpatient sample where we are seeking to assign cases to contracts to every one of the approximately 750 DRGs for every hospital. Many hospitals (especially the smaller ones) will only have one case in a particular DRG over this time period. Recall that the only threshold the cases data have is that a hospital must have at least 50 inpatient cases over *all* DRGs in a year.

Appendix Figure VIII illustrates this issue by showing what is the impact on contract classification (across cases in the inpatient sample) of introducing more stringent cut-offs over the minimum number of cases per DRG in the hospital. We start with our baseline of zero on the

[8] To keep the figure anonymous, we are providing a range of the count of vaginal deliveries performed each year.

far left of the x-axis, i.e. we do not insist on any minimum number of cases per DRG in a hospital. At this point we reproduce the first bar chart in Figure VII for the inpatient sample: 33.6 percent of cases are on prospective contracts; 17.3 percent are share of charges and 49.1 percent are unclassified. As we move to the right we see the fraction of unclassified cases shrink. This is because we are reducing the number of "singleton" prices by focusing on DRGs where we have more chance of identifying contracts. Importantly, the fraction of cases under share of charge contracts asymptotes after we condition on having only about 20 cases per DRG. This suggests, that the true fraction of cases which are on share of charge contracts are genuinely around 23 percent in our sample.

By contrast, the fraction on perspective payments contracts is still rising over the whole range of the x-axis. By the time we restrict attention to DRGs with at least 100 cases in a hospital, we have shrunk the fraction of unclassifieds to under 10 percent and when we reach a 200 cases threshold, it is 4.2 percent.

It is tempting to conclude from this that all the remaining unclassified cases are prospective, so the "true" breakdown of cases is 23 percent on share of charges and 77 percent on prospective contracts. An important caveat to this reading of Appendix Figure VIII is that the sample is changing as we move along the x-axis. We are effectively conditioning on larger and larger hospitals. Hence, the increasing incidence of prospective payment contracts may be due to selection if prospective contracts are more prevalent in the larger volume hospitals. One might have reason to doubt this selection-based explanation of the Figure however, as share of charge contracts are more commonly associated with larger hospitals in the cross-sectional regressions on the full inpatient sample. Appendix Table XI (the full results of Table IV Panel B) shows that there is a *positive* coefficient on hospital size (as measured by number of beds) in the regressions where the percentage of cases on share of charge is the dependent variable (and this is significant in our preferred Column (3)). Hence, our view is that Appendix Figure VIII shows that the unclassifieds are mainly prospective contracts (rather than hybrids) and this is simply disguised by the fact we only have finite samples of patients with many singleton observations.

This selection effect is very unlikely to be an explanation for our estimate of the percent of cases under share of charge contracts, as the fraction does not change much after a threshold of 5 cases per DRG. Hence we feel confident that the true share of charge incidence is really around 23 percent. The breakdown of the remaining 77 percent of cases between prospectives and hybrids has a bit more uncertainty. An upper bound for prospectives is 77 percent, but in principle a lower bound could be the 33.6 percent in the first column in Figure VII. As argued in the previous paragraph, however, our view is that the true incidence of prospective contracts is closer to 77 percent given the evidence in Appendix Figure VIII.

Share of Prospective Payment contracts that are Medicare Related

As discussed in the text, we divide the prospective payments contracts into those that appear to be linked to the Medicare fee schedule and those that are not. Figure VIII in the paper illustrates the methodology for two hospitals.

In the inpatient sample as a whole, 74 percent of prospective payment contracts were linked to Medicare. This fraction was reasonably stable throughout the support of Appendix Figure VIII. At baseline, when we do not require a minimum DRG-hospital count restriction, we observed

that 72 percent of cases paid prospectively were linked to Medicare. This rose to 75 percent when we limited our analysis to DRG-hospital pairs with more than 100 cases. In order to estimate the overall fraction of cases that paid prospectively and linked to Medicare, we have to make an assumption about how the unclassifieds are split. Appendix Figure IX strongly suggests that the share of charge contracts are about 23 percent across all sample restrictions. If *all* of the remaining 77 percent of claims were under prospective contracts (which we have argued is not a bad assumption), the upper bound of the share of claims on Medicare related contracts would be 57 percent (= 77*0.74). Even this upper bound is considerably below the share of physician cases under prospective payment contracts linked to Medicare, which is estimated by Clemens and Gottlieb (2017) to be around 75 percent.

Appendix B4: Medicare Reimbursements

We also construct hospital Medicare reimbursement rates for the services we observe from the HCCI data. Medicare reimburses providers for inpatient care on the basis of DRGs; these are set in an attempt to compensate hospitals slightly above their costs of treating Medicare patients. To calculate the payment for specific cases of care, Federal regulations stipulate that a hospital's base payment is multiplied by a DRG weight that is set by CMS to capture the complexity of treating a particular type of case. Using data obtained from the CMS webpage, we follow the regulations and calculate the base payment rate for every hospital for every year from 2008 through 2011, including adjustments for wage index reclassifications, indirect medical education payments, and disproportionate share payments. The base payment rate is the hospital's Medicare price before any adjustment for its specific mix of DRGs. This is analogous to the risk-adjusted private price. In addition, we also obtain DRG weights from CMS that allow us to know the rates CMS paid hospitals for every DRG per year from 2008 through 2011. We also create Medicare reimbursement rates for our outpatient services using the relevant ambulatory payment classification weights.