EQUILIBRIUM EFFECTS OF HEALTH CARE PRICE INFORMATION*

Zach Y. Brown†

March 2018

Abstract

This paper examines whether information frictions in the market for medical procedures lead to higher prices and price dispersion in equilibrium. I use detailed data on medical imaging visits to examine the introduction of a state-run website providing information about out-of-pocket prices for a subset of procedures. Unlike other price transparency tools, the website could be used by all privately insured individuals in the state, potentially generating both demand- and supply-side effects. Exploiting variation across procedures available on the website as well as the timing of the introduction, estimates imply a 3 percent reduction in spending for visits with information available on the website. This is due in part to a shift to lower cost providers, especially for patients paying the highest proportion of costs. Furthermore, supply-side effects play a significant role—there are lower negotiated prices in the long-run, benefiting all insured individuals even if they do not use the website. Supply-side effects reduce price dispersion and are especially relevant when medical providers operate in concentrated markets. The supply-side effects of price transparency are important given that high prices are thought to be the primary cause of high private health care spending in the US.

Keywords: health care, price transparency, price dispersion, information frictions
JEL Classification: I13, L11, L86

---

*I thank Kate Ho, Chris Conlon, Michael Riordan, Tal Gross, Doug Almond, David Cutler, and many seminar participants for helpful comments and suggestions. I also thank Tyler Brannen and Maureen Mustard for providing website traffic data as well as background on the HealthCost website and the New Hampshire Department of Health and Human Services for access to the claims data. I gratefully acknowledge support from the National Science Foundation and the National Institute on Aging (T32-AG000186). Views expressed in the paper, as well as any errors, are my own.

†National Bureau of Economic Research and University of Michigan. Email: zachb@umich.edu.

1 Introduction

While the price of health care procedures varies widely across medical providers, these prices are often difficult for patients to observe. Consequently, individuals often choose providers without comparing prices.[1] A large theoretical literature, beginning with Stigler (1961) and Diamond (1971), argues that information frictions can impede competition and lead to higher prices. Technological innovations have made it easier for consumers to compare prices in a number of markets, potentially increasing price competition.[2] At the same time, information about prices may facilitate collusion, potentially decreasing price competition.[3]

In this paper, I ask how information about health care prices affects the market for health care services. Exploiting the introduction of a unique website that provided market-wide information for a subset of procedures in a state, I provide evidence on the long-run equilibrium effect of information about health care prices. I emphasize that the supply-side response to price transparency is particularly important. By observing detailed information on copay, coinsurance, deductible, and insurer payments, I also provide evidence about how insurers and patients split the savings that result from price transparency.

While we expect consumers to benefit from price transparency by choosing low-cost providers, price transparency may also allow insurers to negotiate lower prices with health care providers. This is because price transparency effectively increases residual demand elasticity, potentially incentivizing high cost providers to lower prices. These supply-side effects could benefit all consumers, including those that do not use the information. The presence of this externality may imply a role for the public provision of information. Effects on negotiated health care prices are especially important given that high health care expenditure in the United States is often attributed to high prices, and there is currently limited evidence on policies that can reduce health care prices.[4]

I exploit the introduction of a publicly-provided website that allows individuals to access information about their insurer-specific out-of-pocket price for certain medical procedures. While previously studied price transparency efforts have primarily been con-

[1] Surveys show that consumers rarely compare prices for medical services. See "How Much Will it Cost? How Americans Use Prices in Health Care," Public Agenda (2015).

[2] See Clay, Krishnan and Wolff (2001), Morton, Zettelmeyer and Silva-Risso (2001), Brown and Goolsbee (2002), and Goldmanis et al. (2010).

[3] For example, see Cutler and Dafny (2011).

[4] For instance, see Anderson et al. (2003), Koechlin, Lorenzoni and Schreyer (2010), and Cooper et al. (2015).

ducted by specific employers, the website provided information that could be used by all privately-insured individuals in the state. Since the intervention was market-wide, it potentially generated significant supply-side effects in addition to demand-side effects. In the main specification, I employ a difference-in-difference methodology that takes advantage of two sources of variation, namely the timing of the website introduction and variation among procedures available on the website. I also show that results are robust to exploiting cross-state variation. I focus on the universe of outpatient medical imaging visits, which account for over 9 million claims. I argue that the medical imaging procedures that were on the website are quite similar to the medical imaging procedures that were not on the website, allowing for a useful comparison. I also provide empirical support for the assumption that procedures on the website are unlikely to be differentially affected by time-varying demand and cost factors that affect prices in other ways.

First, I examine transaction prices, which include both demand- and supply-side effects. Over the five year period after the website started, there is a 3 percent reduction in total visit cost for medical imaging visits on the website relative to medical imaging procedures not on the website. Much of this savings goes to consumers, reducing out-of-pocket costs by 5 percent. This effect increases over time and by the fifth year, out-of-pocket prices are 11 percent lower relative to the control group. Individuals with the most to gain from using the website—those under their deductible—see almost double the savings over the period. These results are highly significant and robust to the inclusion of individual fixed effects and detailed insurer and individual controls.

Next, I examine the mechanisms driving the reduction in transaction prices. On the demand-side, individuals with access to the website are more likely to choose a low cost provider. Next, I analyze the supply-side effects using a difference-in-difference specification that controls for demand-side effects. Specifically, I include provider-procedure-insurer fixed effects that control for transaction price differences due to switching across providers. Since providers and insurers only negotiate a new price schedule at most once a year, the supply-side effect may take time to materialize. The estimates imply that providers reduce their prices in the long-run, defined as more than two years after the introduction of the website. Visit prices decline by 2 percent. The effect is greater for providers operating in concentrated markets that are likely to have the highest margins in the absence of the website. Although these effects are relatively modest, consistent with the fact that price transparency tools currently receive modest use, they suggest that supply-side effects could be quite large if more consumers were informed about prices.

One concern is that prices for procedures not on the website are indirectly affected. I show that these results are robust to an alternative identification strategy using cross-state variation that helps address this concern.

A theoretical literature has found that price dispersion can result from information frictions in the market.[5] In order to test whether price dispersion in the market for health care services is due in part to information frictions, I use a difference-in-difference methodology to directly examine the effect on price dispersion. The estimates imply that the website reduces price dispersion for affected procedures, as measured by the interquartile range of negotiated prices, by $159 on average relative to the price dispersion of the control procedures.

Prior research has focused on the demand-side response to health care price transparency efforts by individual employers and has found relatively small effects in the short run (Lieber 2017; Whaley 2015a; Desai et al. 2016). In particular, Desai et al. (2016) finds no reduction in spending in the year after an employer offers a price transparency tool. However, the previous literature has focused on price transparency efforts that are available to a small subset of consumers. In contrast, the New Hampshire website was publicly available to all consumers in the state, therefore, as I argue below, supply-side effects may be important in the long-run. In addition, New Hampshire's price transparency tool differed from other tools due to the quality of the underlying price information and the ease of use.

There is little evidence on the supply-side effects of market-wide price transparency. Whaley (2015b) focuses on a website providing information to specific employers and finds a reduction in the price of laboratory tests using an event-study methodology. While the previous literature has focused on price transparency tools for individual employers, I examine the introduction of a first-of-its-kind website that was available to all insured individuals in a state.[6] In a discussion of price transparency, Sinaiko and Rosenthal (2011) note that tools like New Hampshire's website may generate supply-side effects, however the effects may take time to materialize.[7] In addition, the effect of price transparency

[5]Even markets with homogenous products can exhibit price dispersion in equilibrium in the presence of information frictions. This is true with heterogenous consumers (Salop and Stiglitz 1977) as well as homogenous consumers (Burdett and Judd 1983).

[6]Note Christensen, Floyd and Maffett (2015) examine the effect of information about list prices (rather than out-of-pocket prices) and find little evidence of effects on negotiated prices.

[7]The authors hypothesize that price transparency could either lower or raise prices, but note that "it is too early to tell what the outcome of experiments with increased transparency will be."

on prices is theoretically ambiguous given the possibility that price transparency may facilitate provider collusion (e.g. Cutler and Dafny 2011). Using individual-level data on outpatient medical imaging visits by all insured individuals in New Hampshire, this paper provides the first evidence quantifying the overall equilibrium effects of price transparency for both individuals and insurers in a state. Understanding the equilibrium effect is particularly relevant given that many states are currently considering price transparency legislation.[8]

The remainder of this paper is as follows. Section 2 provides additional background on the website and health care pricing and Section 3 describes the data. Section 4 describes the main empirical strategy and discusses the demand-side and supply-side effects on prices. Section 5 concludes.

2 Institutional Details and Background

Recent research has documented a large degree of price dispersion in health care, especially in the private sector (Philipson et al. 2010; Newhouse et al. 2013).[9] Even relatively homogenous medical services vary in price. For instance, Cooper et al. (2015) find that MRI prices vary by a factor of 12 across the country.

There is a large degree of price dispersion even within a geographically constrained area. For example, the total price of a back MRI in New Hampshire for individuals covered by Anthem, the largest insurer in the state, varies widely, with an upper and lower quartile of $1,085 to $2,472 respectively. Consequently, the out-of-pocket price paid by individuals ranges as well, especially for those under their deductible (the out-of-pocket interquartile range is $143). More generally, Table 1 shows the potential savings if all consumers switched to a low cost provider, defined as a provider in the first quartile of the price distribution in the state.[10] Often these lower cost providers are outpatient facilities, such as medical imaging centers, rather than hospitals. Across a range of procedure categories, savings would be between 44 and 73 percent. Even if individuals switched to the provider

[8] At least 27 states proposed price transparency laws in 2015, although many of these proposals would not mandate disclosure of out-of-pocket prices. Price transparency legislation has also been proposed at the Federal level. See Nicholson (2015).

[9] Note that a large literature also focuses on variation in Medicare spending (e.g. Fisher et al. 2003; Fisher, Bynum and Skinner 2009)

[10] I calculate the first quartile of the price distribution conditional on individuals' insurance and procedure. I consider the case in which all individuals paying about this price switch to the provider charging the first quartile price.

with the median price they would save 16 to 58 percent on average.

One explanation for why these price differences persist even for relatively homogenous products is that patients lack information about prices. Health care prices are determined through bargaining between insurers and providers, and insurers often agree not to publicly disclose the negotiated contracts. Perhaps for this reason, surveys show that the majority of individuals do not compare prices before receiving medical care.[11]

In order to allow health care consumers to find low cost options, the state of New Hampshire began requiring health insurers operating in the state to submit medical claims to a centralized database in 2005. These data were then used to calculate the median bundled out-of-pocket prices for various medical procedures. In March 2007, New Hampshire launched their HealthCost website.[12] Individuals enter the procedure, their insurance information (including remaining deductible), their zip code, and search radius and obtain information about each provider's expected out-of-pocket price, insurer price, and total price. The site automatically takes into account copayment and coinsurance levels given their insurance. Results are sorted by out-of-pocket price making it easy to select the least expensive provider from the point of view of the patient. More recently, the tool has added additional information.[13] Although other states have since started price transparency websites of their own, including California, Maryland, Florida, Oregon, and New Jersey, New Hampshire's price transparency efforts are the most comprehensive.[14] It should be noted that although the New Hampshire tool is relatively easy to use compare to other tools, it still requires individuals to understand basic information about their health insurance.[15] There may be additional scope to lesson the burden for patients using these tools.

At the time it was introduced, the website had price information for about 35 procedures. The website focuses on outpatient procedures since patients often schedule these

[11]According to a nationally representative survey, 79 percent of individuals stated that they could not compare prices (or did not even try) before receiving medical care (Public Agenda 2015).

[12]Originally nhhealthcost.org, however the website can now be found at nhhealthcost.nh.gov.

[13]In early 2016, after my period of analysis, the website added information about provider quality and a guide to health insurance. Note the website also has a separate feature providing price information for uninsured individuals. I do not observe uninsured individuals, and therefore I do not examine the effect of this information.

[14]New Hampshire was the only state to receive an "A" grade from Catalyst for Payment Reform's 2015 Report Card on State Price Transparency Laws.

[15]For instance, the website requires individuals to know their remaining deductible. However, there is evidence that some individuals may not know this information (Cunningham, Denk and Sinclair 2001; Handel and Kolstad 2015).

appointments ahead of time and may have more scope for choosing among providers.

The HealthCost website has received significant attention in the state, with over 40 articles in the local public press. In addition, the New Hampshire Insurance Department promoted the website by encouraging primary care doctors to tell patient about the website. Insurers were also encouraged to inform their enrollees of the website.

Among individuals that could have benefited from the website, there was meaningful take-up. I construct a measure of website usage using monthly website traffic logs provided by the New Hampshire Insurance Department. Figure 1 shows the number of price searches on the website since 2005. When the website began, there were roughly 1,000 searches per month for the price of medical imaging procedures, which grew over time. Searches for the price of medical imaging procedures make up about half of all searches using the website.

It has been noted that the use of price transparency tools, including the New Hampshire tool, is low relative to the number of total patients (Mehrotra, Brannen and Sinaiko 2014; Sinaiko and Rosenthal 2016). In contrast to the previous literature, I use website traffic logs to examine take-up.[16] The website only has price information for a limited number of procedures, and individuals are unlikely to use it if they find that their procedure is not listed.[17] They are also unlikely to use it if they are receiving inpatient care. Focusing on privately insured individuals in New Hampshire receiving an outpatient medical imaging procedure that is listed on the website, I find that take-up is 8 percent. Take-up is lower for other procedures available on the website, perhaps because medical imaging procedures tend to be more standardized. Although I focus on medical imaging procedures, I argue understanding the high prices for these procedures is particularly important given that medical technology, especially related to medical imaging, is often cited as one of the key driver of health care cost growth.[18]

In addition to immediate demand-side effects from the website, there is anecdotal evidence of supply-side effects. Analysts have noted that "the balance of plan-provider negotiating power began shifting significantly in New Hampshire, a result in large part

[16]Mehrotra, Brannen and Sinaiko (2014) examine usage of the New Hampshire HealthCost tool from 2011 to 2013 using Google Analytics data and find small take-up relative to the state population. I use server traffic logs starting in 2007, a period in which Google Analytics data was not available. In conversations with the administrators of the HealthCost website, there was concern that Google Analytics data was not capturing all of the ways in which individuals accessed the HealthCost website.

[17]If individuals visit the website but do not use the search tool because their procedure is not listed, they are not counted in the website traffic data.

[18]See, for example, Newhouse (1992) and Cutler (1995).

of public transparency efforts."[19] For instance, Exeter Hospital and Anthem, the largest insurer in New Hampshire, had a public dispute over contract terms in 2010. Anthem argued that prices at Exeter Hospital were too high, pointing to the website as evidence, and was eventually able to negotiate rate cuts.[20]

Why might provider prices respond to price information? First, consider the case in which providers have market power and are able to unilaterally set price. If consumers become more price sensitive due to better information about prices, the profit maximizing price will decline. In the market for private health care, prices are determined through bilateral negotiations between providers and insurers rather than set unilaterally. In this case, a similar mechanism applies. However, equilibrium negotiated prices may also depend on insurer incentives (Ho 2009; Gowrisankaran, Nevo and Town 2015; Ho and Lee 2017). To the extent that the website affects either provider or insurer gains from trade, negotiated prices may be affected in equilibrium.[21]

3 Data

The main dataset covers the universe of private insurance enrollment and medical claims in the state of New Hampshire from 2005 to 2011. These data were collected as part of the New Hampshire Comprehensive Health Care Information System, which assembled data from all commercial insurers with enrollees that were state residents or who receive services under a policy issued in the state. These are the same data used to construct prices for the website.

Each outpatient claim has a CPT/HCPCS code which can be used to identify procedures.[22] These codes are very specific (e.g. code 72120 is "X-ray examination, spine, lumbosacral; bending views only, 2 or 3 views"). I limit the sample to the universe of outpatient medical imaging claims, which includes 289 procedures related to X-rays, computerized tomography (CT) scans, and magnetic resonance imaging (MRI) scans. These procedures all use imaging to diagnose internal conditions. The number of procedures in

[19] See Tu and Gourevitch (2014).

[20] For more information, see "Exeter Hospital Says Costs Being Used as Negotiating Tactic," Seacoastonline.com, Nov. 14, 2010.

[21] I explore these mechanisms in more detail in a follow-up work.

[22] Current Procedural Terminology (CPT) codes are a set of codes developed and maintained by the American Medical Association. Healthcare Common Procedure Coding System (HCPCS) codes are an extension of CPT codes that include additional procedures such as non-physician services.

each category are listed in Table 2.

Inpatient medical imaging procedures, such as those that are part of major surgeries, are excluded from the analysis. Since individuals have little ability to choose a provider when medical imaging procedures are part of an inpatient episode, the website only includes information about outpatient medical imaging procedures.[23]

In addition to the principal medical imaging procedure, there are often supplemental procedures such as contrast agents that are billed along with the main procedure. The quantity and price of these supplemental procedures may also vary across providers. When comparing the cost across medical providers, the relevant price is determined by the entire bundle of procedures. For this reason, the website has information about the cost of an entire visit. For the same reason, my analysis focuses on the price of the visit. I also examine the principal procedure price alone. The construction of the visit price and principal procedure price are described in more detail in Appendix Section A. Conducting analysis at the visit level has important implications for the interpretation of the results and comparisons with the large literature that conduct analysis at the claim level.

There are 811,553 individuals under age 65 with at least one medical imaging claim between 2005 and 2011. Using individuals' zip code, I merge on additional demographic information, including income and education, using the 2007-2011 American Community Survey. I also construct each individual's Charlson Comorbidity Index using International Classification of Diseases (ICD) codes in the claims dataset (Charlson et al. 1987; Stagg 2006). The Charlson Comorbidity Index is an integer score that summarizes comorbid conditions that predict mortality. In addition, I construct the number of medical claims each individual had in the previous year, which I use as a proxy for individuals' experience with the health care system. Individual demographics are summarized in the first panel of Table 3.

Each medical claim is also associated with an anonymized provider identifier that can be linked to additional information such as provider zip code and whether the provider is a hospital or non-hospital facility. This information is used to construct provider concentration in each county.

The vast majority of individuals in the sample are covered by a managed care organization, either a Health Maintenance Organization (HMO) plan, Preferred Provider Organization (PPO) plan, Point-of-Service (POS) plan, or an Exclusive Provider Organi-

[23]The website does include prices for a few inpatient procedures that are not related to medical imaging (e.g. newborn delivery).

zation (EPO) plan. The defining feature of managed care plans is that insurers negotiate lower prices with a selected network of providers. The plan types differ according to the standards used when individuals select providers within the network. Only 3 percent of individuals have an indemnity (fee-for-service) plan. Plan type is summarized in the second panel of Table 3. There are three main insurers operating in New Hampshire: Anthem, Cigna, and Harvard Pilgrim. Less than a a fifth of individuals are enrolled in another plan (see third panel of Table 3).[24]

The plans offered in New Hampshire over the period differ in their cost-sharing characteristics. In particular, 45 percent of individuals pay a deductible at some point over the period (see last panel of Table 3). In general, individuals are responsible for all health care costs under the deductible amount in a given year. Although I do not observe the deductible amount associated with each plan, I do observe the deductible paid on each visit. Using observed deductible payments, I construct an indicator for whether each individual is under or over her deductible in a given year in order to test whether individuals benefit more from the website when they are subject to a deductible.[25]

Over the period, there are 9.2 million claims that constitute 2.1 million medical imaging visits (i.e. there are about 3 supplemental procedures on average per medical imaging visit). For each health claim, I observe the copayment, coinsurance, and deductible paid by the individual, which together makes up the out-of-pocket price. In addition, I observe the insurer paid amount. Together, the out-of-pocket price and insurer paid amount constitute the total price received by the provider, often called the allowed amount.[26]

The average price paid by individuals and insurers is presented in Table 4. Insurers pay the majority of the cost for medical imaging procedures. Although out-of-pocket prices are low on average, there is high variance and some individuals are fully exposed to the total price.

The summary statistics presented in Table 4 preview the results. Although the price of all procedures is increasing over time, the simple difference-in-difference estimate using the average total price implies that the price of procedures on the website declined by \$64 relative to the price of procedures not on the website. However, it is important to

[24]For more detail on the construction of demographic covariates, see Appendix Section A.

[25]Individuals who know they will fulfill their deductible over the course of the year should not be price sensitive. However, to the extent that individuals have uncertainty about their future health care use or are myopic, individuals will be price sensitive even if they are close to hitting their deductible. For this reason, I consider all individuals who have not passed their deductible.

[26]Capitation payments for medical imaging procedures were negligible during the period.

control for changes in the composition of procedures and changes across time affecting the control group.

4 Effect on Prices

I begin by examining the overall effect on transaction prices, including total visit amount, out-of-pocket amount, and insurer amount. I examine the heterogenous effects and show that results are robust to a number of specifications. Using a similar identification strategy, I show that this effect is due to both demand-side and supply-side factors.

4.1 Empirical Strategy

In order to estimate the causal effect of price transparency on prices, I exploit two sources of plausible exogenous variation: the timing of the website introduction and the availability of medical imaging procedures on the website. In particular, I construct OnWeb_m, which indicates whether procedure m is ever available on the website. I also construct Post_t, which indicates if the website is available at month t. This takes the value of 1 if the date of admission is March 2007 or later. The baseline difference-in-difference specification is given by:

$$\log(1 + p_{imjkt}) = \beta(\text{OnWeb}_m \times \text{Post}_t) + \alpha X_{it} + \lambda_m + \lambda_k + \lambda_t + \varepsilon_{imjkt} \tag{1}$$

The outcome of interest is p_{imjkt}, the price of a visit for individual i with insurance k obtaining procedure m from provider j at time t. I consider both the patient's out-of-pocket cost as well as the cost to the insurer. The baseline specification controls for individual covariates X_{it}, which includes age, gender, charlson comorbidity index, income, education, rural classification, and member plan characteristics (deductible, coinsurance, and copay). I also include procedure fixed effects, λ_m, and insurer fixed effects, λ_k, that control for time-invariant factors that may be correlated with prices and the availability of the website.[27] I also include month fixed effects, λ_t, which control for time varying factors that may be correlated with prices and website availability. Finally, ε_{imjkt} is a vector of idiosyncratic random errors. Prices are highly correlated within each month since individuals tend to be subject to a deductible in the beginning of the year, but not

[27]For the insurer fixed effects, I define an insurance plan as a unique combination of insurance firm and insurance type (e.g. Anthem HMO).

at the end of the year. To account for correlation within a month, standard errors are clustered at the month level. The unit of analysis is an individual medical imaging visit.

The dependent variable is transformed using $\log(1+y)$ since the out-of-pocket price and the insurer price can be zero, making $\log(y)$ undefined. An alternative to using OLS with a log transformed dependent variable is to use GLM with a log-link function. I discuss this alternative model along with robustness results in Section 4.3.

The coefficient of interest, β, is interpreted as the change in prices due to the presence of the website in log-points. This should be interpreted as the intent-to-treat effect, keeping in mind that take-up was 8 percent and individuals that did not use the website may be indirectly affected due to supply-side effects. The main identifying assumption is that, in the absence of the website, the procedures on the website and the procedures not on the website would follow common trends. I use a number of methods to examine the validity of this assumption, including examining trends prior to the introduction of the website and a falsification test.

In order to isolate the supply-side effect of price transparency I use a similar identification strategy, but control for the demand-side effects. In particular, I include fixed effects that control for the variation in price of each procedure across providers and insurers. This approach is similar to that of Christensen, Floyd and Maffett (2015). The specification is now

$$\log(1+p_{imjkt}) = \beta(\text{OnWeb}_m \times \text{Post}_t) + \alpha X_{it} + \lambda_{jmk} + \lambda_t + \varepsilon_{imjkt} \tag{2}$$

where the vector λ_{jmk} includes an indicator for each combination of provider, procedure, and insurer. Any variation in transaction prices due to the fact that individuals switch to lower-cost providers after the introduction of the website is absorbed by these fixed effects. Another way to see this is to note that conditional on going to the same provider, with the same insurance, and receiving the same procedure, a change in transaction prices must be due to a supply-side effect. Note that these fixed effects also absorb changes in prices due to the entry of providers over the period. The remaining variation in price identifies β, which can now be interpreted as the reduction in transaction prices due to lower negotiated prices for a given provider.

Due to the fact that the regression is run at the individual level, β can be interpreted as the supply-side effect weighted by quantity demanded after taking into account demand-side effects. For instance, if only rarely chosen providers reduce their price, β

will be smaller than the average unweighted effect on provider prices.[28] I focus on the weighted results since, from a policy perspective, it is important to understand the effect experienced by the average patient.

It is important to note that these supply-side factors could be driven by a number of factors. One mechanism is that insurers negotiate lower prices for specific procedures, however this need not be the case. Providers may reduce list prices (i.e. chargemaster prices), which then get passed on to insurers if contracts are negotiated as a discount relative to list prices. Alternatively, providers could bill less aggressively (either less up-coding or fewer supplemental procedures). Distinguish between these explanations is difficult given the secrecy around provider-insurer negotiations, however I provide some evidence on this issue by examining the effect on the entire visit price (which includes all supplemental procedures) as well as the effect on the principal procedure price alone.

An identifying assumption is that the website only affected prices for procedures on the website, i.e. there are no spillover effects to procedures not featured on the website. This would be violated if, for instance, hospitals responded to the website by cutting prices for all medical imaging procedures. This assumption would also be violated if providers raised prices for procedures not on the website to compensate for lower prices for procedures on the website. I address these concerns by exploiting cross-state variation. In particular, the specification is

$$\log(1 + p_{imjkt}) = \beta(\text{InNH}_j \times \text{Post}_t) + \alpha X_{it} + \lambda_{jmk} + \lambda_t + \varepsilon_{imjkt} \tag{3}$$

where InNH_j indicates if provider j is in New Hampshire, and thus had information available on the website. The identifying assumption is that prices for providers outside of New Hampshire that are in the NHCHIS database do not change in response to the website given that New Hampshire patients make such a small part of their demand. I discuss this in more detail in Section 4.7.

I also examine how the supply-side effect varies by the degree of local competition between providers. In particular, I use the Herfindahl index in each county for each procedure category, which is defined as $\text{HHI}_{cl} = \sum_j s_{jcl}^2$ where s_{jcl}^2 is the market share of provider j in county c among all procedures in procedure category l. The period prior to the introduction of the website is used to calculate HHI_{cl} in order to address concerns

[28] I do in fact find that the magnitude of estimated effects is larger when examining the unweighted supply-side effect using a similar specification after aggregating the data to the provider-procedure-insurer level.

that the market structure may have been endogenously affected by the website.

Finally, I examine price dispersion directly as measured by the interquartile rage of prices. I exploit the same sources of variation but aggregate to the procedure-month level and use the interquartile range of prices, IQR_{mt}, as the outcome variable. To examine the dispersion in transaction prices, IQR_{mt} is defined as the difference between the third and first quartile of transaction prices for each procedure in each month. To examine the dispersion in provider prices (or negotiated prices), IQR_{mt} is defined as the difference between the third and first quartile of prices for each procedure in each month after aggregating to the provider-procedure-month level. Under the same assumptions as previous specifications, β can be interpreted as the dollar change in the interquartile range of prices due to the website.

4.2 Effect on Transaction Prices

Figure 2 presents the main results for transaction prices by half year with the full set of controls and fixed effects.[29] In the periods before the website, there is no significant price effect for procedures that were eventually on the website and those that were never on the website. This provides evidence that the procedures on the website had similar trends in the pre-period as the procedures that were not on the website, supporting the common trends assumption. Once the website launched, the total visit amount (i.e. allowed amount) declined for procedures on the website relative to procedures not on the website. The effect becomes significant in the second year. This effect grows over time, eventually leading to a 4 percent reduction in the total visit amount (Figure 2a) and 11 percent reduction in patients' out-of-pocket amount (Figure 2b) five years after the introduction of the website. As I discuss in subsequent analysis, this is partially due to the fact that supply-side effects take time to materialize, as prices are renegotiated infrequently. In addition, the website was being used more often in the later period (see Figure 1).

The first panel of Table 5 presents the average effect on visit amount over the five-year period. The estimates imply a 3.1 percent reduction from a mean of \$950. This can be interpreted as the reduction in spending per visit due to both demand- and supply-side factors. For patients, the estimates imply a 5.4 percent reduction in out-of-pocket prices due to the website from a mean of \$115.45 (see second panel of Table 5). These results

[29] The specification used for Figure 2 is $\log(1+p_{imjkt}) = \sum_t \beta_t(\text{OnWeb}_m \times \text{SemiYear}_t) + \alpha X_{it} + \lambda_m + \lambda_k + \varepsilon_{imjkt}$. The interaction with the time period before the introduction of the website is omitted.

are significant at the 1 percent level. Next I examine how the effect varies by deductible status. Individuals that are not past their deductible are potentially exposed to the full cost of the procedure, and thus have the most to gain from choosing a low-cost provider.[30] Consistent with this fact, I find that individuals subject to a deductible see a much larger reduction in out-of-pocket cost, a 10.3 percent decline (from a mean of $295).[31]

Individuals who are subject to a coinsurance payment may still have an incentive to find a low-cost provider and benefit from the website.[32] In addition, individuals who do not use the website and find a low-cost provider may still benefit if providers reduce their prices. This is the supply-side effect that I explore in detail in following sections. The results imply that individuals that do not have a plan with a deductible see a significant reduction in prices of about 4 percent (see column 2 in Table 5). I find no evidence of an effect for individuals past their deductible. These individuals often have little exposure to prices.

Although individuals are not likely to internalize the cost to the insurer when choosing a provider using the website, there may be an indirect benefit to the insurer. In particular, there is a mechanical correlation between the individual's out-of-pocket price and the insurer price when the individual is subject to a coinsurance payment. To test whether insurers also benefit from the website, I use the same specification but with the insurer paid amount as the dependent variable. The third panel of Table 5 presents the results. The insurers save 3.7 percent on average over the period (from a mean of $777). This is highly statistically significant. Much of this savings is due to individuals without a deductible, consistent with the fact that most of the savings when there is a deductible accrue to the individual.

The magnitude of the effect is larger for patients and insurers than for the total visit amount. Although it may initially seem that the total effect should be between the effect for patients and the effect for insurers, this is not necessarily the case given that the effect is measured in percentage terms and the fraction of the cost paid by the insurer is not constant. It also should be noted that although the percent change in prices is larger for

[30]Depending on the specifics of the plan design, some procedures may not count towards an individual's deductible. In addition, some individuals classified as under their deductible hit their deductible on the current visit. For these reasons, the out-of-pocket cost is often less than the full price when an individual is not past the deductible.

[31]I conduct a Wald test and determine the difference between the effect for individual subject to a deductible and those not subject to a deductible is significant.

[32]Coinsurance payments are a set percentage of the total price, often between 5 and 25 percent, that are paid by the individual.

out-of-pocket amount than insurer amount, the insurers actually benefit more from the website in absolute terms. This is because the insurer covers the majority of the cost—88 percent of the total price on average.

4.3 Robustness of Demand-Side Effects

Appendix Table A-2 shows that out-of-pocket price and insurer paid amount results are robust to a number of specifications. In particular, the results are not driven by changes in observable characteristics of individuals. In addition, the fact that the results are robust to insurance fixed effects implies that effects are not driven by changes in insurance enrollment over the period. In Appendix Section B I provide additional evidence that the website did not affect insurance enrollment.

Another concern is unobservable individual characteristics. In particular, individuals that obtain private health insurance after the introduction of the website could be different on unobservable dimensions. In Appendix Table A-2 Column 5, I control for individual fixed effects. Identification now comes from the same individuals that received medical imaging procedures before and after the introduction of the website. Although this results in a much smaller sample size, the results are largely robust to this specification, however the effect on insurer paid amount become insignificant.

A related concern is that the website changed the complexity of procedures due to an increase (or decrease) in the probability that an individual has a procedure when information is available. This concern is somewhat mitigated by the fact that medical imaging procedure codes are quite specific, and are standardized across providers. In addition, in Appendix Section C, I show that the website did not have a meaningful effect on the probability of receiving a procedure.

The out-of-pocket price may be zero if the insurer pays the full cost due to full insurance. Similarly, the insurer price may be zero if the individual pays the full cost because the individual is under the deductible. Due to this issue, the dependent variable is transformed using $\log(1+y)$ to avoid undefined values. One alternative to this transformation, which generates point estimates with a similar interpretation, is to use GLM with a log-link function and an untransformed dependent variable (Manning and Mullahy 2001). For computational tractability, I aggregate to the procedure-month level and use a weighted GLM approach. Column 6 in Appendix Table A-2 shows that results are similar to the baseline case, although standard errors are slightly larger. For completeness, Column 5

shows the weighted OLS results, which are also similar.

In Appendix Table A-3 I conduct a falsification exercise in which I test whether there was an effect on prices in the one year period before the website actually existed. Consistent with the assumption that results are not driven by differential price trends, all of the estimates are quite close to zero. Eleven of the twelve estimates are not statistically significant, and the one that is significant implies that there was an *increase* in transaction prices for procedures eventually on the website.

4.4 Heterogenous Effects

I examine results by demographic characteristics to examine which groups benefits most from the price information. These results are presented in Table 6. First, I examine individuals who received a medical imaging procedure immediately after having an emergency. Note these are relatively minor emergency visits since I exclude inpatient admissions. I find no statistically significant effect for outpatient emergency visits. The difference between the effect for emergency and non-emergency visits is statistically significant, consistent with the idea that non-emergency procedures could potentially be scheduled further in advance, allowing time to use the website. The third and fourth column of Table 6 examines the effect for rural and urban patients, who may benefit differently from price information due to the availability of providers. The magnitude of the effect is larger for urban patients, although the difference is statistically significant only at the 10 percent level.

At the time of the website launch, younger and higher income individuals were more likely to have broadband internet. [33] This may have increased access to the price transparency website. The bottom row of Table 6 shows that the magnitude of the effect is larger for younger and higher income individuals, however the differences are not statistically significant.

Taken together, these results imply that price transparency provides benefits across a range of demographic groups. However, the benefits accrue most to those groups that had the highest ability to shop-around, potentially exacerbating health inequality.

[33]Individuals age 18 to 29 were 23 percentage points more likely to have broadband internet then those age 50 to 64. Those with income over $75,000 were 46 percentage points more likely than those with an income under $30,000. See Pew Internet and American Life Project, Home Broadband Adoption, July 2007.

4.5 Demand-Side Effects

The primary motivation for the website was to allow individuals to shop-around for medical care. In Table 7 I directly examine provider choice outcomes using the same difference-in-difference specification to provide evidence that price effects are mediated by changes in demand.

Over the period, 34 percent of individuals with repeat visits went to the same provider as their prior visit. Using a difference-in-difference linear probability model where the dependent variable is an indicator for whether the chosen provider is the same as the prior visit, I examine whether the website made individuals more likely to switch providers. Column 1 in Table 7 implies that the website significantly reduced the probability of going to the same provider as the previous visit by about 6 percent (2 percentage point reduction from the mean).

New Hampshire is a relatively small state and many residents work in surrounding states, particularly in Massachusetts.[34] Almost a third of the individuals in the sample go to medical imaging providers outside the state, however the website only provides information about the price of providers within the state. The third column of Table 7 shows that the website significantly increased the probability that individuals went to a provider within New Hampshire.

Table 7 Column 4 presents the results using distance between the individual and provider zip code as the dependent variable. When individuals lack price information, they may choose a provider close to their home since distance is a known characteristic. Conversely, if prices are known they may be willing to drive further.[35] I find evidence for this hypothesis—when the website is available, individuals drive further on average.

One limitation of the data is that there is no information about patient referrals. The website may have affected individuals' choice of provider or it may have affected physicians' referrals. Since I do not observe referrals, I do not differentiate between these mechanisms.

[34] About 17 percent of workers living in the New Hampshire work in a different state, one of the highest rates in the nation. See Out-of-State and Long Commutes, Census 2011.

[35] In follow-up work, I present a model that formalizes this intuition.

4.6 Supply-Side Effects

Given that individuals switch to lower-cost providers, did this put downward pressure on prices? I examine supply-side effects by estimating a model with controls for demand-side factors, namely provider-procedure-insurer fixed effects.

The supply-side effect for each time period can be seen in Figure 3.[36] Panel a shows the effect on the total visit price, which includes all supplemental procedures. Compare to the equilibrium effect presented in Figure 2 Panel a, the point estimates are smaller in magnitude, especially in the period right after the introduction of the website. However, the estimates are still highly significant, especially in the later period, implying that provider prices decline in the long-run.

Recall that the visit price is determined by the prices of a bundle of procedures. The primary way that the provider can change the price of the bundle is by changing the price of the principal medical imaging procedure, which makes up more than half of the cost of the bundle on average. Figure 3 Panel b examines the effect on the principal procedure price. There is a large supply-side effect three to five years after the website which I interpret as evidence that the website reduced negotiated prices in the long-run.

Table 8 Columns 1 and 2 formalize these results. When isolating the supply-side, the short-run effect is quite small. Visit prices declined by 1.0 percent while the principal procedure price declined is negligible. The long-run effects are larger—there is a 1.7 percent reduction in visit prices and 3.0 percent reduction in principle procedure price. These results are statistically significant. These results should be interpreted as the supply-side effect experienced for the average consumer in the sample.

Overall, this is evidence that there was a significant reduction in negotiated prices, especially in the long-run. The fact that the principal procedure price is most affected in the long-run is consistent with the fact that prices are renegotiated infrequently.

One caveat is that the changes in demand caused providers to reduce the price of supplemental procedures in addition to principal procedure prices. Since supplemental procedures, such as contrast agents and examinations related to medical imaging procedures, are common across procedures on the website and procedures not on the website, these reductions in prices would be "differenced-out". This would lead to an underestimate of the supply-side effects of price transparency. Thus, Table 8 are conservative

[36] The specification used for Figure 2 is $\log(1+p_{imjkt}) = \sum_t \beta_t(\text{OnWeb}_m \times \text{SemiYear}_t) + \alpha X_{it} + \lambda_{mjk} + \lambda_t + \varepsilon_{imjkt}$. The interaction with the time period before the introduction of the website is omitted.

estimates of the savings from the website.

Providers operating in concentrated markets may be able to negotiate higher prices with insurers (e.g. Dranove, Shanley and White 1993; Town and Vistnes 2001; Gowrisankaran, Nevo and Town 2015). I define the Herfindahl index by county and procedure category in the period prior to the introduction of the website. There is significant variation in competition—some counties have a single provider in the market for certain procedure categories while others are relatively unconcentrated.

Table 8 Columns 3 and 4 present the supply-side effect on total visit price by market concentration. In both the short-run and long-run, there is a larger effect of the website in high concentration markets (those with Herfindahl index above the fourth quartile) compare to low concentration markets (those at or below the first quartile). This difference is statistically significant for both the short-run and long-run. This is evidence that price transparency put the most downward pressure on prices in markets where price cost margins were likely the highest.

Finally, Table 8 Columns 5 and 6 compare results for hospitals and non-hospital providers, which are likely free-standing outpatient facilities. The results are insignificant for hospitals, although there is a smaller sample. The supply-side effects are primarily driven by non-hospital providers, which decrease prices by 2.4 percent in the long run. The difference between the effect for hospitals and non-hospitals is statistically significant at the 1 percent level. I also examine a similar specification after aggregating to the provider-procedure-insurer level, thus capturing the unweighted effect across all providers regardless of market share. The magnitude of the supply-side effect is slightly larger, indicating that the providers with low market share decreased prices even more.[37]

4.7 Robustness of Supply-Side Effects

One important concern is that the supply-side effects may be biased due to the fact that procedures not on the website are affected, either due to providers reducing all prices in response to the website or due to increasing prices for procedures that are not on the website to compensate for lost profits from procedures on the website. Although there is little theoretical justification for why profit-maximizing providers would not optimize prices for each procedure individually (see, e.g., Frakt 2011), I address this concern by

[37]Results available upon request.

exploiting cross-state variation in price information.[38]

Although the NHCHIS dataset only includes individuals insured in New Hampshire, many of these individuals live or work outside of New Hampshire and go to providers outside of New Hampshire, largely in Massachusetts and Vermont. Therefore, prices for medical imaging providers outside of New Hampshire can be used as a control group since the website only provided prices for providers within New Hampshire. Unlike prices for medical imaging procedures that are not on the website at providers in New Hampshire, the prices for medical imaging procedures outside of the state are not affected by cost-shifting.[39] I limit the sample to procedures available on the website, exploiting variation across time and across state borders. The specification is presented in Section 4.1.

Appendix Table A-4 presents the results. The results are qualitatively similar as the baseline specification. In the short-run, the estimates do not imply a statistically significant effect on negotiated prices. However, there is a negative and significant effect in the long-run. The magnitude of the effect is larger than the specification presented in Table 8, implying almost a 5 percent reduction in prices in the long-run. Overall, these estimates provide evidence that the supply-side results presented in Table 8 do not reflect providers that raised the price of procedures not on the website to offset lower negotiated prices for procedures on the website. The downside of this approach is that there is a smaller sample.

4.8 Price Dispersion

Theoretical work has emphasized that information frictions can give rise to price dispersion in equilibrium even when products are homogenous (e.g. Salop and Stiglitz 1977; Burdett and Judd 1983). At the same time, a recent literature has documented the large degree of price variation for privately provided health care, even for relatievely standardized procedures (e.g. Cooper et al. 2015), raising questions about the underlying cause of this variation. In this section, I examine whether a reduction in information frictions can reduce price dispersion, as measures by the interquartile range of prices. I find evidence

[38]Note that the cross-price elasticity between different procedures is likely zero (e.g. there is no substitution between arm x-rays and leg x-rays). Therefore, there is little theoretical justification why a change in demand for one procedure would generate spillover effects for other procedures when firms are profit-maximizing.

[39]In particular, any changes in demand due to the website are unlikely to affect prices outside of New Hampshire given that New Hampshire patients likely make up a very small fraction of patients in these states.

that the website reduced the range of transaction prices as well as the range of negotiated provider prices.

Column 1 and 2 in Table 9 presents the results for transaction prices. There is a $231 reduction in the interquartile range of visit prices on the website relative to those not on the website (a 19 percent reduction from the mean of $1,184). There is also a $104 reduction in the interquartile range of principal procedure prices. Both these results are significant at the 1 percent level.

More importantly, I examine the effect on the interquartile range of negotiated provider prices (see column 3 and 4 in Table 9). The interquartile range of visit prices declines by $159, a 16 percent reduction from the mean. Focusing on the principal procedure price, which was likely most affected by the website, the interquartile range of provider prices declined by $96, or 17.8 percent of the mean. These results are also statistically significant.

Together with the previous results, these results imply that website decreased both the mean and variance of the distribution of transaction prices. This was due in large part to a shift in the distribution of negotiated prices. Consistent with the theoretical literature on information frictions and price dispersion, lower information frictions allows patients and insurers greater ability to discipline the market.

5 Discussion and Conclusion

The health care system can be complicated to navigate, and information frictions are thought to be pervasive (Reinhardt 2012). In this paper, I examine how a publicly available website providing price information affected the market for medical imaging procedures. While previous research has focused on the demand-side effect of information supplied by employers, I examine the equilibrium effects of a state-wide initiative.

Overall, the HealthCost website reduced the cost of medical imaging procedures by 5 percent for patients and 4 percent for insurers. A simple calculation implies that individuals saved around $7.9 million and insurers saved $36.0 million on X-Ray, CT scan, and MRI scans over the 5 year period.[40] While demand-side effects are important, there are significant supply-side effects in the long-run when information is available to all individuals. In other words, this is evidence that price opacity softens provider competition,

[40] All figures in 2010 dollars.

leading to higher prices. This is particularly important given that the average price of medical imaging procedures in the U.S. is roughly double that of other OECD countries.[41]

Previous research has found modest effects of price transparency initiatives at the employer level. However, this paper provides evidence that price transparency can be effective in the long-run, especially when available to the entire market. The presence of supply-side effects also implies that usage of the price transparency tool generates positive spillovers for other consumers due to lower prices, motivating the public provision of price information. Given that a sizable portion of benefits accrue to individuals under their deductible, it also implies that insurers may not have a strong incentive to provide these tools.

While this paper focuses on X-rays, CT scans, and MRI scans, it is important to consider whether the results apply more broadly. It has been estimated that 30% to 40% of spending on medical services is for procedures that are shoppable and price transparency may be able to generate equilibrium effects for these procedures as well.[42] Price transparency tools are unlikely to have an effect for other procedures, such as complicated surgeries with prices that are determined on a case-by-case basis.

Finally, this paper does not examine other margins of adjustment such as entry and exit of providers. All specifications implicitly control for changes in the set of providers, however it may be that the website caused new low-cost medical imaging providers to enter the market.[43] In fact, there was entry of free-standing outpatient medical imaging facilities after the website started, although it is not clear that it was due to the website.[44] At the same time, price transparency could negatively affect the profitability of more expensive providers, such as hospitals, potentially leading to exit. Future work should examine these additional margins.

Given that website traffic logs reveal that only a small fraction of individuals receiving medical imaging procedures in New Hampshire use the website, the supply-side effects may be quite large if all consumers were informed about prices. This is particularly important because policies that lower prices are seen as key for lowering the cost of privately-provided health care in the US. I examine these issues in future work.

[41] The average price of an MRI scan is $1,200 in the US but only $569 in other OECD countries with available data. The average price of CT scan is $228 in the US but only $98 in other OECD countries with available data. See Squires (2011).

[42] See White and Eguchi (2014) and Health Care Cost Institute Issue Brief 11 (2016).

[43] In particular, month fixed effects absorb entry and exit of providers.

[44] Analyzing these issues would require a different identification strategy beyond the scope of this paper.

References

Anderson, Gerard F., Uwe E. Reinhardt, Peter S. Hussey, and Varduhi Petrosyan. 2003. "It's the prices, stupid: why the United States is so different from other countries." *Health Affairs*, 22(3): 89–105.

Brot-Goldberg, Zarek C., Amitabh Chandra, Benjamin R. Handel, and Jonathan T. Kolstad. 2017. "What does a Deductible Do? The Impact of Cost-Sharing on Health Care Prices, Quantities, and Spending Dynamics*." *The Quarterly Journal of Economics*, 132(3): 1261–1318.

Brown, Jeffrey R., and Austan Goolsbee. 2002. "Does the Internet Make Markets More Competitive? Evidence from the Life Insurance Industry." *Journal of Political Economy*, 110(3): 481–507.

Burdett, Kenneth, and Kenneth L. Judd. 1983. "Equilibrium Price Dispersion." *Econometrica*, 51(4): 955–969.

Charlson, Mary E., Peter Pompei, Kathy L. Ales, and C. Ronald MacKenzie. 1987. "A new method of classifying prognostic comorbidity in longitudinal studies: development and validation." *Journal of chronic diseases*, 40(5): 373–383.

Christensen, Hans Bonde, Eric Floyd, and Mark G. Maffett. 2015. "The Effects of Price Transparency Regulation on Prices in the Healthcare Industry."

Clay, Karen, Ramayya Krishnan, and Eric Wolff. 2001. "Prices and Price Dispersion on the Web: Evidence from the Online Book Industry." In *E-commerce. NBER Chapters*, 521–539. National Bureau of Economic Research, Inc.

Cooper, Zack, Stuart V. Craig, Martin Gaynor, and John Van Reenen. 2015. "The Price Ain't Right? Hospital Prices and Health Spending on the Privately Insured." National Bureau of Economic Research Technical Report.

Cunningham, Peter J, Charles Denk, and Michael Sinclair. 2001. "Do consumers know how their health plan works?" *Health Affairs*, 20(2): 159–166.

Cutler, David, and Leemore Dafny. 2011. "Designing Transparency Systems for Medical Care Prices." *New England Journal of Medicine*, 364(10): 894–895. PMID: 21388307.

Cutler, David M. 1995. "Technology, health costs, and the NIH." *National Institutes of Health Roundtable on the Economics of Biomedical Research*.

Desai, Sunita, Laura Hatfield, Andrew Hicks, Michael Chernew, and Ateev Mehrotra. 2016. "Association Between Availability of a Price Transparency Tool and Outpatient Spending." *JAMA*, 315(17): 1842–1843.

Diamond, Peter A. 1971. "A model of price adjustment." *Journal of Economic Theory*, 3(2): 156–168.

Dranove, David, Mark Shanley, and William D. White. 1993. "Price and Concentration in Hospital Markets: The Switch from Patient-Driven to Payer-Driven Competition." *Journal of Law and Economics*, 36(1): 179–204.

Fisher, Elliott S., David E. Wennberg, Thrse A. Stukel, Daniel J. Gottlieb, F. Lee Lucas, and Etoile L. Pinder. 2003. "The implications of regional variations in Medicare spending. Part 1: the content, quality, and accessibility of care." *Annals of internal medicine*, 138(4): 273–287.

Fisher, Elliott S., Julie P. Bynum, and Jonathan S. Skinner. 2009. "Slowing the growth of health care costs—lessons from regional variation." *New England Journal of Medicine*, 360(9): 849–852.

Frakt, Austin B. 2011. "How much do hospitals cost shift? A review of the evidence." *Milbank Quarterly*, 89(1): 90–130.

Goldmanis, Maris, Ali Hortaçsu, Chad Syverson, and Onsel Emre. 2010. "E-Commerce and the Market Structure of Retail Industries." *Economic Journal*, 120(545): 651–682.

Gowrisankaran, Gautam, Aviv Nevo, and Robert Town. 2015. "Mergers When Prices Are Negotiated: Evidence from the Hospital Industry." *American Economic Review*, 105(1): 172–203.

Handel, Benjamin R., and Jonathan T. Kolstad. 2015. "Health Insurance for "Humans": Information Frictions, Plan Choice, and Consumer Welfare." *American Economic Review*, 105(8): 2449–2500.

Health Care Cost Institute Issue Brief 11. 2016. "Spending on Shoppable Services in Health Care."

Ho, Katherine. 2009. "Insurer-Provider Networks in the Medical Care Market." *American Economic Review*, 99(1): 393–430.

Ho, Katherine, and Robin S. Lee. 2017. "Insurer Competition in Health Care Markets." *Econometrica*, 85(2): 379–417.

Koechlin, Francette, Luca Lorenzoni, and Paul Schreyer. 2010. "Comparing price levels of hospital services across countries." *Organisation for Economic Co-operation and Development Publishing*.

Lieber, Ethan MJ. 2017. "Does It Pay to Know Prices in Health Care?" *American Economic Journal: Economic Policy*, 9(1): 154–179.

Manning, Willard G, and John Mullahy. 2001. "Estimating log models: to transform or not to transform?" *Journal of health economics*, 20(4): 461–494.

Mehrotra, Ateev, Tyler Brannen, and Anna Sinaiko. 2014. "Use Patterns of a State Health Care Price Transparency Web Site: What Do Patients Shop For?" *Inquiry: The Journal of Health Care Organization, Provision, and Financing*, 51: 1–3.

Morton, Fiona Scott, Florian Zettelmeyer, and Jorge Silva-Risso. 2001. "Internet Car Retailing." *Journal of Industrial Economics*, 49(4): 501–19.

Newhouse, Joseph P. 1992. "Medical care costs: how much welfare loss?" *The Journal of Economic Perspectives*, 6(3): 3–21.

Newhouse, Joseph P., Alan M. Garber, Robin P. Graham, Margaret A. McCoy, Michelle Mancher, Ashna Kibria, et al. 2013. *Variation in Health Care Spending:: Target Decision Making, Not Geography*. National Academies Press.

Nicholson, Elizabeth. 2015. "2015 Price Transparency Initiative State Survey: Price Disclosures." The Source on Healthcare Price and Competition.

Philipson, Tomas J., Seth A. Seabury, Lee M. Lockwood, Dana P. Goldman, Darius N. Lakdawalla, and David M. Cutler. 2010. "Geographic Variation in Health Care: The Role of Private Markets." *Brookings Papers on Economic Activity*, 325–361.

Reinhardt, Uwe. 2012. "Divide et impera: protecting the growth of health care incomes (COSTS)." *Health economics*, 21(1): 41–54.

Salop, Steven, and Joseph Stiglitz. 1977. "Bargains and Ripoffs: A Model of Monopolistically Competitive Price Dispersion." *The Review of Economic Studies*, 44(3): 493–510.

Sinaiko, Anna D., and Meredith B. Rosenthal. 2011. "Increased price transparency in health care—challenges and potential effects." *New England Journal of Medicine*, 364(10): 891–894.

Sinaiko, Anna D, and Meredith B Rosenthal. 2016. "Examining a health care price transparency tool: who uses it, and how they shop for care." *Health Affairs*, 35(4): 662–670.

Squires, David A. 2011. "The US health system in perspective: a comparison of twelve industrialized nations." *Issue Brief (Commonwealth Fund)*, 16: 1–14.

Stagg, Vicki. 2006. "Charlson: Stata module to calculate Charlson index of comorbidity." *Statistical Software Components, Boston College Department of Economics*.

Stigler, George J. 1961. "The Economics of Information." *Journal of Political Economy*, 69: 213.

Town, Robert, and Gregory Vistnes. 2001. "Hospital competition in HMO networks." *Journal of Health Economics*, 20(5): 733–753.

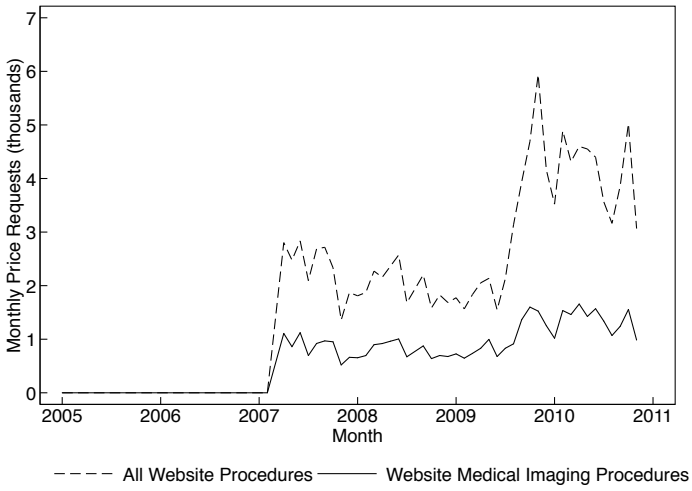
Tu, Ha, and Rebecca Gourevitch. 2014. "Moving Markets: Moving Markets: Lessons from New Hampshire's Health Care Price Transparency Experiment." California HealthCare Foundation.

Whaley, Christopher M. 2015a. "Searching for Health: The Effects of Online Price Transparency." Working Paper.

Whaley, Christopher M. 2015b. "Provider Responses to Online Price Transparency." Working Paper.

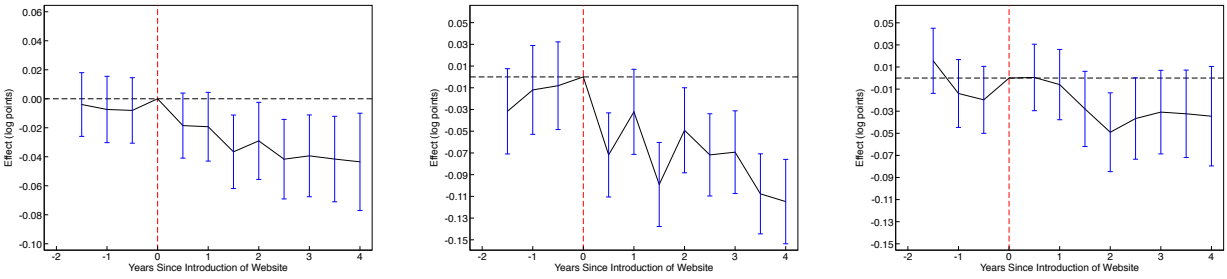
White, Chapin, and Megan Eguchi. 2014. "Reference Pricing: A Small Piece of the Health Care Price and Quality Puzzle." *National Institute for Health Care Reform*.

Figure 1
Website Searches for Health Care Prices
By Month



Notes: Figure shows the number of times the price transparency tool is used to acquire price information in each month. Includes all searches using "Health Costs for Insured Patients" wizard on either nhhealthcost.nh.gov or nhhealthcost.org. Website traffic data is not available for the period after 2010 due to a change in the website host.

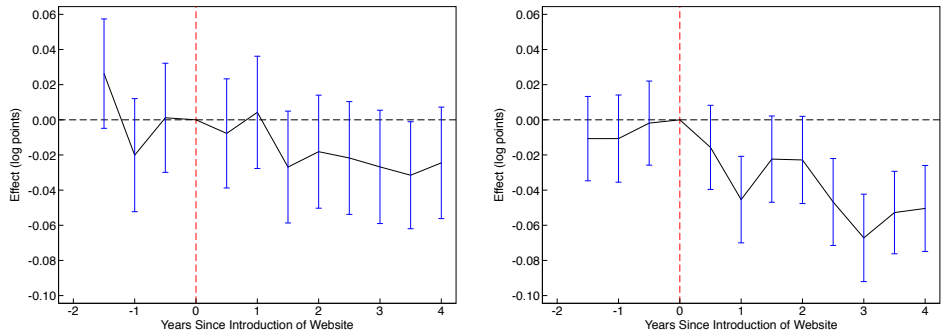
Figure 2
Equilibrium Effect of Price Transparency Website on Spending
By Time from Website Introduction



(a) Total Negotiated Price (b) Patient Out-of-Pocket Price (c) Insurer Price

Notes: Charts show point estimates for each half-year using the difference-in-difference baseline specification as described in Section 4.2. The estimates reflect the overall equilibrium effect, including both demand-side and supply-side effects. The omitted period is the half-year prior to the start of the price transparency website. Error bars indicate 95 percent confidence interval using standard errors clustered at the month-year level.

Figure 3
Supply-Side Effect of Price Transparency Website by Time Period



a. Total visit price b. Principal procedure price

Notes: Charts show point estimates for each half-year using the difference-in-difference specifications described in Section 4.6. The specification controls for demand-side changes, therefore point estimates only reflect supply-side effects. The omitted period is the half-year prior to the start of the price transparency website. The chart on the left shows estimates using the entire visit price as the dependent variable, while the chart on the right shows the effect when the dependent variable does not include supplementary procedures. Error bars indicate 95 percent confidence interval using standard errors clustered at the month-year level.

Table 1
The Potential Cost Savings if Consumers Switched to Low Price Providers

		Consumers Switch to 1st Quartile Provider		Consumers Switch to Median Provider	
Procedure Class	Mean Total Visit Price	Mean	% Savings	Mean	% Savings
Computed Tomography (CT)	1,604	659	58.9%	995	37.9%
Magnetic Resonance Imaging (MRI)	1,767	989	44.0%	1,283	27.4%
X-Ray	593	152	74.3%	240	59.5%

Notes: Table shows the average transaction price paid in 2006, along with the potential savings if every patient paid at most the 25th or 50th percentile of visit price in New Hampshire for each procedure given the patient's insurance company and insurance type. All prices in 2010 dollars. Figures reflect the potential demand-side savings, e.g. hold negotiated prices fixed.

Table 2
The Availability of Outpatient Medical Imaging Procedure Price Information on Website

	Num. Unique Procedures	
Procedure Category	On Website	Not on Website
Computed Tomography (CT)	15	47
Magnetic Resonance Imaging (MRI)	21	65
X-Ray	34	107
Total	70	219

Notes: Table shows the number of unique outpatient medical imaging procedures, as identified using CPT/HCPCS codes, on the price transparency website versus not on the website. Procedure codes with updated descriptions are considered separate procedures.

Table 3
Summary of Privately Insured Individuals with Medical Imaging Claims

	Mean	SD	Min	Max
Male	0.48	0.50	0	1
Age	36.9	17.6	0.0	64.0
Charlson Comorbidity Index	0.5	0.7	0	2
Zip income (1000s)	68.5	21.2	4.9	240.8
Zip more than BA Degree	33.8	13.8	0.0	100.0
Claims in previous year	37.9	55.4	0.0	5136.0
Insurance Type:				
PPO	0.32	0.47	0	1
POS	0.14	0.34	0	1
HMO	0.39	0.49	0	1
EPO	0.07	0.25	0	1
Other	0.09	0.29	0	1
Insurance Company:				
Anthem	0.45	0.50	0	1
Cigna	0.24	0.43	0	1
Harvard Pilgrim	0.13	0.33	0	1
Other	0.18	0.38	0	1
Plan Characteristics:				
Plan has Deductible	0.45	0.50	0	1
Plan has Copay	0.83	0.38	0	1
Plan has Coinsurance	0.24	0.43	0	1
Individuals	811,549			

Notes: Summary statistics are for all unique privately insured individuals in New Hampshire over the period 2005 to 2011 with at least one outpatient medical imaging visit.

Table 4
Summary of Outpatient Medical Imaging Visit Price

	Visits on Website				Visits not on Website			
	Pre-Website		Post-Website		Pre-Website		Post-Website	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Patient Cost:								
Copayment	15.6	41.4	19.2	39.0	15.4	53.2	18.6	40.4
Coinsurance	12.5	81.8	21.0	111.9	14.6	87.1	25.6	132.7
Deductible	46.1	181.7	84.3	298.0	58.1	206.4	103.4	331.2
Total out-of-pocket cost	76.6	226.5	124.8	331.4	90.8	253.8	148.0	371.9
Insurance Cost:								
Paid amount	634.4	1,381.4	793.5	1,737.6	740.8	1,730.7	970.9	2,141.8
Total:								
Allowed amount	846.1	1,716.7	942.9	1,848.3	989.2	2,113.1	1,149.6	2,269.7
Charge amount	1,236.6	2,861.4	1,602.5	3,393.9	1,471.4	3,331.5	1,947.2	3,976.6
Observations (Visits)	501,358		1,176,476		124,017		301,902	
Total Procedures	2,018,224		5,376,584		464,574		1,325,082	

Notes: Table shows summary statistics related to transaction prices. Note prices are lower when the website is available. Includes all outpatient medical imaging visits for privately insured individuals in New Hampshire over the period 2005 to 2011. All prices in 2010 dollars.

Table 5
The Effect of Price Transparency Website on Visit Price
Baseline Difference-in-Difference Estimates

	All	No Deductible	Deductible	
			Not Past	Past
	Dep Var: Log(1+Total Visit Amount)			
$\text{OnWeb}_\text{m} \times \text{Post}_\text{t}$	-0.031^{***}	-0.029^{***}	-0.044^{***}	0.014
	(0.004)	(0.006)	(0.007)	(0.010)
Mean level	950.47	835.65	1038.61	1121.35
Adjusted R2	0.368	0.367	0.360	0.371
Observations	1,984,798	1,004,200	633,716	346,843
	Dep Var: Log(1+Patient Out-of-Pocket Amount)			
$\text{OnWeb}_\text{m} \times \text{Post}_\text{t}$	-0.055^{***}	-0.043^{***}	-0.109^{***}	-0.032
	(0.009)	(0.011)	(0.015)	(0.020)
Mean level	115.26	23.27	295.91	51.54
Adjusted R2	0.323	0.168	0.200	0.091
Observations	1,984,798	1,004,200	633,716	346,843
	Dep Var: Log(1+Insurer Paid Amount)			
$\text{OnWeb}_\text{m} \times \text{Post}_\text{t}$	-0.038^{***}	-0.030^{***}	-0.026^{*}	0.012
	(0.005)	(0.006)	(0.014)	(0.010)
Mean level	777.11	756.81	680.18	1012.49
Adjusted R2	0.305	0.380	0.202	0.383
Observations	1,984,798	1,004,200	633,716	346,843
Individual Controls	Yes	Yes	Yes	Yes
Insurance FE	Yes	Yes	Yes	Yes
Month-Year FE	Yes	Yes	Yes	Yes
Procedure FE	Yes	Yes	Yes	Yes

Notes: Estimates from the baseline difference-in-difference specification presented in Equation 1. The unit of observation is a patient visit, which may contain multiple medical claims. The sample consists of all commercial claims related to outpatient medical imaging procedures in New Hampshire over the period 2005 to 2011. OLS regression standard errors clustered at the month-year level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 6
The Effect of Price Transparency Website on Visit Out-of-Pocket Price By Patient Characteristics

	Emergency Visit		Urbanicity	
	Yes	No	Rural	Urban
$\text{OnWeb}_m \times \text{Post}_t$	−0.018	−0.057***	−0.007	−0.060***
	(0.014)	(0.009)	(0.030)	(0.009)
F statistic of diff.	5.862**		2.960*	
Adjusted R2	0.399	0.325	0.358	0.320
Observations	198,041	1,786,758	189,240	1,795,559
	Age		Income	
	≤ 35	> 35	$\leq$ Mean	$>$ Mean
$\text{OnWeb}_m \times \text{Post}_t$	−0.060***	−0.051***	−0.049***	−0.066***
	(0.018)	(0.011)	(0.011)	(0.011)
F statistic of diff.	0.163		1.103	
Adjusted R2	0.349	0.315	0.324	0.322
Observations	325,523	1,305,073	1,179,840	804,959
Full Controls	Yes	Yes	Yes	Yes
Month-Year FE	Yes	Yes	Yes	Yes
Procedure FE	Yes	Yes	Yes	Yes

Notes: Estimates from baseline difference-in-difference specification for various sub-populations. The dependent variable is Log(1+Patient Out-of-Pocket Price). OLS regression standard errors clustered at the month-year level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 7
The Effect of Price Transparency Website on Search Behavior and Provider Type

	Dependent Variable:			
	Same Provider as Last Medical Imaging Visit	Low Cost Provider	Provider in New Hampshire	Distance to Provider (Miles)
$\text{OnWeb}_m \times \text{Post}_t$	−0.0209**	0.0652***	0.0036***	0.1756**
	(0.0095)	(0.0077)	(0.0012)	(0.0739)
Full Controls	Yes	Yes	Yes	Yes
Month-Year FE	Yes	Yes	Yes	Yes
Procedure FE	Yes	Yes	Yes	Yes
Adjusted R2	0.044	0.038	0.458	0.426
Observations	806,294	1,642,953	1,984,799	1,984,799

Notes: Estimates from a linear probability model using the same controls as the baseline difference-in-difference specification presented in Equation 1. Low cost provider is defined as a provider with an average out-of-pocket cost in the lowest decile in each county conditional on procedure, insurer, and year. OLS regression standard errors clustered at the month-year level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 8
Supply-Side Effect of Price Transparency Website

			Total Visit Effect by County HHI		Total Visit Effect by Provider Type	
	Total Visit Price	Principal Procedure Price	$\leq 1^{st}$ Quartile HHI	$> 4^{th}$ Quartile HHI	Hospital	Non-Hospital
$\text{OnWeb}_m \times \text{PostShortRun}_t$	-0.010^{*}	-0.005	0.007	-0.042^{***}	-0.009	-0.009
	(0.006)	(0.006)	(0.012)	(0.014)	(0.011)	(0.007)
$\text{OnWeb}_m \times \text{PostLongRun}_t$	-0.017^{***}	-0.030^{***}	0.000	-0.048^{***}	0.016	-0.024^{***}
	(0.006)	(0.006)	(0.012)	(0.015)	(0.013)	(0.006)
Indiv. Controls	Yes	Yes	Yes	Yes	Yes	Yes
Provider*Procedure *Insurer FE	Yes	Yes	Yes	Yes	Yes	Yes
Month-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
F statistic of diff. (SR)			7.355^{***}		0.002	
F statistic of diff. (LR)			6.723^{**}		7.393^{***}	
Mean level	950.38	450.01	6.01	5.99	6.60	5.95
Adjusted R2	0.497	0.807	0.475	0.467	0.559	0.464
Observations	1,967,086	1,967,083	609,793	441,664	338,478	1,628,608

Notes: Estimates from the difference-in-difference specification that controls for demand-side factors presented in Equation 2. The dependent variable is $\log(1+y)$, where y is either the visit price or principal procedure price. For visit price, the unit of observation is a patient visit, which may contain multiple medical claims. For principal procedure price, the unit of observation is the primary medical imaging procedure within each visit. HHI is calculated for individuals' county for each procedure class in the period before the website. The sample consists of all commercial claims related to outpatient medical imaging procedures in New Hampshire over the period 2005 to 2011. OLS regression standard errors clustered at the month-year level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 9
The Effect of Price Transparency Website on Price Dispersion

	Interquartile Range of Transaction Prices		Interquartile Range of Provider Prices	
	Total Visit Price	Principal Procedure Price	Total Visit Price	Principal Procedure Price
$\text{OnWeb}_m \times \text{Post}_t$	-231.0^{***}	-103.7^{***}	-158.9^{**}	-96.3^{***}
	(63.8)	(24.0)	(68.7)	(20.7)
Indiv. Controls	Yes	Yes	Yes	Yes
Procedure FE	Yes	Yes	Yes	Yes
Month-Year FE	Yes	Yes	Yes	Yes
Mean IQR	1183.5	658.5	992.4	541.4
Adjusted R2	0.307	0.447	0.271	0.465
Observations	13,572	13,572	13,572	13,572

Notes: Estimates from the difference-in-difference specification described in Section 4.1. The unit of observation is a procedure-month. Interquartile range is defined as the difference between 75th and 25th percentiles price for each procedure-month. OLS regression standard errors clustered at the month-year level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

APPENDIX

A Additional Details on Data Construction

This section describes the construction of the data in further detail.

Sample Selection

In the main specification, I consider the universe of private-health insurance claims for individuals under age 65. Individual age 65 and older likely have Medicare in addition to their private insurance, making them a very selected population. I also remove claims that were denied or refunded.

I identify the universe of medical imaging procedure by linking procedure descriptions from Centers for Medicare & Medicaid Services (CMS) CPT/HCPCS Database to the procedure codes in the claims database. Procedure codes that changed description are assigned separate identifiers.

I also use the CMS CPT/HCPCS Database to identify the subset of medical imaging procedures with price information available on the HealthCost website. A procedure on the website may refer to multiple procedure codes (e.g. the website does not provide separate price information for a knee X-ray with 2 views versus a knee X-ray with 3 views, even though these have different procedure codes.[45] The list of procedures on the website and associated CPT/HCPCS codes are given in Appendix Table A-1.

Visit Price and Principal Procedure Price

Prices on the website are calculated by aggregating all health claims related to the medical imaging procedure, which I call the visit price. I use a similar method as the website, with some important differences. In this section, I describe how visit prices are calculated and how my method differs from that of the website.[46]

[45]The HealthCost website often only used one CPT/HCPCS code to calculate prices, however prices are highly correlated.

[46]The detailed method used by the New Hampshire Insurance Department is described on the website.

Like the website, I sum the price of all medical claims on the day of the visit to get the visit price. I exclude visits in which the individual had inpatient claims as well as visits in which the most expensive procedure was not a medical imaging procedure.

The New Hampshire Insurance Commission removed claims when the total charge was above the 95th percentile. They also remove visits in which the patient out-of-pocket price was in the lowest one percentile or highest fifth percentile. Unlike the website, I do not remove any visits based on price. Although outliers may be an issue for surgical procedures in which the complexity of a given surgery can vary widely, medical imaging procedures are fairly homogenous.

The website generally calculates the prices using a single procedure code. For instance, in order to calculate the price of a foot X-ray, the website consider the price of procedure code 73620, defined as an X-ray exam of the foot with 2 views. However, individuals receiving an X-ray exam with 1 view may also use the website and are likely to be unaware that the posted prices are for 2 views. Since price of these procedures is highly correlated for a given provider, the individual may still benefit from the information. For this reason, I consider all procedures with a description matching a procedure on the website to be treated, even if it was not included when calculating prices for the website.

Additional Data Sources

Nominal prices of medical imaging procedures are generally trending upwards over the period. All prices are inflation-adjusted to 2010 dollars using the Medical Care Services CPI from the U.S. Bureau of Labor Statistics.

In order to construct the Charlson comorbidity index, I use the method developed in Stagg (2006). The Charlson comorbidity index is calculated for each individual for each year. I obtain information about the urbanization of each zip code using the 2014 Rural-Urban Chartbook from the Rural Health Research Center. Finally, I use the CMS CPT/HCPCS Database to identify procedures that are likely a results of an emergency or urgent care episode.

B Insurance Choice and Insurance Plan Characteristics

The website asks users to enter their insurance information and then allows them to compare the price of common procedures under their plan. However, individuals could potentially enter other insurance plans, and compare prices across insurers. Given that there are important information frictions that also affect insurance choice (e.g. Handel and Kolstad 2015), the website could be used by individuals or employers when deciding on which insurance plan to purchase or make available to employees. In this section, I examine this hypothesis and do not find evidence that changes in demand for insurance are driving the reduction in medical imaging prices.[47]

In order to examine whether selection into insurance plans is a factor for medical imaging prices, I examine whether the difference-in-difference specifications are robust to the inclusion of insurance plan fixed effects. In the baseline specifications, I include fixed effects that control for changes in the composition of insurance plans (see Table 5). I also examine a specification without insurance plan fixed effects (see Appendix Table A-2, column 2). The difference in the estimated effect between these specifications is not statistically significant implying that the composition of insurance enrollment is not driving the reduction in medical imaging prices due to the website.

It is still possible that the website affected insurance choice, even though the composition of insurance plans is not responsible for the reduction in medical imaging prices. The composition of insurance plans, both insurance firm and plan type, is presented in Appendix Figure A-1. There does not appear to be a large shift in the composition of insurance plans after the website launched in March 2007. In order to test this within a regression framework, I use the following specification to examine whether there was a shift in the composition of insurance plans.

$$y_{kt} = \beta \text{Post}_t + \alpha X_t + \gamma t + \varepsilon_{kt} \tag{A-1}$$

where y_{kt} is the number of enrollees in each plan type or company in each month. I control for characteristics of individuals in each month, X_t, as well as a linear time

[47] After my period of analysis, the website added separate features for comparing insurance plans. Future research can examine the effect of this information.

trend.[48] This specification required stronger identifying assumptions than the difference-in-difference method, namely constant trends in the absence of the website. I use the period consisting of two years before and after the introduction website in order to avoid confounding factors that influence insurance enrollment.

I examine enrollment for each of the major insurance companies in the state as well as each of the insurance types. Of the ten estimates, only one is statistically significant (see Appendix Table A-5). I interpret this as evidence that the website did not have an immediate effect on insurance choice.

A related mechanism of interest is endogenous plan response to price transparency. For instance, plans may change cost-sharing rules in response to the website, further incentivizing individuals to use the website. I modify the baseline regression specification by interacting insurance fixed effects with an indicator for whether the website is available.[49] The estimates from this specification are not statistically different from the baseline specification (see Appendix Table A-2, column 3). I interpret this as evidence that changes to plan characteristics after the start of the website that affected all procedures are not driving the reduction in prices.[50]

C Effect on Quantity

In this section I examine whether the website changed the quantity of medical imaging visits. In most cases, individuals choose whether to get a medical imaging procedure after a primary care physicians recommends that they receive a specific procedure. To the extent that individuals believe a procedure is optional, they may be more likely to get a procedure if information about price is available and they know they can choose an inexpensive provider. Conversely, the price may be more than the individual expected, leading to lower quantity when price information is available.

I use a difference-in-difference specification to examine whether the introduction of the website changed the probability of having a medical imaging visits for procedures on the website relative to procedures not on the website. The specification is

[48] Individual controls include age, gender, income, and education.

[49] In particular, I estimate $\log(1 + p_{imjkt}) = \beta(\text{OnWeb}_m \times \text{Post}_t) + \alpha X_{it} + \lambda_m + \lambda_k \times \text{Post}_t + \lambda_k \times \text{Pre}_t + \lambda_t + \varepsilon_{imjkt}$ where $\text{Pre}_t = (1 - \text{Post}_t)$.

[50] Note that after the period of analysis, insurers in the state began offering additional incentives for individuals to choose low-cost providers. These incentives may be due to the presence of the website and could potentially lead to a larger long-term effects of the website.

$$y_{iwt} = \beta(\text{OnWeb}_w \times \text{Post}_t) + \gamma \text{OnWeb}_w + \alpha X_{it} + \lambda_k + \lambda_t + \varepsilon_{iwt} \quad \text{(A-2)}$$

where the outcome, y_{iwt}, is either the number of procedures or an indicator for whether the individual ever had the procedure during the year. In the latter case, it becomes a linear probability model. I also include individual covariates, insurer fixed effects, and year fixed effects.[51]

Unlike previous specifications, I use the universe of privately-insured individuals in the state, including those that never had a medical imaging procedure over the period. The unit of observation is an individual in a year for procedures on the website and not on the website (i.e. procedures are aggregated by whether they are on the website, which is indexed by w).

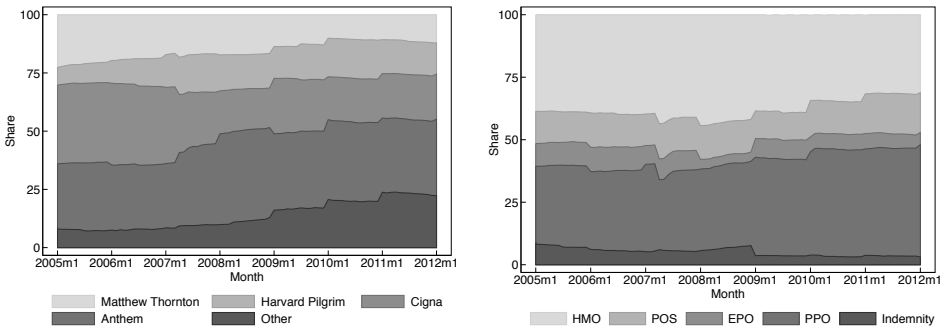
Columns 1 and 2 of Table A-6 show the results from the quantity analysis. Relative to the probability of having a procedure not on the website, the probability of having a procedure on the website decreased by 1.4 percentage points. This estimate is statistically significant a the 10 percent level but not the 5 percent level. The average number of medical imaging visits on the website also saw a very small change. In particular, individuals had 0.006 more visits after the introduction of the website. This results is also not statistically significant at the 5 percent level. I interpret these results as evidence that the quantity of medical imaging visits was not significantly affected by the introduction of the website.[52]

Other work has stressed the importance of the extensive margin when considering health care costs (e.g. Brot-Goldberg et al. 2017). However, it is important to note that my definition of quantity differs from much of the literature. Since I conduct analysis at the visit level rather than the claim level, if an individual switches to a provider that is lower cost due to fewer billed claims, I call it a reduction in price rather than a reduction in the quantity of care.

[51] Individual covariates includes age, gender, charlson comorbidity index, income, education, and rural classification.

[52] It is important to note that this may not be true for all procedures available on the website. X-rays, CT scans, and MRI scans, which are the focus of this paper, tend not to be optional procedures from the point of view of a patient. In contrast, screening procedure such as mammograms are often at the discretion of patients. Consistent with this, I find evidence of an increase in the quantity of mammograms after prices are available on the website.

Figure A-1
Composition of Insurer Firm and Insurance Type by Month



a. Composition of Insurer Firm b. Composition of Insurer Type

Notes: Figure shows cumulative share of each insurer firm and type by month. Sample is the universe of privately-insured individuals in New Hampshire, including those with no medical claims.

Table A-1
Medical Imaging Procedures with Price Information Available on HealthCost Website

Website Procedure Name	CPT/HCPCS Code	Detailed Description
CT - Abdomen	74160	CT abdomen w/dye
	74150	CT abdomen w/o dye
	74170	CT abdomen w/o & w/dye
CT - Chest	71260	CT thorax w/dye
	71250	CT thorax w/o dye
	71270	CT thorax w/o & w/dye
CT - Pelvis	74177	CT Pelvis and Abdomen w/dye
	72193	CT pelvis w/dye
	72192	CT pelvis w/o dye
	72194	CT pelvis w/o & w/dye
	74178	CT Pelvis and Abdomen w/o & w/dye
	74176	CT Pelvis and Abdomen w/o dye
MRI - Back	72148	MRI lumbar spine w/o dye
	72158	MRI lumbar spine w/o & w/dye
	72141	MRI neck spine w/o dye
	72156	MRI neck spine w/o & w/dye
MRI - Brain	70553	MRI brain w/o & w/dye
	70551	MRI brain w/o dye
MRI - Knee	73721	MRI knee w/o dye
	73723	MRI knee w/o & w/dye
MRI - Pelvis	72197	MRI pelvis w/o & w/dye
	72195	MRI pelvis w/o dye
	74181	MRI abdomen w/o dye
	74182	MRI abdomen w/dye
	74183	MRI abdomen w/o & w/dye
	72196	MRI pelvis w/dye
	72198	MRI angiography pelvis w/o & w/dye

Website Procedure Name	CPT/HCPCS Code	Detailed Description
X-Ray - Ankle	73610	X-ray ankle
X-Ray - Chest	71020	Chest x-ray, two views, frontal and lateral
	71035	Chest x-ray, special views
	71022	Chest x-ray, two views, frontal and lateral (with oblique)
	71010	Chest x-ray, single view frontal
	71101	Chest/ribs X-ray exam, three views
X-Ray - Foot	73630	Foot X-ray, $\geq$ three views
	73650	Foot/heel X-ray
	73620	Foot X-ray, two views
X-Ray - Knee	73562	X-ray exam of knee, 3
	73564	X-ray exam, knee, $\geq$ 4 views
	73560	X-ray exam of knee, 1 or 2
	73565	X-ray exam of knees
X-Ray -Shoulder	73030	X-ray shoulder
	73000	X-ray collar bone
	73010	X-ray shoulder blade
	73050	X-ray shoulder joints
X-Ray - Spine	72100	X-ray lower spine, 2 or 3 views
	72040	X-ray neck spine, 2 or 3 views
	72050	X-ray neck spine, $\geq$ 4 views
	72052	X-ray neck spine, complete
	72110	X-ray lower spine, $\geq$ 4 views
	72114	X-ray lower spine, complete
	72120	X-ray lower spine, bending complete
	72090	X-ray exam of trunk spine
	72072	X-ray exam of thoracic spine
X-Ray - Wrist	73110	X-ray exam of wrist, $\geq$ 3 views
	73130	X-ray exam of wrist/hand
	73090	X-ray exam of forearm
	73100	X-ray exam of wrist, 2 views

Notes: Table shows all procedures for which price information was available on the website during the period. Outdated procedure codes and codes not used during the sample period are not shown.

Table A-2
The Effect of Price Transparency Website on Visit Price
Robustness Estimates

	No Controls	No Insurer Controls	Insurer FE × Post Interaction	Individual Fixed Effects	Weighted OLS	Weighted GLM
			Dep Var: Total Visit Amount			
$\text{OnWeb}_m \times \text{Post}_t$	-0.027^{***}	-0.027^{***}	-0.036^{***}	-0.058^{***}	-0.032^{***}	-0.029^{***}
	(0.004)	(0.004)	(0.004)	(0.018)	(0.004)	(0.007)
Mean level	952.16	951.71	950.47	947.40	951.77	951.77
Adjusted R2	0.316	0.325	0.373	0.321	0.982	
Observations	2,103,735	2,095,385	1,984,799	596,237	14,949	14,949
			Dep Var: Patient Out-of-Pocket Amount			
$\text{OnWeb}_m \times \text{Post}_t$	-0.064^{***}	-0.052^{***}	-0.063^{***}	-0.058^{***}	-0.066^{***}	-0.050^{**}
	(0.010)	(0.009)	(0.009)	(0.018)	(0.009)	(0.023)
Mean level	114.60	114.65	115.26	95.94	114.60	114.60
Adjusted R2	0.039	0.306	0.327	0.321	0.791	
Observations	2,103,735	2,095,385	1,984,799	596,237	14,949	14,949
			Dep Var: Insurer Paid Amount			
$\text{OnWeb}_m \times \text{Post}_t$	-0.026^{***}	-0.036^{***}	-0.038^{***}	-0.007	-0.030^{***}	-0.033^{***}
	(0.006)	(0.006)	(0.006)	(0.013)	(0.006)	(0.008)
Mean level	777.91	777.42	777.11	786.04	777.58	777.58
Adjusted R2	0.174	0.281	0.306	0.410	0.964	
Observations	2,103,735	2,095,385	1,984,799	596,237	14,949	14,949
Type	OLS	OLS	OLS	OLS	OLS	GLM Log-Link
Indiv. Controls	No	Yes	Yes	No	Yes	Yes
Individual FE	No	No	No	Yes	No	No
Insurer FE	No	No	Yes	No	Yes	Yes
Insurer FE × Post	No	No	Yes	No	No	No
Month-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Procedure FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Estimates show robustness of the baseline difference-in-difference specification presented in Equation 1. For columns 1 to 4, the unit of observation is a patient visit, which may contain multiple medical claims. For columns 5 and 6, the unit of observation is a procedure-month, and specifications are weighted by the number of visits. The sample consists of all commercial claims related to outpatient medical imaging procedures in New Hampshire over the period 2005 to 2011. Regression standard errors clustered at the month-year level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A-3
The Effect of Price Transparency Website on Visit Price
Falsification Test

	All	No Deductible	Deductible	
			Not Past	Past
	Dep Var: Log(1+Total Visit Amount)			
$\text{OnWeb}_\text{m} \times \text{Post}_\text{t}$	0.005	0.017*	−0.001	0.009
	(0.006)	(0.009)	(0.014)	(0.015)
Mean level	869.30	788.76	914.79	1073.13
Adjusted R2	0.366	0.361	0.362	0.397
Observations	527,144	278,409	178,595	70,140
	Dep Var: Log(1+Insurer Paid Amount)			
$\text{OnWeb}_\text{m} \times \text{Post}_\text{t}$	0.008	0.022	−0.024	−0.017
	(0.012)	(0.016)	(0.024)	(0.029)
Mean level	76.97	18.75	181.33	42.30
Adjusted R2	0.294	0.185	0.202	0.061
Observations	527,144	278,409	178,595	70,140
	Dep Var: Log(1+Insurer Paid Amount)			
$\text{OnWeb}_\text{m} \times \text{Post}_\text{t}$	0.000	0.019**	0.000	0.011
	(0.008)	(0.009)	(0.024)	(0.016)
Mean level	649.22	639.77	582.68	856.20
Adjusted R2	0.298	0.365	0.245	0.408
Observations	527,144	278,409	178,595	70,140
Geographic Controls	Yes	Yes	Yes	Yes
Charlson Comorbidity FE	Yes	Yes	Yes	Yes
Insurer FE	Yes	Yes	Yes	Yes
Insurance Org Type FE	Yes	Yes	Yes	Yes
Month-Year FE	Yes	Yes	Yes	Yes
Procedure (CPT) FE	Yes	Yes	Yes	Yes

Notes: Estimates show a falsification test using the baseline difference-in-difference specification presented in Equation 1. Rather than define $Post_t$ as the period after the website started, $Post_t$ is defined as the period beginning March 2006, a year before the website actually launched. The unit of observation is a patient visit, which may contain multiple medical claims. The sample consists of all commercial claims related to outpatient medical imaging procedures in New Hampshire over the period 2005 to 2007. OLS regression standard errors clustered at the month-year level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A-4
Supply-Side Effect of Price Transparency Website
Robustness Estimates

	Total Visit Price	Principal Procedure Price
$\text{InNH}_j \times \text{PostShortRun}_t$	0.004	−0.014
	(0.012)	(0.013)
$\text{InNH}_j \times \text{PostLongRun}_t$	−0.047***	−0.068***
	(0.007)	(0.009)
Indiv. Controls	Yes	Yes
Provider*Procedure *Insurer FE	Yes	Yes
Month-Year FE	Yes	Yes
Mean level	914.06	440.42
Adjusted R2	0.486	0.806
Observations	1,464,705	1,464,702

Notes: The dependent variable is $\log(1+y)$, where y is either the visit price or principal procedure price. For visit price, the unit of observation is a patient visit, which may contain multiple medical claims. For principal procedure price, the unit of observation is the primary medical imaging procedure within each visit. The sample consists of all commercial claims related to outpatient medical imaging procedures on the website received by individuals insured in New Hampshire over the period 2005 to 2011. OLS regression standard errors clustered at the month-year level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A-5
The Price Transparency Website and Insurance Composition
by Insurance Type and Insurance Firm

	Dependent Variable:				
	Anthem	Cigna	Harvard Pilgrim	Matthew Thornton	Other
Post_t	8,569	−4,624	3,475	−6,430	−987
	(14,916)	(10,769)	(14,996)	(6,701)	(4,173)
Mean level	163,215	102,042	69,845	100,457	50,582
Adjusted R2					
Observations	48	48	48	48	48
	PPO	POS	HMO	EPO	Indemnity
Post_t	10,782	−1,572**	−4,233	−4,551	−422
	(2,272)	(53)	(1,907)	(4,266)	(4,602)
Mean level	116,592	66,921	229,916	41,063	31,650
Adjusted R2	0.987	0.911	0.868	0.938	0.809
Observations	48	48	48	48	48
Indiv. Controls	Yes	Yes	Yes	Yes	Yes
Month Trend	Yes	Yes	Yes	Yes	Yes

Notes: Outcome is number of individuals enrolled in each insurance type or insurance firm in each month. OLS regression with robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A-6
The Effect of Price Transparency Website on Visit Quantity

	Dependent Variable: Any Medical Imaging Visit	Dependent Variable: Number of Medical Imaging Visits
$\text{OnWeb}_\text{m} \times \text{Post}_\text{t}$	-0.0141^*	-0.0065
	(0.0044)	(0.0139)
Full Controls	Yes	Yes
Year FE	Yes	Yes
On Website FE	Yes	Yes
Mean dep. var.	0.58	0.81
Adjusted R2	0.336	0.177
Observations	2,543,932	2,543,932

Notes: Estimates from the difference-in-difference specification. The unit of observation is an individual-year-procedure class. The sample consists of all individuals privately insured in New Hampshire or residing in New Hampshire between 2005 and 2011. OLS regression standard errors clustered at the year level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.