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Health Economic Outcomes of a Consumer Cost-Sharing Reform

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by

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Abstract

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This thesis studies the impacts of a consumer cost-sharing reform on several health economic outcomes. It is motivated in part by a need to better understand the effects of patient-cost sharing programs, which have become increasingly popular over time. Patient cost-sharing programs have become a particular subject of discussion as both public and private agencies are interested in effective ways of curbing the growth in health care spending.

The specific cost-sharing program analyzed is reference pricing, which was introduced by the California Public Employees' Retirement System (CalPERS) in 2011. Reference pricing changed health insurance benefits for CalPERS PPO members such that it was now relatively more expensive for them to use higher-cost facilities (versus lower-cost facilities) when receiving certain medical procedures in the post-reference pricing period. This thesis uses detailed medical claims data to compare health outcomes and cost savings between an unaffected control group and CalPERS members.

In the first chapter, Difference-in-Difference estimators are used to analyze the change in the share of patients using lower-cost health care facilities (versus higher-cost health care facilities) and the associated cost savings from this switching. Results indicate that patients are responsive to the reference pricing program and move to lower cost facilities in response to changes in the financial generosity of health insurance coverage due to reference price implementation. Furthering the analysis, instrumental variables methods are used to estimate the local average treatment effects in order to understand the treatment effects for the subpopulation of compliers. The focus is on measuring the changes in total cost-savings and health outcomes for this group. Additionally, compliers are characterized to understand how their observable characteristics tie into observed cost-savings from their movement to lower-cost health care facilities.

The second chapter estimates the quantile treatment effects of the reference pricing health insurance reform. Specifically, using the estimator of Firpo, 2007, estimations of how the quantiles of the unconditional distribution of medical spending change after the introduction of reference pricing are performed. Heterogeneous impacts along the distribution of medical spending are found for the quantile treatment effect estimates. This suggests that there

is not simply a location shift in the distribution of medical spending resulting from the introduction of reference pricing. Rather, some parts of the distribution are more affected than others, particularly, the right-tail of spending. These heterogeneous impacts are also larger for certain procedures and smaller for others.

In the third chapter, I study how physicians' practice patterns respond to changes in patients' financial incentives, owing to the introduction of reference pricing. Motivating this analysis, I focus on issues of physician agency and how physicians' practice locations are a conduit by which cost-savings may be achieved. The results indicate that those physicians who have flexibility in where they can perform medical services are responsive to the change in the patients' cost-sharing and subsequently respond by increasingly treating CalPERS patients in lower-cost health care facilities (versus higher-cost facilities). This is measured relative to a control group who did not experience cost-sharing changes. These findings suggest that physician practice patterns are responsive to changes in patients' financial incentives.

For my family

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[1]The content is solely the responsibility of the authors and does not necessarily represent the official views of the Agency for Healthcare Research and Quality, CalPERS, or Anthem, Inc.

Chapter 1

Analyzing the Local Average Treatment Effects of Reference Pricing

with Timothy Brown and Christopher Whaley

1.1 Introduction

The rise in health care spending is concerning for both public and private agencies. Health care spending currently makes up approximately 17.5% of GDP and has grown at a rate faster than GDP over the last 50 years [CMS (2014)].[1] Several sources of growth have been discussed including the introduction of new medical technologies as well as population aging and increasing medical prices (Blumenthal et al. (2013)). While these may be important factors, consumers decisions regarding how much medical care to receive and where this care is received/administered are also important considerations. Thus, cost-containment strategies that affect consumer demand have been used to effectively constrain medical spending that is deemed to be "wasteful" or "unnecessary."[2] These strategies typically expose consumers to a greater share of the total costs for the medical care they receive, with the intention of affecting medical utilization as well as the total cost of care received. While such designs may encourage reductions in spending, there are concerns that they may also lead to sacrificed quality of care and/or reductions in the consumption of appropriate and good medical care (e.g. preventative services).

In that vein, we study a relatively new cost-sharing design that aims to reduce total medical costs but also alleviate health outcome and utilization concerns by providing a

[1] "Average annual health [inflation-adjusted] spending growth was 5.5 percent between 1960 and 2013 compared to 3.1 percent growth in GDP (Catlin, Aaron C. and Cowan, Cathy A. (2016))."

[2] Wasteful care can be considered as medical care for which the health benefits are smaller than the associated costs.

guided choice over where consumers receive health care. Within the context of this design, our paper addresses the following questions: 1) How does changing the price of health care, via increased consumer cost-sharing, affect the choice of where people receive their care and 2) How does the change in the location of health care translate into changes in mean total costs and the distribution of total costs?

We address these questions by analyzing a quasi-experiment: the introduction of a health insurance reform known as *reference pricing* to the California Public Employees Retirement System (CalPERS) for screening colonoscopy procedures (i.e. screenings). CalPERS is a California public agency that administers health and retirement benefits and is currently the second largest purchaser of health benefits in the U.S after the federal government.[3]

The reference pricing program incentivized members of CalPERS to choose lower-cost facilities as the site for medical care (Ambulatory Surgical Centers – "ASCs") versus higher-cost facilities (Hospitals) by changing the relative prices across these two facility types. Specifically, reference pricing changed CalPERS screening reimbursement policy by setting a maximum reimbursable amount of $1500 for screenings done at a hospital. Any cost incurred above $1500 was 100% patients' responsibility and did not go toward their annual deductible or out-of-pocket maximum. Prior to reference pricing, there was no set maximum reimbursable amount for screenings received at hospitals. In contrast, the costs associated with using an ASC remained unchanged – before and after reference pricing, patients have no cost-sharing if they go to an in-network ASC.

To understand how changes in the relative price affect consumers' choices of where to receive care and the corresponding effect on total costs (i.e. the sum of insurer and patient costs), we make use of a repeated cross-section of medical claims data consisting of CalPERS members and an unaffected control group. Since Anthem Blue Cross manages the health benefits for both CalPERS and the control group, they face the same price at any given health care facility, conditional on health status.

consider a heterogeneous treatment effects framework and use an instrumental variable strategy to determine the effect of increased ASC use on changes in the mean total costs per screening. We use the exposure of CalPERS members to reference pricing as the "as good as randomly assigned" encouragement mechanism (i.e. instrument) to choose an ASC as the site to receive a screening. In this setting, the choice to receive a screening colonoscopy at an ASC is viewed as receipt of the treatment, while choosing a hospital represents the absence of treatment. Under standard assumptions, we identify the local average treatment effect (LATE), using a Wald Difference-in-Difference estimator. This gives the change in average per-procedure total costs for the subset of patients who now use an ASC because of exposure to reference pricing, but would not have used an ASC otherwise (i.e. the effect for the compliers). This is an interesting population to analyze as they are the ones whose choices are affected by reference pricing. We also focus on the distributional impacts of the program. To do this, we analyze how the probability of costs being below a certain dollar threshold change for the complier subpopulation after the implementation of the program.

[3]CalPERS Medicare Enrollment Guide (2016).

Our analysis finds a strong first stage estimate – exposure to the reference pricing program leads to an approximately 10 percentage point increase in the probability of using an ASC.[4] The estimates of the LATE indicate a reduction in average total costs of approximately $2300. Controlling for any potential price changes by hospitals and ASCs in response to reference pricing, we find average total cost reductions of approximately $1700.[5] This suggests that the cost savings generated by the program are primarily driven by consumers switching to the lower-cost facilities. With regard to distributional effects, using an ASC raises the probability of incurring total costs below $1500 by approximately 67%. We also find that the increase in the probability of being below a certain cost threshold for compliers decreases as we move up from the reference price of $1500. This finding indicates that the largest relative increases in the mass of the distribution occur at regions below the reference price threshold. Additionally, we estimate the LATE for medical complications associated with the screening and find no change in the probability of patients experiencing a medical complication (serious or non-serious). With regard to utilization effects, our estimates suggest that the share of people receiving screenings does not appear to be affected by the introduction of reference pricing.

This work fits into an extensive literature that analyzes consumers' responses to changes in the price of medical care. These studies find that consumers are generally price sensitive and decrease medical spending in response to increased prices. Examples of such work include the analysis of consumers' response to the introduction of high-deductible health plans as discussed in Brot-Goldberg et al. (2015) as well as changes to the deductible and rates of cost-sharing as randomized in the RAND Health Insurance Experiment (Joseph P. Newhouse and Rand Corporation (1993), Aron-Dine et al. (2013)). Additionally, studies that evaluate how changing the set of health providers classified as in-network, and thus cheaper to visit for care, are also discussed (Gruber and McKnight (2016)). Related work by Robinson et al. (2015)–1, Robinson et al. (2015)–2, Robinson et al. (2015)–3, and Robinson et al. (2016)–4 study the reduced form effects of reference pricing over several medical procedures.[6]

This work contributes to the literature in several ways: 1) It is one of the few studies to analyze reference pricing in a U.S. medical setting. Reference pricing has existed in European prescription drug markets for decades (for example, see Kaiser et al. (2014)) but there is limited information on the consumer response to such a program in a U.S. medical setting. 2) We pinpoint a specific mechanism by which total costs are reduced through incentives that encourage consumers to choose lower-cost facilities for medical care. 3) This is one of the few instances where cost-sharing has been introduced on a preventative medical procedure post-Affordable Care Act implementation.[7] In this setting, concern over reduced utilization of medically recommended, preventative care may be mitigated by the existence

[4]The share of CalPERS members using an ASC in the pre-period was approximately 67%.

[5]Our strategy also controls for general price changes due to inflation.

[6]These procedures include hip and knee replacement, arthroscopy, diagnostic and screening colonoscopies, and cataracts surgery.

[7]The ACA expanded patient coverage for medical screenings that have been given a recommendation of "A" by the US Preventative Task Force.

of a no-cost option (the ASC). We also attempt to address potential utilization concerns by looking at CalPERS screening rates in the data. 4) By using the claims data for a large public agency such as CalPERS paired with a control group consisting of California members of Anthem Blue Cross, we believe the results may have strong external validity.

The rest of this paper proceeds as follows; Section 2 discusses the reference price program details and background. In Section 3 we describe the data. Section 4 gives the theoretical motivation while Section 5 discusses the methodology used to estimate the programs impact on cost-savings. Section 6 presents the empirical strategies used. Section 7 presents the results and is followed by the conclusion.

1.2 Reference Pricing Background

Reference pricing was introduced in January 2012 for members of CalPERS Preferred Provider Organization (PPO), which consisted of approximately 22% of active health plan members in 2011. The program set a max reimbursable amount of $1500 for screenings received at hospitals, but prior to January 2012, no maximum existed.[8] At ASCs, reimbursements remained the same there was no patient-cost sharing on screenings received at an in-network ASC.[9] Figure 1.1 helps illustrate the program in the simplest case where there is no health plan deductible or co-insurance; at a hospital, patients pay nothing until the total cost is above $1500, but are responsible for every dollar spent above this threshold. Additionally, the cost incurred above the $1500 threshold does not go toward the annual deductible or annual out-of-pocket maximum. In contrast, if patients choose an ASC, they remain along the horizontal axis in Figure 1.1.

The motivation for the introduction of reference pricing was to reduce total costs as CalPERS deemed that there was no discernible difference in quality of care between ASCs and hospitals. Another important motivating factor for reference price implementation was the Great Recession. With increased budget concerns, strategies to reduce costs were needed and reference pricing was chosen as an alternative to increasing health plan deductibles. Reference pricing was applied to other medical procedures as well; specifically, arthroscopy, cataract-removal surgery, and hip and knee replacement surgery. These procedures were included in the reference pricing program as they were categorized as high-volume, non-emergency procedures that did not vary much in quality of service across the different facility types (i.e. procedures where cost-savings could be reasonably achieved).

The reference pricing program operated by leveraging existing price differentials between ASCs and hospitals within a particular geographic region.[10] Price variation across the

[8]Exemptions from the reference pricing program were made for those who lived more than 30 miles from an ASC or had a medical need to go to a hospital for their screening.

[9]Patient cost sharing at ASCs could occur if there was an out-of-network component to the procedure (e.g. an out-of-network physician) or if the patient had some sort of medical intervention performed during the procedure. Out-of-network health care providers will be generally more expensive for a patient since the insurer does not have agreements set in place with a particular health care facilities.

[10]Cooper et al. (2015) show that price variation exists for procedures like colonoscopies.

health care facility types may be driven by the fact that Medicare compensates hospitals at a higher rate than it does ASCs with regard to facility fees (see Munnich and Parente (2014)), which may affect the way private insurers reimburse the two facility types, as discussed in Clemens and Gottlieb (2013). Reasons for the higher facility fee compensation rate at hospitals include the higher costs associated with running a hospital, such as added regulatory requirements. Figure 1.2 demonstrates the per-procedure variation in prices (total costs) observed at ASCs and hospitals in the the three years before reference price implementation for members of CalPERS who receive a screening.

ASCs and hospitals vary along other dimensions as well. For example, ASCs are typically smaller, free-standing facilities that specialize in fewer medical procedures. They do not have to accept uninsured patients and only perform outpatient procedures. This is in contrast to hospitals, which perform a variety of medical procedures, accept the uninsured and offer inpatient, outpatient, and emergency room services. Additionally, Munnich and Parente (2014) find evidence that ASCs may be faster at performing a given procedure than hospitals, which may be driven by the efficiency gains from procedural specialization.

Reference pricing specifically applied to the facility costs, which is one component of the overall total costs for a screening. However, we will refer to the facility costs as "total costs" throughout this paper as they are generally the largest component of the costs associated with a screening. Facility costs cover the operating expenses associated with running the hospital or ASC. Other costs that a patient may face when receiving a screening are physician costs and the costs associated with any sort of medical intervention (e.g. polyp removal, biopsy).[11] For example, if a polyp is found during a screening, the removal of the polyp will be an added cost to the patient; the patient will generally be responsible for the laboratory and professional costs associated with the removal of the polyp since this part of the service is considered medical and no longer preventative. However, the patient would not have financial responsibility for the facility costs associated with the screening colonoscopy, which are billed separately.

CalPERS PPO health insurance plans are administered by Anthem Blue Cross Health Insurance ("Anthem). As an insurance benefits administrator, Anthem negotiates prices with individual medical practices, ASCs, and hospitals for the members of CalPERS, among other responsibilities. Anthem also administers the health care benefits for other California PPO health plans besides CalPERS. The members of these other California PPO plans form our control group. Thus, CalPERS members and control group members face the same price at any given facility (ASC or hospital) conditional on services delivered, which will be a function of health status.[12]

Lastly, the medical setting in which we analyze reference pricing is the receipt of a

[11]Professional costs are waived for screenings colonoscopies performed by in-network physicians. When professional costs are non-zero, they make up approximately 30% of the "total costs = facility costs + professional costs.

[12]The provisions of the health plan such as coinsurance and deductible, can vary across CalPERS PPO members and the members of the control group. However, since screenings are not subject to coinsurance and deductibles, both the control group and CalPERS face the same price at a given health care facility.

screening colonoscopy. This is a relatively common medical procedure in which the large intestine is checked, using a scope guided by a light. It is one screening method recommended by the US Preventative Task Forces, to check for colorectal cancer, the third most common cancer in the U.S., excluding skin cancer.[13] Adults age 50 years and older are recommended to get a screening every ten years.[14]

1.3 Data

We use medical claims data for CalPERS PPO members and non-CalPERS, Anthem PPO members (i.e. the control group) residing in California who visit a California ASC or hospital during the sample period. The data set is a repeated cross-section available from 2009 to 2013. Thus, we only observe someone if they have a screening done. We use 2011 as the pre-period because in that year both CalPERS members and members of the control group have no cost-sharing for screenings. Prior to 2011, members of the control group faced cost-sharing on screenings but did not face any after ACA implementation in 2011.[15] CalPERS members had no cost-sharing for screenings prior to 2012 and faced costs-sharing after reference pricing implementation in January 2012. The years, 2012-2013, represent the post-period.

The data set includes information on the total cost for the screening received (this is the sum of the amount paid by the insurer plus the amount paid by the patient) as well as information on the date the procedure was performed and the name and zip code of the health care facility at which it was performed. We use this facility name to categorize health care facilities as either an ASC or a hospital, based on the presence of an emergency room or not. The presence of an emergency room would identify the facility as a hospital, while the absence of one would be classified as an ASC.[16] Additionally, we use the zip code of the health care facility to classify the Hospital Referral Region (HRR) of the facility. HRRs represent health care markets. This may be a useful measure since total costs have been shown to vary by region and may be correlated within an HRR; (see Cooper et al. (2015)).[17]

Patient demographic information includes gender, age (18 - 64 years), zip code (used to classify the patient-specific HRR). Also, important, we observe ICD-9M and CPT codes

[13] Source: American Cancer Society (2016).

[14] Other methods to check for colon cancer are fecal occult blood testing and sigmoidoscopy (US Preventative Task Force (2016)).

[15] Source: The Henry J. Kaiser Family Foundation (2015). Also, as part of the ACA mandate, private insurers could not impose cost-sharing on preventative services that had been given an “A rating by the U.S. Preventative task force.

[16] Our classification procedure may not be exact. We also try and gauge the number of services provided at the health care facility generally, if there are fewer than five, we classify the facility as an ASC. Additionally, the name of the facility can be telling. For example, a name such as, “Endoscopy Center of Los Angeles, would be categorized as an ASC.

[17] “HRRs represent regional health care markets for tertiary medical care that generally requires the services of a major referral center. The regions were defined by determining where patients were referred for major cardiovascular surgical procedures and for neurosurgery;” Source: The Dartmouth Atlas of Health Care (2016)

(medical diagnosis and procedure codes) over the previous year for patients. We use these to create the following variables:

- We create a Charlson Comorbidity Index to determine the number of comorbid health conditions of a patient. A Charlson Comorbidity Index value equal to "n" denotes the number of comorbid conditions a patient has (Charlson et al. (1987)). This may be correlated with the total cost for the procedure (i.e. the less healthy the patient, the more costly the screening).

- We determine if a patient has a medical intervention during their screening (e.g. polyp removal, biopsy) using the diagnosis and procedure codes.

- We categorize post-screening complications into either 1) serious or 2) non-serious. Serious complications include intestinal perforation or bleeding in the intestine. Non-serious complications include paralytic ileus, nausea or abdominal pain.

- ICD-9M and CPT codes are used to distinguish between screening (i.e. preventative in nature) and diagnostic colonoscopies.[18].

  - This classification algorithm is done with the guidance of a gastroenterologist. The process classifies colonoscopies in our sample as *diagnostic* by looking at the previous 6 months of medical and diagnosis codes to detect the following diagnoses: Clostridium difficile colitis, Ulcerative colitis, Crohns disease, Ischemic colitis, Colitis NOS, Anorectal bleed, Melena, Gastrointestinal bleeding, Abdominal pain, Abdominal swelling, Abdominal tenderness, Abdominal bloating, Megacolon, Change in bowel habits, Diverticulitis or Diverticular hemorrhage, Volvulus, a history of Colorectal cancer, Iron deficiency anemia, Abnormal stool contents, and Fecal occult blood testing coded within the 6 months prior to colonoscopy. A colonoscopy observed in the data is also classified as diagnostic if a patient had a prior colonoscopy or barium enema within the last three years.
  - Those colonoscopies in our sample not classified as diagnostic (because they do not meet the medical conditions/diagnoses listed above), are classified as screenings colonoscopies ("screenings").[19]

Although medically derived, our method for classifying colonoscopies as either screening or diagnostic may not be perfect. On a general level, this may be less concerning because the medical procedure prices that the insurer (Anthem) negotiates with a health care facility are negotiated at the colonoscopy-intervention status level for a given set of patient characteristics. There is no distinction made between screening or diagnostic colonoscopies. Thus,

[18]In the data provided, we observe if a patient has a colonoscopy but no information on whether it was for screening/preventative or diagnostic purposes

[19]We also exclude upper gastrointestinal colonoscopies and colonoscopies done in an in-patient setting. The facility type of the latter will presumably be less a function of the patients choice.

if a patient's health status and health outcomes are the same, the screening and diagnostic colonoscopies will have the same total cost at any given facility. Essentially, the distinction between screening versus diagnostic colonoscopies is a medical one and is used to determine what share of the total cost will be apportioned to the patient by the insurer.

However, we may be concerned that misclassifying a diagnostic colonoscopy as a screening, will affect our results. Potential misclassification could affect our results if the total costs for a screening colonoscopy systematically differ from the total cost for diagnostic colonoscopy. This may be the case given differences in the medical motivations for each procedure being performed. Our concerns may be mitigated if the probability of incorrectly classifying a colonoscopy is the same in CalPERS as it is in the control group in both the pre and post periods and if the associated total costs of these misspecified colonoscopies are similar. We cannot explicitly test for this but our method for classification does not take time nor group membership into account. Additionally, there may be concern that because diagnostic colonoscopies are subject to a deductible and coinsurance (as opposed to screenings), the non-linear contract design might affect the consumer's decision-making process differently. These concerns may be mitigated for the following reasons: 1) Diagnostic colonoscopies are also subject to the reference price of $1500. Thus, we may expect those receiving diagnostic colonoscopies to use an ASC at a rate similar to those who get a screening colonoscopy and 2) A relevant concern for those who receive diagnostic colonoscopies are the added costs for a medical intervention (e.g. polyp removal), but these are relatively similar across ASCs and hospitals. Thus, the most relevant dimension in total cost variation for both screening and diagnostic colonoscopies, is the surcharge associated with reference pricing.

With regard to the data, Table 1.1 gives the descriptive statistics of our sample. Evident from the descriptive statistics, the control and CalPERS sample appear similar on many dimensions.[20] The control group has a slightly higher share of men obtaining screenings, however the age distribution across the two groups are similar and steady over time. Consistent with medical recommendations for the age at first screening (age 50), the average age observed in both groups is 55 and 56 years, respectively. We also observe that the Charlson Comorbidity Index is equal to zero for a similar share of control and CalPERS members and that a relatively similar share of patients receive some sort of intervention in the pre and post reference price periods. Also interesting is the increase in the share of CalPERS members observed using an ASC and the decrease in mean total costs for CalPERS in the post period. We will discuss this further in the results section.

[20]Mean patient cost differences at ASCs vs. hospitals seem to be driven by right-tail costs. The 75^{th} percentile of patient costs for 1) ASCs and 2) hospitals in the pre-period for CalPERS members and the control group are 1) $0 and 2) $0 for CalPERs and 1) $511 and 2) $617.40 for the control group. In the post-period, the 75^{th} percentiles for patient cost at ASCs and hospitals are 1) $0 and 2) $911 for CalPERS 1) $223.20 and 2) $230.90 for the control group.

1.4 Theoretical Motivation

We consider the decision of where to have screening as a discrete choice and take a random utility approach to understanding the decision-making process.

Let $U_j^i = V_j^i + \epsilon_j^i$ where $j \in \{ASC, Hospital\}$, s.t. U_j^i is the utility from choice j for patient i.

- V_j^i is the representative component of utility.
- ϵ_j^i captures the effect on utility not captured in V_j^i. For example, we can assume it reflects unobserved tastes of the patient.

We observe a patient's choice of facility type, which is either an ASC or hospital (i.e. $Pr(ASC) = 1 - Pr(hospital)$). We also ignore the possibility that utility from choosing an ASC equals the utility from choosing a hospital (i.e. no ties) so that the choice is not indeterminate.

Let V_j^i be a function of X_j, Y, P_j and P_q s.t. $V_j^i = V_j^i\big(X_j, \frac{Y-P_j}{P_q}\big)$.

- X_j represents the choice of facility j at price P_j. The remaining income, Y, is spent on the outside good, X_q, whose price, P_q, will be normalized to 1.

We assume there exists some ex-ante uncertainty over the price of the procedure. This is true both at the ASC and at the hospital. This is due in part to the difficulty of obtaining prices prior to a procedure being performed – patients receive a final bill after their screening. Prices, P_j, are likely a function of personal health state, holding fixed the provisions of the health insurance plan. For simplicity, we assume that variation in prices are a function of whether or not a person has any sort of procedural intervention during the screening, for example, polyp removals or tissue biopsies. Thus, the two potential health states a person may face are 1) No Intervention state (i.e. no polyp removed) or 2) Intervention state (i.e. polyp removed). It is this uncertainty in the health state, prior to having the procedure performed, that we assume drives the uncertainty in price, P_j. This is a relevant consideration since the cost of a polyp removal is not completely covered by insurance and will likely cost the patient money (unless they have reached their out-of-pocket maximum).

- Formally, let state C = Intervention state.
- Let state NC = No intervention state.
- Let V_j^i be the representative utility from choosing the jth facility type, X_j (i.e. ASC (A) or hospital (H)), for patient i. This can be defined as:

$$V_j^i\big(X_j, \frac{Y-P_j}{P_q}\big) = \begin{cases} \gamma_j + \frac{Y-P_j(C)}{P_q}, & \text{if state=C} \\ \gamma_j + \frac{Y-P_j(NC)}{P_q}, & \text{if state = NC} \end{cases}$$

Intervention states C and NC are known and we assume patients draw from a known distribution/probability of having an intervention. Revelation of patients' intervention state occurs after the medical procedure. Also, we assume that the occurrence of an intervention affects costs in the same way for all people (so price is a function of C or NC). Assume γ_j equals the patient's perceived quality of the facility type j and is 1) Known and is the same across patients and 2) Remains the same across intervention/health states.

One can show that for a given state

$$V_A^i\big(X_A, Y - P_A(\cdot)\big) > V_H^i\big(X_H, Y - P_H(\cdot)\big)$$
$$\text{iff.}$$
$$\gamma_A - \gamma_H > P_A(\cdot) - P_H(\cdot)$$

Thus, it is optimal to choose an ASC if the additional quality from choosing an ASC relative to choosing a hospital is greater than the additional cost from that choice.

Taking into account uncertainty over intervention states, it can be shown that:

$$\begin{aligned} E[V_A^i] - E[V_H^i] &= Pr(C)\big[\gamma_A - \gamma_H - P_A(C) - P_H(C)\big] \\ &\quad + Pr(NC)\big[\gamma_A - \gamma_H - P_A(NC) - P_H(NC)\big] \\ &= \gamma_A - \gamma_H - \big(E[P_A] - E[P_H]\big) \end{aligned}$$

Thus, if the difference in perceived quality of the ASC, relative to that of the hospital, is greater than the difference in expected price, the expected utility from choosing an ASC, V_A^i, should be greater than that from choosing a hospital, V_H^i.[21]

1.5 Methodology

We are interested in how the introduction of reference pricing affects the use of ASCs and how this translates into change in total costs and other related outcomes. We assume a heterogeneous treatment effects framework and identify the effect for the subset of compliers – that is, we identify the local average treatment effect (LATE). In this potential outcomes framework, treatment status, D_i, is influenced by exogenous variation in the binary instrument, Z_i. Our instrument, Z_i, is the exposure to reference pricing by being a member of CalPERS in the post-period (i.e. $Z_i = Treat \times Post$ in a regression that includes $Post$ and $Treat$). Thus, Z_i is equal to 1 if the individual is a member of CalPERS after reference pricing is introduced in 2012, and is 0 otherwise.[22]

[21]Note: Probabilities need not be objective but can be subjective reflecting personal beliefs/priors, assuming a common prior. In this setting, $Pr(C) = Pr_i(C)$ and the person would make the choice that maximizes subjective expected utility.

[22]Treat equals 1 if an individual is a member of CalPERS and is 0 if they are part of the control group. Post equals 1 if a person is observed after reference pricing is introduced in January 2012. It is 0 if a person is observed before January 2012.

The instrument induced variation in an individual's treatment status is defined as $D_i = D_{0i} + (D_{1i} D_{0i}) \times Z_i$. Here, D_i takes value 1 if the i^{th} person uses an ASC and 0 if they use a hospital. This should hold for the i^{th} person in a given time period, t.

To capture the "as good as random" variation in our instrument, we use a Difference-in-Difference (DiD) model as our first stage equation, which will be displayed in the next section (Equation 3). By using a DiD strategy, where we show common time trends between the control group and CalPERS and assume the existence of a time-invariant, group-specific effect, we capture the causal effect of exposure to reference pricing on ASC use. We believe that using this DiD strategy to capture the exogenous variation in the instrument and its effect on ASC use is valid because: 1) Reference pricing was introduced with relatively little notice to CalPERS members and 2) Given that the recommendation for the receipt of a screening is related to age, there may be less ability for an individual to manipulate the timing of a screening.[23]Additionally, we have a valid control group for whom the parallel trends assumptions are likely to hold. This is because the control group faces the same price at any given health care facility, conditional on health status and health insurance plan provisions.

To test the parallel trends assumption between our control group and members of CalPERS, we run an event study and estimate the following:

$$\mathbb{1}(ASC_{it}) = \beta_0 + \sum_{r=-12, r\neq -1}^{7} \beta^r \mathbb{1}(L_t)_r + \sum_{r=-12}^{7} \gamma^r \mathbb{1}(L_t)_r \times \mathbb{1}(Treat_i) + X_{it}'\beta + \epsilon_{it}$$

$\mathbb{1}(L_t)_r$ equals 1 if the time period observed is r quarters away from the introduction of reference pricing; it is 0 otherwise. We omit the lag dummy from the quarter before reference price introduction (i.e. omit $\mathbb{1}(L_t)_{-1}$). $\mathbb{1}(ASC)$ is 1 if a person uses an ASC and is 0 if they use a hospital, while $\mathbb{1}(Treat)$ is 1 if an individual is a member of CalPERS and 0 if they are part of the control group. X are patient demographic covariates, which are further discussed in the next section. Our estimates are presented in Figure 1.3 and show the per quarter difference in the mean share using ASCs between CalPERS and the control group (i.e. the coefficient estimates of γ^r), controlling for patient characteristics. Figure 1.4 is analogous to Figure 1.4 but instead uses $Total\,Cost_{it}$ as the outcome variable. Both figures confirm the validity of the parallel trends assumption by showing a relatively stable trend in ASC use between the control group and CalPERS before reference price implementation. Additionally, the figures provide visual evidence for the existence of the first stage and intention-to-treat effects.[24]

[23]CalPERS benefit design changes were made in May/June 2011. Information about reference pricing may have been public after those dates. However, anecdotal evidence suggests little plan switching between the CalPERS health insurance plans, around the introduction of reference pricing.

[24]Future work will estimate bounds on the treatment effect. This may be important to the extent that there is some early movement to use hospitals by members of CalPERS prior to reference price implementation.

We estimate the LATE using a 2SLS estimator for the Wald DiD, which is the ratio of two DiD estimates. This is presented below:[25]

$$\frac{E[Y_i|Treat=1,Post=1]-E[Y_i|Treat=1,Post=0]-\big(E[Y_i|Treat=0,Post=1]-E[Y_i|Treat=0,Post=0]\big)}{E[D_i|Treat=1,Post=1]-E[D_i|Treat=1,Post=0]-\big(E[D_i|Treat=0,Post=1]-E[D_i|Treat=0,Post=0]\big)}$$

To ensure identification of LATE and the interpretation of the IV estimate as the effect of ASC use on total costs for those who now use an ASC because of reference pricing, we make the standard assumptions as discussed by Imbens and Angrist (1994):

- Independence: $\{(Y_i(D_{1i},1), Y_i(D_{0i},0), D_{1i}, D_{0i}\} \perp\!\!\!\perp Z_i$;
  $Y_i(d,z)$ is the potential outcome for person i if they had treatment status $D_i = d$ and the value of the instrument $Z_i = z$.
- Instrument Exclusion Restriction: $Y_i(d,0) = Y_i(d,1) \equiv Y_{di}$ for $d = 0, 1$.
- First Stage: $E[D_{1i} - D_{0i}] \neq 0$
- Monotonicity: $D_{1i} \geq D_{0i}\ \ \forall i$

These assumptions seem valid in this context given the nature in which this program was implemented and our use of the D-i-D strategy to exploit the "as good as random" variation in our instrument. Additionally, we have evidence for our first stage and the assumption of no-defiers seems reasonable in this setting. However, there may be concern over the assumption that reference pricing has no direct impact on total costs. We discuss the validity of the instrument exclusion restriction in the next section.

Methodological Concerns

Our approach faces three key challenges. The first is concern is if we satisfy the instrument exclusion restriction. This assumption may not hold if we believe there are market responses to reference pricing, namely that health care facilities respond to the introduction of reference pricing by changing the price they charge/are willing to accept for colonoscopies. We test for this in the data and construct an alternate total cost measure that is solely a function of pre-period covariates. With this alternative measure, potential supply-side responses should

[25]We also consider the conditions necessary to identify the LATE in a fuzzy design setting such as ours. Here, there is no sharp treatment - some members of CalPERS do not use an ASC while some members of the control group use ASCs after reference pricing is introduced (i.e. no group is fully treated/untreated). However, the rate of ASC use goes up by more for CalPERS after reference pricing is introduced than it does for the control group. Recent work by de Chaisemartin, C. and D'Haultfoeuille, X. (2015) show that the LATE can still be identified if the following two conditions hold: 1) The treatment rate in the control group is stable over time and 2) Time has the same effect on both means of the potential outcomes, $E[Y_{0i}]$ and $E[Y_{1i}]$. We can show that the first condition holds and that the share of ASC users in the control group is steady over time at approximately 71%. Our alternatively constructed total costs variables, that hold time factors fixed, should satisfy the second requirement.

no longer be a concern and should strengthen our belief in the validity of the instrument exclusion restriction.

Secondly, we may be concerned about sample selection bias due to non-random reductions in the utilization of screenings. At this time, we cannot explicitly test for this, but we construct utilization estimates using enrollment data provided by CalPERS. We compare this to the observed number of screenings in our data to see if there are changes in the overall utilization patterns for members of CalPERS.

One may also be concerned about forward-looking behavior and if we are capturing the response of consumers to the spot price of medical care or some forward price. We do not believe this should be a concern in this setting because screening colonoscopies are not subject to deductibles or coinsurance, unlike many other medical procedures.[26] Additionally, the total cost incurred above the \$1500 reference price threshold does not go toward the annual deductible or annual out-of-pocket maximum, thus it will not discount future care in any way. Also, the added cost of a medical intervention (e.g. polyp removal, biopsy), for which the consumer would likely face cost-sharing, is relatively similar across ASCs and hospitals.

1.6 Empirical Strategy

We present the structural, reduced form and first stage equations below. Here, i indexes the individual and t is time {pre-period, post-period}. We pool data from 2011 to 2013 and examine the mean effects of the program using equation 2 and our Wald-DiD, when the outcome variable is $Total\,Cost$. To understand the distributional impacts of the program, we use the outcome, $\mathbb{1}(Total\,Cost_{ikt} \leq Z)$. By varying the value of Z, we can understand how the introduction of reference pricing changes the probability of observing an incurred costs below our specified cut-point/threshold.

<u>Structural Equation</u>:

$$Y_{it} = \pi_0 + \pi_1 \times Post_t + \pi_2 \times Treat_i + \pi_3 \times ASC_{it} + X'_{it}\pi + e_{it} \quad (1.1)$$

<u>Reduced Form</u>:

$$Y_{it} = \beta_0 + \beta_1 \times Post_t + \beta_2 \times Treat_i + \beta_3 \times Post_t \times Treat_i + X'_{it}\beta + \varepsilon_{it} \quad (1.2)$$

- $Y_{it} \in \big\{Total\,Cost_{it},\ \mathbb{1}(Total\,Cost_{it} \leq Z)\big\}$
- $\mathbb{1}(Total\,Cost_{it} \leq Z)\big\} = \begin{cases} 1, & \text{if the total cost of chosen facility is} \leq \text{Z} \\ 0, & \text{if the total cost of chosen facility is} > \text{Z} \end{cases}$
- $Z \in \big\{\$1500, \$2000, \$2500, \$5000, \$10000\big\}$

[26] Screening colonoscopies are not subject to deductibles or coinsurance because they have an A rating from The US Preventative Task Forces.

Our vector of covariates, X, includes the demographic characteristics of patients and is presented below along with the definitions for $Treat$, $Post$ and ASC:

- $X = <\mathbb{1}(\text{Male}), \mathbb{1}(\text{Age Category}), \text{Comorbidity Index}, \mathbb{1}(\text{Intervention})$, Patient Health Care Market Dummy>

$$Treat_i = \begin{cases} 1, & \text{if person i is a member of CalPERS} \\ 0, & \text{if person i is a member of the control group} \end{cases}$$

$$Post_t = \begin{cases} 1, & \text{if the observation is from the post-period (2012, 2013)} \\ 0, & \text{if the observation is from the pre-period (2011)} \end{cases}$$

$$ASC_{it} = \begin{cases} 1, & \text{if facility choice of person i is an ASC} \\ 0, & \text{if facility choice of person i is a hospital} \end{cases}$$

First Stage:

$$ASC_{it} = \delta_0 + \delta_1 \times Post_t + \delta_2 \times Treat_i + \delta_3 \times Post_t \times Treat_i + X_{it}'\delta + v_{it} \tag{1.3}$$

1.7 Results

Table 1.2 presents our estimates of the first stage using equation 3, without and with the inclusion of covariates. Our results show a strong first stage, with the estimated increase in the share using ASCs of approximately 10 percentage points when covariates are included. Prior to reference pricing, the share of CalPERS members using ASCs was approximately 67%. Thus, the increase in the share of members using an ASC is approximately 16%.
Table 1.3 presents the reduced form, OLS estimates, and estimates of the LATE using 2SLS regression. In columns 3-6 ("OLS"' and "IV"), the estimated effect of using an ASC is given in each cell with the relevant outcome variables listed in the left-most column. Columns 3-4 give coefficient estimates using OLS while columns 5-6 give 2SLS regressions estimates. In columns 1-2 ("Reduced Form") each cell gives the estimate for π_3, from equation 1, which measures how exposure to reference pricing affected each outcome variable.

The reduced form results show that exposure to reference pricing has a statistically significant effect on the average per-procedure total cost for screenings among CalPERS members. Exposure to the program leads to a reduction in mean per procedure total costs of approximately $224 (with covariates included in the regression). This is a relatively large reduction considering that the CalPERS pre-reference unadjusted mean total cost for a screening was approximately $1814. For the IV estimates, we find estimates of the LATE to be statistically significant and larger than our reduced form estimates, with a mean per procedure total cost reduction of approximately $2300. We also include the OLS estimates for comparison to our

IV estimates and see that they differ. To decompose the OLS estimate further, we can write π^{OLS} from equation 1 as:

$$\pi^{OLS} = \underbrace{E[Y_{1ikt} - Y_{0ikt}|ASC_{ikt} = 1, X]}_{\text{ATT}} + \underbrace{\left(E[Y_{0ikt}|ASC_{ikt} = 1, X] - E[Y_{0ikt}|ASC_{ikt} = 0, X]\right)}_{\text{Selection Bias}}$$

The first term gives the average effect of ASC use on total costs for those who choose to use ASCs, while the second term shows the selection bias. Because ASC use is not randomly assigned (it is a patient's choice), selection bias will likely be non-zero causing our OLS estimates for the treatment-on-the-treated (ATT) to be biased. In a heterogeneous treatment effects framework, those who receive the treatment consist of always takers and compliers.[27] We do not necessarily expect the effect of treatment on total costs for these two groups to be equal.[28] For example, compliers may have more medically expensive characteristics than always takers, something we explore in a later section. To the extent that LATE = ATT, the difference between our IV and OLS estimates of approximately -$1300 would imply a positive selection bias.[29]

With regard to distributional impacts of the reference pricing program, the estimates in Table 1.3, show that the largest relative increases occur for total costs being below the $1500 threshold, with declines in the increased probability as Z increases. This is likely a function of the lower cost-structure of ASCs. For example, the mean, median and 75^{th} percentile of total costs for CalPERS members who used ASCs in the pre-period were $1335.68, $730 and $1273, respectively.

Testing for Market Effects

In this section, we explore the validity of our instrument exclusion restriction. To do this, we determine if health care facilities respond to reference pricing by changing the amount that they are willing to accept from Anthem insurance. This amount is referred to as the allowed amount (or negotiated amount) and is the amount that the insurer has agreed to pay a health care facility for the specific medical services performed by the facility.[30] This touches

[27]Always takers are the subset of people who always receive the treatment, even when not encouraged to do so as determined by the instrument (e.g. $D_{0i} = D_{1i} = 1$).

[28]In the pre-period, ASC users consist of always takers while in the post-period, ASC users consist of always takers and compliers.

[29]In the example where we assume that LATE = ATT, positive selection bias could occur if for those who now use ASCs because of reference pricing, the costs they would face at hospitals are higher than the costs faced by those who currently use hospitals. This could occur if the former group is more medically expensive at a hospital than the latter group.

[30]The allowed amount is the amount that is accepted by health care facilities that are in-network, by definition of their in-network status. If a facility is out-of-network, the allowed amount exists and is "the amount that Anthem Blue Cross or the local Blue Cross and/or Blue Shield Plan determines is appropriate considering the particular circumstances and the services rendered." (CalPERS Plan Booklet (2012)). Thus, the allowed amount set by the insurer may not be accepted as full payment for services performed; patients would then be responsible for the excess.

on related work by Whaley and Brown (2017). To test for a supply-side response, we assume that the responsiveness to reference pricing is a function of facilities' pre-reference pricing exposure to CalPERs members. Thus, facilities with a higher share of CalPERS members may respond differently than those with a lower share. To analyze this hypothesis, we construct a measure of pre-reference pricing period exposure to CalPERS member, $\widetilde{Treat}$, for those health care facilities that we observe in both the pre and post-reference pricing periods. Thus, $\widetilde{Treat}$ is in the [0,1] interval.[31] One caveat for our measure, $\widetilde{Treat}$, is that it will not perfectly capture a facility's share of patients who are from CalPERS if there are many other non-Anthem patients who use the facility (we do not observe these patients). If this share of patients with non-Anthem insurance is high, then we likely overestimate the share of a facility's patients who belong to CalPERS.

Specifically, for the i^{th} screening colonoscopy procedure, at the n^{th} health care facility, in time period t (pre, post), we pool data from 2011 to 2013 and estimate:

$$P_{int} = \gamma_0 + \gamma_1 \times Post_t + \gamma_2 \times Post_t \times \widetilde{Treat}_n + X'_{int}\gamma + \alpha_n + u_{int} \tag{1.4}$$

- Where $P_{int} \in \left\{ln\, NegotiatedAmount_{int},\, NegotiatedAmount_{int}\right\}$
- $\widetilde{Treat}_n = \frac{CalPERS_{nN}}{CalPERS_{nN}+Control_{nN}}$, is the ratio of the number of CalPERS members observed at facility n, ($CalPERS_{nN}$), to the sum of all patients in our data observed at facility n, ($CalPERS_{nN} + Control_{nN}$), in the year prior to reference pricing (2011).
- α_n represents a health care facility dummy.

We estimate equation 4 separately for ASCs and hospitals, using both the natural log of the negotiated amount and the negotiated amount (in $'s) as outcomes.[32] We limit our samples to patients who go to health facilities observed in both the pre and post reference pricing periods.

Table 1.4 shows the health care facility's response results and demonstrates that results are sensitive to the model specification. Although no effects are found for the hospital sample, in the case of ASCs, we find that in the log specification, ASCs whose 2011 exposure to CalPERS patients was higher have lower negotiated prices in the post-period than those with a lower share of CalPERS patients. The sign on our estimate for γ_2 when the outcome is ln Negotiated Amount among the ASC sample is negative with a coefficient estimate of

[31] The minimum and maximum observed for $\widetilde{Treat}$ are 0 and 1, respectively. However, the median and 75^{th} percentiles for health care facilities for observations in the sample are 0.156 and 0.25, which suggests most facilities have a relatively low exposure to CalPERS in the pre-period, based on our measure.

[32] Our estimates will be biased by the inclusion of out-of-network facilities if the negotiated amounts listed for them are artificially low since these facilities have not agreed to the price set by the insurer. For example, the set allowed amount for out-of-network ASCs is $350 and $380. For these ASCs, we use the sum of the insurer amount paid + patient amount paid ($'s) to get the amount that these facilities are charging. The same thing is done for hospitals since the maximum allowed amount is now $1500 for CalPERs members.

-0.26. It is also statistically different from zero at the 5% significance level.[33] These negative estimates may occur because of the bargaining power of Anthem insurance. Ho and Lee (2013) and Gaynor and Town (2011) discuss the importance of (hospital) bargaining power in price setting with insurers. If health care facilities have lower levels of bargaining power and are willing to accept a lower price for increased volume, this could explain our results. While it is an interesting result, we caution direct interpretation as we do not observe the "other" patients who do not belong to the control or CalPERS group at each facility.

Controlling for Market Effects

To control for any potential market effects, we construct two alternative total cost variables that are solely a function of pre-period data. Doing this should remove any potential supply-side effects as well as other price changes due to factors like inflation. Thus, our results should only reflect the cost-savings from patients' movement to ASCs. We begin by limiting our sample to those patients who go to a health care facility that is observed in both the pre and post-periods.[34] From this sample, we define two alternative total cost variables:

- Total Cost 1: We use an exact matching strategy to match patients observed in the post-period, to patients observed in the pre-period that have the same observable characteristics. Specifically, we group observations into "cases" defined by 1) The specific health care facility used 2) Whether or not the patient had any medical intervention and 3) The patient's Charlson Comorbidity Index.[35] We create 1,113 unique cases using this strategy, leaving approximately 1.63% unmatched observations from the pre and post periods. Within these cases, we take the mean total cost for the pre-period observations and apply this mean to every observation within the case.[36]

- Total Cost 2: Our alternative strategy uses regression adjustment to generate total costs that are purely a function of pre-period observables. Specifically, we predict what a person observed in the post-period would have paid had they been observed in the pre-period instead. To determine this, we limit our sample to pre-period only observations and estimate the coefficients from the regression, $Total\,Cost_{int}^{Pre} = X_{it}^{Pre} \times \beta^{pre} + \alpha_n^{pre} + u_{it}^{pre}$. X consists of the covariates discussed in the Empirical Section and

[33]Negative coefficient estimates suggest that increased pre-period exposure to CalPERS results in lower negotiated amounts than would have been realized if the CalPERS exposure was lower. This may be indicative of a slower growth in negotiated amount/prices among the facilities more likely to be visited by members of CalPERS.

[34]This restriction removes approximately 8% of our total observations

[35]We think these are the relevant observables on which to categorize since insurer negotiated prices vary at the facility-intervention status level, as discussed earlier.

[36]We omit cases that do not contain of at least one pre and one post-reference pricing observation (i.e. we omit those cases for whom only pre or post period observations are contained in the case).

α_n^{pre} represents the facility fixed effect. From this regression, we generate predicted total costs for post-period observations as, $Total\,\hat{Cost}_{int}^{Post} = X_{it}^{Post} \times \hat{\beta}^{pre} + \hat{\alpha}_n^{pre}$.[37]

Our result are shown in Tables 1.5 and 1.6. Both tables give the reduced form, OLS, and 2SLS regression estimates using the Total Cost 1 and Total Cost 2 definitions, respectively. The estimates are similar in direction to those presented in Table 1.3, although they are generally smaller in magnitude, depending on the model specification. In Table 1.5, the estimate of the LATE for average total cost reductions is statistically significant and is -$1670 (versus the analogous estimate of approximately -$2300 presented in Table 1.3). Additionally, the increased probability of being below $1500 among compliers is equal to approximately 60% in contrast to an approximately 67% increase in Table 1.3. Using our Total Cost 2 definition, we find similar estimates across our specifications in Table 1.6, which is reassuring. Together, these results suggest that supply-side responses may not be a large contributor to the total cost reductions associated with reference pricing. Rather, it appears that the reductions in total costs from the reference price program are largely driven by patient facility switching.

Health Outcomes

To better understand the health impacts of this program, we estimate the LATE for several patient outcomes. We distinguish between outcomes that occur on the day-of the screening (i.e. 0^{th} day complications) from those that occur the day after the screening. We focus on the following measured patient outcomes: 1) Any Complications (0-30 days post-screening) 2) Any Complications (1-30 days post-screening) 3) Serious Complications (0-30 days post-screening) 4) Serious Complications (1-30 days post-screening) 5) Non-Serious Complications (0-30 days post-screening) 6) Non-Serious Complications (1-30 days post-screening) and 7) Whether or not a patient has any medical intervention performed during the screening (i.e $\mathbb{1}$(Intervention)).[38] Health outcome variables 1-6 are defined as follows:

$$Health\,Complication_{it} = \begin{cases} 1, & \text{if person i has a health complication in period t} \\ 0, & \text{Otherwise} \end{cases}$$

Table 1.7 presents the LATE for the seven health outcomes discussed above, with each cell giving the coefficient estimate on ASC from a 2SLS regression using $Post \times Treat$ as the instrument. Our results indicate that none of the regression estimates for the LATE are statistically different from zero. This reaffirms that this program does not have negative

[37] We use the actual observed total costs for those patients observed in the pre-period. The R^2 from this regression is approximately 0.84. We also limit the sample to those with a minimum total cost above $300; the minimum from 2011.

[38] Serious complications include intestinal perforation or bleeding in the intestine while non-serious complications include paralytic ileus, nausea or abdominal pain and are determined using the medical CPT and ICD-9M codes of the patient. Any complications encompasses serious and non-serious complications and also includes cardiac and anesthesia-related complications

health impacts on patients and that the quality of care received for compliers, as measured by these outcomes, is similar at ASCs and hospitals.[39]

We are also interested in whether CalPERS members cut back on their utilization of screenings in response to the reference pricing program. Utilization reductions are often a concern when implementing policies that increase patients' medical cost-sharing and are especially concerning if they occur for preventative procedures, since these are medically encouraged. To analyze this question, we obtain annual PPO enrollment data from CalPERS for those who "should" be obtaining a screening based on their age (i.e. the population of 50-64 year olds).[40] We then create our utilization estimate, which is the ratio of CalPERS screenings observed in the data (for those ages 50-64 years) to the CalPERS enrollment number (for those ages 50-64 years). Unfortunately, we do not have enrollment data for the control group health plan.

Figure 1.5 plots these estimates of CalPERS screening utilization over time. There is a utilization drop between 2009 and 2010, before reference pricing, but screening utilization rates are relatively steady between the year before reference price implementation and the years after it was introduced. Specifically, the CalPERS utilization rates calculated are 4.58%, 3.26%, 3.22%, 3.64%, and 3.53% in 2009, 2010, 2011, 2012, and 2013, respectively. Thus, we have rough evidence that utilization rates may not have been negatively impacted by reference pricing.

Complier Characteristics

We are also interested in the characteristics of compliers in order to understand how they differ from those who used ASCs prior to reference pricing (i.e. the always takers) and those members of CalPERS who continue to use hospitals after reference pricing implementation (i.e. the never takers). To the extent that compliers differ in observable characteristics that make them more medically expensive at hospitals, this may lead to larger mean total cost reductions from their switching to ASCs. To estimate mean complier characteristics, we implement the estimation strategy of Abadie (2002).

Table 1.8 presents our results. We see that the share male appears to be lower among compliers as is the share that are between 50 and 59 years old. However, while the average age is similar across the groups, the share that are between 60 and 64 years old is higher among the compliers. Additionally, the share with a comorbidity index equal to 0 is lower, while the share with a medical intervention is higher in the complier versus always taker and never taker samples.[41] We test for changes in the probability of having an intervention driven by increased ASC use due to reference pricing (i.e. the LATE where the outcome is

[39] In the medical literature, a good measure of the quality of a colonoscopy is the withdrawal time. This measures the length of time taken to remove the scope from the colon. We do not observe this in the data. Source: Rex et al. (2015).

[40] Enrollment data tell us the number of people enrolled in a health plan.

[41] We do not test whether the means are statistically different between always takers and compliers. If we assume independence between samples, we can test this difference.

$\mathbb{1}$(Intervention)), but do not find estimates that statistically differ from zero (see Table 1.7). This suggests that while the average intervention rate may be similar at hospitals and at ASCs for compliers, the probability of needing an intervention appears to be slightly higher for compliers (relative to the other two groups). Additionally, we find that compliers are more likely to come from Northern California versus always takers and never takers. This may be a result of differences in the mean price between Northern California hospitals and ASCs, which are generally large compared to other regions. In the pre-period, the difference between the mean hospital and mean ASC price was approximately \$1840 in Northern California. This difference was approximately \$924 in Southern California and \$1225 in Central California.

Welfare Analysis

To understand the efficiency gains or losses associated with the reference pricing program, we determine if the program is efficient in the sense of Kaldor (1939) and Hicks (1939).[42] To do this, we compare the savings (\$'s) generated from the movement of the compliers to ASCs to the losses (\$'s) experienced by those members of CalPERS who use hospitals after reference price implementation (i.e. the never takers). Assuming a constant share of always takers, there are approximately 68% of CalPERS members who are classified as always takers.[43] With 7,243 members of CalPERS observed in the post-period and 5,685 members of CalPERS using an ASC, this implies that there are approximately 4,925 always-takers and 760 compliers (i.e. $5,685 - 7,243 \times 0.68$).

Taking the number of compliers, we estimate the average total cost savings generated by their move to ASCs from hospitals to be approximately \$1,748,000 ($= -\$2300 \times 760$), where we use the LATE on total cost from Table 1.3. We observe the additional out-of-pocket amount (\$'s) paid by CalPERS members who use hospitals in the post-period in the data. The additional out-of-pocket amount paid by never takers is equal to: $H_i = Total\,Cost_i$ - \$1500. We exclude from our analysis those hospital goers who face a total cost less than \$1500 (N = 158), leaving us with 638 CalPERS members who use hospitals in the post reference pricing period.[44] For these 638, $\sum_{i=1}^{638} H_i = \$855,810.70$. This implies an average per person additional cost of approximately, \$1341.40. Thus, the overall savings from this program for 2012 and 2013, accounting for the never-taker losses, are approximately \$892,189.30.

Applying the continuous mapping theorem, we compute the 95% confidence interval for our total savings estimate.[45] Using our estimates in Table 1.3, the 95% confidence interval

[42] Here, we assume that total cost is equal to marginal cost. However, to the extent that hospital prices reflect subsidizations of free care (e.g. to indigent populations), we are not able to capture this.

[43] $ASC_{2009} = 68\%,\ ASC_{2010} = 68.97\%,\ ASC_{2011} = 67.41\%$ for members of CalPERS.

[44] Those with total cost less than \$1500 should not have an additional out-of-pocket cost. We also exclude the CalPERS members who are exempt from the reference price program since they did not face additional out-of-pocket costs after the program implementation.

[45] Let $G(\hat{\beta}) = J \times \hat{\beta}$, where J is equal to the number of compliers and $\hat{\beta}$ is the estimate for the LATE on total costs. By the continuous mapping theorem, $s.e.(G(\hat{\beta})) \rightarrow J \times s.e.(\hat{\beta})$. This implies that the 95% confidence interval is: $G(\hat{\beta}) \pm 1.96 \times \big(J \times s.e.(\hat{\beta})\big)$.

for our savings estimate from compliers switching to ASCs is [$326,921.60, $3,169,078.40]. Given that we directly observe the amount paid by the never takers in the data, we do not compute a confidence interval for this amount. Our estimate for the additional cost incurred by the never takers (i.e. $\sum_{i=1}^{638} H_i$) is included in the 95% confidence interval. Thus, while the estimated savings of $892,189.30 are positive, we cannot say that they are statistically different from zero.

1.8 Conclusion

With public and private interest in implementing effective cost-containment strategies, it is important to understand the mechanisms by which cost-savings are achieved as well as the related health consequences of such policies. This analysis contributes to this by studying how changes to patient cost-sharing affect the choice of where medical care is received. The setting in which we analyze this is the introduction of reference pricing to CalPERS. By focusing on the program design which incentivized CalPERS members to choose lower-cost ASCs over hospitals, we are able to understand how shifts toward ASCs affect total costs and the distribution of total costs. Using DiD and IV-DiD strategies, our results tell us about treatment effects for the complier subpopulation of CalPERS. We show that there is a relatively large increase in the share of patients using ASCs (approximately 10 percentage points) in response to reference price implementation. We find that the associated reductions in average per-procedure total costs range between approximately $2300 and $1700, depending on model specification. Additionally, the largest relative increase in the distribution occurs for the area below the reference price threshold of $1500, likely driven by the lower ASC pricing structure. Also important, we show that there are no health complications arising as a result of this program and provide some evidence that screening colonoscopy utilization may not be greatly affected.

Future areas for research include determining to what other types of medical procedures reference pricing could be similarly applied. For services like screening colonoscopies where there are different health care facility types that provide a similar quality of care, the introduction of a reference pricing program seems to have been successful. While CalPERS introduced reference pricing for three other procedures (Arthroscopy, Cataracts, and Hip and Knee replacement surgery) around the same time, a better understanding of how extrapolatable our results are to a broader setting is still needed. To the extent that CalPERS members are similar to other health consumers within and outside of California, our estimates may be externally valid. However, understanding the supply-side responses, including how many more ASCs would be needed to meet the potentially increased demands for service as well as the associated changes in negotiated price due to a changing market structure, are also important considerations.

Table 1.1: Descriptive Statistics

	Pre-Period (2011)		Post-Period (2012-2013)	
	Control	CalPERS	Control	CalPERS
Share Male	0.51	0.47	0.50	0.46
Mean Age	55.11	56.28	55.20	56.39
Share 40-49 Yrs	0.06	0.04	0.05	0.04
Share 50-59 Yrs	0.67	0.63	0.67	0.60
Share 60-64 Yrs	0.25	0.32	0.26	0.35
Share w/Comorbidity Index= 0	0.95	0.95	0.96	0.94
Share w/Intervention	0.49	0.48	0.52	0.51
Share using ASC	0.72	0.67	0.72	0.78
Share patient from Northern Cal	0.41	0.56	0.37	0.55
Share patient from Southern Cal	0.50	0.39	0.55	0.40
Share patient from Central Cal	0.09	0.05	0.08	0.05
Mean Total Cost ($)	1794.43	1813.94	2061.10	1820.44
Median Total Cost ($)	996.60	1129.00	1128.00	979.50
Mean Total Cost ($) - ASC	1479.91	1335.68	1811.39	1515.24
Mean Total Cost ($) - Hospital	2603.14	2803.03	2714.66	2934.07
Mean Patient Cost ($)	643.79	317.42	734.91	516.35
Median Patient Cost ($)	0.00	0.00	0.00	0.00
Mean Patient Cost ($) - ASC	721.82	412.28	897.25	472.46
Mean Patient Cost ($) - Hospital	443.14	121.25	310.00	676.50
N	22,020	3,651	53,492	7,243

Note: Data consists of screening colonoscopy claims data for CalPERS and the control group, pooled from 2011-2013. Means are presented. Note: Northern Cal = HRRs in Alameda, Chico, Contra Costa, Modesto, Napa, Redding, Sacramento, Salinas, San Francisco, San Jose, San Mateo, Santa Rosa, Santa Cruz, and Stockton. Southern Cal = HRRs in Los Angeles, Orange County, Palm Springs, San Bernardino, San Diego, San Luis Obispo, Santa Barbara, and Ventura. Central Cal = HRRs in Bakersfield and Fresno.

Table 1.2: First Stage Estimates

ASC	No Cov. (1)	W/Cov. (2)
$Post \times Treat$	0.107***	0.098***
	(0.020)	(0.020)
N	86,406	86,406

1: Data consists of screening colonoscopy claims data from 2011-2013. Column 1 excludes covariates, while column 2 includes covariates: $\mathbb{1}$(Male),$\mathbb{1}$(Age Category), Comorbidity Index, $\mathbb{1}$(Intervention), Patient Health Care Market Dummy.
2: ***$p \leq 0.01$, **$p \leq 0.05$, *$p \leq 0.10$
3: Cluster s.e. at healthcare facility level – 541 clusters

Table 1.3: Regression Estimates

	Reduced Form		OLS		IV	
Outcome Variable	No Cov.	W/Cov.	No Cov.	W/Cov.	No Cov.	W/Cov.
	(1)	(2)	(3)	(4)	(5)	(6)
Total Cost	-260**	-224**	-1025***	-984***	-2425**	-2300**
	(101)	(89.8)	(253)	(267)	(965)	(954)
$\mathbb{1}(TC \leq \$1.5\text{K})$	.0691***	.0657***	.608***	.602***	.644***	.673***
	(.0196)	(.0172)	(.0597)	(.0499)	(.138)	(.135)
$\mathbb{1}(TC \leq \$2\text{K})$	.0497*	.046	.451***	.436***	.464*	.472*
	(.0294)	(.0282)	(.0629)	(.0547)	(.255)	(.278)
$\mathbb{1}(TC \leq \$2.5\text{K})$	.0358**	.0291**	.303***	.306***	.334**	.298**
	(.0154)	(.0135)	(.0563)	(.0533)	(.138)	(.135)
$\mathbb{1}(TC \leq \$5\text{K})$	.0127**	.0104*	.0144	.0173	.118*	.106*
	(.00597)	(.00544)	(.0199)	(.0207)	(.0615)	(.0612)
$\mathbb{1}(TC \leq \$10\text{K})$	.00605	.00515	-.0231***	-.025**	.0564	.0527
	(.004)	(.0036)	(.00889)	(.0104)	(.0398)	(.0393)
N	86,406	86,406	86,406	86,406	86,406	86,406

1: Data consists of screening colonoscopy claims data pooled from 2011-2013. Columns 1-2 give the effect of $Post_t \times Treat_k$ on outcomes, while Columns 3-6 give the effect of ASC_{it} on outcomes.
2: Columns 1, 3, and 5 exclude covariates, while columns 2, 4, and 6 include covariates: $\mathbb{1}$(Male),$\mathbb{1}$(Age Category), Comorbidity Index, $\mathbb{1}$(Intervention), Patient Health Care Market Dummy.
3: $^{***}p \leq 0.01$, $^{**}p \leq 0.05$, $^{*}p \leq 0.10$
4: Cluster s.e. at health care facility level– 542 clusters

Table 1.4: Coefficient Estimates of γ_2

Outcome	ASC Sample	Hospital Sample
	(1)	(2)
ln Negotiated Amount	-0.262**	-0.048
	(0.120)	(0.110)
Negotiated Amount ($)	-339.662	-185.996
	(215.777)	(266.911)
N	58,637	23,257

1: Each cell represents the coefficient estimate from γ_2 from equation 5.
2: Data is limited to health care facilities observed in all three years of 2011, 2012, and 2013.
3: $^{***}p \leq 0.01$, $^{**}p \leq 0.05$, $^{*}p \leq 0.10$
4: Cluster s.e. at health care facility level– 209 ASC clusters, 167 Hospital clusters

Table 1.5: Regression Estimates using Total Cost 1 Definition

	Reduced Form		OLS		IV	
Outcome Variable	No Cov.	W/Cov.	No Cov.	W/Cov.	No Cov.	W/Cov.
	(1)	(2)	(3)	(4)	(5)	(6)
Total Cost	-209***	-169**	-1162***	-1107***	-1832***	-1670***
	(77.9)	(69.8)	(229)	(239)	(641)	(648)
$\mathbb{1}(TC \leq \$1.5K)$	.0689***	.0603***	.605***	.592***	.604***	.595***
	(.02)	(.0177)	(.068)	(.0583)	(.126)	(.123)
$\mathbb{1}(TC \leq \$2K)$	.0617***	.0534***	.419***	.404***	.541***	.527***
	(.0187)	(.0166)	(.0718)	(.0608)	(.137)	(.141)
$\mathbb{1}(TC \leq \$2.5K)$	.0441***	.0357**	.287***	.285***	.387***	.352***
	(.0164)	(.0141)	(.0659)	(.0615)	(.136)	(.131)
$\mathbb{1}(TC \leq \$5K)$	.0038	.0025	-.00535	-.0101	.0333	.0247
	(.00838)	(.00805)	(.0167)	(.018)	(.0734)	(.0791)
$\mathbb{1}(TC \leq \$10K)$	.00266	.00201	-.0117	-.0146	.0233	.0198
	(.00325)	(.00286)	(.00831)	(.00993)	(.029)	(.0285)
N	80,550	80,550	80,550	80,550	80,550	80,550

1: Data consists of screening colonoscopy claims data pooled from 2011-2013. Columns 1-2 give the effect of $Post_t \times Treat_k$ on outcomes, while Columns 3-6 give the effect of ASC_{it} on outcomes.
2: Columns 1, 3, and 5 exclude covariates, while columns 2, 4, and 6 include covariates: $\mathbb{1}$(Male),$\mathbb{1}$(Age Category), Comorbidity Index, $\mathbb{1}$(Intervention), Patient Health Care Market Dummy.
3: $***p \leq 0.01$, $**p \leq 0.05$, $*p \leq 0.10$
4: Cluster s.e. at health care facility level– 373 clusters

Table 1.6: Regression Estimates using Total Cost 2 Definition

	Reduced Form		OLS		IV	
Outcome	No Cov. (1)	W/ Cov. (2)	No Cov. (3)	W/ Cov. (4)	No Cov. (5)	W/ Cov. (6)
Total Cost	-204**	-166**	-1146***	-1082***	-1803***	-1630**
	(79.4)	(70.7)	(226)	(238)	(662)	(658)
$\mathbb{1}(TC \leq \$1.5K)$	.0695***	.0619***	.611***	.6***	.612***	.607***
	(.0205)	(.0183)	(.0646)	(.0552)	(.13)	(.128)
$\mathbb{1}(TC \leq \$2K)$	.0484*	.0405*	.449***	.433***	.427**	.397*
	(.0248)	(.023)	(.0644)	(.0576)	(.195)	(.21)
$\mathbb{1}(TC \leq \$2.5K)$	.0475***	.0396***	.279***	.28***	.419***	.389***
	(.0166)	(.0148)	(.0624)	(.0587)	(.14)	(.14)
$\mathbb{1}(TC \leq \$5K)$	-.00412	-.00616	-.000522	-.00568	-.0363	-.0605
	(.00773)	(.00777)	(.0146)	(.0161)	(.067)	(.0746)
$\mathbb{1}(TC \leq \$10K)$	.00227	.00156	-.0121	-.0151	.02	.0153
	(.00329)	(.00288)	(.00825)	(.00995)	(.0294)	(.0285)
N	81,837	81,837	81,837	81,837	81,837	81,837

1: Data consists of screening colonoscopy claims data pooled from 2011-2013, omitting those with a predicted cost lower than $300 (the minimum observed cost from 2011). Columns 1-2 give the effect of $Post_t \times Treat_k$ on outcomes, while Columns 3-6 give the effect of ASC_{it} on outcomes.
2: Columns 1, 3, and 5 exclude covariates, while columns 2, 4, and 6 include covariates: $\mathbb{1}$(Male),$\mathbb{1}$(Age Category), Comorbidity Index, $\mathbb{1}$(Intervention), Patient Health Care Market Dummy.
3: $***p \leq 0.01$, $**p \leq 0.05$, $*p \leq 0.10$
4: Cluster s.e. at health care facility level– 376 clusters

Table 1.7: Health Complication/Intervention Outcomes

	IV		Pre-Period Occurrence
Health Outcome	No Cov.	W/Cov.	
	(1)	(2)	(3)
Any Complications (0-30d)	0.040	0.042	0.029
	(0.041)	(0.038)	
Any Complications (1-30d)	-0.031	-0.025	0.007
	(0.023)	(0.021)	
Serious Complications (0-30d)	0.018	0.018	0.003
	(0.018)	(0.016)	
Serious Complications (1-30d)	-0.006	-0.005	0.002
	(0.011)	(0.010)	
Non-Serious Complications (0-30d)	0.009	0.009	0.006
	(0.019)	(0.017)	
Non-Serious Complications (1-30d)	-0.008	-0.006	0.003
	(0.013)	(0.012)	
$\mathbb{1}$(Intervention)	0.036	0.025	0.485
	(0.118)	(0.113)	
N	86,406	86,406	25,671

1: Columns 1-2 give the effect of ASC_{it} on outcomes using a 2SLS regression with $Post_t \times Treat_k$ as the instrument.
2: The pre-period mean for each binary outcome variable is presented in column 3.
3: Data consists of screening colonoscopy claims data pooled from 2011-2013. Column 1 excludes covariates, while column 2 includes covariates: $\mathbb{1}$(Male), $\mathbb{1}$(Age Category), Comorbidity Index, $\mathbb{1}$(Intervention), Patient Health Care Market Dummy.
4: ***$p \leq 0.01$, **$p \leq 0.05$, *$p \leq 0.10$
5: Cluster s.e. at health care facility level– 542 clusters

Table 1.8: Characteristics of Compliers, Always Takers, and Never Takers

	Compliers	Always Takers	Never Takers
Share Male	0.36	0.50	0.50
	(0.08)	(0.01)	(0.02)
Average Age	55.69	55.32	56.41
	(1.04)	(0.07)	(0.21)
Share 40-49 Yrs	0.07	0.05	0.03
	(0.04)	(0.00)	(0.01)
Share 50-59 Yrs	0.49	0.67	0.61
	(0.10)	(0.00)	(0.02)
Share 60-64 Yrs	0.42	0.26	0.35
	(0.10)	(0.00)	(0.02)
Share w/Comorbidity	0.92	0.96	0.92
Index = 0	(0.03)	(0.00)	(0.01)
Share w/Intervention	0.59	0.51	0.48
	(0.10)	(0.01)	(0.02)
Share Northern Cal	0.64	0.39	0.49
	(0.14)	(0.05)	(0.07)
Share Southern Cal	0.17	0.53	0.46
	(0.15)	(0.05)	(0.07)
Share Central Cal	0.19	0.08	0.05
	(0.10)	(0.04)	(0.02)

Covariate means for compliers, in column 1, are computed using the technique described in Abadie (2002), using pooled 2011-2013 data. Clustered standard errors are presented in parentheses. Note: Covariate means for Always Takers and Never Takers are are estimated in the data using the years 2011-2013. Never Taker means exclude the reference price exempt population. Clustered standard errors are presented in parentheses. Data consists of screening colonoscopy claims data from members of CalPERS and the control group who use ASCs. Means and standard deviations, in parentheses, are presented. Note: Northern Cal = HRRs in Alameda, Chico, Contra Costa, Modesto, Napa, Redding, Sacramento, Salinas, San Francisco, San Jose, San Mateo, Santa Rosa, Santa Cruz, and Stockton. Southern Cal = HRRs in Los Angeles, Orange County, Palm Springs, San Bernardino, San Diego, San Luis Obispo, Santa Barbara, and Ventura. Central Cal = HRRs in Bakersfield and Fresno.

Figure 1.1: How Reference Pricing Works

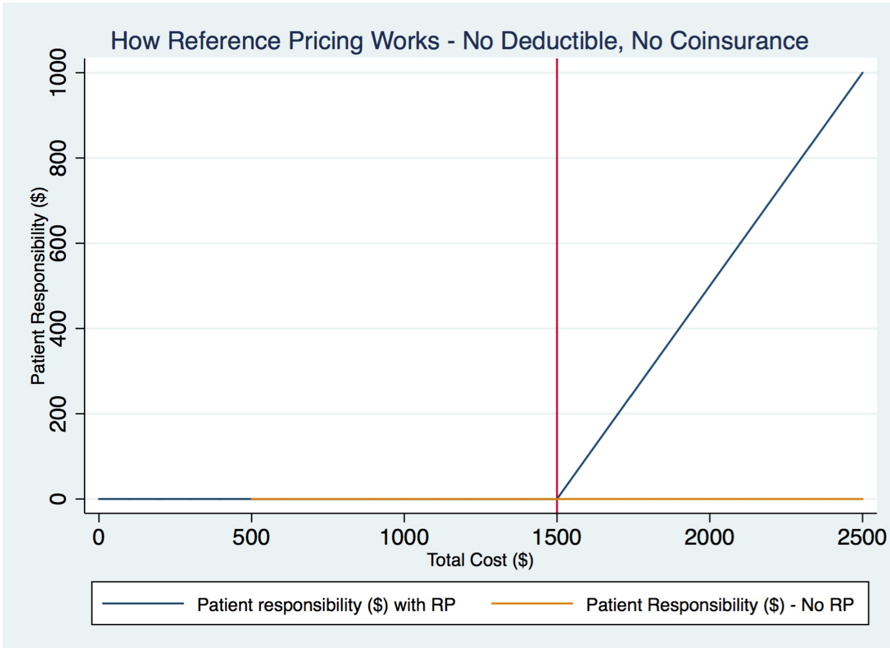
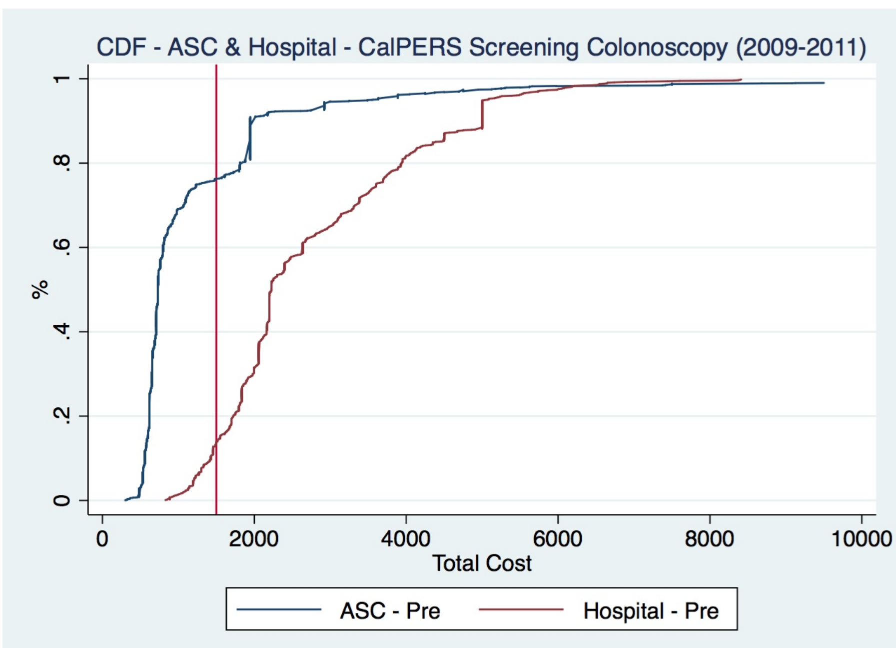
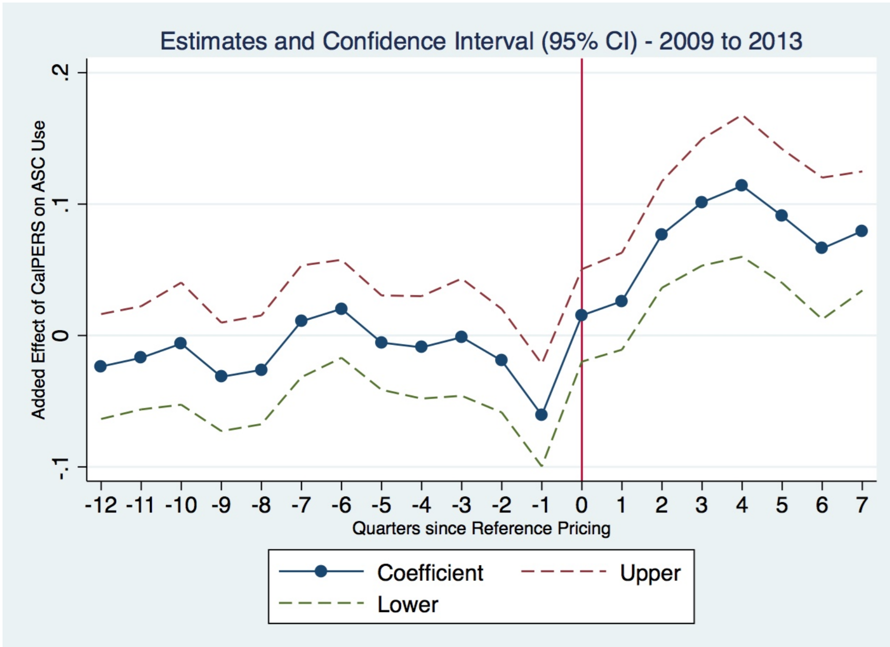


Figure 1.2: ASC vs. Hospital Per-Procedure Price Distribution (CDF)



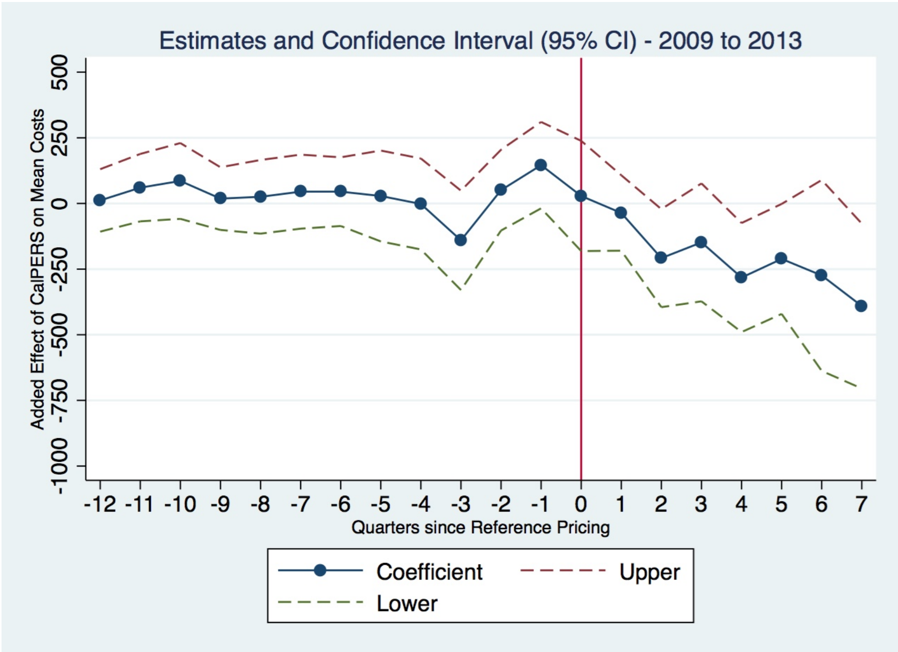
Note: Data consists of screening colonoscopy claims data for CalPERS members for the year 2011.

Figure 1.3: Event Study - Added Effect of CalPERS on ASC Use



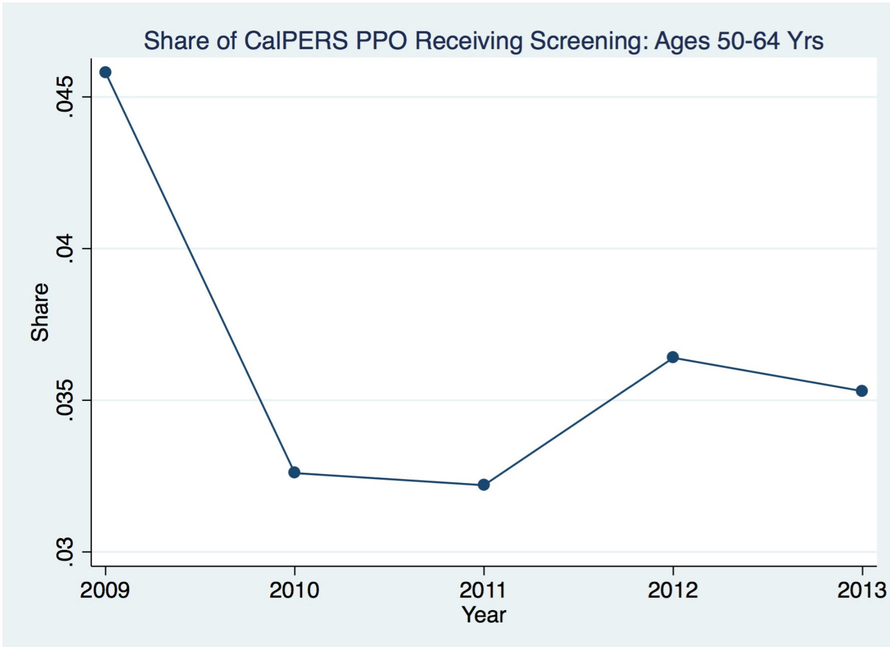
Note: Figure plots the coefficient estimates of γ^r from the event study presented in the methodology section, where the outcome variable is ASC.

Figure 1.4: Event Study - Added Effect of CalPERS on Mean Total Costs



Note: Figure plots the coefficient estimates of γ^r from the event study presented in the methodology section, where the outcome variable is $Total\,Cost$.

Figure 1.5: Estimated CalPERS Screening Colonoscopy Rates by Year



Note: Data used to construct the utilization estimates consists of 1) Active PPO enrollment numbers provided by CalPERS (members ages 50-64 years) and 2) Screening colonoscopy claims data for CalPERS members in the corresponding years.

Chapter 2

Quantile Treatment Effects of Reference Pricing

with Timothy Brown and Christopher Whaley

2.1 Introduction

Between 2000 and 2015, spending on health care has increased from 13.3% of GDP to 17.8% and is expected to outpace GDP growth by 1.2 percentage points per year over the next decade (CMS (2016)). Some estimates suggest that in the United States, approximately one third of health care spending is wasteful (Berwick and Hackbarth (2012)), with market pricing failures accounting for $131 billion (14%) of wasteful spending. Health care pricing failures are evidenced by the wide degree of price variation even within narrow categories of common health care services. Many studies document ten-fold variation in the local-market prices for such services, without concomitant variation in quality (Cooper et al. (2015)).

Due to the magnitude of spending on health care, there is significant interest among public and private policymakers in finding effective ways to reduce wasteful spending and to improve the efficiency of health care markets. While policies that increase patient cost-sharing have been introduced to address this issue, a better understanding of the mechanisms by which these patient cost-sharing programs may reduce wasteful spending is still needed. This analysis focuses on a specific mechanism by which wasteful spending can be reasonably achieved: affecting the health care provider choices of patients. The specific setting we consider is the introduction of a health insurance reform known as reference pricing to the California Public Employees Retirement System (CalPERS). Reference pricing changes the relative prices faced by members of CalPERS when choosing sites of care for colonoscopy and arthroscopy procedures. CalPERS set a maximum reimbursable amount (i.e. the reference price) for procedures done in a high-cost site of care (hospital outpatient department/hospital), while it set no maximum reimbursable amount if a patient chose to use a low-cost site of care (ambulatory surgical center). Prior to reference price implementation, no maximum reimbursable amount existed and insurer reimbursement was paid according to the standard features of the health insurance plan. With the introduction of the reference pricing program, patients now face strong financial incentives to receive services at lower-priced sites of care.

The reference pricing program is a recent innovation to the US health care landscape and adds to the array of available programs that use cost-sharing mechanisms to reduce the moral hazard effects associated with insurance coverage. Many studies have analyzed the effects of these earlier programs on patients' health care consumption choices, the most reliable being the RAND Health Insurance Experiment. The RAND Health Insurance Experiment was the first large-scale experiment to evaluate how variation in the level of cost-sharing required by health insurance plans affected medical utilization, and how the resulting variation in medical utilization affected the health outcomes of patients. (Manning et al. (1987),Joseph P. Newhouse and Rand Corporation (1993), Aron-Dine et al. (2013)).

In contrast, research into US applications of reference pricing is still in its early stages. Most of the early studies in this area have used difference-in-differences approaches and found that patients respond to the the program's incentives by switching to from hospital to ambulatory surgical centers (ASCs) Robinson et al. (2015), Robinson et al. (2015), and Robinson et al. (2015). Similarly, these basic results have been extended to examine the LATE effects of compliance with the program (Aouad et al. (2016)), the program's impact on moral hazard (Whaley et al. (2016)), and provider responses to the reference pricing program (Whaley and Brown (2017)). However, the previous studies have only examined the mean effects, rather than the distributional effects of the program. Because the CalPERS reference pricing program was explicitly designed to address the wide distribution of prices, fully understanding the distributional effects of the program is essential. In fact, our results suggest that by focusing on the mean effects, the existing studies of the CalPERS reference pricing program have missed distributional effects that have important implications for policy.

In this study, we implement the quantile treatment estimation method of Firpo (2007) and the quantile treatment estimator of Frölich and Melly (2010). We estimate the effects of reference pricing on the quantiles of the unconditional distribution of medical spending among CalPERS patients and capture the quantile treatment effect (QTE). This approach allows us to explore the heterogeneous impacts of the program and gives us a better understanding of what parts of the spending distribution are driving the observed cost reductions discussed in related studies. In particular, finding a larger right-tail reduction in the distribution of spending (relative to the left-tail or median) is an important policy finding if right-tail spending is synonymous with waste since words, total costs may not be positively correlated with better quality health care.[1].

To estimate the distributional effects of the reference pricing program, we use detailed medical claims data from both CalPERS and a comparison group, each of whom are covered by the same health benefits administrator. The comparison group is not subject to reference pricing during the study period.

[1]For a review of this subject, please see Hussey et al. (2013)

Our results indicate that there are heterogeneous effects of reference pricing across the distribution of spending and across the medical procedures considered. With respect to heterogeneous effect across the distribution of spending, the largest reductions in spending occur at the higher quantiles. That is, the right-tail shifts in by more than other parts of the distribution such as the median or lower quantiles. Across medical procedures, we generally only observe QTE estimates that are statistically different from zero for colonoscopy, suggesting that variation in the distributional effects is procedure-specific.

The paper proceeds as follows: Section 2 will provide the institutional background, Section 3 will discuss and describe the data, and Sections 4 and 5 will discuss the methodology and results, respectively. We conclude in Section 6.

2.2 Institutional Background

The California Public Employees Retirement System (CalPERS) offers health insurance, retirement, and other employee and retiree benefits to all state of California employees and their dependents. Other California local municipalities and governments–such as city governments, school boards, and public agencies– are allowed to provide their benefits through CalPERS. With over one million enrollees, CalPERS is the second largest purchaser of commercial health insurance benefits in the country. CalPERS provides health insurance benefits primarily through three health insurers–an integrated delivery plan provided by Kaiser Permanent, a health maintenance organization (HMO) plan provided by Blue Cross, and a preferred provider organization (PPO) plan provided by Anthem BlueCross.

The decision to implement the reference pricing program in the PPO plan was largely motivated by the observed variation in prices. In 2011, the year before the implementation of the program, the weighted average coefficient of variation for the three services was 1.05.[2] For these three services, this variation in prices was not linked to observable differences in quality, patient satisfaction, or clinical outcomes.

In addition, each of the surgical services are commonly performed in ambulatory surgical centers (ASCs), which are typically less expensive than the outpatient departments of hospitals, which have traditionally performed these surgical services. ASCs tend to have lower prices than hospitals largely for several reasons. Firstly, ASCs typically do not provide emergency or inpatient services. The lack of these services both reduces the costs of building and operating an ASC relative to a hospital. Additionally, because ASCs do not have emergency departments, they do not have to accept uninsured patients, who may be cross-subsidized by the commercially insured population in hospitals Moreover, ASCs also specialize in a smaller number of services, which further reduces the operating costs of ASCs. Finally, because ASCs do not typically perform high-value services (for example, maternity care) for which patients select insurance networks, ASCs have less bargaining power with insurers than hospitals.

[2]In comparison, in Baye et al. (2004), the average coefficient of variation in online marketplaces was 0.09.

The reference pricing program implemented by CalPERS limits the amount that CalPERS reimburses patients for care. CalPERS implemented reference prices of $6,000 for arthroscopy and $1,500 for colonoscopy services for care received at a hospital. Every dollar of total cost incurred above this reference price threshold is the entire financial responsibility of the patient and does not go toward their annual health insurance deductible or the out-of-pocket maximum. Another important feature of the program is that no reference price is set for care received at an ASC. This scheme simplifies the program design. Based on the 2011 price distribution for the CalPERS population, these prices are at the 63^{rd} and 59^{th} distribution of prices. Among hospitals, the reference prices fall at the 44^{th} and 13^{th} percentiles of the 2011 distribution of prices for arthroscopy surgery and colonoscopy, respectively. Because the reference prices are relatively low in the hospital price distribution, the reference pricing program provides a strong incentive for patients to receive care from ASCs or less expensive hospitals.[3]

Patients receive exemptions from the program based on clinical recommendations by the patient's physician. Patients are also exempted if they live more than 30 miles from an ASC. These patients are not subject to the reference price if they receive care at a hospital.

2.3 Data

To estimate the distributional effects of the program, we use detailed medical claims data that cover the 2009 to 2013 period from two populations. The first population consists of all CalPERS employees and dependents who are enrolled in an Anthem Preferred Provider Organization (PPO) and received one of the two categories of surgical services discussed. This population was subject to the reference pricing program starting in 2012. For our comparison group population, we obtained similar medical claims data for Anthem PPO enrollees who do not receive coverage through CalPERS. Anthem is the largest non-Kaiser insurer in California and administers health insurance benefits for CalPERS PPO members and numerous other employer populations and self-insured individuals. The insurance networks and prices are set at the insurer (Anthem) level rather than the at the individual employer level. Thus, the non-CalPERS Anthem population faces the same price at any given health care provider. Thus, they are an ideal control group for the CalPERS population.

For both populations, we restrict the sample population to California residents aged 18-64 who receive one of the two procedures in California. These services are identified using the Current Procedural Terminology (CPT) codes in the claims data. For simplicity, our arthroscopy classification pools several specific types of arthroscopy (i.e. knee and shoulder). Likewise, we pool colonoscopies that are preformed for screening and diagnostic purposes into a single colonoscopy category. In the Appendix, we present results that separate the different arthroscopy and colonoscopy procedures. The results are similar to our main specifications.

The claims data contains detailed information on patient characteristics, provider identifiers, and characteristics of the surgical procedure. In our regressions, we include controls for

[3] However, it is generally difficult to find out the cost of a medical procedure before it has been performed.

patient age (in 10-year groupings) and gender. To adjust for differences in patient health, we include each patient's Charlson Comorbidity risk score in the year prior to the procedure (Charlson et al. (1987)). The Charlson comorbidity score is based on the diagnosis codes in each patient's medical claims over the 12 months preceding the date of their surgical procedure. To control for market-specific differences, we include dummy variables for the Hospital Referral Region (HRR) of the patient. [4]

Our key dependent variable is the total expenditure for each procedure. We measure this cost/price as the sum of what the patient pays and what the employer/CalPERS pays. We define the patient's payment as the sum of all copayments, coinsurance, and deductible payments. As a result, our prices are not the billed "chargemaster" price, but instead, reflect the actual transacted price.

Descriptive Statistics

Table 2.1 presents descriptive statistics for the patients included in this study. For all services, Table 2.1 shows the basic demographics for both the CalPERS and non-CalPERS populations before (2009-2011) and after (2012-2013) the program's implementation. Across all services, there is little baseline difference between the two populations, and the demographics of the populations do not meaningfully change following the implementation of the reference pricing program.

Table 2.1 also presents the descriptive statistics for the surgical procedures for both populations over both time periods. Following the implementation of the reference pricing program, the share of CalPERS patients using an ASC increased from 61.9% to 69.2% for arthroscopy and from 66.6% to 75.0% for colonoscopy. The changes in the site of service lead to sizable changes in the mean price per service. For arthroscopy, the average price among the CalPERS population increased by $742 (9.7%). For the non-CalPERS population, prices increased by $1,721 (24.1%). For colonoscopies, the difference between the price changes among the CalPERS and non-CalPERS populations results in a reduction in the average cost per procedure of $284 (11.5%).

While the mean total price of each service decreased, Table 2.1 also shows increases in mean patient cost-sharing for each of the services. Relative to the non-CalPERS population, patient cost-sharing for the CalPERS population increased by $508 (13.3%) for arthroscopy. For colonoscopies, there is only an $8 increase in patient cost-sharing. The increases in patient cost-sharing are largely driven by the sizable increase in cost-sharing for patients who received care at a hospital. Relative to the non-CalPERS population, the cost-sharing for CalPERS patients who received care at a hospital increased by $456 for arthroscopy and $644 for colonoscopies.

[4] HRRs are a geographic unit developed by the Dartmouth Atlas of Care to measure local health care markets **?**

Cumulative Density Functions

For each of the three services, Figures 2.1 through 2.2 show the the price distributions for each service by estimating the empirical cumulative density functions (CDFs). For each figure, four categories of distributions are presented: the price distributions for both the treatment (CalPERS) and control (non-CalPERS) populations in both the pre-implementation (2009-2011) and post-implementation (2012-2013) periods are shown. These distributions illustrate the wide degree of price variation that motivated the implementation of the reference pricing program.

For arthroscopy (Figure 2.1), prices for all four categories range from a few hundred dollars up to $40,000. There is little noticeable difference in the pre- and post-implementation price distribution for the control population. However, for the CalPERS population, there is a inward shift in the price distribution near the reference price between the pre- and post-implementation price distributions. The most noticeable distributional shift is seen in Figure 2.2 for colonoscopy services. Compared to the pre-implementation period, there is a substantial inward shift just above the reference price for the CalPERS population that is not observed for the non-CalPERS pricing.

These descriptive figures support examining the distributional effects of the program, instead of solely focusing on the mean effects. Traditional mean estimation approaches miss the important distributional effects that are demonstrated by these figures. The differences across the three surgical services in both the price distributions and the changes in the distributions, supports examining each procedure separately.

2.4 Methodology

We apply the quantile treatment effect (i.e. QTE) estimation method of Firpo (2007) using a potential outcomes framework. We follow their notation and methods and define treatment as:

$$T_i = \begin{cases} 1, & \text{if person } i \text{ is exposed to reference pricing through CalPERS membership} \\ 0, & \text{otherwise} \end{cases}$$

Since treatment occurs only in the post- reference pricing period, we limit our sample to those years of data for which reference pricing is in place, which are 2012 and 2013. When $T_i = 1$, we will observe $Y_i(1)$, which is the total cost of the medical procedure when the individual is exposed to reference pricing. Otherwise, we observe $Y_i(0)$. Thus we can write the observed outcome in the standard way as, $Y_i = Y_i(1) \times T_i + Y_i(0) \times (1 - T_i)$.

We define the QTE parameter of interest as, $\Delta_\tau = q_{1,\tau} - q_{0,\tau}$ where $q_{k,\tau} \equiv \inf_q Pr[Y_k \leq q] \geq \tau$, $k = 0, 1$. It is not necessary to assume rank preservation since we are interested in the change in the quantiles of the *unconditional* distribution of total costs, rather than the quantiles of the treatment effects. This is a meaningful measure because we are concerned with the reductions in "wasteful spending," which in this setting is synonymous with reductions in the right-tail of the total cost distribution.

Identification of the QTE relies on the assumption of selection on observables holding. We believe that this is likely to hold in this setting since reference pricing was introduced without regard to the observable characteristics of patients and was applied with minimal advanced notice to CalPERS members.[5] [6] An additional required assumption is common support, which we show in the propensity score figures 2.3 through 2.4. We also assume uniqueness of the quantiles.

Estimation of the QTE, $\hat{\Delta_\tau} = \hat{q_{1,\tau}} - \hat{q_{0,\tau}}$ are obtained using the IVQTE Estimator implemented in STATA by Frölich and Melly (2010). The estimator for the QTE, $\hat{\Delta_\tau}$, is given by:

$$(\hat{\alpha}, \hat{\Delta^\tau}) = arg\, min_{\alpha,\Delta} = \frac{1}{N}\sum_{i=1}^{N} \hat{w_i} \times \rho_\tau(Y_i - \alpha - D_i\Delta).$$

ρ_τ is the check function (Koenker and Bassett Jr (1978)). For some real number x, $\rho_\tau(x) = x(\tau - \mathbb{1}(x \leq 0))$.
$\hat{w_i} = \frac{T_i}{p(\hat{X_i})} + \frac{1-T_i}{p(\hat{X_i})}$ are the inverse propensity weights estimated using a logit model, where the treatment propensity is:

$$p(X_i) = Pr[T_i = 1|X] = \frac{e^{X_i'\beta}}{1 + X_i'\beta}$$

Here, X represents a vector of patient covariates: Age, gender, geographic health care market of the patient (i.e. Hospital Referral Region) and Charlson Comorbidity Index (Charlson et al. (1987)). An indicator variable for whether a patient has a medical intervention is also included in X. This is done under the presumption that those who may knowingly need a medical intervention (e.g. those patients who may be more sick) may exempted from the reference price policy and thus will not be exposed to the treatment.[7]

[5] Also, the alternative health plans that CalPERS members could choose from, offer a narrower choice of providers than the PPO plan. If this is a consideration for members when deciding which health plan to choose, this will reduce the likelihood of switching to a different health plan.

[6] The details of the program would have been available in the annual health plan book which would have been available in late October/early November in the calendar year prior to the implementation of the policy.

[7] The patient covariates are categorized as: Age; $\mathbb{1}$(18-29 Yrs), $\mathbb{1}$(30-39 Yrs), $\mathbb{1}$(40-49 Yrs), $\mathbb{1}$(50-59 Yrs), $\mathbb{1}$(60-64 Yrs), Gender;$\mathbb{1}$(Male), Charlson Comorbidity Index; $\mathbb{1}$(Comorbodity Index = 0), $\mathbb{1}$(Comorbodity Index = 1), $\mathbb{1}$(Comorbodity Index = 2), HRR: $\mathbb{1}$(HRR = L) where $\mathbb{1}$(HRR = L) = 1 if the patient lives in HRR "L" and is zero, otherwise. We omit a single category for each category of categorical variables to avoid multicollinearity.

2.5 Results

Propensity Score:

In Figures 2.3 through Figure ??, we test our assumption of the common support. These figures display the distribution of the propensity score across the treated (i.e. CalPERS) and control groups using a a histogram with bin widths of 0.025. These figures show that there exists variation in the propensity to be treated across the treatment and control groups. They also show that there is overlap in the propensity to be treated across these groups. Thus the common support assumption should hold in our sample.

Reduced Form Results

Before we present the QTE estimates, we discuss the treatment effects from a Difference-in-Difference (DiD) model for comparison. The estimating equation is:

$$Y_{it} = \beta_0 + \beta_1 \times Post_t + \beta_2 \times Treat_i + \beta_3 \times Post_t \times Treat_i + X_{it}'\beta + \varepsilon_{it}$$

Y_{it} represents the total cost, in dollars, for the medical procedure. $Treat_i$ is a dummy variable that takes the value 1 if an observation is from the CalPERS group and 0 if the patient is from the control group. $Post_t$ takes the value 1 if the observation is from 2012-2013 and is 0 if the observation is from 2009-2011 (i.e. the period before reference pricing was implemented). X_{it} is a vector of patient covariates described in the previous section. We estimate this regression using OLS and cluster the standard errors at the health care facility-level (i.e. the health care facility where medical services are received).

Table 2.6 displays the results for the coefficient estimates of β_3. Our results indicate that for arthroscopy and colonoscopy procedures, reference pricing led to statistically significant reductions in the average total cost observed for these procedures. Specifically, for arthroscopy, the introduction of reference pricing led to an average reduction in the total cost observed of \$1029.07, which is statistically significant at the 1% significance level. Prior to reference pricing (2009-2011), the mean total cost observed in our sample was approximately, \$7659.84. Thus \$1,029 represents about 13% of the total cost in the pre-period. For colonoscopy procedures we find that the introduction of reference pricing led to an average per-procedure savings of approximately \$266. This is again sizeable, when compared to the pre-period average total cost of \$1,862.

Quantile Treatment Effect Results:

Turning to our estimates of the QTE, Table 2.3 displays the main QTE results, with each medical procedure analyzed separately. The 95% confidence intervals are presented below each QTE estimate in brackets. These confidence intervals are estimated by bootstrapping the sample, using 1,000 replications, and taking the 2.5^{th} and 97.5^{th} percentile estimates of this bootstrap distribution at each quantile estimate.[8]

For arthroscopy procedures, our results indicate that there is variation in the sign of our QTE estimates across the quantiles. However, the only QTE estimates that statistically differ from zero for are for the 0.95^{th} and 0.99^{th} quantiles. Those estimates are -$4,523 and -$16,767, respectively. This implies that there is an approximately $4500 reduction in the 0.95^{th} quantile as a result of the reference pricing program and an approximately $17,000 reduction in the 0.99^{th} quantile. These effects indicate a large reduction in right-tail spending. Comparing this to the DiD estimate of $-1,029, the QTE estimates clearly demonstrate the distributional effects that are not evident from the DiD estimate. Thus, the results suggest that the program effects are driven by reductions in the right-tail of spending as evidenced by the large, negative and statistically significant QTEs for the 0.95^{th} and 0.99^{th} quantile and small, not-statistically significant estimates at the lower quantiles of the distribution.

For colonoscopies, most QTE estimates are statistically different from zero. The few QTE estimates that are not statistically different from zero are concentrated at the lower quantiles, specifically at the 0.01, 0.05, 0.10, 0.15. and 0.25 quantiles. The estimates also appear to become more negative as the quantile considered increases, although this is not a clearly consistent pattern. For example, the QTE for the 0.30^{th} quantile is -$25. This is smaller than the QTE for the median, which is -$168. Both of these estimates are smaller than the QTEs for the 0.95^{th} and 0.99^{th} quantile, which are -$1,438 and -$6,950, respectively. In comparison to our DiD estimate of -$266, our QTE estimates reveal the heterogeneity in the distributional effects and help to make clear how exactly the reference pricing program-associated cost reductions occur. Specifically, our results indicate that the biggest cost reductions are occurring at the higher quantiles of the medical spending distribution (e.g. the 0.80, 0.95, and 0.99 quantiles) with smaller cost reductions are concentrated at the lower quantiles.

Across the arthroscopy and colonoscopy procedures, the relatively large reductions in higher quantiles could be driven by the existence of a large right-tail in pre-period medical spending, as observed in the cumulative density function. This suggests that a policy which encourages health care facility switching (from hospitals to ASCs) may also achieve desired distributional effects by reducing right-tail spending and leaving lower quantiles, relatively unaffected.

2.6 Conclusion

Reference pricing is a reimbursement policy in which a health insurer sets a maximum reimbursable amount (i.e. the reference price) that they will pay for a given medical procedure. The patient must then pay the difference between the reference price and actual price charged

[8] For the q^{th} quantile, the 95% confidence interval = $[\hat{\Delta_{q,26}}, \hat{\Delta_{q,975}}]$ where $\hat{\Delta_{q,26}}$ is the 0.025^{th} quantile of the bootstrap distribution and $\hat{\Delta_{q,975}}$ is the 0.975^{th} quantile of the bootstrap distribution (StataCorp (2015)).

by the medical provider when services are received at a hospital. The purpose of reference pricing is to motivate patients to choose lower-cost medical providers by making the patient's marginal out-of-pocket price vary with the particular medical provider the patient chooses.

While variants of reference pricing have been used in many OECD countries to reimburse for pharmaceuticals, its application in the US is a recent innovation. In the US, reference pricing is mainly applied to medical procedures and tests. Reference pricing differs from traditional indemnity insurance. Indemnity insurance pays a fixed amount to patients for a specific insured medical service, leaving patients to pay the balance between this fixed amount and whatever price the medical provider charged. It also does not place an upper limit on the price a medical provider could charge, leaving patients with uncertainty as to what their actual out-of-pocket expenses would be.

The application of reference pricing by the California Public Employees' Retirement System is innovative in a number of ways. Firstly, it simplifies the choices available to consumers by applying reference pricing asymmetrically. Patients who receive colonoscopy or arthroscopy procedures are subject to reference pricing if they receive their procedures in a hospital (a high-cost setting), but are not subject to reference pricing if they receive their procedures in an ambulatory surgical center (a low-cost setting). Thus, the only necessary decision a consumer needs to make to avoid any additional out-of-pocket expense is to choose an ambulatory surgical center.

While the mean effects of this program across each procedure category are of interest, the mean effects do not distinguish whether the reductions in spending are due to movements across all parts of the distribution (i.e. a location shift), or if there is a much larger reduction from the upper end of the price distribution. In contrast, the quantile treatment effects will yield exactly this information, and the quantile treatment effects do support the latter scenario. The reduction in the upper end of the price distribution after the implementation of reference pricing was largest for colonoscopy and moderate for arthroscopy. These differences largely reflect where along the distribution of pre-period prices the reference price was set. The reference pricing was set lowest in the distribution of prices for colonoscopy and higher in the distribution of prices for arthroscopy.

To the extent that price is not synonymous with the quality of medical care received, our findings suggest that reference pricing may be able to successfully target areas of wasteful spending (i.e. the right-tail), while leaving areas that we may not typically associate with waste, relatively unaffected.

These findings have important policy implications. The primary policy implication is that public policy makers and insurers should give careful thought to the point along the price distribution where the reference price is set. From a public policy perspective, the value of reference pricing is to reduce wasteful spending. Thus, setting the reference price too low may cut into spending that is not wasteful and induce a reduction in quality. Thus, public policy should encourage the use of reference pricing, but be mindful of the potential abuses of reference pricing that might result in a degradation of the quality of medical services. From the insurers' perspective, in addition to the above concern, setting the reference price too high is also a concern, since little to no impact will result if the reference price is set too high.

Finally, given the heterogeneity of the impact of reference pricing across procedures, there may be no clear rule of thumb regarding where along the distribution to set the reference price, as its impact likely depends on the shape of the distribution, and other factors such as how correlated price and quality are for a given medical procedure.

Reference pricing is a powerful tool in the design of health insurance. If wielded wisely, reference pricing may have a significant long-term effect on the growth of health care expenditures in the US.

Table 2.1: Descriptive Statistics

	Pre-Period (2009-2011)		Post-Period (2012-2013)	
	Control	CalPERS	Control	CalPERS
Arthroscopy				
Share Male	58.6%	50.8%	58.0%	50.4%
Mean Age	47.1	51.0	47.3	51.3
Share 18-29 Yrs	12.9%	7.6%	13.2%	8.5%
Share 30-39 Yrs	11.8%	6.2%	10.5%	5.6%
Share 40-49 Yrs	24.0%	19.4%	23.0%	18.3%
Share 50-59 Yrs	35.8%	41.3%	36.9%	40.1%
Share 60-64 Yrs	15.5%	25.5%	16.3%	27.4%
Share w/Comorbidity Index= 0	95.5%	94.2%	95.4%	94.5%
Share using ASC	67.0%	61.9%	67.1%	69.2%
Mean Total Cost	$7,146	$7,660	$8,867	$8,401
Mean Total Cost- ASC	$6,794	$6,743	$8,941	$7,696
Mean Total Cost - Hospital	$7,872	$9,150	$8,717	$9,986
Mean Patient Cost	$2,763	$2,866	$4,005	$3,600
Mean Patient Cost - ASC	$3,581	$3,786	$5,393	$4,349
Mean Patient Cost - Hospital	$1,081	$1,370	$1,172	$1,917
N	35,238	4,317	24,501	2,751
Colonoscopy				
Share Male	46.6%	44.5%	46.8%	43.2%
Mean Age	52.6	54.7	52.8	54.8
Share 18-29 Yrs	3.2%	1.6%	3.3%	2.0%
Share 30-39 Yrs	4.9%	2.8%	4.7%	2.8%
Share 40-49 Yrs	14.6%	9.9%	12.8%	9.3%
Share 50-59 Yrs	55.2%	56.0%	56.1%	53.7%
Share 60-64 Yrs	22.0%	29.6%	23.1%	32.3%
Share w/Comorbidity Index= 0	92.9%	92.5%	93.4%	92.8%
Share using ASC	71.9%	66.6%	72.4%	75.0%
Mean Total Cost	$1,902	$1,862	$2,431	$2,109
Mean Total Cost- ASC	$1,609	$1,383	$2,232	$1,734
Mean Total Cost - Hospital	$2,649	$2,820	$2,956	$3,232
Mean Patient Cost	$875	$504	$1,114	$751
Mean Patient Cost - ASC	$987	$614	$1,365	$737
Mean Patient Cost - Hospital	$589	$282	$457	$794
N	163,004	24,698	117,584	15,192

Table 2.2: Difference in Difference Estimates - Estimate of β_3 coefficient

Outcome	Arthroscopy	Colonoscopy
Total Cost ($)	-1029.074***	-266.300**
	(354.450)	(113.276)
N	66,807	320,478

1: Data consists of medical procedure claims data pooled from 2009-2013.
2: Covariates are included in the estimation: $\mathbb{1}$(Male),$\mathbb{1}$(Age Category), Comorbidity Index, Patient Health Care Market Dummy, and $\mathbb{1}$(Intervention) for colonoscopy procedures and an arth dummy differentiating between knee (1) and shoulder (0) procedures.
3: $***p \leq 0.01$, $**p \leq 0.05$, $*p \leq 0.10$
4: Standard errors are clustered at the health care provider level; 582 for Arthroscopy and 709 for Colonoscopy.

Table 2.3: QTE Regression Estimates

Quantile	Arthroscopy *Knee & Shoulder*	Colonoscopy *Diagnostic & Screening*
0.01	56.000	0.000
	[0.000, 69.000]	[0.000, 0.000]
0.05	0.000	0.000
	[-92.500, 155.500]	[-5.000, 0.000]
0.10	28.000	-14.000
	[-67.000, 115.250]	[-15.000,6.000]
0.15	-24.500	-15.000
	[-76.000, 81.500]	[-22.000, 12.000]
0.20	53.000	-8.000
	[-29.000, 98.000]	[-8.000, -3.000]
0.25	6.500	-21.000
	[-165.000, 230.935]	[-34.000, 20.000]
0.30	-18.500	-25.000
	[-154.500, 106.500]	[-30.000, -11.000]
0.35	-65.000	-28.000
	[-208.815, 67.750]	[-48.000, -26.000]
0.40	-43.500	-52.000
	[-191.000, 171.000]	[-72.000, -38.500]
0.45	-15.000	-55.000
	[-153.985, 128.500]	[-79.250, -30.000]
0.50	-41.000	-168.000
	[-139.625, 183.640]	[-184.500, -152.000]
0.55	-25.000	-243.000
	[-70.530, 152]	[-276.705, -191.25]
0.60	-36.250	-317.000
	[-262.000, 293.500]	[-361.050, -269.750]
0.65	-45.230	-185.000
	[-384.055, 348.750]	[-253.580, -120.020]
0.70	57.000	-135.000
	[-357.000, 452.000]	[-135.000, -110.000]
0.75	-19.000	-148.000
	[-421.750, 414.375]	[-153.000, -126.000]
0.80	-166.000	-292.840
	[-992.760, 490.000]	[-367.000, -181.000]
0.85	-555.400	-74.490
	[-1495.965, 552.075]	[-237.260, -41.670]
0.90	-2000.000	-294.610
	[-3453.530, 556.055]	[-436.000, -141.410]
0.95	-4523.320	-1438.810
	[-8110.234, -555.311]	[-1805.735, -1035.99]
0.99	-16767.453	-6950.000
	[-21560.000, -5606.730]	[-6950.000, -1250.000]
N	27,252	132,776

1: Data consists of medical procedure claims data pooled from 2012-2013.
2: Covariates are included in the estimation: $\mathbb{1}$(Male),$\mathbb{1}$(Age Category), Comorbidity Index, Patient Health Care Market Dummy, $\mathbb{1}$(Intervention).
3: 95^{th} percentile of bootstrapped standard errors are presented in brackets below coefficient estimates.

Figure 2.1: Arthroscopy Knee & Shoulder CDF

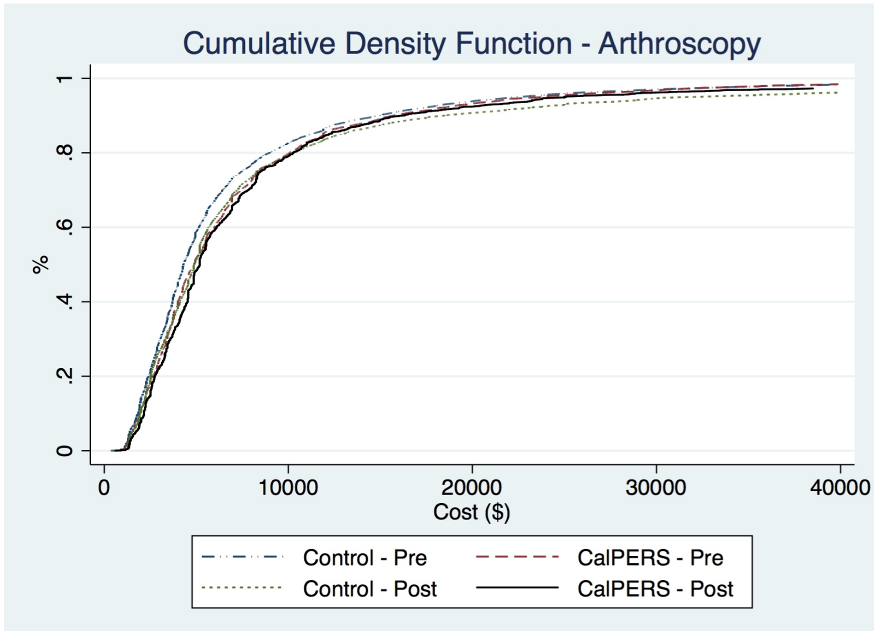


Figure 2.2: Colonoscopy Diagnostic & Screening CDF

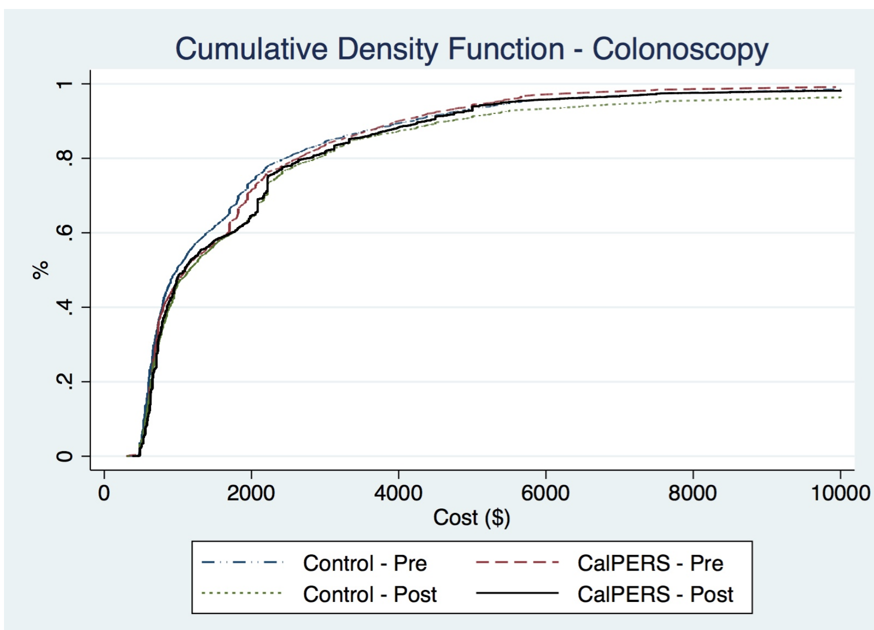
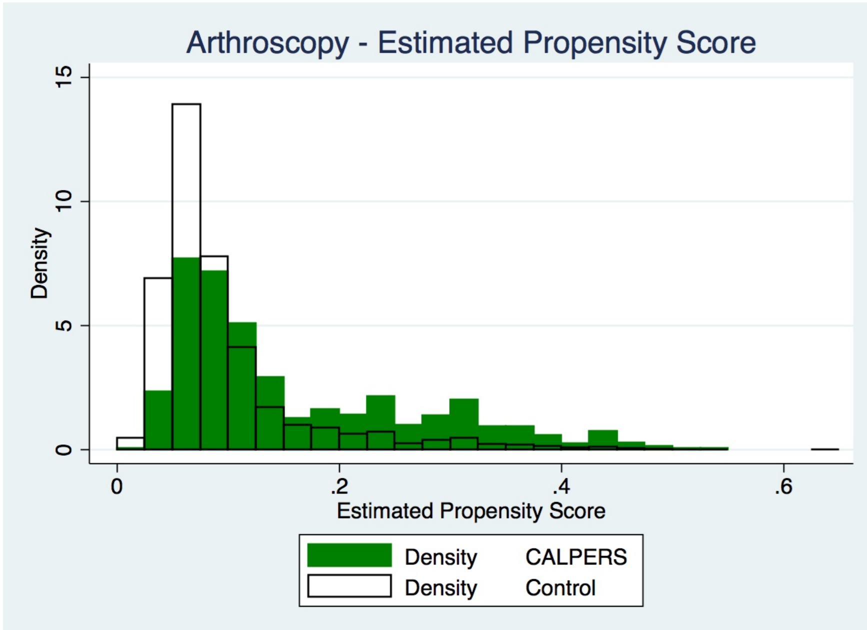
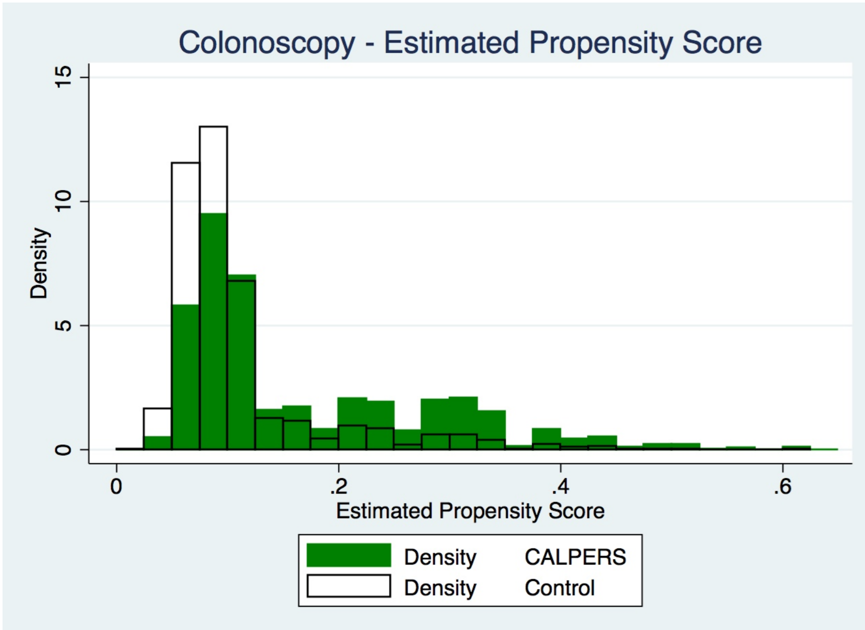


Figure 2.3: Arthroscopy Knee & Shoulder Propensity Score Distribution



Estimates of the propensity score using logit model. Data consists of post-period pooled claims data.

Figure 2.4: Colonoscopy Diagnostic & Screening Propensity Score Distribution



Estimates of the propensity score using logit model. Data consists of post-period pooled claims data.

Chapter 3

Understanding Physician Responses to Reference Pricing

3.1 Introduction

Understanding the role of the physician in deciding how much care but also in what setting to provide care is important for determining how physicians' behavior contributes to variations in total medical spending and the medical costs faced by patients. To address this issue, this analysis evaluates how physicians' care decisions change when there is a change in patients' financial circumstances. This question is answered by exploiting a natural experiment that changes the cost-sharing/financial responsibility of patients for procedures that can be performed in either a lower-cost care setting (Ambulatory Surgical Center/ASC) or in a higher-cost care setting (Hospital Outpatient Department/Hospital). The cost-sharing reform analyzed is a health insurance reform introduced by the California Public Employees Retirement System (CalPERS) called reference pricing. Reference pricing was introduced as a way to reduce medical spending by incentivizing patients to choose ASCs over hospitals for medical treatment across several medical procedures.

The effects of reference pricing reform on changes in total spending and patients choice of where to receive care has been studied in earlier papers (see Aouad et al. (2016), Whaley et al. (2016), Robinson et al. (2015), Robinson et al. (2015)). While these studies focus on the financial effects of the program (e.g. total cost-savings) and changes in the negotiated prices set by health care facilities, it is also important to investigate how physicians respond to this policy. Since the physician performs the medical service in a particular location, which is crucial to the determination of total costs, this analysis allows us to understand how physicians responses contribute to the observed facility switching and the cost savings associated with the reference pricing program. Specifically, for those physicians who can work in both the ASC and hospital setting, this analysis investigates if reference pricing causes these physicians to be more likely to perform medical procedures in ASCs for CalPERS patient.

The proposed question is related to issues of physician agency (McGuire (2000)). In this particular setting, I analyze how physicians respond to changes in CalPERS patient's cost-sharing. From this, it is possible to learn if the drivers of increased ASC use are a mixture of physician switching from hospitals to ASCs or a movement of CalPERS patients to physicians who only work at ASCs.

There is a vast literature that investigates issues of physician agency, such as the existence of physician-induced demand. These analyses typically explore how physicians financial incentives affect their treatment patterns and influence the location where they treat their patients. Yee (2011) evaluates if physician's board membership in ASCs affects their volume of procedures. She finds that physicians with board membership affiliation, which is positively associated with financial remuneration, perform more procedures and choose to treat lower-risk patients. Baker et al. (2016) analyze how hospitals' ownership of physician practices affects the likelihood of those physicians' patients using the affiliated hospitals. They find that physician-hospital affiliation does matter for where patients elect to have their medical procedures.

While there is no extensive literature that discusses the location practice decisions of physicians, some articles note that physicians can be observed working in multiple location. David and Neuman (2011) discuss variation in the medical treatment location decisions of physicians, given a patient's medical risk profile. Differentiating between physicians who only work at an ASC versus those who work at both an ASC and at a hospital, they find that physicians who only work at ASCs are more likely to treat a risky patient at the ASC than a physician who works at both an ASC and at a hospital. Rizzo and Goddeeris (1998) discuss hospital admitting privileges, which are agreements that allow physicians to admit patients to certain hospitals. They focus on the financial effects of physicians' hospital admitting privileges and find that among non-primary care specialists who are self-employed, there is a positive association between the number of admitting privileges and earnings. This may be important for understanding the physicians' motivations for working across multiple settings.

While many analyses related to physician agency discuss the financial incentives of doctors and its effect on patients outcomes and the choices made on patients' behalf, they also demonstrate how influential physicians are in the health care decision process. This paper contributes to the existing literature by focusing on a setting where the immediate financial compensation for physicians should be the same across care/workplace settings but there is now an exogenous change to patient cost-sharing (financial responsibility). Additionally, the same physicians are observed before and after the policy change. Thus, rather than looking at direct changes to physicians' financial compensation, this study looks at indirect changes owing to changes in patients' health insurance benefits. To the extent that these types of benefit changes become more common, this analysis helps to elucidate if this is a policy lever that can be used to affect physician behavior in a way that reduces medical spending.

This will allow us to understand how patients demands influence physician behaviors/practice patterns. This, in turn, will allow us to understand how influential physicians are in mediating the effects of health insurance programs that are designed to incentivize lower medical spending.

To perform the analysis, I use Anthem BlueCross PPO medical claims data.[1] This data consists of claims data for CalPERS patients and control group patients, who did not face the reference pricing program. Both groups received a colonoscopy between 2009 and 2013 and have a PPO health plan administered by Anthem BlueCross of California. Since patient data is linked to the physician who performed that service, a short panel dataset of physicians observed in the pre and post reference pricing periods is formed. From this dataset, it can be determined if physicians respond to reference pricing by increasing their probability of treating CalPERS patients at ASCs (versus at hospitals) after the program is introduced, relative to members of the control group.

The results indicate that physicians are responsive to the reference pricing program and increase their probability of treating CalPERS members at the ASCs after reference pricing has been introduced. This finding varies depending on how much switching bandwidth a physician appears to have. For those physicians who are observed practicing at an ASC and at a hospital in the year before reference pricing, they are more likely to be observed at an ASC in the post-period and the probability of treating a CalPERS member at an ASC increases by approximately 6.6 percentage points. For physicians observed at only hospitals in the year prior to reference pricing, they are not more likely to be observed at an ASC in the post-period, however, when treating a CalPERS member, the probability of treating them at an ASC in the post-period increases by approximately 3.1 percentage points. No switching effects are found for those physicians who are observed working at only ASCs in the pre-period when they treat CalPERS members. This finding is consistent with the fact that for physicians already working at an ASC, there is little room for an increase in the probability of being observed at an ASC.

The paper will proceed as follows: Section 2 will give a brief discussion of the institutional background of the reference pricing program. In Section 3, the conceptual framework and motivating models are developed. In Section 4, the data is described and in Section 5, the methodology and empirical section are introduced. Section 6 presents the results and Section 7 concludes.

3.2 Institutional Background

Reference pricing was first introduced in 2011 for members of the California Public Employees' Retirement System (CalPERS) who were part of the PPO health insurance plan.[2] The program was later applied in 2012 to colonoscopy, arthroscopy, and cataracts medical procedures. Anthem BlueCross (i.e. Anthem) of California administer the health benefits for these CalPERS PPO members and for other Californians as well. Thus, the control group observed in the data consists of these other Californians who have a PPO plan administered

[1] PPO stands for Preferred Provider Organization.

[2] CalPERS is a public agency that manages the health and retirement benefits for over one million public employees as well as retired individuals. Approximately, 20% of active members who have health insurance through CalPERS are in a PPO plan (versus an HMO or Kaiser) (CalPERS (2016)).

by Anthem. This is an ideal setting since the control group members face the same price as CalPERS members at any given health care facility/provider but are not subject to the reference pricing policy.

The reference pricing program sets a maximum reimbursable amount for patients who continue to visit hospitals for their medical procedures after the policy is introduced. Every dollar of the total cost observed above this reference price at the hospital is 100% the responsibility of the patient and does not go toward their annual out-of-pocket maximum nor their annual deductible. However, if a patient instead chooses to go to an ASC after reference pricing is introduced, they do not face a reference price and face the standard cost-sharing they faced in the pre-reference pricing period (i.e. there is no cost-sharing if the procedure is a preventative procedure and there is standard cost-sharing for non-preventative procedures). Exemptions from the program are made for those CalPERS members who either present with a medical need to use a hospital or live more than 30 miles from an ASC.

Although reference pricing applies to several medical procedures, this analysis focuses on colonoscopy procedures. The reason for this is that these are relatively high-volume procedures (Healthcare Cost and Utilization Project (2016)). Also, because some colonoscopies are done for preventative purposes (i.e. screening colonoscopies), we should see a relatively large number of people receiving this procedure. In a previous study, Aouad et al. (2016) focus only on screening colonoscopies. This is done to mediate concerns that unobserved variation in forward-lookingness across patients, could affect their willingness to switch across health care facilities when facing the reference price.[3] Analyzing screening colonoscopies mediates this concern because patients do not have to pay a deductible or co-insurance since the procedures are considered preventative in nature (US Preventative Task Force (2016)). However, analyses of the diagnostic colonoscopy sample (i.e. those colonoscopies that are not performed for screening purposes) show that these patients are also responsive to the reference pricing program and do switch to the ASCs after the policy is introduced.[4] Thus, to increase the sample size for the analysis and the precision of estimates, both screening and diagnostic colonoscopies are included in the analysis.

3.3 Conceptual Framework

Motivation 1

The decision of where to perform the colonoscopy is modeled as a discrete choice for the physician. In Motivation 1, it is assumed that: 1) The patient knows about the reference

[3]In conjunction with a non-linear cost-sharing design, unobserved variation in forward-lookingness across patients could affect their willingness to switch to ASCs. For example, someone who at the beginning of the calendar year expects to reach their annual out-of-pocket-maximum, may be less likely to switch to an ASC in response to the program than someone who (at the beginning of the calendar year) does not expect to reach their annual deductible/out-of-pocket maximum.

[4]The introduction of reference pricing led to a statistically significant (at the 1% significance level) increase in the probability of using an ASC of approximately 7 percentage points.

pricing program and the additional costs incurred from using a hospital after the policy has been put into place 2) The patient chooses the physician and the physician then chooses where the medical service will be performed. The patient may have a particular facility preference (which could potentially discussed in a pre-procedure consultation) but the doctor ultimately decides the location of the medical service and 3) The physician's compensation from performing a non-complex procedure is similar at the ASC and at the hospital.[5]

Following the methodology discussed in McGuire (2000), let:
Let $U_j^{k(i)} = \alpha B_j^i + (1-\alpha)\pi_j^{k(i)} + \epsilon_j^{k(i)}$ where $j \in \{ASC, Hospital\}$ and $\alpha \in [0,1]$.
$U_j^{k(i)}$ is the utility for the k^{th} physician from performing a procedure in medical setting j for patient i.

Thus the physician's utility function is:

$$U^{k(i)} = \begin{cases} \alpha B^i_{ASC} + (1-\alpha)\pi^{k(i)}_{ASC} + \epsilon^{k(i)}_{ASC}, & \text{if choose ASC} \\ \alpha B^i_{Hosp} + (1-\alpha)\pi^{k(i)}_{Hosp} + \epsilon^{k(i)}_{Hosp}, & \text{if choose hospital} \end{cases}$$

- B_j^i is the benefit or utility to patient i from having a procedure done in facility j.
- $\pi_j^{k(i)}$ is the profit received by the physician from performing a medical procedure for patient i at facility j.
- α represents the weight that the physician puts on their own profit versus the weight that they put on the patient's benefit.
- $\epsilon_j^{k(i)}$ captures the effect on utility not captured in B_j^i or $\pi_j^{k(i)}$. For example, we can assume it reflects unobserved tastes of the physician.

In order to maximize utility, physician k chooses to perform the procedure at either an ASC or hospital for each patient i. Since it is assumed that the profit from performing a procedure at the ASC and hospital is similar (i.e. $E[\pi^{k(i)}_{ASC}] = E[\pi^{k(i)}_{Hosp}]$), this implies that $E[U^{k(i)}_{ASC} - U^{k(i)}_{Hosp}] = \alpha \times E[B^i_{ASC} - B^i_{Hosp}]$.[6]

If α is equal to zero, such that the physician puts no weight on the patient's benefit, $E[U^{k(i)}_{ASC}] = E[U^{k(i)}_{Hosp}]$. This would imply that the physician should be indifferent in where they perform a medical procedure and thus, we should not see them respond to reference pricing by changing the location in which they perform medical procedures.

If $\alpha > 0$, then one would expect changes in patient utility to affect the location chosen by the physician. The patients' utility from the choice of either an ASC or a Hospital is itself a discrete choice and is discussed in Aouad et al. (2016). The patient's choice between an ASC

[5] If these results are to generalize to a randomly selected physician, it must also be assumed that 1) Patients do not pick a physician based on that physician's propensity to switch to a different location and that 2) Although physicians may differ in their practice settings, they do not differ in their underlying propensity to switch locations over where they perform a colonoscopy.

[6] It is assumed that $E[\epsilon^{k(i)}_{ASC}] = [\epsilon^{k(i)}_{Hosp}]$.

and a hospital is not directly observed by the researcher. Instead the joint decision between the physician and the patient is observed. Thus, physicians who switch practice locations after reference pricing implementation are assumed to do so out of consideration for their patients.

Motivation 2

An alternative explanation for physician switching is that the physicians only maximize profits and patient's utility does not directly enter the utility function of the physician. Instead, increased physician presence at ASCs is driven by the potential loss of profit from a physician not treating a CalPERS patient at an ASC. This could occur in a competitive market with increased CalPERS patient demand for ASCs and an availability of many, similar physicians who can provide colonoscopies at ASCs. Thus, the physician would profit only if they were willing to treat a CalPERS member at an ASC.

Taken together, this analysis will allow for the investigation of whether physicians respond to changes in the financial circumstance of patient and how this may be a mechanism by which reference price-related cost savings are achieved. This is key to understanding how physicians can contribute to reductions in medical spending, especially if they carry influence in the health care decision process. Further work is needed to distinguish between these two channels/motivations for physicians' responses and is an interesting area for future work.

3.4 Data

The data consists of Anthem PPO medical claims for CalPERs and control group members who have a colonoscopy between 2009 and 2013. From this, a short panel of physicians who are observed in 2011, 2012 and 2013, is formed.[7] Linked to the physician data are the characteristics of each patient treated as well as information on the location in which the colonoscopy is performed (i.e. ASC or hospital). Patient-linked data includes information on the patient's age (between 18 and 64 years), sex, an indicator for whether or not the patient has a medical intervention during the colonoscopy (e.g. a polyp removed) as well as the Charlson Comorbidity score, which is a proxy for the patient's health status Charlson et al. (1987). For example, a Charlson Comorbidity score of zero means that the patient has no other comorbid conditions/diseases.

Table 3.1 details the distribution of the share of physician time spent at an ASC. From 2009 to 2013, approximately half of physicians worked exclusively at an ASC or hospital. This implies that around half of observed physicians worked at both an ASC and at a hospital within year and highlights the potential flexibility in the location where colonoscopy procedures can be performed for this group of physicians.

[7]If a physician appears in 2011, 2012 and 2013, observations for that physician from 2009 and 2010 are also used, if they are available.

Physicians are classified into three groups based on the locations in which they perform colonoscopies: 1) "A-type" = ASC-only 2) "H-type" = Hospital-only and 3) "S-type" = Splitters, who work at both ASCs and hospitals.[8] The last term is borrowed from David and Neuman (2011) as are the definitions used to define A-type and S-type physicians. A-type physicians consist of those physicians who are observed working at ASCs more than 95% of the time while H-type physicians are classified as those physicians who work at an ASC fewer than 5% of the time, and thus are primarily observed working at hospitals. Splitters consist of all other physicians, namely those physicians who are observed working between 5% and 95% of the time at an ASC. Table 3.3 details the number of physicians falling into the three physician categories and is limited to those physicians who appear in at least all three years of 2011, 2012 and 2013. As is shown, physicians are distributed across the three groups, however, the H-type sample is the smallest physician group with most physicians belonging to the A-type group. Additionally, it is evident that physician classification is not stable from 2011 to 2013. The share of physicians who are classified as A-type increases between 2011 and 2013 with declines in the number belonging to H and S-types.

Table 3.4 provides summary statistics by physician type in the three years prior to reference pricing and two years post reference pricing. The statistics demonstrate that within physician type, the characteristics of the patients treated remain relatively steady over time. For example, the share of patients who are male is relatively steady around 47% while the average age of a treated patient is approximately 53 years across all physician types. Some exceptions to this are the rate of medical interventions being performed during colonscopies and the total cost for a colonoscopy. Both outcomes are on an upward trend for all physician-types over time, possibly reflecting time trends. For physicians classified as S-type in a given year, it also appears that the share of time spent at the ASC in a given year is declining over time. This result could be driven by movement of S-types into A-types (i.e. those who were close to the 95% boundary that separates these two groups, are now above the 95% threshold and reclassified), leaving those physicians who spend more time in the hospitals in the S-type group. Table 3.3 shows this increase in the number of A-types between 2012 and 2013 with a similar decrease in the number of S-types in this time period.

To evaluate the validity of the assumption of equal compensation across the ASC and hospital for physicians, the outcome $C\Delta$ is defined as: $\frac{1}{K}\sum_{k=1}^{K}(\bar{Y_k}^{ASC} - \bar{Y_k}^{Hospital})$, where Y is the physician's compensation for performing a procedure. $C\Delta$ is the mean compensation difference (at an ASC versus a hospital) for a given physician, averaged across all physicians. For S-type physicians, distributional statistics for $C\Delta$ are tabulated. Physician type is anchored to the physician's 2011 classification. Tabulations are presented in Tables C.1 and C.2, where Table C.2 limits the sample to those physicians who treat patients who have no medical intervention and have a Charlson Comorbidity Index equal to zero.[9] Looking at the mean of $C\Delta$ for S-type physicians, this number is small and close to zero. It ranges from

[8]The A-type physician groupings can also include an ASC medical practice group if no specific physician is mentioned.

[9]This is done in the event that physician's compensation differs depending on the complexity of the patient's case, such as whether or not a medical intervention is required or not.

a low of -\$11.82 to a high of \$1.27 between 2009 to 2013. The median is also quite small and varies between -\$2.63 and \$8.09 in this time period. Thus, it seems that physicians are compensated similarly for work performed at an ASC versus a hospital. The lower percentiles of the distribution of $C\Delta$ demonstrate that across the patients treated, there can be large variations in compensation received at the ASC versus the hospital for a physician. However, since it is not possible to observe the same patient being treated at both an ASC and at a hospital by the physician, differing physician compensations between ASCs and hospitals could be driven by variation in the characteristics of patients treated in these different settings. For example, the findings of David and Neuman (2011) indicate that more medically risky patients are more likely to be treated in hospital settings.

Figures 3.1 through 3.5 look at the share of patients visiting each physician-type over time. This is presented to see how much movement there is across physician type by patients. If there is significant movement to A-types, increased ASC use among CalPERS patients would be minimally driven by changes in physician behavior and instead would driven by the increased use of physicians who worked in ASCs. Figure 3.1 shows a relatively similar trend in the use of S-type physicians among Control and CalPERS patients. The share of people using these physicians declines as reference price implementation is approached. However, it increases slightly from this initial decline. Figure 3.3 shows a similar trend in the share of patients using H-types across CalPERS and control patients. However, the use of H-types is higher among CalPERS patients in the quarters leading up to the introduction of reference pricing and is much more similar in magnitude to that of the control group in the post-reference pricing periods. In Figure 3.5, the share using A-types is again similar for both groups over time. However, while both groups steadily increase their use of A-type physicians in the post-period, there is a larger increase in the share of CalPERS patients using an A-type in this period. Thus it appears from these raw estimates that there is movement among CalPERS patients toward A-type physicians and away from H-type and S-types. However, looking at Figures 3.2, 3.4, and 3.6, which control for patient covariates, it is evident that there is rather steady use of each physician-type across time between CalPERS and control group patients. Thus, changes in the use of ASC would be driven, in part, by changes to physicians' practice patterns.

3.5 Methodology & Empirics

To address the questions posed, a Difference-in-Difference (DiD) model is estimated. The use of this empirical strategy is driven by the fact that the financial consequences of using an ASC for CalPERS members have changed relative to that of the control group. Thus, if physicians respond to changes in patients' financial circumstance when choosing where to perform a medical procedure, one should observe an increase in the share of colonoscopies being performed at ASCs for CalPERS members relative to the control group for a given physician. The below equation presents the main empirical strategy:

$$\mathbb{1}(ASC_{nt}) = \gamma_0 + \gamma_1 \times Post_t + \gamma_2 \times Treat_i + \gamma_3 \times Post_t \times Treat_i + X_i'\gamma + \alpha_n + u_{int}$$

Here, ASC_{nt} is a binary variable that takes the value one if physician n is observed treating a patient at an ASC and is zero if the physician is observed at the hospital. $Post_t$ takes the value of one if an observation is from the post-reference pricing period and is zero if it is from the pre-period. $Treat_i$ is also binary and is equal to one if the patient being treated by the n^{th} physician belongs to CalPERS and is zero if they belong to the control group. X_i represent patient covariates that could affect the probability of observing a physician performing a colonoscopy at an ASC. This vector of patient covariates includes categorical variables representing a patient's age (i.e. 18-64 years), a binary variable indicating the sex of a patient, the Charlson Comorbidity Index of the patient, which can take on three values here: 0, 1, and 2. Additionally, a binary variable indicating whether or not a patient has a medical intervention (e.g. having a polyp removed) is included. To account for unobserved time-invariant heterogeneity across physicians, a physician fixed effect, α_n, is also included.

The main empirical strategy is estimated separately by physician type. Since the margin upon which each physician-type can respond to a request to switch to an ASC differs (due to differences in practice locations, which may reflect differences in hospital admitting privileges), it is best to consider these groups as distinct and analyze them separately. Physicians are classified into groups according to the group that physician belonged to in the year prior to reference price implementation (2011). This is done in the event that labor contracts/admitting privileges are negotiated with some frequency, thus one should want the most recent labor circumstance as reflected by the year closest to reference price implementation.

Parallel Trends

To test the parallel trends assumption necessary to identify γ_3, the unadjusted share of patients seen at an ASC (versus) a hospital are plotted by physician type. Plots that controls for patient characteristics are also estimated by an event study as presented below:

$$\mathbb{1}(ASC_{nt}) = \beta_0 + \sum_{r=-12, r\neq -1}^{7} \beta^r \mathbb{1}(S_t)_r + \sum_{r=-12}^{7} \gamma^r \mathbb{1}(S_t)_r \times \mathbb{1}(CalPERS_i) + X_i'\beta + \epsilon_{int}$$

$\mathbb{1}(S_t)_r$ takes the value one if the time period observed is r quarters away from when reference pricing was introduced and is zero otherwise. $\mathbb{1}(ASC_{nt})$ is equal to one if physician n in time period t is observed in an ASC and is zero if they are observed at the hospital. $\mathbb{1}(CalPERS_i)$ is equal to one if patient is part of CalPERS and is zero if they belong to the control group. Also included are patient demographic covariates, X_i, as discussed previously.

Limitations

There are a few limitations to this study. Firstly, given the dataset, it is not possible to perfectly identify if a physician works at an ASC (hospital) that does not appear in the data.

Thus there may be some physicians who are incorrectly categorized. Since the outcome of interest is if a physician does switch practice locations, and not their classification, this may be fine. However, if one believes that the propensity to switch varies by physician-type, it would be best to ensure the most accurate classification of a physician's type to estimate this correctly. Additionally, one may be worried that there is non-random selection out of the sample by CalPERS patients who strongly prefer to use hospitals.

3.6 Results

Parallel Trends

Figures 3.7, 3.8, and 3.9 plot the share of patients treated over time at ASCs by physicians' 2011 classification type. As is shown in Figure 3.7, the share of control group patients treated at ASCs is relatively steady in the pre-reference price period but is slightly increasing over time. In the period leading up to reference pricing, the share of CalPERS patients treated at ASCs by S-type physicians is not completely smooth in pattern but similar to the control group, the share using an ASC hovered around 70 percent. After the introduction of reference pricing, the share of CalPERS patients being treated at ASCs by S-type physicians increases and is generally above 80 percent for each quarter after reference pricing. Figure 3.8 shows a similar pattern. Prior to reference pricing, the share of CalPERS patients and control patients being treated at ASCs by H-type physicians trended similarly and was quite low. This is consistent with the definition of H-types as treating fewer than 5% of their patients at ASCs. After reference pricing is introduced, there is a much larger increase in the share of CalPERS patients being treated at ASCs than control group patients among H-types. Figure 3.9 shows the patient shares being treated at ASCs by A-types. The control and CalPERS groups are trending similarly over time and increase in their probability of being treated at an ASC, although there is some noise in the figure. There is no significant shift in the probability of being treated at an ASC after the introduction of reference pricing for CalPERS patients, which is consistent with the fact that these physicians were primarily already working at ASCs.

Figures 3.10 through 3.12 present the event study estimates. These display the added effect of CalPERS group membership, in each quarter, on ASC use conditional on the patient covariates discussed in the data section. Figure 3.10 indicates a similar story with the added effect of CalPERS membership on the probability of being treated at an ASC as positive and statistically different from zero among the S-type physicians after reference pricing is introduced. Figure 3.11 shows an increase in the treatment of CalPERS patients at ASCs among H-type physicians after the introduction of reference pricing. However, for each quarter-cell after reference pricing, the estimates are not statistically different from zero, which could be driven by the relatively small cell sizes. Figure 3.12 demonstrates the consistently similar treatment rate of CalPERS to control group patients at ASCs among A-type physicians. That is patients who visit A-type physicians are of a similar likelihood of being treated at ASCs over time, regardless of group membership. This is consistent with A-type physicians being primarily based in ASCs.

Main Results

The results from the main empirical strategy are presented in Tables 3.7 and in 3.8. Table 3.7 shows the results across all physician types, while Table 3.8 shows the results broken down by the three physician types. In Table 3.7, the results show that physicians are three percentage points more likely to be present in an ASC in the post-period than they were in the pre-reference pricing period. This indicates that there is an upward trend in physicians practicing at ASCs over time, for both CalPERS and control group patients. The coefficient on the $Post \times Treat$ interaction is the main estimate of interest (i.e. the γ_3 coefficient). This result gives the treatment effect of reference pricing on a physicians probability of treating a CalPERS patient at an ASC after the policy has been introduced. The coefficient estimate indicates that the probability of treating a CalPERS patient at an ASC, relative to a control group patient, increases by approximately 3.4 percentage points. This is a relatively sizeable gain when considering that in the pre-period, approximately 68% of patients were being treated at ASCs among physicians. This result is consistent with physicians responding to the shifts in ASC demand by CalPERS patients as induced by changes to patient cost-sharing. The results also indicate that the less healthy, as indexed by a Charlson Comorbidity score greater than zero, are less likely to be treated at an ASC than the more healthy patients.

To further analyze the effect of reference pricing on a physician's propensity to perform procedures at an ASC, the main empirical strategy is estimated separately for each physician-type. Results are presented in Table 3.8. Focusing on Column 2, where patient covariates are included, the results are similar to that presented in Table 3.7. The coefficient on $Post$ and $Post \times Treat$ are both statistically significant at the 1% significance level and are equal to 0.068 and 0.066, respectively. This implies that S-type physicians increase their probability of performing a procedure at an ASC by 6.6 percentage points across all patients in the post-period. For CalPERS patients, there is an additional increase in the probability of being seen by these physicians at an ASC equal to 6.8 percentage points. The pre-period share of CalPERS patients seen at ASCs among S-type physicians was approximately 73%.[10] Thus, there is an approximately 16.4% increase in the probability of treating CalPERS patients at ASCs by S-types between the pre and post periods. For H-type physicians, Column 4 shows that there is no increase in the probability of being observed at an ASC in the post-period. However, among the CalPERS patients treated by these physicians, we see that there is a 3.1 percentage point increase in the probability of being treated by an H-type physician at an ASC, relative to that of a control group patient. This is an interesting finding and reinforces the idea that physicians have changed their practice patterns as a result of reference

[10] This number is approximately 2% in the pre-period for H-types and 98% in the pre-period for A-types.

pricing.[11] For A-types, neither of the estimates on $Post$ or $Post \times Treat$ are statistically different from zero, as one would expect since these physicians already spend more than 95% of their time at ASCs. Coefficients on the Charlson Comorbidity Index variables are negative and statistically significant. This suggests that poorer health status of the patient reduces their probability of being treated at the ASC.[12]

Robustness Check

To understand if results are sensitive to the inclusion of those who work between greater than 0% but less than 5% among the H-types and those who work less than 100% but greater than 95% among the A-types, results are estimated for those who work at the hospital and ASC 100% of the time in 2011, respectively. Table 3.9 presents the results. The results do not appear to be sensitive to the inclusion of those who work between greater than 0% but less than 5% among the H-types and those who work less than 100% but greater than 95% among the A-types, as evidenced by the similar statistically significant estimates. Specifically, the probability of observing a physician who is observed 100% of the time at a hospital in 2011 treating a CalPERS patient at an ASC increases by 3.5 percentage points after reference pricing, relative to the control group. For physicians observed only working at ASCs in 2011, there is no change in their probability of treating a CalPERS patient at an ASC after reference pricing is introduced.

3.7 Conclusion

As agents in the health care system whose actions can greatly impact patients, it is important to understand how physicians respond to policies designed to reduce medical spending. Reference pricing is one such policy, whose straight-forward, binary choice design has been shown to incentivize patients to choose lower cost health care facilities through increased patient cost-sharing. Given the role of the physician within the health care system, this study analyzes how reference pricing changes where physicians perform medical procedures. Specifically, I analyze how the probability of performing a colonoscopy at an ASC changes for physicians who have different bandwidths for switching to ASCs, as indicated by the observed practice locations in the year prior to reference price implementation.

The results show that for physicians who are observed working at both ASCs and hospitals in the pre-reference pricing period (Splitters), they increase their treatment of CalPERS patients at ASCs by approximately seven percentage points, relative to an unaffected control group. Movement to ASCs is also found among physicians who were observed working almost exclusively at hospitals prior to the introduction of reference pricing. These physicians

[11]In 2012, there are 11 H-type physicians who treat CalPERS patients at ASCs. This number is 17 in 2013.

[12]This could perhaps be due to the fact that ASCs tend to have a smaller number of more specialized medical staff, which may be problematic in the event of an emergency.

were only more likely to be observed at ASCs in the post-period when treating CalPERS patients (by approximately three percentage points). No switching effects were found for those physicians who almost exclusively work at ASCs in the pre-period, which is consistent with ASCs being the primary location base for these physicians. Potential motivations for the observed movement to ASCs away from hospitals among physicians include the inclusion of the patient's utility in the physician's utility function or a strategy that is consistent with physician profit maximization in a competitive market. Although, a definitive explanation cannot be determined at this time, this is an interesting area for future work.

3.8 Data and Figures

Table 3.1: Share of Physicians' Time Spent at ASC

	2009	2010	2011	2012	2013
0%	184	197	199	188	190
(0%, 5%)	13	6	4	8	4
[5%, 10%)	6	9	8	3	11
[10%, 25%)	14	16	16	24	17
[25%, 50%)	34	24	45	40	27
[50%, 75%)	70	71	74	65	60
[75%, 95%)	134	129	140	135	132
[95%, 100%)	81	86	108	108	103
100%	143	176	160	183	210
N	679	714	754	754	754

1: Data is limited to those physicians observed in at least 2011, 2012 and 2013.

Table 3.2: Share of Physicians' Time Spent at ASC - by Number of Patients

	2009	2010	2011	2012	2013
0%	8,285	8,164	8,050	7,156	6,683
(0%, 5%)	870	662	211	1,713	245
[5%, 10%)	468	499	576	111	2,526
[10%, 25%)	701	547	991	1,445	946
[25%, 50%)	1,390	1,282	2,120	2,143	1,844
[50%, 75%)	5,875	5,420	4,425	4,422	3,834
[75%, 95%)	11,891	12,500	14,225	13,494	12,649
[95%, 100%)	14,667	13,568	15,835	19,020	18,279
100%	7,554	8,818	7,110	8,315	10,719
N	51,701	51,460	53,543	57,819	57,725

1: Data is limited to those physician-patient observations for physicians observed in at least 2011, 2012 and 2013.

Table 3.3: Classification of Physician Types by Year

Physician Type	2009	2010	2011	2012	2013
S-Type	258	249	283	267	247
H-Type	197	203	203	196	194
A-Type	224	262	268	291	313
Total Number of Physicians	679	714	754	754	754

1: Data is limited to those physicians observed in at least 2011, 2012 and 2013.

Table 3.4: Data Summary by Physician Type

S-Type	2009	2010	2011	2012	2013
Share Male	0.47	0.46	0.47	0.47	0.48
Mean Age	52.70	52.73	52.82	52.79	52.90
% w/Charlson Index = 0	0.93	0.93	0.93	0.93	0.93
Share w/intervention	0.53	0.56	0.58	0.59	0.62
Share Northern Cal	0.38	0.42	0.38	0.36	0.38
Share Southern Cal	0.55	0.50	0.53	0.55	0.52
Share Central Cal	0.07	0.08	0.09	0.09	0.10
% Time at ASC	0.74	0.74	0.73	0.71	0.66
Share CalPERS patients	0.12	0.13	0.13	0.12	0.11
Avg Total Cost	2085.79	2139.73	2292.04	2554.12	2858.26
Avg Prof fee	661.74	602.36	649.77	692.22	799.91
Avg Prof fee - ASC	661.03	588.64	643.89	696.66	809.58
Avg Prof fee - Hospital	663.73	641.17	665.35	681.12	781.57
N	20,325	20,248	22,337	21,615	21,799

H-Type	2009	2010	2011	2012	2013
Share Male	0.48	0.48	0.47	0.47	0.47
Mean Age	52.68	52.68	52.74	52.35	52.59
% w/Charlson Index = 0	0.92	0.92	0.92	0.92	0.91
Share w/intervention	0.51	0.55	0.56	0.58	0.61
Share Northern Cal	0.45	0.46	0.53	0.54	0.60
Share Southern Cal	0.45	0.45	0.42	0.41	0.36
Share Central Cal	0.09	0.10	0.05	0.05	0.04
% Time at ASC	0.00	0.00	0.00	0.00	0.00
Share CalPERS patients	0.16	0.16	0.18	0.14	0.13
Avg Total Cost	2646.06	2863.42	3072.36	3254.77	3349.95
Avg Prof fee	602.98	553.24	590.04	629.77	635.63
Avg Prof fee - ASC	556.26	382.32	453.11	731.04	1492.74
Avg Prof fee - Hospital	603.08	553.45	590.12	629.32	635.01
N	9,155	8,826	8,261	8,869	6,928

A-Type	2009	2010	2011	2012	2013
Share Male	0.45	0.45	0.46	0.46	0.45
Mean Age	52.77	52.87	52.95	53.12	53.33
% w/Charlson Index = 0	0.93	0.93	0.93	0.94	0.94
Share w/intervention	0.52	0.54	0.56	0.57	0.59
Share Northern Cal	0.39	0.35	0.38	0.36	0.34
Share Southern Cal	0.49	0.54	0.51	0.55	0.59
Share Central Cal	0.12	0.11	0.11	0.09	0.08
% Time at ASC	0.99	0.99	0.99	0.99	0.99
Share CalPERS patients	0.12	0.12	0.12	0.12	0.11
Avg Total Cost	1165.15	1333.08	1606.82	1631.40	1933.19
Avg Prof fee	541.04	454.65	451.83	463.63	465.32
Avg Prof fee - ASC	540.94	454.05	451.41	463.10	465.35
Avg Prof fee - Hospital	548.15	493.39	483.80	499.30	462.91
N	22,221	22,386	22,945	27,335	28,998

1: Data is limited to a patient observations for those who visit physicians observed in at least 2011, 2012 and 2013.

Table 3.5: Distribution of Mean Compensation Difference ($'s) at ASC versus Hospital (CΔ)

Distribution of CΔ	2009	2010	2011	2012	2013
min	-611.27	308.53	-1730.71	-1001.00	-803.16
mean	-10.09	-3.85	-11.82	1.27	-2.84
p25	-40.21	-32.86	-30.58	-25.37	-28.00
p50	-2.31	-1.96	-2.63	8.09	0.60
p75	26.36	21.36	28.59	37.01	27.85
p95	113.10	118.53	115.82	125.27	106.77
p99	308.53	350.33	414.21	238.02	354.34
max	485.66	503.00	487.50	535.71	486.76
N	258	249	283	267	247

1: Data represents the average over the physician-level mean physician compensation at ASC minus the mean physician compensation at the hospital in a given year.
2: Data is limited to S-Type physicians.

Table 3.6: Distribution of Mean Compensation Difference ($'s) at ASC versus Hospital (CΔ) – Alternative Case

Distribution of CΔ	2009	2010	2011	2012	2013
min	-421.51	-476.45	-1000.00	-808.33	-1553.14
mean	2.36	-2.84	-2.90	1.14	-7.89
p25	-18.79	-23.50	-19.69	-17.68	-23.73
p50	0.00	0.00	0.00	1.35	0.00
p75	16.91	17.13	19.27	28.01	20.35
p95	67.63	113.19	95.34	93.25	137.76
p99	354.55	366.67	350.00	243.80	436.97
max	1050.00	513.59	460.00	637.5	615.28
N	211	198	223	208	200

1: Data represents the average over the physician-level mean physician compensation at ASC minus the mean physician compensation at the hospital in a given year.
2: Data is limited to S-Type physicians who treat patients who have no medical intervention and have a Charlson Comorbidity Index equal to 0.

Table 3.7: OLS Regression Results where Outcome is $\mathbb{1}(ASC)$

All Physicians *Variable*	(1)	(2)
Post	0.030***	0.030***
	0.007	0.007
Treat	-0.001	0.000
	0.004	0.004
$Post \times Treat$	0.034***	0.034***
	0.012	0.012
$\mathbb{1}$(Charlson Index=1)		-0.029***
		0.004
$\mathbb{1}$(Charlson Index=2)		-0.035***
		0.005
$\mathbb{1}$(Age 30-39Yrs)		0.010
		0.006
$\mathbb{1}$(Age 40-49Yrs)		0.013*
		0.007
$\mathbb{1}$(Age 50-59Yrs)		0.012*
		0.007
$\mathbb{1}$(Age 60-64Yrs)		0.007
		0.006
$\mathbb{1}$(Male)		0.003
		0.002
$\mathbb{1}$(Intervention)		-0.001
		0.002
N	272,248	272,248

1: Data consists of physician panel data.
2: Patient covariates are included in the estimation: $\mathbb{1}$(Male),$\mathbb{1}$(Age Category), Comorbidity Index, Patient Health Care Market Dummy, $\mathbb{1}$(Intervention).
3: $***p \leq 0.01$, $**p \leq 0.05$, $*p \leq 0.10$
4: Standards errors are clustered at the physician-level; 754 clusters.

Table 3.8: OLS Regression Results by Physician Type where Outcome is $\mathbb{1}(ASC)$

Variable	***S-Type*** (1)	(2)	***H-Type*** (3)	(4)	***A-Type*** (5)	(6)
$Post$	0.068***	0.068***	0.009	0.009	0.000	0.000
	0.015	0.015	0.014	0.014	0.004	0.004
$Treat$	-0.002	-0.001	-0.001	-0.001	0.000	0.000
	0.011	0.011	0.002	0.002	0.002	0.002
$Post \times Treat$	0.066***	0.066***	0.031*	0.031*	0.005	0.005
	0.022	0.022	0.018	0.018	0.004	0.004
$\mathbb{1}$(Charlson Index=1)		-0.062***		0.001		-0.011**
		0.007		0.003		0.005
$\mathbb{1}$(Charlson Index=2)		-0.063***		-0.001		-0.023***
		0.009		0.004		0.005
$\mathbb{1}$(Age 30-39Yrs)		0.021		0.003		0.000
		0.014		0.003		0.003
$\mathbb{1}$(Age 40-49Yrs)		0.029*		0.003		0.001
		0.015		0.004		0.003
$\mathbb{1}$(50-59Yrs)		0.026*		0.002		0.002
		0.015		0.004		0.003
$\mathbb{1}$(60-64Yrs)		0.015		0.001		0.000
		0.014		0.004		0.004
$\mathbb{1}$(Male)		0.008**		-0.001		-0.001
		0.004		0.001		0.001
$\mathbb{1}$(Intervention)		-0.003		0.002		-0.002
		0.005		0.004		0.001
N	113,106	113,106	43,256	43,256	115,616	115,616

1: Data consists of physician panel data.
2: Patient covariates are included in the estimation: $\mathbb{1}$(Male),$\mathbb{1}$(Age Category), Comorbidity Index, Patient Health Care Market Dummy, $\mathbb{1}$(Intervention).
3: ***$p \leq 0.01$, **$p \leq 0.05$, *$p \leq 0.10$
4: Standards errors are clustered at the physician-level; 283 clusters for S-type, 203 clusters for H-type and 268 clusters for A-type.

Table 3.9: OLS Regression Results where Outcome is $\mathbb{1}(ASC)$ – Robustness Check

Variable	100% Hospital in 2011-Type		100% ASC in 2011-Type	
	(1)	(2)	(3)	(4)
Post	-0.001	-0.001	-0.005	-0.005
	0.012	0.012	0.006	0.006
Treat	-0.002	-0.002	0.001	0.001
	0.002	0.002	0.003	0.004
$Post \times Treat$	0.035*	0.035*	0.007	0.007
	0.018	0.018	0.005	0.005
$\mathbb{1}$(Charlson Index=1)		0.001		0.000
		0.003		0.004
$\mathbb{1}$(Charlson Index=2)		-0.001		-0.016*
		0.003		0.008
$\mathbb{1}$(Age 30-39Yrs)		0.001		0.003
		0.003		0.005
$\mathbb{1}$(Age 40-49Yrs)		0.000		0.002
		0.003		0.004
$\mathbb{1}$(Age 50-59Yrs)		-0.001		0.003
		0.003		0.004
$\mathbb{1}$(Age 60-64Yrs)		0.000		0.001
		0.004		0.004
$\mathbb{1}$(Male)		-0.001		0.001
		0.001		0.001
$\mathbb{1}$(Intervention)		0.002		0.001
		0.004		0.002
N	42,375	42,375	36,082	36,082

1: Data consists of physician panel data.
2: Patient covariates are included in the estimation: $\mathbb{1}$(Male),$\mathbb{1}$(Age Category), Comorbidity Index, Patient Health Care Market Dummy, $\mathbb{1}$(Intervention).
3: ***$p \leq 0.01$, **$p \leq 0.05$, *$p \leq 0.10$
4: Standards errors are clustered at the physician-level; 199 clusters for 100% Hospital in 2011-type and 160 clusters for 100% ASC in 2011-type.

Figure 3.1: Share Using S-Type Physicians

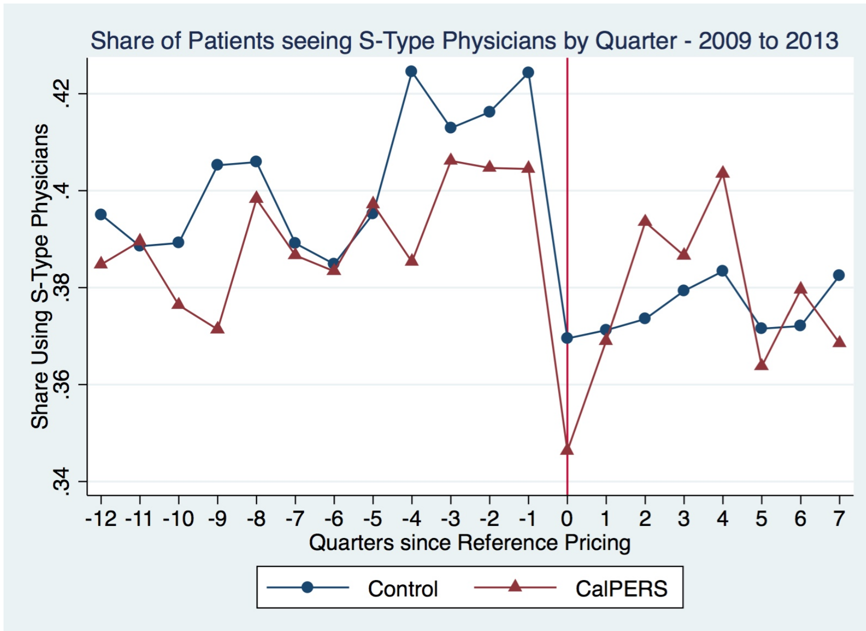


Figure 3.2: Added Probability of using an S-Type Physicians if CalPERS Patient; Adjusted for Patient Covariates

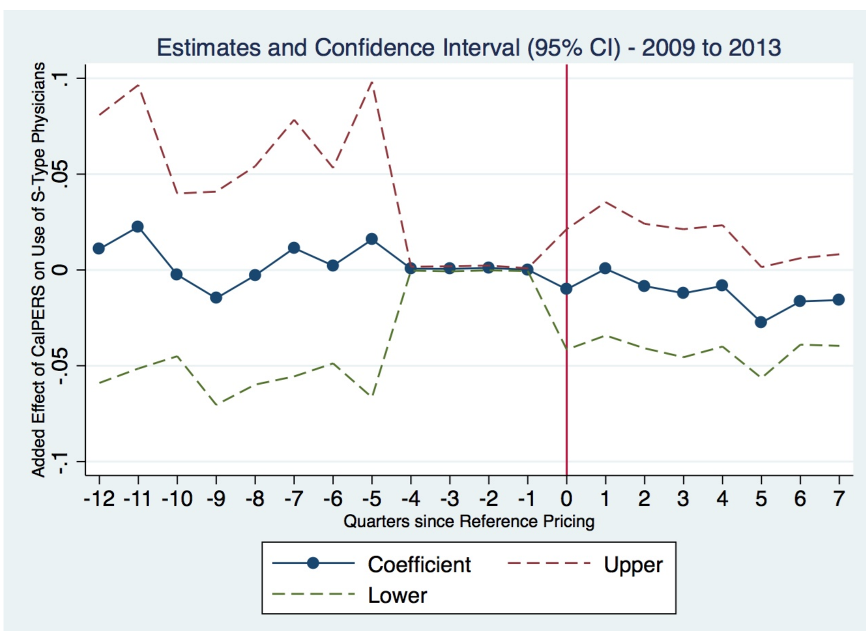


Figure 3.3: Share Using H-Type Physicians

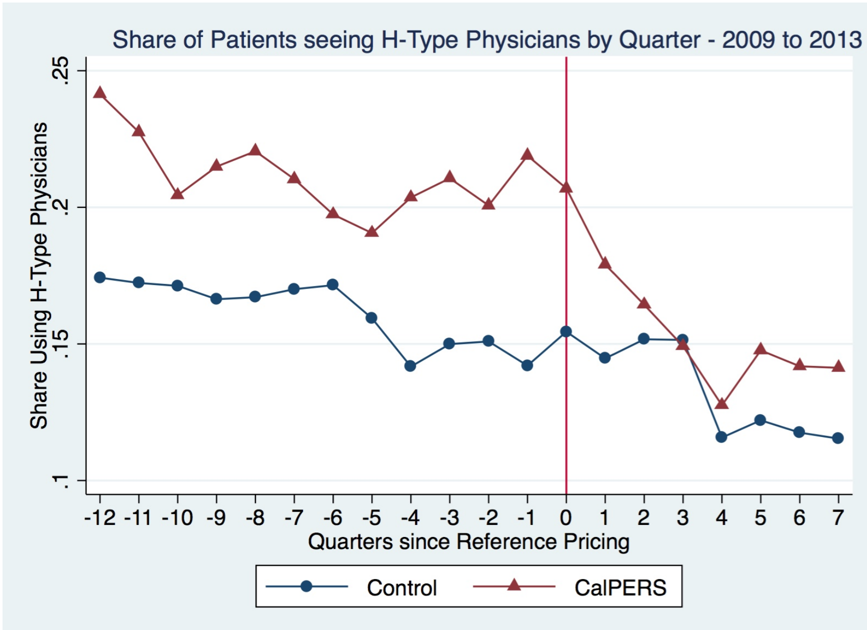


Figure 3.4: Added Probability of using an H-Type Physicians if CalPERS Patient; Adjusted for Patient Covariates

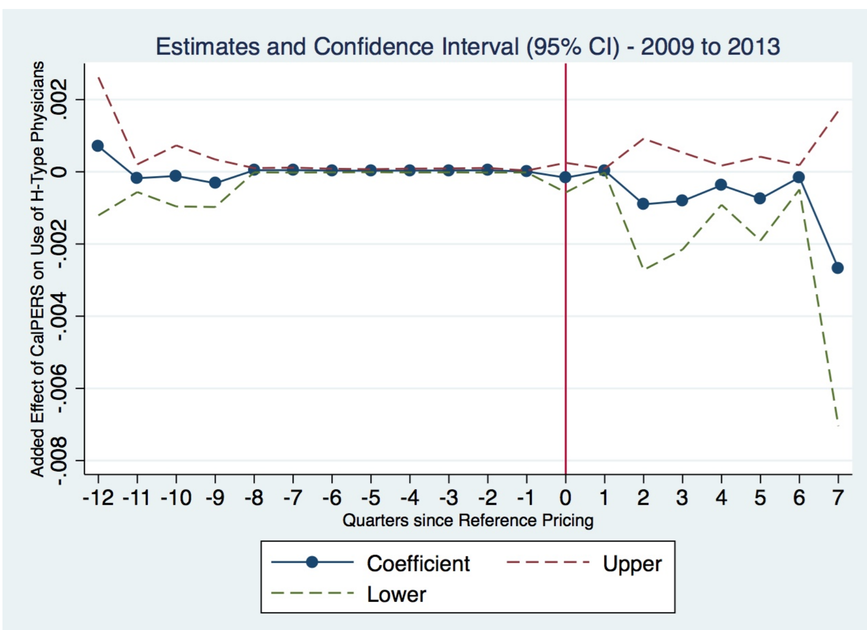


Figure 3.5: Share Using A-Type Physicians

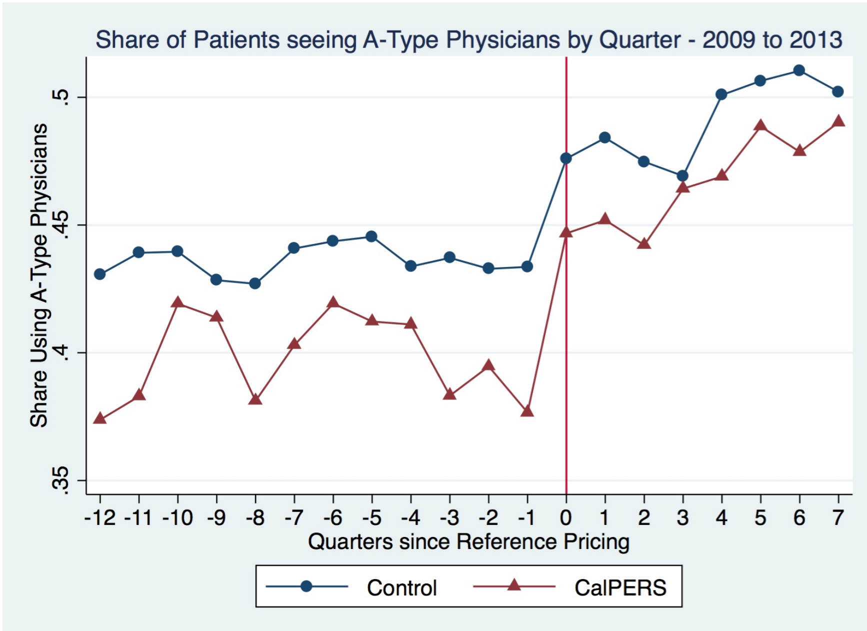


Figure 3.6: Added Probability of using an A-Type Physicians if CalPERS Patient; Adjusted for Patient Covariates

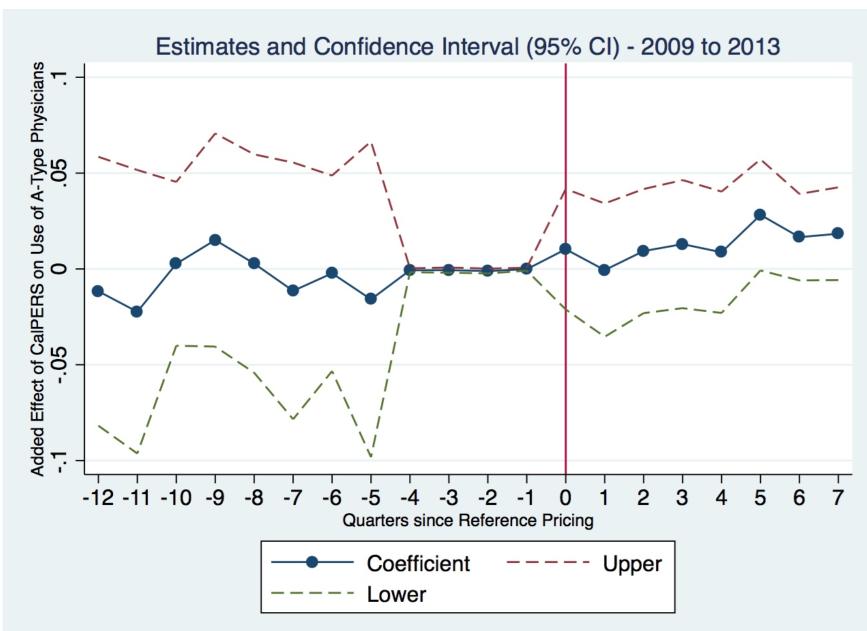


Figure 3.7: Splitter-Type; Share Observed at ASC

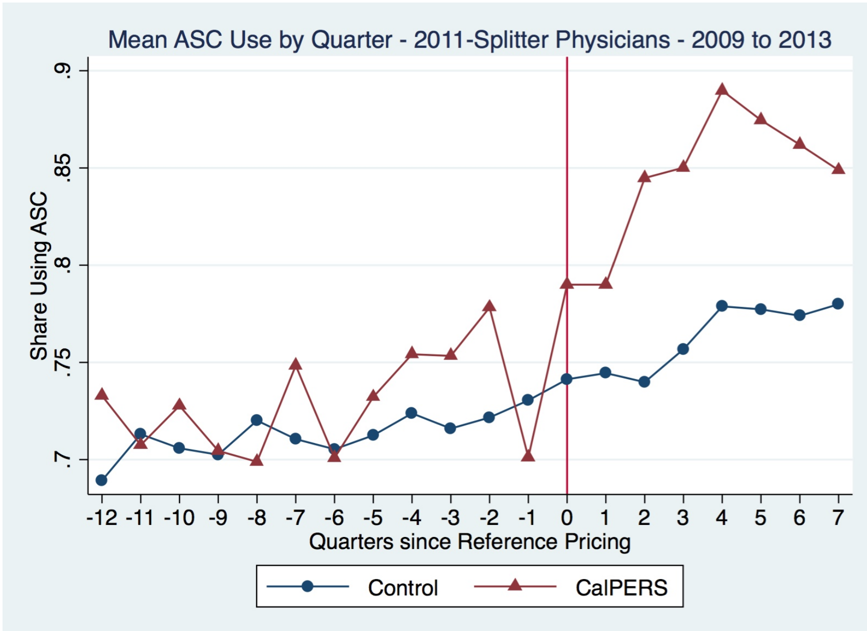


Figure 3.8: Hospital-Type; Share Observed at ASC

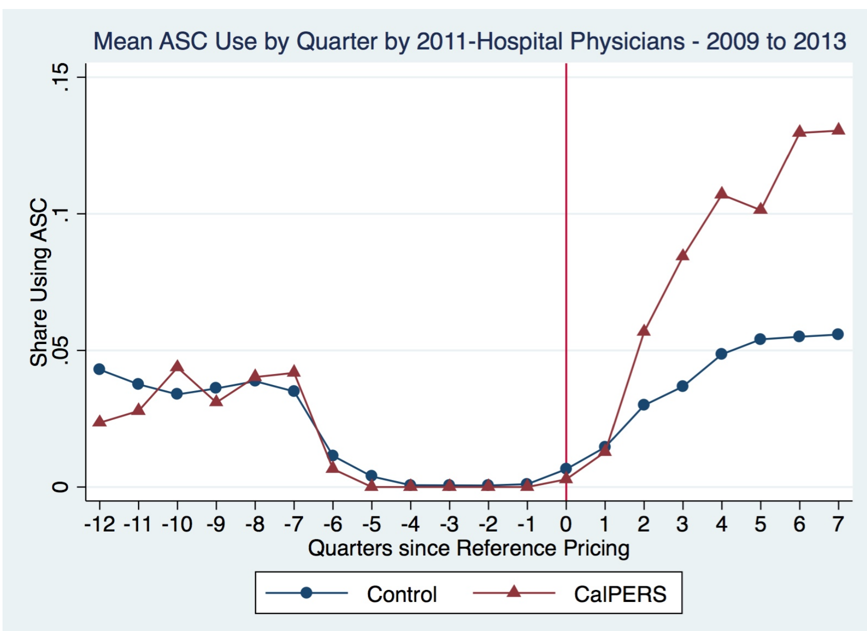


Figure 3.9: ASC-Type; Share Observed at ASC

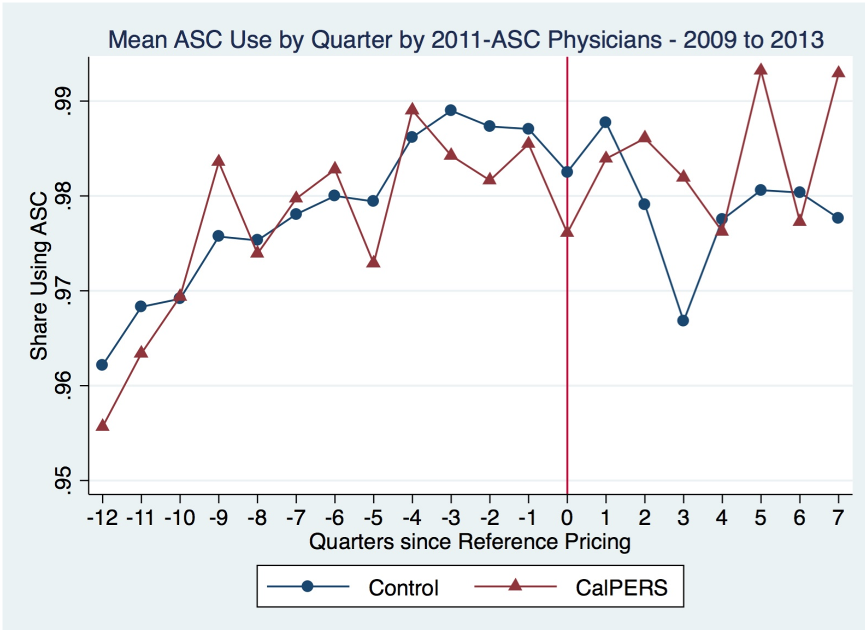
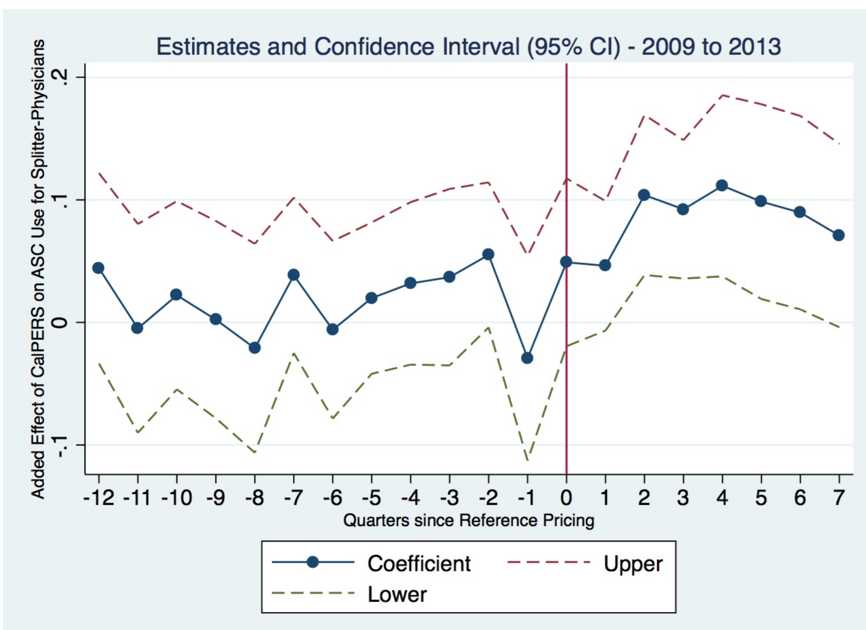
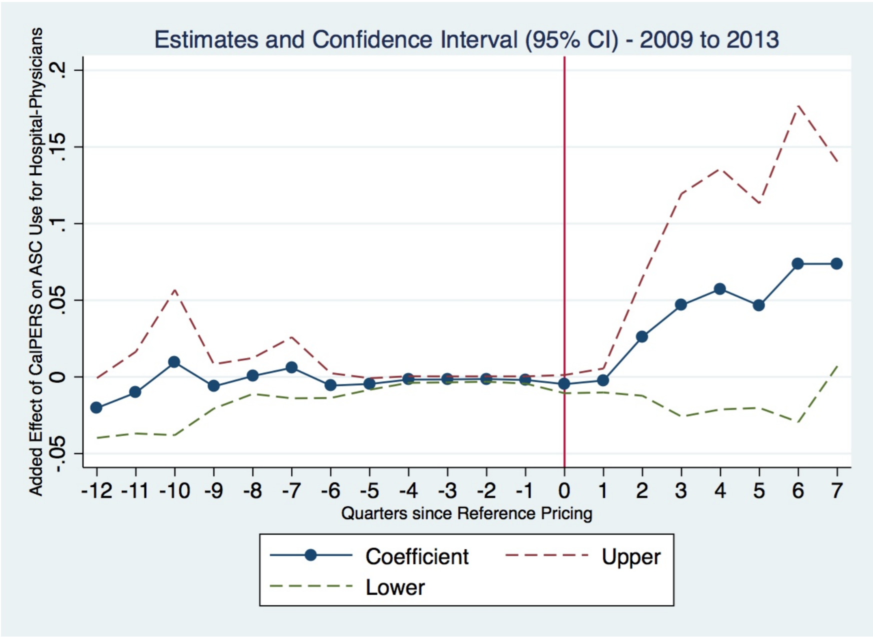


Figure 3.10: Splitter-Type; Share Observed at ASC - Adjusted for Patient Characteristics



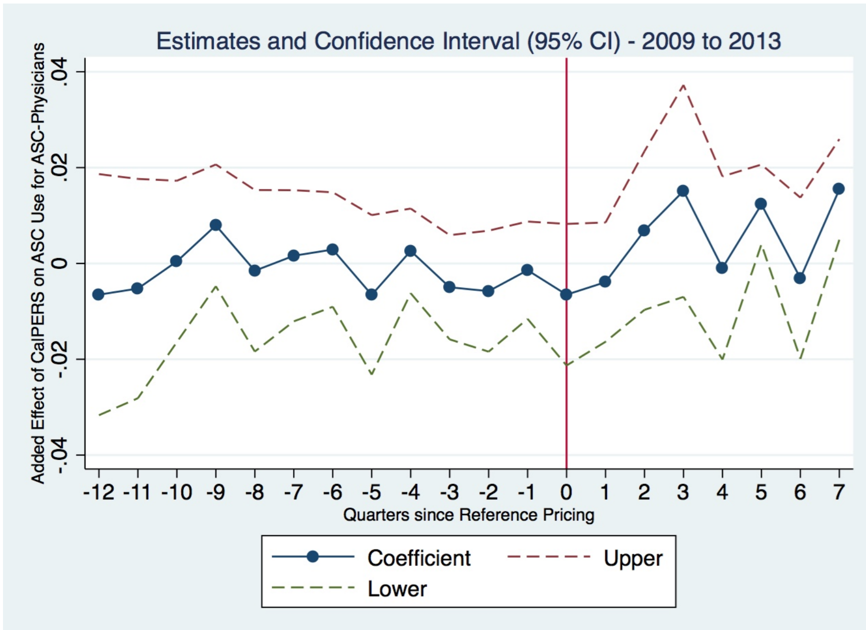
Note: Added effect of being from CalPERS on increased probability of using an ASC when seeing a Splitter-Type physician.

Figure 3.11: Hospital-Type; Share Observed at ASC - Adjusted for Patient Characteristics



Note: Added effect of being from CalPERS on increased probability of using an ASC when seeing a Hospital-Type physician.

Figure 3.12: ASC-Type; Share Observed at ASC - Adjusted for Patient Characteristics



Note: Added effect of being from CalPERS on increased probability of using an ASC when seeing an ASC-Type physician.

Bibliography

Abadie, A. (2002). Bootstrap Tests for Distributional Treatment Effects in Instrumental Variable Models. *Journal of the American Statistical Association 97*(457), 284–292.

American Cancer Society (2016). www.cancer.org [Accessed: September 2016].

Aouad, M., T. Brown, and C. Whaley (2016). Reference Pricing: The Case of Screening Colonoscopies. *UC Berkeley Working Paper*.

Aron-Dine, A., L. Einav, and A. Finkelstein (2013). The RAND Health Insurance Experiment, Three Decades Later. *The Journal of Economic Perspectives 27*(1), 197–222.

Baker, L. C., M. K. Bundorf, and D. P. Kessler (2016). The Effect of Hospital/Physician Integration on Hospital Choice. *Journal of Health Economics 50*, 1–8.

Baye, M. R., J. Morgan, and P. Scholten (2004, December). Price Dispersion in the Small and in the Large: Evidence from an Internet Price Comparison Site. *The Journal of Industrial Economics 52*(4), 463–496.

Berwick, D. M. and A. D. Hackbarth (2012, April). Eliminating Waste in US Health Care. *JAMA 307*.

Blumenthal, D., K. Stremikis, and D. Cutler (2013). Health Care Spendinga Giant Slain or Sleeping? *New England Journal of Medicine 369*(26), 2551–2557.

Brot-Goldberg, Z. C., A. Chandra, B. R. Handel, and J. T. Kolstad (2015). What Does a Deductible Do? The Impact of Cost-Sharing on Health Care Prices, Quantities, and Spending Dynamics. *National Bureau of Economic Research*.

CalPERS (2016). CalPERS Annual Financial Report; 2015-2016. https://www.calpers.ca.gov/docs/forms-publications/cafr-2016.pdf [Accessed: April 2017].

CalPERS Medicare Enrollment Guide (2016). www.calpers.ca.gov/docs/forms-publications/medicare-enrollment-guide.pdf [Accessed: October 2016].

CalPERS Plan Booklet (2012). https://www11.anthem.com/ca/national/f0/s0/t0/pw_e175308.pdf?refer=popcontent [Accessed: October 2016].

Catlin, Aaron C. and Cowan, Cathy A. (2016). History of Health Spending in the United States, 1960-2013. www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/Downloads/HistoricalNHEPaper.pdf [Accessed: September 2016].

Charlson, M. E., P. Pompei, K. L. Ales, and C. R. MacKenzie (1987). A New Method of Classifying Prognostic Comorbidity in Longitudinal Studies: Development and Validation. *Journal of Chronic Diseases 40*(5), 373–383.

Clemens, J. and J. D. Gottlieb (2013). In the Shadow of a Giant: Medicare's Influence on Private Physician Payments. *National Bureau of Economic Research*.

CMS (2014). National Health Expenditures 2014 Highlights. `www.cms.gov/research-statistics-data-and-systems/statistics-trends-and-reports/nationalhealthexpenddata/downloads/highlights.pdf` [Accessed: September 2016].

CMS (2016). National Health Expenditures Fact Sheet. Technical report, Centers for Medicare & Medicaid Services.

Cooper, Z., S. V. Craig, M. Gaynor, and J. Van Reenen (2015). The Price aint Right? Hospital Prices and Health Spending on the Privately Insured. *National Bureau of Economic Research*.

David, G. and M. D. Neuman (2011). Physician Division of Labor and Patient Selection for Outpatient Procedures. *Journal of Health Economics 30*(2), 381–391.

de Chaisemartin, C. and D'Haultfoeuille, X. (2015). Fuzzy Differences-in-Differences. *arXiv preprint arXiv:1510.01757*.

Firpo, S. (2007). Efficient Semiparametric Estimation of Quantile Treatment Effects. *Econometrica 75*(1), 259–276.

Frölich, M. and B. Melly (2010). Estimation of Quantile Treatment Effects with STATA. *The STATA Journal 10*(3), 423–457.

Gaynor, M. and R. J. Town (2011). Competition in health care markets. *National Bureau of Economic Research*.

Gruber, J. and R. McKnight (2016). Controlling Health Care Costs through Limited Network Insurance Plans: Evidence from Massachusetts State Employees. *American Economic Journal: Economic Policy 8*(2), 219–50.

Healthcare Cost and Utilization Project (2016). Most Frequent Procedures Performed in U.S. Hospitals, 2011. `https://www.hcup-us.ahrq.gov/reports/statbriefs/sb165.jsp` [Accessed: April 2017].

Hicks, J. R. (1939). The foundations of welfare economics. *The Economic Journal 49*(196), 696–712.

Ho, K. and R. S. Lee (2013). Insurer Competition in Health Care Markets. *National Bureau for Economic Research*.

Hussey, P. S., S. Wertheimer, and A. Mehrotra (2013). The Association between Health Care Quality and Cost: A Systematic Review. *Annals of Internal Medicine 158*(1), 27–34.

Imbens, G. W. and J. D. Angrist (1994). Identification and estimation of local average treatment effects. *Econometrica 62*(2), 467–475.

Joseph P. Newhouse and Rand Corporation (1993). *Free for All?: Lessons from the RAND Health Insurance Experiment*. Harvard University Press.

Kaiser, U., S. J. Mendez, T. Rønde, and H. Ullrich (2014). Regulation of Pharmaceutical Prices: Evidence from a Reference Price Reform in Denmark. *Journal of Health Economics 36*, 174–187.

Kaldor, N. (1939). Welfare propositions of economics and interpersonal comparisons of utility. *The Economic Journal*, 549–552.

Koenker, R. and G. Bassett Jr (1978). Regression Quantiles. *Econometrica: Journal of the*

Econometric Society, 33–50.

Manning, W. G., J. P. Newhouse, N. Duan, E. B. Keeler, and A. Leibowitz (1987, June). Health Insurance and the Demand for Medical Care: Evidence from a Randomized Experiment. *The American Economic Review 77*(3), 251–277.

McGuire, T. G. (2000). Physician agency. *Handbook of Health Economics 1*, 461–536.

Munnich, E. L. and S. T. Parente (2014). Procedures Take Less Time at Ambulatory Surgery Centers, Keeping Costs Down and Ability to Meet Demand Up. *Health Affairs 33*(5), 764–769.

Rex, D. K., P. S. Schoenfeld, J. Cohen, I. M. Pike, D. G. Adler, M. B. Fennerty, J. G. Lieb, W. G. Park, M. K. Rizk, M. S. Sawhney, et al. (2015). Quality Indicators for Colonoscopy. *The American Journal of Gastroenterology 110*(1), 72.

Rizzo, J. A. and J. H. Goddeeris (1998). The Economic Returns to Hospital Admitting Privileges. *Journal of Health Politics, Policy and "Law 23*(3), 483–515.

Robinson, J. C., T. Brown, and C. Whaley (2015). Reference-Based Benefit Design Changes Consumers Choices and Employers Payments for Ambulatory Surgery. *Health Affairs 34*(3), 415–422.

Robinson, J. C., T. T. Brown, C. Whaley, and K. J. Bozic (2015). Consumer Choice Between Hospital-Based and Freestanding Facilities for Arthroscopy. *J Bone Joint Surg Am 97*(18), 1473–1481.

Robinson, J. C., T. T. Brown, C. Whaley, and E. Finlayson (2015). Association of Reference Payment for Colonoscopy with Consumer Choices, Insurer Spending, and Procedural Complications. *JAMA Internal Medicine 175*(11), 1783–1789.

Robinson, J. C., C. Whaley, and T. T. Brown (2016). Association of Reference Pricing for Diagnostic Laboratory Testing with Changes in Patient Choices, Prices, and Total Spending for Diagnostic Tests. *JAMA Internal Medicine 176*(9), 1353–1359.

StataCorp (2015). *Stata Statistical Software: Release 14. College Station, TX: StataCorp LP*.

The Dartmouth Atlas of Health Care (2016). `http://www.dartmouthatlas.org/` [Accessed: September 2016].

The Henry J. Kaiser Family Foundation (2015). Preventative Services Covered by Private Health Plans Under the Affordable Care Act. `http://kff.org/health-reform/fact-sheet/preventive-services-covered-by-private-health-plans/` [Accessed: September 2016].

US Preventative Task Force (2016). `www.uspreventiveservicestaskforce.org/Page/Document/UpdateSummaryFinal/colorectal-cancer-screening` [Accessed: September 2016].

Whaley, C. and T. Brown (2017). Firm Responses to Targeted Consumer Incentives: Evidence from Reference Pricing. Technical report, University of California, Berkeley.

Whaley, C., C. Guo, and T. T. Brown (2016). The Moral Hazard Effects of Consumer Responses to Targeted Cost-Sharing. *UC Berkeley Working Paper.*

Yee, C. A. (2011). Physicians on Board: An Examination of Physician Financial Interests in ASCs Using Longitudinal Data. *Journal of Health Economics 30*(5), 904–918.

Appendix A

Analyzing the Local Average Treatment Effects of Reference Pricing

Table A.1: Data Description - ASC

Outcome Variable	ASC-Pre Control	ASC-Pre CalPERS	ASC-Post Control	ASC-Post CalPERS
Share Male	0.51	0.47	0.50	0.45
Share Charlson Index=0	0.96	0.95	0.96	0.95
Avg. Age	55.08	56.24	55.25	56.31
Share 40-49 Yrs	0.06	0.04	0.05	0.04
Share 50-59 Yrs	0.68	0.62	0.68	0.61
Share 60-64 Yrs	0.25	0.33	0.26	0.35
Share w/Intervention	0.49	0.47	0.53	0.52
Share Northern Cal	0.40	0.54	0.36	0.53
Share Southern Cal	0.52	0.41	0.56	0.41
Share Central Cal	0.09	0.05	0.08	0.06
Mean Total Cost ($)	1479.91	1335.68	1811.39	1515.24
Mean Patient Cost ($)	721.82	412.28	897.25	472.46
Median Total Cost ($)	735.00	730.00	783.00	783.00
Median Patient Cost ($)	0.00	0.00	0.00	0.00
N	15,854	2,461	38,704	5,685

Note: Data consists of screening colonoscopy claims data from members of CalPERS and the control group who use ASCs. Means and standard deviations, in parentheses, are presented. Note: Northern Cal = HRRs in Alameda, Chico, Contra Costa, Modesto, Napa, Redding, Sacramento, Salinas, San Francisco, San Jose, San Mateo, Santa Rosa, Santa Cruz, and Stockton. Southern Cal = HRRs in Los Angeles, Orange County, Palm Springs, San Bernardino, San Diego, San Luis Obispo, Santa Barbara, and Ventura. Central Cal = HRRs in Bakersfield and Fresno.

Table A.2: Data Description - Hospitals

	Hospital-Pre		Hospital-Post	
Outcome Variable	Control	CalPERS	Control	CalPERS
Share Male	0.52	0.46	0.51	0.49
Share Charlson Index=0	.0.94	0.95	0.95	0.92
Avg. Age	55.20	56.36	55.08	56.66
Share 40-49 Yrs	0.06	0.04	0.06	0.04
Share 50-59 Yrs	0.66	0.64	0.66	0.58
Share 60-64 Yrs	0.27	0.32	0.26	0.37
Share w/Intervention	0.48	0.49	0.51	0.48
Share Northern Cal	0.43	0.60	0.39	0.61
Share Southern Cal	0.46	0.36	0.51	0.35
Share Central Cal	0.11	0.05	0.09	0.04
Mean Total Cost ($)	2603.14	2803.03	2714.66	2934.07
Mean Patient Cost ($)	443.14	121.25	310.00	676.50
Median Total Cost ($)	2199.00	2225.00	2344.00	2442.23
Median Patient Cost ($)	0.00	0.00	0.00	363.13
N	6,166	1,190	14,788	1,558

Note: Data consists of screening colonoscopy claims data from members of CalPERS and the control group who use hospitals. Means and standard deviations, in parentheses, are presented. Note: Northern Cal = HRRs in Alameda, Chico, Contra Costa, Modesto, Napa, Redding, Sacramento, Salinas, San Francisco, San Jose, San Mateo, Santa Rosa, Santa Cruz, and Stockton. Southern Cal = HRRs in Los Angeles, Orange County, Palm Springs, San Bernardino, San Diego, San Luis Obispo, Santa Barbara, and Ventura. Central Cal = HRRs in Bakersfield and Fresno.

Appendix B

Quantile Treatment Effects of Reference Pricing

Table B.1: Descriptive Statistics - Arthroscopy Knee

	Pre-Period (2009-2011)		Post-Period (2012-2013)	
	Control	CalPERS	Control	CalPERS
Share Male	0.574	0.479	0.566	0.485
Mean Age	46.138	50.36	46.216	50.426
Share 18-29 Yrs	0.149	0.092	0.156	0.1
Share 30-39 Yrs	0.129	0.069	0.116	0.067
Share 40-49 Yrs	0.235	0.188	0.229	0.182
Share 50-59 Yrs	0.341	0.404	0.35	0.39
Share 60-64 Yrs	0.145	0.247	0.149	0.261
Share w/Comorbidity Index	0.958	0.942	0.958	0.942
Share using ASC	0.679 0.625	0.672	0.705	
Mean Total Cost ($)	6615.862	6662.294	8037.621	7323.758
Mean Total Cost ($) - ASC	6343.17	6026.286	8090.09	6830.512
Mean Total Cost ($) - Hospital	7193.923	7723.076	7930.158	8503.139
Mean Patient Cost ($)	2725.237	2657.51	3783.383	3257.569
Mean Patient Cost ($) - ASC	3497.21	3497.27	5038.238	3910.945
Mean Patient Cost ($) - Hospital	1088.785	1256.897	1213.292	1695.308
N	24,291	2,948	16,914	1,821

Note: Data consists of screening colonoscopy claims data for CalPERS and the control group, pooled from 2009-2013. Means are presented.

Table B.2: Descriptive Statistics - Arthroscopy Shoulder

	Pre-Period (2009-2011)		Post-Period (2012-2013)	
	Control	CalPERS	Control	CalPERS
Share Male	0.614	0.572	0.61	0.542
Mean Age	49.111	52.478	49.797	52.912
Share 18-29 Yrs	0.084	0.042	0.079	0.056
Share 30-39 Yrs	0.091	0.047	0.082	0.034
Share 40-49 Yrs	0.249	0.207	0.232	0.186
Share 50-59 Yrs	0.396	0.431	0.41	0.424
Share 60-64 Yrs	0.179	0.272	0.196	0.3
Share w/Comorbidity Index	0.946	0.941	0.945	0.952
Share using ASC	0.659	0.606	0.67	0.667
Mean Total Cost ($)	8323.839	9807.960	10717.435	10510.495
Mean Total Cost ($) - ASC	7824.860	8334.887	10843.486	9488.77
Mean Total Cost ($) - Hospital	9286.938	12069.4	10461.557	12553.946
Mean Patient Cost ($)	2847.597	3313.764	4500.386	4270.896
Mean Patient Cost ($) - ASC	3771.662	4428.994	6185.312	5255.602
Mean Patient Cost ($) - Hospital	1064.021	1601.68	1080.068	2301.484
N	10,947	1,369	7,587	930

Note: Data consists of screening colonoscopy claims data for CalPERS and the control group, pooled from 2009-2013. Means are presented.

Table B.3: Descriptive Statistics - Diagnostic Colonoscopy

	Pre-Period (2009-2011)		Post-Period (2012-2013)	
	Control	CalPERS	Control	CalPERS
Share Male	0.439	0.425	0.437	0.406
Mean Age	51.034	53.541	50.81	53.309
Share 18-29 Yrs	0.051	0.028	0.059	0.036
Share 30-39 Yrs	0.074	0.045	0.078	0.048
Share 40-49 Yrs	0.196	0.141	0.19	0.143
Share 50-59 Yrs	0.482	0.512	0.468	0.478
Share 60-64 Yrs	0.197	0.274	0.206	0.295
Share w/Comorbidity Index=0	0.912	0.906	0.917	0.913
Share w/Intervention	0.589	0.582	0.617	0.613
Share using ASC	0.725	0.653	0.724	0.718
Mean Total Cost ($)	2089.313	2034.653	2740.642	2371.043
Mean Total Cost ($) - ASC	1821.468	1522.094	2582.118	1952.206
Mean Total Cost ($) - Hospital	2793.858	2999.798	3157.449	3439.846
Mean Patient Cost ($)	1028.848	638.932	1431.118	965.024
Mean Patient Cost ($) - ASC	1193.122	789.376	1754.524	999.823
Mean Patient Cost ($) - Hospital	596.738	355.647	580.784	876.221
N	89,784	12,936	64,090	7,949

Note: Data consists of screening colonoscopy claims data for CalPERS and the control group, pooled from 2009-2013. Means are presented.

Table B.4: Descriptive Statistics - Screening Colonoscopy

	Pre-Period (2009-2011)		Post-Period (2012-2013)	
	Control	CalPERS	Control	CalPERS
Share Male	0.499	0.468	0.505	0.460
Mean Age	54.526	55.894	55.20	56.386
Share 18-29 Yrs	0.009	0.004	0.003	0.002
Share 30-39 Yrs	0.019	0.01	0.01	0.005
Share 40-49 Yrs	0.086	0.054	0.054	0.038
Share 50-59 Yrs	0.638	0.612	0.671	0.601
Share 60-64 Yrs	0.249	0.32	0.261	0.354
Share w/Comorbidity Index=0	0.950	0.946	0.955	0.944
Share w/Intervention	0.47	0.451	0.522	0.513
Share using ASC	0.712	0.681	0.724	0.785
Mean Total Cost ($)	1671.629	1673.068	2061.099	1820.44
Mean Total Cost ($) - ASC	1344.243	1236.446	1811.386	1515.244
Mean Total Cost ($) - Hospital	2479.601	2605.195	2714.663	2934.071
Mean Patient Cost ($)	685.973	354.752	734.905	516.349
Mean Patient Cost ($) - ASC	728.742	429.924	897.255	472.459
Mean Patient Cost ($) - Hospital	580.423	194.271	309.995	676.502
N	73,212	11,762	53,492	7,243

Note: Data consists of screening colonoscopy claims data for CalPERS and the control group, pooled from 2009-2013. Means are presented.

Reduced Form Results

Table B.5: Difference in Difference Estimates - Estimate of β_3 coefficient

	Arthroscopy		Colonoscopy	
Outcome	*Knee*	*Shoulder*	*Diagnostic*	*Screening*
Total Cost ($)	-790.425**	-1378.071**	-282.754**	-239.869***
	(319.867)	(697.206)	(138.848)	(93.368)
N	45,974	20,833	174,759	145,881

1: Data consists of medical procedure claims data pooled from 2009-2013, except for screening colonoscopies which are pooled from 2011-2013.
2: Covariates are included in the estimation: $\mathbb{1}$(Male),$\mathbb{1}$(Age Category), Comorbidity Index, Patient Health Care Market Dummy, and $\mathbb{1}$(Intervention) for colonoscopy procedures.
3: $***p \leq 0.01$, $**p \leq 0.05$, $*p \leq 0.10$
4: Standard errors are clustered at the provider level; 570 for Arthroscopy Knee, 492 for Arthroscopy Shoulder, 688 for Colonoscopy Diagnostic, and 621 for Colonscopy Screening.

Table B.6: Quantiles: CalPERS pre-period

	Arthroscopy		Colonoscopy	
Quantile	*Knee*	*Shoulder*	*Diagnostic*	*Screening*
0.01	1115.00	1329.00	482.00	482.00
0.05	1389.00	2013.00	526.00	531.00
0.10	1721.00	2599.50	569.00	580.00
0.15	2083.50	3233.60	606.00	606.00
0.20	2341.50	3570.00	653.00	630.00
0.25	2726.81	3868.00	690.00	655.00
0.30	3000.00	4237.00	730.00	690.00
0.35	3346.00	4588.16	765.50	717.00
0.40	3700.00	4947.00	862.00	740.00
0.45	3987.04	5500.00	982.50	861.00
0.50	4299.75	5986.50	1131.00	1050.00
0.55	4883.00	6405.00	1423.00	1276.00
0.60	5387.00	6955.00	1701.00	1609.00
0.65	6048.00	7795.65	1916.57	1706.00
0.70	6868.00	9095.00	2120.00	1836.00
0.75	7944.00	10389.50	2507.11	1974.55
0.80	8943.00	12404.00	3000.00	2199.00
0.85	10908.00	16830.00	3696.00	2730.00
0.90	13297.06	21690.75	4378.00	3485.97
0.95	18734.00	32101.50	5662.00	4750.00
0.99	39177.75	59715.00	11295.44	7500.00

Table B.7: QTE Regression Estimates - by sub-procedure

	Arthroscopy		Colonoscopy	
Quantile	*Knee*	*Shoulder*	*Diagnostic*	*Screening*
0.01	93.00	172.50	0.00	0.00
	[-71.00, 112.00]	[24.00, 468.25]	[0.00, 0.00]	[0.00, 0.00]
0.05	60.00	60.00	14.00	0.00
	[-15.50, 171.00]	[-76.75, 246.50]	[0.00, 0.00]	[-1.00, 1.00]
0.10	0.00	24.00	-8.00	-11.00
	[-144.50, 82.00]	[-158.50, 263.25]	[-16.00, 11.00]	[-15.00, -6.00]
0.15	-84.00	161.00	-9.00	-17.00
	[-123.50, 153.75]	[-197.25, 394.50]	[-20.00, 4.00]	[-27.00, -14.00]
0.20	-38.00	124.00	-2.00	-6.00
	[-104.50, 193.00]	[-141.50, 314.00]	[-16.00, 17.00]	[-10.50, -3.00]
0.25	0.00	247.00	-26.00	-6.00
	[-43.00, 79.00]	[-70.38, 361.50]	[-48.00, -0.50]	[-20.00, -6.00]
0.30	-70.00	167.00	-26.00	-36.00
	[-206.67, 190.00]	[-40.75, 367.50]	[-42.00, -16.50]	[-44.00, -7.00]
0.35	-56.00	53.00	-37.00	-42.00
	[-300.00, 103.00]	[-105.25, 287.75]	[-52.00, -20.00]	[-47.00, -28.25]
0.40	-212.00	156.00	-54.00	-78.00
	[-401.86, 19.00]	[-163.00, 419.10]	[-74.00, -34.00]	[-80.00, -55.00]
0.45	-213.00	31.00	-41.50	-92.00
	[-513.50, 94.27]	[-144.50, 365.00]	[-56.00, -21.50]	[-113.00, -61.75]
0.50	-109.00	215.56	-128.00	-178.00
	[-430.95, 155.00]	[-211.38, 628.00]	[-191.00, -64.50]	[-201.35, -154.00]
0.55	-186.50	147.00	-156.50	-293.00
	[-283.50, 130.75]	[-232.82, 614.11]	[-224.00, -118.50]	[-366.75, -245.00]
0.60	-112.00	286.05	-277.00	-396.80
	[-227.00, 187.50]	[-129.95, 825.90]	[-347.50, -167.40]	[-473.60, -295.75]
0.65	-182.00	232.00	-133.00	-213.29
	[-515.76, 327.75]	[-165.00, 903.33]	[-231.00, -83.00]	[-305.60, -125.00]
0.70	-44.50	102.50	-49.00	-33.00
	[-633.00, 402.82]	[-489.33, 73.45]	[-140.00, -5.00]	[-78.50, 0.00]
0.75	0.00	-77.87	-257.00	-16.00
	[-669.00, 491.50]	[-1186.54, 897.86]	[-360.00, -134.76]	[-50.00, 0.00]
0.80	-86.00	-583.00	-183.00	-176.43
	[-1221.88, 1000.70]	[-1499.54, 920.50]	[-236.78, -32.28]	[-198.00, -72.00]
0.85	-179.74	-1698.51	-304.28	-140.00
	[-1132.64, 1242.97]	[-3225.58, 1997.16]	[-481.09, -115.47]	[-363.00, 0.00]
0.90	-861.41	-2619.46	-634.26	-176.26
	[-2068.93, 899.70]	[-7621.63, 2427.73]	[-786.07, -413.00]	[-329.81, 22.09]
0.95	-4051.62	-7645.78	-2164.92	-384.89
	[-6380.80, 13.79]	[-12691.18, 1595.85]	[-2672.63, -1703.94]	[-550.00, -206.06]
0.99	-8462.50	1423.36	-4750.00	-2000.00
	[-21774.00, -1842.00]	[-30644.02, 14403.63]	[-11700.00, 0.00]	[-3850.00, -1800.00]
N	18,735	8,513	72,039	60,735

1: Data consists of medical procedure claims data pooled from 2012-2013.
2: Covariates are included in the estimation: $\mathbb{1}$(Male),$\mathbb{1}$(Age Category), Comorbidity Index, Patient Health Care Market Dummy, $\mathbb{1}$(Intervention).
4: 95^{th} percentile of bootstrapped standard errors are presented in brackets below coefficient estimates.

Figure B.1: Arthroscopy Knee CDF

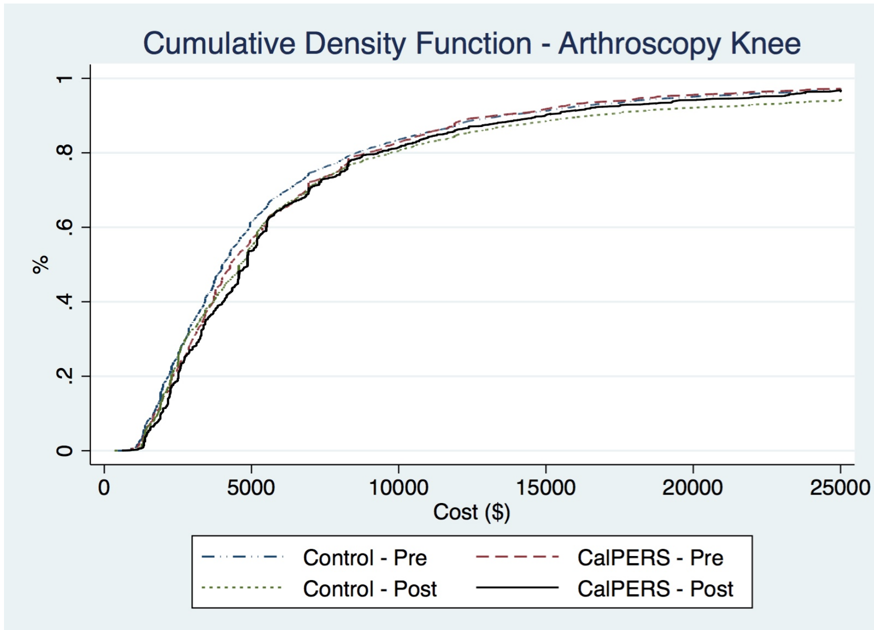


Figure B.2: Arthroscopy Shoulder CDF

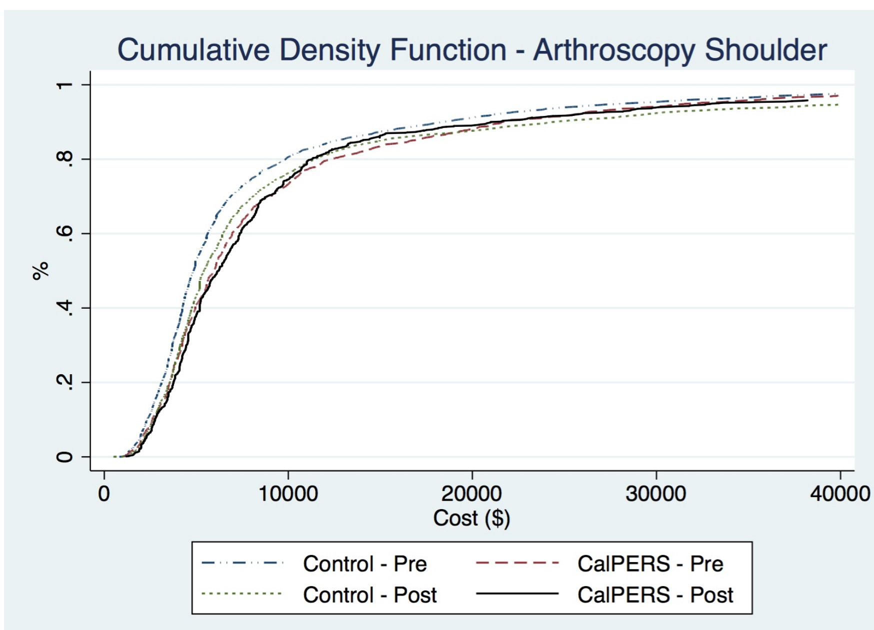


Figure B.3: Diagnostic Colonoscopy CDF

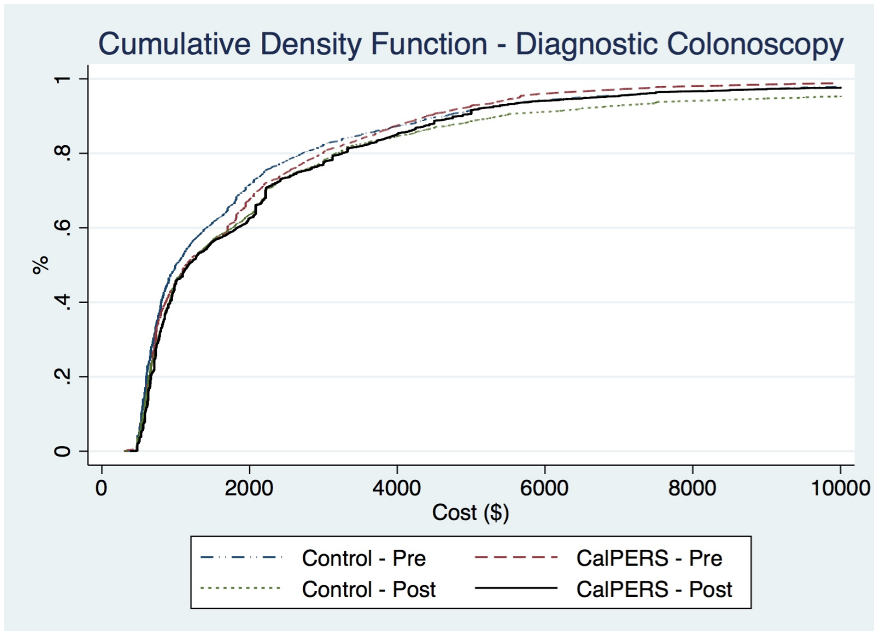


Figure B.4: Screening Colonoscopy CDF

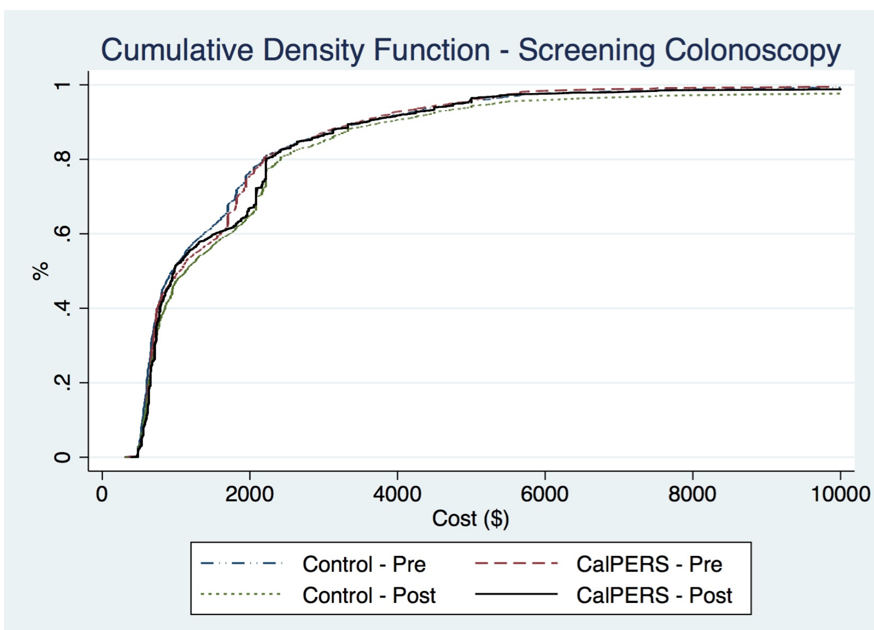


Figure B.5: Arthroscopy Knee Propensity Score Distribution

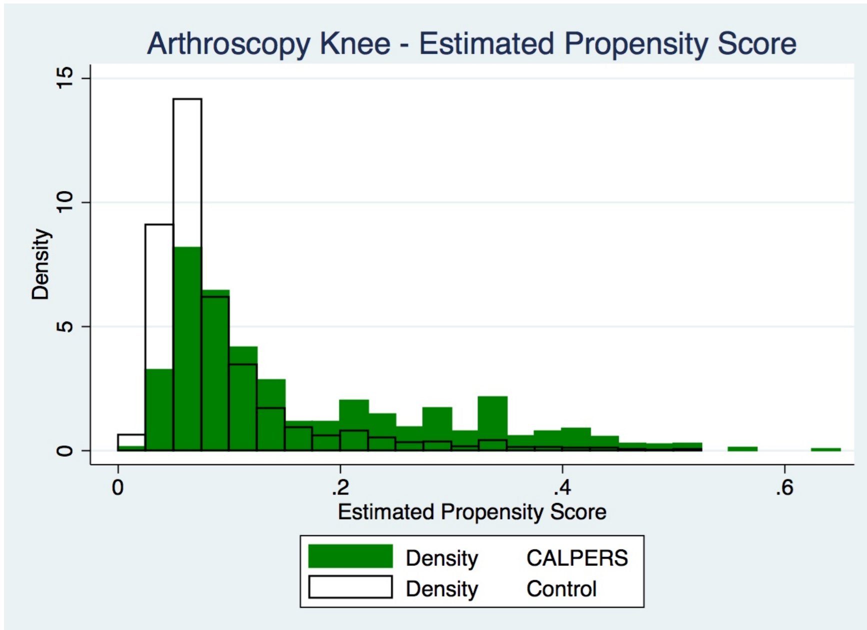


Figure B.6: Arthroscopy Shoulder Propensity Score Distribution

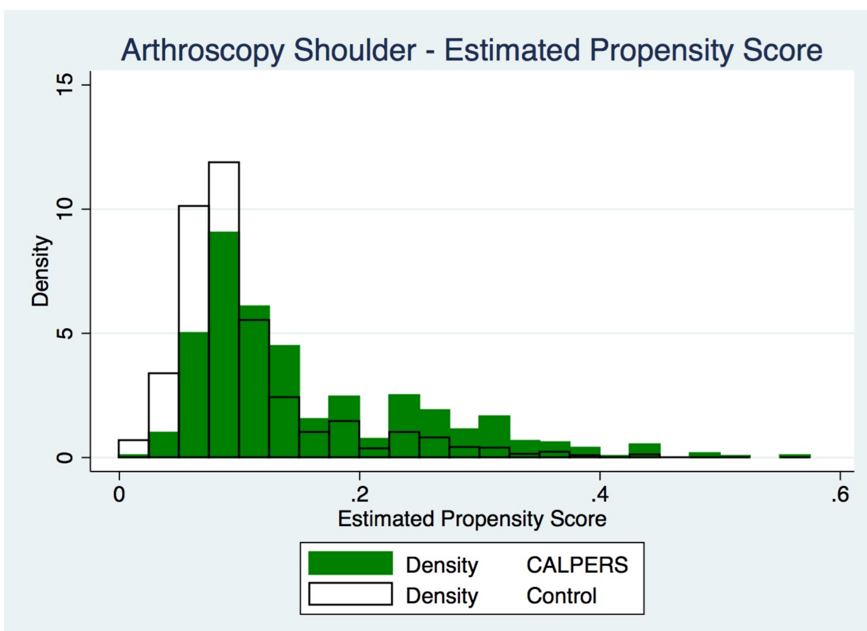


Figure B.7: Diagnostic Colonoscopy Propensity Score Distribution

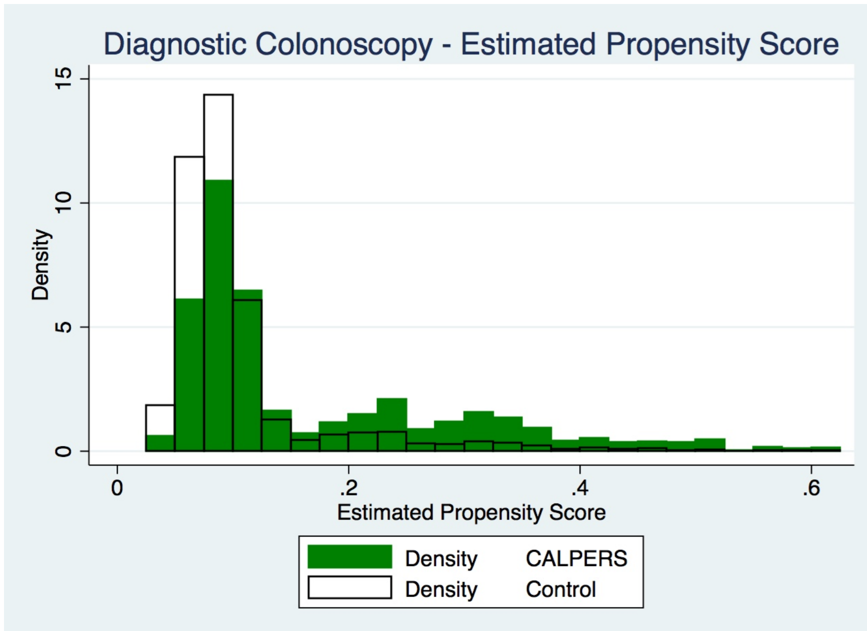
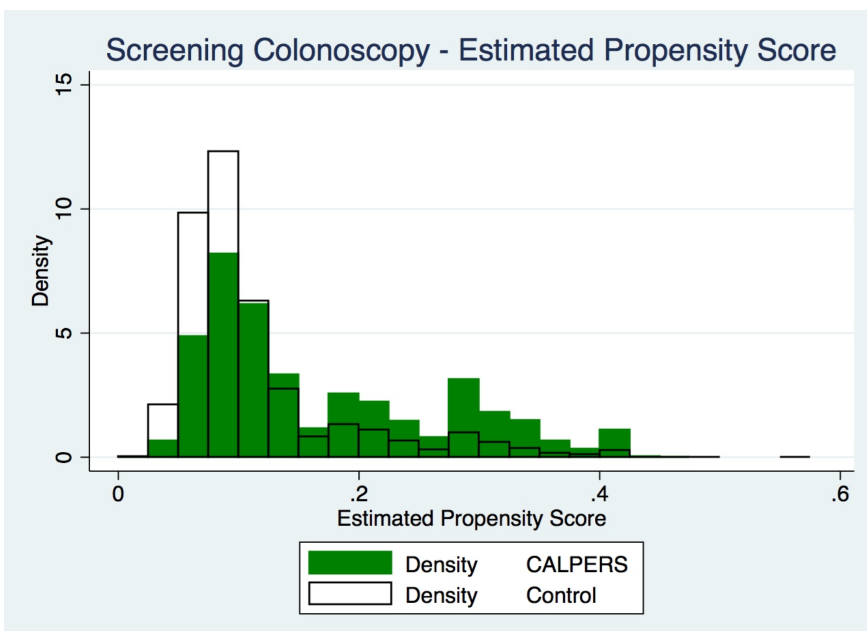


Figure B.8: Screening Colonoscopy Propensity Score Distribution



Appendix C

Understanding Physician Responses to Reference Pricing

Table C.1: Distribution of Mean Compensation Difference ($'s) at ASC versus Hospital - CalPERS Patients (CΔ)

Distribution of CΔ	2009	2010	2011	2012	2013
min	-274.95	-65.97	-1000.00	-90.99	-163.18
mean	0.45	15.05	-106.10	21.86	25.39
p25	-46.40	-35.57	-144.61	-56.47	-44.55
p50	16.37	0.00	-61.06	8.64	19.27
p75	65.54	60.62	18.54	55.76	84.83
p95	128.89	177.17	115.63	241.29	172.35
p99	128.89	177.17	179.11	241.29	172.35
max	128.89	177.17	179.11	241.29	172.35
N	10	15	12	12	12

1: Data represents the average over the physician-level mean physician compensation at ASC minus the mean physician compensation at the hospital in a given year.
2: Data is limited to S-Type physicians.

Table C.2: Distribution of Mean Compensation Difference ($'s) at ASC versus Hospital - Control Patients (CΔ)

Distribution of CΔ	2009	2010	2011	2012	2013
min	-612.56	-569.65	-1850.00	-1001.00	-795.00
mean	-9.09	-5.37	-5.06	0.56	-8.37
p25	-41.83	-33.31	-29.94	-25.33	-24.61
p50	-3.09	-3.35	-2.94	7.09	-1.24
p75	24.92	20.09	28.69	36.07	22.86
p95	112.40	129.25	125.00	115.85	89.18
p99	330.77	341.67	405.11	241.42	182.04
max	485.66	503.00	487.50	670.00	503.58
N	234	218	241	237	219

1: Data represents the average over the physician-level mean physician compensation at ASC minus the mean physician compensation at the hospital in a given year.
2: Data is limited to S-Type physicians who treat patients who have no medical intervention and have a Charlson Comorbidity Index equal to 0.