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(2006) uses simulation methods to identify differences in treatment costs between CON and non-CON states, finding that CON was associated with relatively small reductions in costs. Turning to volume effects, Popescu et al find significantly lower use rates in states with CON, while Ho (2006) found no significant difference in the statewide procedure volume between states with and without CON. Using a difference in difference approach, Ho, et al. (2009) found that the number of hospitals performing cardiac revascularization rose in states that repealed CON, coupled by offsetting decreases in average hospital volume in these states.

While studies focusing on the impact of discrete policy events

which are relatively common and well identifiable in administered databases. Specifically, we H[SORUH KRZ HQWU\ DIIHFWV WKH OLNHOLKRRG RI XQGHUJRLQJ PRUH intensive CABG and the relatively less intensive PCI for patients with coronary artery disease (CAD), as well as the likelihood of encountering these treatments at incumbent hospitals before and after deregulation.

By focusing on shifts in patient volume, we are able to further hone in on strategic responses related to the distribution of patients by levels of risk and illness severity. While previous research has explored this issue of risk allocation in the context of hospital competition in general (Capps, Dranove, Satterthwaite, 2003; Kessler and Geppert, 2005),[6] the allocation of low risk versus high risk patients has not been previously studied in relation to either CON regulation or market entry specifically. This latter analysis, which we implement, carries certain ZHOIDUH LPSOLFDWLRQV DV ZHOO IURP WKH SDWLHQW¶V SHU VSHFWLYH to appropriate intensity of care? From the KRVSLWDO SHUVSHFWLYH GR HQWUDQW V WHDOLQJ (i.e., Mark, Wan, Morrisey, and Wolinston, 1986; Bresnahan and Reiss, 1990, 1991), such that incumbents are left with a greater proportion of high-risk patients in the post-deregulation period?

Thus, our analysis complements and extends previous studies by exploring the interaction of CON deregulation and the degree of market entry. Moreover, unlike previous studies of CON, we focus on changes in patient volume at the level of local markets, rather than hospital averages. Furthermore, we analyze the reallocation of patients based on severity, among incumbents and

[5] The PCI procedure involves only a small incision through which a balloon-tipped catheter is threaded and inflated within the coronary artery to improve the blood supply. PCI is less invasive compared to CABG, and more often performed on patients with relatively mild CAD. PCI was formerly labeled PTCA, and

perceived threat of business stealing is pervasive in these markets.[9] Given that incumbent market share is necessarily reduced when new firms enter the market[10], in this study we are able to infer business stealing effects from changes in the likelihood of receiving cardiac treatment at incumbent hospitals associated with entry into an incumbent's local area. We base our analysis on patient level UHJUHVVLRQV ZKLFK DOORZV IRU GHWDLOHG ULVN clinical characteristics while incorporating market-level variables, notably the share of entrants in treatment volume within the local market area. Predicted entrant market share is constructed using a method used by Kessler and McClellan (2000) (see Appendix).

3. Risk-allocation Effect (Patient sorting) – refers to the allocation of high risk patients and low risk patients into incumbent hospitals versus entrant hospitals. To the extent business stealing is found, its effects may be more harmful from the perspective of incumbent for a given medical condition, relatively healthy patients ³ORUL V N´ DUH by and large more profitable \ ZKLOH VLFNHU-UDWLHQWV DUH NQRZQ WR EH XQSURILWDEOH ZKHQ we ask whether entrants exhibit business stealing behavior such that incumbents are left with a greater proportion of high risk patients in following deregulation[11].

Previous studies found evidence that specialty cardiac hospitals tend to serve relatively healthier patients than general hospitals (Barro et al., 2006; Cram et al., 2005) and tend to enter markets in which cardiac patients are healthier to begin with (Barro et al., 2006). However, given their interest in specialty hospital reimbursement issues, these studies took a narrow view of

[9] Ellison and Ellison (2011) find similar results in the case of the pharmaceutical industry, where investment in research and development in established product lines acts as a deterrent for entry by new drug developers.

[10] As an illustrative example, let $\Delta L = \Delta E$, where Δ, Δ, and Δ denote the change in total demand, change in incumbent demand, and change in entrant demand, respectively. Assume that the baseline market volume was 100, and that following entry, ΔL ráand ΔL s r. In this case, even though the incumbent share declines from 1 to 0.91 (=100/110), there is no business stealing because the entrant obtains its market share through creating new demand.

[11] Note that under the Medicare Prospective Payment System (PPS) hospitals receive a fixed fee for a given diagnosis with minimal compensation for outlier costs; for the most part, private insurers also use PPS or similar fixed-price reimbursement methods that do not provide for full risk adjustment (Capps and Dranove, 2004). Thus, high risk patients are also less profitable for the hospital.

patients with severe coronary arterial disease as it achieves better health outcomes than PCI (Serruys et al., 2009). Given the longitudinal nature of our data from Pennsylvania, one concern is that our estimates of demand augmentation may reflect a general time trend in cardiac treatment rates that began prior to the repeal of CON, which may confound our estimates of the trend due to CON and related effects of post-deregulation entry. To address this concern, we adopt a diffce n e] TJ ET BT 1 0 0 1 126946 617(ay)9(r)-3 1 90.02R

program has been rekindled, and legislative attempts to reinstate the program are currently underway[14]

Figure 1 illustrates the striking increase in the number of cardiac surgery centers after the 1996 repeal of CON relative to the pre-policy trend. Five centers, all of whom were located in general hospitals, entered the market immediately after the repeal, consequently increasing the total number of providers from 43 to 48. By 2004, there were a total of 28 CON-post new entrants, accounting for 41% of all hospitals providing cardiac revascularization in Pennsylvania.[15] The majority of entry occurred in urban or suburban areas. All cardiac surgery centers in Pennsylvania were affiliated with general acute hospitals rather than cardiac specialty hospitals.

Figure 2 shows the type of procedures provided by new entrants since the 1996 repeal of CON. A hospital is considered to be a participant in the market for CABG in a particular year if it performed at least 5 CABGs in that year (Ghali et al, 2007; Nallamothu et al, 2007).[16] The same threshold is used to identify PCI hospitals. Although PCIs are less invasive than CABGs, and are performed in catheterization laboratories instead of operating rooms, hospitals performing PCIs are required to have on-site surgical backup in case an emergency CABG is needed following a failed PCI. For this reason, all participating hospitals in Pennsylvania had provided both types of procedures before the 2000s. However, as PCI became nationally more diffused in the mid-1990s, some of the new entrants began specializing in PCI only. As shown in Figure 2, only one of the six new entrants during 2003 and 2004 was providing both procedures; the other five were providing only PCI procedures. This trend suggests that the cardiac revascularization markets in Pennsylvania may be evolving toward a greater degree of treatment specialization following the

[14] See http://www.legis.state.pa.us/cfdocs/Legis/CSM/showMemoPublic.cfm?chamber=S&SPick=20130&cosponId=10038; and http://wesa.fm/2012/05/08/proposed-legislation-calls-certificate-need. Both accessed on January 14, 2013.

[15] During the sample period, St. Francis Medical Center and Medical College of Pennsylvania closed on 2001 and 2004. UPMC Shadyside merged with UPMC Presbyterian in 2003. As a result, the total number of cardiac surgery centers was 68 by 2004.

[16] In our main analysis, entrants are defined as hospitals that started performing CABG or PCI procedures as of 1997, (more than 5 CABG or PCI cases in a given year) with no cases in previous years.

entry of new programs.

IV. Data and Sample

This study uses longitudinal inpatient records of all CAD patients who reside in Pennsylvania from 1995 through 2004 to investigate the effects of free entry in cardiac revascularization markets. The data is collected by the Pennsylvania Health Care Cost Containment Council (PHC4), and provides a wide range of patient clinical and utilization information including diagnosis/procedure codes, admission type and source, discharge status, and charges. It also includes patient demographic information such as age, gender, race, insurance type, and zip code of residence. A unique patient identifier allows us to track H D F K L Q G L - Y L G X D O ¶ V hospital records over time.

7 K H 3 + & D O V R U H F R U G V S D W L H Q W ¶ V M e d i Q u a l s c o r e , w h i c h i s V V H Y H U L W \ calculated based on patient characteristics and key clinical variables abstracted from admission medical records including vital signs, other physical findings, historical factors, and radiographic and laboratory findings (Lezzoni and Moskowtiz, 1988). This severity measure ranges from 0 to 4, with 4 being the most severe. The MediQual score captures not only acute symptoms, but also long- W H U P F R Q G L W L R Q V W K D W P D \ D I I H F W W K H S D W L H Q W ¶ V E D V

The second source of data for this study is the American Hospital Association (AHA) Annual Survey of Hospitals. Each admission record in the PHC4 data is associated with a unique facility identifier, which enables us to link it to comprehensive facility characteristics in the AHA data, including location (longitude and latitude), bed capacity, teaching status, ownership, and system member status.

Our study sample includes Pennsylvania residents who were admitted to any hospital in the state with a new diagnosis of CAD[17] between 1995 and 2004. During the sample period, a total of 1,112,777 patients were hospitalized due to CAD.

for the same diagnosis in the previous year, and repeated admission records within the same quarter, the final sample contains 714,038 CAD patients.

The analysis centers on two outcomes[18] and includes a procedure within a three month period (a quarter) after admission for CAD, and the incidence of CABG or PCI procedure at any incumbent hospital within one quarter after admission for CAD. The first outcome is used to assess the response of patient demand for procedure to the entry of new cardiac surgery centers. The second outcome is used to identify how patient flow is redistributed from existing centers to new centers following entry. Table 1 presents the summary statistics of procedure incidences and surgical outcomes by patient severity. Patients with MediQual scores greater than or equal to 2 are identified as high severity. More than half of hospitalized CAD patients in the study period received either a CABG or PCI procedure within 3 months after admission. Without adjusting for age, gender, and other individual factors, low-severity patients were more likely to undergo CABG and PCI procedures than the high-severity patients.

Figure 3 contrasts the trends of 3-month CABG and PCI rates between 1995 and 2004, which are further divided into trends in markets where entry occurred versus markets where entry never occurred. These rates are expressed as the number of procedures per 1,000 new CAD patients in the study sample, and markets are defined as Hospital Service Areas (HSA)[19]. As shown in Figure 3, markets that experienced entry had higher rates of CABG and PCI than markets that did not experience entry both before and after the CON repeal. Nevertheless, the average CABG rate gradually declined since 1997, despite the continuing entry of new surgery centers in these markets. In contrast, PCI diffused rapidly in both entry and non-entry

[18] Procedure codes for CABG: ICD-9-CM 3610-3619. Procedure codes for PCI: ICD-9-CM 3601, 3602, 3605, 3606, 3607, and 3609.

[19] HSAs are groups of zip codes whose residents receive most of their hospitalizations from the hospitals in that area. There are 127 HSAs in Pennsylvania. Our market definition differs from Cutler et al. (2010), which used Hospital Referral Regions (HRRs). The use of HRRs can create measurement error of entrant market share because 7 out of 21 HRRs include areas of neighboring states, where we do not observe patient flows. Therefore, we use smaller geographic markets, the HSAs, to mitigate the boundary problem.

markets, mirroring national trends that occurred with the introduction of stent technology during the mid-1990s (Epstein et al., 2011).

However, taken by itself, Figure 3 does not necessarily provide evidence that free entry in the post-CON period[3]

$$;_{\ddot{U}\,\hat{e}_{\ddot{C}}} \; L \; \grave{U}_{\dot{D}} \div : * \; 5\#_{\dot{D}} \; ; \; E \; \acute{U}_{\dot{C}} \div : U \; AN\ddagger_{\dot{C}} \; ; \; E \; \hat{U} : 5_{\dot{D}\,\dot{C}} \circledR 2 \; K\wp_{\dot{C}} \; ; \; E : \tilde{N}_{\dot{U}\,\beta_{\dot{C}}} \; E \; <^{\tilde{N}}_{U_{\dot{C}}} \ddot{U} E \; \acute{o}_{\ddot{U}\,\hat{e}_{\ddot{C}}} \acute{a} \qquad (1a)$$

$$;_{\ddot{U}\,\hat{e}_{\ddot{C}}} \; L \; \grave{U}_{\dot{D}} \div : * \; 5\#_{\dot{D}} \; ; \; E \; \acute{U}_{\dot{C}} \div : U \; AN\ddagger_{\dot{C}} \; ; \; E \; \grave{a}_{\dot{D}} > \div : * \; 5\#_{\dot{D}} \; ; \; \circledR \wp_{\dot{C}} ? E \; \hat{U} : 5_{\dot{D}\,\dot{C}} \circledR 2 \; K\wp_{\dot{C}} \; ; \; E : \tilde{N}_{\dot{U}\,\beta_{\dot{C}}}$$
$$E \; <^{\tilde{N}}_{U_{\dot{C}}} \ddot{U} E \; \acute{o}_{\ddot{U}\,\hat{e}_{\ddot{C}}} \acute{a} \qquad (1b)$$

where the dependent variable $;_{\ddot{U}\,\hat{e}_{\ddot{C}}}$ equals one if patient E from market G admitted to hospital D at time P received CABG or PCI procedure within a period one quarter after admission to a hospital for CAD; $\div : * \; 5\#_{\dot{D}}$ are market fixed effects; $\div : U \; AN\ddagger_{\dot{C}}$ are year fixed effects; $:^{\tilde{N}}_{\dot{U}\,\beta_{\dot{C}}}$ is a vector of patient characteristics; $<^{\tilde{N}}_{U_{\dot{C}}}$ is a vector that controls for characteristics of the admitting hospital, and $\acute{o}_{\ddot{U}\,\hat{e}_{\ddot{C}}}$ is an error term. Standard errors are clustered by market area to account for any within-area correlation.

In both models, $\hat{U}$ is the policy parameter of interest. In equation (1a), the corresponding variable of interest is defined as $5_{\dot{D}\,\dot{C}} \circledR 2 \; K\wp_{\dot{C}}$, the interaction between the

2 K O

this concern, equation (1b) imposes area-specific linear trend[22] and allows for a shift in trend after the repeal of CON that varies with the entrant market share. Here, the coefficient indicates the differential shift from pre-existing trends experienced by markets with higher entrant share relative to markets with zero entrant share.

Next, we attempt to identify business stealing behavior. Accordingly, new cardiac surgery centers have an incentive to draw patients away from existing hospitals even if total demand has expanded. To test for this effect, we simply re-estimate equations (1a) and (1b), by replacing the previous dependent variable with a binary variable that equals one if the patient received CABG or PCI procedure at any incumbent hospitals within one quarter of admission for CAD ( ). Thus we estimate:

$$\text{(2a)}$$

$$\text{(2b)}$$

If higher entrant market share leads, on average, to a decrease in patient demand at incumbent hospitals, then a negative value for coefficient would be expected. On the other hand, if entrant hospitals create new demand from the potential patients such that the incumbent hospitals' [illegible] would be reduced, we would expect to approximately equal zero. A positive may reflect either a spillover of demand augmentation from entrant hospitals to all hospitals, or strategic behavior on

omitted group), race (White, Black, Asian; omitted group is other races), gender, urban residence, MediQual severity score (1, 2, 3, and 4; omitted group is 0), admission status (emergency admission and transferred admission), insurance type (Medicare and Medicaid) and major clinical indications at admission (cardiogenic shock, hypertension, dialysis, heart failure, renal failure, and acute myocardial infarction). We also include in $\tilde{N}_{ijt}$ a continuous variable for the annual percentage of HMO enrollees in the patient's county to control for the potential impact of HMO penetration on procedure use (Town and Vistnes 2001; Miller and Luft 1997).[23]

The vector $<\tilde{N}_{ijt}$ includes the indicator variables for the hospital's bed capacity (200 to 400 beds and >400 beds; omitted group is <200 beds), teaching status , whether for-profit or not-profit, and whether it belongs to a health care system. In addition, the literature on volume-outcome relationship suggests that hospitals with a higher volume of a particular surgical

acceptable substitutes for established providers (Capps et al., 2003). To test this hypothesis, we estimate another variant of the above equations, allowing for heterogeneous demand response for high-severity versus low-severity patients. Specifically, focusing on the full interrupted time series design from equations (1b) and (2b), we add interactions between

from 1997 to 2004. The actual entrant market shares are slightly smaller than the predicted entrant market shares, meaning that patients are more likely to choose entrant hospitals if their decisions are based only on exogenous factors. By either measure, the entrant share distributions are highly skewed to the right, with more than half of the markets having extremely small entrant share.

To deal with the possibly nonlinear relationship between entrant share and outcome variables, we categorize markets into zero-, low-, and high-entrant share groups. The reference group is zero entrant share group, which contains all markets in 1995-96 and most markets in 1997-98. The markets with non-zero entrant shares are divided into two groups with the median entrant share value as the cutoff; this is roughly 21 percent and 14 percent for CABG and PCI markets, respectively. In the CAD patients sample, approximately 28%, 37%, and 35% of all patients fall into each category.

VI. Results

VI.A. Main Results

Table 3 reports the results of eight sets of logistic regressions where the dependent variables

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less as of the repeal of CON in 1996; concomitantly, entrants with more than three consecutive years of market presence as of 1997 were reassigned as incumbents. Switching to the 3-year definition caused the number of entrants in the data to fall from 28 to 13 in 2004; the new threshold for high entrant share is roughly 4 percent compared with 12 percent under the original definition. This repeated analysis also provides answers to additional questions of interest.

3UHYLRXVO\ LGHQWLILFDWLRQ FDPH IURP YDULDWLRQ LQ WKH

markets. To this extent, the estimated coefficients revealed the long-run effects of entry since the repeal of CON. Instead we now examine short-run effects: Did the demand for revascularization grow immediately after new cardiac surgery centers entered the market? Was the negative demand shock on incumbent hospitals

to 2.[26] In the study sample, the Elixhauser comorbidity score ranges from 0 to 7, and the correlation between the MediQual score and Elixhauser score is 0.13. The estimates in columns (2) and (3) ar

baseline results. Perhaps the only exception is in the last panel, where the estimated business-stealing effects among high-severity PCI Medicare patients appeared to be larger than the baseline estimates.

VII. Conclusion

The majority of hospital markets in the United States currently operate under state-mandated certificate-of-need regulation which impedes market entry. Concerns over anticompetitive effects and adverse impacts on availability of services to consumers led a number of states to repeal CON regulation in recent years. Previous research has focused primarily on the efficiency consequences of CON, generally finding no significant differences between CON and non-CON states, with little evidence provided on volume effects (e.g. Ho and Hou, 2013). Moreover, little has been previously known about the degree to which deregulation correlates with market entry, or the effect unimpeded entry on has on the incidence and flow of

patients into the more invasive CABG procedure and low-severity patients into the less invasive PCI procedures. Regarding risk-allocation among hospitals, we find evidence that entry shifted a disproportionate volume of low-severity patients from incumbent hospitals to entrants.

While our analysis on impacts of market level entry and entrant concentration on procedure volume and trends are novel, our results echo findings from studies in related literature which suggest that hospital entry contributed to increased quantity of services (Abraham et al. 2007; Bian and Morrisey 2007; Mitchell 2007). Our results on business stealing by entrants parallel those of Huckman (2006), which show that acquiring hospital chains tend to draw volume from target hospitals. The finding that entrant hospitals tended to attract a disproportionate volume of low-severity patients away from incumbent hospitals is consistent with Barro et al. (2006), thereby suggesting that the risk-allocation effect of entry is not unique to specialty hospitals. Finally, focusing on per unit costs of hospitalizations, Kessler and Geppert (2005) show that low-risk and high patients are sorted more efficiently into low-intensity and high intensity care when markets are competitive.

As for welfare implications for policies, such as CON, designed to remove barrier entries in hospitals markets, our results are mixed: on the one hand, free entry may lead to improved access to care rather than business stealing for CABG procedures; on the other hand, the empirical evidence is in favor of business-stealing for PCI procedures. Moreover, free-entry improves the match between underlying medical risk and treatment intensity, pointing to potential improving quality of care. These findings underscore the importance of considering strategic responses by hospitals when evaluating the imp ET BT 1 1 0 0 Thermers911(3s2 ..65 BT 1 0 0 G0 1 32

local market area, and thus provide more nuanced understanding of the responses to entry as measured by patient flows. Future research might apply our analytical framework to efficiency measures such as costs or patient outcomes.

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Table 1 Sample Statistics of Patients

	Overall	Low-Severity	High-Severity
Receiving CABG in one quarter	0.231	0.257	0.203
ReceivingPCI in one quarter	0.360		

Table 3 Effects of Entry on Procedure Incidences

	CABG in 3 months at any hospital	PCI in 3 months at any hospital	CABG in 3 months at any incumbent hospital	PCI in 3 months at any incumbent hospital
	(1)	(2)	(3)	(4)
Panel A: Not controlling for HSA-specific time trend				
Low entrant share*Post	0.002	0.001	-0.001	-0.006
	[0.006]	[0.005]	[0.007]	[0.007]
High entrant share*Post	0.015***	0.02***	-0.015**	-0.033***
	[0.005]	[0.006]	[0.006]	[0.009]
Panel B: Controlling for HSA-specific time trend				
Low entrant share*Post	0.003**	-0.005	-0.001	-0.016***

Table 4 Effects of Entry on Procedure Incidences by Patient Severity

	CABG in 3 months at any hospital	PCI in 3 months at any hospital	CABG in 3 months at any incumbent hospital	PCI in 3 months at any incumbent hospital

Table 6 Robustness Checks on CABG and PCI Procedure Incidence

	Baseline	Prior-year expenditures	Elixhauser score	Surgeon supply	Medicare Sample
	(1)	(2)	(3)	(4)	(5)
	CABG in 3 months at any hospital				
Effects on low-severity patients					
Low entrant share*Post	0.003	0.008	0.004	0.003	0.003
	[0.006]	[0.005]	[0.006]	[0.006]	[0.006]
High entrant share*Post	-0.001	0.011	0.001	0	-0.005
	[0.006]	[0.006]	[0.006]	[0.006]	[0.007]
Effects on high-severity patients					
Low entrant share*Post	0.018***	0.017***	0.019***	0.017***	0.017***
	[0.005]	[0.005]	[0.005]	[0.005]	[0.006]
High entrant share*Post	0.034***	0.028***	0.034***	0.035***	0.027***
	[0.006]	[0.006]	[0.007]	[0.007]	[0.007]
	PCI in 3 months at any hospital				
Effects on low-severity patients					
Low entrant share*Post	-0.006	-0.006	-0.004	-0.006	-0.007
	[0.004]	[0.004]	[0.004]	[0.004]	[0.005]
High entrant share*Post	0.011*	0.008	0.013*	0.012*	0.01
	[0.006]	[0.006]	[0.007]	[0.006]	[0.007]
Effects on high-severity patients					
Low entrant share*Post	-0.003	-0.001	-0.008	-0.003	-0.011**
	[0.005]	[0.006]	[0.005]	[0.005]	[0.005]
High entrant share*Post	0.004	0.013*	0.001	0.005	-0.005
	[0.01]	[0.007]	[0.008]	[0.01]	[0.009]
	CABG in 3 months at any incumbent hospital				
Effects on low-severity patients					

Figure 1 Number of Cardiac Revascularization Centers in Pennsylvania 1993–2004

Figure 2 New CABG and PCI Centers in Pennsylvania 1997–2004

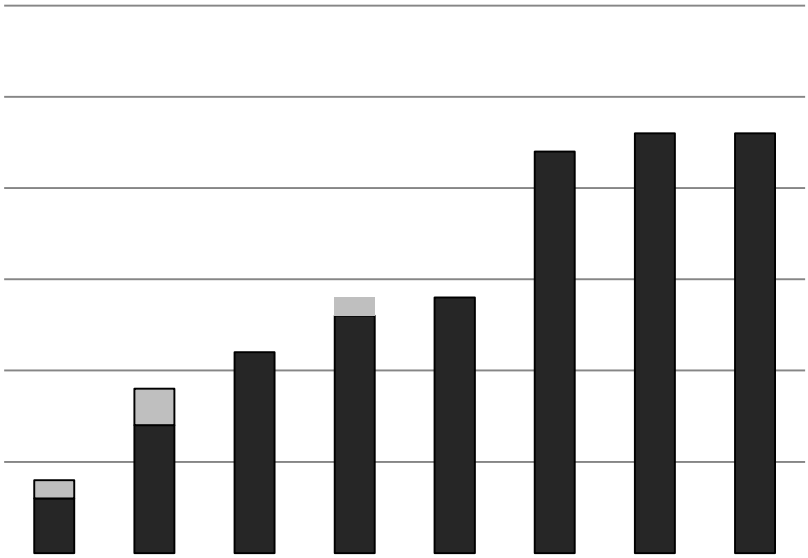


Figure 3 Unadjusted CABG and PCI Procedure Rates Among New CAD Patients

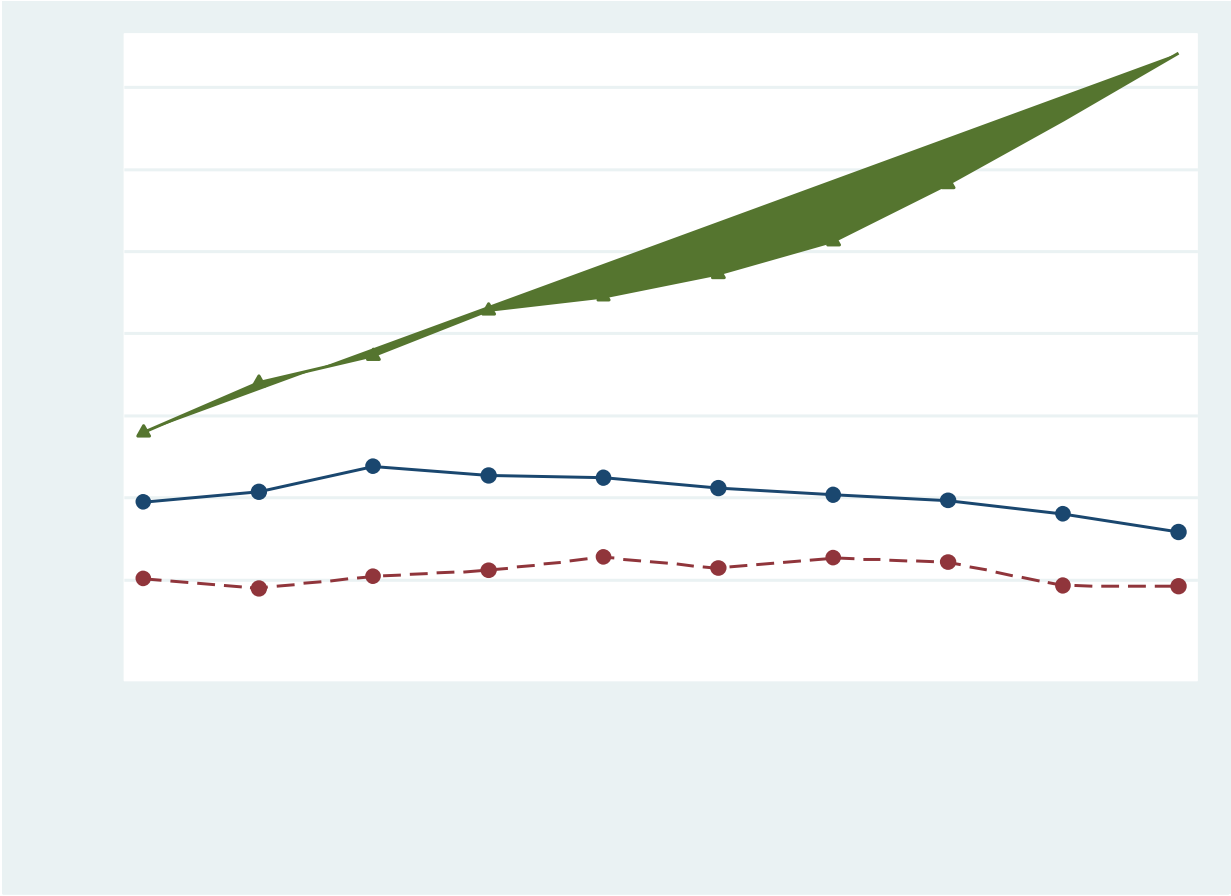
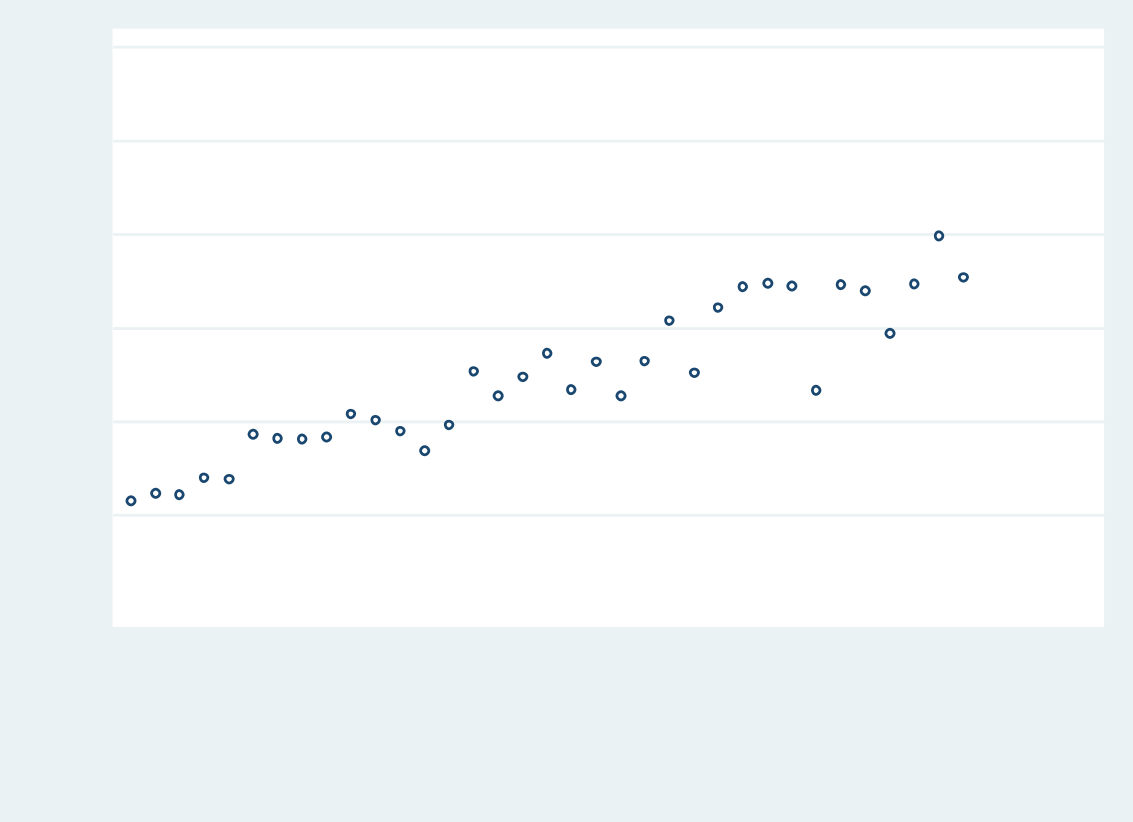


Figure 5 Regression-Adjusted Three-Month Probabilities of PCI for First-Time CAD Patients, 1995 ±2004



Note: Fitted trends are quadratic, allows to vary across the before and after-CON repeal period, and are adjusted for factors included in equation (2b).

Table A-1 Descriptive Statistics of Patient Samples (Continued)

substitute).[27]

The choice set for each individual i at year t is comprised of all non-federal hospitals offering at least five CABG (PCI) within 50-mile radius of her residence. We compute the

and the relative distances to its poorest institutes (different type). To allow for any nonparametric

U H O D W L R Q V K L S E H W Z H H Q G L V W D Q F H V and D Q G L Q W H U T X D U W L O H W ¶ V F K R L F

dummies based on the distribution of the respective relative distance. That is,

patients living in market m who go to new centers for cardiac procedures as a proportion of the total number of patients in market m:

$$s_{pm} = \frac{\sum_{h \in J_p} n_{hm}}{\sum_{h \in J} n_{hm}} \qquad \text{(A-6)}$$

where J_p denotes the set of entrant hospitals and J denotes the full set of hospitals providing CABG (PCI) procedures. Each patient i then is assigned an entrant share s_{pm} at his/her market of residence (instead of at the admitting hospital).