Affirmative Action Exemptions and Capacity Constrained Firms

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Abstract

This paper studies how affirmative action exemptions in public procurement can improve efficiency and government expenditures without harming disadvantaged business enterprise (DBE) utilization. I examine a unique program employed by the Iowa Department of Transportation, where prior to 2013 prime contractors were allowed an exemption from a project's affirmative action requirement if their history of DBE utilization was sufficiently high. I find that prime contractors use the exemption to smooth demands on capacity constrained DBEs, building a history of utilization during low demand periods and exploiting the resulting exemption during high demand. The exemption policy was unexpectedly eliminated in 2013, which I exploit to evaluate its effect on DBE utilization and procurement costs. I find that average DBE utilization was unchanged and bids rose on affirmative action contracts.

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1 Introduction

Affirmative action is often used in public procurement to increase government purchases from disadvantaged business enterprises (DBEs), usually defined as firms owned by minorities and women. Since the size of the public procurement sector is large[1] and the use of affirmative action programs is widespread, such programs can have significant effects on distribution and efficiency. Despite this, our knowledge remains limited about many of the key effects of affirmative action programs and how important elements of program design affect the utilization of DBEs and the cost of government contracts.

A common form of affirmative action requires a prime contractor to award some minimum percentage of the contract value to DBE subcontractors. This constraint is usually enforced unless the contractor can demonstrate it made a good faith effort to locate ready, willing, and available DBEs. In this paper, I provide evidence from a unique program used by the Iowa Department of Transportation in highway construction contracting suggesting that the design of this form of affirmative action could be perturbed to improve economic efficiency and reduce government cost without harming the utilization of preferred firms.

Prior to a change in policy in 2013, Iowa allowed a prime contractor to fall short of the affirmative action requirement of a contract if it had a sufficiently strong history of employing DBE subcontractors. A contractor who utilizes DBEs more heavily than required today is thereby rewarded with a future exemption option. These exemptions are valuable if the costs of DBE subcontractors are time varying, since firms can build a history of DBE utilization when DBE costs are low, then take advantage of the resulting exemption when DBE costs are high.

A potentially important source of time-varying DBE cost could arise if subcontractors face capacity constraints. The volume of contracts with affirmative action goals varies over time, creating some periods of time where demand for DBE subcontractors is high and other times where it is low. My results suggest that prime contractors in Iowa utilize DBE subcontractors in such a way to smooth this demand. Firms build a history of DBE utilization to obtain exemption eligibility when demand is low and capacity constraints are slack, and then take advantage of the exemption when capacity constraints bind. This could reduce government cost, both through an improvement in efficiency and a reduction in bidders' markups. A prime contractor's incentive to obtain exemption eligibility should be priced into its bid. Using a simple model, I show this compresses the bid

[1] OECD (2001) estimates that government purchases from the private sector represent 19 percent of GDP in the US

distribution and thereby lowers the information rents of stronger bidders. As a result, an exemption program can have benefits for government expenditures disproportionate to the efficiency gains.

I present three sets of empirical results. First, I provide evidence that prime contractors value the exemption, and that DBE subcontractors likely face capacity constraints. Second, I establish that the intertemporal pattern of subcontractor utilization is countercyclical to affirmative action project volume, consistent with theoretical predictions. Finally, to establish the exemption program's effect on average DBE use and procurement cost, I exploit the unexpected elimination of the program in 2013 resulting from a ruling by the Federal Highway Administration.

I find that an exemption from affirmative action is valued by firms, as the distribution of DBE utilization history exhibits bunching just above the exemption eligibility threshold. Furthermore, I provide evidence suggesting that DBE subcontractors face capacity constraints, which is consistent with previous studies in the construction literature documenting such constraints for prime contractors (see Balat, 2014; Jofre-Bonet and Pesendorfer, 2003). After a subcontractor participates on a winning bid, the likelihood that it is utilized on another project in the subsequent five months is reduced compared to the five months prior, an effect concentrated in those occasions where the subcontract is large relative to the subcontractor's capacity.

I then document how the DBE utilization decisions of prime contractors differ depending on the aggregate demand for DBE subcontractors. Prime contractors work to build points during times when DBE demand is low, then elect to utilize the exemption when DBE demand is high. Using within-firm variation in exemption eligibility, I find that when a prime contractor is exemption eligible, it is 27 percentage points more likely to be non-compliant than when it is not eligible for the exemption. When the volume of contracts with affirmative action goals is high, compliance with affirmative action falls and the utilization of DBE subcontractors declines. Furthermore, the difference between exemption eligible and inelegible firms in both compliance and DBE utilization grows during these times. This evidence is consistent with firms preserving eligibility status for periods where DBEs are more heavily utilized, effectively smoothing demands on DBE capacity.

In the final set of results, I examine the policy change eliminating the exemption program to estimate its effect on DBE utilization and government procurement cost. Following the reform, the DBE utilization of the average bidder did not change, which reflects two competing effects. Prime contractors are more likely to meet the affirmative action goal after the reform, however they also no longer had an incentive to over-comply to gain future exemption eligibility. I also find evidence that the exemption program had an effect on bidding. Contracts with affirmative action goals have higher bids than those without, and this difference grew substantially after the elimination of the exemption program. Taken together, these results suggest that the exemption program improved efficiency, in that it reduced costs without adversely affecting DBE utilization.

The results have several policy implications. Allowing affirmative action requirements to vary with the backlog of demand for DBE firms could achieve efficiency improvements, though it is worth noting that tracking the state of backlog over time may not be practical. The results also provide support for affirmative action programs that increase DBE capacity, for instance by providing lines of credit, access to equipment, or assistance in acquiring bonding.

The paper proceeds as follows. Section 2 provides a review of the related literature. Section 3 describes the Iowa Department of Transportation's affirmative action program. The model of the subcontracting decision is discussed in section 4. Section 5 describes the data, and section 6 presents the main set of results related to capacity constraints and exemption use. In section 7, I discuss the effect on DBE utilization of changing the good faith effort criteria. Finally, section 8 concludes.

2 Literature Review

The prior literature studying either the effectiveness or efficiency of affirmative action is sparse, particularly for non-standard program design. A recent exception is De Silva et al. (2013), who study a training program in Texas for disadvantaged business enterprises that increases their auction participation and potentially lowers the cost of procurement. Marion (2009) studies California's Proposition 209, which led to the elimination of affirmative action requirements in state-funded contracting, finding that the winning bids on highway procurement contracts using only state funds fell relative to federally funded projects for which affirmative action still applied. Furthermore, DBE goals affect bids more when future contract volume is high. Krasnokutskaya and Seim (2011) and Marion (2007) estimate the effects of bid preferences for small businesses on bidding and entry behavior in government contracting.

Marion (2011) finds that affirmative action benefits minority-owned firms by increasing their utilization on government contracts. However, the evidence on the effects of affirmative action on minority entrepreneurship and firm survival is mixed. Chatterji et al. (2014) finds that rates of minority entrepreneurship rose relative to that of whites after cities enact affirmative action programs in contracting. Fairlie and Marion (2012) find that minority self-employment rose following California's Proposition 209, which disallowed the consideration of race in government contracting and employment. Bates and Williams (1995) and Bates and Williams (1996) find heterogeneous effects, often negative, of affirmative action in contracting on the formation and survival of minority-owned enterprises.

Several studies using data from highway construction contracts note that project backlog increases a firm's bid and have explored its implications for firm strategy and government cost. For instance, Jofre-Bonet and Pesendorfer (2003) estimate a dynamic game where contractors anticipate the effect that winning an auction today will have on the likelihood of winning future contracts via increased backlog. Balat (2014) estimates how the effectiveness of the American Recovery and Reinvestment Act was affected by the sudden surge of projects when highway construction firms have upward sloping marginal cost curves. Finally, the use of subcontracting to manage capacity has been studied in a computational paper by Jeziorski and Krasnokutskaya (2013).

A larger literature has examined the effects of affirmative action in employment. Griffin (1992) considers the constraints affirmative action place on the production function of firms. McCrary (2007) and Miller and Segal (2012) examine the effect of court-ordered hiring quotas, finding they increase the employment of black police officers both in the short-term and long-term without having a measurable adverse impact on policing quality. Miller (2014) provides further evidence of the persistent effects of affirmative action, finding that becoming a federal contractor leads to increases in the firm's black employment share, an effect that continues to grow even after a firm exits federal contracting.

My results fit in with other work showing firm responses to eligibility thresholds, since I document that firms utilize DBEs in such a way to just qualify for the affirmative action exemption. Two examples of similar behavior in other contexts are Onji (2009), who show that Japanese firms choose a small enough firm size to qualify for small business standards, and Hahn et al. (2001), who demonstrate that the firm employment size distribution exhibits bunching just below the threshold for discrimination laws.

Procurement studies outside of affirmative action are also relevant. In related work on how procurement policy affects subcontracting, Branzoli and Decarolis (2015) considers the effect of auction format on entry and the subcontracting decision. Arozamena and Cantillon (2004) analyze the incentive to engage in cost-reducing investments in procurement. In my setting, building a history of DBE utilization is an investment that is potentially costly in the near term but reduces cost in the long term.

Highway procurement is a setting that is particularly well suited to the examination of affirmative action due to clear program parameters that are readily observed. A project-specific goal is usually set for the participation of disadvantaged business enterprises, and there is considerable variation in DBE goals across projects within a particular state. While highway construction contracts also vary in scale and type of work, much of the key project characteristics are observed enabling the comparison of contracts with differing affirmative action requirements.

A number of recent papers have also used the highway procurement setting to study a variety of other topics in public economics and industrial organization. These include the provision of time incentives (Bajari and Lewis, 2014), the cost of incomplete contracts (Bajari et al., 2014), the differential effects of entry and competition in auctions (Li and Zheng, 2009), the winners curse (Hong and Shum, 2002), information in auctions (De Silva et al., 2008), among others.

3 Background

3.1 Contracting

The Iowa Department of Transportation awards contracts for road construction projects using first-price sealed bid auctions. Auctions occur on specified letting dates, with most projects being awarded on one letting day per month. On the median letting date, 42 auctions are conducted. The letting date for a particular project is decided well in advance. Each month, Iowa announces the projects that will be auctioned over the next five months. Detailed letting documents, including project plans and other project-related information, are made available approximately one month before the letting date.

3.2 Iowa's affirmative action program

The US Department of Transportation mandates each state implement an affirmative action plan in the awarding of highway construction and repair contracts using federal funds and sets forth guidelines that these programs must follow. As a result, state affirmative action programs for federally funded contracts tend to be similar. Affirmative action programs outside of federally funded highway procurement vary considerable in program parameters and the degree of reporting, making general comparisons difficult.[2]

Every three years Iowa must set a statewide goal for the participation of DBE firms on federally funded highway construction projects.[3,4] The goal is based to a large degree on the number of DBE

[2](Chatterji et al., 2014) in their estimation of the effects of city affirmative action programs had difficulty uncovering the dates the programs began, and they report that "Information on other program aspects was limited and not consistent across cities."

[3]A firm is considered "socially and economically disadvantaged" if it is owned and managed by a woman or member of a minority group. This generally includes Black, Hispanic, Native American, and Asian business owners. In Western States Paving v. Washington State Department of Transportation, the federal 9th circuit court of appeals ruled that race-conscious affirmative action must be limited to those racial groups actually suffering the effects of discrimination. This has raised the bar for showing disparate treatment in states affected by this ruling. For instance, California failed to establish disparate treatment for Hispanic- and Sub-Continent Asian-owned businesses in their most recent disparity study, and therefore are not eligible for race-conscious benefits.

[4]The goal was 4.5 percent from 2012-2014 and 5.75 percent from 2015-2017.

firms operating within the state, and the state is instructed to meet the goal by race-neutral means if possible.[5] The state estimates how much of the goal can be met by race-neutral means based on the rate of DBE utilization on projects without goals, and the excess utilization of DBEs on projects with goals. The difference between the overall goal and the projected race-neutral achievement is met using race-conscious means. The statewide race-conscious goal is achieved by setting project-specific goals dictating the portion of the contract value that the prime contractor must award to DBE subcontractors. The project-specific goal is set based on the local availability of DBE firms and the type of work involved on the project.

While many states also implement affirmative action requirements for projects that are entirely state funded, in Iowa goals are only applied to projects that use federal funds. Most Iowa projects do not require DBE participation. A positive goal is set for 23% of projects, and in almost all of these cases the goal is either 2.5 percent or 5 percent (respectively 82% and 17% of contracts with a positive goal).

For a bidder to be awarded the contract, the percent of its bid going to DBE subcontractors must exceed the project goal, or it must demonstrate that it made a good faith effort to meet the goal.[6] Prior to 2013, Iowa utilized a unique standard to establish whether a good faith effort was made. The prime contractor must either (1) award a percent of the contract to DBE subcontractors that exceeds 80 percent of the project goal, (2) award a percent of the contract to DBE subcontractors exceeding 80 percent of the average percentage commitment of the other bidders, or (3) have a demonstrated history of utilizing DBE subcontractors.

Criteria (3) is established based on a firm's "good faith effort points" (henceforth referred to as "points"), defined as the percent of contract dollars awarded to DBE subcontractors in the prior two years. In order to meet criteria (3), the prime contractor's points must exceed a threshold value equal to 67 percent of the statewide DBE goal. In most years the threshold is around 3 percent. I will refer to these firms meeting this criteria as "exemption eligible." A contractor is only allowed to use its exemption if its bid is lower than a maximum value, which is determined by the size of projects the contractor has completed in the prior two years. This prevents a firm from building up points on smaller projects, then avoiding the DBE goal on larger projects.

In January 2013, the US Department of Transportation instructed Iowa to cease the use of a quantitative good faith effort criteria. After this decision, the good faith effort criteria used by

[5] Currently only six states – Florida, Idaho, Maine, Montana, New Hampshire, Vermont, and Wyoming are able to satisfy their entire goal using race-neutral means.

[6] The utilization of DBE trucking companies counts toward the goal, as does sixty percent of purchases from DBE suppliers. A DBE prime contractor can count itself toward the satisfaction of the goal.

Iowa became similar to that used by other states. Under this standard, a bidder establishes its good faith effort by documenting the various steps it took to locate ready, willing, and able DBE subcontractors that "could reasonably be expected to obtain sufficient DBE participation, even if they were not fully successful." This may include advertising and outreach, subdividing work to be feasibly accomplished by DBE subcontractors, assisting DBEs in obtaining bonding, credit and insurance, or physical inputs such as necessary equipment. A prime contractor is not required to accept an unreasonably high quote from a DBE, however the presence of a lower cost non-DBE subcontractor is not sufficient justification for failing to meet the DBE goal.

4 Model

A government awards one road construction contract per period. There are two prime contractors in the market. Each project is infinitely divisible into tasks with unit mass. The government sets an affirmative action goal g_t for the period t project, which dictates the minimum portion of tasks that must be completed by DBE subcontractors.[7] Prime contractor i selects the portion of tasks to subcontract out to DBEs, h_{it}. The government allows at most $\overline{h}$ tasks be subcontracted out.

The winning bidder must either satisfy the affirmative action requirement or must have a recent history of utilizing DBE subcontractors. This history is measured by points $p_{it} = \sum_{s=t-T}^{t-1} h_{is}$, which is the total subcontractor utilization by the prime contractor over the prior T periods. If p_{it} exceeds a minimum level $\overline{p}$, the firm is considered "eligible" and is not required to use DBE subcontractors, though it still might elect to do so.[8]

In each period, the prime contractor learns its private per-task cost of c_{it}, drawn independently from the distribution $F(c)$. Prime contractors are capacity unconstrained. However, subcontractors' costs are affected by the aggregate subcontract awards to DBEs in the prior period, H_{t-1}. Since there is only one project awarded per period, H_{t-1} is simply equal to the subcontracting choice of the winner in period $t-1$. The subcontractor's per-unit cost is $c_{ht} + \gamma H_{t-1}$. The first component is the baseline per-unit cost if there were no backlog and is potentially time-varying for idiosyncratic reasons. The second component is depends on the prior period's awards to DBE subcontractors. The parameter γ is greater than zero and describes the degree to which backlog increases the per-unit cost of hiring DBE subcontractors. The prime contractor's total construction cost is therefore $C_{it} = (1 - h_{it})c_{it} + h_{it}(c_{ht} + \gamma H_{t-1})$.

[7]In practice, the goal is based on the percent of the contract value. In the model, this would substantially complicate characterizing the bid decision without adding insight regarding the firm's decision regarding DBE utilization.

[8]Consistent with institutional details, past subcontracting choices are observed by all firms in period t.

The points of a firm and its opponent are the state variables, which affect future profits through the exemption from affirmative action and the anticipated capacity constraints of subcontractors. The law of motion for the state variable is $p_{i,t+1} = p_{it} + h_{it} I(b_{it} < b_{-it}) - h_{i,t-T}$, reflecting the accumulation of new points should the firm win and the expiration of old points.

The contractor chooses a bid and subcontracting level to maximize the discounted value of expected profits. The Bellman equation for this problem is

$$V(p_i, p_{-i}) = \left[R(b_i) - C_i + \delta V(p_i^{'}, p_{-i}^{'}; win)\right] Pr(b_i < b_{-i}) + \delta(1 - Pr(b_i < b_{-i}))V(p_i^{'}, p_{-i}^{'}; lose) \quad (1)$$

$R(b_i)$ is the expected revenue associated with choosing bid b. The discount rate rate is δ. The term in brackets is the profits if winning, which is multiplied by the probability of winning. The continuation value of winning and losing is given by $V(p_i^{'}, p_{-i}^{'}; win)$ and $V(p_i^{'}, p_{-i}^{'}; lose)$, respectively.

In Appendix A.1 I describe a simplified version of the model, where there are two periods the per-task costs of prime contractors are assumed to be uniformly distributed, and the government runs a second price auction. These simplifications retain the model's key features while allowing for an analytical solution to what is otherwise a very complex dynamic subcontracting game.

Two key results arise from the model. First, factors that increase the future costs of affirmative action increase the level of DBE subcontracting in the current period. These factors include anticipated exogenous increases in DBE costs, $c_{h,t+1}$, future increases in the affirmative action goal, g_{t+1}, and a greater impact of backlog on DBE costs, as captured by the parameter γ. When subcontractor costs will be exogenously high or when capacity constraints are important, becoming exemption eligible is especially valuable due to the anticipated future cost advantage.

Second, the expected winning bid is lower under the exemption program across the range of parameter values considered, potentially even lower than would be the case without affirmative action. This result is an application of the Bertrand supertrap presented in Cabral and Villas-Boas (2005). In their model, an increase in economies of scope can perversely lower firm profits. If increasing production today lowers marginal cost in the future, this economy of scope has a direct effect of increasing profits, but also leads to a countervailing strategic effect, where firms lower prices in order to increase production today. The strategic effect lowers profits and can overwhelm the direct effect.

In the case of affirmative action exemptions, winning a contract today reduces costs in the future if it leads to exemption eligibility. The continuation value of winning will be priced into bids. Moreover, according to the model, high-cost bidders in an auction will find it cheapest to subcontract more heavily, since the difference between own-task and subcontractor cost will be the lowest. The continuation value of winning therefore will be greatest for higher cost firms. Since this is priced into bids, it has the effect of compressing the bid distribution and thereby lowering the markup of low-cost firms. The lowering of information rents could be large enough to outweigh the inefficiency of affirmative action's constraint on prime contractor's subcontracting choice, making winning bids lower than without an affirmative action program.

5 Data

The data include the universe of highway construction contracts awarded by the Iowa Department of Transportation from 2005 until 2014. These data contain the bids of the winning and losing bidders and the project-specific DBE goal selected by the Iowa Department of Transportation. The data provide each bidder's percentage DBE commitment on the projects with an affirmative action goal, and the dollar value that it would award to each DBE it intended to employ. For each letting date, the points of each firm is given. For lettings in 2011 and 2012, this includes both eligible and ineligible firms, and it lists the maximum project size to which a firm can apply its eligible status.

In Table 1, I present the summary statistics at the contract level separately for projects requiring DBE utilization and those with no DBE goal. The data contains 6581 contracts. The average winning bid is $1.18 million, though this his highly skewed due to several extremely large projects. The median winning bid is $351 thousand. Since only contracts using federal aid ever have affirmative action requirements in Iowa, and federal aid projects tend to be larger, this results in projects with a DBE goal tending to be much larger. The average bid on projects to which affirmative action applies is $2.9 million compared to $653 thousand for projects without a DBE goal. This difference is not driven by outliers, as the median winning bid on the two types of projects is $1.16 million and $249 thousand, respectively.

The average contract sees 4.1 bidders, and bidder participation is virtually identical between projects with and without DBE goals. However, the composition of bidders is different. The number of bidders who are exemption eligible is twice as high on affirmative action projects. There are 1.44 exemption eligible bidders on affirmative action projects compared to 0.76 on other projects. Sometimes the project winner is itself a DBE. This is true for 4.25 percent of all contracts and is nearly twice as likely on projects with a DBE goal than those without. Two factors may contribute to this. First, DBE bidders may have a comparative advantage on affirmative action projects since they can count themselves toward the satisfaction of the DBE goal. More importantly, goals are set higher in areas of the state and on types of projects where DBE availability is greater. Therefore, it is also likely that more prime contractors will be DBEs on projects with goals.

Most of the winning bidders are either compliant with the project's affirmative action requirements or are exempt. This is evidenced by the high rate of exemption eligibility by non-compliers. Among auction winners who failed to meet the DBE goal during this period, 81.5 percent were exemption eligible.

In Table 2, I present the summary statistics at the bidder level. Reflecting the larger project size, the average bid is substantially higher on affirmative action projects. The portion of bidders who are DBEs is only slightly higher than the portion of DBEs who are winners, suggesting that the average DBE bidder is about as successful as the average bidder overall.

The average bidder on projects with DBE goals has a DBE commitment percentage of 7.7 percent, which exceeds the DBE goal by 4.7 percentage points on average. Those figures include bidders who are DBEs and can count their own work in calculation of the DBE commitment. For bidders who are not DBEs, on average 3.9 percent of projects are awarded to DBEs, and the average commitment exceeds the goal by 0.97 percentage points. Though the average firm exceeds the DBE goal set for a project, only a little over one-half (51.6 percent) of bidders commit to using DBEs at a rate that meets or exceeds the DBE goal.

5.1 Exemption eligibility

In Figure 1, I examine the likelihood a prime contractor is exemption eligible in the months before and after winning an auction, plotted separately by whether or not the firm meets the affirmative action goal set for the project. This figure shows how exemption eligibility is affected by the affirmative action compliance decision. Date $t = 0$ is the month of auction victory. The rate of exemption eligibility among those firms that are compliant is 25.1 percent on the date of the auction win compared to 78.6 percent for those firms that are noncompliant. In the months following the auction win, the rate of exemption eligibility grows among compliant firms, likely because these firms gain points as a result of their auction win. In contrast, the rate of eligibility falls among non-compliant firms. Within one year of winning a project with an affirmative action goal, the difference in the likelihood of exemption eligibility between compliant and non-compliant firms shrinks to only 9 percentage points.

Exemption eligibility appears to be valued by firms. Figure 2 shows kernel density estimates of the distribution of points, the criteria for eligibility.[9] This distribution exhibits bunching just

[9] Points are not available for ineligible firms for all letting dates, so only those where points are observed for both eligible and ineligible firms are included.

above the eligibility threshold, consistent with prime contractors utilizing DBE subcontractors just enough gain eligibility. The bunching observed is not sharp, which is not surprising since there are likely to be optimization frictions preventing companies from precisely choosing their desired level of points. To accumulate more points, a prime contractor would need to win an auction where it will use DBE subcontractors, and winning the auction is a random event.[10]

6 Results

In this section, I present the primary findings of the paper showing how exemptions are used to smooth demand for DBE subcontractors. The focus in this section is on projects awarded during the pre-reform period. I begin by establishing that affirmative action requirements are enforced, and second I provide evidence suggesting that capacity constraints exist for DBE subcontractors. These lead to the primary specifications, where I use intertemporal variation in the volume of contracts with affirmative action goals to estimate how the compliance decision depends on current and future demands on DBE capacity.

6.1 Evidence that Affirmative Action Requirements are Binding

I begin by examining the distribution of DBE utilization and the rates of compliance with affirmative action, which will establish that affirmative action is a binding constraint on subcontracting.

In Figure 3, I plot the distribution of the ratio of the DBE commitment percentage chosen by the bidder divided by the DBE goal set for the auction. In panel (a), I plot the distribution across all bidders, while in panel (b) I display the distribution separately for auction winners and losers. Most auction participants tend to bunch at three different levels of DBE utilization: no utilization, utilization just above the project goal, and utilization just above 80 percent of the project goal. The latter is consistent with program rules allowing the contractor to meet only 80 percent of the goal. The distribution of the commitment-goal ratio does not differ substantially between firms that won and lost the auction.

In panel (c) of Figure 3, this same distribution is presented separately for exemption eligible firms. The bunching of firms at zero commitment is entirely due to eligible contractors. Firms therefore comply with the minimum allowable level of DBE utilization. Ineligible firms tend to satisfy the affirmative action requirements of a project, while eligible firms either fully meet the goal or take full advantage of their exemption.

[10] The bunching of the criteria variable calls into question the appropriateness of a regression discontinuity design, which would evaluate how outcomes such as bidding and participation on affirmative action projects change discontinuously at the eligibility threshold. The manipulation of the running variable potentially invalidates such an approach, so it is not taken here.

To formalize this evidence, Table 3 presents the results of regressing an indicator for compliance with the project goal on exemption eligibility. Two compliance variables are considered. One defines compliance as meeting the project goal. The other defines compliance as meeting 80 percent of the goal, as this also satisfies the good faith effort criteria in the pre-reform period.

Consistent with the results presented in the figure, exemption eligible firms are less likely to comply with affirmative action. Not controlling for other covariates, eligible firms are 6.9 percent less likely than ineligible firms to meet the project goal. This is somewhat misleading, as exemption eligible firms by definition utilize DBEs more heavily. The difference between eligible and ineligible firms grows once I condition on contractor fixed effects (column (2)). When a firm is exemption eligible it is 19 percent less likely to meet the project goal compared to when that same firm is ineligible. Adding letting-day and contract fixed effects in columns (3) and (4) respectively leaves this conclusion virtually unchanged.[11]

The results are similar when compliance is defined as DBE utilization exceeding 80 percent of the project goal. Exemption eligible contractors are 25 percentage points less likely to comply with the project goal under this definition. Including contractor fixed effects increases this estimate to 28 percent. As with the previous definition of compliance, including letting effects and contract effects changes this conclusion little.

6.2 Evidence of DBE Capacity Constraints

I next document evidence consistent with capacity constraints among DBE subcontractors. At each letting date and for each DBE subcontractor, I form a participation rate for the DBE, defined as the portion of auctions with a positive DBE goal where at least one bidder intended to utilize the subcontractor. I examine how this participation rate changes in the months after a subcontractor is utilized by a winning bidder. Subcontractor costs are not observed directly, but the participation rate will be an indirect measure if a subcontractor is more likely to be hired when its costs are low.[12] A required assumption is that cost shifters are not serially correlated for DBEs. Suppose a DBE has a favorable cost draw and is utilized as a subcontractor today. A violation of this assumption would occur if projects in subsequent periods are unfavorable for that DBE. An example would be if affirmative action projects in a particular location were typically let in June, while affirmative action projects in other locations were let in subsequent months.

[11]The model suggests that the DBE utilization decision is made independent of the bidding decision and will therefore be unrelated to the degree of competition faced in the auction. Consistent with this hypothesis, the coefficient on the number of competing bidders faced in the auction is small and statistically insignificant.

[12]The value of the subcontract is observed in the data, however any further details regarding the scale or scope of the subcontract is not.

In Figure 4, I plot the average participation rate for DBE subcontractors around the month of being utilized on a successful bid. The participation rate declines markedly in the month following being listed in a successful bid, and remains depressed for five months.[13] Notably, this is only the case for subcontracts that represent a large portion of the firm's capacity.[14] For low capacity utilization subcontracts, a decline in participation is not evident.

In Table 4, I present the regression results that correspond to this figure. In the specifications shown in this table, the participation rate for the subcontractor is regressed on indicators for being utilized on a winning bid in the previous six months and between 7 and 12 months ago, and an indicator for being on a winning bid in the current letting month. Due to the inherent correlation of participation rates across subcontractors within the same month (one subcontractor is likely hired at the expense of another), standard errors are clustered by year-month. These results show that receiving a subcontract reduces the rate of participation by a statistically significant 3.0 percent in the following six months when the subcontract represents a high portion of a subcontractor's capacity, as seen in column (1). This result is virtually unchanged when including subcontractor fixed effects, as seen in column (2).

Prime contractors are likely capacity constrained as well, which leads to the worry that a subcontractor's participation is falling simply because the company that tends to hire it is participating less after winning an auction. I address this concern in the specification shown in column (3) by controlling for the participation rate of primes who hired the sub at $t = 0$. For prime contractors who utilized a particular subcontractor on a winning bid at $t = 0$, I measured the average auction participation rates for those primes in each month from $t = -6$ to $t = 12$. This is included as a control variable. As expected, the estimated coefficient on this variable is positive – a subcontractor is more likely to participate on a project in a month when the prime contractors with whom it works participate. Despite this, the inclusion of this variable has little effect on the main coefficient of interest.

In columns (4)-(6), I present similar specifications for subcontracts utilizing a lower portion of capacity. In contrast to the results shown in columns (1)-(3), small subcontracts have almost no impact on the participation rate.

[13] The spike in participation at date $t = 0$ is mechanical, since the firm participates in at least one bid on this date.

[14] Firm capacity is defined as the maximum dollar value of subcontracts the firm was awarded on any given letting date in the data. A high capacity utilization subcontract is defined as one in the 75th percentile of the percentage capacity utilization distribution. Empirically, a 75th percentile subcontract is 35 percent of capacity.

6.3 Contract volume and the utilization of DBE subcontractors

If subcontractors are capacity constrained as suggested by the results in section 6.2, how are prime contractors' subcontracting decisions affected? The number of projects with affirmative action goals varies over time, and we would expect that prime contractors would utilize DBEs more heavily when affirmative action contract volume is low and less heavily when volume is high. High DBE costs lead exemption eligible firms to exercise their exemption option, and it also reduces the incentive to over-comply to accumulate points. Therefore, we expect that a higher number of recently awarded affirmative action contracts will be associated with a lower rate of DBE utilization.

Anticipated future contract volume in the near term could either reduce or increase DBE utilization. On the negative side, DBE subcontractors may price into a current subcontract the effect its award would have on future capacity. On the other hand, prime contractors may wish to preserve or gain exemption status for periods in the near future when DBE subcontractors are likely to be constrained.

As a measure of aggregate capacity utilization in the DBE market, I use the total number of prime contracts with DBE goals awarded over the prior three months.[15] I also form a similarly defined measure of anticipated future demand, the number of affirmative action projects to be awarded over the following three months.

I estimate the following specification of the compliance decision.

$$c_{ikt} = \beta_0 + \beta_1 e_{ik} + \beta_2 e_{ik} * d_t + \rho_t + \alpha_i + \epsilon_{ikt} \tag{2}$$

The variable e_{ik} is an indicator for the exemption eligibility of contractor i on project k, d_t is the measure of demand for DBE subcontractors on letting date t, and ρ_t and α_i capture letting date and prime contractor fixed effects, respectively.

One concern in estimating equation (2) arises if d_t is endogenously determined by compliance decisions made today, leading to reverse causality. That is, if DBEs are used more heavily by prime contractors today, Iowa may choose to reduce the number of projects with affirmative action goals in the future. The variation in future affirmative action contract volume has two sources – the number of prime contracts that are awarded and the portion of these contracts to which affirmative action goals are applied. The first source of variation is exogenous, as projects to be auctioned

[15] A nontrivial proportion of the variation in the affirmative action contract volume arises due to the American Recovery and Reinvestment Act. It was signed into law in 2009 and entailed a substantial amount of highway funding that was required to be obligated by March 2010. For the average contract let in Iowa in 2009, 92.5 projects with affirmative action goals had been awarded over the preceding three months. This is nearly twice as much as any other year in the data.

over the next five months are publicized in advance. Any endogeneity must operate through the second channel. Though there is no indication that Iowa operates in this manner, to alleviate this concern, I form two instruments for the volume of affirmative action contracts. In one measure, I calculate for each county the likelihood that an affirmative action goal is applied, and I use this likelihood to predict the number of affirmative action contracts in the prior and upcoming three months based on the total number of contracts let in the county during that time. The second instrument is based on the number of federal aid contracts let in the prior and upcoming three months, since affirmative action is only ever applied to federal aid contracts.

In Table 5, I present the results of estimating equation (2). As prior and expected future demand for DBE subcontractors rises, the average firm reduces its rate of compliance. A one standard deviation increase in the number of DBE contracts awarded in the prior three months (34.9 contracts) decreases the rate of compliance by 1.8 percentage points. This is a nontrivial decrease in compliance, since the average rate of compliance in the pre-reform period is 82.9 percent. The effect is in fact stronger for anticipated future demand. A one standard deviation increase in the number of affirmative action contracts let in the following three months decreases compliance by 2.4 percentage points.

The response to DBE capacity constraints depends on exemption eligibility. Eligible bidders are 3.5 percentage points less likely to comply with the affirmative action goal in response to a one standard deviation increase in prior DBE contract volume, while the response of ineligible firms is less than one-quarter as large and not statistically significant.

The effect of upcoming contract volume is more complex. This variable is negatively related to the compliance of the average bidder, as seen in column (1) of Table 5. In column (2), which includes an interaction between upcoming contract volume and eligibility, we see that ineligible firms are responsible for this negative effect. The direct effect of upcoming contract volume is negative, while the coefficient on its interaction with eligibility status is positive and offsetting. Thus, the rate of affirmative action compliance by exemption eligible firms does not respond to future contract volume. One explanation for this result is that DBE subcontractors consider the effect that today's subcontract has on future capacity utilization and incorporate this into the price they charge. This would act to reduce DBE utilization among prime contractors, particularly those who are not seeking exemption eligibility. Furthermore, exemption eligible firms may wish to maintain eligibility status to prepare for upcoming affirmative action requirements.[16]

[16] I explore this explanation in Appendix Table A2. Past and future contract volume is interacted with an indicator for having zero points toward exemption eligibility. A firm with zero points is less likely to seek eligibility, and therefore be particularly discouraged by higher DBE prices. In this same table, I also include the HHI of DBE market shares by county and by letting date, interacting these measures with future contract volume. DBEs with market power may incorporate future contract volume into their current price to a greater extent. The results in this table are consistent with the hypothesis that future contract volume discourages DBE use today through a price effect.

The results in column (3) show that the coefficients on the interactions between eligibility status and past and future affirmative action contract volume are robust to the inclusion of letting date fixed effects, which eases concerns that some letting dates both have high demand and are disadvantageous for affirmative action compliance for an unobserved reason. The coefficient of interest in this specification uses within letting date variation, comparing affirmative action compliance by eligible and ineligible firms on letting dates with varying degrees of DBE demand. In columns (4) and (5), I present IV estimates of specifications otherwise identical to the OLS specifications. As described earlier, the instruments for past and future affirmative action contract volume are the number of past and future federal aid contracts, and the predicted number of past and future contracts with goals based on the counties in which projects were awarded. The results indicate that the OLS and IV estimates are very close to one another.[17]

Past and future affirmative action contract volume may influence the degree of DBE utilization in addition to the compliance decision. In Figures 5 and 6, the distribution of DBE utilization, as measured by the ratio of the percentage DBE commitment by the bidder to the project goal, is presented separately for periods of high and low DBE demand. Exemption eligible firms are more likely to use their exemption during high-DBE demand periods. The pattern is reversed for future DBE demand. Exemption eligible firms bunch at zero utilization to a greater extent when the value of future DBE subcontracts is low, likely reflecting the value of maintaining the exemption eligibility in times when it will be most valuable. No such excess bunching at zero utilization is observed for ineligible firms.

In Table 6, I present estimates of a specification where the dependent variable, rather than an indicator for compliance, is instead the ratio of the DBE commitment to the DBE goal.[18] DBE subcontractors are used less intensively when more projects with DBE goals are upcoming, an effect driven by ineligible firms. In all specifications, exemption eligible firms utilize DBE subcontractors less intensively, though the incentive to maintain eligibility status when future DBE requirements are high offsets this substantially.

In the specification shown in column (4), I control for project size using the log bid of the firm.[19] Doing so could be relevant if some project tasks are indivisible or there are fixed costs of hiring

[17] One difference is that the number of observations is lower in the IV specification. This is due to the funding source not being available for all letting dates and auctions.

[18] The distribution of this ratio has a long right tail, so I have topcoded observations above the 98th percentile.

[19] Controlling for the firm's bid is meant to capture the scale of the project, though is potentially problematic if DBE utilization affects firm costs. An alternative measure is the average bid for a contract. Using this measure instead leads to nearly identical results. The estimated coefficient on the log bid in column (4) is -0.971 compared to -0.977 if the average project bid was used instead.

subcontractors. The results show that larger projects are associated with a lower percent DBE utilization, however the estimates of the main coefficients of interest are virtually unchanged.

Finally in column (5), I restrict attention to firms with non-zero DBE utilization to investigate the intensive margin of DBE utilization. The results indicate that a majority of the difference in DBE utilization between eligible and ineligible firms is due to the bunching at zero utilization by exemption eligible firms, as the coefficient on the eligible indicator shrinks from -0.52 to -0.16. The sign and magnitude of the other main coefficients of interest are largely unaffected, indicating that past and future affirmative action contract volume have similar effects on both the intensive and extensive margin of exemption eligible firms.

7 Good faith effort reform

In January 2013, the Federal Highway Administration required Iowa to drop its exemption program. Instead, a firm falling short of the affirmative action goal would need to establish its good faith effort to hire DBE subcontractors, as is standard in other states. In this section, I describe the effects of the reform on DBE utilization and the bidding behavior of firms. In contrast to the empirical work described in section 6, the specifications in this section utilize data from auctions conducted between January 2011 and August 2014, which spans the reform.

7.1 DBE utilization effect of eliminating exemptions

I begin by considering how the good faith effort policy used by the state affected the utilization of DBE subcontractors. I exploit the timing of the reform to estimate the pre- versus post-reform difference in the utilization of DBE subcontractors by the average bidder. In Figure 7, I plot the distribution of DBE utilization separately for the pre- and post-reform periods. The elimination of the exemption program had a significant impact on the distribution of DBE commitments. Non-compliance with project goals was virtually eliminated. This implies that the good faith effort criteria was rarely used post-reform. The increased compliance may or may not result in greater DBE utilization overall, depending on whether there was an offsetting reduction in over-compliance post-reform, as we would expect. This is difficult to assess visually in this figure.

To better understand the underlying mechanisms, I examine how the utilization response differed between firms that were and were not exemption eligible at the time of the reform. These two types of firms had differing incentives leading up to the reform and symmetric incentives post-reform. I hypothesize that the utilization of previously eligible firms should rise relative to previously ineligible firms for two reasons. First, prior to the reform, eligible firms had the option to exercise their exemption. The reform takes away this option, and therefore has the direct effect of increasing average utilization among previously eligible firms. Second, the exemption program created stronger dynamic incentives for DBE utilization among ineligible firms. Contractors had an incentive to maintain points already accumulated and to increase points to obtain exemption eligibility in the future. The latter was presumably not relevant for contractors who were already eligible. However both incentives were relevant for non-eligible firms. Therefore, eliminating the exemption program should lower DBE utilization for ineligible contractors compared to eligible ones.

Figure 8 plots the average DBE utilization over time for firms exemption eligible and ineligible at $t = 0$, focusing on a narrow time window since eligibility status changes over time. This figure shows the average residual ratio of the DBE commitment percentage to the DBE goal separately by exemption eligibility status at the time of the reform. This is the residual from a regression of the commitment-to-goal ratio on month effects and indicators for each of the three possible values for the DBE goal.[20] The results indicate that the average commitment-to-goal ratio was similar for the two types of firms in the pre-reform period.[21] As predicted, in the post reform period, the utilization of previously exemption eligible firms rose relative to their ineligible counterparts.

In Table 7, I present the regression results that correspond to this figure. Specifically, I estimate the regression specification

$$h_{ikt} = \beta_0 + \beta_1 post_{kt} + \beta_2 post_{ikt} * elig_i^{t=0} + \beta_3 g_k + \gamma_i + \epsilon_{ikt} \quad (3)$$

where h_{ikt} is the percentage DBE utilization, $post_{ikt}$ indicates the post-reform period, $elig_i^{t=0}$ indicates that a firm was exemption eligible at the time of the reform, g_k is the DBE goal on project k, and γ_i represents a firm-specific effect. In an alternative specification, I will also include contract effects, which preclude the identification of β_1 and β_3.

In column (1), I present estimates of a specification including only a post-reform indicator (all specifications include prime contractor fixed effects). The percent DBE commitment for the average bidder in the post-reform period is nearly half a percent lower than in the pre-reform period. This decline in DBE utilization is explained by a decline in the affirmative action goal faced by the

[20] I take out month effects in case there is a seasonal pattern in utilization, and I include dummy variables for the goal values to capture any non-linearities in the commitment-goal gradient. The general time pattern is robust to alternative representations, such as plotting the raw values of DBE commitments or the commitment-to-goal ratio.

[21] Two quarters prior to the reform, the average utilization appears to decline noticeably for ineligible firms. It is important to note that the DBE goal was zero for all contracts in August and September of 2012, so that the commitment-to-goal ratio was missing for all but 34 bids for this quarter. By comparison, the quarter before has 232 observations and the quarter after 182.

average bidder. In column (2), I include the DBE goal as a regressor, and the estimated post-reform indicator coefficient becomes much smaller, positive and statistically insignificant.

The specification shown in column (3) includes an interaction between the post-reform indicator and the $t = 0$ exemption eligible dummy. Relative to firms who were ineligible at the time of the reform, exemption eligible firms increased their percentage DBE subcontractor commitment by 0.66 percentage points, which rises to 0.96 upon the inclusion of contract effects in specification (4). This is a substantial increase given that the average white-owned prime contractor awards 3.9 percent of the contract value to DBE subcontractors.

Finally, in column (5) I include interactions between the post-reform variable, the exemption eligibility indicator, and the measures of past and future DBE contract volume. This is meant to show how exemption eligible firms altered their response to aggregate DBE demand in the post-reform period. A drawback of this exercise is that the post-reform window is fairly short, which reduces the power of this test. The coefficients on these interaction terms are negative, but not statistically significant.

7.2 Procurement cost effect of eliminating exemptions

I now examine how changing the good faith effort policy affected bidding behavior and government procurement cost. A firm's bid is comprised of the cost of completing the project and a markup over this cost. The exemption policy could affect both of these components, as it could allow for more efficient use of DBE subcontractors over time and more aggressive bidding for affirmative action contracts.

I estimate what is essentially a difference-in-difference approach, comparing projects with goals to those without, before-versus-after the reform, though the DBE goal can take on multiple values. The equation to be estimated is

$$ln(b_{ikt}) = \alpha_0 + \alpha_1 g_k + \alpha_2 post_{kt} + \alpha_3 post_{kt} * g_k + \alpha_4 n_k + AX_{ikt} + \epsilon_{ikt} \tag{4}$$

where b_{ikt} is the bid submitted by firm i for project k auctioned at date t. The variable $post_{kt}$ indicates that the auction was held after the reform. This variable in most specifications will be subsumed by more detailed controls for common time effects. The variable n_k is the number of bidders, and X_{ikt} is a vector of other project, firm, and time controls. As before, g_k is the DBE goal set by the state for project k, and it usually takes on a value of either 0, 2.5 percent, or 5 percent. The coefficient of interest will be α_3.

It is critical to account for project heterogeneity through the set of controls, X_{ikt}. Project scale varies widely. Even a relatively small change in the size of the average affirmative action project could seriously bias the estimate of α_3. The engineer's estimate of project cost is the control most commonly used in the highway construction literature. While many states include it in the publicly available project documents, unfortunately Iowa keeps this estimate confidential.

I instead use the value of the proposal guaranty, which is a bond guaranteeing that a firm will enter into contract if its bid is accepted. The amount of the proposal guarantee is based directly on the engineer's estimate, and it accounts for 96 percent of the variation of the log bid across contracts.[22] The proposal guaranty takes on one of twenty-four values depending on bins of the *ex ante* estimated project cost, and I control for dummy variables for each of these values to allow for any nonlinearities in the relationship between project scale and the proposal guaranty.[23] To further control for cost shifters, I will also include indicators for the county in which the project takes place and the type of work to be performed.

I begin by showing the distribution of residual bids in the pre- and post-reform periods, plotted separately for projects with and without affirmative action goals. This variable is the residual from a regression of the log bid on project characteristics, including indicators for each level of the proposal guaranty, and type of work, county, and firm effects. In Panel (a) of Figure 9 I show the distribution for projects without an affirmative action requirement. The distribution of bids changed little from the pre-reform to the post-reform period for these projects. This stands in contrast to the distribution of bids on affirmative action projects, for which the bid distribution is shifted noticeably to the right post-reform, as seen in Panel (b).

The results of estimating equation (4) are presented in Tables 8 and 9, first for all bids for federally funded contracts and then for only winning bids. The specification shown in column (1) of Table 8 includes no covariates aside from the post-reform indicator, the DBE goal, the interaction of these two variables, and the number of bidders. The coefficient on the DBE goal variable is 0.75, and the coefficient on the interaction between the post-reform indicator and the DBE goal is 3.84. The magnitude of these two coefficients are very large and are substantially attenuated by the inclusion of controls for year, month and project type indicators (column (2)) and county indicators

[22] In a regression with the log bid on the left hand side, and no other covariates, the coefficient on the log proposal guaranty is 1.01 (0.002), $R^2 = 0.9577$. These data are somewhat more limited than the broader sample, as I have not been able to obtain proposal guaranty information for auctions prior to 2007. A handful of other letting dates were also unavailable.

[23] See Table A3 in the appendix. It is worth noting that the bins are often quite wide, especially relative to the location of the bin. As an example, the same proposal guaranty is assigned to projects between \$250 and 500 thousand. In Figure A2 in the appendix, I plot the mean log bid, interquartile range, and 5th and 95th percentiles of log bids conditional on the proposal guaranty. The relationship is close to linear. However, the amount of variation across bids for a given proposal guaranty is not trivial, and there is noticeable overlap in the distribution of bids across different levels of the proposal guaranty. Consequently, the bidding results should be interpreted with some caution.

(column(3)).[24] Including these controls substantially reduce estimated coefficients of interest, α_1 and α_3, to 0.44 and 2.4 respectively. In column (4), I include a finer set of time controls, which are year-month dummies. The finer set of time controls increases the estimated pre-reform effect of the goal to 1.02, while somewhat attenuating the estimate of the coefficient on the goal*post-reform interaction to 1.72. In column (5), I show that the results are similar when including firm fixed effects, suggesting that the results are not due to a change in bidder composition.

The estimated effect of affirmative action on both the average bid is very large, particularly after the reform. An increase in the DBE goal from 0 to 2.5 percent implies an increase in the average bid of 2.6 percent prior to the DBE reform and 6.9 percent after the DBE reform.[25] Cost differences seem insufficient as an explanation, unless there exists a fixed cost of hiring subcontractors. The DBE in the post-reform period would need to cost nearly three times as high compared to completing the same task in-house or hiring a non-DBE subcontractor. A second explanation is that the bidding response of eliminating the exemption could be disproportionate to the cost effect. In the theoretical model, the continuation value of winning is largest for weaker bidders under the exemption program, thereby decreasing the information rents for the stronger bidders.

A final possibility is that minority-owned subcontractors are able to exercise market power, particularly when capacity constraints bind for their competitors. The county-level Herfindahl-Hirschman index (HHI) in the DBE subcontractor market is 0.31 for the average county, which is highly concentrated.[26] This suggests that market power could be a contributing factor. To investigate this further, column (6) of Table 8 includes an interaction between county HHI in the DBE subcontractor market with the affirmative action goal. In the regressions, the minimum value has been subtracted from HHI, so that the interpretation of the DBE goal coefficient is the effect for the county with the lowest HHI. In this least-concentrated county, the affirmative action goal has little estimated effect on the average bid.[27] The effect of affirmative action increases substantially as concentration rises, as the estimated coefficient on the HHI-goal interaction term is 6.46 and statistically significant. A one standard deviation increase in county-level HHI is 0.15, which would increase the coefficient on the affirmative action goal by 0.97. This is sizable. Consider a county with an HHI one standard deviation above the least concentrated county. A one percentage point

[24] I include dummies for the most common project types – hot mixed asphalt paving, rigid pavement, bridge, and culvert. These accounted for 55.8 percent of projects. All other work types were in the excluded category.

[25] By comparison, Marion (2009) using data from California highway construction projects estimates a DBE goal coefficient between 0.3 and 0.6.

[26] This is calculated using the DBE's share of subcontracts awarded on affirmative action projects in a county.

[27] It is worth noting that while the point estimate is only -0.018, the standard error of this coefficient is 0.58. The confidence interval of this coefficient is therefore fairly wide.

increase in the affirmative action goal in this county is associated with nearly a one percent increase in the average bid.

The effect of the project goal on the average bid may not reflect its effect on government procurement cost. In Table 9, I present the results of estimating equation (4) using only winning bids. A similar pattern emerges as for average bids, though the coefficients are estimated with less precision, probably due to the smaller sample size. In the full specification with controls for the number of bidders and project type, county, firm, and detailed time effects, the estimated effect of the DBE goal in the pre-reform period is 2.12, rising by 1.59 in the post-reform period. The latter effect is not statistically significant in the full specification, though is similar in magnitude as the effect estimated for all bidders. As with the average bid, DBE concentration has a noticeable effect on the affirmative action goal coefficient.

8 Conclusion

The results shown in this paper suggest how affirmative action programs could be designed to reduce their cost to the government without reducing the utilization of preferred firms. Allowing for affirmative action exemptions allows prime contractors to handle time varying costs of DBE subcontractors, particularly related to capacity constraints, a source of inefficiency not previously considered in the affirmative action literature. The volume of contracts to which goals apply varies over time, creating periods where demand for DBE subcontractors is high and capacity constraints are binding. When exemptions from affirmative action requirements are based on DBE utilization history, I find that prime contractors utilize DBE subcontractors in such a way to smooth this demand. Firms build a history of DBE utilization to obtain exemption eligibility when capacity constraints are slack, and then take advantage of the exemption when capacity constraints bind. I provide suggestive evidence that this lowers the cost of affirmative action to the government.

The results imply that policies that smooth demand from DBE subcontractors can be efficiency enhancing. The traditional good faith effort criteria could conceivably serve this purpose if binding capacity constraints reduce the number of ready, willing, and able subcontractors. However, if the prime contractor solicits bids from DBE subcontractors and finds firms that are available yet charge a higher price than what it would cost to complete the tasks in-house, this is not sufficient evidence of a good faith effort in a typical affirmative action program. Therefore, the traditional good faith effort criteria may not be successful in reducing the costs of time varying demands on DBE capacity. Furthermore, meeting the good faith effort criteria is a subjective judgment call made by the procuring agency, which raises the question of how strictly the criteria is enforced. Policy makers may need to take DBE backlog into account in setting the project-specific goals in much the same way as static measures of firm availability currently are used.

References

Arozamena, Leandro and Estelle Cantillon, "Investment incentives in procurement auctions," *The Review of Economic Studies*, 2004, *71* (1), 1–18.

Bajari, Patrick and Gregory Lewis, "Moral Hazard, Incentive Contracts, and Risk: Evidence from Procurement," *The Review of Economic Studies*, 2014, p. rdu002.

_ , Stephanie Houghton, and Steven Tadelis, "Bidding for incomplete contracts: an empirical analysis of adaptation costs," *The American Economic Review*, 2014, *104* (4), 1288–1319.

Balat, Jorge, "Highway Procurement and the Stimulus Package: Identification and Estimation of Dynamic Auctions with Unobserved Heterogeneity," 2014.

Bates, Timothy and Darrell Williams, "Preferential Procurement Programs and Minority-Owned Businesses," *Journal of Urban Affairs*, 1995, *17* (1), 1–17.

_ and _ , "Do preferential procurement programs benefit minority business?," *The American Economic Review*, 1996, pp. 294–297.

Branzoli, Nicola and Francesco Decarolis, "Entry and Subcontracting in Public Procurement Auctions," *Management Science*, 2015.

Cabral, Luís MB and Miguel Villas-Boas, "Bertrand supertraps," *Management Science*, 2005, *51* (4), 599–613.

Chatterji, Aaron K, Kenneth Y Chay, and Robert W Fairlie, "The impact of city contracting set-asides on black self-employment and employment," *Journal of Labor Economics*, 2014, *32* (3), 507–561.

De Silva, Dakshina G, Timothy Dunne, Anuruddha Kankanamge, and Georgia Kosmopoulou, "The impact of public information on bidding in highway procurement auctions," *European Economic Review*, 2008, *52* (1), 150–181.

_ , Timothy P Hubbard, and Georgia Kosmopoulou, "Efficacy of a Bidder Training Program: Lessons from LINC," Technical Report, University Library of Munich, Germany 2013.

Fairlie, Robert and Justin Marion, "Affirmative action programs and business ownership among minorities and women," *Small Business Economics*, 2012, *39* (2), 319–339.

Griffin, Peter, "The impact of affirmative action on labor demand: A test of some implications of the Le Chatelier principle," *The Review of Economics and Statistics*, 1992, pp. 251–260.

Hahn, Jinyong, Petra Todd, and Wilbert Van der Klaauw, "Identification and estimation of treatment effects with a regression-discontinuity design," *Econometrica*, 2001, *69* (1), 201–209.

Hong, Han and Matthew Shum, "Increasing competition and the winner's curse: Evidence from procurement," *The Review of Economic Studies*, 2002, *69* (4), 871–898.

Jeziorski, Przemyslaw and Elena Krasnokutskaya, "Dynamic Auction Environment with Subcontracting," 2013.

Jofre-Bonet, Mireia and Martin Pesendorfer, "Estimation of a dynamic auction game," *Econometrica*, 2003, *71* (5), 1443–1489.

Krasnokutskaya, Elena and Katja Seim, "Bid preference programs and participation in highway procurement auctions," *The American Economic Review*, 2011, *101* (6), 2653–2686.

Li, Tong and Xiaoyong Zheng, "Entry and competition effects in first-price auctions: theory and evidence from procurement auctions," *The Review of Economic Studies*, 2009, *76* (4), 1397–1429.

Marion, Justin, "Are bid preferences benign? The effect of small business subsidies in highway procurement auctions," *Journal of Public Economics*, 2007, *91* (7), 1591–1624.

_ , "How costly is affirmative action? Government contracting and California's Proposition 209," *The Review of Economics and Statistics*, 2009, *91* (3), 503–522.

_ , "Affirmative Action And The Utilization Of Minority-And Women-Owned Businesses In Highway Procurement," *Economic Inquiry*, 2011, *49* (3), 899–915.

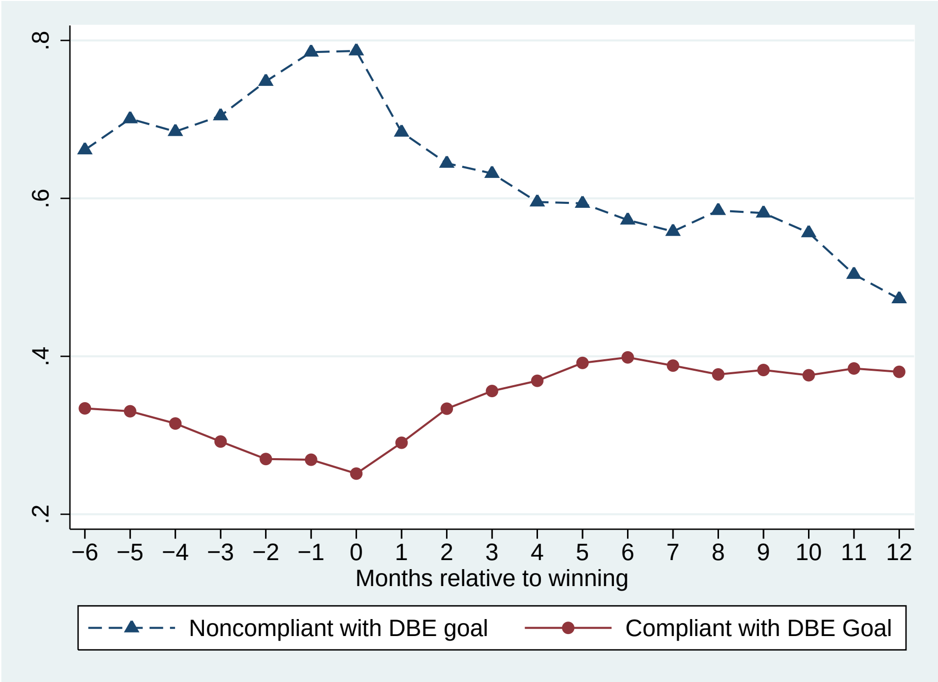
McCrary, Justin, "The effect of court-ordered hiring quotas on the composition and quality of police," *The American Economic Review*, 2007, pp. 318–353.

Miller, Amalia R and Carmit Segal, "Does temporary affirmative action produce persistent effects? A study of black and female employment in law enforcement," *Review of Economics and Statistics*, 2012, *94* (4), 1107–1125.

Miller, Conrad, "The Persistent Effect of Temporary Affirmative Action," 2014. Working paper.

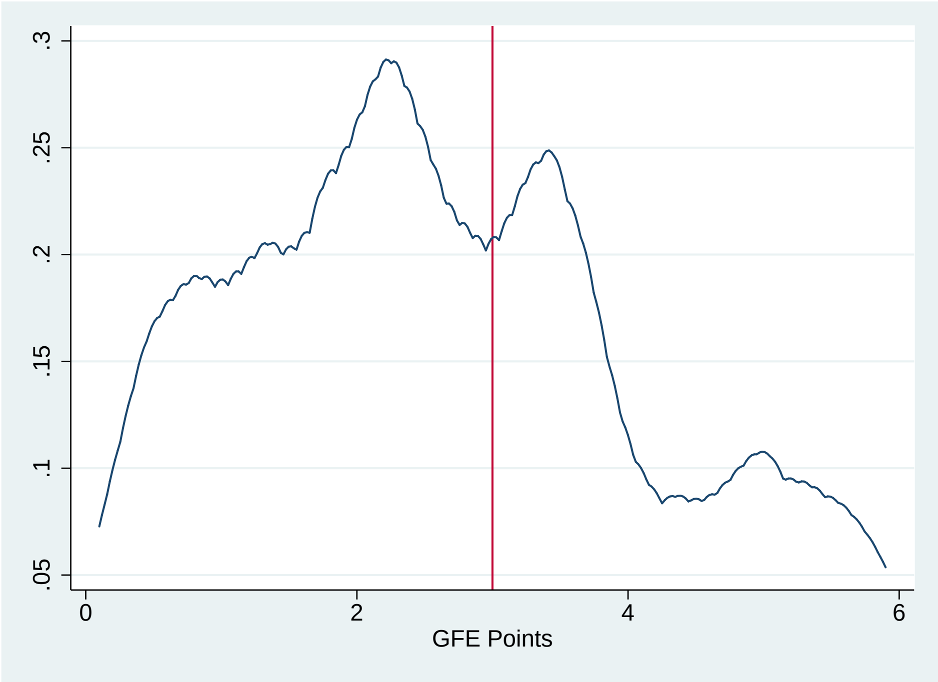
Onji, Kazuki, "The response of firms to eligibility thresholds: Evidence from the Japanese value-added tax," *Journal of Public Economics*, 2009, *93* (5), 766–775.

Figure 1: Exemption Eligibility Around Affirmative Action Auction Win, By DBE Goal Compliance



In this figure, all winners of affirmative action auctions are separated by whether they were compliant or noncompliant with the project goal. The data is centered at the month of auction win. The figure plots the portion of these winners that were exemption eligible by month relative to the month of auction victory.

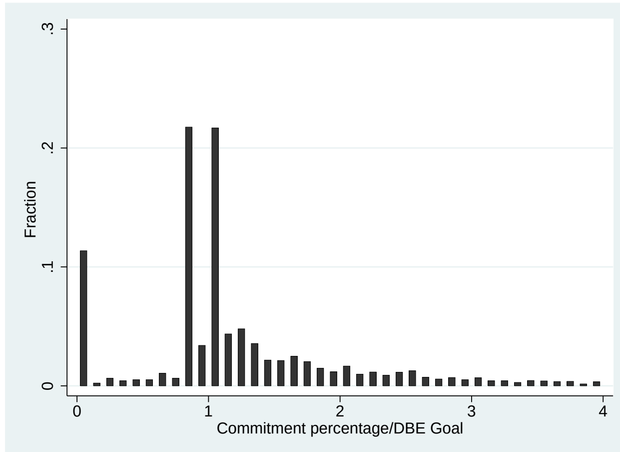
Figure 2: Distribution of Points



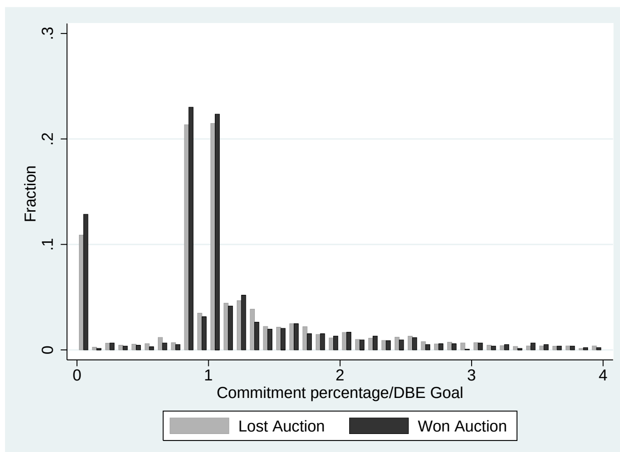
This figure plots kernel density estimates of the distribution of points, where the unit of observation is the firm-letting date level. There is one observation for each firm with positive points on each letting date, so the same firm contributes to the density estimates potentially multiple times.

Figure 3: Distribution of DBE Commitment/DBE Goal Ratio

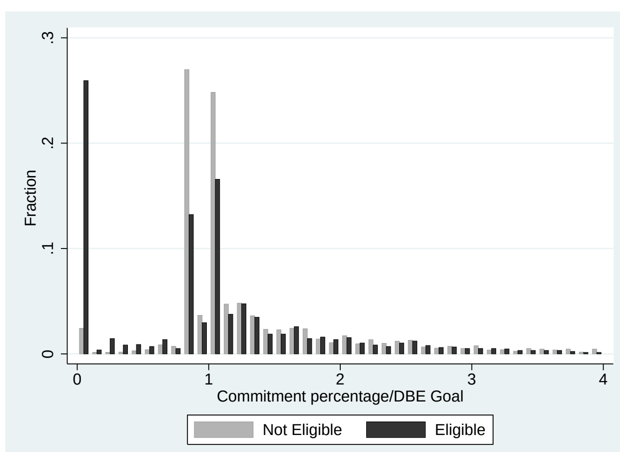
(a) All bidders



(b) By auction winner

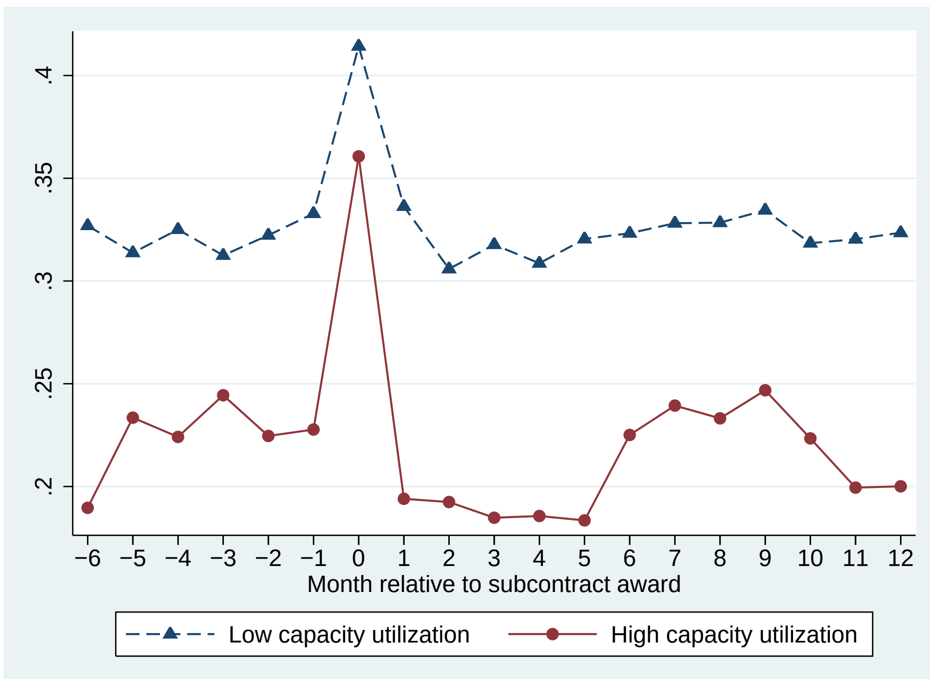


(c) By exemption eligibility



The commitment-goal ratio divides the percentage DBE commitment of a bidder by the percentage DBE goal of the auction. Each bin is 0.1 wide, and the histogram is truncated as a handful of bidders utilize DBE subcontractors well in excess of the project goal.

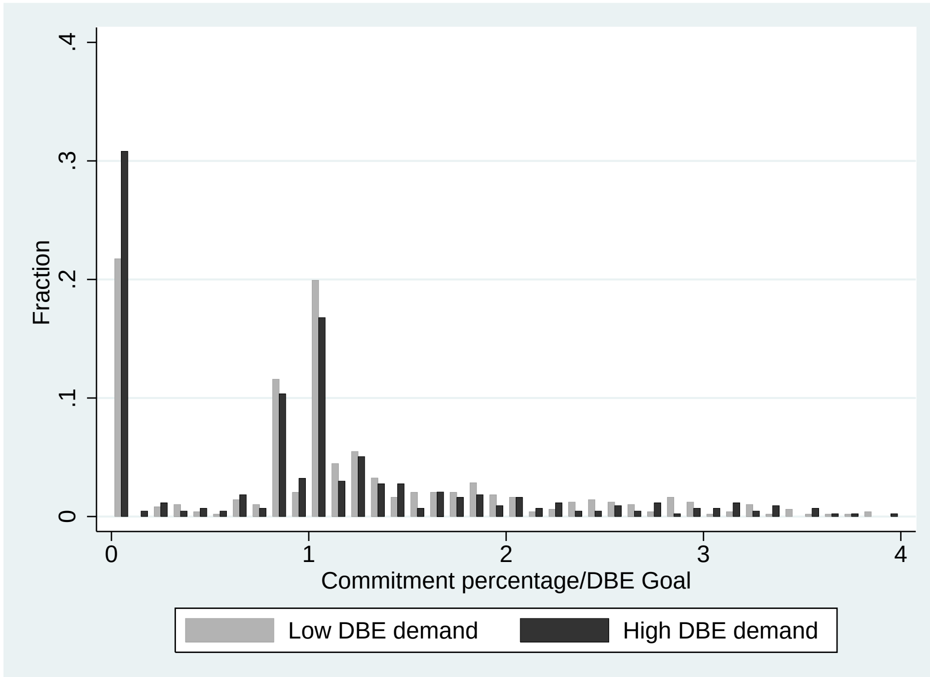
Figure 4: DBE Subcontractor Participation on Affirmative Action Projects Before and After Subcontractor Award, By Subcontractor Capacity Utilization



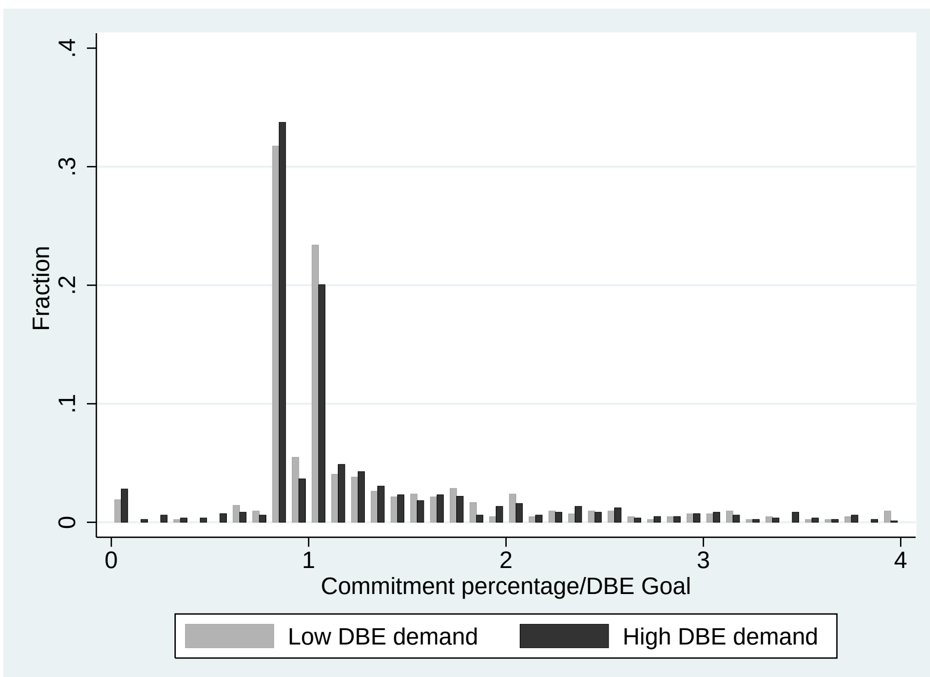
Date zero is the month in which a DBE subcontractor was listed by the prime contractor on a winning bid. The percent capacity utilization is the value of the subcontract divided by the maximum subcontract awarded to that subcontractor in the data. A high (low) capacity utilization subcontract is one whose percent capacity utilization is in the top (bottom) 25 percentile. Plotted is the number of bidders per affirmative action auction intending to utilize the subcontractor.

Figure 5: Distribution of DBE Commitments: By DBE demand in prior 3 months

(a) Exemption Eligible Firms



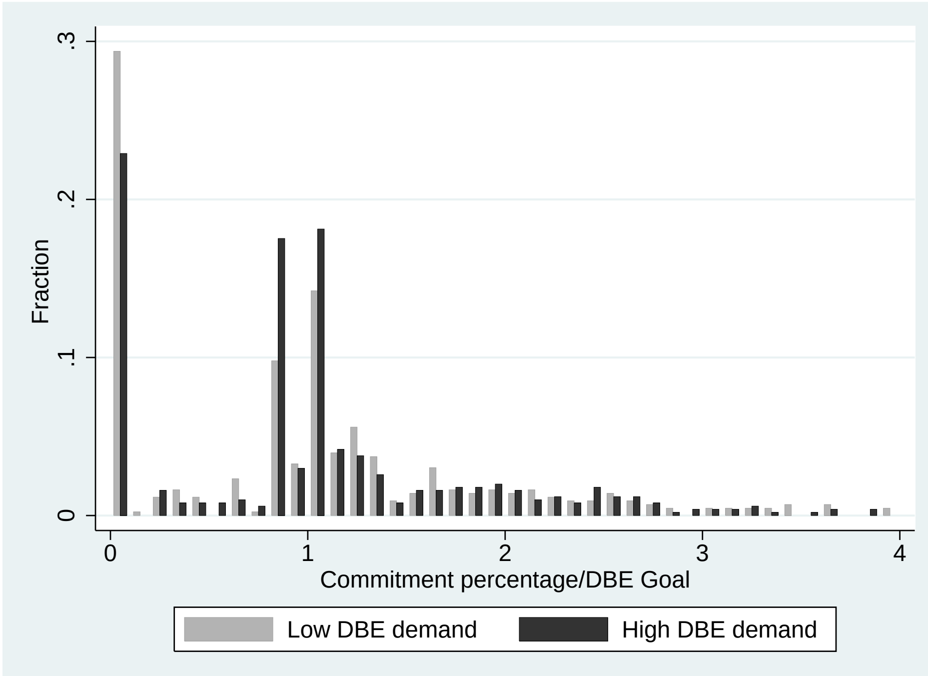
(b) Exemption Ineligible Firms



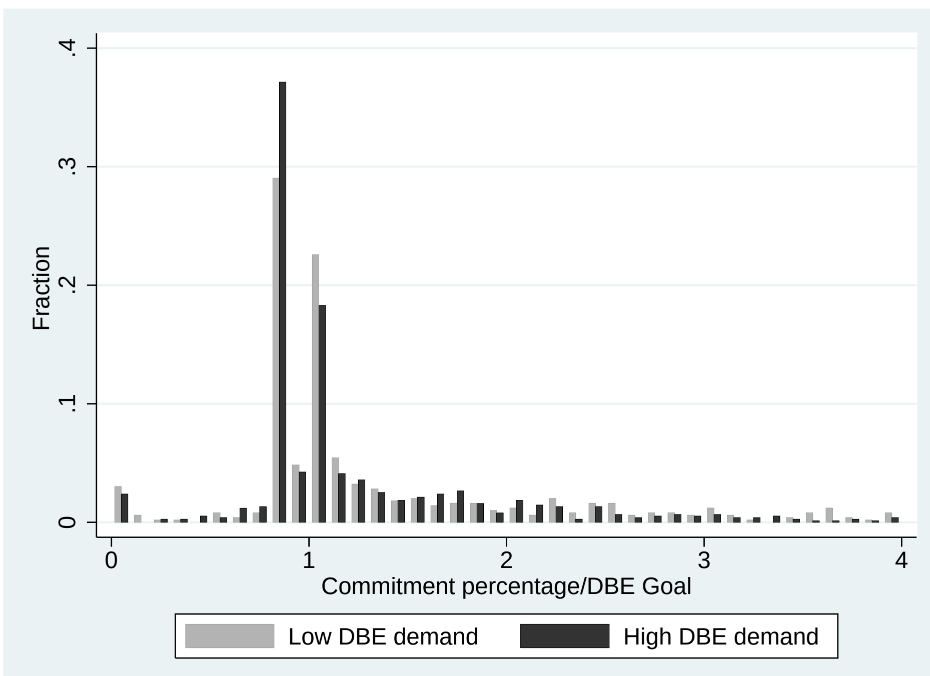
The commitment-goal ratio divides the percentage DBE commitment of a bidder by the percentage DBE goal of the auction. Each bin is 0.1 wide, and the histogram is truncated as a handful of bidders utilize DBE subcontractors well in excess of the project goal. A period of high (low) DBE demand is defined as one where the value of DBE subcontracts awarded over the prior three months is in the top (bottom) 25 percent of all letting dates.

Figure 6: Distribution of DBE Commitments: By DBE demand in upcoming 3 months

(a) Exemption Eligible Firms

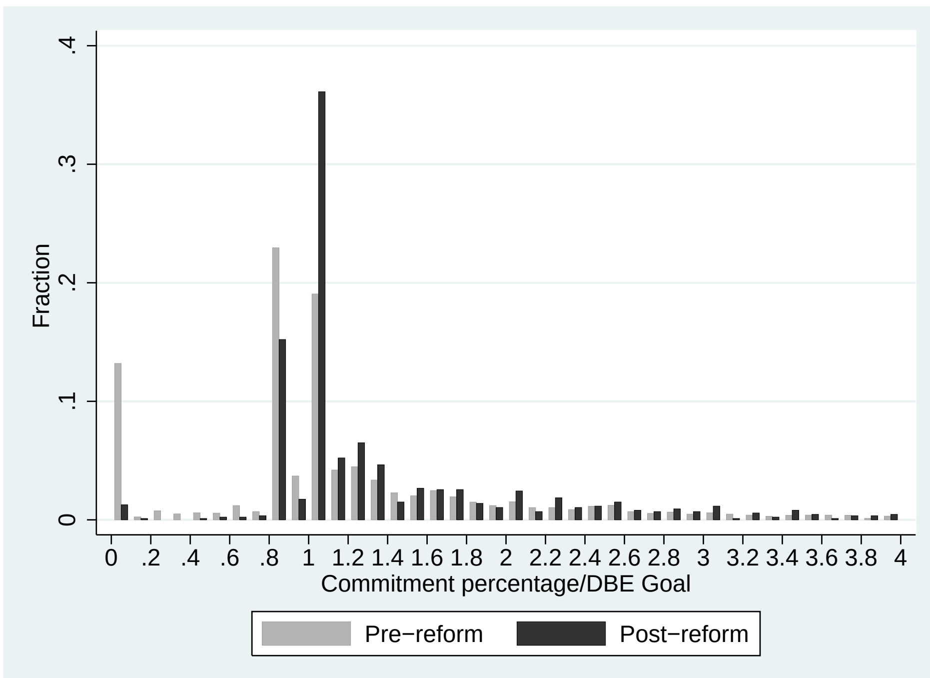


(b) Exemption Ineligible Firms



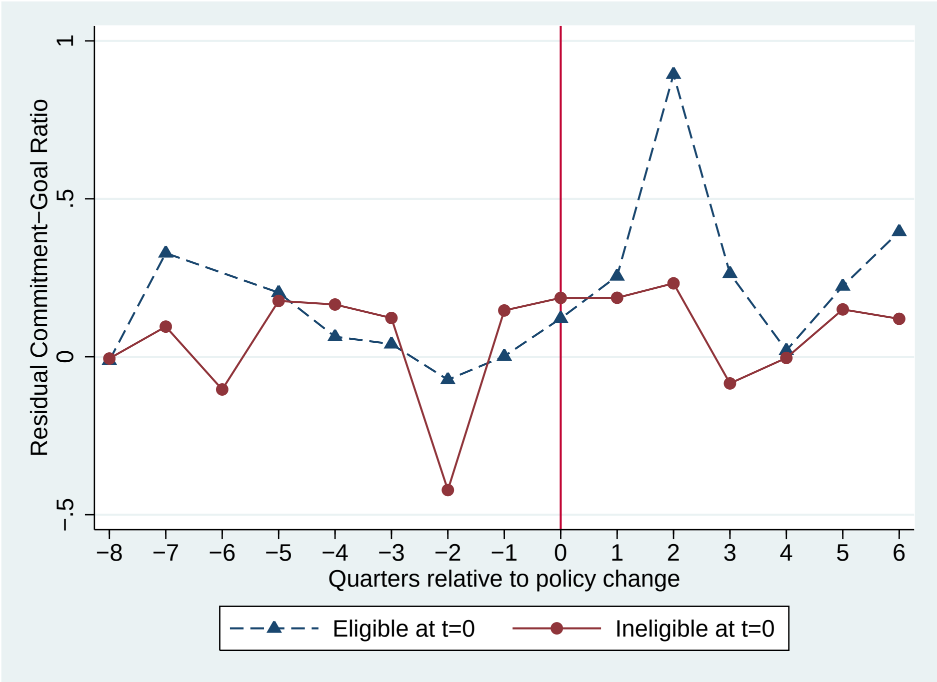
The commitment-goal ratio divides the percentage DBE commitment of a bidder by the percentage DBE goal of the auction. Each bin is 0.1 wide, and the histogram is truncated as a handful of bidders utilize DBE subcontractors well in excess of the project goal. A period of high (low) DBE demand is defined as one where the value of DBE subcontracts awarded over the upcoming three months is in the top (bottom) 25 percent of all letting dates.

Figure 7: Distribution of DBE Commitment/DBE Goal Ratio, Pre- and Post-Exemption Reform



The commitment-goal ratio divides the percentage DBE commitment of a bidder by the percentage DBE goal of the auction. Each bin is 0.1 wide, and the histogram is truncated as a handful of bidders utilize DBE subcontractors well in excess of the project goal. The reform occurred in January 2013 and involved eliminating the quantitative good faith effort criteria.

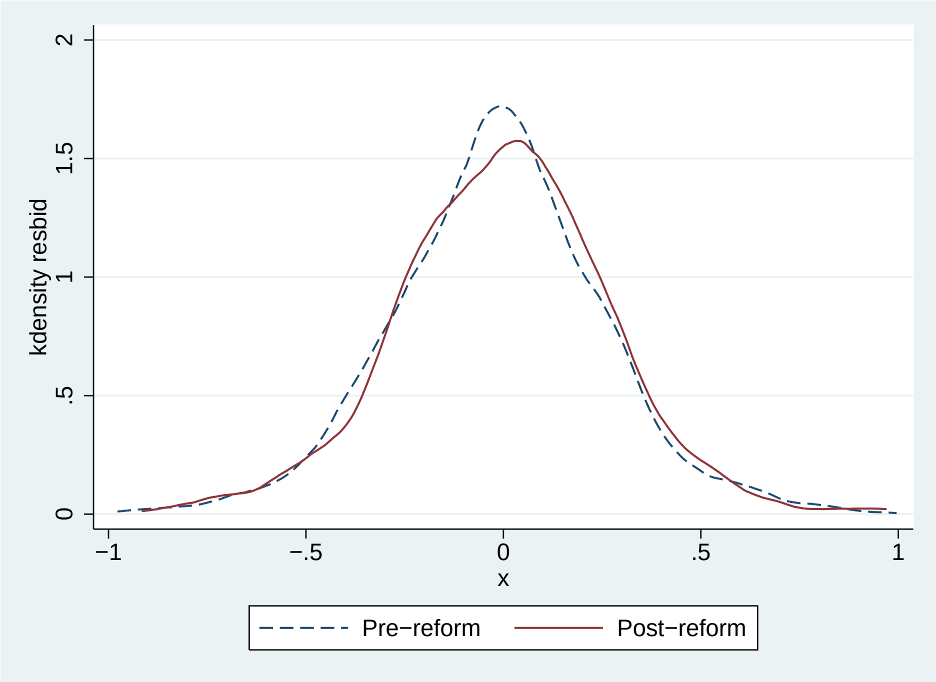
Figure 8: DBE Utilization/Goal



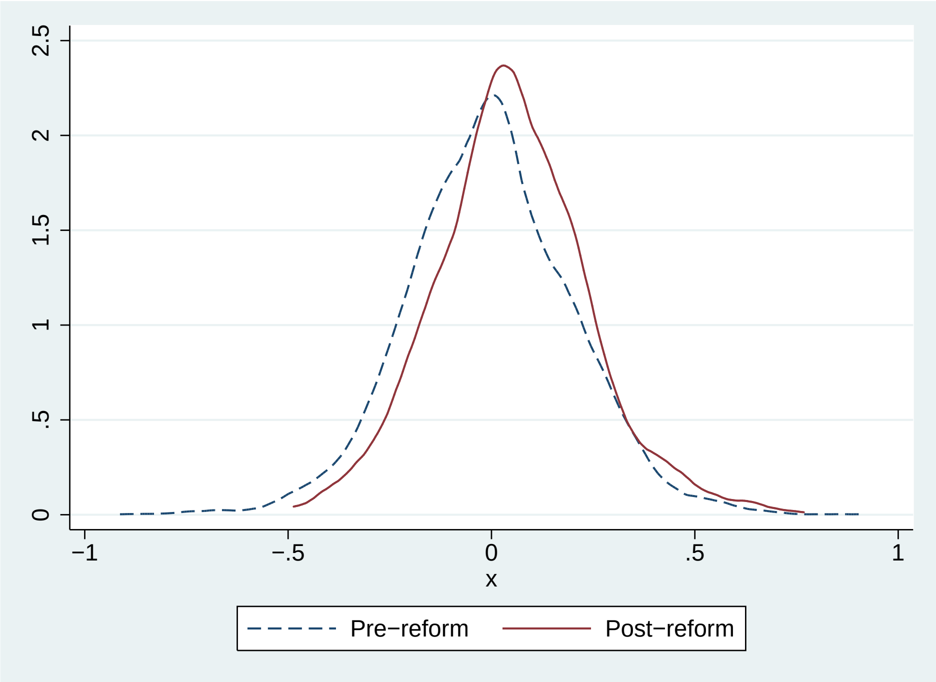
This figure plots the average residual ratio of the DBE commitment percentage to the project DBE goal by quarter. The variables are the residuals after conditioning on letting month effects and the project goal. The graph is separated by whether the bidder was eligible for an affirmative action exemption in the month prior to the reform.

Figure 9: Distribution of residual bids, pre- and post-reform

(a) DBE Goal = 0%



(b) DBE Goal > 0%



Residual bids are obtained from the residuals of a regression of the log bid on the project covariates, including indicators for each level of the proposal guaranty, and type of work, county, and firm effects.

Table 1: Contract-level Summary Statistics

	DBE Goal > 0	DBE Goal=0	Total
Number of Bidders	4.121	4.112	4.114
	(2.121)	(2.121)	(2.121)
Exemption eligible bidders	1.442	0.761	0.919
	(1.642)	(1.225)	(1.364)
Project DBE goal	2.949	0	0.683
	(0.959)	(0)	(1.327)
Value of winning bid (000s)	2935.4	653.0	1181.8
	(5888.7)	(1310.3)	(3205.6)
Winner is a DBE	0.0663	0.0347	0.0420
	(0.249)	(0.183)	(0.201)
A. A. Contracts prior 3 months	51.90	43.47	45.42
	(34.92)	(28.85)	(30.57)
Observations	6380		

Table 2: Bidder-level Summary Statistics

	DBE Goal > 0	DBE Goal=0	Total
Value of bid (000s)	2882.5	680.0	1191.9
	(5693.7)	(3199.6)	(4032.0)
Exemption Eligible	0.355	0.187	0.226
	(0.479)	(0.390)	(0.418)
Pct. committed to DBE subs.	7.682		7.682
	(18.30)		(18.30)
% DBE Commitment, bidder not DBE	3.922		3.922
	(3.879)		(3.879)
Commitment-goal gap	4.714		4.714
	(18.24)		(18.24)
Commitment-goal gap, bidder not DBE	0.969		0.969
	(3.806)		(3.806)
Comply with DBE goal	0.516		0.516
	(0.500)		(0.500)
Comply with 80% of DBE goal	0.863		0.863
	(0.344)		(0.344)
Bidder is a DBE	0.0748	0.0468	0.0533
	(0.263)	(0.211)	(0.225)
Points if eligible	4.790	4.749	4.764
	(1.880)	(2.241)	(2.116)
Observations	6294	20787	27081

Table 3: Compliance with Project Goal

	100% comply				80% comply			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Exemption Eligible	-0.069***	-0.19***	-0.18***	-0.18***	-0.25***	-0.28***	-0.27***	-0.27***
	(0.014)	(0.016)	(0.017)	(0.019)	(0.011)	(0.013)	(0.013)	(0.015)
Bidders		0.00066	0.0026			0.0017	0.0026	
		(0.0031)	(0.0032)			(0.0024)	(0.0024)	
Contractor effects		X	X	X		X	X	X
Contract Effects				X				X
Letting Effects			X				X	
Observations	4942	4942	4942	4942	4942	4942	4942	4942
R-Squared	0.0048	0.32	0.34	0.58	0.11	0.34	0.36	0.55

Standard errors are in parentheses. *,**,*** denote significance at the 10%, 5%, and 1% level, respectively.
The unit of observation is a bidder. Contracts with a DBE goal of zero are excluded.
The dependent variable in the specifications of columns (1)-(4) is an indicator for the contractor's DBE commitment exceeding the project DBE goal, while in columns (5)-(8) it is an indicator for the commitment exceeding 80 percent of the goal.

Table 4: Subcontractor capacity constraints

	High capacity utilization			Low capacity utilization		
	(1)	(2)	(3)	(4)	(5)	(6)
1-6 months after auction win	-0.030**	-0.035***	-0.032**	-0.0034	-0.0058	-0.0053
	(0.015)	(0.013)	(0.013)	(0.011)	(0.011)	(0.010)
7-12 months after auction win	-0.0010	-0.015	-0.012	0.0032	0.00042	0.000084
	(0.016)	(0.013)	(0.013)	(0.012)	(0.011)	(0.011)
Month of auction win	0.14***	0.13***	0.12***	0.092***	0.089***	0.080***
	(0.042)	(0.043)	(0.043)	(0.016)	(0.016)	(0.015)
Avg participation rate of primes			0.84***			0.43***
			(0.22)			(0.11)
Firm effects		X	X		X	X
Observations	3379	3379	3379	9801	9801	9801
R-Squared	0.0068	0.66	0.66	0.0018	0.58	0.58

The unit of observation is a subcontractor-month. The specifications includes only those observations from 6 months prior to the subcontractor participating in a successful bid until 12 months after.
The dependent variable is the number of bidders per affirmative action contract within the month listing the subcontractor.
The dependent variables are indicators for the number of months since the subcontractor participated in a winning bid. The excluded category is between one and six months prior. The variable "Average participation rate of primes" averages the auction participation rate of the prime contractors who utilized the subcontractor at date 0.
Standard errors corrected for clustering by month-year are in parentheses.
*,**,*** denote significance at the 10%, 5%, and 1% level, respectively.

Table 5: Compliance with Project Goal, By Past and Future DBE Demand

	(1) OLS	(2) OLS	(3) OLS	(4) IV	(5) IV
Contracts with DBE goal prior 3 mo.	-0.00053*	-0.00031		-0.00020	
	(0.00030)	(0.00028)		(0.00034)	
Prior 3 mo. contract*Eligible		-0.0010*	-0.00096*	-0.00087**	-0.00083**
		(0.00052)	(0.00054)	(0.00038)	(0.00038)
Contracts with DBE goal, upcoming 3 mo.	-0.00071*	-0.0012***		-0.00035	
	(0.00036)	(0.00035)		(0.00043)	
Future 3 mo. contract*Eligible		0.0012***	0.0015***	0.00088**	0.0011**
		(0.00044)	(0.00050)	(0.00044)	(0.00043)
Exemption Eligible	-0.29***	-0.30***	-0.31***	-0.29***	-0.30***
	(0.020)	(0.040)	(0.042)	(0.035)	(0.034)
Goal=5 percent	-0.0024	-0.00029	0.0023	-0.018	-0.017
	(0.018)	(0.018)	(0.020)	(0.018)	(0.019)
Letting date Effects			X		X
Observations	4725	4725	4725	3089	3089
R-Squared	0.34	0.34	0.37	0.33	0.35

Standard errors clustered by month-year in parenthesis. *,**,*** denote significance at the 10%, 5%, and 1% level, respectively.
The unit of observation is a bidder in an auction. Contracts with a DBE goal of zero are excluded.
The dependent variable is an indicator for complying with at least 80 percent of the project goal. Each specification includes contractor fixed effects.

Table 6: DBE Utilization, by Past and Future DBE Demand

	(1)	(2)	(3)	(4)	(5)
Exemption Eligible	-0.45***	-0.52***	-0.51***	-0.52***	-0.15**
	(0.036)	(0.069)	(0.071)	(0.071)	(0.075)
Contracts with DBE goal prior 3 mo.	0.00063	0.00081			
	(0.00081)	(0.00085)			
Contracts with DBE goal, upcoming 3 mo.	-0.0018*	-0.0027***			
	(0.00094)	(0.00098)			
Prior 3 mo. contract*Eligible		-0.0012	-0.0012	-0.0012	-0.0015*
		(0.00086)	(0.00087)	(0.00087)	(0.00092)
Future 3 mo. contract*Eligible		0.0028***	0.0031***	0.0033***	0.0024**
		(0.00097)	(0.00099)	(0.00099)	(0.0011)
Log bid				-0.097***	-0.18***
				(0.017)	(0.017)
Letting date effects			X	X	X
Observations	4725	4725	4725	4722	4125
R-Squared	0.27	0.27	0.29	0.30	0.30

Standard errors clustered by letting date are in parentheses. *,**,*** denote significance at the 10%, 5%, and 1% level, respectively.
The unit of observation is a bidder in an auction. Contracts with a DBE goal of zero are excluded.
The dependent variable is the ratio of the percentage DBE commitment to the project goal. Each specification includes contractor fixed effects. The top 2 percent of the commitment-goal ratio has been topcoded. The specification shown in column (5) only includes those bidders with a positive level of DBE utilization.

Table 7: DBE Utilization Around Good Faith Effort Reform

	(1)	(2)	(3)	(4)	(5)
Post-Reform	-0.45***	0.14	-0.17		
	(0.17)	(0.16)	(0.18)		
DBE Goal		0.87***	0.88***		
		(0.096)	(0.096)		
Post-Reform X Eligible at t=0			0.66**	0.96***	2.57**
			(0.30)	(0.27)	(1.23)
Post X Eligible X Prior 3 mo. contract					-0.022
					(0.024)
Post X Eligible X Future 3 mo. contract					-0.021
					(0.013)
Contract effects				X	X
Observations	1882	1882	1882	1882	1785
R-Squared	0.35	0.40	0.40	0.66	0.66

Standard errors clustered by contractor are in parentheses.
*,**,*** denote significance at the 10%, 5%, and 1% level, respectively.
The unit of observation is a bidder in an auction. Contracts with a DBE goal of zero are excluded.
The dependent variable is the percentage commitment by the prime contractor to DBE subcontractors. Each specification includes contractor fixed effects. Columns (1)-(3) year-month effects.

Table 8: Bidding behavior and the good faith effort reform

	(1)	(2)	(3)	(4)	(5)	(6)
Post-reform	-0.025**					
	(0.012)					
DBE Goal	0.75***	0.47**	0.44*	1.02***	1.03***	-0.018
	(0.18)	(0.22)	(0.23)	(0.26)	(0.25)	(0.58)
Post-reform x DBE Goal	3.84***	3.28***	2.40***	1.72***	1.73***	1.63
	(0.55)	(0.54)	(0.53)	(0.56)	(0.57)	(1.12)
DBE Goal X County HHI						6.46***
						(2.22)
Number of bidders	-0.016***	-0.015***	-0.016***	-0.015***	-0.014***	-0.014***
	(0.0013)	(0.0015)	(0.0016)	(0.0016)	(0.0017)	(0.0035)
Project type		X	X	X	X	X
County effects			X	X	X	X
Year and month effects		X	X			
YearXmonth effects				X	X	X
Firm effects					X	X
Observations	10417	10417	10417	10417	10417	10396
R-Squared	0.95	0.96	0.96	0.96	0.97	0.97

Standard errors are in parentheses.
*,**,*** denote significance at the 10%, 5%, and 1% level, respectively.
The unit of observation is a bidder in an auction.
The dependent variable is the log bid. The sample includes only those contracts using federal funds. Each specification includes dummy variables for the amount of the performance guaranty, which is based on the engineer's estimate of project cost.
The HHI is calculated based on each DBE's share of the dollar value of DBE subcontracts awarded in a county on projects with affirmative action goals. The minimum level of observed in the data has been subtracted from this variable, so the direct effect of the DBE goal is for the minimum county (HHI=0.119). Standard errors are clustered by county in specification (6).

Table 9: Winning bids and the good faith effort reform

	(1)	(2)	(3)	(4)	(5)	(6)
Post-reform	-0.012					
	(0.024)					
DBE Goal	1.47***	1.30***	1.44***	2.04***	2.12***	0.87
	(0.36)	(0.47)	(0.49)	(0.58)	(0.54)	(0.70)
Post-reform x DBE Goal	3.06***	2.33**	1.71	0.82	1.59	1.45
	(1.08)	(1.09)	(1.06)	(1.10)	(1.16)	(1.41)
DBE Goal X County HHI						7.44**
						(3.26)
Number of bidders	-0.035***	-0.033***	-0.035***	-0.034***	-0.031***	-0.030***
	(0.0028)	(0.0034)	(0.0035)	(0.0036)	(0.0041)	(0.0044)
Project type		X	X	X	X	X
County effects			X	X	X	X
Year and month effects		X	X			
YearXmonth effects				X	X	X
Firm effects					X	
Observations	2449	2449	2449	2449	2449	2442
R-Squared	0.96	0.96	0.96	0.96	0.97	0.97

Standard errors are in parentheses.
*,**,*** denote significance at the 10%, 5%, and 1% level, respectively.
The unit of observation is a bidder in an auction.
The dependent variable is the log bid. The sample includes only those contracts using federal funds. Each specification includes dummy variables for the amount of the performance guaranty, which is based on the engineer's estimate of project cost.
The HHI is calculated based on each DBE's share of the dollar value of DBE subcontracts awarded in a county on projects with affirmative action goals. The minimum level of observed in the data has been subtracted from this variable, so the direct effect of the DBE goal is for the minimum county (HHI=0.119). Standard errors are clustered by county in specification (6).

A Appendix

A.1 Two period model

Here I present a simplified version of the model with an analytical solution. I assume that the game lasts only two periods, procurement contracts are allocated using a sealed bid second-price auction and each bidder's per-task cost is independent and uniformly distributed over the unit interval. The latter, along with the assumption $c_h \geq 1$, ensures that affirmative action will be binding in period two.

One project is awarded per period. In period one, each firm receives its cost draw for that period's project, and chooses a bid $b_{i,1}$ and subcontracting level $h_{i,1}$. The firm submitting the lowest bid wins and receives as payment the bid of the second lowest bidder. The winner from period 1 is exempt from affirmative action in period 2 if $h_{i,1} \geq \overline{p}$.[28] Otherwise, neither firm is exempt. In period 2, each firm learns its cost c_{i2} for the period 2 project, chooses a bidding and subcontracting strategy subject to the affirmative action constraint, and a new auction is conducted. Then the game ends.

Period 2:

The model can be solved by backward induction. Period 2 is the end of the game, so firms will select the minimum level of subcontracting allowed. Since it is not possible in the model for both firms to be eligible in the same time period, there are two relevant cases to analyze. Case 1: neither i nor j are exemption eligible. Case 2: one firm is eligible, the other is not. The total cost of an ineligible firm is $C_i = (1 - g_2)c_i + g_2(c_{2h} + \gamma H_{t-1})$, distributed $U[\underline{C}(H), \overline{C}(H)]$, where $\underline{C}(H) = g_2(c_{h2} + \gamma H_1)$ and $\overline{C}(H) = 1 - g_2 + g_2(c_{h2} + \gamma H_1)$.[29] An eligible bidder's cost is simply $C_i = c_i$, distributed $U[0, 1]$. The dominant period 2 strategy is to submit a bid equal to total cost.[30]

Case 1: Here the two firms are symmetric. The *ex ante* expected profit for each firm is

$$E\Pi_{case1} = (1 - g_2)/6. \tag{5}$$

This will represent the continuation value of winning the period 1 auction when using a subcontracting level that does not qualify the firm for an exemption, as well as the continuation value of losing when the firm's opponent in period 1 sets a non-qualifying subcontracting level.

[28] In the full model, exemption eligibility was determined by several periods of subcontracting choices. Note that with only two periods, the points determining firm i's exemption eligibility are simply given by $p_i = h_{i1}I(b_i < b_{-i}$, the amount of period 1 DBE subcontracting selected if i wins.

[29] I will mostly refer to the boundaries of the cost distribution as $\underline{C}$ and $\overline{C}$, dropping the reference to their dependence on H. The term H_1 will depend on the subcontracting choices made by the winner in period 1.

[30] When one firm is eligible, eg firm i, it is possible that $C_{-i} > 1$, I assume that in those cases firm $-i$ also bids its cost even though the probability of winning is zero.

The expected winning bid is the expected second highest cost:

$$E[C_{\{2\}}] = \underline{C} + \frac{2}{3}(\overline{C} - \underline{C}) \tag{6}$$

while the expected cost of the winning bidder is

$$E[C_{\{1\}}] = \underline{C} + \frac{1}{3}(\overline{C} - \underline{C}) \tag{7}$$

Note that equations (5)-(7) highlight one overlooked aspect of affirmative action. More intensive affirmative action shrinks the cost distribution, which reduces information rents and mitigates the cost of affirmative action to the government.

Case 2: Here, one firm is eligible while the other is not, leading to a cost asymmetry. If i is eligible, the expected profits of the eligible and ineligible firms are respectively given by

$$E\Pi_{i,case2} = \frac{\overline{C}(\overline{C} - 1) + (1 - \underline{C}^3)/3}{2(1 - g_2)} \tag{8}$$

and

$$E\Pi_{-i,case2} = \frac{\underline{C}(\underline{C} - 1) + (1 - \underline{C}^3)/3}{2(1 - g_2)} \tag{9}$$

where $\underline{C}$ and $\overline{C}$ refer to the lower and upper bounds of the ineligible firm's cost distribution. The eligible firm enjoys higher profits, since the first term in the numerator is positive for firm i and negative for $-i$. The average winning bid is

$$E[C_{\{2\}}] = \frac{\overline{C} + \underline{C}}{2} - \frac{(\underline{C} - 1)^3}{6(1 - g_2)} \tag{10}$$

and the expected cost of the winning bidder is

$$E[C_{\{1\}}] = \frac{1}{2} + \frac{(\underline{C} - 1)^3}{6(1 - g_2)}. \tag{11}$$

The first term of this expression is the average cost of the eligible firm. The average cost of the winning firm is lower than this since the winning cost is the minimum of the eligible and ineligible firms.

Period 1:

Having established the payoffs for each outcome in period 2, we can characterize the continuation values in the Bellman equation given in equation (1). Firm i's objective function is

$$V = [E[b_{-i}|b_i < b_{-i}] - C_i(h_i) + V(h_i, 0)]\, Pr(b_i < b_{-i}) + (1 - Pr(b < b_{-i}))E[V(0, h_{-i})] \tag{12}$$

where the discount rate is set at $\delta = 1$. As in Jeziorski and Krasnokutskaya (2013), the level of subcontracting does not effect the probability of winning or the continuation value of losing. Therefore, substituting for $C_i(.)$, h_i is chosen to maximize $-(1-h_i)c_i - h_i c_{h1} + V(h_i, 0)$. Notice that this is independent of the subcontracting choice of $-i$.

The key strategic decision in setting h involves raising rival's costs. An eligible firm increasing h today increases its rival's costs in the future but not its own. Therefore an incentive exists to subcontract more than is required to gain eligibility ($h_i > \overline{p}$).

The objective function is not concave in h_i and an interior solution does not obtain. The optimal level of subcontracting will take on one of three values: $h_i \in \{g_1, \overline{p}, \overline{h}\}$, determined by the contractors' per-task cost c_i relative to thresholds $\widetilde{c}_g$ and $\widetilde{c}_p$. Lower cost firms choose lower levels of subcontracting. The thresholds are derived by comparing the objective function at $h = \overline{p}$, $h = g_1$, and $h = \overline{h}$ and are given by

$$\widetilde{c}_g = c_{h1} - \frac{V(\overline{p}, 0) - V(g_1, 0)}{\overline{p} - g_1} \tag{13}$$

and

$$\widetilde{c}_p = c_{h1} - \frac{V(\overline{h}, 0) - V(\overline{p}, 0)}{\overline{h} - \overline{p}}. \tag{14}$$

This highlights two determinants of the subcontracting decision. First, when the firm's current own per-task cost is high relative to that of the subcontractor, meeting or exceeding the level of utilization needed for eligibility is more attractive. Second, the expected future value of being exemption eligible leads to a dynamic incentive for subcontracting. The difference $V(\overline{p}, 0) - V(g_1, 0)$ is driven by both the value of having lower future cost and from raising the cost of the rival, while $V(\overline{h}, 0) - V(\overline{p}, 0)$ is driven by the latter.

The dominant bidding strategy involves submitting a bid equal to the firm's total period 1 cost less the difference in continuation value between winning and losing:

$$b(c_i) = C_i(h_i^*(c_i)) - (V(h_i^*(c_i), 0) - E[V(0, h_{-i})]). \tag{15}$$

The intuition is as follows. Suppose the firm bid its construction cost. It would then be possible to lose to a competitor bidding $C_i - \epsilon$, though winning any auction where $b_{-i} \geq C_i - (V(h_i^*(c), 0) - E[V(0, h_{-i})])$ would increase the present value of profits.

The expected continuation value of losing, $E[V(0, h_{-i})]$, depends on the set of costs to which the firm loses. This is because h_{-i} depends on c_{-i}. In a symmetric equilibrium firm i will only lose to $-i$ if $c_i > c_{-i}$. Therefore,

$$E[V(0, h_{-i})] = \begin{cases} V(0, g_1) & \text{if } c < \widetilde{c}_g \\ \frac{\widetilde{c}_g}{c_i} V(0, g_1) + \frac{c_i - \widetilde{c}_g}{c_i} V(0, \overline{p}) & \text{if } \widetilde{c}_g < c < \widetilde{c}_p \\ \frac{\widetilde{c}_g}{c_i} V(0, g_1) + \frac{\widetilde{c}_p - \widetilde{c}_g}{c_i} V(0, \overline{p}) + \frac{c_i - \widetilde{c}_p}{c_i} V(0, \overline{h}) & \text{if } c > \widetilde{c}_p \end{cases} \tag{16}$$

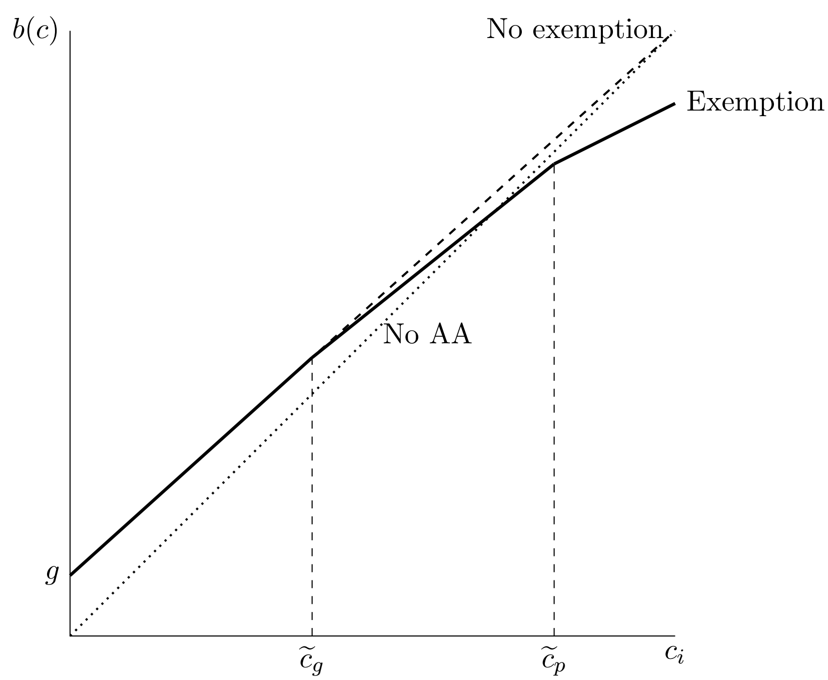
where $V(0, g_1)$, $V(0, \overline{p})$, and $V(0, \overline{h})$ are as calculated in equations (5) and (9).

The bid function described in equation (15) is monotonic in c_i. Consequently, the lowest cost firm wins and receives payment equal to the bid of the highest cost firm. The distribution of the winning and losing costs are $F_{\{1\}}(c) = 1 - (1 - F(c))^2$ and $F_{\{2\}}(c) = F(c)^2$. The expected period one winning bid is therefore $\int_0^1 b(c) f_{\{2\}}(c) dc$ and expected winning cost $\int_0^1 c f_{\{1\}}(c) dc$.

Equations (15) and (16) reveal that the continuation value of winning is highest for high-cost firms, and the continuation value of losing is lowest. The exemption program therefore will have the largest effect on the bids of high-cost firms and will thereby lower the expected winning bid.

This effect is illustrated in Figure A1, where I have plotted the optimal bid against the prime contractor's per-task cost c_i. With a second-price auction and no affirmative action, $b_i = c_i$. With affirmative action, the firm's total cost is increased to $C = (1 - g)c_i + gc_h$ and bids are correspondingly higher. The exemption program has no effect on the bid function of the lowest cost firms, since the low cost firms do not seek exemption eligibility, making the continuation values of winning and losing identical. However, the exemption program leads to a lower bid for firms where $c_i > \widetilde{c}_g$, since winning an auction would mean being exempt next period while losing might result in facing an exempt firm in the next period.

Figure A1: Bid as function of firm's own per-task cost



A.1.1 Subcontracting comparative statics

Consider the response of period 1 subcontracting to parameters affecting period 2 cost: c_{h2}, γ, and g_2. The expected value of period one DBE subcontracting across bidders is

$$E[h_{i1}] = \widetilde{c}_g g_1 + (\widetilde{c}_p - \widetilde{c}_g)\overline{p} + (1 - \widetilde{c}_p)\overline{h} \tag{17}$$

$$= \overline{h} - \widetilde{c}_g(\overline{p} - g_1) - \widetilde{c}_p(\overline{h} - \overline{p}) \tag{18}$$

If we consider some parameter ζ, then the derivative of $E[h_{i1}]$ with respect to ζ reduces to $\frac{\partial E[h_{i1}]}{\partial \zeta} = \frac{\partial V(\overline{h},0)}{\partial \zeta} - \frac{\partial V(g_1,0)}{\partial \zeta}$. Applying this expression to each of the parameters of interest, we see the following:

$$\frac{\partial E[h_{i1}]}{\partial \gamma} = \frac{\overline{h} g_2(2\overline{C}(\overline{h}) - 1 - \underline{C}(\overline{h})^2)}{2(1-g_2)} > 0. \tag{19}$$

$$\frac{\partial E[h_{i1}]}{\partial c_{h2}} = \frac{g_2(2\overline{C}(\overline{h}) - 1 - \underline{C}(\overline{h})^2)}{2(1-g_2)} > 0. \tag{20}$$

Neither γ nor c_{h2} affect the continuation value of winning when ineligible, so their effect works entirely through $V(\overline{h}, 0)$. Both have a positive impact on the continuation value of winning, as they increase the cost advantage of period two eligibility.

$$\frac{\partial E[h_{i1}]}{\partial g_2} = \frac{\partial V(\overline{h}, 0)}{\partial g_2} + \frac{1}{6} > 0. \tag{21}$$

Increasing next period's goal increases the continuation value of over-complying, since it raises rival's cost in the next period, and decreases the continuation value of exactly complying since this is decreasing in the anticipated affirmative action goal.

A.1.2 Parameterized model

I now parameterize the model with and without an exemption program. In this parametrization, I vary the values of c_{h2}, while fixing the values of the other parameter values: $\gamma = 1$, $c_{h1} = 1$, $\overline{p} = 0.05$, $g_1 = 0.025$, and $g_2 = 0.05$.

The results are shown in Table A1. In column 1, I show the benchmark case without affirmative action. In the following columns, I show the winning bid, winning cost, and level of subcontracting with and without an exemption program under two scenarios for the period 2 cost of the subcontractor, one where it does not change and the other where it is anticipated to go up by 20 percent.

The degree of subcontracting without exemptions is by definition equal to the affirmative action goal. The exemption program leads to a virtually identical level of subcontracting. The cost thresholds $\widetilde{c}_g$ and $\widetilde{c}_p$ illustrate how the model parameters affect the dynamic subcontracting incentives. Increasing the period two DBE cost reduces $\widetilde{c}_g$ noticeably, leading to a greater range of firms wanting to subcontract in excess of the affirmative action requirement to gain future exemption eligibility.

Affirmative action is more efficient under the exemption program, and the effect is greatest when DBE subcontractor costs are expected to increase. The exemption program improves the cost per subcontracted task by 8.2 percent when DBE costs increase in period 2 compared to 4.5 percent when DBE costs are stable.

The effect of the exemption program on government expenditures is disproportionate to the construction cost effect. The sum of the expected winning bid across the two periods is substantially lower under the exemption program. Furthermore, when DBE costs are expected to rise, and consequently the continuation value of winning is high, the procurement cost is actually lower under the exemption program than under the no affirmative action benchmark. In other words, affirmative action along with exemptions lowers government expenditures in this scenario.

Table A1: Parameterization exercise

		$c_{h1} = c_{h2} = 1$		$c_{h1} = 1, c_{h2} = 1.2$	
	No AA Benchmark	No exemption	Exemption	No exemption	Exemption
E[Construction cost]	0.67	0.7179	0.7153	0.7279	0.7219
E[Winning Bids]	1.333	1.360	1.340	1.370	1.330
E[Subcontracting]		0.075	0.075	0.075	0.074
Extra cost per sub.		0.683	0.652	0.817	0.750
Extra bid per sub.		0.350	0.088	0.483	-0.043
$\widetilde{c}_g$			0.264		0.051
$\widetilde{c}_p$			0.973		0.973

This table shows the results of parameterizing the model under several scenarios. The first column shows the expected outcomes in a benchmark scenario of no affirmative action. The construction cost, winning bid, and subcontracting figures are the sum of their expected values across the two periods. The extra cost and extra bid per subcontracted task are the difference in cost from the no affirmative action benchmark divided by the number of tasks awarded to subcontractors. The eligibility threshold for the exemption program is $\overline{p} = 0.05$. In all cases, $\gamma = 1$ and $\overline{h} = 0.5$.

A.2 Further evidence for contract volume

Table A2: Interactions with Past and Future DBE Demand

	(1) Commit/goal	(2) Overcomply	(3) Comply	(4) Commit/goal	(5) Overcomply	(6) Comply	(7) Commit/goal	(8) Overcomply	(9) Comply
Exemption eligible	-0.31***	-0.053	-0.28***	-0.44***	-0.095***	-0.29***	-0.45***	-0.098***	-0.29***
	(0.10)	(0.049)	(0.038)	(0.040)	(0.018)	(0.021)	(0.040)	(0.018)	(0.020)
DBE contracts fut. 3 mo.	0.0014	0.00051	-0.00036	-0.0019*	-0.0011***	-0.00014	-0.00048	-0.000037	-0.00017
	(0.0048)	(0.0015)	(0.0013)	(0.0010)	(0.00042)	(0.00047)	(0.0015)	(0.00068)	(0.00047)
DBE contracts prior 3 mo.	-0.0049	-0.0023	-0.0054**	0.0034***	0.0016***	0.000057	0.0015	0.00056	-0.00047
	(0.0060)	(0.0033)	(0.0019)	(0.0011)	(0.00043)	(0.00046)	(0.0013)	(0.00055)	(0.00046)
Zero points X fut. contracts	-0.0092	-0.0043*	-0.00032						
	(0.0057)	(0.0023)	(0.00083)						
Zero points X past contracts	-0.0034	-0.0013	0.0014						
	(0.0071)	(0.0035)	(0.0012)						
Zero points	0.26	0.12	-0.11						
	(0.46)	(0.21)	(0.071)						
HHI by date X fut. contracts				-0.0034	-0.00029	-0.0032**			
				(0.0032)	(0.0011)	(0.0014)			
HHI by date X past contracts				-0.017***	-0.0087***	-0.0045*			
				(0.0062)	(0.0024)	(0.0024)			
DBE HHI by date				0.58*	0.33**	0.15			
				(0.35)	(0.14)	(0.16)			
County HHIXfut. contracts							-0.0036	-0.0018	-0.0016*
							(0.0030)	(0.0012)	(0.00084)
County HHIXpast contracts							-0.0015	-0.00062	-0.00018
							(0.0033)	(0.0016)	(0.00095)
DBE HHI in county							0.27	0.14	0.10
							(0.25)	(0.11)	(0.077)
Observations	1006	1006	1006	4683	4683	4683	4723	4723	4723
R-Squared	0.40	0.36	0.38	0.29	0.21	0.34	0.29	0.21	0.34

Standard errors are in parentheses. *,**,*** denote significance at the 10%, 5%, and 1% level, respectively.
The unit of observation is a bidder in an auction. Contracts with a DBE goal of zero are excluded.
As indicated by the column titles, the dependent variables are either the ratio of the percentage DBE commitment to the project goal or an indicator for meeting at least 80 percent of the project goal. Each specification includes contractor fixed effects. The top 5 percent of the commitment-goal ratio is topcoded.
Other covariates are contractor effects, an indicator for the goal being 5 percent, and letting year and month effects.
The specifications in Columns (1) and (2) only include auctions conducted in 2011 and 2012, where points are observed for both eligible and ineligible bidders.

A.3 Proposal guaranty

Table A3: Estimated cost and proposal guaranty, 2013

Estimated size	Proposal guaranty
< $5,000	250
5,000 - 10,000	500
10,000 - 20,000	1,000
20,000 - 40,000	2,000
40,000 - 80,000	4,000
80,000 - 125,000	6,250
125,000 - 250,000	12,500
250,000 - 500,000	25,000
500,000 - 750,000	37,500
750,000 - 1,000,000	50,000
1,000,000 - 1,250,000	62,500
1,250,000 - 1,500,000	75,000
1,500,000 - 2,000,000	100,000
2,000,000 - 2,500,000	125,000
2,500,000 - 3,000,000	150,000
3,000,000 - 3,500,000	175,000
3,500,000 - 4,000,000	200,000
4,000,000 - 5,000,000	250,000
5,000,000 - 7,500,000	375,000
7,500,000 - 10,000,000	500,000
10,000,000 - 15,000,000	750,000
15,000,000 - 20,000,000	1,000,000
20,000,000 - 25,000,000	1,250,000
25,000,000 - 30,000,000	1,500,000

Figure A2: Relationship between log bid and log proposal guaranty