Subcontracting Networks, Competition and Firm Participation in Public Procurement

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Motivation

In public procurement

- Competitors form persistent, strategic relationships
- Winning firms often outsource part of the contract to other firms
- Subcontracting provides a path to steady revenue, survival, and growth
- A firm's decision to form subcontracting links depends critically on its network created through past contractual relationships

Contribution

We develop a model of strategic network formation and analyze road construction auction spanning more than a decade

- Using network analysis to study the evolution of subcontracting networks
- Studying the impact of subcontracting on firms' bidding and market presence
- Considering the impact of DBE participation goals on strategic choices
- Evaluating empirically the impact of networks on the DBE program whose targeted support has gradually shifted from race-conscious to race-neutral means.

Preview of the Findings

- Previous contractual relations have a notable impact on firms' subcontracting decisions – particularly for non-DBE firms – and affect their chances to maintain market presence.
- While the network structure of non-DBE firms plays a significant role in their subcontracting choices, the connections to DBE subcontractors do not hold as much weight in decisions regarding outsourcing activities.
- The DBE program has effectively increased subcontracting activities, enabling DBE firms to remain active in the industry without raising the cost of procurement.
- DBE prime contractors bid lower that other firms

Related Literature & Contribution

On network formation

- Christakis et al. (2020) on friendships; He and Kosmopoulou (2021) on airlines; De Silva et al., (2022) on artists and dealers; Lux (2015) on interbank credit relationships

On subcontracting in the public procurement industry

- Gil and Marion (2013); Miller (2014); Marion (2015); Jeziorski and Krasnokutskaya (2016); and Rosa (2020)

Related Literature & Contribution

DBE participation and program efficiency

- Marion (2009, 2011); De Silva et al. (2012); Marion (2017); Rosa (2019)

Survival of firms competing for public procurement projects

- De Silva, Kosmopoulou and Lamarche (2012, 2017)

- Our paper considers the simultaneous outsourcing/ subcontracting decisions of prime and subcontractors in the road construction market, based on project, bidder, auction characteristics and the relationships firms build dynamically within a network.

Background of ODOT Procurement Auctions

The Oklahoma Department of Transportation (ODOT) holds monthly lettings:

- Public construction projects offered via low price sealed bid auction.
- Project are advertised 5 weeks prior to the letting.
- Interested contractors may request detailed plans two weeks later at a minimal cost, becoming plan holders.
- The plan-holders' list is common knowledge.
- On bid opening day, bids are submitted and reviewed, and the winners are announced.

Background of ODOT Procurement Auctions

Secondary Subcontracting Markets:

- Subcontracting is a common practice
- Contractors may subcontract due to cost consideration, special needs, time constraints, risk allocation and market competition
- Subcontractors may benefit by undertaking business activity
  - — without the cost of bidding
  - — without prequalification from ODOT

Background of ODOT Procurement Auctions

Subcontracting Relationships:

- Formal relationships are established by the project winner
- A formal relationship starts with an informal connections when firms prepare for bids
  - — Bidders need to consider potential subcontractors' characteristics, etc.
  - — Subcontractors need to consider the bidders' chances to win

Background of ODOT Procurement Auctions

Disadvantaged Business Enterprise (DBE) Program and Subcontracting

- Federal funded program, designed to remedy the discrimination against small businesses owned and controlled by socially and economically disadvantaged individuals
- ODOT imposes DBE goal requirements for some projects
  - race-conscious approach
- Subcontracting is a way to fulfill the requirement
- Switching from race-conscious means to race-neutral means.
  - race-neutral programs benefit DBE firms without focusing solely on them.

The Model and Estimation Method

Setting

- F firms, P_{mt} projects in division m in period t, M division, T time periods.
- $Link_{pmt}$ is an F by F matrix.
- If firm i wins the project and subcontracts to the subcontractor j in project p in division m in period t
  - — Firm i forms a link with firm j
  - — The ith and jth element in $Link_{pmt}$, $Link_{ijpmt} = 1$
- If they don't form a link, $Link_{ijpmt} = 0$
- $Link_t$ is the aggregation of $Link_{pmt}$ across projects and divisions in period t.
- $Network_t$ is an F by F matrix. It represents a 24-month moving window of $Link_t$ formed between i and j.

The Model and Estimation Method

The payoff function can be thought of from the traditional perspective as

$$\Pi^k_{ijpmt} = \alpha^k + R^k_{ijpmt} + C^k_{ijpmt} + \tau^k_{ijpmt} + \epsilon^k_{ijpmt},$$

where

R^k_{ijpmt} consists of variables linked to revenues (or in this case the winning bid),

C^k_{ijpmt} represents material and labor costs,

τ^k_{ijpmt} are transaction or coordination costs

The Model and Estimation Method

Probability of Each Link Formation

The payoff of each link formation

$$\Pi^k_{ijpmt} = \alpha^k + \beta^k_1 NetworkVar_{t-1} + \beta^k_2 X + \beta^k_3 \Psi + \beta_4 \omega_{t+1} + \epsilon^k_{ijpmt}.$$

- $NetworkVar_{t-1}$ is the 24-month moving window of the network
- X other covariates, such as project and firm characteristics
- Ψ represents homophily measures that capture firm similarities
- ω_{t+1} contains variables for future business opportunities
- ϵ^k_{ijmt} follows a type I extreme value distribution.

The Model and Estimation Method

Variables in Payoff Function

		Π^1_{ijmt}	Π^2_{ijmt}
R^k_{ijmt}	$AuctionCompetition^k_{pmt}$	$PlanNumber_p$ $RivalLinkMax_{i,t-1}$	$PlanNumber_p$ $RivalLinkMax_{j,t-1}$
	$MarketCompetition^k$	$ProjectValue_{m,t+1}$ $ProjectDBE_{pmt}$	$ProjectValue_{m,t+1}$ $ProjectDBE_{pmt}$
C^k_{ijmt}	c^1_i / c^2_j	$log(Distance)_{ipm}$ $log(Distance)_{jpm}$ $log(SubAmount)_{i,t-1}$ $log(SubAmount)_{j,t-1}$ $log(Backlog)_{i,t-1}$ $log(Backlog)_{j,t-1}$ $ProjectDBE_{pmt} BidderDBE_i$ $ProjectDBE_{pmt} SubDBE_j$ $SubEntrant_{jt}$	$Log(Distance)_{jpm}$ $Log(Distance)_{ipm}$ $log(SubAmount)_{j,t-1}$ $log(SubAmount)_{i,t-1}$ $log(Backlog)_{j,t-1}$ $log(Backlog)_{i,t-1}$ $ProjectDBE_{pmt} SubDBE_j$ $ProjectDBE_{pmt} BidderDBE_i$ $SubEntrant_{jt}$
	c^1_{pmt}	$log(Cdays)_{pmt}$ $log(EngEst)_{pmt}$ $log(ItemNumber)_{pmt}$	$log(Cdays)_{pmt}$ $log(EngEst)_{pmt}$ $log(ItemNumber)_{pmt}$

The Model and Estimation Method

Variables in Profit Function

	Π^1_{ijmt}	Π^2_{ijmt}
τ^k_{ijmt}	$Network_{ij,t-1}$	$Network_{ij,t-1}$
	$NetworkSum_{ij,t-1}$	$NetworkSum_{ij,t-1}$
	$MetricDistance_{ij,t-1}$	$MetricDistance_{ij,t-1}$
	$DegreeCentrality_{i,t-1}$	$DegreeCentrality_{i,t-1}$
	$DegreeCentrality_{j,t-1}$	$DegreeCentrality_{j,t-1}$
	$HubCentrality_{i,t-1}$	$HubCentrality_{i,t-1}$
	$AuthCentrality_{j,t-1}$	$AuthCentrality_{j,t-1}$
	$log(Distance)_{ij}$	$log(Distance)_{ij}$

The Model and Estimation Method

Probability of Each Link Formation

The probability that a firm gains a non-negative payoff and is willing to form a link satisfies the following equation

$$ln(\frac{Pr(\Pi^k_{ijpmt} \geq 0)}{1 - Pr(\Pi^k_{ijpmt} \geq 0)}) = \alpha^k + \beta^k_1 NetworkVar_{t-1} + \\ + \beta^k_2 X + \beta^k_3 \Psi + \beta_4 \omega_{t+1}$$

A link forms only if both firms' profits are non-negative.

$$P_{ijpmt} = Pr(Link_{ijpmt} = 1) = Pr(\Pi^1_{ijpmt} \geq 0) Pr(\Pi^2_{ijmt} \geq 0)$$

The Model and Estimation Method

Likelihood Function

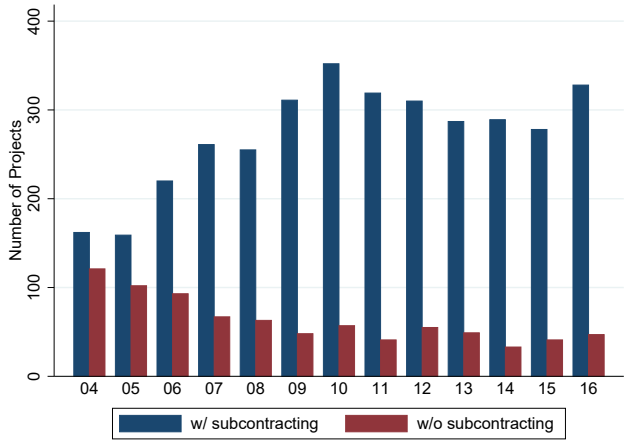
The joint likelihood function for a given network is

$$\mathcal{L}(\beta|Link) = \prod_{t\in\{25,\ldots,T-11\}} \prod_{m\in\{1,\ldots,M\}} \prod_{p\in Project_{mt}} \prod_{i\in I_{pmt}, j\in J_t, i\neq j} (P_{ijpmt})^{Link_{ijpmt}} (1 - P_{ijpmt})^{1-Link_{ijpmt}}.$$

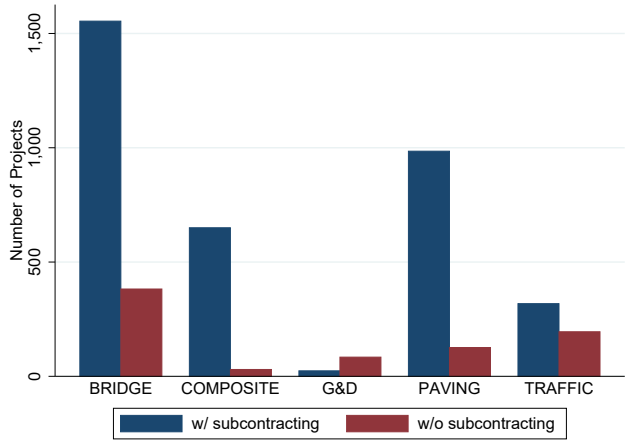
- I_{pmt} represents the set of all bidders.
- J_{mt} the set of all candidate subcontractors, firms that are present in the previous 24 month, the current period and the next 11 months to capture potential entrants.
- Use Markov-Chain-Monte-Carlo to estimate β

Data and Variables

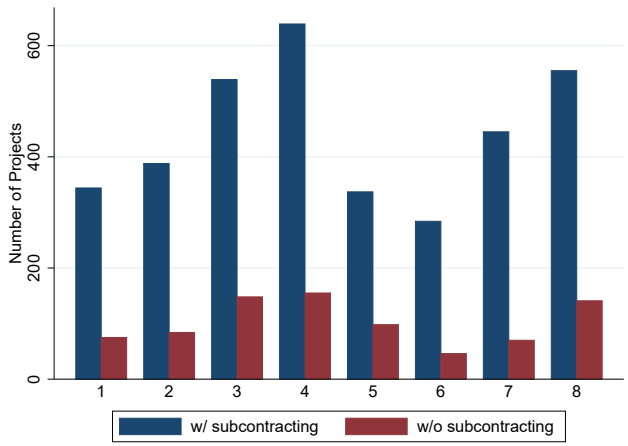
- The data is between 2004 and 2016, 143 months.
- 4348 projects, 81% employ subcontractors.



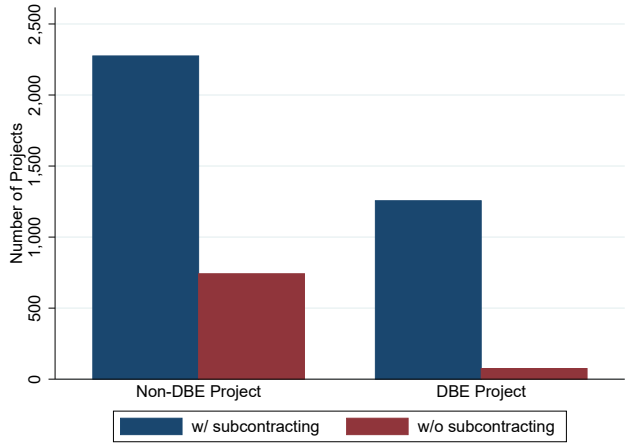
(a) Project Numbers over Time



(b) Project Numbers by Type



(c) Project Numbers by Location

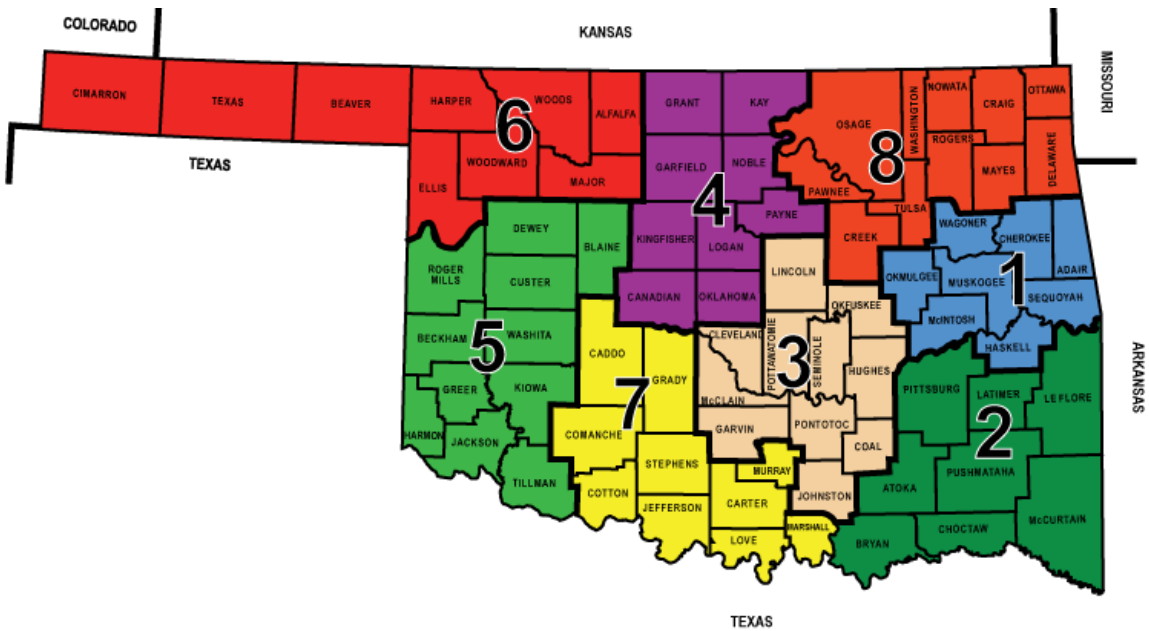


(d) Project Numbers by DBE Status

Data and Variables

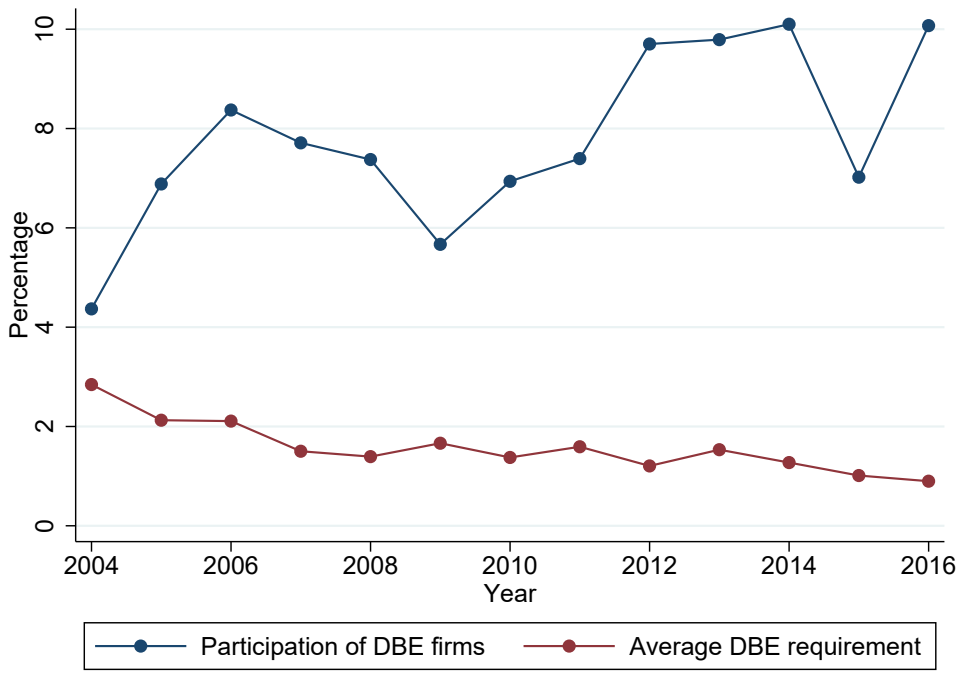
Division Map

Figure: Division Map

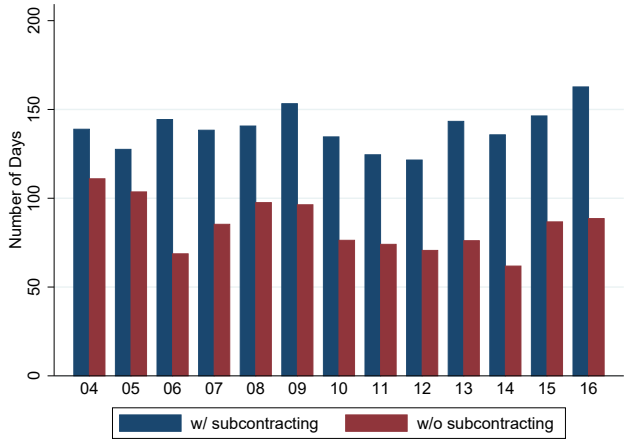


Data and Variables

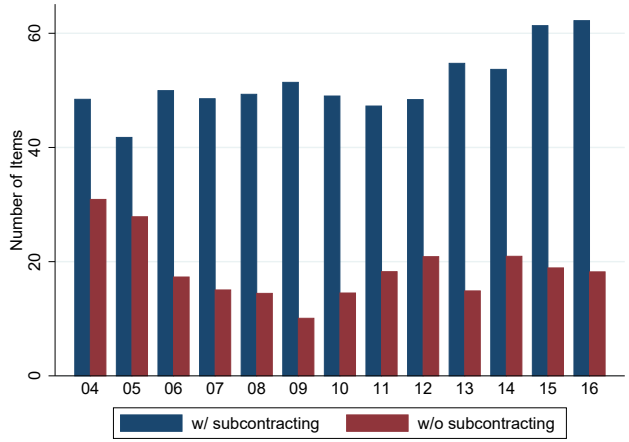
Figure: DBE requirement and DBE Firm Participation



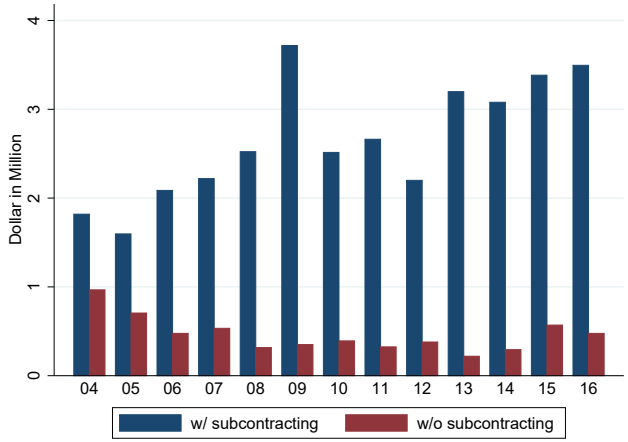
Data and Variables



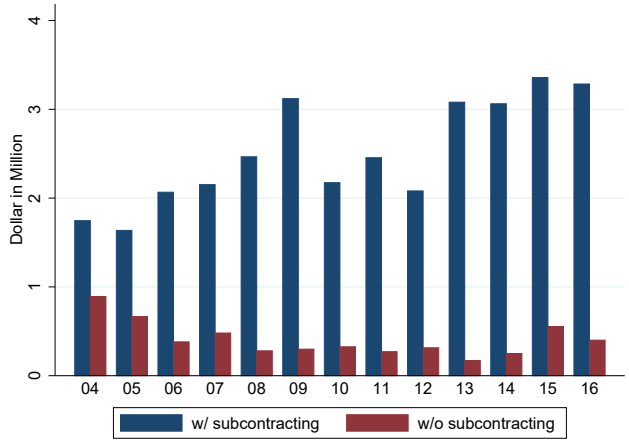
(a) Project Average Duration



(b) Project Average Complexity



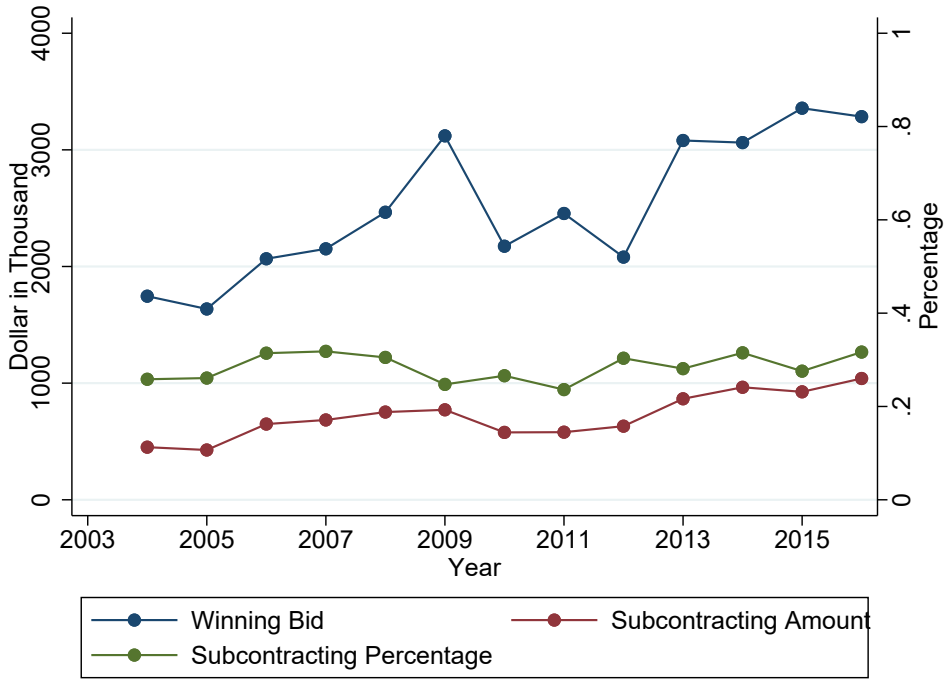
(c) Project Average Engineer's Estimate



(d) Project Average Winning Bid

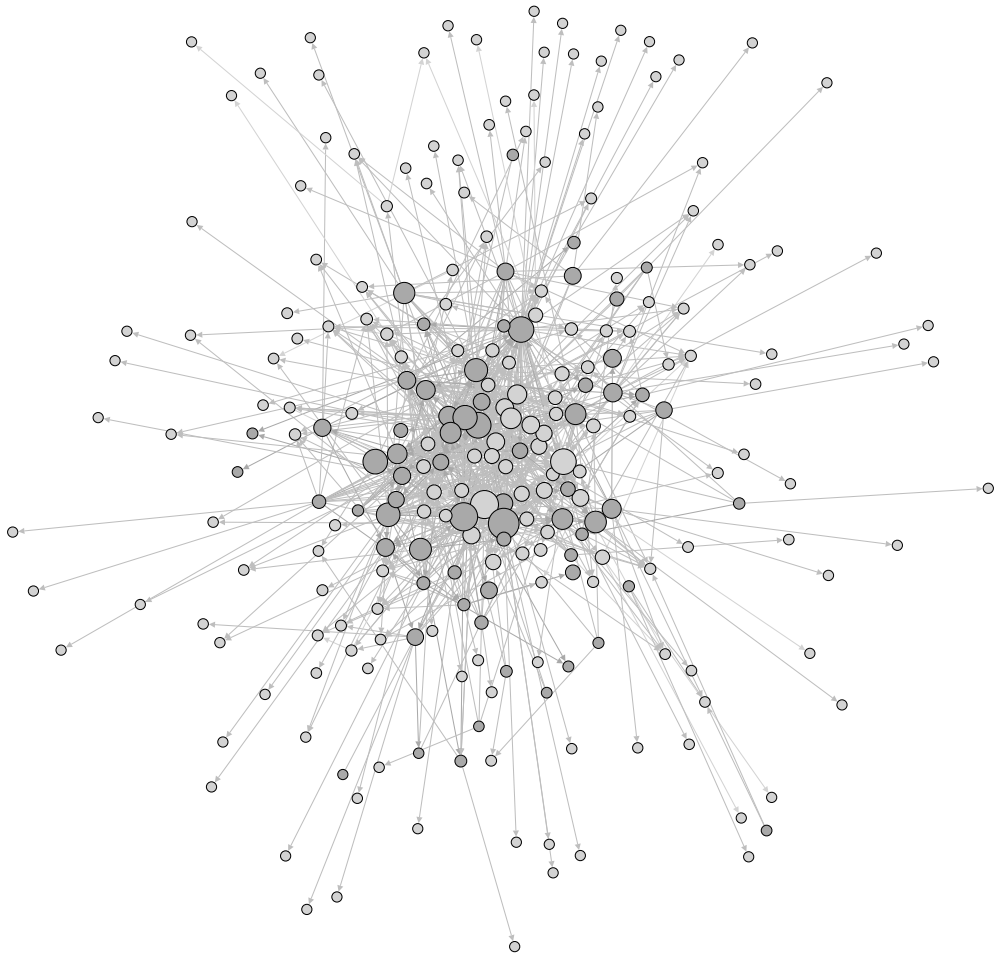
Data and Variables

Figure: Average Subcontracting Amount in a Project with Subcontracting



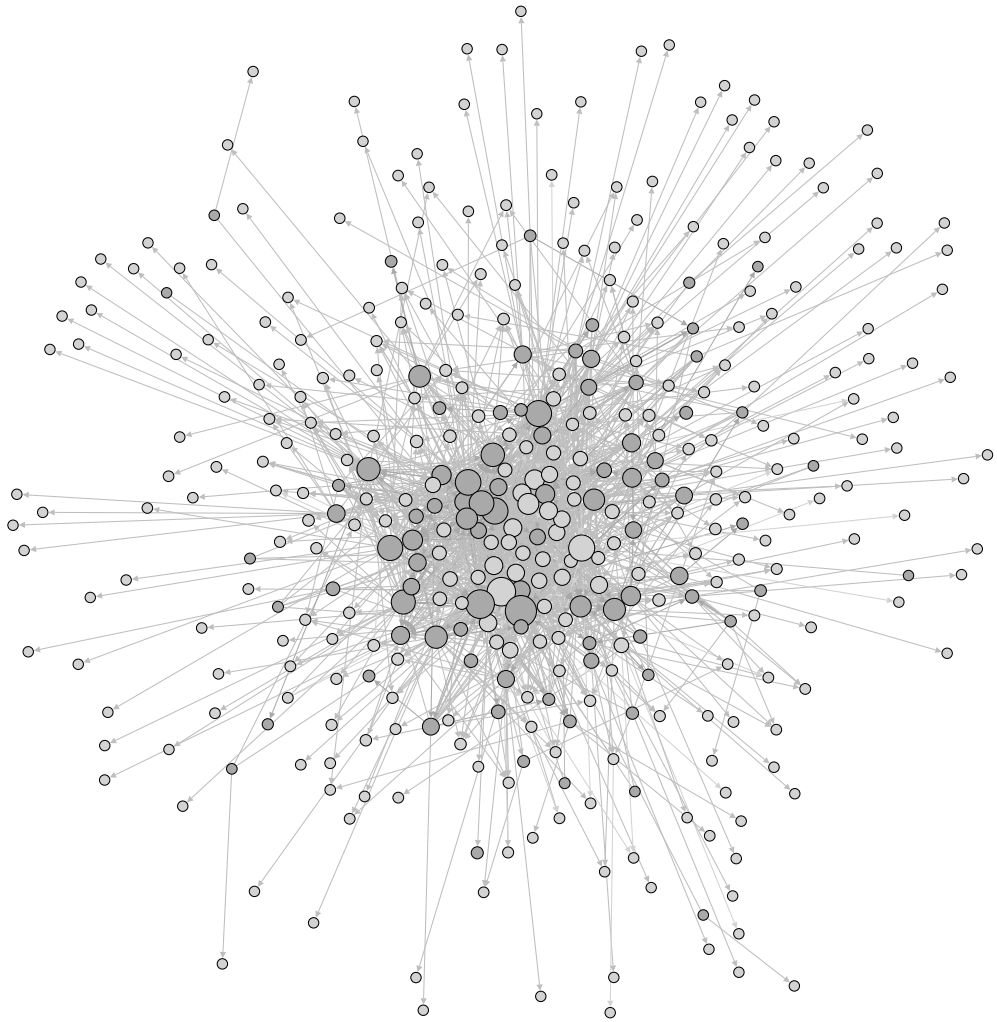
Data and Variables

Network in 2006M1



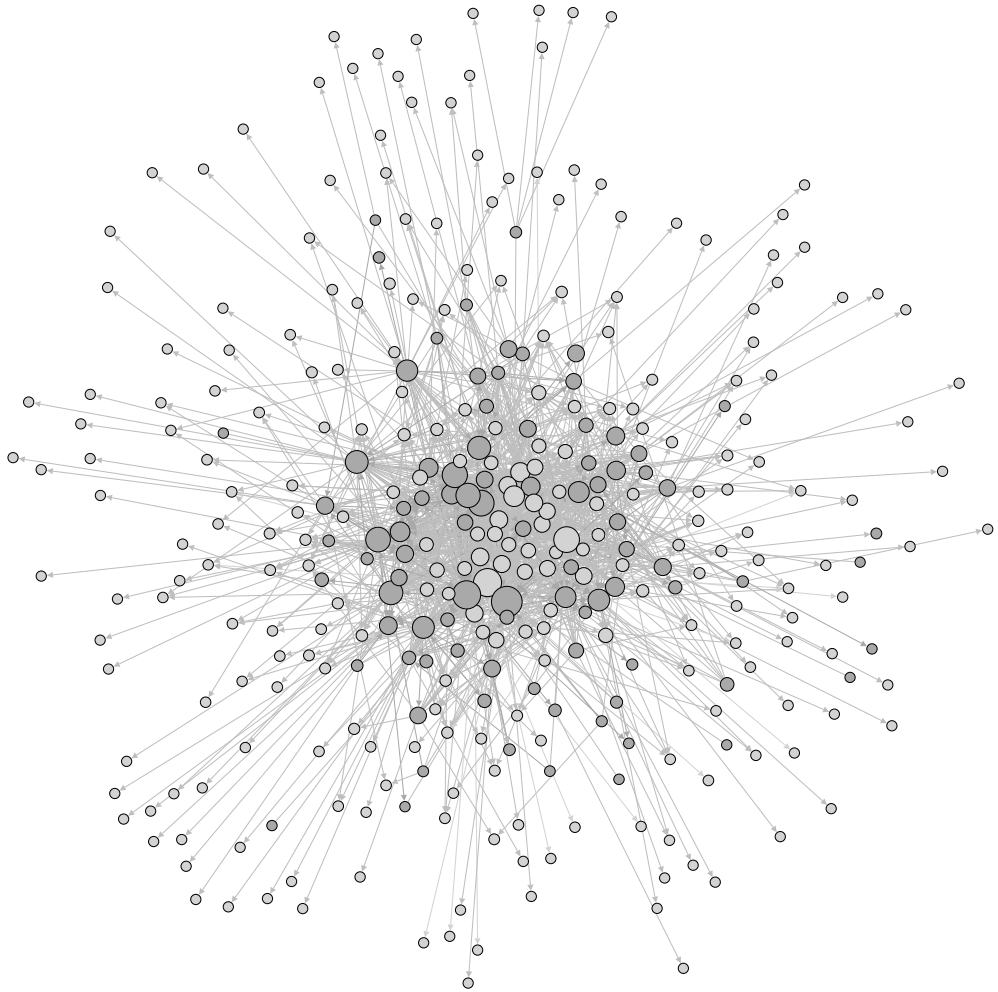
Data and Variables

Network in 2011M1



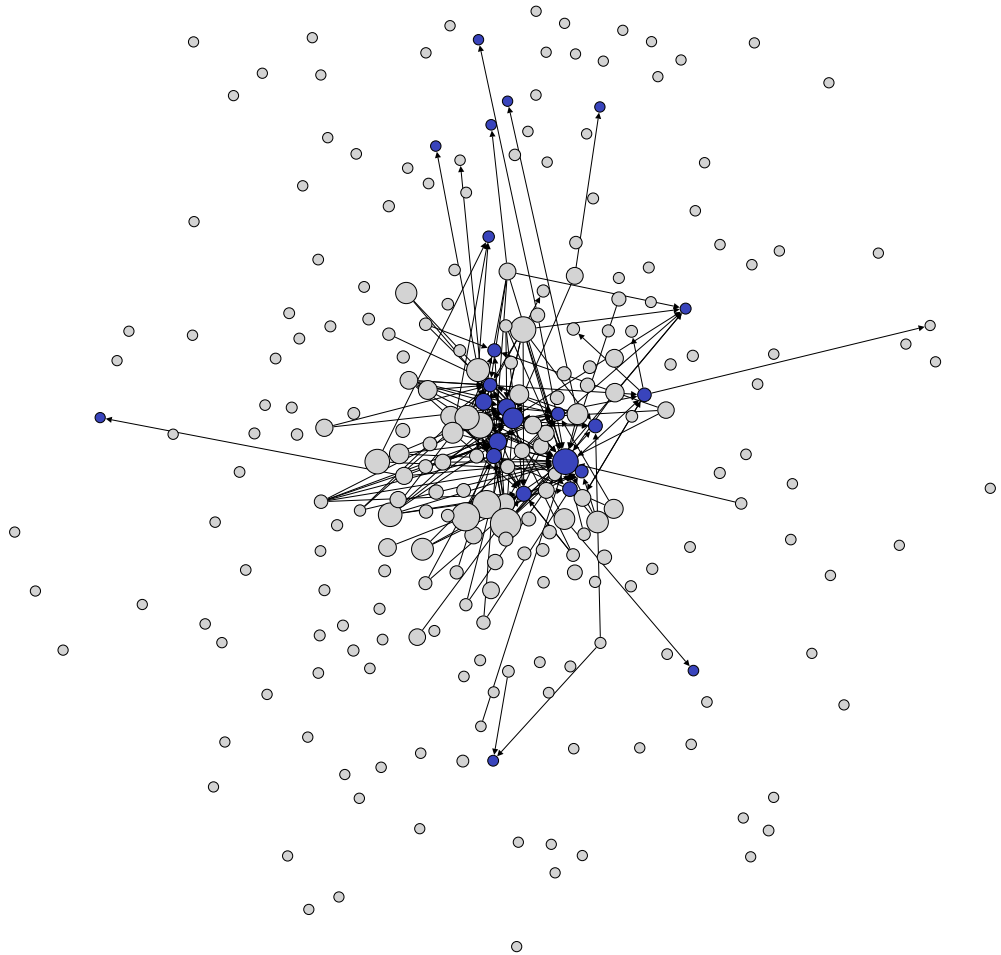
Data and Variables

Network in 2016M1



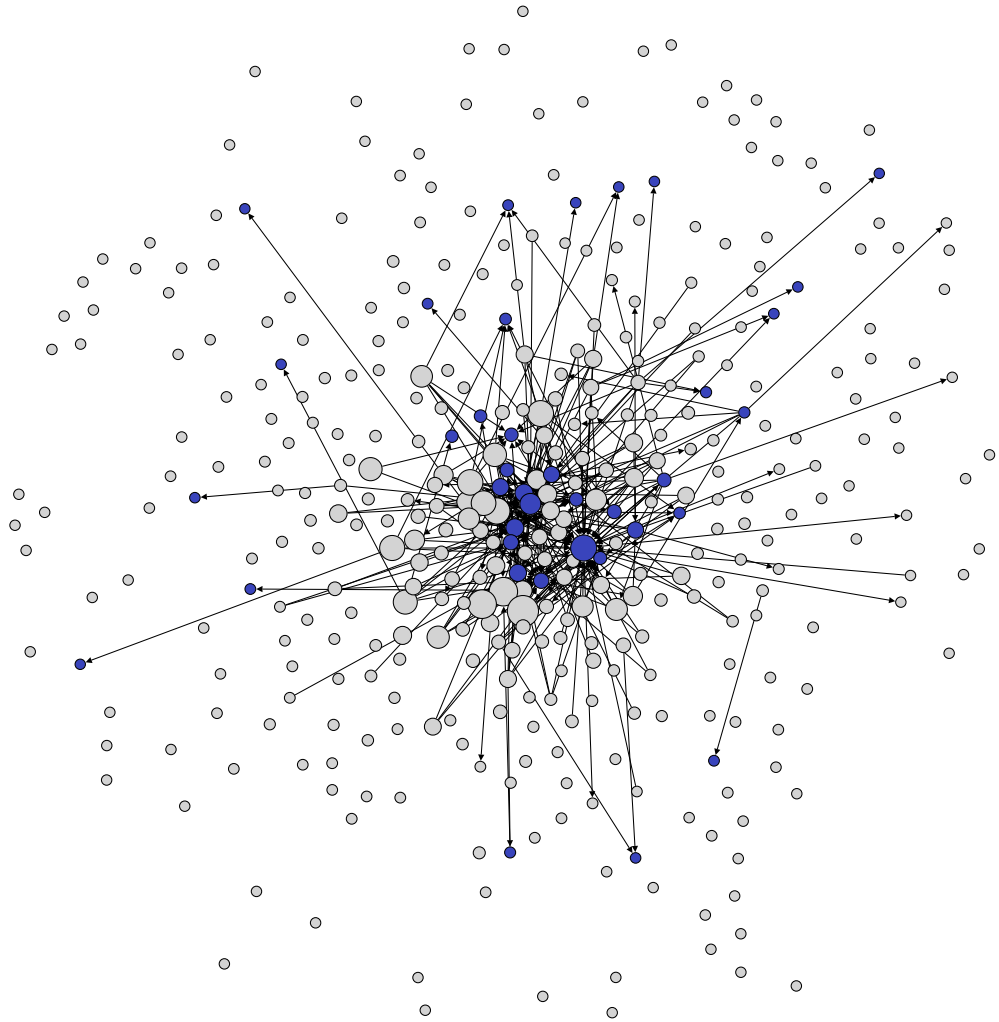
Data and Variables

DBE Network in 2006M1



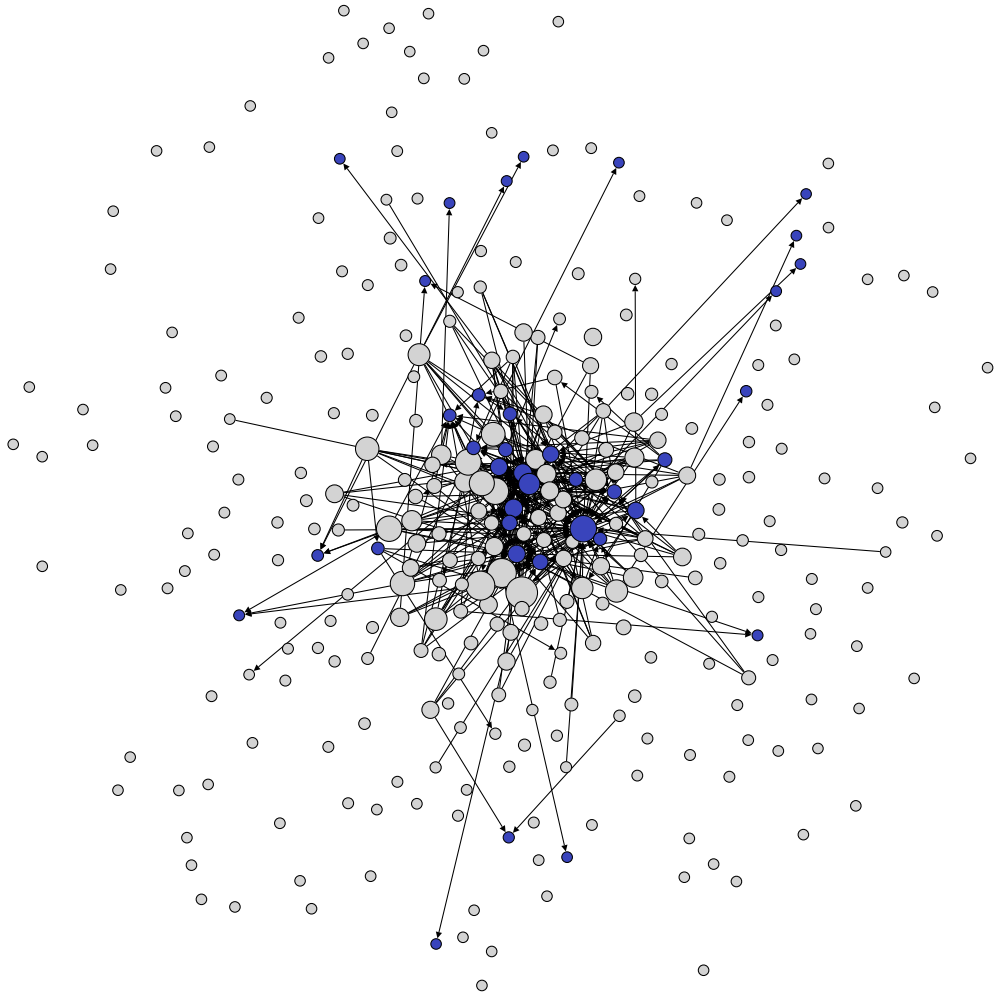
Data and Variables

DBE Network in 2011M1



Data and Variables

DBE Network in 2016M1



Data and Variables

Summary Statistics

	OB	Mean	SD	Min	Max
$PlanNumber_{pmt}$	3429	6.517	3.061	1.000	20.000
$BidderNumber_{pmt}$	3429	3.812	1.907	1.000	11.000
$SubNumber_{pmt}$	3429	3.661	3.149	0.000	22.000
$PotentialSubNumber_{pmt}$	3429	456.797	55.784	346.000	535.000
$Cdays_{pmt}$	3429	128.504	104.122	5.000	1129.000
$EngEst_{pmt}$ (in thousand dollars)	3429	2397.350	5776.487	12.632	96537.186
$ItemNumber_{pmt}$	3429	45.713	50.171	1.000	616.000
$ProjectDBE_{pmt}$	3429	0.298	0.458	0.000	1.000
$Distance_{ipmt}$	13072	184.125	265.017	1.023	1635.666
$RivalLinkMax_{ipmt}$	13072	78.337	61.075	0.000	257.000
$Distance_{jpmt}$	1566357	247.752	277.109	0.218	1696.163
$RivalLinkMax_{jpmt}$	1566357	221.881	54.220	76.000	316.000
$SubEntrant_{jpmt}$	1566357	0.170	0.376	0.000	1.000
$FirmDBE_{i(j)}$	962	0.072	0.258	0.000	1.000
$PrimeEx_{i}$	962	0.075	0.263	0.000	1.000
$SubEx_{j}$	962	0.693	0.461	0.000	1.000
$Prime\&Sub_{i(j)}$	962	0.154	0.361	0.000	1.000
$Perspective_{i(j)}$	962	0.078	0.268	0.000	1.000

Notes: The table presents the summary statistics of variables at various levels.

Data and Variables

Summary Statistics

	OB	Mean	SD	Min	Max
$Backlog_{i(j)t}$ (in thousand dollars)	126984	371.830	2959.113	0.000	117189.568
$BacklogPrimeWork_{i(j)t}$ (in thousand dollars)	126984	262.089	2744.191	0.000	113371.952
$BacklogSubWork_{i(j)t}$ (in thousand dollars)	126984	109.741	644.468	0.000	24093.696
$DegreeCentrality_{it}$	126984	2.514	13.405	0.000	257.000
$HubCentrality_{it}$	126984	0.001	0.006	0.000	0.177
$SubAmount_{it}$ (in thousand dollars)	126984	419.055	3072.660	0.000	88041.931
$DegreeCentrality_{jt}$	126984	2.514	12.766	0.000	342.000
$AuthCentrality_{jt}$	126984	0.001	0.005	0.000	0.126
$SubAmount_{jt}$ (in thousand dollars)	126984	419.055	1778.398	0.000	39594.695
$Network_{ijt}$	122031624	0.001	0.035	0.000	1.000
$NetworkSum_{ijt}$	122031624	0.003	0.109	0.000	29.000
$MetricDistance_{ijt}$	122031624	0.523	0.485	0.000	1.414
$Distance_{ij}$	924482	385.988	372.619	0.000	2720.764
$ProjectValue_{mt}$ (in million dollars)	1056	8.891	13.892	0.000	136.748

Notes: The table presents the summary statistics of variables at various levels.

Data and Variables

Prime Location

State	FirmNumber	FirmNumberPct	SubProjectNumber	SubProjectNumberPct	SubAmount	SubAmountPct
Arizona	1	0.005	76	0.005	6.4263	0.0025
Arkansas	4	0.018	40	0.003	4.6173	0.0018
Colorado	3	0.014	52	0.003	11.7883	0.0045
Florida	13	0.059	65	0.004	12.2188	0.0047
Illinois	1	0.005	252	0.016	34.2130	0.0131
Indiana	3	0.014	55	0.004	3.2105	0.0012
Iowa	3	0.014	90	0.006	14.0010	0.0054
Kansas	19	0.086	1404	0.091	241.9375	0.0929
Kentucky	2	0.009	11	0.001	0.7133	0.0003
Michigan	5	0.023	24	0.002	4.4294	0.0017
Minnesota	5	0.023	60	0.004	9.6898	0.0037
Missouri	9	0.041	85	0.005	9.1907	0.0035
Nebraska	3	0.014	180	0.012	48.9024	0.0188
New Jersey	1	0.005	2	0.000	0.1256	0.0000
Ohio	6	0.027	8	0.001	0.7586	0.0003
Oklahoma	129	0.586	12770	0.824	2175.8936	0.8355
Pennsylvania	2	0.009	0	0.000	0.0000	0.0000
Tennessee	1	0.005	4	0.000	0.5244	0.0002
Texas	9	0.041	268	0.017	22.7305	0.0087
Washington	1	0.005	44	0.003	2.7965	0.0011
Total	220	1	15490	1	2604.168	1

Data and Variables

Subcontractor Location

State	FirmNumber	FirmNumberPct	SubProjectNumber	SubProjectNumberPct	SubAmount	SubAmountPct
Alabama	2	0.002	2	0.0001	0.2797	0.00011
Arizona	1	0.001	1	0.0001	0.5549	0.00021
Arkansas	22	0.027	124	0.0080	16.0099	0.00615
California	4	0.005	6	0.0004	0.6205	0.00024
Colorado	4	0.005	17	0.0011	5.0964	0.00196
Delaware	1	0.001	1	0.0001	0.2268	0.00009
Florida	13	0.016	27	0.0017	10.3245	0.00396
Georgia	6	0.007	23	0.0015	3.4642	0.00133
Illinois	8	0.010	202	0.0130	60.6310	0.02328
Indiana	6	0.007	11	0.0007	0.7747	0.00030
Iowa	6	0.007	16	0.0010	15.5961	0.00599
Kansas	58	0.071	408	0.0263	161.1014	0.06186
Kentucky	1	0.001	1	0.0001	0.1436	0.00006
Maryland	2	0.002	4	0.0003	3.9815	0.00153
Michigan	5	0.006	9	0.0006	1.9857	0.00076
Minnesota	9	0.011	96	0.0062	8.5136	0.00327
Missouri	32	0.039	180	0.0116	62.0677	0.02383
Nebraska	5	0.006	11	0.0007	5.4808	0.00210
Nevada	2	0.002	3	0.0002	0.7284	0.00028
New Jersey	1	0.001	13	0.0008	9.6328	0.00370
New York	1	0.001	1	0.0001	0.0760	0.00003
North Carolina	1	0.001	1	0.0001	0.0850	0.00003
North Dakota	1	0.001	1	0.0001	0.0016	0.00000
Ohio	2	0.002	2	0.0001	0.1630	0.00006
Oklahoma	528	0.648	13601	0.8781	2134.5892	0.81968
Pennsylvania	4	0.005	80	0.0052	2.1204	0.00081
Tennessee	4	0.005	7	0.0005	0.1725	0.00007
Texas	70	0.086	555	0.0358	82.7036	0.03176
Utah	3	0.004	4	0.0003	6.1075	0.00235
Virginia	2	0.002	14	0.0009	0.4661	0.00018
Washington	3	0.004	3	0.0002	0.5585	0.00021
Wisconsin	6	0.007	63	0.0041	8.8011	0.00338
Wyoming	2	0.002	3	0.0002	1.1089	0.00043
Total	815	1.000	15490	1.0000	2604.1677	1.00000

Estimation Results

Probability of forming a link

	Regular Network				Discounted Network			
	All		Subcontracting Projects		All		Subcontracting Projects	
	Bidder	Sub	Bidder	Sub	Bidder	Sub	Bidder	Sub
$Network_{ij,t-1}$	-0.7588^{***}	3.0156^{***}	-0.6411^{***}	2.9176^{***}	-0.6271^{***}	2.8040^{***}	-0.6888^{***}	3.1267^{***}
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$NetworkSum_{ij,t-1}$	0.9844^{***}	5.1545^{***}	1.0061^{***}	5.7677^{***}	1.8430^{***}	9.2666^{***}	1.9344^{***}	9.6674^{***}
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$NetworkSum_{ij,t-1}BidderDBE_i$	0.3930^{*}	1.0224	0.3766^{*}	1.0378	0.6057	0.8854	0.6988^{*}	0.9088
	(0.080)	(0.142)	(0.084)	(0.144)	(0.108)	(0.190)	(0.060)	(0.194)
$NetworkSum_{ij,t-1}SubDBE_j$	-0.1551^{***}	-0.4574	-0.1179^{*}	-0.2995	-0.2610^{**}	0.0086	-0.2481^{***}	0.2485
	(0.000)	(0.168)	(0.072)	(0.370)	(0.018)	(0.482)	(0.000)	(0.360)
$log(Distance)_{ij}$	-0.4376^{***}	-4.7547^{***}	-0.9650^{***}	-3.3459^{***}	-0.6845^{***}	-4.6204^{***}	-0.8491^{***}	-3.7828^{***}
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$log(Distance)_{ij}^2$	1.2309^{***}	-0.1136	1.1394^{***}	-0.5159^{***}	2.4877^{***}	-0.0974	1.5226^{***}	-0.4907^{*}
	(0.000)	(0.428)	(0.000)	(0.002)	(0.000)	(0.428)	(0.000)	(0.064)
$log(Distance)_{ipmt}$	0.2769^{***}	-2.0613^{***}	0.2483^{***}	0.0172	0.0680^{*}	-0.8560^{***}	0.4117^{***}	-1.1795^{***}
	(0.000)	(0.000)	(0.000)	(0.312)	(0.078)	(0.000)	(0.000)	(0.000)
$log(Distance)_{ipmt}^2$	-0.4628^{***}	0.6383	-0.6143^{***}	-0.6738^{**}	-0.1528	0.3215	-0.8286^{***}	0.2155
	(0.000)	(0.148)	(0.000)	(0.042)	(0.174)	(0.188)	(0.000)	(0.188)
$log(Distance)_{jpmt}$	-0.9271^{***}	-3.1591^{***}	-1.0305^{***}	-2.6268^{***}	-1.0967^{***}	-2.4522^{***}	-0.9870^{***}	-2.2413^{***}
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$log(Distance)_{jpmt}^2$	-2.3068^{***}	-2.4960^{***}	-1.9731^{***}	-2.5309^{***}	-2.0848^{***}	-2.7300^{***}	-2.9754^{***}	-2.7494^{***}
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$log(Distance)_{ij}log(Distance)_{ipmt}$	1.7806^{***}	2.8293^{***}	2.0924^{***}	1.6038^{***}	1.2321^{***}	1.5799^{***}	1.7220^{***}	1.6742^{***}
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$log(Distance)_{ij}log(Distance)_{jpmt}$	-0.2773^{***}	0.9230^{***}	-0.2406^{*}	-0.1926	-0.8615^{***}	0.3665	-0.5387^{***}	0.3047
	(0.000)	(0.000)	(0.076)	(0.148)	(0.000)	(0.296)	(0.000)	(0.196)
$log(Distance)_{ipmt}log(Distance)_{jpmt}$	-1.2755^{***}	0.0044	-2.3128^{***}	-0.5307^{***}	-1.4183^{***}	-0.8689^{***}	-1.3632^{***}	-0.4836^{***}
	(0.000)	(0.346)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$log(Distance)_{ipmt}log(Distance)_{jpmt}log(Distance)_{ij}$	-2.6761^{***}	0.7368^{**}	-0.7521^{***}	0.6200	-1.7545^{***}	1.4229^{***}	-0.9019^{***}	0.9562^{**}
	(0.000)	(0.018)	(0.000)	(0.182)	(0.000)	(0.000)	(0.000)	(0.014)
$MetricDistance_{ij,t-1}$	0.0306^{**}	-0.5976^{***}	-0.0187	-0.6008^{***}	0.0327^{***}	-0.6139^{***}	-0.1640^{***}	-0.4086^{***}
	(0.024)	(0.000)	(0.102)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Estimation Results

Probability of forming a link

	Regular Network				Discounted Network			
	All		Subcontracting Projects		All		Subcontracting Projects	
	Bidder	Sub	Bidder	Sub	Bidder	Sub	Bidder	Sub
$RivalLinkMax_{i,t-1}$	-0.3108^{***}		-0.3659^{***}		-0.5413^{***}		-0.5930^{***}	
	(0.000)		(0.000)		(0.000)		(0.000)	
$log(Backlog)_{i,t-1}$	-0.6117^{***}	0.2465^{***}	-0.5738^{***}	0.1204^{***}	-0.5470^{***}	0.2015^{***}	-0.4932^{***}	0.0747^{***}
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$log(Backlog)^2_{i,t-1}$	0.1539^{***}	0.0504^{***}	0.1822^{***}	0.0536^{***}	0.1095^{***}	0.0994^{***}	0.1432^{***}	0.0908^{***}
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$DegreeCentrality_{i,t-1}$	-0.6537^{***}	-0.4616^{***}	-0.8029^{***}	-0.2209^{***}	-1.6270^{***}	-0.4681^{***}	-1.6590^{***}	-0.4097^{***}
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$DegreeCentrality_{i,t-1} BidderDBE_i$	-0.2285	-0.8278	-0.3974	-0.7802	-0.0206	-0.4117	-0.1489	-0.1599
	(0.308)	(0.160)	(0.250)	(0.178)	(0.498)	(0.284)	(0.414)	(0.414)
$log(SubAmount)_{i,t-1}$	-0.1598^{***}	-0.3113^{***}	-0.1324^{***}	-0.3455^{***}	-0.1077^{***}	-0.3547^{***}	-0.2253^{***}	-0.2651^{***}
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$HubCentrality_{i,t-1}$	-0.9923	0.7899	-0.4219	0.3985	-0.2096	0.8701	0.1507	0.5731
	(0.120)	(0.136)	(0.262)	(0.320)	(0.356)	(0.106)	(0.478)	(0.224)
$HubCentrality_{i,t-1} BidderDBE_i$	-0.1306	-0.2737	-0.1188	-0.3484	-0.1232	-0.3315	-0.0755	-0.2879
	(0.452)	(0.394)	(0.460)	(0.352)	(0.464)	(0.362)	(0.468)	(0.374)
$ProjectDBE_{pmt} BidderDBE_i$	-0.3151^{**}	0.3687	-0.2480^{*}	0.2879	-0.2588^{**}	0.2709^{*}	-0.2583^{*}	0.3463
	(0.028)	(0.142)	(0.064)	(0.138)	(0.040)	(0.086)	(0.072)	(0.128)

Estimation Results

Probability of forming a link

	Regular Network				Discounted Network			
	All		Subcontracting Projects		All		Subcontracting Projects	
	Bidder	Sub	Bidder	Sub	Bidder	Sub	Bidder	Sub
$RivalLinkMax_{j,t-1}$		-0.0610^{***}		-0.0305^{***}		-0.2430^{***}		-0.1691^{***}
		(0.000)		(0.000)		(0.000)		(0.000)
$SubEntrant_{jt}$	-1.6865^{***}	2.3366^{***}	-1.8525^{***}	2.7754^{***}	-1.6799^{***}	2.3662^{***}	-2.1152^{***}	3.1400^{***}
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$log(Backlog)_{j,t-1}$	-0.3952^{***}	-0.1443^{***}	-0.4072^{***}	0.4763^{***}	-0.4129^{***}	-0.0031	-0.2865^{***}	0.3513^{***}
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.480)	(0.000)	(0.000)
$log(Backlog)^2_{j,t-1}$	-0.1965^{***}	0.9574^{***}	0.1322^{***}	0.1900^{***}	-0.2929^{***}	0.8987^{***}	0.0654^{***}	0.1914^{***}
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$DegreeCentrality_{j,t-1}$	-0.1059^{***}	0.9353^{***}	0.0385^{***}	0.8014^{***}	0.0623^{***}	1.2966^{***}	-0.2252^{***}	2.0443^{***}
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$DegreeCentrality_{j,t-1}SubDBE_j$	0.3375^{***}	-0.8522^{***}	0.0687^{***}	-0.4610^{***}	0.2660^{***}	-0.7831^{***}	0.3411^{***}	-1.3056^{***}
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$log(SubAmount)_{j,t-1}$	-0.0323^{***}	-0.1689^{***}	-0.0428^{***}	-0.1037^{***}	-0.0347^{***}	-0.1040^{***}	0.0088	-0.1413^{***}
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.300)	(0.000)
$AuthCentrality_{j,t-1}$	-0.2054	0.2393	-0.5842	0.0596	0.6656	0.7583	0.8221	0.5040
	(0.378)	(0.412)	(0.220)	(0.488)	(0.228)	(0.278)	(0.150)	(0.274)
$AuthCentrality_{j,t-1}SubDBE_j$	0.2944	0.2270	0.8674	0.1583	0.6328	0.0639	0.9683	0.0786
	(0.294)	(0.424)	(0.148)	(0.486)	(0.166)	(0.498)	(0.120)	(0.460)
$ProjectDBE_{pmt}SubDBE_j$	0.2430^{***}	0.2641^{***}	0.2146^{***}	0.2870^{***}	0.1984^{***}	0.3459^{***}	0.2172^{***}	0.3056^{***}
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

The probability that the parameter has the opposite sign of its mean is shown in parentheses.
$*p < 0.1, * * p < 0.05, * * *p < 0.01$

Estimation Results

Probability of forming a link

	Regular Network				Discounted Network			
	All		Subcontracting Projects		All		Subcontracting Projects	
	Bidder	Sub	Bidder	Sub	Bidder	Sub	Bidder	Sub
$log(Cdays)_{pmt}$	1.1046***	0.6312***	0.8136***	0.3894***	1.3707***	0.7269***	0.9228***	0.1998***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$log(EngEst)_{pmt}$	0.0601***	−0.0286***	0.0551***	−0.1328***	−0.0405***	0.1216***	0.1023***	0.0942***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$log(ItemNumber)_{pmt}$	3.9565***	4.4091***	3.7863***	4.1404***	3.7850***	4.1591***	3.9945***	3.3741***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$ProjectDBE_{pmt}$	−0.1034***	0.0631***	−0.0870***	0.0364	−0.0764***	−0.0001	−0.0654***	−0.0132
	(0.000)	(0.000)	(0.000)	(0.172)	(0.000)	(0.420)	(0.000)	(0.380)
$PlanNumber_{pmt}$	−0.7865***	0.0485**	−0.7828***	0.0821***	−0.7286***	−0.0691***	−0.7242***	−0.0417*
	(0.000)	(0.036)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.092)
$log(ProjectValue)_{m,t+1}$	0.0375***	−0.1372***	0.0103	−0.1791***	0.0512***	−0.1932***	0.0214***	−0.1126***
	(0.000)	(0.000)	(0.342)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Division Fixed Effect	Yes		Yes		Yes		Yes	
Project Type Fixed Effect	Yes		Yes		Yes		Yes	
Bidder Fixed Effect	Yes		Yes		Yes		Yes	
Subcontractor Fixed Effect	Yes		Yes		Yes		Yes	
Time Fixed Effect	Yes		Yes		Yes		Yes	

Summary Statistics for the Bidding Regression Data Set

	OB	Mean	SD	Min	Max
WinBid (in thousand dollars)	3005	2093.6	4959.8	9.399	90449.9
Markup	3005	-5.374	17.59	-74.93	104.3
Subcontracting	3005	0.849	0.358	0	1
SubPercentage	3005	0.193	0.175	0	0.942
SubItemNumber	3005	22.15	33.96	0	337
SubNumber	3005	3.506	3.028	0	22
ProjectDBE	3005	0.285	0.451	0	1
PrimeDBE	3005	0.0606	0.239	0	1
SubDBE	3005	0.595	0.491	0	1
ProjectDBEpercent	3005	1.356	2.374	0	10
EngineerEstimate (in thousand dollars)	3005	2232.8	5445.2	12.63	90784
BidderNumber	3005	3.766	1.896	1	13
CalanderDays	3005	123.6	101.4	5	1129
ItemNumber	3005	45.07	48.59	1	489
PrimeBacklog (in thousand dollars)	3005	5810.5	10419.4	0	91360.6
Distance	3005	119.3	187.2	1.025	1155.5
$DegreeCentrality_{t-1}$	3005	54.49	50.33	0	257
PrimeInState	3005	0.881	0.324	0	1
$ProjectValue_{t+1}$ (in million dollars)	3005	9.021	14.32	0	136.7
RivalMinBacklog (in thousand dollars)	3005	10468.9	29037.1	0	105570.6

Impact of Subcontracting on Bidding Outcomes

	(1) $log(WinBid)$	(2) $log(WinBid)$	(3) $log(WinBid)$	(4) $log(WinBid)$	(5) $log(WinBid)$	(6) $log(WinBid)$
Subcontracting	0.0872***	0.553***				
	(0.0138)	(0.138)				
Subcontracting × $log(EngEst)$		-0.0373***	0.0443***			
		(0.0107)	(0.00828)			
Subcontracting × $(log(EngEst))^2$			-0.00299***			
			(0.000633)			
SubPercentage				0.268***		
				(0.0573)		
$SubPercentage^2$				-0.272***		
				(0.0856)		
SubItemNumber					0.000548*	
					(0.000290)	
$SubItemNumber^2$					-0.00000243**	
					(0.000000975)	
SubNumber						0.0180***
						(0.00382)
$SubNumber^2$						-0.00121***
						(0.000248)

Standard error in parentheses is robust. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Impact of Subcontracting on Bidding Outcomes

	(1) $log(WinBid)$	(2) $log(WinBid)$	(3) $log(WinBid)$	(4) $log(WinBid)$	(5) $log(WinBid)$	(6) $log(WinBid)$
SubDBE	0.00659	0.00843	0.00658	0.0183**	0.0284***	0.0139
	(0.00854)	(0.00850)	(0.00852)	(0.00811)	(0.00790)	(0.00848)
PrimeDBE	-0.0671***	-0.0525***	-0.0549***	-0.0763***	-0.0908***	-0.0811***
	(0.0194)	(0.0199)	(0.0196)	(0.0197)	(0.0198)	(0.0200)
ProjectDBE × *PrimeDBE*	0.101*	0.0700	0.0672	0.115**	0.110*	0.107*
	(0.0598)	(0.0595)	(0.0589)	(0.0574)	(0.0589)	(0.0579)
ProjectDBE × *PrimeDBE* × *t*	-0.000136	-0.0000279	-0.0000277	-0.000115	0.0000232	-0.0000110
	(0.000464)	(0.000458)	(0.000453)	(0.000455)	(0.000459)	(0.000456)
ProjectDBE × *SubDBE*	-0.0471***	-0.0438***	-0.0434***	-0.0510***	-0.0518***	-0.0527***
	(0.0142)	(0.0142)	(0.0141)	(0.0143)	(0.0143)	(0.0144)
ProjectDBE × *SubDBE* × *t*	0.000369***	0.000383***	0.000406***	0.000358***	0.000342***	0.000365***
	(0.000130)	(0.000130)	(0.000129)	(0.000131)	(0.000132)	(0.000132)

Standard error in parentheses is robust. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Impact of Subcontracting on Bidding Outcomes

	(1) $log(WinBid)$	(2) $log(WinBid)$	(3) $log(WinBid)$	(4) $log(WinBid)$	(5) $log(WinBid)$	(6) $log(WinBid)$
$log(EngEst)$	0.958***	0.989***	0.990***	0.959***	0.957***	0.957***
	(0.00511)	(0.0107)	(0.00975)	(0.00513)	(0.00535)	(0.00525)
$log(BidderNumber)$	-0.113***	-0.114***	-0.115***	-0.110***	-0.109***	-0.111***
	(0.00734)	(0.00735)	(0.00735)	(0.00737)	(0.00744)	(0.00739)
$log(Cdays)$	0.0521***	0.0508***	0.0497***	0.0509***	0.0515***	0.0493***
	(0.00931)	(0.00929)	(0.00926)	(0.00930)	(0.00932)	(0.00939)
$log(ItemNumber)$	0.0426***	0.0442***	0.0455***	0.0413***	0.0467***	0.0439***
	(0.00727)	(0.00730)	(0.00734)	(0.00750)	(0.00879)	(0.00780)
$log(PrimeBacklog)$	-0.000208	0.0000359	0.000159	-0.000239	-0.000110	-0.000100
	(0.000956)	(0.000955)	(0.000955)	(0.000967)	(0.000969)	(0.000961)
$log(Distance)$	0.00523	0.00464	0.00494	0.00354	0.00379	0.00520
	(0.00399)	(0.00399)	(0.00398)	(0.00400)	(0.00399)	(0.00400)
$DegreeCentrality_{t-1}$	0.000218***	0.000218***	0.000193**	0.000255***	0.000272***	0.000193**
	(0.0000822)	(0.0000819)	(0.0000820)	(0.0000826)	(0.0000832)	(0.0000843)
$PrimeInState$	-0.0109	-0.0105	-0.00912	-0.00951	-0.00653	-0.00582
	(0.0142)	(0.0142)	(0.0142)	(0.0143)	(0.0144)	(0.0143)
$log(ProjectValue)_{t+1}$	-0.000452	-0.000518	-0.000489	-0.000492	-0.000472	-0.000507
	(0.000500)	(0.000499)	(0.000500)	(0.000504)	(0.000507)	(0.000506)

Standard error in parentheses is robust. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Impact of Subcontracting on Bidding Outcomes

	(1)	(2)	(3)	(4)	(5)	(6)
	$log(WinBid)$	$log(WinBid)$	$log(WinBid)$	$log(WinBid)$	$log(WinBid)$	$log(WinBid)$
$log(RMinbacklog)$	-0.00124**	-0.00125**	-0.00122**	-0.00112**	-0.00110**	-0.00123**
	(0.000542)	(0.000541)	(0.000540)	(0.000546)	(0.000550)	(0.000547)
$UnemploymentRate$	-0.0382***	-0.0380***	-0.0379***	-0.0380***	-0.0383***	-0.0381***
	(0.00410)	(0.00410)	(0.00409)	(0.00412)	(0.00415)	(0.00413)
$log(BuildingPermit)$	-0.00354	-0.00312	-0.00284	-0.00704	-0.00868	-0.00403
	(0.0143)	(0.0142)	(0.0142)	(0.0144)	(0.0143)	(0.0144)
Constant	0.393**	0.00145	-0.0109	0.451**	0.494***	0.437**
	(0.188)	(0.226)	(0.219)	(0.190)	(0.191)	(0.191)
Observations	3005	3005	3005	3005	3005	3005
$PrimeDBE + ProjectDBE \times PrimeDBE$	0.0336	0.0175	0.0123	0.0382	0.0192	0.0264
F-text P-value	0.564	0.761	0.830	0.492	0.736	0.639
$SubDBE + ProjectDBE \times SubDBE$	-0.0405	-0.0353	-0.0368	-0.0328	-0.0234	-0.0388
F-text P-value	0.00669	0.0172	0.0128	0.0261	0.113	0.0109

Standard error in parentheses is robust. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Impact of Subcontracting on Markup

	(1) *Markup*	(2) *Markup*	(3) *Markup*	(4) *Markup*	(5) *Markup*	(6) *Markup*
Subcontracting	7.647***	46.53***				
	(1.237)	(11.43)				
Subcontracting × *log*(*EngEst*)		-3.119***	3.564***			
		(0.886)	(0.679)			
Subcontracting × (*log*(*EngEst*))^2			-0.237***			
			(0.0519)			
SubPercentage				23.72***		
				(5.412)		
SubPercentage^2				-23.08***		
				(8.017)		
SubItemNumber					0.0780***	
					(0.0264)	
SubItemNumber^2					-0.000296***	
					(0.0000933)	
SubNumber						1.679***
						(0.352)
SubNumber^2						-0.108***
						(0.0225)

Standard error in parentheses is robust. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Impact of Subcontracting on Markup (Continued)

	(1) *Markup*	(2) *Markup*	(3) *Markup*	(4) *Markup*	(5) *Markup*	(6) *Markup*
SubDBE	0.437	0.590	0.442	1.434*	2.314***	0.981
	(0.809)	(0.808)	(0.808)	(0.773)	(0.749)	(0.809)
PrimeDBE	-6.599***	-5.380***	-5.668***	-7.361***	-8.498***	-7.739***
	(1.752)	(1.780)	(1.761)	(1.781)	(1.796)	(1.810)
ProjectDBE × *PrimeDBE*	10.53*	7.969	7.927	11.82**	11.68**	11.27**
	(5.769)	(5.746)	(5.689)	(5.554)	(5.721)	(5.606)
ProjectDBE × *PrimeDBE* × *t*	-0.0238	-0.0147	-0.0153	-0.0232	-0.0116	-0.0141
	(0.0455)	(0.0450)	(0.0447)	(0.0447)	(0.0453)	(0.0448)
ProjectDBE × *SubDBE*	-3.946***	-3.670***	-3.659***	-4.300***	-4.393***	-4.489***
	(1.374)	(1.372)	(1.367)	(1.377)	(1.382)	(1.387)
ProjectDBE × *SubDBE* × *t*	0.0311**	0.0322**	0.0340***	0.0301**	0.0278**	0.0307**
	(0.0126)	(0.0125)	(0.0125)	(0.0126)	(0.0127)	(0.0127)

Standard error in parentheses is robust. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Impact of Subcontracting on Markup (Continued)

	(1) *Markup*	(2) *Markup*	(3) *Markup*	(4) *Markup*	(5) *Markup*	(6) *Markup*
$log(EngEst)$	-4.042***	-1.423	-1.564*	-3.911***	-4.230***	-4.109***
	(0.467)	(0.895)	(0.841)	(0.469)	(0.494)	(0.482)
$log(BidderNumber)$	-10.68***	-10.79***	-10.83***	-10.43***	-10.33***	-10.55***
	(0.673)	(0.674)	(0.674)	(0.676)	(0.681)	(0.678)
$log(Cdays)$	4.442***	4.334***	4.254***	4.336***	4.404***	4.176***
	(0.820)	(0.821)	(0.821)	(0.820)	(0.821)	(0.826)
$log(ItemNumber)$	3.427***	3.565***	3.660***	3.281***	3.471***	3.469***
	(0.625)	(0.625)	(0.628)	(0.640)	(0.723)	(0.660)
$log(PrimeBacklog)$	-0.0531	-0.0326	-0.0243	-0.0558	-0.0506	-0.0445
	(0.0875)	(0.0879)	(0.0880)	(0.0884)	(0.0886)	(0.0880)
$log(Distance)$	0.413	0.364	0.390	0.262	0.303	0.417
	(0.357)	(0.357)	(0.356)	(0.359)	(0.358)	(0.359)
$DegreeCentrality_{t-1}$	0.0213***	0.0212***	0.0193**	0.0243***	0.0261***	0.0183**
	(0.00772)	(0.00769)	(0.00773)	(0.00776)	(0.00782)	(0.00786)
$PrimeInState$	-1.652	-1.615	-1.511	-1.519	-1.174	-1.203
	(1.365)	(1.363)	(1.366)	(1.374)	(1.385)	(1.378)
$log(ProjectValue)_{t+1}$	-0.0252	-0.0307	-0.0279	-0.0288	-0.0279	-0.0307
	(0.0474)	(0.0472)	(0.0473)	(0.0477)	(0.0480)	(0.0480)

Impact of Subcontracting on Markup (Continued)

	(1) *Markup*	(2) *Markup*	(3) *Markup*	(4) *Markup*	(5) *Markup*	(6) *Markup*
log(*RMinbacklog*)	-0.130**	-0.131**	-0.128**	-0.119**	-0.117**	-0.130**
	(0.0509)	(0.0508)	(0.0508)	(0.0513)	(0.0516)	(0.0514)
UnemploymentRate	-3.444***	-3.425***	-3.419***	-3.428***	-3.450***	-3.432***
	(0.373)	(0.373)	(0.372)	(0.375)	(0.377)	(0.376)
log(*BuildingPermit*)	-0.108	-0.0737	-0.0559	-0.428	-0.560	-0.132
	(1.314)	(1.311)	(1.308)	(1.330)	(1.320)	(1.325)
Constant	42.46**	9.725	11.09	47.67***	53.33***	46.76***
	(17.31)	(19.68)	(19.20)	(17.53)	(17.53)	(17.55)
Observations	3005	3005	3005	3005	3005	3005
$PrimeDBE + ProjectDBE \times PrimeDBE$	3.933	2.589	2.259	4.462	3.182	3.528
F-test P-value	0.485	0.643	0.683	0.409	0.567	0.519
$SubDBE + ProjectDBE \times SubDBE$	-3.510	-3.080	-3.218	-2.865	-2.079	-3.508
F-test P-value	0.0147	0.0319	0.0246	0.0428	0.143	0.0165

Standard error in parentheses is robust. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Summary Statistics for the Market Participation Regression Data Set

	OB	Mean	SD	Min	Max
$Exit_{\geq 24mo}$	77170	0.463	0.499	0	1
$Exit_{\geq 36mo}$	77170	0.436	0.496	0	1
UnemploymentRate	77170	4.917	0.902	3.200	7
BuildingPermit	77170	157893.9	42323.8	70255.3	232023.3
$DegreeCentrality_i$	77170	4.129	17.00	0	257
$DegreeCentrality_j$	77170	4.121	16.17	0	342
InState	77170	0.660	0.474	0	1
PrimeWork	77170	0.0685	0.253	0	1
SubWork	77170	0.389	0.487	0	1
FirmDBE	77170	0.0805	0.272	0	1
$PrimeWork \times SubWork$	77170	0.111	0.315	0	1
DBEPercentAsPrime	77170	1.758	8.245	0	154
DBEPercentAsSub	77170	10.71	37.56	0	678
DBEProjectAsPrime	77170	0.0881	0.283	0	1
DBEProjectAsSub	77170	0.364	0.481	0	1

Impact on Firms' Market Participation

	(1) $Exit_{\geq 24mo}$	(2) $Exit_{\geq 24mo}$	(3) $Exit_{\geq 36mo}$	(4) $Exit_{\geq 36mo}$
PrimeWork	-2.351***	-2.325***	-2.301***	-2.283***
	(0.0463)	(0.0471)	(0.0499)	(0.0509)
SubWork	-1.755***	-1.470***	-1.607***	-1.304***
	(0.0305)	(0.0328)	(0.0327)	(0.0352)
PrimeWork × *SubWork*	-3.127***	-2.818***	-3.020***	-2.695***
	(0.0822)	(0.0830)	(0.0863)	(0.0874)
FirmDBE	-1.230***	-1.230***	-1.196***	-1.200***
	(0.0498)	(0.0498)	(0.0548)	(0.0548)
DBEPercentAsPrime	0.00322		0.00575	
	(0.00740)		(0.00745)	
DBEPercentAsSub	-0.101***		-0.100***	
	(0.00368)		(0.00379)	
DBEProjectAsPrime		-0.226**		-0.125
		(0.0932)		(0.0987)
DBEProjectAsSub		-0.847***		-0.881***
		(0.0336)		(0.0360)

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Impact on Firms' Market Participation

	(1) $Exit_{\geq 24mo}$	(2) $Exit_{\geq 24mo}$	(3) $Exit_{\geq 36mo}$	(4) $Exit_{\geq 36mo}$
UnemploymentRate	0.148***	0.165***	0.168***	0.186***
	(0.0148)	(0.0148)	(0.0147)	(0.0146)
$log(BuildingPermit)$	0.823***	0.833***	0.616***	0.599***
	(0.0471)	(0.0471)	(0.0496)	(0.0497)
$DegreeCentrality_i$	-0.0474***	-0.0406***	-0.0442***	-0.0386***
	(0.00455)	(0.00383)	(0.00484)	(0.00400)
$DegreeCentrality_j$	-0.104***	-0.248***	-0.0880***	-0.236***
	(0.0111)	(0.00986)	(0.0114)	(0.0102)
InState	-0.133***	-0.127***	-0.124***	-0.115***
	(0.0236)	(0.0236)	(0.0255)	(0.0255)
Constant	-8.913***	-9.129***	-6.738***	-6.636***
	(0.609)	(0.609)	(0.630)	(0.631)
Observations	77170	77170	57963	57963
Last 24 Months Dropped	No	No	Yes	Yes

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Conclusion

- Firms' networks play an critical role on subcontracting decisions
- Subcontracting has a significant nonlinear impact on winning bid
- DBE prime contractors have benefited from subcontracting/networking opportunities and tend to submit lower winning bids
- Firms that engage DBE subcontractors submit lower, competitive bids in DBE projects
- Subcontracting activities and the DBE program increase firms' market participation

Conclusion

- DBE programs and other affirmative action policies are under scrutiny
- DBE programs have helped firms establish networks whose impact is likely to persist in the intermediate run
- Network effects, however, are stronger for non-DBE firms
- Without the program, this differential impact of networks on current decisions has the potential to create divergent opportunities for the two groups in the long run.

Thank you!