Government Incentives and Firm Location Choices

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Abstract

State governments in the United States have been increasingly using business incentives such as grants and tax abatements to compete for firms. I examine the welfare consequences of this competition. I develop a model of state government competition and firm location choice combining a first-price auction among states with discrete choice by firms. I estimate this model using firm-level data on accepted incentives augmented with data on state attributes. To learn about state valuations for attracting firms and firms' geographic preferences, I exploit the first-order conditions for states' optimal bidding strategies and variation in firms' accepted offers and locations. I find that the effect of competition on overall welfare of states and firms is mostly zero, as firm location choices are relatively unresponsive to incentives, which become government transfers. States that are less profitable for firms without incentives tend to have higher valuations for firms but infrequently benefit from competition. My findings are consistent with the view that state government competition using incentives generates large corporate welfare and little allocative efficiency.

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1 Introduction

State governments in the United States have been increasingly using business incentives such as grants and tax abatements to compete for firms. The total amount of incentives paid to firms more than tripled since the 1990s, reaching $45 billion in 2015.[1] As a result, the debate on whether state governments should use incentives to compete for firms has received much public attention. Recent competition among governments to attract Amazon's second headquarter with incentives has further intensified this debate. Despite growing public interest, our understanding of the welfare consequences of state government competition using incentives is limited.[2] Does competition improve the overall welfare of states and firms? How are the welfare impacts distributed across different states and firms?

I approach these questions by using data on accepted incentives and state attributes to quantify states' valuations for attracting firms and firms' geographic preferences. I provide empirical evidence that competition mostly has zero effect on the overall welfare of states and firms due to the insensitivity of firm location choices to incentives, which become government transfers. I find that firms capture substantial rents from states. States that are less profitable for firms without incentives tend to have higher valuations for firms but infrequently benefit from competition. My findings are consistent with the view that state government competition using incentives generates large corporate welfare and little allocative efficiency.

To build intuition for how state valuations for firms and firm preferences shape welfare consequences of competition, consider a firm choosing between California and Nevada. Suppose California is more profitable for the firm in absence of state competition (no incentives). If California's valuation for the firm is higher than Nevada's, the firm's location choice would be efficient without competition. If the firm's choice is unresponsive to incentives or if Nevada's valuation for the firm and equilibrium incentive offer are not sufficiently high, the firm would choose California regardless of whether states compete. In such cases, competition would not change

[1]This estimate includes incentives provided by both state and local governments (Bartik (2017)). Other existing estimates include $80.4 billion (Story et al. (2012)) and $65 billion Thomas (2010)). A wide range of estimates exists mainly because incentive information is not always made public.

[2]Existing empirical work related to this question include a recent work by Slattery (2019) and studies of local competition using incentives (e.g., Mast (2020)), individual place-based policies (e.g., Busso et al. (2013), Neumark and Kolko (2010)), and state taxes (e.g., Suárez Serrato and Zidar (2016), Fajgelbaum et al. (2015), Moretti and Wilson (2017)).

welfare, since incentives become pure government transfers.[3] On the other hand, if Nevada's valuation and equilibrium incentive offer are sufficiently high, the firm would choose Nevada. In this case, the firm and Nevada would gain from competition while California would lose. States as a whole would be better off if California's valuation is lower than Nevada's valuation net of incentives. In other words, competition would improve welfare if Nevada's valuation for the firm is sufficiently high and the firm chooses Nevada when states compete.[4]

To learn about state valuations and firm preferences, I use firm-level data on accepted incentives from the Good Jobs First Subsidy Tracker combined with data on state attributes that likely determine state valuations and firm preferences. Incentive data contains information on accepted incentive amount, awarding state, and firm attributes such as size and sector. I begin by gathering suggestive evidence on how states and firms value each other. Descriptive regression results suggest that states value firm attributes that likely deliver greater local benefits (manufacturing jobs) and that states with weaker economic conditions and more Republican voters have higher valuations for firms. Firms, on the other hand, appear to take into account local costs and workforce accessibility and quality. These suggestive findings are mostly consistent with a recent work by Bartik (2017). Challenged by the lack of data on unaccepted incentive offers, I am unable to further learn from this exercise about the actual trade-offs that firms faced in choosing locations and the distribution of states' latent valuations for firms. This motivates me to develop a structural model to interpret the accepted incentive data which are an outcome of a strategic interaction among state governments and firm choice.

I develop a model of state government competition and firm location choice that combines a first-price auction among states with discrete choice by firms. State governments draw private valuations for firms and simultaneously offer incentives to firms. Upon receiving incentive offers, each firm draws latent profit shocks and chooses the state that delivers the maximum total profit, which depends on incentive offers, state attributes, and the profit shocks. While this model resembles a first-

[3]If incentives incur deadweight loss of taxation, incentives would be costly government transfers. Competition would then reduce welfare since incentives paid by California incur deadweight loss of taxation; states would face a prisoner's dilemma, and welfare would improve if states could commit not to offer incentives.

[4]Competition may improve overall welfare even though the states as a whole are worse off. This can happen if Nevada offers large incentives and the firm's gain more than makes up for the loss in states' welfare.

price scoring auction, there are two key distinguishing features.[5] First, firm profit function parameters are unknown to the econometrician, whereas auction scores are typically known in scoring auctions. Second, unlike most auctions, the state with the highest sum of bid and deterministic profit (highest auction score) does not necessarily win due to the presence of random profit shocks for each state attribute and each firm-state combination, similar to attribute-specific and product-specific taste shocks commonly used in discrete choice models. These shocks are unobserved by both states and the econometrician. Using a numerical example, I illustrate that in this model, welfare gain from competition increases with firms' sensitivity to incentives and the heterogeneity in state valuations when firm profits and state valuations are negatively correlated. Model primitives are state valuation distributions and the profit function parameters.

To learn about state valuations and firm preferences using data on accepted incentives and state attributes, I exploit the first-order conditions for states' optimal offers and variation in conditional distributions of accepted incentives. The first-order conditions from the government competition model provide a way of inferring state valuations for firms from observations on incentives accepted by firms. This strategy is commonly used in empirical studies of first-price auctions following Guerre et al. (2000). Variation in accepted incentive distributions conditional on observable determinants of state valuations (e.g., firm size, state's economic and political conditions) is informative of how firm profitabilities vary across states. Intuitively, states that are less profitable for firms would, on average, bid more aggressively, but would also win only with particular high bids. I illustrate this intuition for identification in a numerical exercise.

I use the method of simulated moments to estimate model parameters. For most states, estimated parameters of the firm profit function imply a relatively low bid elasticity of less than one. Firms prefer states with higher population, higher college attainment rates, and lower wages. The implied dollar values of the location characteristics are fairly large. State valuations for firms exhibit substantial heterogeneity. Average state valuations and firm profitabilities are negatively correlated (i.e. states with high valuations for firms tend to have low base profits for firms).

[5]My model falls under a class of multi-attribute auctions which is little studied. See Krasnokutskaya et al. (2017) for a recent study of this class of models with an application to an online procurement market.

Further, political leanings of states are strong predictors of state valuations, suggesting that political factors have large impacts on how states formulate their valuations for firms. Overall, a large heterogeneity in state valuations and a negative correlation between firm profits and state valuations imply that state government competition is more likely to improve welfare, while firms' unresponsiveness to incentives implies the opposite.

Using estimated parameters, I consider a counterfactual elimination of state government competition in which firms choose states without incentives. I find that competition mostly has zero effect on overall welfare due to the insensitivity of firm location choices to incentives. About 84% of firms choose the same states regardless of whether competition is in place, and 16% of incentives are spent on such immobile firms. Firm profits increase by more than 0.44% from extracting state valuations, and firms whose choices are altered by competition benefit more. States that are less profitable for firms without incentives tend to have higher valuations for firms but infrequently benefit from competition. In result, states as a whole mostly lose from paying transfers to firms whose choices are not altered by competition. This finding is consistent with the view that state government competition using incentives generates large corporate welfare and little allocative efficiency.

The rest of this paper proceeds as follows. Remainder of this section discusses related literature. Section 2 outlines the context of state government competition using incentives and describes the dataset used in this paper. Section 3 provides suggestive evidence on how states and firms value each other. Section 4 presents the model of state government competition and firm location choice, and Section 5 provides intuition for model identification. Section 6 describes the estimation procedure. Section 7 presents the estimation results, and Section 8 analyzes the welfare implications of state government competition. Section 9 concludes.

Related literature

Most closely related to this paper are Mast (2020) who studies local competition among towns in New York state and Slattery (2019) who studies national competition among states. My model of government competition as a first-price sealed bid auction is similar to Mast (2020)'s, but my model incorporates randomness in government valuations conditional on observable determinants of valuations such as firm size and local economic conditions. This randomness in government valuations implies that government incentive offers are stochastic and accounts for the empirical variation in accepted incentive offers conditional on observables.[6] Despite the difference in the scope of competition studied, I find similar to Mast (2020) that firm location choices are not very sensitive to incentives. On the other hand, Slattery (2019) models government competition as an oral ascending auction and uses hand-collected data on winning and runner-up bids to estimate the model primitives. I make less restrictive assumptions on information structure and estimate model primitives using winning bids.[7] We reach qualitatively similar results on the welfare effects of state competition, but I find that firm choices are substantially more unresponsive to incentives. These divergent findings are likely explained by our different approaches of modeling government competition.

Related literature on assessing individual place-based policies includes Busso et al. (2013), Greenstone et al. (2010), Kline and Moretti (2014), Neumark and Kolko (2010), and Jensen (2017). I take a different approach of estimating local values of attracting firms by not focusing on specific local outcomes or mechanisms (e.g., agglomeration) but using incentive data to infer states' latent valuations for firms. I also provide empirical evidence of how place-based policies may only infrequently generate welfare gain for the states as a whole if considering the strategic aspect of how such policies are designed. Using a different methodology, Ossa (2015) studies the subsidy competition among states in a trade framework with agglomeration externalities and calibrates it with aggregate data. Bartik (2017) documents the overall trend in incentive provision using a newly constructed database.

Theoretical work on government competition using firm-specific subsidies includes Black and Hoyt (1989), Garcia-Mila et al. (2002), Glaeser (2001). I address the normative question raised in Glaeser (2001) regarding social desirability of government competition using incentives. Related literature on fiscal federalism dates back to Tiebout (1956) and is reviewed by Oates (1999) and Wilson (1999).

More broadly, empirical work on firm mobility is expansive and places emphasis on the role of state taxes or other statewide policies such as right-to-work laws and

[6] Mast (2020) uses the variation in firms' preferred locations, calibrated outside the model, to account for the empirical variation in accepted incentives conditional on observables.

[7] In my model, state valuations for firms and firm profits are private information. In Slattery (2019)'s model, states are assumed to know firms' exact profits in all states and observe all competing incentive offers.

their welfare consequences (e.g., Suárez Serrato and Zidar (2016), Fajgelbaum et al. (2015), Moretti and Wilson (2017), Giroud and Rauh (2015), Holmes (1998), Bartik (1985)). Another strand of literature focuses on how the cost and network structure of firms impact their location decisions (e.g., Rosenbaum (2013), Holmes (2005), and Henderson and Ono (2008)). My study differs in both topic and methodology from some of these studies using spatial equilibrium framework. I focus on firm-specific incentives rather than state taxes and directly model state government competition and firm location choice, drawing on methodologies from the Industrial Organization literature. Despite these differences, I find, similar to Suárez Serrato and Zidar (2016), that firms are substantially immobile due to the differences in the local productivities.

I use methods building on the empirical auction (Guerre et al. (2000)) and discrete choice (Berry (1994)) literature. This paper's model is similar to the one used by Krasnokutskaya et al. (2017) who study online procurement markets and provide identification and estimation strategies. Large number of potential bidders and possible combinations characterize the main econometric challenge in their study whereas the lack of information on losing bids (unaccepted incentives) is the main difficulty in this paper.

2 Context and data

State and local economic development agencies of various names (e.g., Department of Economic and Community Development in CT, Economic Development Administration in New Haven, CT) are government agencies whose general mission is to advance the economies of the respective jurisdictions. Inevitably, attracting and retaining businesses is one of the stated objectives of these agencies, and incentive provision to firms has been increasingly used to fulfill that goal. Estimates of how much state and local governments spend on incentives each year range from \$45 to \$80.4 billion (Bartik (2017), Story et al. (2012)).

Many different types of incentives exist, and the details of incentive contracts are often reached through interactions with individual firms. Prevalent types of incentives include tax credits, grants, cost reimbursement, job training, and infrastructure assistance. Incentive contracts also specify the timing of payments (front vs. backloading) and may include clawback provisions to ensure that firms fulfill employment and investment requirements. Bartik (2017) discusses in detail various types and terms of incentives. Firms that receive incentives also vary widely in sizes and industries, ranging from local restaurants looking to relocate to multinational corporations looking to construct manufacturing plants. The level of government competition changes with firm characteristics as well; small businesses are likely to search over a preferred local area and prompt a government competition at the local level, while large companies are likely to conduct a national search and scale up the government competition to the state level.

The specifics of how governments compete and negotiate with firms over incentives vary, but firms typically conduct preliminary surveys of available locations and produce shortlists of candidate locations.[8] In private meetings with government representatives, firms will illustrate the benefits that they can bring to regions, while government representatives will highlight the strengths of their locations and offer incentive packages. Firms may address specific needs regarding properties, infrastructure, and workforce, which may be reflected in incentive contracts. Governments will also try to ensure that firms fulfill their promises by backloading payments or including clawback provisions. Search and negotiation costs are likely to hinder small firms from considering locations that are distant from one another, and firms are also known to commonly employ consultants to act on their behalf.

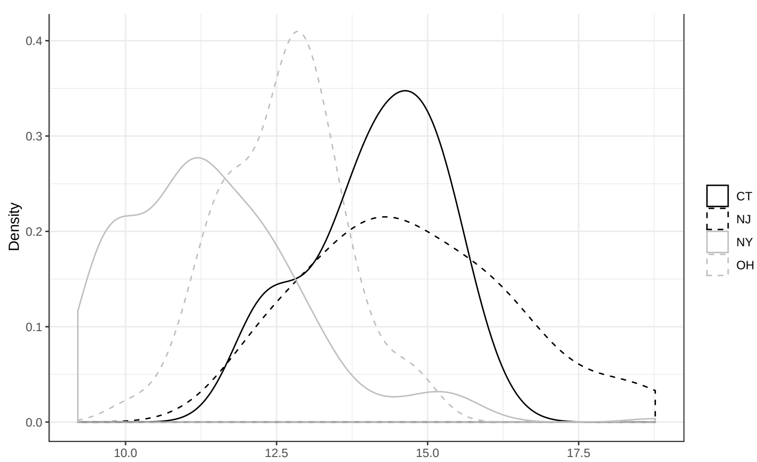
As much of the interaction between governments and firms happens behind closed doors, public information on incentives is mostly limited to incentives that firms accept. The lack of information on unaccepted incentives presents a major challenge in studying government competition using firm-specific incentives. Furthermore, data on accepted incentives that are individually published by state and local economic development agencies are often less than ideal, only covering incentives provided under selected programs, lacking key details like firm characteristics, and in formats that are not readily usable. Numerous organizations have aggregated publicly available data, reinforcing them with information directly provided by governments upon individual requests.

This paper uses a dataset named Good Jobs First Subsidy Tracker, made available by Good Jobs First, an advocacy research organization. This dataset is publicly available and comprehensive, tracking incentives provided by federal, state, and local

[8] LeRoy (2005) describes a typical site selection process. Individual firm cases are occasionally reported by the Site Selection magazine (e.g., `https://siteselection.com/ssinsider/bbdeal/bd060316.htm`)

governments to firms from 1976 to present, along with information on firm characteristics.[9] Details on sample selection are provided in the appendix. Key variables of interest for this paper include the incentive amount, awarding state, year, number of jobs, and sector. Summary statistics of these key variables are shown in Panel A of Table 1. The large variance in the amount of incentive awarded per job suggests that incentive bids vary widely both across and within states. Figure 1 plots densities of incentives provided by selected states conditional on firm characteristics. The substantial across state variation shown in this figure may be explained by heterogeneities in states' profitabilities for firms and states' valuations for firms. This paper aims to quantify these heterogeneities. Further, substantial within-state variation in accepted incentives hint at the importance of unobserved firm attributes in determining states' incentive bids. My model accounts for this by allowing state valuations to be random conditional on observable determinants of state valuations (e.g., firm size). Although rich information on different types of incentives (e.g., property tax abatement) is also available in the dataset, I only use information on incentive benefits converted to dollar amounts, since it is difficult to compare the various terms of incentives offered by individual agencies. Table 2 shows that 80% of incentives are awarded in the form of tax reduction and grants.

Figure 1: Density plots of accepted incentives



Notes: Density plots of log of incentives provided by the selected states to manufacturing firms with jobs $\in [100, 200]$ in 2000-2016.

[9] I combine all incentives provided at the local level to the state level.

Table 1: Summary statistics

Statistic	N	Mean	St. Dev.	Median	Min	Max
Panel A: Accepted incentives and firm characteristics						
Incentives ($ mil)	117300	1.59	41.02	0.07	0.01	8700
Incentives per job ($ mil/job)	39859	0.03	0.27	3.34e-03	3.14e-07	20.24
Jobs	39859	172.49	989.63	45	1	120262
Hourly wage ($)	4629	18.49	11.20	15.23	6	96
Investment ($ mil)	34626	29.85	641.15	1.97	1e-05	1e+05
Manufacturer	28994	0.57	0.49	1	0	1
Distance from HQ (thou km)	16860	1.07	1.07	0.78	0	4.31
Panel B: State characteristics						
Population (mil)	589	7.21	6.59	5.48	0.57	39.25
College attainment rate (%)	462	9.40	3.24	8.7	4.5	27.5
Right-to-work law	589	0.44	0.50	0	0	1
Unemployment rate (%)	591	6.21	2.06	5.80	2.30	13.66
Corporate income tax rate (%)	542	6.47	2.82	6.9	0	12
Vote % diff (Dem-Rep) in gubernatorial elections	498	-4.38	19.17	-3.8	-58.4	44.1
Median monthly rent in 2016 ($)	47	888.30	171.31	816	658	13
Mean hourly wage ($)	564	9.97	3.57	19.47	13.06	39.88
Per capita income ($ thou)	583	39.23	7.92	38.12	21.54	69.09
Mfg employees in 2016 (ten thou)	47	23.46	22.28	16.01	1.22	111.99
Enplanements in 2016 (logs)	46	116.02	122.22	79.38	21.84	791.39
Waterborne tonnage in 2016 (thou)	37	77.25	117.10	40.94	5	545.10
Vehicle-miles of travel in 2016 (bil)	47	66.75	65.90	52.15	5.26	340.12
Number of Metropolitan Statistical Areas in 2010	47	9.17	6.06	8	1	26

Notes: Years and data sources are shown in the appendix.

Table 2: Types of accepted incentives

Tax credit/rebate	61%
Grant	19%
Training reimbursement	10%
Enterprise zone	6%
Others	4%

Notes: Tax credit/rebate includes property tax abatement. Others include cost reimbursement (1.09%), industrial revenue bond (0.05%), grant/loan hybrid program (1.94%), tax increment financing (1.08%), infrastructure assistance (0.14%), and Megadeal (0.20%; this is a classification introduced by Good Jobs First and refers to incentives worth over $75 million).

I augment the incentive dataset with separately collected data on state characteristics that are likely to impact states' incentive bidding behaviors through affecting either state valuations for firms or firm profitabilities. Whether and how these characteristics enter government and firm preferences are discussed in the next section, providing basis for the structural model that I develop. Summary statistics of these variables are shown in Panel B of Table 1, and data sources are provided in the appendix.

3 Suggestive evidence on how states and firms value each other

Because the dataset has no information on unaccepted incentive offers, it is difficult to learn directly about firms' geographic preferences nor states' latent valuations for firms. Nonetheless, accepted incentive data can still provide useful insights on how states and firms value each other based on the argument that states' bidding behaviors are affected by states' valuations for attracting firms and firms' profitabilities in states. A state with high valuations for attracting firms, perhaps due to high unemployment rate, is likely to bid more aggressively and end up paying higher incentives for its accepted offers, than another state of comparable firm profitability. On the other hand, a state that firms find very attractive, perhaps due to high quality of the labor force, can likely afford to bid less aggressively and end up paying lower incentives for its accepted offers, than another state sharing comparable valuations for firms. In the former case, comparing accepted incentives made by states that are observationally equivalent in terms of the determinants of firm profitability provide evidence on the extent to which state valuations differ. In the latter case, comparing accepted incentives made by states that are observationally equivalent in terms of the determinants of state valuations provide evidence on the extent to which firm profitabilities differ. Based on this idea, preliminary evidence on how states and firms value each other is presented using the following regression specification:

$$b_{jst} = \alpha^v v_{jst} + \alpha^\pi \pi_{jst} + \epsilon_{jst}, \tag{1}$$

where b_{jst} denotes the incentive offered by state s and accepted by firm j in year t, v_{jst} denotes the determinants of state s's valuation for firm j, and π_{jst} denotes the determinants of firm j's profitability in state s.

Proposed v_{jst} variables include firm characteristics that likely impact state valuations for firms: the number of jobs and a manufacturing dummy. State economic and political conditions that likely impact state valuations are also included as v_{jst} variables: unemployment rate, per capita income, and the percentage difference of Democratic and Republican votes in gubernatorial elections. These variables capture the likely sources of heterogeneity in state valuations. The political variable, in particular, highlights the fact that state valuations may not only reflect projected economic benefits but also state residents' willingness to spend public funds for incentive provision.[10]

Proposed π_{jst} variables include state characteristics that likely affect firms' profitabilities: wage, rent, college attainment rate, size (population and number of Metropolitan Statistical Areas (MSA)), corporate income tax rate, transportation infrastructure (highways, airports, and seaports), and the right-to-work law status.[11] Distance from firm's headquarter location is also added as a π_{jst} variable to account for geographic attractiveness of states. Vast survey evidence suggests that proposed π_{jst} variables influence firms' site selection decisions.[12]

Table 3 shows the regression results for selected specifications. Overall, proposed v_{jst} and π_{jst} variables carry anticipated signs, suggesting that they impact state valuations and firm profits in plausible directions. As for state valuations, firms that promised to bring more jobs were awarded higher incentives; manufacturers were also awarded higher incentives likely because they have higher local multipliers. States with higher unemployment rates that likely have higher valuations for new jobs provided higher incentives, while states with higher percentage of Democratic votes in gubernatorial elections provided lower incentives. As for firm profits, college attainment rate and number of MSA carry negative signs while rent and distance from

[10] Jensen and Malesky (2018) find in a survey experiment that independent voters are more likely to support governors who offer more generous incentives to firms regardless of whether they are accepted.

[11] One rationale for including the state size variable is that firms likely have higher probabilities of finding a profitable location in a state that has more and bigger labor markets.

[12] Site Selection (2016) list taxes, incentives, infrastructure, regulatory environment, quality education system, and workforce as the most cited answers when consultants were surveyed about the top two or three elements of "state business climate." These characteristics are also incorporated into widely used state business climate indices published by various media outlets (e.g., CNBC). Amazon HQ2's Request for Proposal also lists similar characteristics as "key preferences and decision drivers."

headquarter carry positive signs. Coefficients on right-to-work laws and corporate income tax rates are insignificant likely because they are strongly correlated with other variables included. I find that substituting unemployment rate with income, rent with wage, and number of MSA with population produce similar results.

Table 3: Descriptive regression

	Dependent variable:		
	Accepted incentives ($ mil)		
	(1)	(2)	(3)
Jobs	0.028***	0.053***	0.055***
	(0.0003)	(0.001)	(0.001)
Manufacturer		5.260***	6.333**
		(1.416)	(2.732)
Unemployment rate (%)	0.558***	1.913***	2.674***
	(0.148)	(0.407)	(0.744)
Vote % (D-R)	−0.027*	−0.140***	−0.155*
	(0.016)	(0.042)	(0.081)
# MSA	−0.347***	−1.181***	−1.254***
	(0.072)	(0.184)	(0.338)
College attainment rate (%)	−0.988***	−2.214***	−3.708***
	(0.200)	(0.555)	(1.023)
Corporate income tax rate (%)	0.012	−0.317	0.289
	(0.152)	(0.421)	(0.697)
Right-to-work law	0.104	1.792	2.734
	(0.890)	(2.257)	(4.323)
Median monthly rent ($)	0.010***	0.017**	0.031**
	(0.003)	(0.008)	(0.014)
Distance from HQ (thou km)			4.716***
			(1.434)
Constant	0.119	−2.561	−16.619
	(2.653)	(7.094)	(13.313)
Observations	38,454	12,729	6,185
R^2	0.219	0.407	0.426

Notes: *p<0.1; **p<0.05; ***p<0.01

These findings are mostly in agreement with the results of an extensive descriptive analysis by Bartik (2017) using a different database. For example, he also finds that higher incentives are awarded to firms that pledged to bring greater local benefits, in particular to larger firms and manufacturers, and that states with higher gross taxes and lower per capita income tend to pay more incentives.[13] Bartik (2017) further notes that a substantial part of state variation in incentives appears to to be derived from different political leanings, which is confirmed by my findings.

4 Model

In this section, I present a model of state government competition and firm location choice using features of first-price auction and discrete choice models. Firms are denoted by $j \in \mathcal{J} := \{1 \cdots J\}$ and state governments are denoted by $s \in \mathcal{S} := \{1 \cdots S\}$. Year subscript t is abbreviated for convenience.

4.1 Setup and timing

State government s derives private value from attracting firm j to its own jurisdiction according to an independent draw, v_{js}, from a valuation distribution denoted by $F_V(\cdot|x^v_{js})$ with bounded support $[\underline{v}, \overline{v}_s]$, where x^v_{js} denotes the observable determinants of state valuations.[14] Based on suggestive evidence from the earlier section, x^v_{js} includes firm size and sector and state economic and political variables. Each state government s then makes an optimal incentive offer b_{js} to each firm j.

Firm j chooses a state $s \in \{1 \cdots S\}$ that maximizes j's total profit. Firm j's profit from choosing state s is

$$\pi_{js} = \sum_{k=1}^{K} (\beta^{x0}_k + \beta^{x1}_k \zeta_{jk}) x^\pi_{sk} + \beta^b b_{js} + \xi_s + \epsilon_{js}, \tag{2}$$

where x^π_s is a $K \times 1$ vector of exogenous characteristics of s (e.g., college attainment rate), b_{js} is s's incentive offer to j, and ξ_s is unobserved characteristic of s common across firms. $\zeta_j = (\zeta_{j1}, \cdots, \zeta_{jK})$, which are drawn iid from standard normal distribution, represent firm's unobserved tastes for state attributes. $\epsilon_j = (\epsilon_{j1}, \cdots, \epsilon_{jS})$, which are drawn iid from Type I Extreme Value distribution, represent random profit shocks.

[13] Nonetheless, Bartik (2017) emphasizes that incentives "do not vary as much as they should with industry characteristics that predict greater local benefits."

[14] This approach of modeling state valuations for firms does not restrict firm presence to affect state valuations according to a particular mechanism. One downside of my approach, however, is that it is difficult to discern mechanisms generating state valuations.

Deterministic attributes of j's profit in s is denoted by $\chi^{\pi}_{js} = (x^{\pi}_{s}, \xi_s)$. I refer to firm j's profits in state s excluding the incentive offer (i.e., $\sum_{k=1}^{K}(\beta^{x0}_k + \beta^{x1}_k \zeta_{jk}) x^{\pi}_{sk} + \xi_s + \epsilon_{js}$) as firm j's base profit in state s.

Given this setup, firm j's site selection process proceeds in two stages.

1. **Government competition**: Each state government s independently draws its private valuation for j, v_{js}, from $F_V(\cdot|x^{v}_{js})$. States are aware that all states are competing and know each other's valuation distribution but not the realized values. States also know $\theta^{\pi} = (\beta^{x}, \beta^{b}, \xi)$ but not ζ_j nor idiosyncratic shocks ϵ_j. States then simultaneously bid incentives to j.

2. **Firm decision**: Firm j receives a vector of incentive offers, $(b_{j1}, \cdots, b_{jS})$ and selects the state that maximizes its total profit.

4.2 Equilibrium incentive bids

State government s offers b that maximizes its expected value of attracting firm j given its valuation draw, v, by solving

$$\max_{b}\ (v - b) \cdot w_{js}(b),$$

where $w_{js}(b) : [\underline{b}, \overline{b}_s] \rightarrow [0, 1]$ denotes the probability of j accepting b from s.

The first-order condition for s's optimal bid b is then given by

$$b = v - \frac{w_{js}(b)}{w'_{js}(b)}, \tag{3}$$

where the second term on the right-hand side represents s's strategic markdown from its valuation for j.

The equilibrium bidding strategy of s is denoted by $m_s : [\underline{v}, \overline{v}_s] \rightarrow [\underline{b}, \overline{b}_s]$, which maps valuations into optimal incentive bids.[15] I focus on type-symmetric equilibrium in which states use symmetric bidding strategies conditional on having same valuation distributions and firm profitability attributes (i.e. same x^{v}_{js} and $\chi^{\pi}_{js} = (x^{\pi}_{s}, \xi_s)$). The equilibrium bid distribution of s is denoted by $G_B(\cdot|x^{v}_{js}, \chi^{\pi}_{js})$.

[15] Theoretical advancements formally showing equilibrium existence and properties in this variant of first-price auction model are needed, but outside the scope of this paper.

$w_{js}(b)$ can now be derived by integrating over all possible equilibrium bids of opponent states, b_{-s}, and firm j's unobserved tastes for state attributes, ζ_j, as

$$w_{js}(b) = \int_{\mathcal{B}_{-s}} \int_{\mathcal{R}^K} \gamma_{js}(b, b_{-s}, \zeta_j) d\Phi_\zeta(\zeta_j) dG_{B_{-s}}(b_{-s}), \tag{4}$$

where

$$\gamma_{js}(b, b_{-s}, \zeta_j) = \frac{\exp\left(\sum_{k=1}^{K} (\beta_k^{x0} + \beta_k^{x1} \zeta_{jk}) x_{sk}^{\pi} + \beta^b b_{js} + \xi_s\right)}{\sum_{\hat{s} \in \mathcal{S}} \exp\left(\sum_{k=1}^{K} (\beta_k^{x0} + \beta_k^{x1} \zeta_{jk}) x_{\hat{s}k}^{\pi} + \beta^b b_{j\hat{s}} + \xi_{\hat{s}}\right)}.$$

Above, $\mathcal{B}_{-s}$ is the possible region of opponent bids, and $\gamma_{js}(b, b_{-s}, \zeta_j)$ is the probability of j accepting b from s when offers from other states are equal to b_{-s} and j's unobserved tastes for state attributes are equal to ζ_j. $d\Phi_\zeta$ is the known joint density function of ζ_j, and $dG_{B_{-s}}$ is the joint density function of equilibrium bids of opponent states.

Primitives of this model are firm profit function parameters, $\theta^\pi = (\beta^x, \beta^b, \xi)$, and state valuation distributions, $F_V(\cdot|\cdot)$.

4.3 Relation to first-price auction and discrete choice models

The proposed model of state government competition resembles a first-price scoring auction with independent asymmetric values, while the proposed model of firm location choice resembles a standard discrete choice model. Despite similarities, this paper's competition model differs from a first-price scoring auction in two important ways. First, firm profit function parameters, $\theta^\pi = (\beta^x, \beta^b, \xi)$, are unknown to the econometrician, and part of this paper's objective is to learn about these parameters which govern firms' trade-offs between incentives and other state attributes. These parameters would be analogous to auction score weights in scoring auction models which are typically known to the econometrician (e.g., weights on cost and time in highway procurement auctions).[16] Second, in my model, competition outcome is partly determined by firms' unobserved tastes for state attributes (ζ) and random

[16] See Asker and Cantillon (2008) and related papers for literature on scoring auctions. In standard scoring auctions bidders submit multi-dimensional bids, whereas in my model state governments optimally choose b_{js} but not x_s, ξ_s.

profit shocks (ϵ) which are unobserved by both states and the econometrician. In terms of standard auctions, these shocks can be interpreted as auctioneers' (firms') unobserved preferences over bidders (states) and their characteristics. This approach of incorporating unobserved preference heterogeneity is commonly adopted in discrete choice models. One consequence of having this feature in my model is that even if state s were to possess the highest $\beta^{x0}x_s + \beta^b b_{js} + \xi_s$ (analogous to highest auction score), it may not win if firm j draws a sufficiently low ϵ_{js} or ζ_j that is unfavorable for s's attributes. Standard scoring auctions do not feature such stochastic allocation rules. These departures from standard auction models prevent direct application of existing results in the auction literature, but this model may be used to describe settings in which bidders compete and winners are determined based on an unknown function of bids, bidder characteristics, and auctioneers' unobserved preferences.[17]

4.4 Model simplifications

This model makes at least four important simplifications. First, I assume that all states compete for all firms in the sense that all states are potential bidders. Because I do not observe losing bids, there will be no meaningful distinction between a state's choice not to bid for a firm and the choice to make a very low bid with essentially no chance of winning. Second, I assume that states and firms cannot breach incentive agreements (i.e. j must deliver v_{js} to s and s must deliver b_{js} to j). This assumption is occasionally violated in reality, as discussed in Section 2. The dynamic aspect to how governments and firms negotiate over incentive contracts is outside the scope of this paper. Third, I assume that each state endorses one location within state as a representative location. I treat π_{js} as the highest profit j can realize from different locations within s and abstract away from the possibility of local competition to focus on state competition. Fourth, this model cannot account for possible spillovers across states, which would be a source of efficiency loss generated by competition. Cross-state spillovers would be relevant for state competition within same metropolitan areas or regions surrounding state borders; well-known examples include competition between Kansas and Missouri in Kansas City and ongoing competition among states in Washington D.C. area for Amazon HQ2.

[17] See Krasnokutskaya et al. (2017) for discussion of various non-standard auction formats.

4.5 Welfare implications of state government competition: an illustration

In this section, I illustrate the welfare implications of state government competition in my model. For simplicity, I consider an environment with J identical firms. I simplify and re-express the firm profit function as

$$\pi_{js} = \beta^b b_{js} + \pi^d_{js},$$

where $\pi^d_{js} \equiv \beta^x x^\pi_s + \epsilon_{js}$ is firm j's base profit in state s in absence of state competition. I further define $\mathcal{J}_{ss'}$ as the subset of firms that choose state s when states do not compete and state s' when states do compete:

$$\mathcal{J}_{ss'} \equiv \left\{ j \in \mathcal{J} \;\middle|\; \pi^d_{js} > \pi^d_{js'},\ \beta^b b_{js} + \pi^d_{js} < \beta^b b_{js'} + \pi^d_{js'} \right\}.$$

State s gains from competition by attracting firms that would have chosen other states in absence of competition (i.e., $j \in \{\mathcal{J}_{\hat{s}s}\}_{\hat{s}\in\mathcal{S}\setminus s}$). State s loses from competition by: (1) losing firms that would have chosen state s if states did not compete (i.e., $j \in \{\mathcal{J}_{s\hat{s}}\}_{\hat{s}\in\mathcal{S}\setminus s}$); and (2) paying incentives to firms that would have chosen state s regardless of whether states compete (i.e., $j \in \mathcal{J}_{ss}$). State s's welfare change is the difference between these gain and losses as derived below.

$$\Delta \text{ State } s\text{'s welfare} = \sum_{j\in\mathcal{J}} \sum_{\hat{s}\in\mathcal{S}} \Big\{ \mathbb{1}\left[s \neq \hat{s}\right] \mathbb{1}\left[j \in \mathcal{J}_{\hat{s}s}\right] (v_{js} - b_{js}) - \mathbb{1}\left[s \neq \hat{s}\right] \mathbb{1}\left[j \in \mathcal{J}_{s\hat{s}}\right] (v_{js}) - \mathbb{1}\left[s = \hat{s}\right] \mathbb{1}\left[j \in \mathcal{J}_{s\hat{s}}\right] (b_{js}) \Big\}.$$

The first term in the braces shows that competition would improve state s's welfare if firms are likely to choose state s only when states compete so that most firms belong to $\{\mathcal{J}_{\hat{s}s}\}_{\hat{s}\in\mathcal{S}\setminus s}$. On the other hand, firms can only gain from competition. The change in total firm profits is derived as

$$\Delta \text{ Firm profits} = \sum_{j\in\mathcal{J}} \sum_{s\in\mathcal{S}} \sum_{\hat{s}\in\mathcal{S}} \Big\{ \mathbb{1}\left[s \neq \hat{s}\right] \mathbb{1}\left[j \in \mathcal{J}_{s\hat{s}}\right] (\beta^b b_{j\hat{s}} + \pi^d_{j\hat{s}} - \pi^d_{js}) + \mathbb{1}\left[s = \hat{s}\right] \mathbb{1}\left[j \in \mathcal{J}_{s\hat{s}}\right] (\beta^b b_{js}) \Big\},$$

where the first term in the braces shows that when competition alters a firm's choice, the firm is at least compensated for choosing a state that would not have maximized its profit had there been no competition. The second term shows that when competition does not alter a firm's choice, the firm receives government transfers from the state that would have maximized its profit even in absence of competition.

Overall welfare change is the sum of changes in states' welfare and firm profits:

$$\Delta \text{ Welfare} = \sum_{j \in \mathcal{J}} \sum_{s \in \mathcal{S}} \sum_{\hat{s} \in \mathcal{S}} \left\{ \mathbb{1}\left[s \neq \hat{s}\right] \mathbb{1}\left[j \in \mathcal{J}_{s\hat{s}}\right] \left(v_{j\hat{s}} - v_{js} + \frac{\pi^d_{j\hat{s}} - \pi^d_{js}}{\beta^b} \right) \right\}. \quad (5)$$

The first term in the braces shows that state competition for firm j would improve overall welfare if: (1) firms make different choices with and without competition; and (2) the match value under competition $\left(v_{j\hat{s}} + \frac{\pi^d_{j\hat{s}}}{\beta^b}\right)$ exceeds the match value in absence of competition $\left(v_{js} + \frac{\pi^d_{js}}{\beta^b}\right)$.

4.5.1 Simple example: competition between two states for a single firm

To obtain intuition on how state competition changes the welfare of states and firms, I consider a simple example in which two states compete for a single firm. Suppressing the firm subscript j, suppose without loss of generality that the firm would choose state 1 in absence of state competition (i.e., $\pi^d_1 > \pi^d_2$). I explore the welfare changes from state competition in this example in Table 4 by considering two cases.

Table 4: Illustration of welfare changes from state competition for a single firm

	Firm's choice when states compete	
	1	2
Δ State 1's welfare	$-b_1$	$-v_1$
Δ State 2's welfare	0	$v_2 - b_2$
Δ State welfare	$-b_1$	$v_2 - v_1 - b_2$
Δ Firm profits	$\beta^b b_1$	$\pi^d_2 - \pi^d_1 + \beta^b b_2$
Δ Overall welfare	0	$v_2 - v_1 + \frac{\pi^d_2 - \pi^d_1}{\beta^b}$

Table 4 shows that if the firm continues to choose state 1 when states compete, overall welfare remains constant, as the incentives paid by state 1 are pure government transfers. This case would correspond to the popular narrative of corporate welfare. On the other hand, if the firm chooses state 2 when states compete, overall welfare would improve if $v_2 - v_1 > \frac{\pi^d_1 - \pi^d_2}{\beta^b}$. Since the right-hand side of the inequality is positive by assumption, this inequality would hold if state 2's valuation for the firm is sufficiently higher than state 1's; in specific, the difference in state valuations must exceed the difference in base profits normalized by β^b. When the inequality is rearranged as $v_2 + \frac{\pi_2^d}{\beta^b} > v_1 + \frac{\pi_1^d}{\beta^b}$, it expresses that overall welfare would improve if the overall welfare from having the firm in state 2 is greater than the overall welfare from having the firm in state 1.

This example highlights that, in general, state competition would improve overall welfare if the following two requirements are met. First, there must be enough firms whose choices differ depending on whether states compete. For this to happen, states' incentive offers must be an important part of firm profits (i.e., high β^b) so that firm choices are sensitive to incentive offers. There also must exist states that have higher valuations but lower base profits than states that win in absence of competition (i.e., negative correlation between state valuations and base profits); such states can attract firms only under competition by offering incentives. Second, the difference in the valuations of the winning states with and without state competition must be sufficiently greater than the difference in base profits in those states (i.e., large (small) heterogeneity in valuations of (base profits in) the winning states with and without competition). Overall welfare with state competition is increasing in the valuations of and base profits in states that win under competition.

An overall welfare improvement under state competition does not guarantee that the welfare of the states as a whole will also improve. In specific, states as a whole will lose despite the overall welfare improvement if the realized values (valuations minus the total costs of incentives) of the winning states under competition are smaller than the valuations of the winning states in absence of competition. In the above example, this condition would be $v_2 - b_2 \leq v_1$. A large (small) heterogeneity in valuations of (base profits in) the winning states with and without competition implies that the states as a whole will gain from competition. Using above example to obtain intuition, if state 2's valuation is much higher than state 1's, state 2's realized value from competition is also likely to be higher than state 1's valuation. Furthermore, if state 2's base profit is not much lower than state 1's, state 2 will not have to offer high incentives meaning that state 2's realized value from competition is likely to be higher than state 1's valuation.

4.5.2 Model simulations

I illustrate the intuition described in above example using simulations of the model under different parametric specifications. I assume that states 1 and 2 draw their valuations for firms from truncated normal distributions on support $[5, 15]$ with parameters (μ_1, σ_1) and (μ_2, σ_2) as shown in Table 5. This table also shows the assumed parameter values of the firm profit function (x_1^{π}, x_2^{π}, β^b, and β^x).

Table 5: Assumed parameter values in the model simulations

Specification	(μ_1, μ_2)	(σ_1, σ_2)	(x_1^{π}, x_2^{π})	β^b	β^x
1	$(10, 7)$	$(1, 1)$	$(5, 2.5)$	$[1.0, 2.5]$	1
2	$(7, 10)$	$(1, 1)$	$(5, 2.5)$	$[1.0, 2.5]$	1
3	$(4, 16)$	$(1, 1)$	$(5, 2.5)$	$[1.0, 2.5]$	1
4	$(7, 10)$	$(1, 1)$	$(5, 2.6)$	$[1.0, 2.5]$	1

In all specifications, I assume that the average base profit in state 1 is higher than in state 2 so that in absence of state competition, state 1 has a higher win share than state 2. In specification 1 (specifications 2, 3, and 4), state 1 has higher (lower) average valuations for firms than state 2, and state valuations and base profits are positively (negatively) correlated.[18] The heterogeneity in state valuations is higher in specification 3 than in specification 2.[19] On the other hand, the heterogeneity in base profits is smaller in specification 4 than in specification 2.[20] To make specifications comparable, the decrease in the heterogeneity in base profits in specification 4 is restrained to maintain the same firm choices in absence of competition as in the other specifications. If state 2's base profit is made substantially close to state 1's, more firms would choose state 2 in absence of state competition, and there would be less scope for competition to increase state 2's win share.

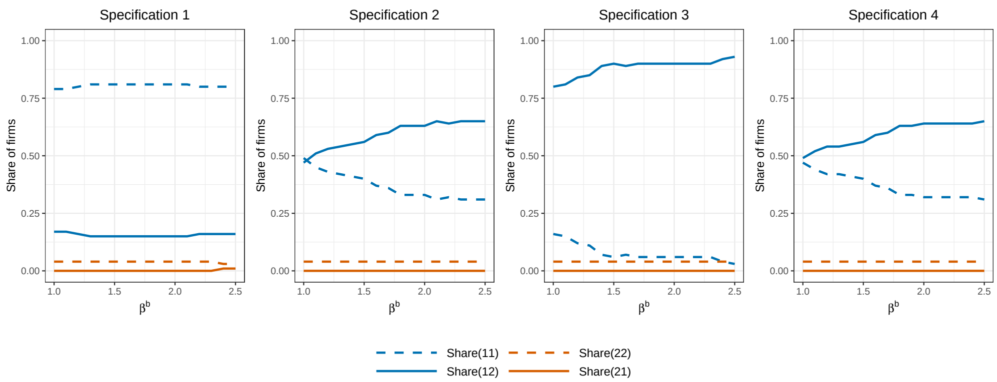
Details of the model simulation procedure are provided in Appendix C. Figure 2 shows the shares of firms by their choices depending on whether states compete. Figure 3 shows the percentage changes in welfare from state competition. Figure 4 shows the average bids and average winning bids of the states.

[18]The covariances between state valuations and base profits (i.e., $\text{Cov}(v_{js}, \beta^x x_s + \epsilon_{js})$) are 1.82, -1.94, -5.73, and -1.87 in specifications 1, 2, 3, and 4 respectively.

[19]The average differences between state valuations (i.e., $\mathbb{E}(v_{j1} - v_{j2})$) are 2.80, -3.09, -9.01, and -3.09 in specifications 1, 2, 3, and 4 respectively.

[20]The average differences between base profits (i.e., $\mathbb{E}(\pi_{j1}^d - \pi_{j2}^d)$) are 2.54, 2.54, 2.54, and 2.44 in specifications 1, 2, 3, and 4 respectively.

Figure 2: Model simulations: shares of firms by choices with and without state competition



Notes: Share(ss') indicates the share that choose states s and s' without and with state competition respectively.

Figure 3: Model simulations: welfare changes from state competition

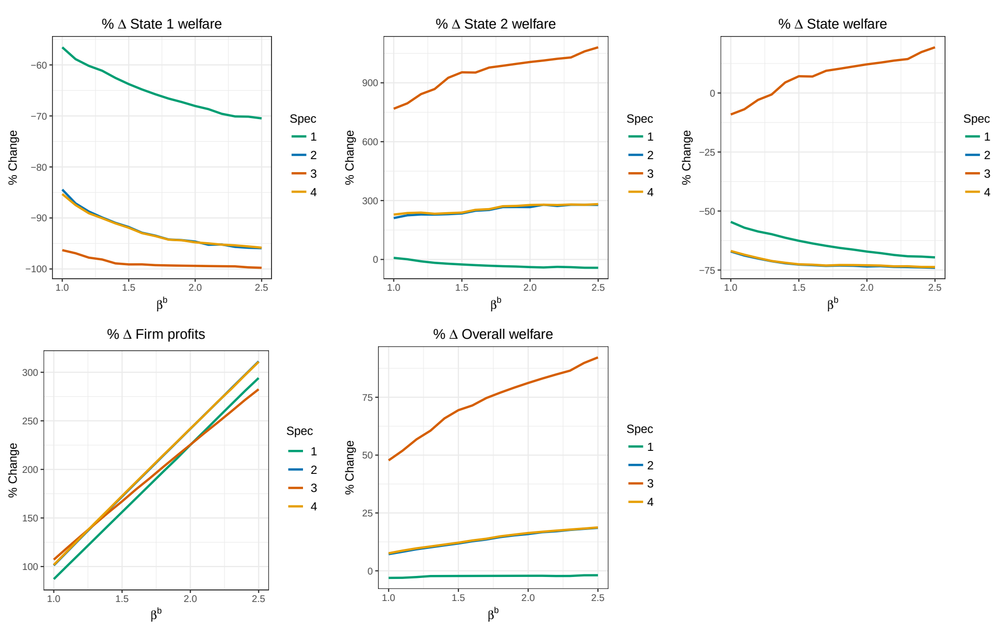
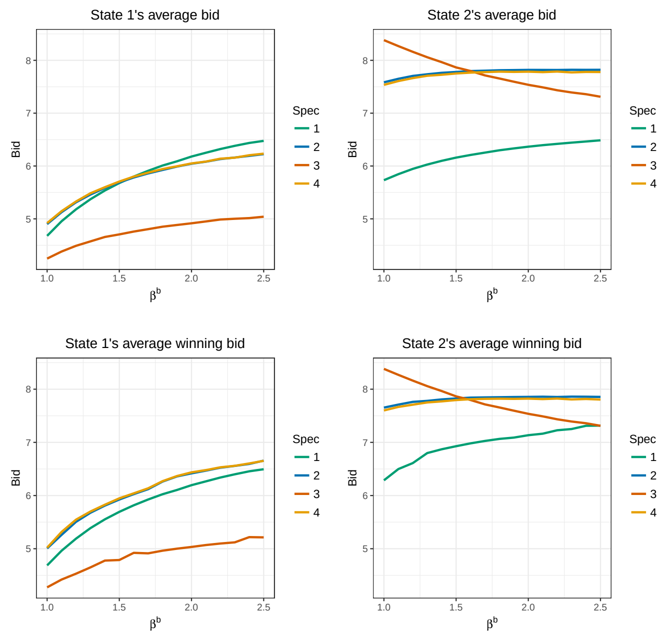


Figure 4: Model simulations: average bids and average winning bids



Correlation between state valuations and base profits

Figure 2 shows that in specification 1, about 80% (4%) of firms choose state 1 (2) regardless of whether states compete. On the other hand, about 16% (0%) of firms choose state 1 (2) when states do not compete but state 2 (1) when states do compete. Due to the positive correlation between state valuations and base profits, state 1 is, on average, more profitable regardless of whether states compete. Figure 3 shows that under state competition, state 1's welfare decreases, which arises partly from losing some firms to state 2 but mostly from paying incentives to firms that always choose state 1. State 2's welfare change is negligible; state 2's gain from attracting a small share of firms away from state 1 is countered by the loss from paying incentives to firms that always choose state 2. Firm profits increase when states compete. As state competition in this specification mostly generates government transfers to firms that make the same choices regardless of whether states compete, overall welfare change is negligible. Nonetheless, if the deadweight loss of taxation is assumed to be positive, such government transfers would be costly and overall welfare would further decrease.

Figure 2 shows that in specifications 2, 3, and 4, larger shares of firms make choices that differ depending on whether states compete. In comparison to specification 1, substantial shares of firms in specifications 2, 3, and 4 choose state 1 when states do not compete but state 2 when states do compete. Due to the negative correlation between state valuations and base profits, state 1 is, on average, more profitable only in absence of state competition. Figure 3 shows that under state competition, state 1's welfare decreases but state 2's welfare increases, as state 2 attracts a substantial share of firms away from state 1. Firm profits increase when states compete. State competition in these specifications improves overall welfare by inducing firms to choose state 2 which has higher average valuations for firms but is unable to win in absence of state competition due to having lower average base profits.

Heterogeneity in state valuations

Figure 3 shows that state competition delivers a larger overall welfare gain in specification 3 than in specification 2. States as a whole lose from competition in specification 2 but they gain in specification 3. These findings are explained by the larger heterogeneity in state valuations in specification 3. When state 2's valuations outweigh state 1's by more, the overall welfare from having firms choose state 2 increases, and state 2's equilibrium incentive offers also outweigh state 1's by more as shown in Figure 4. In result, the share of firms that choose state 1 when states do not compete but state 2 when states do compete is larger in specification 3 than in specification 2 as shown in Figure 2.

Heterogeneity in base profits

Figure 3 shows that state competition delivers a slightly larger overall welfare gain in specification 4 than in specification 2. This is explained by a smaller heterogeneity in base profits in specification 4. When the base profits in state 2 are made closer to state 1's without altering firm choices in absence of competition, the overall welfare from having firms choose state 2 increases. Nonetheless, the magnitude of welfare improvement is not as large as in specification 3, since the share of firms that choose state 1 when states do not compete but state 2 when states do compete is only slightly lager in specification 4 than in specification 2 as shown in Figure 2.

Sensitivity of firm choices to incentives

Figure 3 shows that in specifications 2, 3, and 4, the overall welfare improvement from competition is increasing in β^b, the sensitivity of firm choices to incentives. This is because the share of firms that choose state 1 when states do not compete but state 2 when states do compete is increasing in β^b as shown in Figure 2. As incentives offers become more important for firm profits, firms are more likely to accept state 2's incentive offers which are, on average, higher than state 1's as shown in Figure 4.

5 Identification

In this section, I provide intuition for identification of state valuation distributions and firm profit function parameters.

5.1 State valuation distributions

First-order conditions for states' optimal bid strategies (Equation 3) provide a way of inferring state valuations for firms using observations on accepted incentives. This approach follows a standard method shown by Guerre et al. (2000) in the first-price auction literature. I duplicate Equation 3 below for convenience:

$$v = b + \frac{w_{js}(b)}{w'_{js}(b)}.$$

This equation shows that the distribution of state s's valuations for firm j, $F_V(\cdot|x^v_{js})$, can be recovered if I know: (1) the equilibrium bid distribution of s, $G_B(\cdot|x^v_{js}, \chi^\pi_{js})$; and (2) the strategic markdown of s associated with equilibrium bid b, $\frac{w_{js}(b)}{w'_{js}(b)}$. As shown by Equation 4, the latter is a function of the equilibrium bid distributions of s's opponents, $\left\{G_B(\cdot|x^v_{js'}, \chi^\pi_{js'})\right\}_{s'\in\mathcal{S}\setminus s}$. Therefore, the equilibrium bid distributions of all states, $\left\{G_B(\cdot|x^v_{js}, \chi^\pi_{js})\right\}_{s\in\mathcal{S}}$, is necessary to recover $F_V(\cdot|x^v_{js})$.[21]

In order to identify $\left\{G_B(\cdot|x^v_{js}, \chi^\pi_{js})\right\}_{s\in\mathcal{S}}$ using empirical distributions of accepted incentives, $\left\{G_B(\cdot|j \text{ accepts } s\text{'s offers}, x^v_{js}, \chi^\pi_{js})\right\}_{s\in\mathcal{S}}$, I express s's equilibrium bid density function, denoted by $g_B(\cdot|x^v_{js}, \chi^\pi_{js})$, as follows:[22]

$$g_B(b|x^v_{js}, \chi^\pi_{js}) = \frac{g_B(b|j \text{ accepts } s\text{'s offers}, x^v_{js}, \chi^\pi_{js}) \cdot \Pr(j \text{ accepts } s\text{'s offers})}{w_{js}(b)}. \tag{6}$$

[21] Equation 4 shows that the firm profit function parameters are also necessary to compute $w_{js}(b)$.

[22] In standard first-price auctions, winning bid distributions are sufficient to identify equilibrium bid distributions (Theorem 3.2 in Athey and Haile (2007)).

This equation is derived by expressing $g_B(b|j \text{ accepts } s\text{'s offers}, x_{js}^v, \chi_{js}^\pi)$ using the definition of conditional probability as shown in Appendix D. Numerator of the right-hand side in Equation 6 consists of observables; $\Pr(j \text{ accepts } s\text{'s offers})$ is the relative frequency of j accepting s's offers. All other terms in the equation are functions of unknown $\left\{g_B(\cdot|x_{js}^v, \chi_{js}^\pi)\right\}_{s\in\mathcal{S}}$.

$\left\{g_B(\cdot|x_{js}^v, \chi_{js}^\pi)\right\}_{s\in\mathcal{S}}$ is the solution to the system of functional equations formed by stacking Equation 6 for all states. Given that the equilibrium bid density function is fully parameterized with x_{js}^v, χ_{js}^π, I can recover $\left\{g_B(\cdot|x_{js}^v, \chi_{js}^\pi)\right\}_{s\in\mathcal{S}}$ by solving for a fixed number of parameters.

5.2 Firm profit function parameters

I use variation in distributions of accepted incentives conditional on observable determinants of state valuations (x_{js}^v) to identify firm profit function parameters, $\theta^\pi = (\beta^x, \beta^b, \beta^d, \xi)$.[23] [24] As state valuation distributions are fully parameterized with x_{js}^v, variation in distributions of accepted incentives conditional on x_{js}^v would be attributed to variation in firm profitabilities across states. For example, conditional on x_{js}^v, a state that is less profitable for firms would, on average, bid more aggressively to attract firms and pay higher incentives. If firms were completely indifferent to state attributes entering the firm profit function, $\chi_{js}^\pi = (x_s^\pi, \xi_s)$, and only cared about incentives, the conditional distributions of accepted incentives would be invariant to χ_{js}^π (i.e., $G_B(\cdot|j \text{ accepts } s\text{'s offers}, x_{js}^v) = G_B(\cdot|j \text{ accepts } s\text{'s offers}, x_{js}^v, \chi_{js}^\pi)$. This is because states' equilibrium bid strategies and distributions would be invariant to χ_{js}^π (i.e., $G_B(\cdot|x_{js}^v) = G_B(\cdot|x_{js}^v, \chi_{js}^\pi)$). On the other hand, if χ_{js}^π were relatively more important for firm profits, conditional distributions of accepted incentives would now vary with χ_{js}^π, since states' equilibrium bid strategies and distributions would vary with χ_{js}^π. It is important to note that this line of reasoning prohibits unobserved heterogeneity in state valuations and relies on the assumption that the state valuation distributions conditional on observable x_{js}^v do not vary with χ_{js}^π. If unobserved determinants of state valuations and firm profitabilities are positively correlated, for example, the importance of incentives for firm profits (β^b) would be overestimated;

[23] This argument implies that the variation in states' win shares ($\Pr(j \text{ accepts } s\text{'s offers}) = \int g_{js}(t)w_{js}(t)dt$) conditional on x_{js}^v also can be used.

[24] Guerre et al. (2009) shows nonparametric identification of risk aversion of bidders in first-price auctions using variation in equilibrium bid distributions conditional on bidder's valuation distributions.

conditional on x^v_{js}, states more profitable for firms would be winning with high bids not because incentives are so important but because they have high valuations for firms.

5.3 Illustration

I demonstrate the intuition for identification laid out above using a numerical exercise. The results are shown in Appendix E. I assume that two states compete for J identical firms. I further assume that the two states have identical valuation distributions ($x^v_1 = x^v_2$) but that state 1 is more profitable for firms than state 2 ($x^\pi_1 > x^\pi_2$) so that state 1 has lower winning bids on average than state 2. As discussed in subsection 5.1, given θ^π, data on distributions of winning bids can be used to recover the equilibrium bid distributions and valuation distributions. As discussed in subsection 5.2, differences in states' winning bid distributions conditional x^v_s can be used to learn about θ^π. The assumed model primitives are recovered reasonably well overall. Details of the exercise are provided in the appendix.

6 Estimation

I use the method of simulated moments to estimate $\theta^\pi = (\beta^x, \beta^b, \xi)$ and $F_V(\cdot|\cdot)$. To simulate state government competition and firm location choice, I first specify the firm profit function and states' equilibrium bid distributions.[25] I use the firm profit function as specified in Equation 2. I specify states' equilibrium bid distributions, $G_B(\cdot|x^v_{js}, \chi^\pi_{js})$, as a log-normal distribution with its log mean and standard deviation parameterized as follows:

$$\mu_{js} = \mu^0 + \mu^1 x^v_{js} + \mu^2 \left(\beta^{x0} x^\pi_s + \xi_s\right)$$
$$\sigma_{js} = \sigma^0 + \sigma^1 x^v_{js} + \sigma^2 \left(\beta^{x0} x^\pi_s + \xi_s\right).$$

I include x^v_{js} and $\beta^{x0} x^\pi_s + \xi_s$ in this specification to parsimoniously capture the model prediction that states' equilibrium bids are functions of both their valuations and profitabilities for firms. Following the model, I impose the constraint that $\mu^2 < 0$. Parameters of the equilibrium bid distribution are denoted by $\theta^b = (\mu, \sigma)$.

[25] I use parametric equilibrium bid distributions to avoid solving for equilibrium bid strategies, which can be computationally burdensome.

Based on suggestive evidence from Section 3, I include in x_s^π the likely determinants of firm profits: college attainment rate, population, corporate income tax rate, right-to-work law status, wage, and vehicle-miles of travel. I include in x_{js}^v the likely determinants of states' valuations for firms: number of jobs, manufacturing dummy, unemployment rate, and vote share difference between Democratic and Republican candidates in gubernatorial elections.

Using above specifications for firm profit function and states' equilibrium bid distributions, I simulate the model for each candidate vector of (θ^π, θ^b) in following steps. First, I draw firm characteristics (firm size, manufacturing dummy, and year) from the Statistics of the U.S. Businesses (SUSB).[26] Second, for each draw of firm j, I simulate state government competition by drawing states' incentive offers from specified equilibrium bid distributions. Third, I simulate each j's location choice by drawing j's latent preferences ($\zeta = (\zeta_{j1}, \cdots, \zeta_{jK})$ and $\epsilon = (\epsilon_{j1}, \cdots, \epsilon_{jS})$ from standard normal and Type I Extreme Value distributions respectively) and choosing the state that maximizes j's total profit. Draws of firm characteristics and latent firm preferences are kept constant for each candidate (θ^π, θ^b).

I use the following four sets of moments to estimate (θ^π, θ^b): (1) quantiles of accepted incentives by state; (2) quantiles of accepted incentives by firm size; (3) covariance between accepted incentives and manufacturing dummy by firm size; and (4) share of firms by state and firm size.[27] Denoting the vector of empirical moments by m^{data} and the vector of simulated moments by m^{sim}, I search for $\theta = (\theta^\pi, \theta^b)$ that minimizes the distance between the simulated and empirical moments as follows:

$$\min_\theta (m^{data} - m^{sim}(\theta)) J (m^{data} - m^{sim}(\theta))',$$

where J indicates the weight matrix.[28]

With estimated (θ^π, θ^b), I recover $\left\{F_V(\cdot|x_{js}^v)\right\}_{s\in\mathcal{S}}$ using the first-order conditions for states' optimal bid strategies. In specific, for each state s, I draw bids from the estimated $G_B(\cdot|x_{js}^v, \chi_{js}^\pi)$ and compute $\frac{w_{js}(b)}{w'_{js}(b)}$ for each bid draw b using numerical integration which requires draws of opponent states' bids from estimated $\left\{G_B(\cdot|x_{js'}^v, \chi_{js'}^\pi)\right\}_{s'\in\mathcal{S}\setminus s}$

[26] I use the annual 2005-2016 SUSB data. Firm size is classified into four employment bins: <20,20-99, 100-499, and 500+. I draw firm characteristics taking shares of firms in each size-manufacturer-year cell as sampling weights.

[27] For the empirical portion of the fourth moment, I use the 2010 SUSB data.

[28] I use a diagonal weight matrix for J as the moment functions are highly collinear.

(see Equation 4). b and $\frac{w_{js}(b)}{w'_{js}(b)}$ are then plugged into Equation 3 to recover the valuation corresponding to b.

7 Results

Panel A of Table 6 shows that the proposed determinants of firm profitabilities (x_s^π) impact firm profits in anticipated directions. Implied dollar values of state attributes are fairly large; one percent increase in college attainment rate, for example, is worth about 10.56 ($\approx 0.1059 \div 1.0033 \times 100$) million dollars. For each firm type j, I use the parameter estimates and Equation 4 to compute $w_{js}(\tilde{b}_{js})$, the probability of firm j accepting $\tilde{b}_{js}$ from state s, where $\tilde{b}_{js}$ is the median of estimated equilibrium bid distribution $G_B(\cdot|x_{js}^v, \chi_{js}^\pi)$. Table 7 shows that states with lower $\tilde{b}_{js}$ and higher base profits ($\overline{\pi}_s = \beta^{x0} x_s^\pi + \xi_s$) have higher implied $w_{js}(\tilde{b}_{js})$. This pattern hints at the relative insignificance of incentives for firm choices, since states that offer lower median incentives face higher chances of landing firms, as such states tend to have more profitable attributes for firms such as larger population and higher college attainment rate. Heterogeneity in $\overline{\pi}_s$ across states is substantial; for example, the horizontal axis of Figure 5 shows that $\overline{\pi}_s$ ranges from $-$ 0.43 million dollars (West Virginia) to 4.43 million dollars (California) in 2016. The elasticities of $w_{js}(\tilde{b}_{js})$ to $\tilde{b}_{js}$ are low; increasing s's incentive offer by 1% from $\tilde{b}_{js}$ raises the probability of j accepting the offer by less than 0.5% for most states. Figure 5 shows that states with low base profits have higher bid elasticities and have more to gain from raising their bids. Overall, I find that firm location choices are relatively insensitive to incentives and driven mostly by key state attributes included in the profit function. This insensitivity to incentives would reduce the likelihood of firms choosing states with high valuations for firms that would not have been chosen without incentives, hence rendering state government competition less likely to improve welfare.

Panel B in Table 6 shows that the proposed determinants of state valuations (x_{js}^v) impact equilibrium bids in anticipated directions. For each firm type j, I use the parameter estimates and Equation 3 to compute distributions of states' valuations. Figure 6 shows, as an example, California and Nevada's valuations and equilibrium bids for a particular firm type. Nevada is more likely to draw a higher valuation, and for the same valuation draw, Nevada bids higher than California. Table 8 shows that state valuations for firms are substantially heterogeneous; median valuation for

Table 6: Parameter estimates

Panel A: Profit function				
College attainment rate	0.1059		(0.0001)	
× random coeff.	0.0088		(0.0000)	
Log population	0.5701		(0.0131)	
× random coeff.	0.1093		(0.0320)	
Corporate income tax rate	-0.0946		(0.0000)	
Right-to-work	0.0040		(0.0654)	
Mean hourly wage	-0.0943		(0.0005)	
× random coeff.	0.0050		(0.0000)	
Vehicle-miles of travel	0.1017		(0.0200)	
Incentive	1.0033		(0.0377)	
Panel B: Bid distribution				
	μ		σ	
Jobs $\in [1, 19]$	-0.0214	(0.0013)	0.0043	(0.2091)
Jobs $\in [20, 99]$	-0.0063	(0.0014)	0.0699	(0.2996)
Jobs $\in [100, 499]$	0.0088	(0.0078)	0.0009	(2.7406)
Jobs ≥ 500	0.0247	(0.0017)	-0.0475	(0.3036)
Manufacturer	0.0237	(0.0038)	0.1342	(0.4655)
Unemployment rate	0.0418	(0.0376)	0.0055	(0.2808)
Vote % (Dem - Rep)	-0.0087	(0.0008)	0.0173	(12.7909)
Profitability	-0.0013	(0.0001)	-0.0017	(0.0130)
Intercept	0.8879	(0.0009)	-2.3041	(0.3581)

Notes: Profit funciton includes state fixed effects. Standard errors in parentheses. Standard errors account for simulation errors.

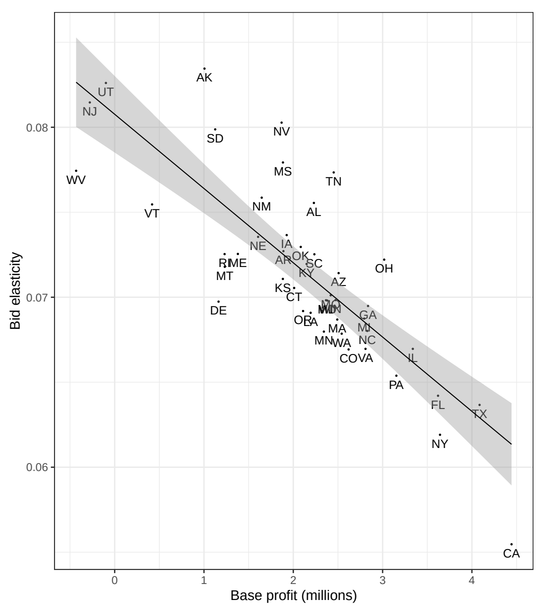
a manufacturing plant with more than 500 jobs ranges from 0.70 million dollars (Virginia) to 1.32 million dollars (New Jersey), for example, in 2016. This substantial heterogeneity in valuations would allow government competition to deliver larger welfare gains given that states with higher valuations for firms are less likely to attract firms without incentives. Consistent with the suggestive findings from Section 3, I find that much of the heterogeneity in state valuations is explained by local economic and political conditions. First column of Table 9 shows that more Republican states tend to have higher valuations, suggesting that local political factors impact how state governments formulate their valuations for firms. States with higher unemployment rates also tend to have higher valuations likely because such states are in more dire

Table 7: Determinants of probability of accepting median equilibrium bids

	Dependent variable:
	Probability of accepting median equilibrium bid: $w_{js}(\tilde{b}_{js})$
Median equilibrium bid: $\tilde{b}_{js}$	-0.054^{***}
	(0.002)
Base profit: $\overline{\pi}_s = \beta^{x0} x_s^{\pi} + \xi_s$	0.010^{***}
	(0.0002)
Constant	-0.001^{***}
	(0.001)
Observations	4,320
R^2	0.517

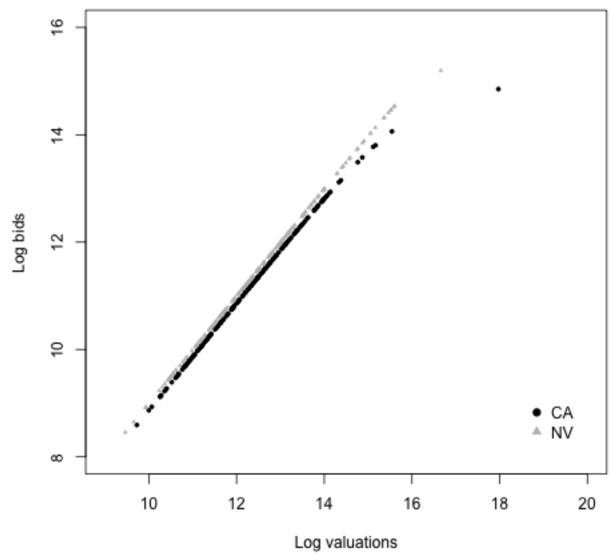
Notes: *p<0.1; **p<0.05; ***p<0.01

Figure 5: Bid elasticities and base profits



Notes: This plot shows the estimated base profits and bid elasticities of states bidding for a particular firm type: a manufacturing firm with jobs $\in [20, 99]$ in 2016. Bid elasticity is defined as $e_{js} = \frac{\partial w_{js}(x)}{\partial x} \frac{x}{w_{js}(x)}$ and is evaluated at the median equilibrium bid.

Figure 6: Estimated valuations and equilibrium bids



Notes: This plot shows the estimated valuations and equilibrium bids for a particular firm type: a manufacturing firm with jobs $\in [20, 99]$ in 2016.

need of jobs. State valuations are higher for manufacturing jobs and are increasing in firm size.

As discussed in Section 4.5, the correlation between state valuations and firm profits is crucial for determining whether there is scope for welfare gains to be generated by government competition. The second column in Table 9 shows that states with lower base profits ($\overline{\pi}_s$) tend to have higher valuations for firms. This negative correlation implies that under competition, states with lower base profits are more likely to attract firms that would not have chosen them without incentives, since such states can leverage their higher valuations to offer higher incentives.

Appendix Figure 1 compares empirical and simulated unconditional densities of accepted incentives for each state, and Appendix Table 3 compares empirical and simulated shares of firms for each state by job bins. The model fit is reasonable overall but with some difficulties in explaining the right tails of observed densities of accepted incentives and win shares of very large and small states such as Texas and New Jersey.

Table 8: Median estimated state valuations for firms in 2016 ($ million)

State	Jobs $\in [1, 19]$		Jobs $\in [20, 99]$		Jobs $\in [100, 499]$		Jobs ≥ 500	
	Non-mfg	Mfg	Non-mfg	Mfg	Non-mfg	Mfg	Non-mfg	Mfg
AL	0.15	0.22	0.22	0.38	0.31	0.61	0.49	1.15
AK	0.18	0.27	0.22	0.50	0.35	0.83	0.69	1.14
AZ	0.13	0.28	0.19	0.52	0.27	0.59	0.45	0.90
AR	0.15	0.28	0.20	0.42	0.37	0.68	0.45	0.95
CA	0.15	0.29	0.18	0.44	0.29	0.49	0.48	0.96
CO	0.12	0.22	0.15	0.35	0.26	0.60	0.54	0.97
CT	0.11	0.23	0.16	0.41	0.25	0.59	0.48	0.90
DE	0.13	0.26	0.20	0.34	0.24	0.51	0.54	0.97
FL	0.14	0.25	0.18	0.29	0.27	0.52	0.46	0.89
GA	0.14	0.31	0.17	0.39	0.31	0.57	0.44	0.99
IL	0.13	0.20	0.23	0.34	0.34	0.61	0.48	1.01
IN	0.12	0.25	0.19	0.44	0.31	0.73	0.52	0.83
IA	0.12	0.23	0.20	0.38	0.29	0.64	0.51	1.24
KS	0.11	0.24	0.20	0.32	0.26	0.65	0.46	1.10
KY	0.13	0.23	0.22	0.43	0.34	0.60	0.57	1.14
LA	0.12	0.23	0.18	0.43	0.37	0.58	0.48	0.84
ME	0.12	0.26	0.22	0.35	0.31	0.52	0.45	0.94
MD	0.13	0.28	0.25	0.30	0.25	0.61	0.52	0.86
MA	0.13	0.19	0.20	0.37	0.33	0.50	0.41	0.85
MI	0.15	0.23	0.26	0.34	0.30	0.60	0.49	0.86
MN	0.13	0.22	0.17	0.38	0.28	0.60	0.36	1.03
MS	0.18	0.32	0.24	0.36	0.38	0.72	0.55	0.90
MO	0.13	0.24	0.23	0.34	0.31	0.54	0.44	0.95
MT	0.12	0.28	0.17	0.33	0.29	0.41	0.51	1.08
NE	0.14	0.27	0.20	0.39	0.34	0.65	0.51	0.92
NV	0.14	0.27	0.26	0.40	0.34	0.63	0.47	1.20
NJ	0.12	0.24	0.25	0.46	0.34	0.71	0.50	1.32
NM	0.12	0.27	0.20	0.34	0.35	0.65	0.38	1.13
NY	0.12	0.28	0.19	0.39	0.24	0.61	0.40	0.93
NC	0.12	0.27	0.18	0.37	0.35	0.56	0.43	0.98
OH	0.16	0.28	0.20	0.51	0.30	0.75	0.40	0.90
OK	0.14	0.30	0.20	0.30	0.34	0.64	0.43	1.07
OR	0.12	0.26	0.20	0.35	0.25	0.48	0.50	1.05
PA	0.13	0.26	0.17	0.39	0.31	0.49	0.44	0.91
RI	0.12	0.25	0.16	0.40	0.26	0.54	0.56	1.10
SC	0.13	0.30	0.23	0.36	0.32	0.62	0.43	1.16
SD	0.13	0.27	0.20	0.43	0.32	0.67	0.57	1.10
TN	0.14	0.31	0.22	0.35	0.30	0.65	0.48	1.03
TX	0.14	0.26	0.23	0.49	0.32	0.51	0.47	0.84
UT	0.13	0.27	0.25	0.39	0.35	0.63	0.59	1.11
VT	0.14	0.28	0.23	0.41	0.27	0.67	0.49	1.03
VA	0.12	0.21	0.23	0.38	0.23	0.61	0.56	0.70
WA	0.12	0.26	0.17	0.35	0.38	0.51	0.42	0.83
WV	0.15	0.25	0.18	0.39	0.30	0.52	0.53	1.10
WI	0.11	0.29	0.18	0.30	0.28	0.62	0.43	1.15

Table 9: Regression of median state valuations on firm and state characteristics

	Dependent variable:	
	Median valuation	
	(1)	(2)
Unemployment rate	1.169^{***}	
	(0.085)	
Vote % (Dem-Rep)	-0.259^{***}	
	(0.009)	
Jobs $\in [1, 19]$	-1.327^{***}	
	(0.005)	
Jobs $\in [20, 99]$	-0.919^{***}	
	(0.005)	
Jobs $\in [100, 499]$	-0.481^{***}	
	(0.005)	
Manufacturer	0.675^{***}	
	(0.004)	
Base profit		-0.023^{**}
		(0.009)
Constant	13.038^{***}	12.824^{***}
	(0.007)	(0.021)
Observations	4,320	4,320
R^2	0.963	0.001

Notes: *p<0.1; **p<0.05; ***p<0.01. Jobs ≥ 500 is the omitted category.

8 Welfare consequences of state government competition

Based on previous section's discussion, whether competition improves the overall welfare of states and firms is not obvious, as estimation results show that there are opposing effects at play. While the substantial heterogeneity in state valuations and the negative correlation between state valuations and firm profits imply that competition is likely to generate welfare gains, the relative unresponsiveness of firm choices to incentives implies the opposite.

I consider a counterfactual elimination of government competition and compare simulated welfare in this counterfactual to the one simulated under competition. In specific, I first simulate firm choices with competition as in the original model and compute resulting welfare of states and firms. I then remove incentives from firm profits, simulate firm choices, and compute resulting welfare. This second simulation corresponds to counterfactual elimination of competition. To compare welfare in these two simulations, I maintain the same draws of firm characteristics, random firm preferences (ζ, ϵ), and states' equilibrium bids and valuations.

I measure welfare as the sum of state valuations and firm profits as expressed by Equation 5. Instead of aggregating welfare changes across all draws of firms, I report quantiles of welfare changes resulting from competition for individual firms. I assume the deadweight loss of taxation to be 0.25, which captures the efficiency loss that arises from using tax dollars to pay incentives.[29]

Panel A of Table 10 shows that roughly 84% of firms choose the same states regardless of whether states compete.[30] This large inertia in firm choices arises from incentives being a relatively unimportant portion of firm profits as discussed in Section 7. The sum of incentives provided to such immobile firms amounts to 16% of total simulated incentives. In other words, 84% of incentives are paid to make about 16% of firms choose states different from what would have been chosen without incentive offers; large amounts of incentives are used to change locations of small share of firms.

When assuming zero deadweight loss of taxation, Panel B of Table 10 shows that

[29] 0.25 is within a range of existing estimates of deadweight loss of taxation in the Public Finance literature (e.g., (Chetty, 2009)). Higher measures would imply lower welfare gains from competition.

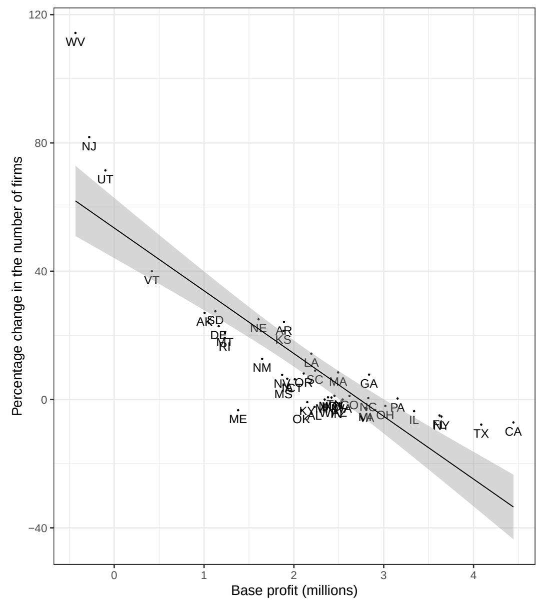
[30] In context of local government competition, Mast (2020) finds that about 85% of firms would choose the same towns in New York regardless of whether property tax exemptions are provided.

Table 10: Counterfactual elimination of state government competition

Panel A: Firm choices					
% immobile firms			84.42		
% incentives provided to immobile firms			15.94		
Panel B: Welfare change relative to no competition					
			Quantiles		
	0	0.25	0.5	0.75	1
% change in firm profits	0.03	0.44	1.07	3.26	670.86
immobile firms	0.03	0.38	0.85	1.99	305.57
mobile firms	0.16	3.93	12.73	36.63	670.86
% change in state welfare (DWL=0)	-36.88	-36.24	-35.27	-31.71	8.52e+254
immobile firms	-36.88	-36.29	-35.80	-33.82	-0.00
mobile firms	-32.87	551.91	2981.69	85565.27	8.52e+254
% change in state welfare (DWL=0.25)	-46.10	-45.30	-44.08	-39.64	8.52e+254
immobile firms	-46.10	-45.36	-44.74	-42.27	-0.00
mobile firms	-42.52	468.17	2646.54	84867.59	8.52e+254
% change in overall welfare (DWL=0)	0.00	0.00	0.00	0.00	1.29e+254
immobile firms	0.00	0.00	0.00	0.00	0.00
mobile firms	0.07	21.67	100.76	4055.92	1.29e+254
% change in overall welfare (DWL=0.25)	-5.21	-0.39	-0.16	-0.05	1.29e+254
immobile firms	-5.21	-0.47	-0.21	-0.09	-0.00
mobile firms	-0.18	18.81	90.65	4019.44	1.29e+254

the effects of competition on overall welfare is zero in most cases, since only a small fraction of firms' location choices are altered by competition. When firm choices are not altered, incentives are pure government transfers that distribute taxpayers' money to firms; states lose by more than 31.71% and firms gain by more than 0.44% in three quarters of competitions. However, in three quarters of cases when firm choices are altered, state welfare increases by more than 551.91%, and overall welfare increases by more than 21.67%. Figure 7 shows that under competition, states with lower base profits attract more firms than they could have without competition, but the magnitude of the percentage change is small for many states. Firms capture substantial rents from states especially when they choose less profitable (higher valuation) states that they would not have chosen without incentives. In about three quarters of competitions, firm profits increase by more than 3.93% when firm choices are altered compared to 0.38% when firm choices are unaltered. In other words, firms are substantially overcompensated when they choose what would have been less profitable states without incentives. When deadweight loss of taxation is taken into account, states lose by more than 39.64% and overall welfare decreases by more than 0.05% in three quarters of competitions.[31]

Figure 7: Percentage change in the number of firms



While I find in this section that competition mostly generates pure government transfers and infrequently improves welfare, whether the transfer of rents from states to firms is socially desirable is a normative question.[32] My welfare calculations suggest that competition is likely to be an ineffective solution if local economic development is prioritized, as states face substantial reduction in welfare in most cases due to insensitivity of firms to incentives. Furthermore, as I find that a substantial part of the state valuations for firms is explained by a political variable, economic gains for state residents are likely to be even lower than the state welfare change that I calculate using estimated state valuations.

[31] Anecdotal evidence suggests that incentive provision often results in depreciation of public goods and services that appear to not have been fully incorporated into governments' valuations for firms and bid strategies (e.g., `https://www.nytimes.com/2012/12/02/us/how-local-taxpayers-bankroll-corporations.html` and `https://www.nytimes.com/2018/04/24/opinion/amazon-hq2-incentives-taxes.html`).

[32] Glaeser (2001) discusses various aspects of the debate on the social desirability of government transfers to firms.

9 Conclusion

Using data on accepted incentives to learn about state valuations for firms and firms' geographic preferences, I provide empirical evidence that state government competition using incentives mostly has zero effect on the overall welfare of states and firms due to the insensitivity of firm location choices to incentives. Firms benefit by having states compete for them and by capturing rents. States, on the other hand, mostly face substantial welfare reduction from paying incentives to immobile firms. States that are less profitable for firms tend to have higher valuations for firms but infrequently benefit from competition. These findings are consistent with the view that state competition generates large corporate welfare and little allocative efficiency.

Either due to lack of data or for tractability, I made important simplifications in this paper that may be relaxed in a future research. The notion of state valuations for firms introduced in this paper does not arise from a particular mechanism and is difficult to interpret. Data on how an arrival of a firm impacts local outcomes would be informative of how well such valuations capture realized local economic benefits, which are often the subject of interest in assessments of place-based policies (e.g., Greenstone et al. (2010), Patrick (2016)). Data on unaccepted incentive offers would allow model primitives to be identified without assuming which states are competing for each firm. Lastly, the rich heterogeneity in types of incentives, the dynamic aspects of an incentive contract, and possible cross-state spillovers of benefits of attracting firms may be studied in richer models as well.

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Online Appendix

A. Data sources

Appendix Table 1: Data sources

Variable	Years	Source
Incentives and firm characteristics	2000-2017	Good Jobs First Subsidy Tracker
Population	2000-2016	U.S. census
College attainment rate	2005-2016	American Community Survey
Corporate income tax rate	2002-2017	The Council of State Governments
Unemployment rate	2000-2017	Bureau of Labor Statistics
Mean hourly wage	2001-2016	Bureau of Labor Statistics
Gubernatorial election outcomes	2003-2017	The Council of State Governments
Passenger boarding (enplanements)	2016	Federal Aviation Administration
Vehicle-miles of travel	2016	Federal Highway Administration
Waterborne tonnage	2016	US Army Corps of Engineers
Number of manufacturing employees	2016	Annual Survey of Manufacturers
Median monthly housing cost for renter-occupied housing	2016	American Community Survey
Per capita personal income	2000-2017	Bureau of Economic Analysis
Metropolitan Statistical Areas	2010	Bureau of Economic Analysis
Number of establishments	2005-2016	Statistics of U.S. Businesses

B. Sample selection

Raw data from the Good Jobs First Subsidy Tracker (December 2016 version) contains 525,613 observations on incentives provided by federal, state, and local governments. I exclude incentives provided at the federal level and incentives worth less than $10,000. Sample resulting from these two restrictions is used for Figure 2. I further exclude training and cost reimbursements, and incentives provided to oil refineries. I combine multiple incentives provided to the same firm by same state in same year. With these restrictions, I obtain a sample of 117,300 observations which are used for descriptive analysis in Tables 1 and 3 and Figure 1. In model estimation, I further restrict my sample to states with at least forty observations after 2005. With these restrictions, I obtain a sample of 100,339 observations for 45 states.

C. Numerical example in Section 4.5

Using parameter values shown in Table 5, I simulate the model in following steps:

1. For each state ($s = 1, 2$), draw J independent state valuations ($v_1 = (v_{11}, \cdots, v_{J1})$ and $v_2 = (v_{12}, \cdots, v_{J2})$) from truncated normal distributions with parameters (μ, σ) and support $[5, 15]$.

2. Solve each state's equilibrium bid function using the first-order conditions. I use a third-order polynomial to approximate equilibrium bid strategies: $b_{j1} = \gamma_1 + \gamma_2 v_{j1} + \gamma_3 (v_{j1})^2 + \gamma_4 (v_{j1})^3$ and $b_{j2} = \gamma_5 + \gamma_6 v_{j2} + \gamma_7 (v_{j2})^2 + \gamma_8 (v_{j2})^3$. As an example, densities of state valuations and equilibrium bids using Case 2 parameters with $\beta^b = 2$ are shown in Appendix Figure 1.

3. For each firm ($j = 1, \cdots, J$), simulate the location choice by drawing iid profit shocks $(\epsilon_{j1}, \epsilon_{j2})$ from Type I Extreme Value distribution and choosing the state that maximizes total profit: $\pi_{js} = \beta^x x_s^\pi + \beta^b b_{js} + \epsilon_{js}$. Profit shocks are kept constant across specifications.

D. Equation 6 in Section 5.1

Fix a state s and firm j and suppress their covariates from the notation. By the definition of conditional probability,

$$\begin{aligned}\Pr(B < b | s \text{ wins}) &= \frac{\Pr(s \text{ wins}, B_s < b)}{\Pr(s \text{ wins})} \\ &= \frac{\int_{\underline{b}}^{b} w_s(\tilde{b}) g_s(\tilde{b}) d\tilde{b}}{\Pr(s \text{ wins})},\end{aligned}$$

where g_s denotes the unconditional density of s's bid. The denominator on the RHS is equal to $\int_{\underline{b}}^{\bar{b}_s} w_s(\tilde{b}) g_s(\tilde{b}) d\tilde{b}$, but is directly observed. Differentiating with respect to b,

$$g_s(b | s \text{ wins}) = \frac{w_s(b) g_s(b)}{\Pr(s \text{ wins})}$$

so that

$$g_s(b) = \frac{g_s(b | s \text{ wins}) \Pr(s \text{ wins})}{w_s(b)}.$$

E. Numerical exercise in Section 5.3

For each state, I take 1000 iid valuations draws from the truncated normal distribution with mean and standard deviations equal to 10 and 1 respectively on bounded support $[5, 15]$. Let v_s^q denote state s's valuation at quantile q. Firm profit function is specified as $\pi_{js} = \beta^b b_{js} + \beta^x x_s^\pi + \epsilon_{js}$, where $(\beta^b, \beta^x, x_1^\pi, x_2^\pi) = (1, 2.5, 2, 1)$. ϵ_{js} is an iid draw from the Type I Extreme Value distribution. I solve for equilibrium bid functions and simulate location choices of firms as described in Appendix C. Let p_s denote Pr(s wins), b_s^q denote state s's simulated winning bids at quantile q, and $g_s^W(\cdot)$ denote the density of state s's winning bids. Treating $p_1, p_2, b_1^q, b_2^q, g_1^W(\cdot), g_2^W(\cdot)$ as data, I estimate state valuation distributions and firm profit function parameters (β^b, β^x) as follows.

- Specify states' equilibrium bid distributions as normal distributions with parameters $(\hat{\mu}_1, \hat{\sigma}_1)$ and $(\hat{\mu}_2, \hat{\sigma}_2)$.
- For each candidate parameter vector, $\theta^i = (\hat{\beta}^b, \hat{\beta}^x, \hat{\mu}_1, \hat{\mu}_2, \hat{\sigma}_1, \hat{\sigma}_2)$, simulate location choices of firms and states' winning bids as described in Appendix C. Let $\tilde{p}_s(\theta^i)$ and $\tilde{g}_s(\cdot; \theta^i)$ denote state s's simulated win share and the density of winning bids respectively using θ^i.
- Use the first-order conditions to recover implied state valuations distributions. Let $\tilde{v}_s^q(\theta^i)$ denote state s's valuations at quantile q.
- Compute the following squared distances:

$$m_1(\theta^i) = \sum_{s=1,2} \sum_{t \in T} \left(\tilde{g}_s(t; \theta^i) - \frac{g_s^W(t) p_s}{\tilde{w}(t; \theta^i)} \right)^2$$
$$m_2(\theta^i) = \sum_{s=1,2} \sum_{q \in Q} \left(b_s^q - \tilde{b}_s^q(\theta^i) \right)^2$$
$$m_3(\theta^i) = \sum_{q \in Q} \left(\tilde{v}_1^q(\theta^i) - \tilde{v}_2^q(\theta^i) \right)^2$$
$$m_4(\theta^i) = \left(p_1 - \tilde{p}_1(\theta^i) \right)^2,$$

  where T is the set of selected points in the support of the observed winning bids, and Q is the set of selected quantiles.

- Find θ^i such that minimizes $M = m_1 + m_2 + m_3 + w m_4$, where w is a chosen constant.

I include m_1 based on Equation 6, which is needed to recover the equilibrium bid distributions using data on $g_s^W(\cdot)$ and p_s. I include m_2, m_3, and m_4 based on the argument that the variation in conditional distribution of winning bids is informative of the relative importance of x_s^π versus the bids. $m_3(\theta^i)$ is minimized to satisfy the constraint that the two states have the same valuation distributions.

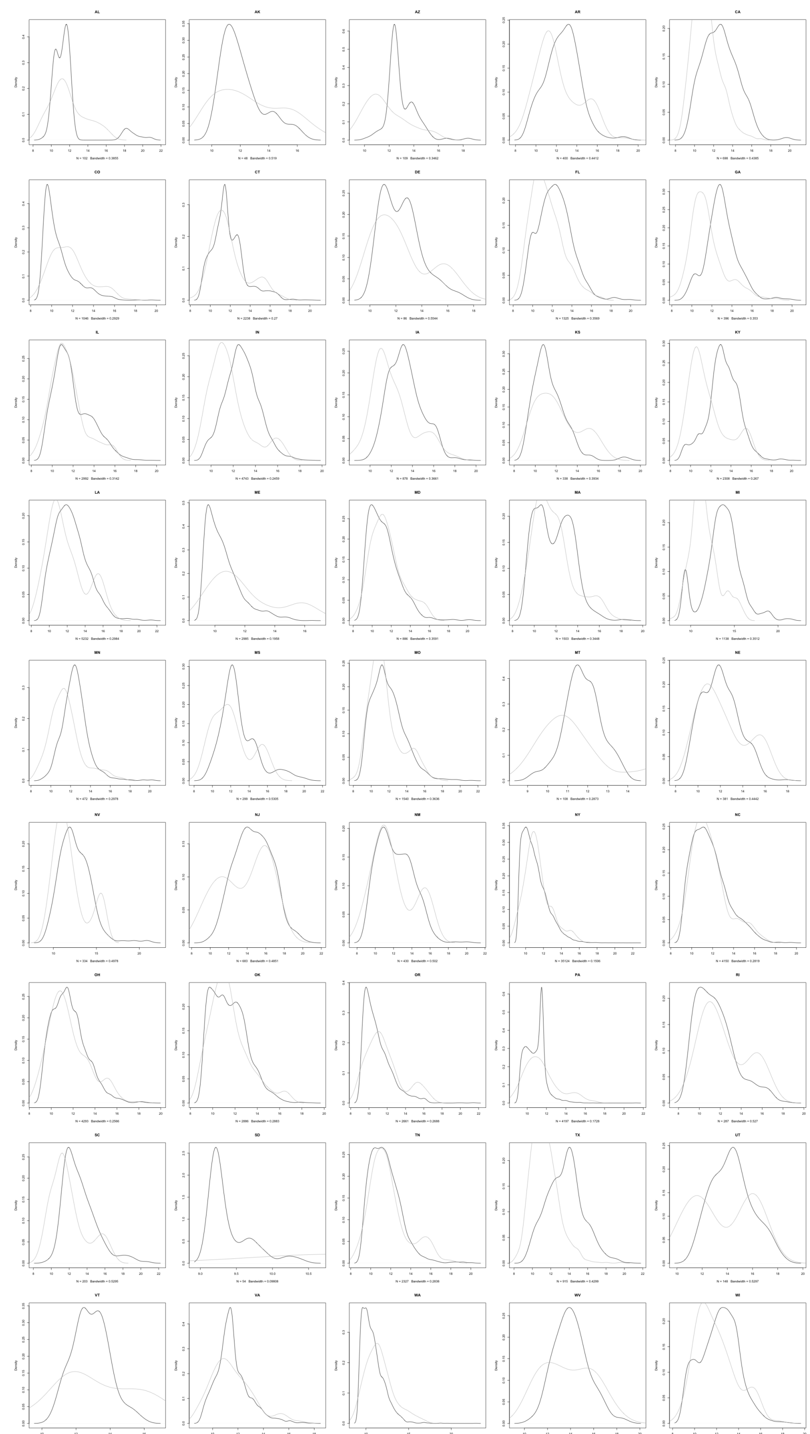
Appendix Table 2 shows the results of 100 replications of this exercise. β^b, β^x and the valuation distributions are estimated reasonably well overall. Lower quantiles of the valuation distributions are not recovered as well, as states would likely lose when they draw very low valuations, and hence the observed winning bids are unlikely to be associated with the very low valuation draws. This problem suggests that identifying the left tail of the valuation distribution would be challenging.

Appendix Table 2: Numerical exercise results

A. Firm profit function parameters		
	True value	Estimates (Min, 1Q, Med, Mean, 3Q, Max)
β^b	1	(0.72, 0.95, 1.04, 1.07, 1.13, 1.85)
β^x	2.5	(1.90, 2.31, 2.49, 2.48, 2.60, 3.23)
B. State valuation distributions		
	True value	Estimates (Min, 1Q, Med, Mean, 3Q, Max)
State 1 min	5	(6.47, 7.15, 7.57, 7.52, 7.86, 8.65)
State 2 min	5	(6.35, 7.12, 7.45, 7.49, 7.88, 8.53)
State 1 1Q	9.33	(8.19, 8.92, 9.28, 9.23, 9.52, 10.27)
State 2 1Q	9.33	(8.15, 8.97, 9.22, 9.23, 9.47, 10.16)
State 1 med	10	(8.75, 9.60, 9.84, 9.82, 10.11, 10.77)
State 2 med	10	(8.71, 9.57, 9.75, 9.78, 9.95, 10.71)
State 1 mean	10	(8.89, 9.71, 9.93, 9.92, 10.18, 10.85)
State 2 mean	10	(8.88, 9.68, 9.85, 9.87, 10.04, 10.76)
State 1 3Q	10.67	(9.41, 10.29, 10.51, 10.50, 10.75, 11.40)
State 2 3Q	10.67	(9.37, 10.22, 10.38, 10.40, 10.59, 11.28)
State 1 max	15	(12.68, 13.66, 14.26, 14.42, 14.78, 20.51)
State 2 max	15	(12.11, 13.63, 14.53, 14.65, 15.41, 20.26)

F. Model fit

Appendix Figure 1: Densities of log accepted incentives (data vs. simulated)



Notes: Empirical and simulated densities are in black and gray respectively.

Appendix Table 3: Share of firms (simulated − data)

State	Jobs $\in [1, 19]$	Jobs $\in [20, 99]$	Jobs $\in [100, 499]$	Jobs ≥ 500
AL	0.003	0.001	0.009	0.006
AK	0.002	0.002	0.008	0.007
AZ	0.004	-0.000	-0.000	-0.002
AR	0.006	0.007	0.016	0.007
CA	0.015	0.000	-0.008	0.000
CO	-0.000	0.007	0.004	0.005
CT	0.003	0.006	0.001	0.000
DE	0.002	0.006	-0.001	0.002
FL	-0.019	0.004	-0.000	-0.005
GA	-0.002	-0.005	-0.001	-0.009
IL	0.003	-0.010	0.001	-0.006
IN	0.001	0.017	-0.010	-0.004
IA	0.000	-0.007	-0.008	0.004
KS	0.001	-0.006	0.000	0.004
KY	0.004	0.003	-0.004	0.005
LA	0.002	-0.010	0.006	0.007
ME	0.001	0.007	0.001	0.004
MD	0.001	-0.004	0.000	-0.005
MA	-0.004	-0.005	0.010	-0.009
MI	-0.003	0.002	-0.001	0.001
MN	-0.002	-0.001	0.003	-0.004
MS	0.003	0.003	0.004	0.012
MO	-0.000	0.003	0.002	-0.003
MT	0.003	-0.000	0.007	0.007
NE	0.003	-0.002	0.007	0.013
NV	0.004	0.001	0.007	0.003
NJ	-0.031	-0.026	-0.020	-0.018
NM	0.004	0.003	0.002	0.007
NY	-0.009	0.013	-0.002	-0.000
NC	0.000	-0.000	-0.016	-0.004
OH	-0.001	-0.012	-0.004	-0.009
OK	0.003	0.002	0.000	-0.000
OR	-0.000	-0.002	0.010	0.013
PA	-0.000	-0.008	-0.003	-0.000
RI	0.003	0.005	0.009	0.004
SC	0.002	-0.007	0.004	0.008
SD	0.002	0.004	0.011	0.004
TN	0.005	0.011	-0.006	-0.003
TX	0.032	0.037	-0.009	-0.003
UT	-0.008	-0.006	0.003	-0.003
VT	-0.001	-0.000	0.003	0.009
VA	0.002	-0.005	-0.000	-0.012
WA	-0.003	0.001	-0.002	-0.006
WV	-0.004	-0.003	-0.001	-0.001
WI	-0.001	-0.000	-0.003	-0.002