Political Economy of Transport Investments: Evidence from the California High-Speed Rail [Preliminary]

Pablo Fajgelbaum[‡], Cécile Gaubert[†], Nicole Gorton[‡], Eduardo Morales[*] and Edouard Schaal[§]

[‡]UCLA,[†]UC Berkeley, [*]Princeton, [§]CREI

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Motivation and Research Question

- Transportation infrastructure projects are typically massive public investments
- Economic gains studied by a vast literature (Redding and Turner, 2015)
- Values and political beliefs also influence how people/policy makers value transportation investments:
  - Constituents' preferences for public good, environmental concerns, party line
  - Policy makers may favor some constituents over others

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  - Constituents' preferences for public good, environmental concerns, party line
  - Policy makers may favor some constituents over others
- **How important are economic and political/ideological forces in people's and planner's policy preferences?**
- **How do they shape transportation policy?**

Empirical setting: the California High Speed Rail (HSR)

- Second largest transport project in US history
  - Electric high-speed train connecting San Francisco to Los Angeles
  - Projected cost $>$ \$40 bn
- Initial funding for HSR put on the ballot in California in 2008 (Prop 1a)
  - Referendum approved by 52.6% of voters
- We observe granular voting data across 8k census tracts

This Paper

1. **Individual's preferences.**
   To what extent do individuals' policy preferences reflect their economic gains?
   - Intermediate step: develop and estimate a model of real income gains from HSR
   - Estimate relative weight of real income gains in voting
   - Counterfactuals: vote with different weights; vote on alternative HSR designs
2. **Planner's preferences.**
   How much do distributional considerations influence the HSR design?
   - From HSR design: estimate preferences of hypothetical planner over demographic groups and votes
   - Counterfactuals: compute optimal HSR designs under different planner's preferences
     - e.g., what if policymakers had equal preference over groups, and didn't care about votes?

Preliminary Results

- Economic gains matter in preferences and votes, but are dominated by political/ideological factors
  - Votes in favor of HSR (Prop 1a) seem more driven by ideological preferences than by economic gains
  - Distributional impacts of HSR seem much stronger on ideological ground than on economic ground
- [Planner's preferences: in progress.]

Literature Review

- Vast literature on the real income effects of infrastructure (summary Redding and Turner 15)
  - Donaldson 12, Faber 14, Donaldson and Hornbeck 16,...
  - Rails: Gupta et al. 21, Severen 21, Bernard et al. 19, Borusyak and Hull 21, Dong et al. 20
- Quantitative spatial models (summ Redding and Rossi-Hansberg 17) dive into:
  - Commuting: Ahlfeldt et al. 15, Monte et al. 18, Dingel and Tintelnot 21,...
  - Distributional effects: Tsivanidis 19, Balboni et al. 20, Barwick et al. 21
  - Optimal Infrastructure Design: Alder 19, Fajgelbaum and Schaal 20, Allen and Arkolakis 21
- Political Economy of Transportation
  - Brueckner and Selod 06, Glaeser and Ponzetto 18
- Estimation of individual's policy preferences
  - Holian and Kahn 13, Kahn and Matsusaka 97, Mendez and Van Patten 22
- Estimation of planner's preferences
  - Burguess et al. 15, Alder and Kondo 20
  - Goldberg Maggi 99, Bourguignon and Spadaro 12, Jacobs et al. 17

Empirical setting: California HSR

Voters' preferences

Planner's preferences

California HSR: 2008 Plan and Background

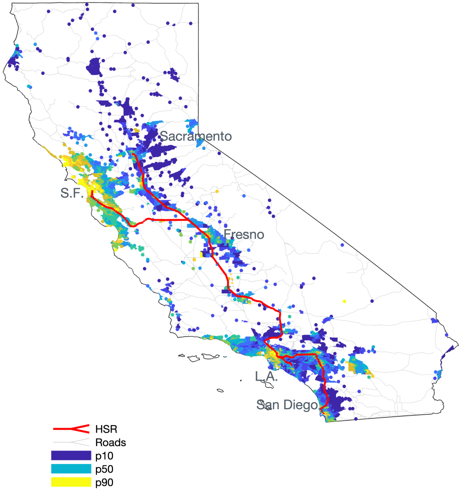
Figure: Planned Route (2008 Business Plan)

- 1996: California HSR Authority is established
- 2008: Prop 1a approved, same election as Obama vs McCain
  - Issue bonds for \$10 bn (0.4% CA GDP)
  - Electric train, $\geq$ 200 mph (SF-LA: 2:40')
  - 24 stations over 800 miles
  - Phase 1: LA- SF through Central Valley; later: Sacramento, SD
  - Projections: >\$40 bn; first segment: est. 2022
- 2015: Construction begins. But:
  - Ballooning costs, legal challenges
  - Planned completion of Central Valley segment (180 miles) by 2029

HSR Planned Route and % Yes on Prop 1a

Figure: Planned Route (2008 Business Plan)

Figure: % Yes on Prop 1a

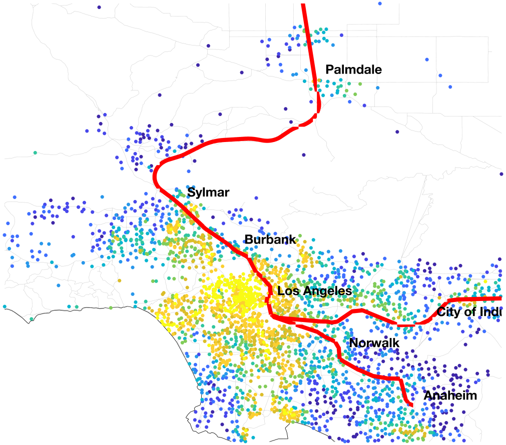


Note: (p10,p50,p90) = (0.45,0.54,0.68)

HSR Planned Route and % Yes on Prop 1a

Figure: Planned Route (2008 Business Plan)

Figure: % Yes on Prop 1a



Empirical setting: California HSR

Voters' preferences

- **How much do individuals' policy preferences reflect their economic gains?**

Planner's preferences

Voting on HSR

- Probabilistic voting (Dixit and Londregan, 1996) of agent ω in location (census tract) i:
  - Vote on HSR status $s =$ built/not (B, NB):
  - Utility depends on expected real income $W(i,s)$ and ideological preference over HSR status $\varepsilon_{\omega}^{a}(s)$

$$\max_s \mathbb{E}\left[\ln W(i,s) \mid \mathcal{I}_i\right] + \varepsilon_{\omega}^{a}(s)$$

  - Assume $\varepsilon_{\omega}^{a}(s) \sim$ Type-I extreme value $(\theta_V, \ln a(i,s))$

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  - Assume $\varepsilon_\omega^a(s) \sim$ Type-I extreme value $(\theta_V, \ln a(i,s))$
- Share of votes in favor of HSR $v(i)$:

$$\ln\left(\frac{v(i)}{1-v(i)}\right) = \theta_V \mathbb{E}\left[\ln \hat{W}(i) \mid \mathcal{I}_i\right] + \ln \hat{a}(i)$$

  - Welfare impact of HSR: $\hat{W}(i) \equiv \frac{W(i,B)}{W(i,NB)}$, $\hat{a}(i) \equiv \frac{a(i,B)}{a(i,NB)}$

Estimating the Voting Equation

Goal is to estimate

$$\ln\left(\frac{v(i)}{1-v(i)}\right) = \theta_V \mathbb{E}\left[\ln \hat{W}(i) \mid \mathcal{I}_i\right] + \ln \hat{a}(i)$$

- Measurement issues:
  - need a proxy for $\mathbb{E}\left[\ln \hat{W}(i) \mid \mathcal{I}_i\right]$. Construct it from a range of models [next]
  - construct empirical proxies for $\ln \hat{a}(i)$
- Identification issues:
  - e.g. correlation between $\mathbb{E}\left[\ln \hat{W}(i) \mid \mathcal{I}_i\right]$ and unobserved ideological forces

Real-Income Effects of HSR?

- Construct $\hat{W}(i)$ using quantitative spatial model
  - What forces shall we consider?

- Key forces typically emphasized for high-speed rails:
  - saving time on trips, value of time saved
    - inter-city travel (long-distance commuters, leisure travel)
    - improvements in firm performance (Bernard, Moxnes, Saito 19, Dong, Zheng, Kahn 20)
  - local economic development
  - reduced congestion on roads $\rightarrow$ not today
  - environmental benefits $\rightarrow$ load heterogeneity on ideological preferences

Ingredients of the model

- Direct effect of HSR (time savings):
  - Workers commute to work as in Ahlfehldt, Redding, Sturm and Wolf (2015)
  - Workers take inter-urban leisure trips
  - Firms send workers on business trips
  - [In progress]: Modal choice (car, airplane, public transit)
- Indirect equilibrium effects of HSR:
  - Housing market
  - Endogeneous productivity and consumption amenities (agglomeration spillovers)
- Consider model variants for voter's beliefs: only direct effects (baseline) , full model

Model overview

- $N_R(i)$ residents of location (census tract) i. Indirect utility:

$$W(i,s) = \mathbb{E}\left[\max_{j_C} V(i,j_C,s)\,\varepsilon_\omega^C(j_C)\right]$$

  where residents make discrete choices of where to commute (j_C).

- Residents consume the traded good, housing, and leisure trips:

$$V(i,j_C,s) = \frac{I(i,j_C,s)/\tau(i,j_C,s)^\rho}{r(i,s)^{\mu_{H_c}} P_L(i,s)^{\mu_L}} A_C(i,s)$$

  - income $I(i,j_C,s) = (1-t(s))\left[w(j_C,s) + \eta(i)\,r(i,s)\right]$
  - commuting travel time: $\tau(i,j_C,s)$
  - endogenous consumption amenities: $A_C(i,s)$
  - idiosyncratic preference shock $\varepsilon_\omega^C(j_C)$: Frechet, θ^C

details

Model overview - leisure and business trips

- **Leisure trips.** Price index $P_L(i,s)^{\mu_L}$ derived from discrete choice of destination j_L with sub-utility:

$$\left(\frac{A_L(i,j_L,s)}{\tau(i,j_L,s)^{\rho}}R_L\right)^{\mu_L}\varepsilon^L_{\omega}(j_L)$$

  - Idiosyncratic shock $\varepsilon^L_{\omega}(j_L)$: Frechet, θ^L.

details L

- **Business trips.** Traded good producers in j_C send workers to productivity-enhancing business trips:

$$Y(j_C,j_B)=A_Y(j_C,s)\,L^{\mu_L}H_Y^{\mu_{H_y}}\left(\frac{A_B(j_C,j_B,s)}{\tau(j_C,j_B,s)^{\rho}}R_Y\right)^{\mu_B}\varepsilon^B_{\omega}(j_B)$$

  - Discrete choice of destination. Idiosyncratic shock $\varepsilon^B_{\omega}(j_B)$: Frechet, θ^B.

details Y

Model-predicted impact of HSR

- Real income change in tract i, with vs without HSR:

$$\hat{W}(i) = \hat{A}_C(i) \frac{\hat{I}(i)}{\hat{r}(i)^{\mu_{H_c}} \hat{P}_L(i)^{\mu_L}}$$

- **Baseline**. Gains = time saving on long-distance commute and leisure travel:

$$\hat{I}(i) = (1-t)\left(\sum_{j_C} \lambda^C(i,j_C)\left(\hat{w}(j_C)\,\hat{\tau}(i,j_C)^{-\rho}\right)^{\theta^C}\right)^{\frac{1}{\theta^C}}$$

$$\hat{P}_L(i) = \left(\sum_{j_L} \lambda^L(i,j_L)\left(\hat{A}_C(j_L)\,\hat{\tau}(i,j_L)^{-\rho}\right)^{\mu_L\theta^L}\right)^{\frac{1}{\mu_L\theta^L}}$$

  - with $\hat{w}(j_C) = 1; \hat{A}_C(j_L) = 1$

Model-predicted impact of HSR

- Real income change in tract i, with vs without HSR:

$$\hat{W}(i) = \hat{A}_C(i)\,\frac{\hat{I}(i)}{\hat{r}(i)^{\mu_{H_c}}\,\hat{P}_L(i)^{\mu_L}}$$

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$$\hat{P}_L(i) = \left(\sum_{j_L}\lambda^L(i,j_L)\left(\hat{A}_C(j_L)\hat{\tau}(i,j_L)^{-\rho}\right)^{\mu_L\theta^L}\right)^{\frac{1}{\mu_L\theta^L}}$$

- **Full model**. Productivity, amenities and rents also adjust, for instance:

$$\hat{w}(j_C) = \hat{A}_Y(j_c)^{\frac{1}{\mu_L}}\left(\sum_{j_B}\lambda^B(j_C,j_B)\left(\hat{A}_Y(j_B)\hat{\tau}(j_C,j_B)^{-\rho}\right)^{\mu_B\theta^B}\right)^{\frac{1}{\mu_B\theta^B}}\hat{r}(j_c)^{-\frac{\mu_{H_y}}{\mu_L}}$$

▸ spillovers

Quantification

- Computing real income changes from HSR requires:
  - data on initial trip shares $\lambda^k(i,j)$ for Commuting, Leisure, Business trips
  - data on initial distribution of workers, wages, floor space prices
  - estimate of time gain due to HSR $\hat{\tau}(i,j)$
  - elasticities estimate: ρ, θ^k estimated from travel decisions, shares μ_k
- Model calibrated on granular data: 7866 census tracts (avg. working pop: 2600)

Data

- Trip shares $\lambda^k(i,j)$:
  - Matrix of commuting flows between 7866 census tracts: ACS
  - Matrix of leisure and business trips: California Household Travel Survey ▸ CHTS
- Wages and housing prices
  - US Census 2008 and 2019, LEHD Origin-Destination Employment Stats
  - Zillow
- Travel time
  - Compute time on fastest route [for now] given transport network (car, air, HSR) ▸ details
- Tax to finance HSR
  - calibrated to 2008 cost projection
- Spillover elasticities
  - Calibrate using estimates from Ahlfehldt et al. (2015)

Estimating elasticities from travel decisions

- Estimate model elasticities from **model-based gravity** for C,L,B trips. Use PPML: ▸ gravity eq.
  - **Commuting**:

$$\ln \lambda^C(i,j) = \nu^C(i) + \underset{\substack{\theta^C = 2.75^{***} \\ (.117)}}{\theta^C \ln w(j)} - \underset{\substack{\rho = 1.34^{***} \\ (.058)}}{\theta^C \rho \ln \tau(i,j)} + \varepsilon(i,j)$$

  - **Leisure trips**:

$$\ln R^L(i,j_L) = q^L(i,j_L) + \nu^L(i) + \underset{\substack{= 1.77 \\ (0.02)}}{\mu^L \theta^L \rho \ln \tau(i,j_L)} + \varepsilon(i,j_L)$$

    - $q_L(i,j_L)$: proxies for quality of j_L (beach, national park); [business] ij_L industry similarity
    - share of leisure trips in expenditure: $\mu_L = 0.05$ (BLS)

▸ tables ▸ business trips

- Use model-generated commuting flows:
  - overcomes sparsity of survey data and overfitting (Dingel and Tintelnot, 2022)

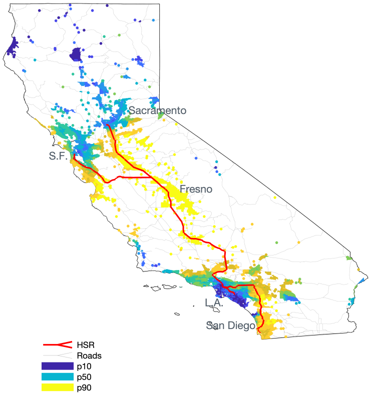
Time Saved and Economic Gains from HSR

- Distribution of time savings $\{\hat{\tau}(i,j)\}$

	% Travelers who save time	Time saved median	Time saved 75 ptile
Commute	.94%	12 ' (10%)	25 ' (18%)
Leisure	24%	19 ' (10%)	43 ' (22%)
Business	20%	19 ' (11%)	42 ' (22%)

raw data

Figure: Distribution of Economic Gains $\hat{W}(i)$



Note: med -0.2%, avg 0.3%, sd 1.4%. Baseline case.

Empirical setting: California HSR

Voters' preferences

- Real income gains
- **Estimating voters' preferences**

Planner's preferences

HSR Votes and Real Income Gains

Figure: % Yes on Prop 1a

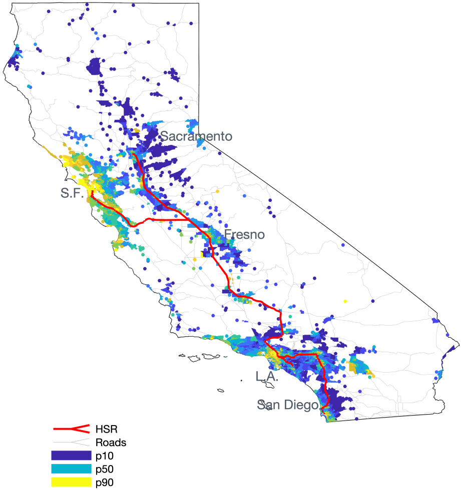
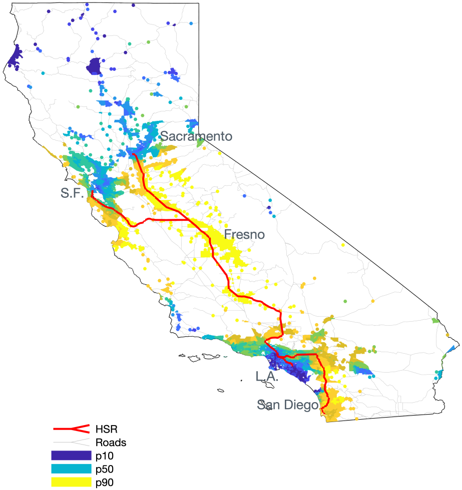


Figure: % Real Income Gains



HSR votes net of Obama Votes and Real Income Gains

Figure: % Yes on Prop 1a - % Obama

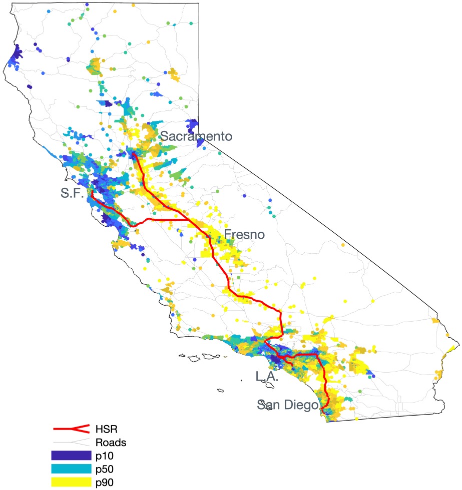
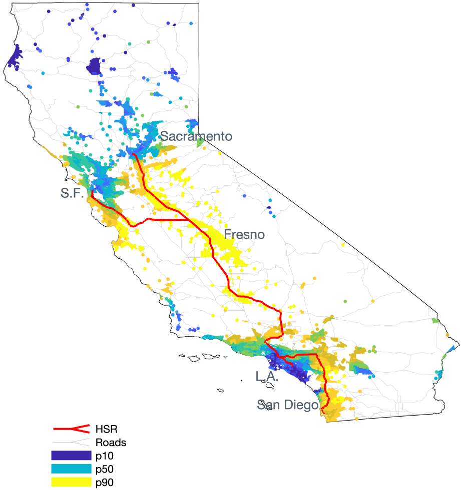


Figure: % Real Income Gains



Voting on HSR

- Estimating equation from the model:

$$\ln\left(\frac{v(i)}{1-v(i)}\right) = \theta_V \mathbb{E}\left[\ln \hat{W}(i) \mid \mathcal{I}_i\right] + \ln \hat{a}(i)$$

- Proxy for $\mathbb{E}\left[\ln \hat{W}(i) \mid \mathcal{I}_i\right]$:

- Proxy for $\ln \hat{a}(i)$:

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- Proxy for $\mathbb{E}\left[\ln \hat{W}(i) \mid \mathcal{I}_i\right]$:
  - Voter form rational expectations: $\ln \hat{W}(i) = \mathbb{E}\left[\ln \hat{W}(i) \mid \mathcal{I}_i\right] + \epsilon_W(i)$
  - Use model-based 2019 real income gains as proxy: $\ln \hat{W}_{19}(i) = \ln \hat{W}(i) + \epsilon_{19}(i)$

- Proxy for $\ln \hat{a}(i)$:

Voting on HSR

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  - Use model-based 2019 real income gains as proxy: $\ln \hat{W}_{19}(i) = \ln \hat{W}(i) + \epsilon_{19}(i)$

- Proxy for $\ln \hat{a}(i)$:
  - Percentage registered democrats
  - Vote in related referenda (Prop 10 (renewable energy '08), Prop 1B (transportation funding '06))
  - Population density

$$\ln \hat{a}(i) = a_0 + \sum_k \beta_k \ln\left(\frac{v_k(i)}{1-v_k(i)}\right) + \gamma X(i) + \epsilon_a(i)$$

Estimating Equation and Threats to Identification

Estimating equation:

$$\ln\left(\frac{v(i)}{1-v(i)}\right) = \theta_V \ln \hat{W}_{19}(i) + a_0 + \sum_k \beta_k \ln\left(\frac{v_k(i)}{1-v_k(i)}\right) + \gamma X(i) + \varepsilon(i)$$

where $\varepsilon(i) = -\epsilon_{19}(i) - \epsilon_W(i) + \epsilon_a(i)$. Potential threats to identification:

- Expectational error of voters
- $\hat{W}$ may be correlated with unobserved political values (non-random placement of stations)
- Model misspecification

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where $\varepsilon(i) = -\epsilon_{19}(i) - \epsilon_W(i) + \epsilon_a(i)$. Potential threats to identification:

- Expectational error of voters
  - Instrument for $\hat{W}_{19}$ with $\hat{W}_{08} \in \mathcal{I}_i$ using 2008 data
- $\hat{W}$ may be correlated with unobserved political values (non-random placement of stations)
  - Instrument for $\hat{W}$ using alternative HSR designs:
  - Pick stations at random along HSR route, compute $\hat{W}$
  - Pick stations at random along actual and alternative routes, compute $\hat{W}$ routes
- Model misspecification
  - Use different restrictions on the sample or different economic models
  - e.g. Additional forces for tracts on the HSR tracks (e.g. eminent domain, noise) $\Rightarrow$ drop closest tracts

more

Voting Equation

Table: Estimates of θ_v, baseline

	OLS		IV		
	(1)	(2)	(3) 2008 IV	(4) Random Stations IV	(5) Random Stations+Route IV
$\log(\hat{W})$, 2019	-2.386	2.522*	2.675*	2.495*	2.914**
	(2.164)	(1.060)	(1.089)	(0.976)	(1.045)
log-odds Reg Dems Share		0.413***	0.413***	0.413***	0.413***
		(0.0813)	(0.0813)	(0.0813)	(0.0815)
Environment: log odds Yes on Prop. 10		0.360***	0.360***	0.360***	0.360***
		(0.0522)	(0.0520)	(0.0521)	(0.0516)
Transportation: log odds Yes on Prop. 1b		-0.00267	-0.00299	-0.00261	-0.00351
		(0.139)	(0.139)	(0.139)	(0.138)
pop. density		0.0469***	0.0469***	0.0469***	0.0469***
		(0.0103)	(0.0103)	(0.0103)	(0.0103)
Avg. MA Pop. Dens.		0.0404	0.0440	0.0397	0.0497
		(0.127)	(0.127)	(0.124)	(0.122)
Constant	0.193*	-0.161	-0.170	-0.159	-0.184
	(0.0871)	(0.290)	(0.291)	(0.283)	(0.277)
First stage F-stat			7839.2	102.3	30.50
R2	0.00736	0.712	0.712	0.712	0.712
N	7866	7866	7866	7866	7866

Note: Prop 10, which measures environmental values, would have allowed California to sell 5 billion in bonds for a variety of renewable energy projects and was on the general election ballot in 2008 (Ballotpedia). Prob 1B, which measures attitudes towards infrastructure spending, would have allowed the sale of 19.9 billion in general obligation bonds designated for highway and street repair and reconstruction and other related transportation projects and was on the general election ballot in 2006 (Ballotpedia).

GE | $>$ 5 km | Vary ρ | Larger S.E. bandwidth

Takeaway: Drivers of Voting and Distributional Considerations

- With these estimates, insight on drivers of votes and policy preferences
  - have estimates for $\ln \hat{W}(i)$, $\ln \hat{a}(i)$ and θ_V
  - hence have estimates and decomposition of impact of HSR on tract i (compared to status quo):

$$\Delta U(i) \equiv \mathbb{E}_{\varepsilon^a_\omega}\left[\Delta U_\omega(i)\right]) = \ln \hat{W}(i) + \ln \hat{a}(i)$$

- Distribution of real income gains $\ln \hat{W}(i)$ (aggregate $= +0.4\%$) is very skewed:
  - 30% of tracts gain (avg: $+$ 1.8%), 70% of tracts lose (avg: -0.2%)
- Vote on economic grounds alone:
  - Prop1a would have barely passed (50.3% in favor)
  - Under 1 tract $=$ 1 vote, Prop1a would not pass

Takeaway: Drivers of Voting and Distributional Considerations

$$\Delta U(i) = \ln \hat{W}(i) + \ln \hat{a}(i)$$

- Ideological response to HSR $\ln \hat{a}(i)$ is much more positive (aggregate $= +4\%$)
  - 63% of tracts gain
- Vote on ideological grounds alone:
  - HSR would have passed (52.1% in favor)
  - Under 1 tract $=$ 1 vote, HSR largely passes
- Ideological component dominates economic component:
  - For distributional implications: $\frac{p75(ln\hat{a})}{p25(ln\hat{a})} = 4.4 \times \frac{p75(ln\hat{W})}{p25(ln\hat{W})}$ graph
  - In terms of contribution to favorable vote: $(v(\hat{a}) - 50\%) = 9 \times \left(v(\hat{W}) - 50\%\right)$

Robustness Across Model Variants

Table: Decomposition of the Welfare Gains and Votes

	θ_V	Average % Gain	Median % Gain	Only $\hat{a}$ vote	Only $\hat{W}$ vote
No GE	2.91	0.41	-0.19	52.13	50.27
GE	4.01	0.30	-0.19	52.11	50.29
No GE w/ 5km buffer	2.75	0.41	-0.19	51.88	50.26
GE w/ 5km buffer	3.66	0.30	-0.19	51.90	50.26
No GE+exponential	2.34	1.83	0.51	51.42	50.99
No GE+Vary ρ	.82	4.78	1.24	51.56	50.85
No GE+No air	6.18	1.69	1.26	49.76	52.70

- Political/ideological preferences are major drivers of vote:
  - contribute to the aggregate vote 2 to 9 times more than real income component

Empirical setting: California HSR

Voters' economic and non-economic preferences

Planner's preferences

Economic and Political Drivers of HSR Design

- Allow for economic and political drivers of planner's decision:
  - maximizing constituent's welfare - allowing for different weights $\Omega(i)$ for different constituencies
  - perhaps: planner takes votes in favor of HSR as additional objective (weight λ)

- Formally, posit social welfare function:

$$SWF = \mathbb{E}\left[\sum_i N(i)\,\Omega(i)\ln \hat{W}(i) + \lambda \sum_i N(i)\,v(i) \mid \mathcal{I}_P\right]$$

- Parameterize Pareto weights $\Omega(i)$ as function of demographics in i $Z_k(i)$
  - k :share college, pop. density, av. wage

$$\Omega(i) = 1 + \sum_{k=1}^{K} \beta_k Z_k(i)$$

- Goal: estimate $\{\beta_k, \lambda\}$

Planner's Choice of HSR Design

- Planner's problem: choose where to put the HSR stations to maximize *SWF*?
- A priori, combinatorial problem
  - Different investment problem from existing literature Fajgelbaum Schaal '20, Allen Arkolakis '21
- Formalize the station location problem as a problem in the space of geographic coordinates
  - Constrain 24 stations to be on the HSR route (1-dimensional route, plus branches)
  - Planner problem is continuous, but highly non-convex.

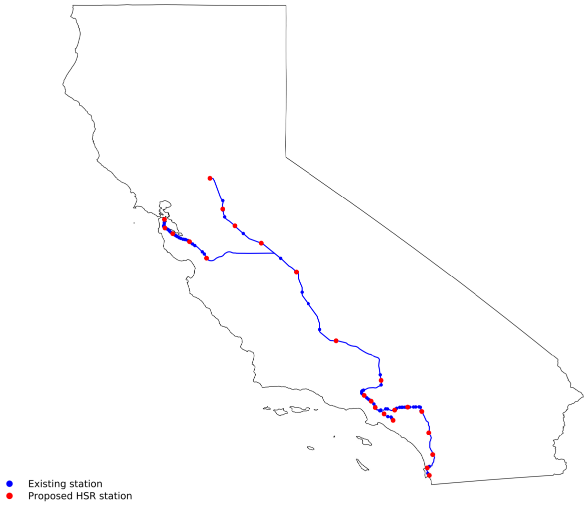
Estimation of Planner Weights

- Assume observed HSR design maximizes SWF. For any alternative design:

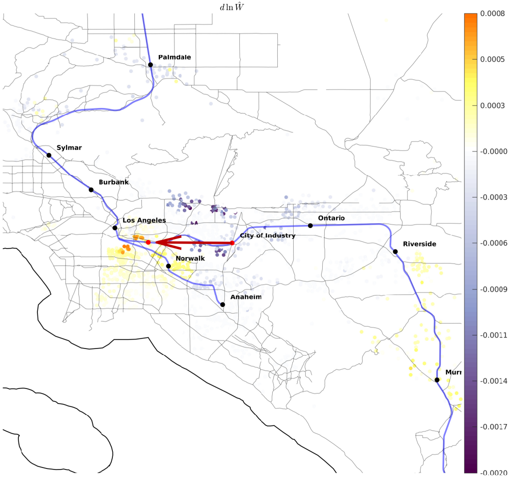
$$\Delta SWF \equiv SWF(alt) - SWF(HSR) < 0$$

- This set of moment inequalities identifies intervals for (β, λ)
- Choose alternative station locations = pre-existing stations
  - also: peaks and troughs of pop. density
- Compute confidence set using modified method of moments (Andrews and Soares, 2010)

Existing Stations as Potential Locations



Example of a Deviation



Modified Method of Moments: Preliminary Results

Planner solves: $\max \sum_i \mathbb{E}\left[N_R(i)\,\Omega(i) \ln \hat{W}_T\right] + \lambda \sum_i N_R(i)\,\mathbb{E}\left[v_R(i)\right]$, with $\Omega(i) = const + \sum_{k=1}^{K} \beta_k Z_k(i) + e(i)$

Observable	(1)	(2)	(3)
Population	0.000 [0.000, 0.053]	0.000 [0.000, 0.105]	0.000 [0.000, 0.281]
Wage	0.054 [−0.056, 0.211]		0.000 [−0.395, 0.365]
Share college		0.054 [−0.054, 0.211]	0.107 [−0.136, 0.581]
Share non-white	0.432 [0.315, 0.537]	0.377 [0.3055, 0.537]	0.214 [0.315, 0.537]
Votes	0.108 [0.000, 0.418]	0.216 [0.000, 1.019]	0.320 [0.000, 3.172]
Const	0.981 [0.958, 0.986]	0.985 [0.942, 0.989]	0.991 [0.873, 1.009]

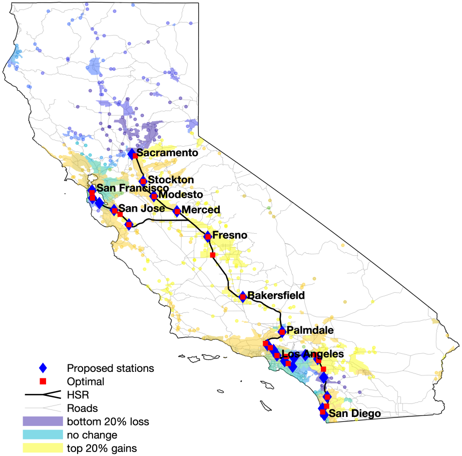
Note: Centroids of a 99% confidence set. Brackets indicate [min max]. Parameters normalized so that mean($\Omega(i)$) = 1

- Takeaway (preliminary!): estimated planner...
  - seems to favor high wage/share college and nonwhite places
  - no clear trade-off between votes and welfare gains
  - data seems to call for other wedges beyong relative weights between groups - in progress

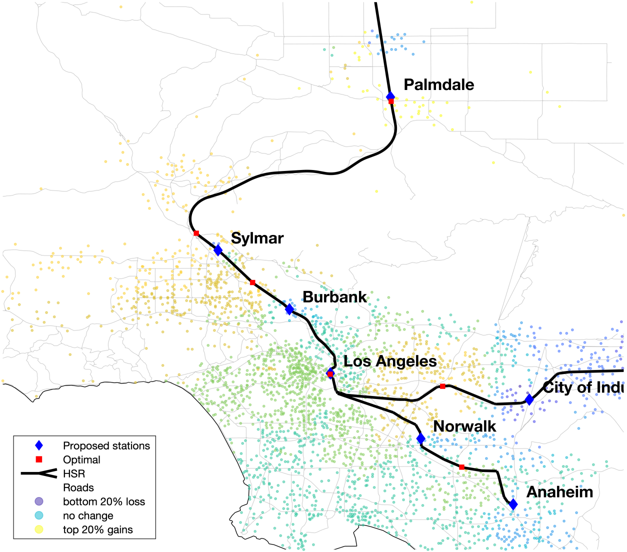
Optimal Station Placement: Utilitarian Case

Benchmark = utilitarian planner: $\Omega(i) = 1, \lambda = 0$

- Solve for optimal HSR station placement, compare to actual placement
- Compute welfare difference deviations



Optimal Station Placement: Zooming on LA county



Conclusion

- How important are political/ideological considerations for transport infrastructure policy, beyond real income gains?
- HSR is quite unique: spatially disaggregated voting data
  - Insight on what drive constituents policy preferences
  - Economic gains matters, but seem dominated by other considerations that ultimately drive the vote
- Use HSR design to back out planner's preferences
  - Insight on how political considerations may shape transport infrastructure
- In progress! Thanks for the feedback

Consumption

- Indirect utility of resident ω from i commuting to j_C and traveling to j_L:

$$W(i,s) = \mathbb{E}\Big\{\max_{j_C, j_L} A_C(i,s) \frac{I(i, j_C, s) / \tau(i, j_C, s)^{\rho}}{r(i,s)^{\mu_{H_c}} \Bigg(\underbrace{p_L(j_L) \frac{\tau(i, j_L, s)^{\rho}}{q_L(i, j_L) A_C(j_L, s)}}_{\text{sub-utility of leisure trips}} \Bigg)^{\mu_L}} \varepsilon_{\omega}^{C}(j_C) \varepsilon_{\omega}^{L}(j_L) \Big\}$$

- Corresponding price index for leisure:

$$P^L(i,s) = \left(\sum_{j_L} \left(\frac{p_L(j_L) \tau(i, j_L, s)^{\rho}}{q_L(i, j_L) A_C(j_L, s)} \right)^{-\mu_L \theta^L} \right)^{-\frac{1}{\mu_L \theta^L}}$$

- Endogenous amenities

$$A_C(i,s) = Z_C(j) \left(\frac{N_Y(j,s)}{H(j)} + \sum_{k \neq j} e^{-\rho_C \tau(j,k,s)} \frac{N_Y(k,s)}{H(k)} \right)^{\gamma_C}$$

  - where $N_Y(j,s)$ is the number of in-commuters to j back back LD

Production

- Output Y combines land H_Y, workers E, and business trips R_B:

$$\max_{N_Y,H_Y} \mathbb{E}\left[\max_{R_B,E,j_B,m_B} A_Y(j,s) H_Y^{\mu_{H_y}} \left(\frac{q_B(j,j_B)\,A(j_B,s)}{\tau(j,j_B,s)^{\rho_B}} R_B\right)^{\mu_B} E^{\mu_L} \varepsilon_\omega^B(j_B) - p_R(j_B)\,R_B\right] - w(j,s)\,N_Y - r(j,s)\,H_Y$$

$$E^\chi R_B^{1-\chi} = N_Y; \chi = 1$$

  - Productivity spillovers:

$$A_Y(j,s) = Z_Y(j)\left(\frac{N_Y(j,s)}{H(j)} + \sum_{k\neq j} e^{-\rho_Y \tau(j,k,s)} \frac{N_Y(k,s)}{H(k)}\right)^{\gamma_Y}$$

- Land and labor markets
  - Inelastic supply of floor space: $H(i) = H_Y(j,s) + H_R(j,s)$
  - In-commuters equal labor demand $N_Y(j,s) = \sum_i \lambda^C(i,j,s)\,N_R(i)$

- Equilibrium: $\left\{w(i,s), r(i,s), \lambda^C(i,j,s), H_Y(j,s)\right\}$ such that labor and floor markets clear

back

Trip shares

- Commuting trip shares:

$$\lambda^C(i, j_C, s) = \frac{I(i, j_C, s)^{\theta^C} / \tau(i, j_C, s)^{\rho\theta^C}}{\sum_{j'_C} I(i, j'_C, s)^{\theta^C} / \tau(i, j'_C, s)^{\rho\theta^C}}$$

- Leisure trips:

$$R^L(i, j_L, s) = \mu_L \bar{I}(i, s) \frac{\left(\frac{p_L(j_L)\tau(i, j_L, s)^\rho}{q_L(i, j_L) A_C(j_L, s)}\right)^{-\mu_L \theta^L}}{\sum_{j'_L} \left(\frac{p_L(j'_L)\tau(i, j'_L, s)^\rho}{q_L(i, j'_L) A_C(j'_L, s)}\right)^{-\mu_L \theta^L}}$$

- Business trips:

$$R^B(j, j_B, s) = \psi^B(j, s) \frac{\left(\frac{p_B(j_B)\tau(j, j_B, s)^\rho}{q_B(j, j_B) A_B(j_B, s)}\right)^{-\mu_B \theta^B}}{\sum_{j'_B} \left(\frac{p_B(j'_B)\tau(j, j'_B, s)^\rho}{q_B(j, j'_B) A_B(j'_B, s)}\right)^{-\mu_B \theta^B}}$$

- where $\psi^L(i, s) = \mu_L N_R \sum_{j_C} I(i, j_C, s)$ and $\psi^B(j, s) = \frac{\mu_B}{1-\mu_B} \frac{Y(j, s)}{p_B(j, j_B, s)}$

back LD back gravity

Spillover changes

- Productivity / consumption spillovers for $a = C, Y$:

$$\hat{A}_a(j) = \left(\sum_k \frac{e^{-\rho_a \tau(j,k,B)} \frac{N_Y(k,NB)}{H(k)}}{\sum_{k'} e^{-\rho_a \tau(j,k',NB)} \frac{N_Y(k',NB)}{H(k')}} \hat{N}_Y(k) \right)^{\gamma_a},$$

where

$$\hat{N}_Y(j) = \sum_i \frac{\lambda(i,j,NB) N_R(i)}{N_Y(j,NB)} \hat{\lambda}^C(i,j)$$

and

$$\hat{\lambda}^C(i,j) = \frac{\hat{W}^C(i,j)^{\theta^C}}{\sum_{j'} \lambda^C(i,j',NB) \hat{W}^C(i,j')^{\theta^C}}$$

back

Leisure and Business Travelers

- Survey:
  - travel $>$ 50 miles over 8 weeks
  - 18,008 households, 68,193 trips.
- Leisure Travel:
  - entertainment, vacation, shopping, visit friends/family
  - 5,832 destination /4,818 origin tracts
- Business Travel:
  - meeting, convention, seminar
  - 1,821 destination/ 1,698 origin tracts

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	Time traveled (minutes)		
	25 ptile	50 ptile	75 ptile
Leisure	72 '	104 '	174 '
Business	65 '	92 '	145 '

	Top Destination Tracts
Leisure	Disneyland, Yosemite, Mission Beach (San Diego), Downtown SF, Downtown San Diego
Business	State Capitol (Downtown Sacramento), Downtown LA Downtown SF, Downtown San Diego

Measuring Travel Times

- Commuters: 89% via car, 5% via public transit, 4% via walking or biking (ACS, 2006-2010)

1. Road: Use google maps driving times to calibrate road travel along different road types road
2. Air: Integrate air travel using:
    - Data on air routes operating within California (Bureau of Transportation, 2008)
    - Flight times and airport locations (Google)
3. HSR travel times between stations according to 2008 plan

- Transfer costs between road and air (45 minutes) and road and HSR (8.5 min)
    - transfer time calibrated to match Google maps estimates of public transport times with transfers
- Travel time on route i is the quickest path between the centroid of route i's origin tract and route i's destination tract given:
    - Pre-HSR: road and air networks
    - Post-HSR: road and air networks plus HSR

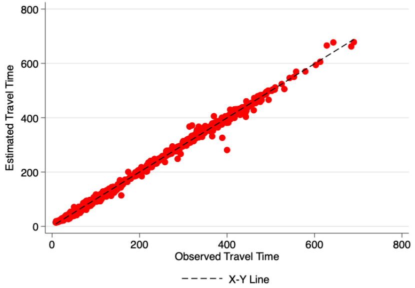
back

Road Travel Time Calibration

- Use California primary and secondary road network (U.S. Census, 2008)
- Calibrate average speeds α^* on four types of roads:
  - primary/secondary roads
  - roads in urban/not urban areas
- Match Google maps driving travel times along 1000 randomly selected routes:

$$\alpha^* = \arg\min_{\alpha} \sum_{i=1}^{1000} (ModelTime_i(\alpha) - GoogleTime_i)^2$$

Figure: Fit of Calibrated Road Travel Times



Correlation with (noisy) reported travel times in ACS: 0.49

back

Gravity for business trips

- Business trips

$$\ln R^{L}(i, j_{L}) = \mu^{B}\theta^{B} \ln\left(q_{B}(i, j_{B}) A_{B}(j_{B}, s)\right) - \underset{\substack{1.95 \\ (0.06)}}{\mu^{B}\theta^{B}\rho} \ln \tau(i, j_{B}) + \nu^{B}(i)$$

- share of leisure trips in expenditure: $\mu_B = 0.10$ (Sales Trip, 2022)
- back

Time Elasticity: Commuting (Full Table)

$$\ln \lambda^{C}(i,j) = \theta_A^C \ln w(j) - \left(\theta_A^C \rho_C\right) \ln \tau(i,j) + \psi^C(i)$$

	2008				2019			
	(1) PPML	(2) PPML	(3) FS	(4) IV	(5) PPML	(6) PPML	(7) FS	(8) IV
log(pre-HSR travel time)	-3.671***	-3.704***			-3.741***	-3.773***		
	(0.00452)	(0.00443)			(0.00454)	(0.00446)		
log(workplace earnings, LEHD, 2008)	2.634***			2.749***				
	(0.00884)			(0.118)				
log(earnings, ACS, 2006-2010)			0.347***					
			(0.00870)					
log(workplace earnings, LEHD, 2019)					3.091***			2.669***
					(0.00973)			(0.108)
log(earnings, ACS, 2012-2016)							0.317***	
							(0.00624)	
ρ_C	1.39			1.35	1.21			1.41
θ_A	2.63			2.75	3.09			2.67
N	61873956	61873956	7866	7866	61873956	61873956	7866	7865
R2			0.227	0.186			0.291	0.234
F-stat				1600				2600
Destination FE	No	Yes			No	Yes		

Source: LEHD, 2008 and 2019; ACS, 2006-2010; ACS, 2012-2016.

Implies: $\theta_A^C = 2.75^{***}$ $(.117)$ and $\rho_C = 1.34^{***}$ $(.058)$

- Similar estimates of value of time vs. literature:
  - Monte et al. 18: $\theta_A^C = 3.3, \rho_C = 1.34$ (counties)
  - 10% time save $\approx$ 10% real income gain back

Time Elasticity: Business and Leisure (Full Table)

	(1) Business	(2) Leisure
log(pre-HSR travel time)	-2.022***	-1.779***
	(0.0656)	(0.0276)
log(A tilde)	4.019***	
	(0.331)	
dest. management share	3.128***	
	(0.196)	
log(OD industry similarity)	0.0405*	
	(0.0175)	
log(B tilde)		-2.242***
		(0.0876)
dest. log(distance to beach)		-0.0705***
		(0.0109)
dest. has natl park		1.743***
		(0.123)
dest. hospitality share		6.819***
		(0.169)
dest. log(population)		-0.388***
		(0.0329)
N	9824665	29375132
$\theta_A^L \cdot \mu^L$	1.5	
$\theta_A^B \cdot \gamma$		1.3

- Estimating equation:

$$\ln R^L(i,j) = \left(\mu_L \theta_A^L\right) B(i,j) - \left(\mu_L \theta_A^L \rho_L\right) \ln \tau(i,j) + \psi^L(i)$$

where $B(i,j) \equiv \ln\left(q_L(i,j) B(j)\right)$

- Calibrate $\mu_L = 5\%$ (BLS) and $\mu_B = 10\%$ (Sales Trip)
- Fix $\rho_L = \rho_B = \rho_C$, recover θ_B and θ_L
- Use model-generated commuting flows

Time Saved and Economic Gains from HSR

- Time savings (raw data) $\{\hat{\tau}(i,j)\}$

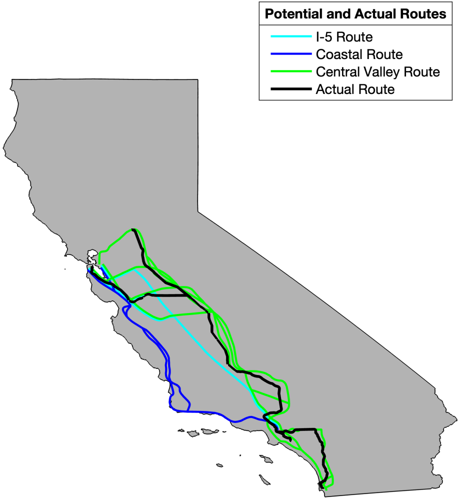
	% Travelers who save time	Time saved median	Time saved 75 ptile
Commute	.48%	11 ' (10%)	23 ' (16%)
Leisure	24%	19 ' (12%)	42 ' (21%)
Business	20%	19 ' (11%)	42 ' (22%)

- Time savings (model) $\{\hat{\tau}(i,j)\}$

	% Travelers who save time	Time saved median	Time saved 75 ptile
Commute	.94%	12 ' (10%)	25 ' (18%)
Leisure	12.27%	20 ' (12%)	48 ' (23%)
Business	9.85%	19 ' (12%)	48 ' (23%)

back

Alternative HSR Routes



Source: 2005 HSR Environmental Impact Report reprint of 1996 map.

Potential Sources of Misspecification

- Additional forces for tracts on the HSR tracks $\Rightarrow$ drop closest tracts
  - eminent domain
  - e.g., noise of trains
- HSR costs: Republicans vs Democrats have different perception of cost (vs tax t uniform in model)?
  - $t(i)$ enters $\varepsilon(i)$
  - $\varepsilon(i)$ correlated with $\hat{a}(i)$, not $\hat{W}(i)$
  - $\hat{\theta}_V$ unbiased and variance decomposition gives a lower bound for importance of $\hat{W}$
- HSR benefits: Low-skill/rural areas have systematically less leisure/business trips, $\hat{W}$ overestimated in these areas?
  - [in progress] compare data and model on trip intensity. If anything, trip intensity under-erestimated in low-wage areas
  - [in progress] if necessary, incorporate additional heterogenity in trip intensity

back

Voting Equation, GE

Table: Estimates of θ_v with spillovers

	OLS		IV		
	(1)	(2)	(3) 2008 IV	(4) Random Stations IV	(5) Random Stations+Route IV
$\log(\hat{W})$, 2019	-3.019	3.265*	3.429**	3.230**	4.009**
	(2.814)	(1.268)	(1.299)	(1.176)	(1.281)
log-odds Reg Dems Share		0.413***	0.413***	0.413***	0.413***
		(0.0814)	(0.0815)	(0.0814)	(0.0817)
Environment: log odds Yes on Prop. 10		0.359***	0.358***	0.359***	0.358***
		(0.0522)	(0.0520)	(0.0521)	(0.0512)
Transportation: log odds Yes on Prop. 1b		-0.00168	-0.00191	-0.00164	-0.00270
		(0.139)	(0.139)	(0.139)	(0.138)
pop. density		0.0471***	0.0471***	0.0471***	0.0470***
		(0.0103)	(0.0103)	(0.0103)	(0.0102)
Avg. MA Pop. Dens.		0.0437	0.0469	0.0430	0.0581
		(0.126)	(0.126)	(0.124)	(0.119)
Constant	0.193*	-0.168	-0.176	-0.166	-0.204
	(0.0868)	(0.288)	(0.289)	(0.281)	(0.271)
First stage F-stat			17675.7	79.30	31.10
R2	0.00771	0.713	0.713	0.713	0.712
N	7866	7866	7866	7866	7866

Note: Prop 10, which measures environmental values, would have allowed California to sell 5 billion in bonds for a variety of renewable energy projects and was on the general election ballot in 2008 (Ballotpedia). Prob 1B, which measures attitudes towards infrastructure spending, would have allowed the sale of 19.9 billion in general obligation bonds designated for highway and street repair and reconstruction and other related transportation projects and was on the general election ballot in 2006 (Ballotpedia).

back

Voting Equation, Larger Bandwidth

Table: Estimates of θ_v with Conley (1999) 50km Bandwidth

	OLS		IV		
	(1)	(2)	(3) 2008 IV	(4) Random Stations IV	(5) Random Stations+Route IV
$\log(\hat{W})$, 2019	-2.386	2.522*	2.675**	2.495**	2.914*
	(2.087)	(0.995)	(1.015)	(0.939)	(1.219)
log-odds Reg Dems Share		0.413***	0.413***	0.413***	0.413***
		(0.0855)	(0.0856)	(0.0855)	(0.0859)
Environment: log odds Yes on Prop. 10		0.360***	0.360***	0.360***	0.360***
		(0.0548)	(0.0545)	(0.0548)	(0.0539)
Transportation: log odds Yes on Prop. 1b		-0.00267	-0.00299	-0.00261	-0.00351
		(0.156)	(0.156)	(0.156)	(0.155)
pop. density		0.0469***	0.0469***	0.0469***	0.0469***
		(0.00787)	(0.00782)	(0.00789)	(0.00781)
Avg. MA Pop. Dens.		0.0404	0.0440	0.0397	0.0497
		(0.136)	(0.136)	(0.132)	(0.130)
Constant	0.193*	-0.161	-0.170	-0.159	-0.184
	(0.0872)	(0.302)	(0.302)	(0.293)	(0.287)
First stage F-stat			6929.8	48.50	13.50
R2	0.00736	0.712	0.712	0.712	0.712
N	7866	7866	7866	7866	7866

Note: Prop 10, which measures environmental values, would have allowed California to sell 5 billion in bonds for a variety of renewable energy projects and was on the general election ballot in 2008 (Ballotpedia). Prob 1B, which measures attitudes towards infrastructure spending, would have allowed the sale of 19.9 billion in general obligation bonds designated for highway and street repair and reconstruction and other related transportation projects and was on the general election ballot in 2006 (Ballotpedia).

back

Voting Equation, No GE + exponential function

Table: Estimates of θ_v with exponential function and without spillovers

	OLS		IV		
	(1)	(2)	(3) 2008 IV	(4) Random Stations IV	(5) Random Stations+Route IV
$\log(\hat{W})$, 2019	-0.0594	1.905***	1.942***	1.671***	2.342***
	(0.998)	(0.472)	(0.475)	(0.450)	(0.526)
log-odds Reg Dems Share		0.407***	0.407***	0.408***	0.405***
		(0.0809)	(0.0809)	(0.0809)	(0.0816)
Environment: log odds Yes on Prop. 10		0.349***	0.348***	0.351***	0.345***
		(0.0514)	(0.0513)	(0.0516)	(0.0502)
Transportation: log odds Yes on Prop. 1b		0.00000147	-0.0000525	0.000342	-0.000636
		(0.137)	(0.136)	(0.137)	(0.135)
pop. density		0.0454***	0.0454***	0.0457***	0.0450***
		(0.00983)	(0.00981)	(0.00997)	(0.00973)
Avg. MA Pop. Dens.		0.0916	0.0938	0.0779	0.117
		(0.128)	(0.128)	(0.127)	(0.122)
Constant	0.185	-0.297	-0.302	-0.262	-0.363
	(0.0962)	(0.297)	(0.297)	(0.291)	(0.281)
First stage F-stat			65717.1	244	21
R2	0.0000193	0.721	0.721	0.721	0.720
N	7866	7866	7866	7866	7866

Note: Prop 10, which measures environmental values, would have allowed California to sell 5 billion in bonds for a variety of renewable energy projects and was on the general election ballot in 2008 (Ballotpedia). Prob 1B, which measures attitudes towards infrastructure spending, would have allowed the sale of 19.9 billion in general obligation bonds designated for highway and street repair and reconstruction and other related transportation projects and was on the general election ballot in 2006 (Ballotpedia).

back

Voting Equation, Varying ρ

Table: Estimates of θ_v varying ρ

	OLS		IV		
	(1)	(2)	(3) 2008 IV	(4) Random Stations IV	(5) Random Stations+Route IV
log($\hat{W}$), 2019	-0.314	0.702**	0.712***	0.633**	0.816***
	(0.484)	(0.215)	(0.216)	(0.207)	(0.219)
log-odds Reg Dems Share		0.410***	0.410***	0.410***	0.409***
		(0.0810)	(0.0810)	(0.0810)	(0.0814)
Environment: log odds Yes on Prop. 10		0.355***	0.355***	0.356***	0.354***
		(0.0510)	(0.0509)	(0.0512)	(0.0501)
Transportation: log odds Yes on Prop. 1b		-0.00376	-0.00385	-0.00312	-0.00482
		(0.138)	(0.138)	(0.138)	(0.137)
pop. density		0.0461***	0.0461***	0.0462***	0.0460***
		(0.00998)	(0.00997)	(0.0101)	(0.00994)
Avg. MA Pop. Dens.		0.0820	0.0834	0.0720	0.0985
		(0.130)	(0.130)	(0.128)	(0.123)
Constant	0.197*	-0.276	-0.280	-0.250	-0.320
	(0.0972)	(0.303)	(0.303)	(0.296)	(0.285)
First stage F-stat			94268.5	168.5	26
R2	0.00320	0.718	0.718	0.718	0.717
N	7866	7866	7866	7866	7866

Note: Prop 10, which measures environmental values, would have allowed California to sell 5 billion in bonds for a variety of renewable energy projects and was on the general election ballot in 2008 (Ballotpedia). Prob 1B, which measures attitudes towards infrastructure spending, would have allowed the sale of 19.9 billion in general obligation bonds designated for highway and street repair and reconstruction and other related transportation projects and was on the general election ballot in 2006 (Ballotpedia).

back

Voting Equation, no GE+excluding tracts near tracks

Table: Estimates of θ_v , excluding tracts within 5km from HSR tracks

	OLS		IV		
	(1)	(2)	(3) 2008 IV	(4) Random Stations IV	(5) Random Stations+Route IV
log($\hat{W}$), 2019	-2.450	2.118*	2.229*	2.032*	2.752**
	(1.987)	(0.891)	(0.932)	(0.850)	(1.035)
log-odds Reg Dems Share		0.404***	0.403***	0.404***	0.403***
		(0.0715)	(0.0716)	(0.0716)	(0.0720)
Environment: log odds Yes on Prop. 10		0.416***	0.416***	0.416***	0.415***
		(0.0647)	(0.0647)	(0.0648)	(0.0643)
Transportation: log odds Yes on Prop. 1b		0.0690	0.0688	0.0691	0.0679
		(0.135)	(0.135)	(0.135)	(0.134)
pop. density		0.0358*	0.0358*	0.0358*	0.0359*
		(0.0149)	(0.0149)	(0.0149)	(0.0148)
Avg. MA Pop. Dens.		0.0725	0.0748	0.0708	0.0855
		(0.115)	(0.115)	(0.113)	(0.111)
Constant	0.114	-0.229	-0.235	-0.225	-0.262
	(0.0846)	(0.254)	(0.255)	(0.250)	(0.245)
First stage F-stat			11018.1	156.1	24.20
R2	0.00678	0.751	0.751	0.751	0.750
N	5014	5014	5014	5014	5014

Note: Prop 10, which measures environmental values, would have allowed California to sell 5 billion in bonds for a variety of renewable energy projects and was on the general election ballot in 2008 (Ballotpedia). Prob 1B, which measures attitudes towards infrastructure spending, would have allowed the sale of 19.9 billion in general obligation bonds designated for highway and street repair and reconstruction and other related transportation projects and was on the general election ballot in 2006 (Ballotpedia).

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Voting Equation, GE+excluding tracts near tracks

Table: Estimates of θ_v , excluding tracts within 5km from HSR tracks

	OLS		IV		
	(1)	(2)	(3) 2008 IV	(4) Random Stations IV	(5) Random Stations+Route IV
$\log(\hat{W})$, 2019	-2.883	2.697*	2.854*	2.551*	3.664**
	(2.542)	(1.095)	(1.136)	(1.060)	(1.316)
log-odds Reg Dems Share		0.403***	0.403***	0.403***	0.402***
		(0.0715)	(0.0715)	(0.0715)	(0.0721)
Environment: log odds Yes on Prop. 10		0.415***	0.415***	0.415***	0.414***
		(0.0646)	(0.0645)	(0.0647)	(0.0640)
Transportation: log odds Yes on Prop. 1b		0.0699	0.0698	0.0700	0.0690
		(0.135)	(0.135)	(0.135)	(0.134)
pop. density		0.0360*	0.0360*	0.0360*	0.0362*
		(0.0149)	(0.0149)	(0.0149)	(0.0148)
Avg. MA Pop. Dens.		0.0733	0.0758	0.0709	0.0891
		(0.114)	(0.114)	(0.113)	(0.110)
Constant	0.112	-0.230	-0.236	-0.224	-0.269
	(0.0839)	(0.252)	(0.253)	(0.248)	(0.243)
First stage F-stat			17075.8	133.3	25.60
R2	0.00604	0.751	0.751	0.751	0.750
N	5014	5014	5014	5014	5014

Note: Prop 10, which measures environmental values, would have allowed California to sell 5 billion in bonds for a variety of renewable energy projects and was on the general election ballot in 2008 (Ballotpedia). Prob 1B, which measures attitudes towards infrastructure spending, would have allowed the sale of 19.9 billion in general obligation bonds designated for highway and street repair and reconstruction and other related transportation projects and was on the general election ballot in 2006 (Ballotpedia).

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Aggregate Impact of Individual Stations

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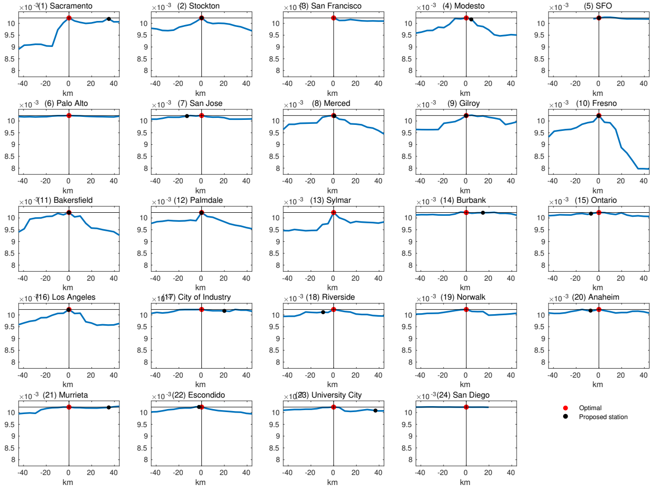
Figure: Welfare Effect of Moving Stations (utilitarian)



Note: Left is towards San Francisco, Right is towards San Diego

Distributional Considerations: ln $\hat{a}$ vs ln $\hat{W}$ back

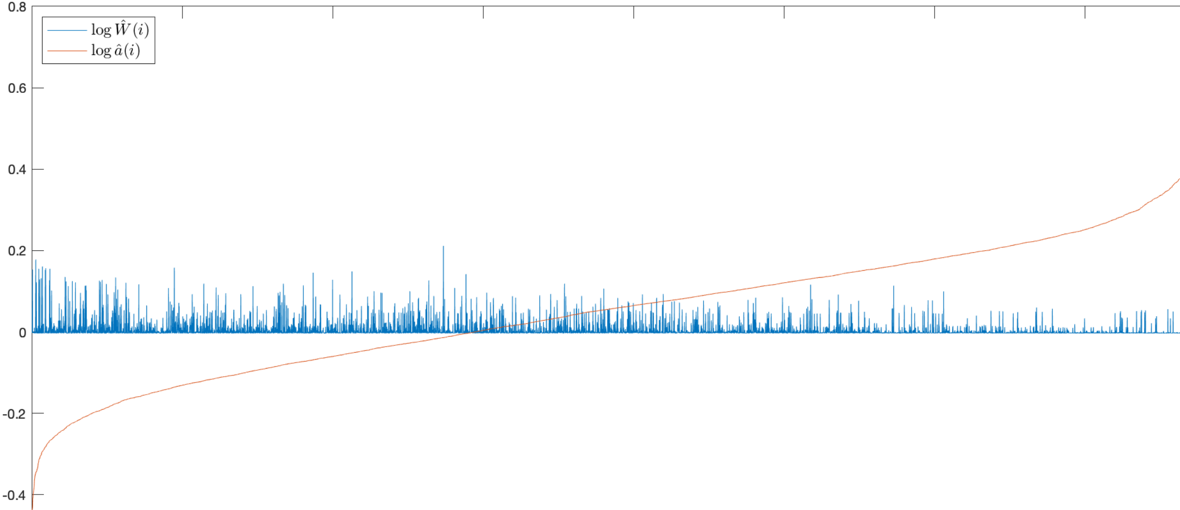


Figure: ln $\hat{a}$ vs ln $\hat{W}$ across tracts