Estimating the Economic Impacts of Highway Infrastructure

Daniel Wilson
(Federal Reserve Bank of San Francisco)

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*The views expressed in this paper are those of the authors should not be attributed to the Federal Reserve Bank of San Francisco or the Federal Reserve System.

Introduction

- Infrastructure investment is a major share of government spending
- Often used as countercyclical fiscal policy (WPA, TVA, ARRA)
- Yet there is little consensus on its economic impact

E.g., consider grandiose expectations of Interstate Highway System

"[T]he greatest public-works program in the history of the world..."

Sinclair Weeks, Secretary of Commerce, June 1956

"[T]he highway program will constitute a growing and ever more important share of the gross national product. It will affect all types of transportation, the construction industry and scores of others, employment, taxes, commodity prices, marketing, plant location -- in fact, every phase of economic life in this country."

New York Times, January 13, 1957

Previous Research on Public Investment

- Perotti (2004)
  - Quarterly data from 1960– 2001
  - Finds short-run multiplier of 1.7, long-run multiplier (after 5 years) of just 0.4
  - Low long-run multiplier stems from crowd-out of private investment
- Kamps (2005) and Afonso & Aubyn (2009) follow similar approach but with annual data and find statistically insignificant multipliers at all horizons.

- **Concern:** These papers assume fiscal policy does not respond contemporaneously to GDP is problematic, esp. at annual frequency

Previous Research on Transportation Spending

- **Chandra & Thompson (2000)**
  - Analyze short- and longer-run effects of interstate highways on local earnings
  - Argue that for rural counties having vs. not having a highway is due to whether counties lie between two economically important cities and is unrelated (exogenous) to county's economic conditions.
  - So can compare outcomes in rural counties that received a highway versus ones that did not.
  - Earnings in rural highway counties rise 2-6 years before highway completion (construction period) and again 2-5 years after completion

Evidence from Other Countries

- Kuttner & Posen (2002) look at Japan's lost decade (1990–2000)
  - Finds cumulative 4-year GDP multiplier on total government spending of 2
- Brückner & Tuladhar (2011) look at government investment across Japan's prefectures during lost decade
  - Finds very small short-run multipliers (0.3 on impact, 0.7 after one year)
- Acconcia, Corsetti, & Simonelli (2012) estimate effects of federal infrastructure spending in Italy
  - Find short-run multiplier on GDP of 2

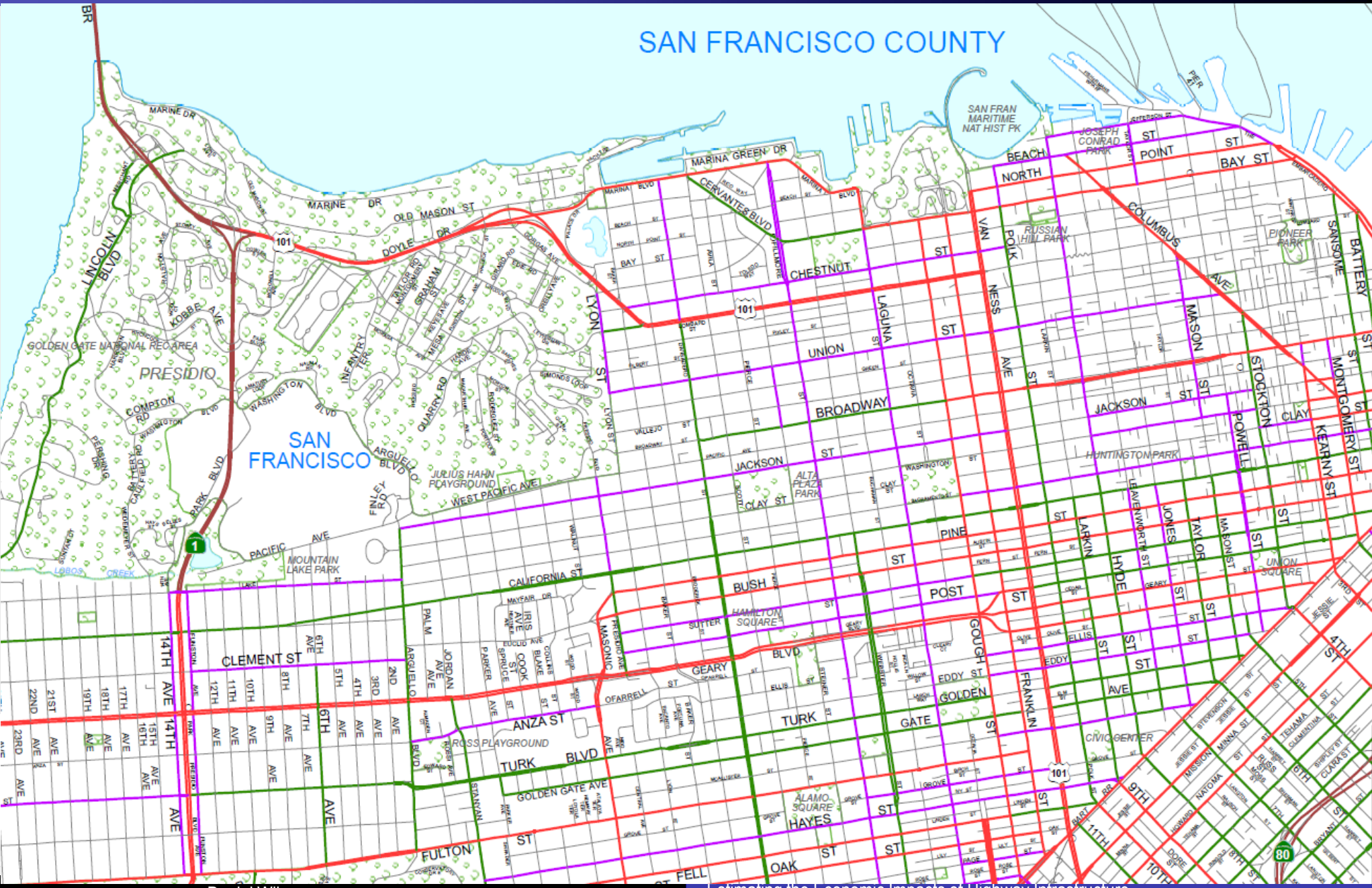
Leduc & Wilson (2013)

- Construct new measure of shocks to public infrastructure spending, using federal highway grants
  - uses institutional details of how federal grants are distributed to states
  - captures revisions in expectations of future highway spending
- Estimate dynamic effects of shocks on local GDP and other variables
- Compare empirical results to results from simulated open-economy model of regions within fiscal and monetary union

Some Background

- Federal government in U.S. finances bulk of spending on major roads via Federal-Aid Highway Program

Most major roads are federal-aid highways



Some Background

- Federal government in U.S. finances bulk of spending on major roads via Federal-Aid Highway Program

- Spending adminstered by state governments
  - Feds reimburse 80% of state's spending up to limit set by federal highway grants

- Congressional authorization bills cover 5-6 year periods, setting

  (1) national annual grant totals (by program – e.g., interstates, bridges, etc.)
  (2) formulas for apportioning totals to states

Identification (1 of 3)

Institutional mechanism of grant apportionment allow us to address 3 key issues:

1. **Endogeneity**

(fed govt giving more $ to states with better/worse economic prospects)

- **Grants distributed to states via legislated formulas**
  - road-related formula factors
  - data on factors lagged 3 years

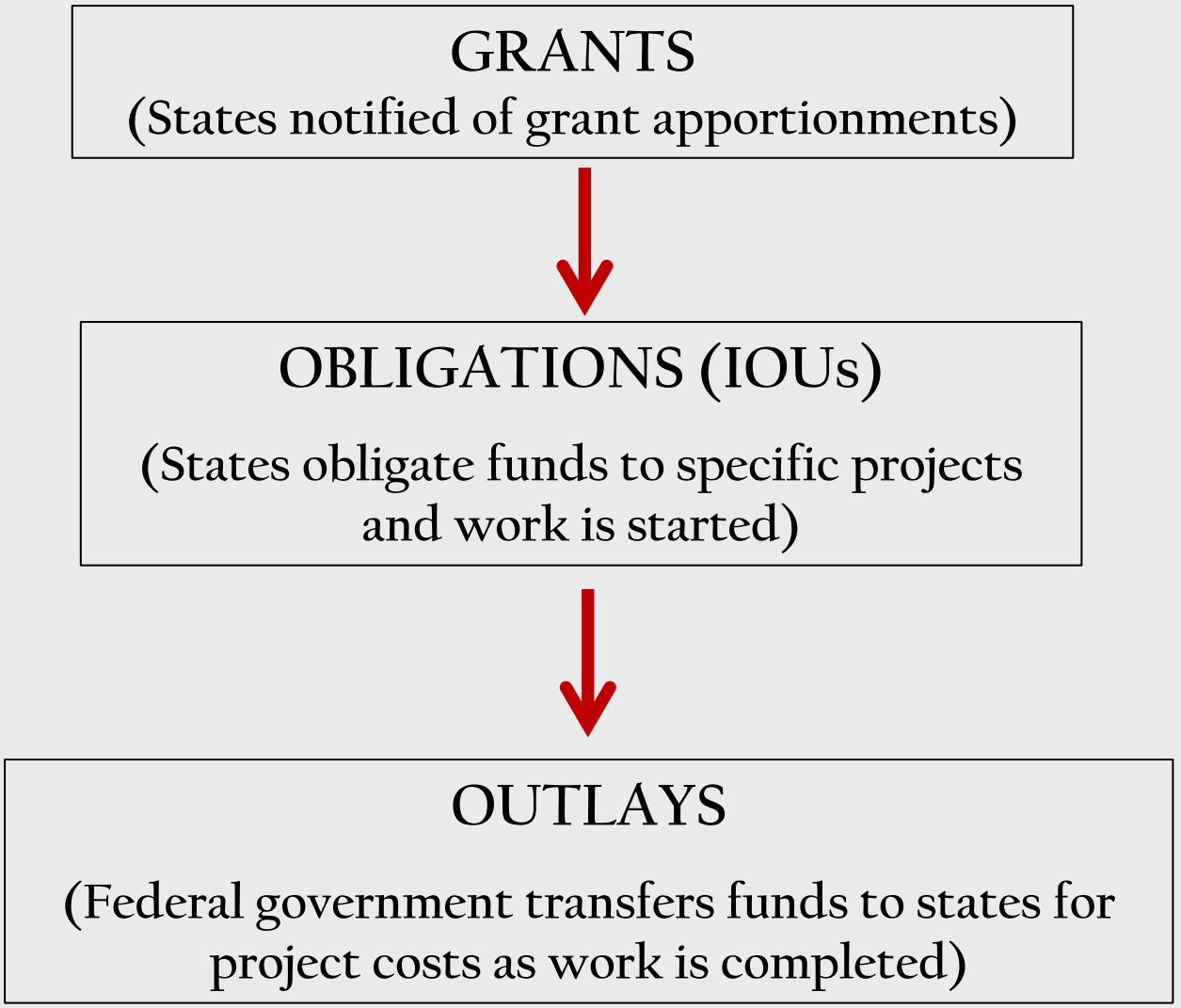
Identification (2 of 3)

Institutional mechanism of grant apportionment allow us to address 3 key issues:

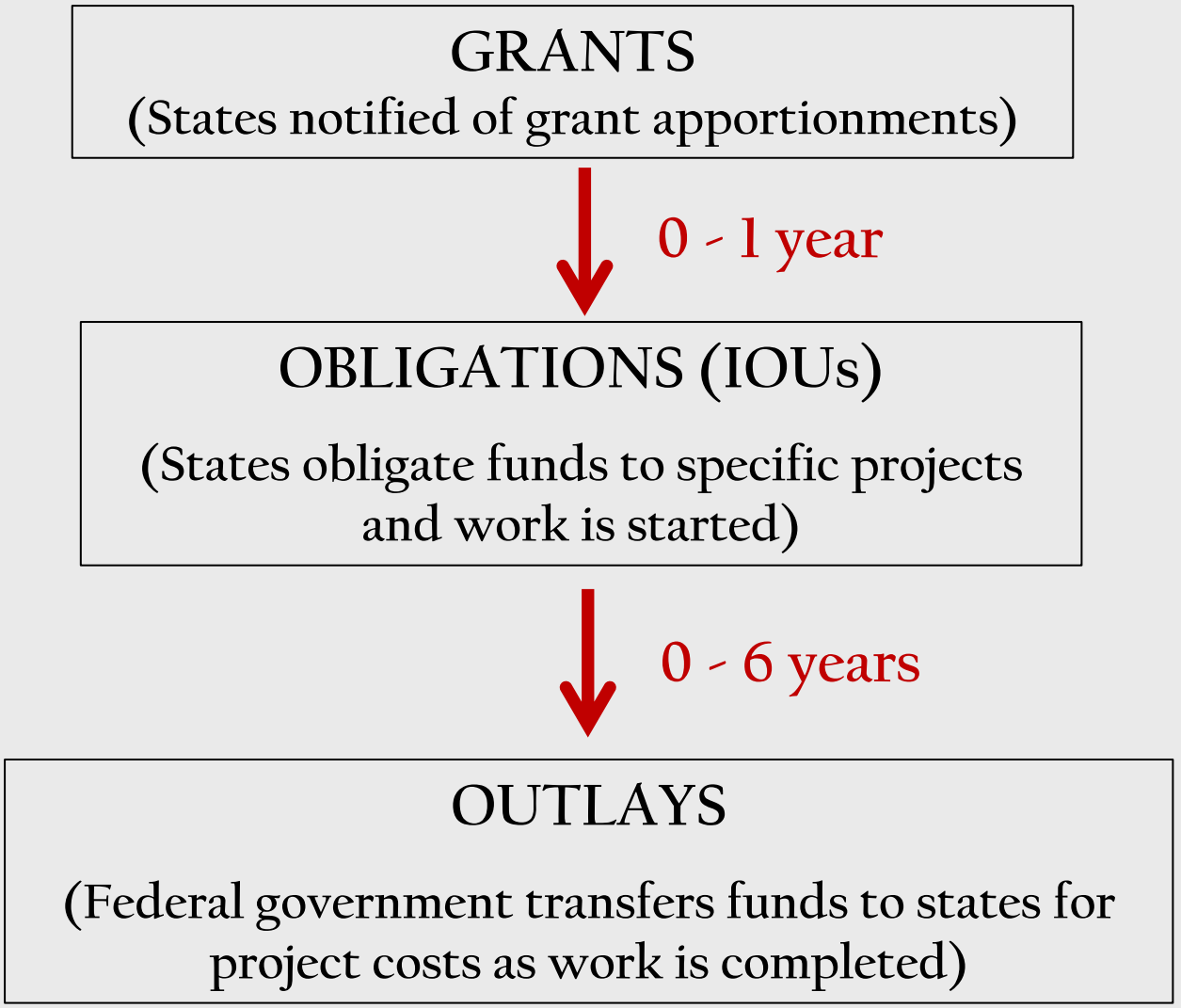
2. **Implementation Lags**

(state receives spending authorization from FHWA this year, but outlays & reimbursements occur several years later)

Implementation Lags



Implementation Lags



Identification (3 of 3)

Institutional mechanism of grant apportionment allow us to address 3 key issues:

3. **Anticipation Effects**

(some portion of future spending authorizations/grants can be anticipated years in advance…could effect economy in advance…screws up estimation of economic effects)

- we look at grant surprises relative to forecasts

Measuring Highway Spending Shocks

- We construct forecasts of current and future highway grants by state and year (A_{it})

$$E_t\left[A_{i,t+s}\right]$$

- Use same methodology as FHWA used for most recent bill
  - Forecasts assume current formula mechanisms
  - assume constant factor shares

Measuring Highway Spending Shocks

- Define expected present value of future apportionments

$$\mathrm{E}_t\left[PV_{i,t}\right]=\sum_{s=0}^{\infty}\frac{E_t\left[A_{i,t+s}\right]}{(1+R_t)^s}$$

- *Shock* is percentage change between *t-1* and *t*

- *Shock* composed of error in forecast of current spending and revisions to forecasts of future spending:

$$E_t\left[PV_{i,t}\right]-E_{t-1}\left[PV_{i,t}\right]=$$

$$\underbrace{\left(A_{i,t}-E_{t-1}\left[A_{i,t}\right]\right)}_{\text{Error in forecast of current spending}}+\underbrace{\left(\sum_{s=1}^{\infty}\frac{E_t\left[A_{i,t+s}\right]}{(1+R_t)^s}-\sum_{s=1}^{\infty}\frac{E_{t-1}\left[A_{i,t+s}\right]}{(1+R_{t-1})^s}\right)}_{\text{Revisions in forecasts of Future Spending}}$$

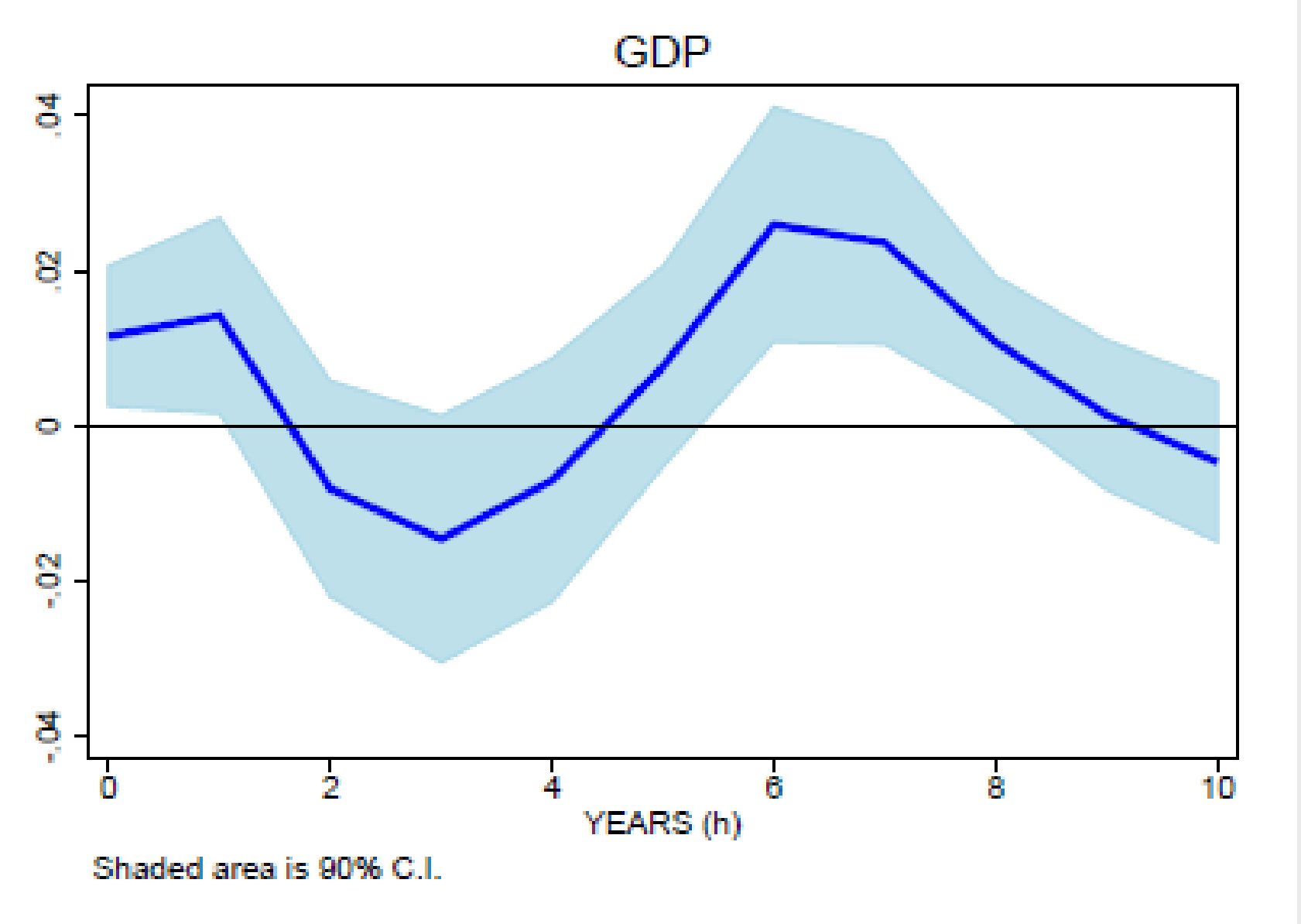
Estimating Dynamic Effects of Highway Grant Shock

"Direct Projection" Method

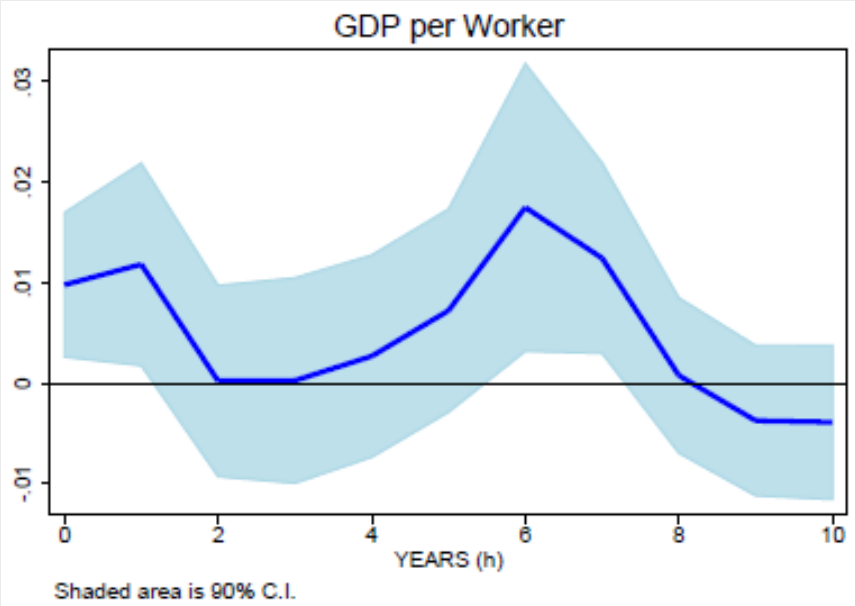
$$y_{i,t+h} = \alpha_i^h + \alpha_t^h + \sum_{s=1}^{3} \beta_s^h y_{i,t-s} + \sum_{s=1}^{3} \gamma_s^h g_{i,t-s} + \delta^h \cdot shock_{it} + \epsilon_{i,t+h},$$

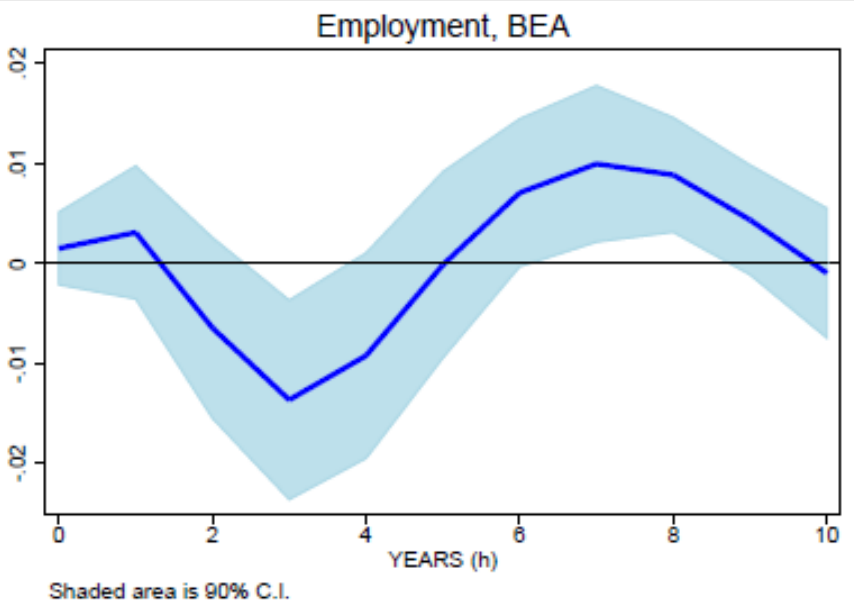
- Estimates *Impulse Response* (δ^h) for each horizon (h) separately
- Control for state and time fixed effects
  - national effects "swept out"
- Sample: 49 states (drop AK), 1990 – 2010

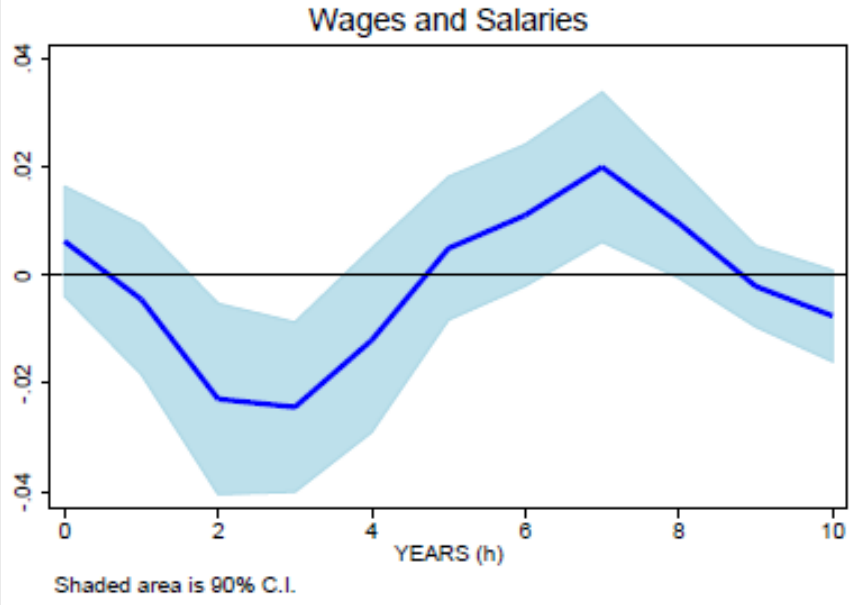
Results → Effect on GDP

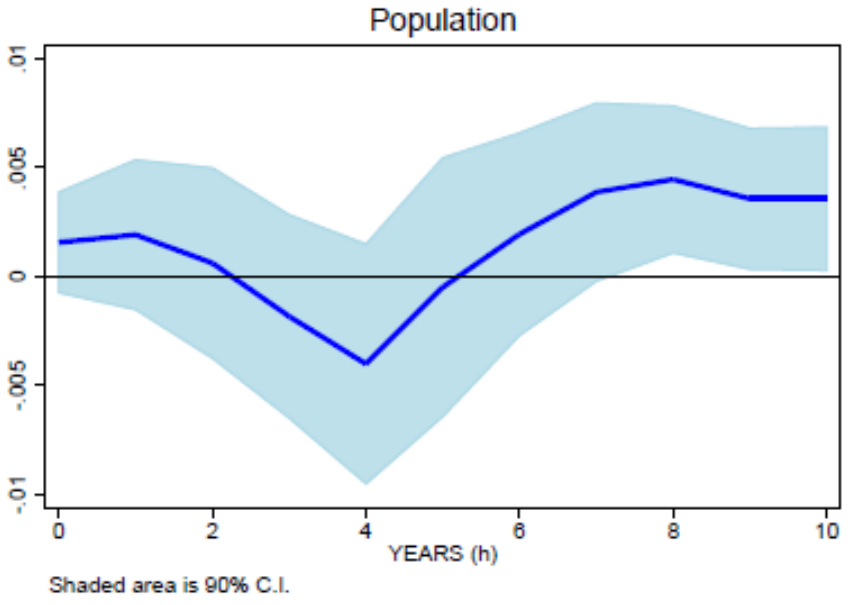


Results → Effects on Other Macro Variables

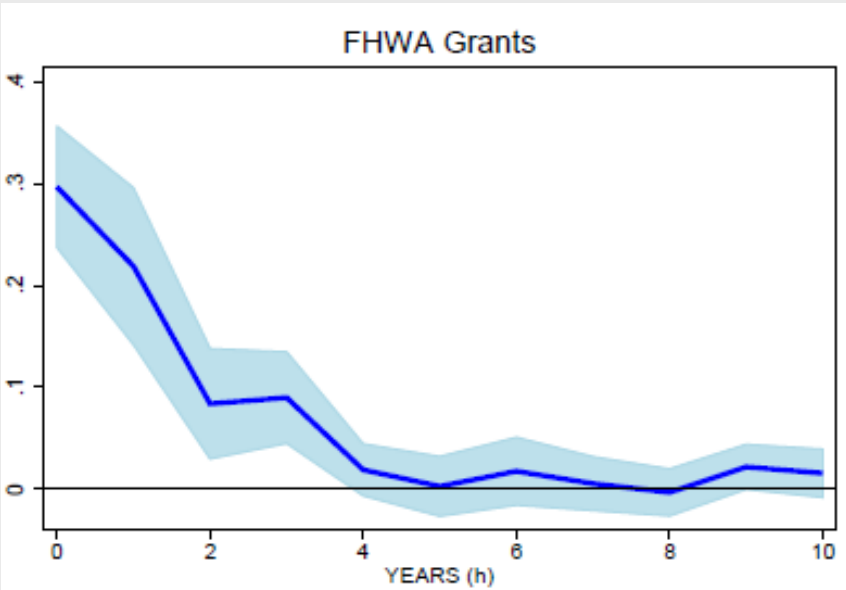


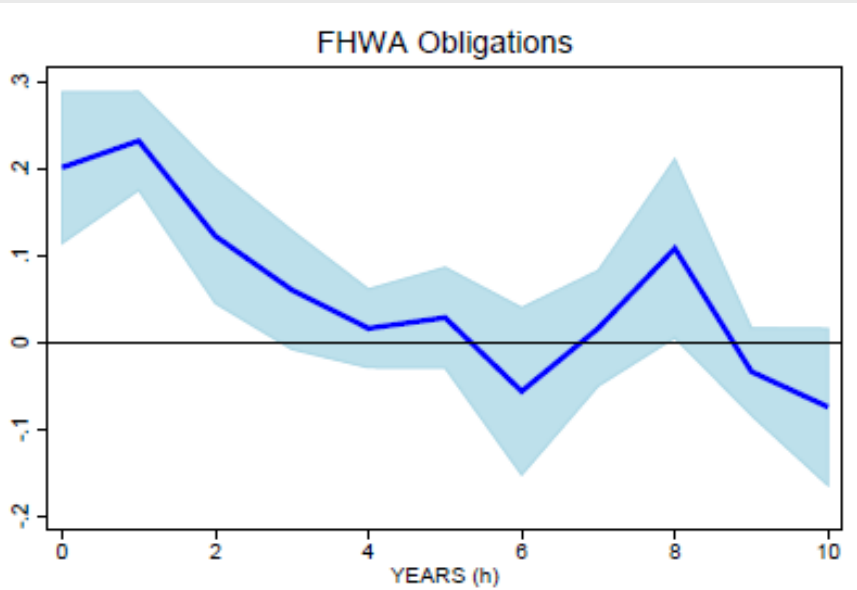


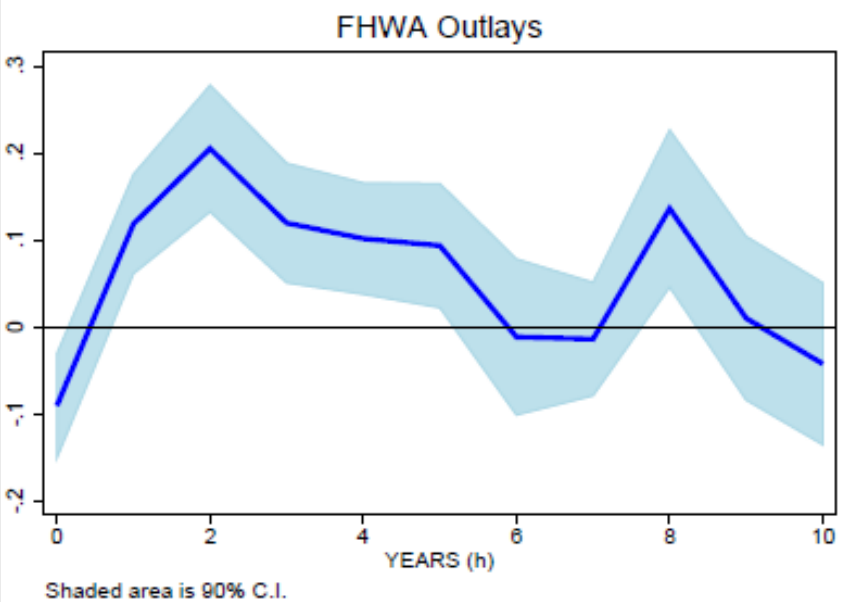


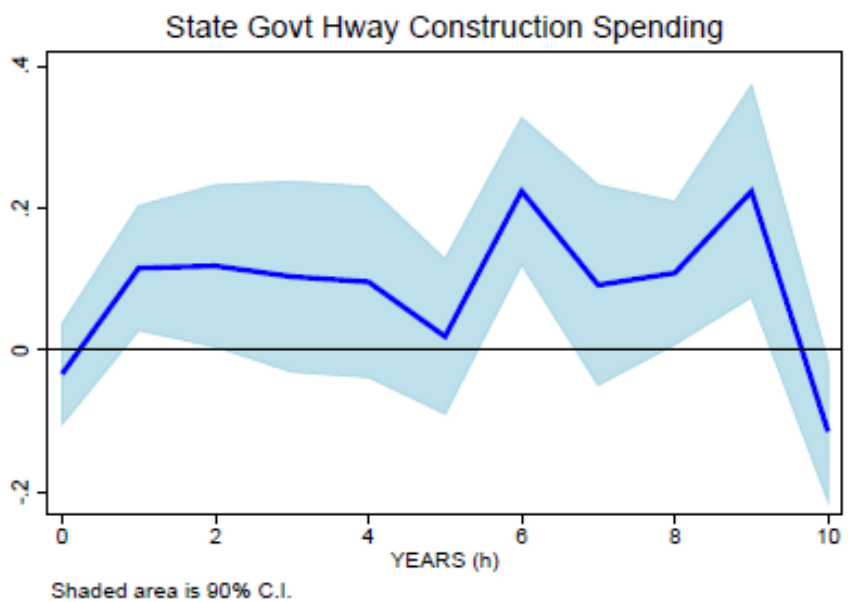


Results → Transmission Channel (financing)









Translating results to multipliers

- Multiply point estimates (elasticities) by ratio of GDP to spending
- Implied multiplier on state road spending is

  1.4 on impact, 3.0 at peak

Model

- Open-economy, New Keynesian model of regions within monetary and fiscal union
- Households consume composite of home- and foreign-produced goods, supply labor to home producers
- Producers in home region use labor, private and public capital

$$Y_t = L_t^{\phi} K_t^{1-\phi} G_t^{\phi_g}$$

- Public investment turns into capital with time-to-build lag

$$G_{t+1} = (1-\delta)G_t + A_{t-J}$$

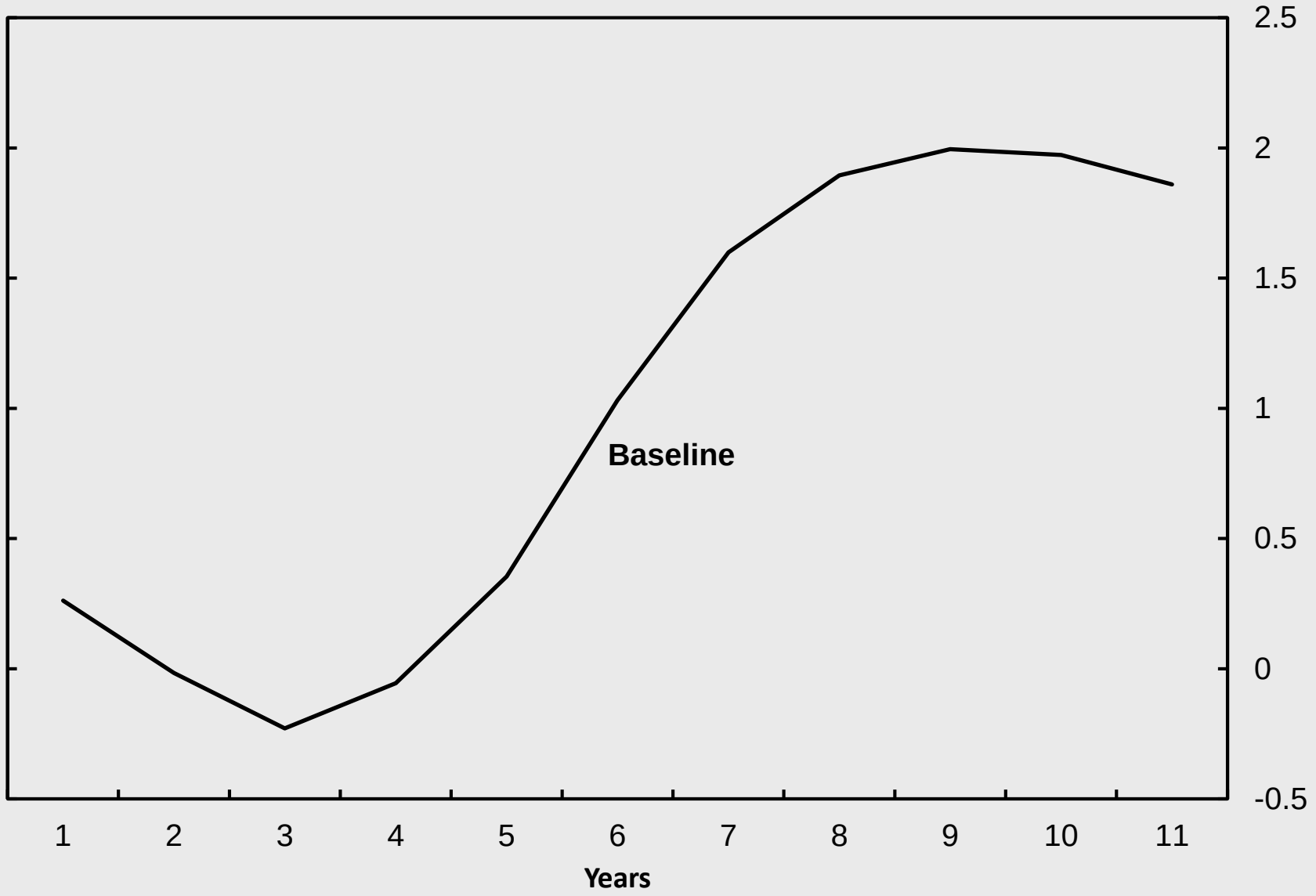
- Public investment chosen by federal govt and financed by distortionary consumption tax (on both regions)
- National interest rate determined by Taylor rule

Model

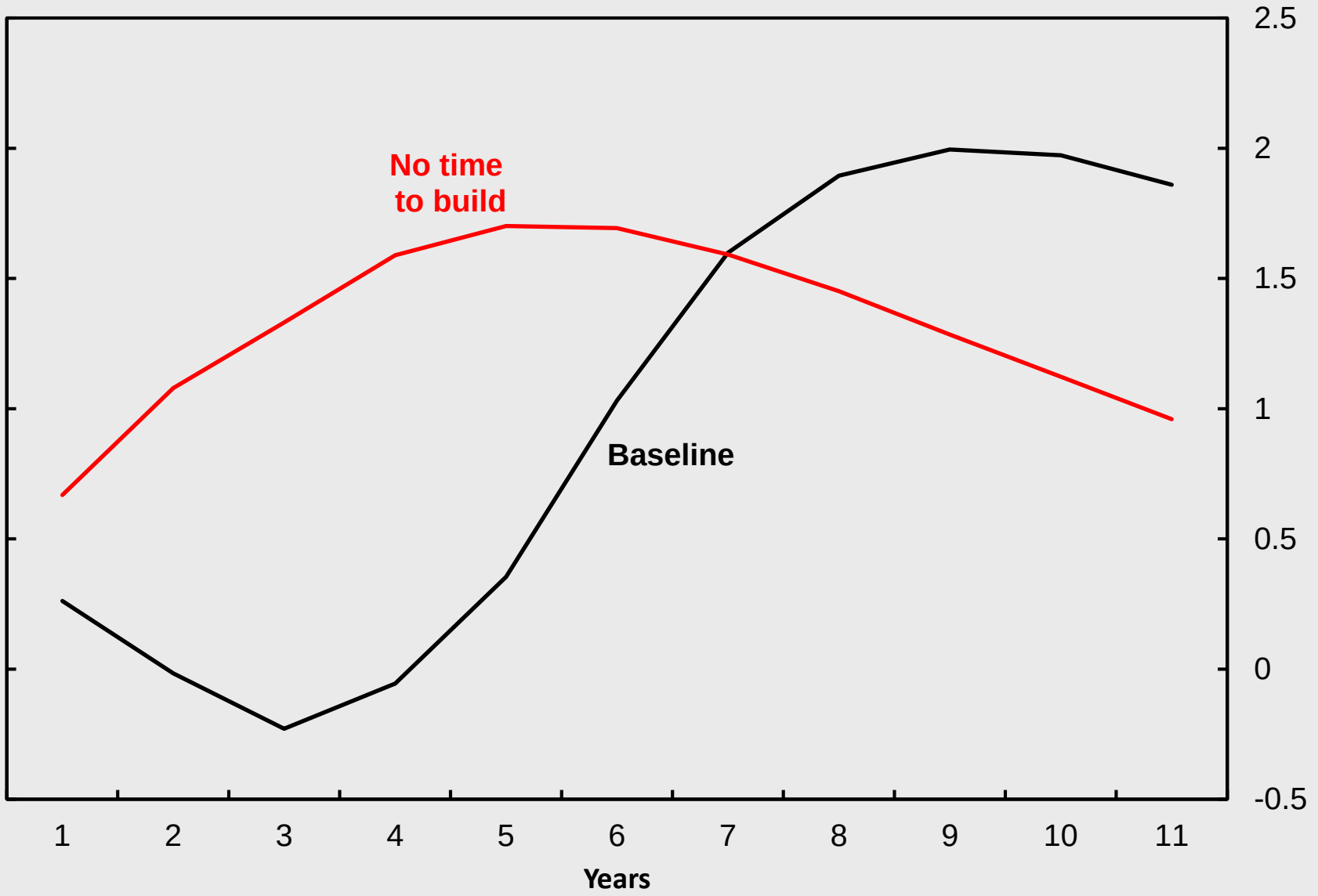
- Calibrate model and simulate data given shocks to grants

- Estimate Impulse Responses using simulated data and using same methodology as in empirical analysis

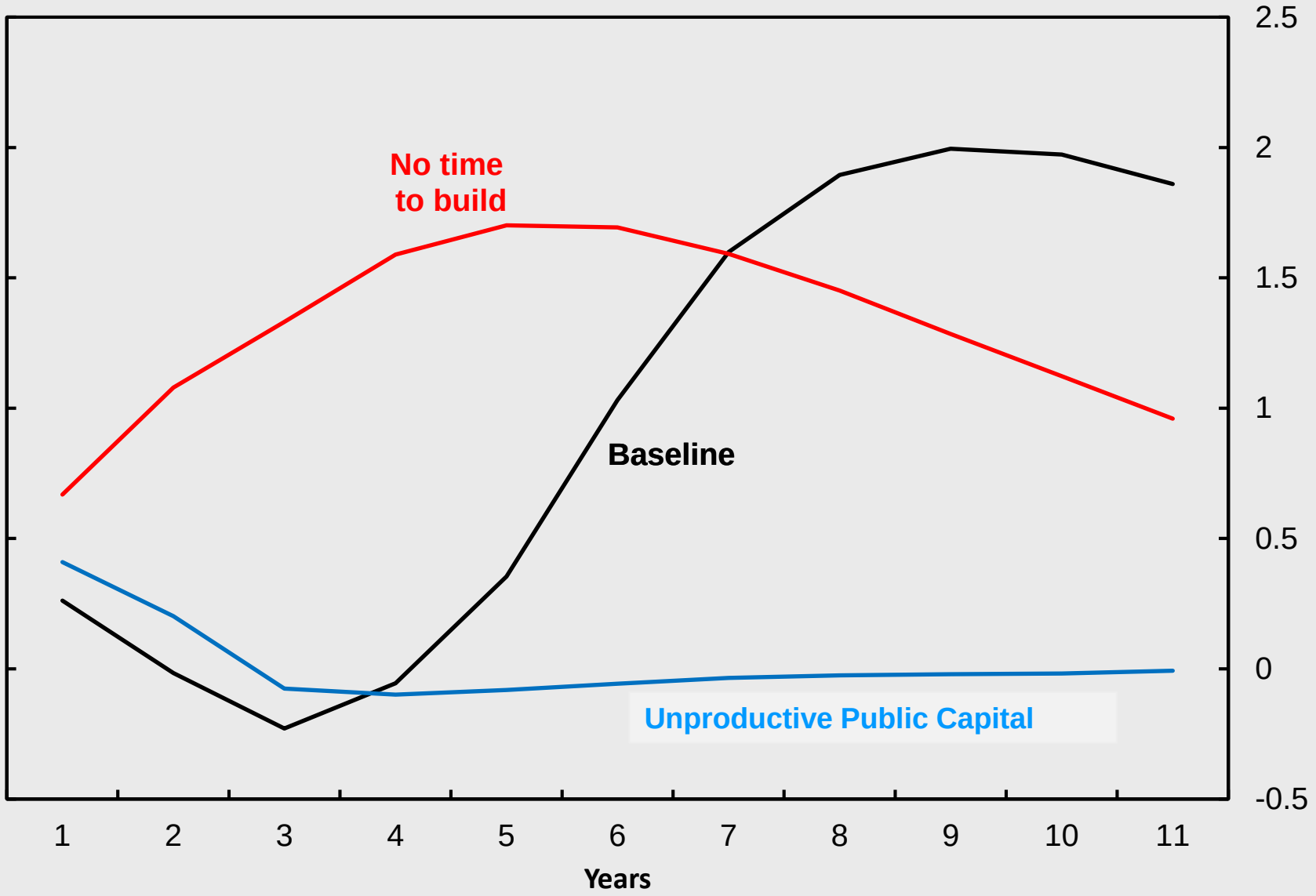
GDP Local Multiplier



GDP Local Multiplier



GDP Local Multiplier



Summary of Findings

- Infrastructure spending has large near-term and medium-term effects on local economic activity
- Theoretical explanation:

Shock to grants

→ more highway spending by state govt ("flypaper effect")

→ more roadwork

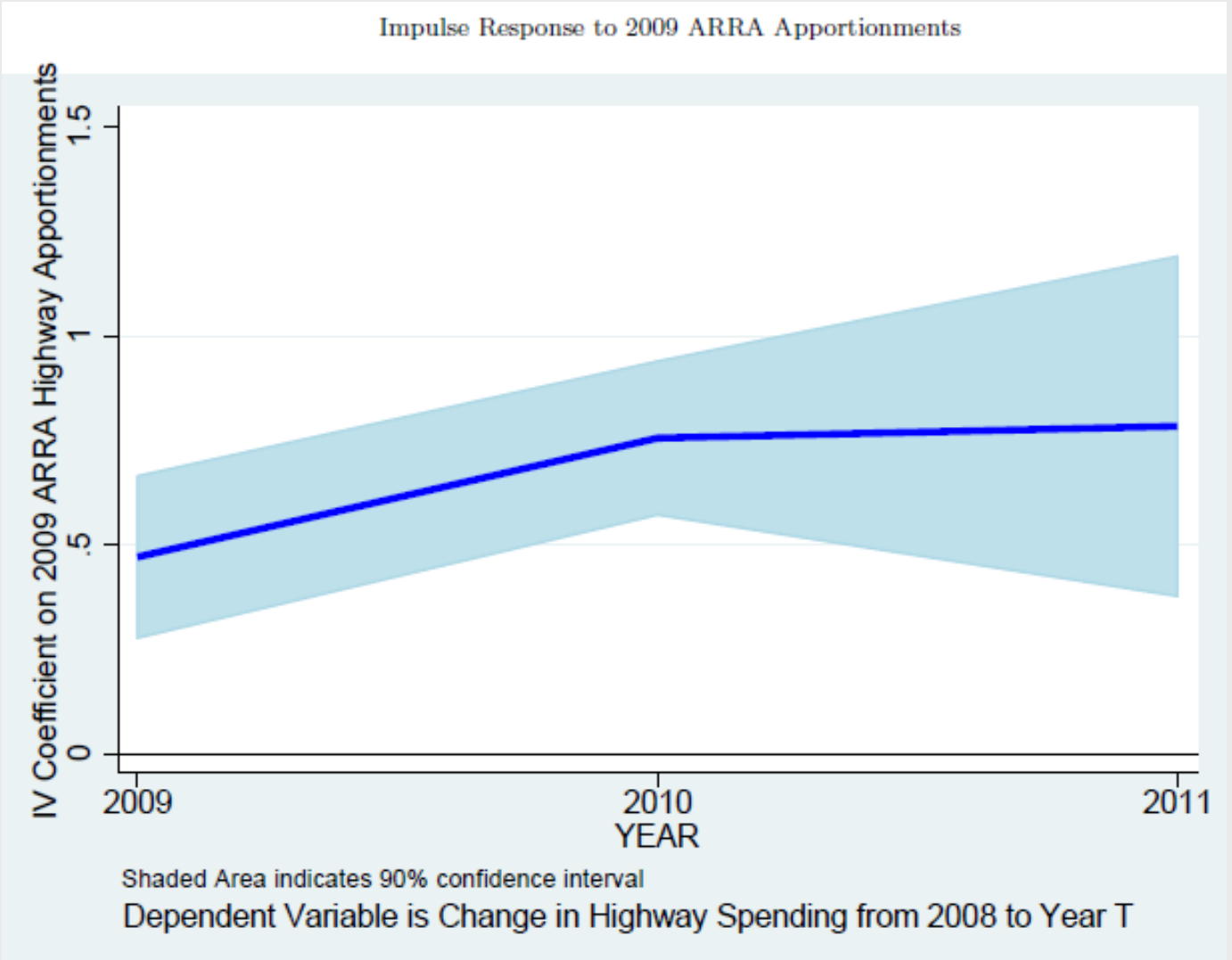
→ higher initial GDP

→ (eventually) more public capital

→ (eventually) higher GDP, employment, productivity, wages, personal income, etc.

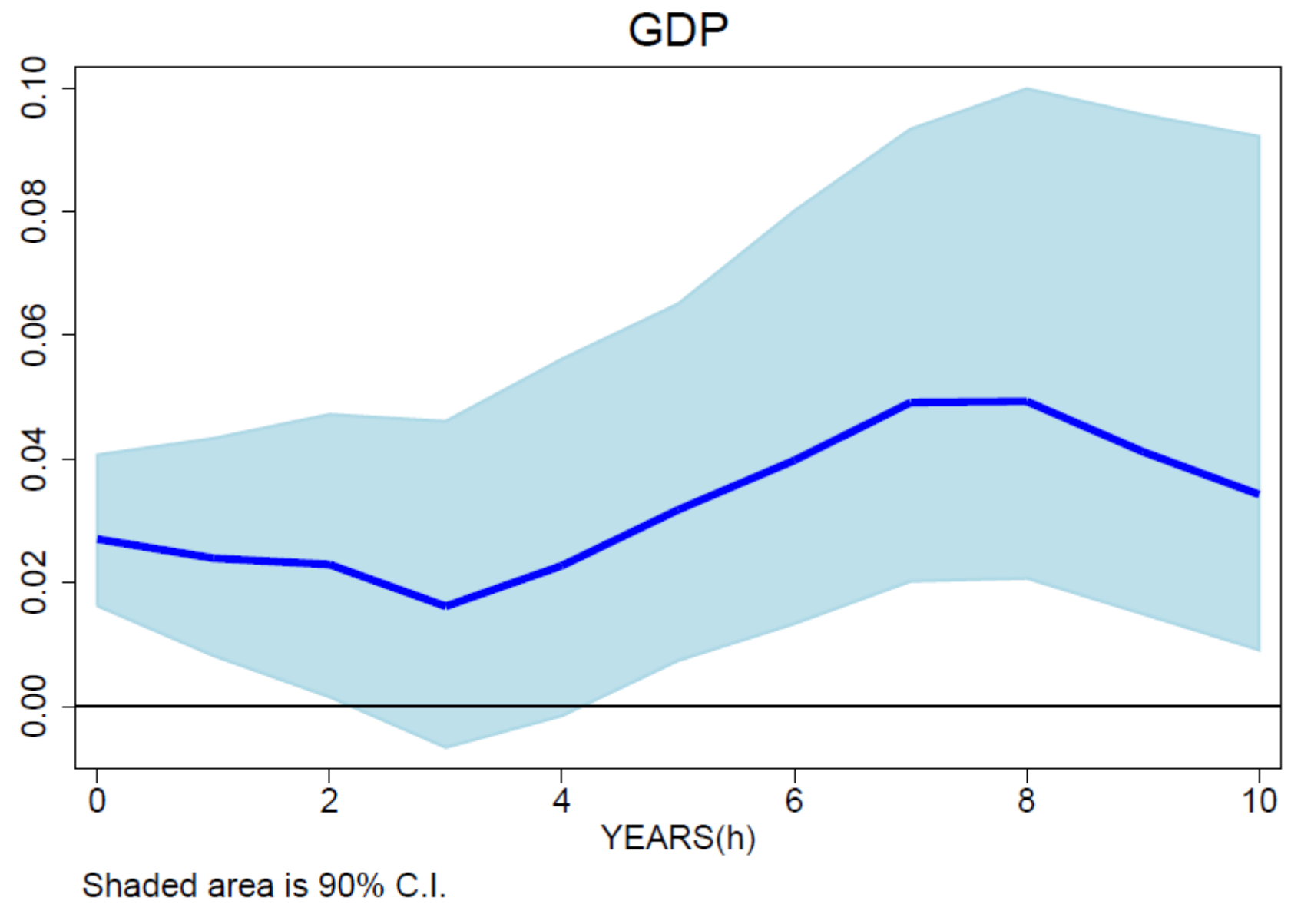
Other Evidence of "Flypaper Effect," from ARRA

- In Leduc & Wilson (2014), we find that federal highway grants increase state highway spending more than dollar-for-dollar

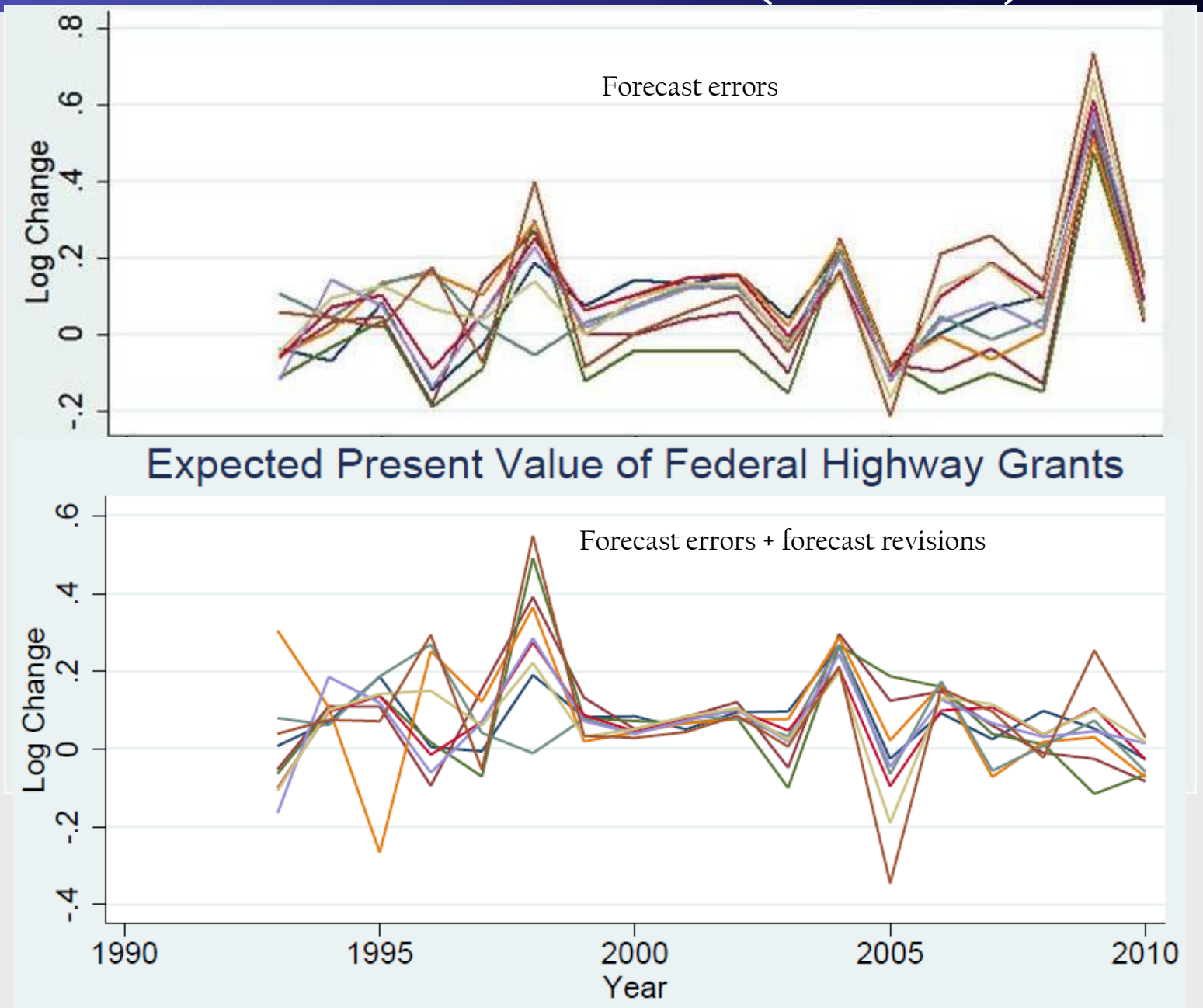


Extra Slides

GDP Response Estimated Via Panel VAR



Variation in shock measure (9 states)



Identification → Implementation Lags

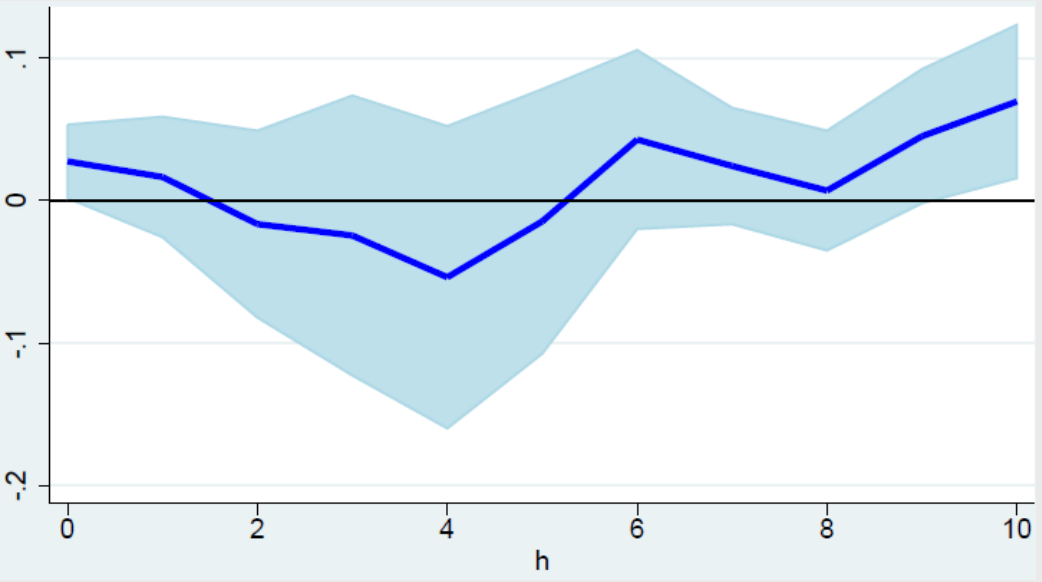
	Obligations	*Outlays*
FHWA Grants	**0.700** (0.106)	**0.122** (0.064)
FHWA grants, lagged 1 year	**0.345** (0.133)	**0.526** (0.081)
FHWA grants, lagged 2 years	-0.037 (0.101)	**0.108** (0.062)
FHWA grants, lagged 3 years	-0.020 (0.038)	**0.044** (0.023)
FHWA grants, lagged 4 years	-0.016 (0.036)	**0.058** (0.022)
FHWA grants, lagged 5 years	-	**0.053** (0.016)
FHWA grants, lagged 6 years	-	**0.063** (0.015)
FHWA grants, lagged 7 years	-	0.021 (0.015)
Year fixed effects	Yes	Yes
State fixed effects	Yes	Yes
Cumulative effect	**0.973** (0.064)	**0.996** (0.042)

- 70% of grants obligated in first year, ~100% over two years
- Only 12% of grants are outlaid in first year, ~100% after 7 years
- So…using outlays to measure highway spending shocks is problematic
  - Neither reflects when highway work takes place
  - Nor unanticipated
- Hence…we use **grants** in construction of our spending shock
- We use **obligations** to measure spending (as control)

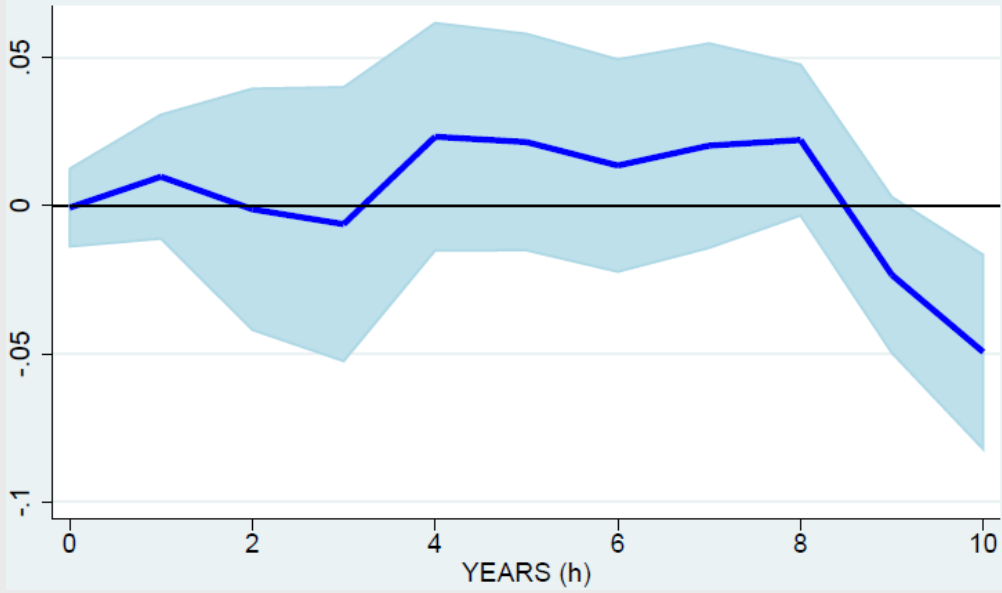
Effects in Recession vs. Expansion

- Use non-linear Direct Projections approach, as in Auerbach & Gorodnichenko (2011)

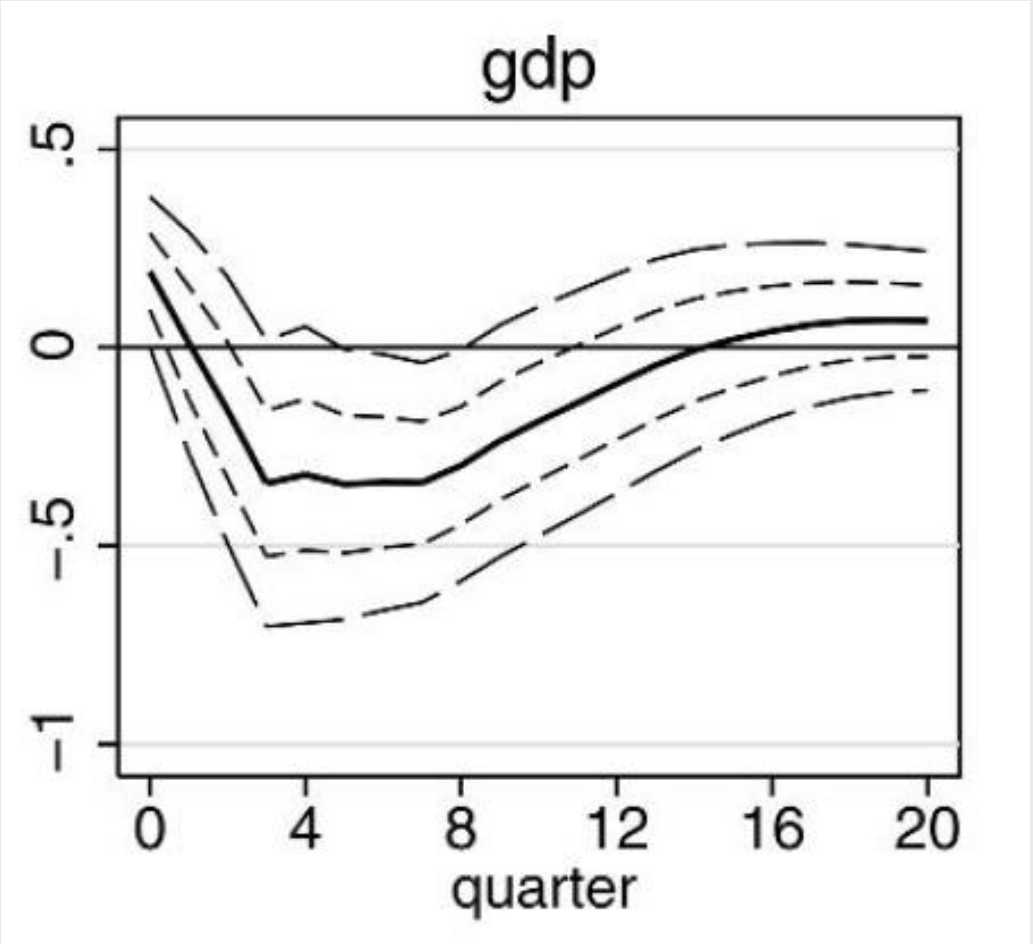
RECESSIONS



EXPANSIONS



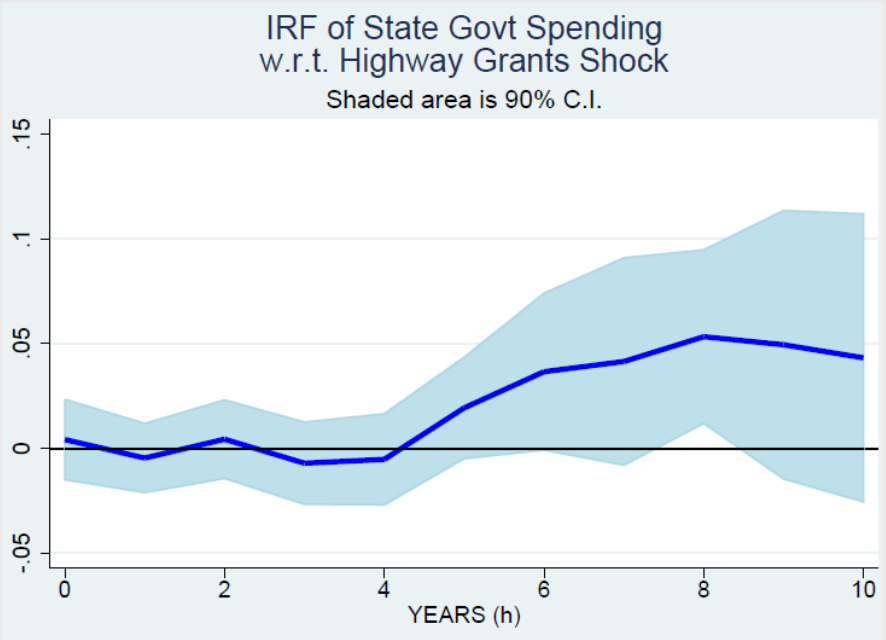
Comparison to Literature on Defense Spending

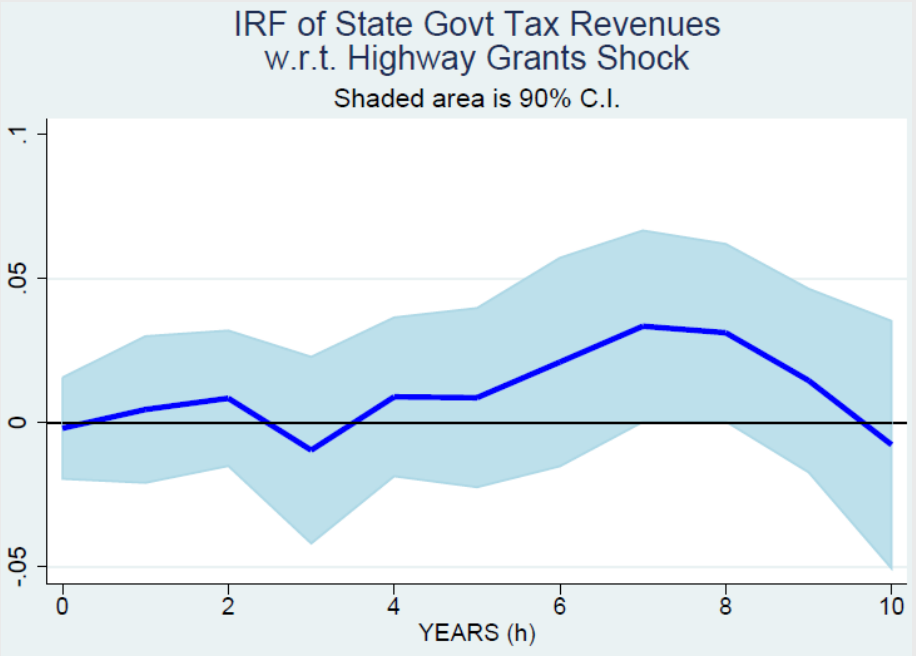


- Ramey (2011 QJE), using shocks to professional forecasts, 1969- 2008
- Also U-shaped, though shifted down and with sooner second peak (4-5 years)

Effects on Other Macro Variables

- **State govt spending and tax revenues rise 6-8 years out**





Identification → Endogeneity

Formula Apportionment

FUND	FACTORS	WEIGHT	MINIMUM APPORTIONMENT	SHARE OF TOTAL FUNDS
Interstate Maintenance (IM)	Interstate System lane miles Vehicle miles traveled on the Interstate System Annual contributions to the Highway Account of the Highway Trust Fund attributable to commercial vehicles	33.33% 33.33% 33.33%	1/2 percent of Interstate Maintenance and National Highway System apportionments combined	18.2%
National Highway System (NHS)	Remainder apportioned as follows: Lane miles on principal arterial routes (excluding the Interstate System) Vehicle miles traveled on principal arterial routes (excluding the Interstate System) Diesel fuel used on highways Total lane miles on principal arterials divided by the State's total population	25% 35% 30% 10%	1/2 percent of Interstate Maintenance and National Highway System apportionments combined	22.1%
Surface Transportation Program (STP)	Total lane miles of Federal-aid highways Total vehicle miles traveled on Federal-aid highways Estimated tax payments attributable to highway users paid into the Highway Account of the Highway Trust Fund	25% 40% 35%	1/2 percent	23.3%
Bridge Replacement and Rehabilitation (BRR)	Relative share of total cost to repair or replace deficient bridges	100%	1/4 percent (10 percent maximum)	14.8%
Congestion Mitigation and Air Quality Improvement Program (CMAQ)	Weighted nonattainment and maintenance area population	100%	1/2 percent	6.1%
Recreational Trails Program (RT)	Equal shares to each eligible State Non-highway recreational fuel use during the preceding year	50% 50%	None	0.2%
Metropolitan Planning (MP)	Urbanized area population*	100%	1/2 percent	0.8%
Highway Safety Improvement Program	Total lane-miles of Federal-aid highways Total vehicle miles traveled on lanes on Federal-aid highways Total fatalities on the Federal-aid system	33.33% 33.33% 33.33%	1/2 percent	3.9%

- Federal Grants distributed to states based on exogenous formulas

National Highway Spending and Estimated No-ARRA Counterfactual