Congestion, Economic Performance, and Autonomous Vehicles

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Outline

- **Basic data about the US transportation system**
- **Analyzing the system in the context of an economy**
- **The effects of congestion on performance**
- **Ameliorating congestion with autonomous vehicles**

Basic Data on Transport System and US Economy

- Total pecuniary spending by firms and consumers $2.1 trillion
- Government spending on infrastructure $0.26 trillion
- Transportation's share of GDP (17%) is similar to healthcare's share
- Expenditures in time (freight and travelers) $3 trillion

Value of the Capital Stock

- **Highways $2.8 trillion**
- **Rail network $0.34 trillion**
- **Pipelines $0.17 trillion**
- **Public airways, waterways, and transit structures $0.57 trillion**
- **Challenge is to efficiently use the capital stock**

Transportation's Effects On Other Sectors

- **Labor Markets—job matching, employment, and wages**
- **International & Domestic Trade Flows—trade costs, product variety**
- **Industry Competition and Efficiency—scale and scope economies**
- **Agglomeration Economies in Metropolitan areas—exchange ideas and information**
- **Transport Inefficiencies Generate Huge Costs Because Entire Economy is Affected**

Congestion

- **Congestion adversely affects travelers and non-transport sectors of the economy—evidence on the former but little evidence on the latter**
- **We explore how congestion affects the California economy accounting for the growth in employment, GDP, wages, and freight flows**
- **Policy mindset is to increase infrastructure spending to reduce congestion costs**
- **Autonomous cars remind us that modes lead infrastructure not the other way around**

Measuring the Effect of Congestion

- **Fundamental challenge is that unobserved influences that affect congestion will also affect any measure of economic performance**
- **Determining a causal relationship between congestion and economic performance requires a valid instrument for congestion**
- **Our analysis is confined to California counties with measurable congestion**
- **California has self-help counties that starting in the 1980s could pass legislation to pay for road improvements to relieve congestion**

Self-Help (SH) County Taxes as a Valid Instrument for Congestion

- **Measure is the cumulative share of highway spending generated by SH taxes**
- **CUMULATIVE = Σ tax rate • share of SH revenue allocated to highway projects**

First stage results:

Log Annual hours of delay per commuter =

0.25 CUMULATIVE* -0.017 CUMULATIVE SQUARED* + Population and urban area and year fixed effects

R-Square = 0.91 *p <0.05 N=256 county years

Are SH County Taxes Exogenous?

- Note we include only CA counties that enacted a SH tax. Tax rate was nearly always 0.5%, so it is independent of a county's economic performance
- Year in which a SH tax was enacted and share of tax revenue allocated to highways are exogenous
  - Many SH taxes failed on first try, indicating importance of political mobilization
  - Threshold for approval was raised by CA Supreme Court from 50% to 67%
  - Spending plans (earmarks) cater to a variety of interests and sub-regions within a county

Specification for GDP, Employment & Wages

Basic Model (suppressing time/county subscripts)

$$\text{Log}(G) = \beta * \log(C) + \boldsymbol{X\delta} + \varepsilon,$$

where G is the growth rate of a performance variable, employment, GDP, or wages, β is the causal effect of congestion level C on the growth rate; $\boldsymbol{X\delta}$ is an array of controls and coefficients, and ε is the random error term

Sample: 256 county years for CA counties with observed congestion that previously voted for a SH tax and eventually enacted one by 2011.

Specification for Freight Flows

- We obtained data for freight flows between CA counties (N=100) for the years 2007 and 2010 and constructed a three year trade flow growth rate between urban area i and urban area j, FG_{ij}
- Our model: $\ln FG_{ij} = \beta_0 + \beta_1 \ln(congestion_i) + \beta_2 \ln(congestion_j) + \beta_3 population_i + \beta_4 population_j + \varepsilon_{ij}$
- Congestion at the origin and destination is instrumented by CUMULATIVE at the origin and destination

Estimation Results for β: Effect of Congestion on the Economy

	OLS	2SLS	2SLS R^2
Job Growth	-0.011*	-0.025*	0.72
GDP Growth	-0.008	-0.026*	0.72
Wage Growth	-0.01	-0.018***	0.63

*p<0.01 ***p<0.1

Estimation Results for Freight Flows

Delay at the Origin	OLS	2SLS
Urban Area	-0.099*	-0.318*

Delay at the Destination	OLS	2SLS
Urban Area	-0.005	-0.118

*p<0.01

Annual freight flow growth rate elasticity with respect to origin congestion= -0.106

Annual freight flow growth rate elasticity with respect to destination congestion= -0.039

Ameliorating Congestion: Stimulating Economic Growth

- **Increase government spending: raise gas tax, infrastructure bank, repatriation of foreign profits**
- **Institutional reform: efficient road pricing, investment, and allocation of funds; implement latest technologies**
- **Quasi-experiments: public-private partnerships; outright privatization**
- **Technological change and innovation: autonomous vehicles**

Modes Lead Infrastructure

- **Transportation modes have improved their performance and safety regardless of the state of their infrastructure**
- **Autonomous Vehicles: have the potential to prevent collisions and reduce regular and incident delays by creating a smoother traffic flow**
- **Benefits depend on market penetration—50% penetration could reduce congestion delays 50% and yields annual benefits to travelers of some $200 billion**
- **Benefits to the broader economy could be even larger**

Counterfactual Analysis for California

Scenario: Autonomous vehicles reduce congestion 50%

Recall, $\text{Log}(G) = \beta * \log(C) + \boldsymbol{X\delta} + \varepsilon$

Given the scenario, the post growth rate is:

$\text{Log}(G_{post}) = \beta * \log(C \bullet (1 - \alpha)) + \boldsymbol{X\delta} + \varepsilon$, where α is the percentage reduction in congestion.

Thus, we can express the post-scenario growth rate as:

$$G_{post} = G \bullet \exp(\beta * \log(1 - \alpha))$$

Scenario Results

Jobs	Increase in Annual Growth	+ jobs 2011
	1.7%	251,624
GDP	Increase in Annual Growth	+ GDP 2011
	1.8%	$36.6 billion
Wages	Increase in Annual Growth	+ Wages 2011
	1.24%	$10.5 billion
Freight	Increase in Annual Growth	+ Freight 2008
Flows	7.6%	$57 billion

National Multiplier: 7.6 based on BEA

2010 GDP comparison

Summary

- **A nation's transportation system is a large and vital part of its economy**
- **Transport affects many sectors besides the users and suppliers of transportation**
- **Transportation infrastructure has been compromised by inefficiencies, especially due to congestion**
- **Status quo bias indicates it is unlikely that congestion will be reduced efficiently by policy reforms**

Summary continued

- **Historically, private modes have led infrastructure through technological advance**
- **Autonomous vehicles have the potential to greatly improve infrastructure efficiency, which would generate large benefits to travelers and non-transport sectors of the economy**
- **Government's role is to expedite—not impede—implementation of this technology**